ENGINEERING
TOMORROW

Installation and Operation Guide

ED-DT318B

Drive Train Systems with Traction Control Converter and Machine with 2 Speed Transmission

Revision D

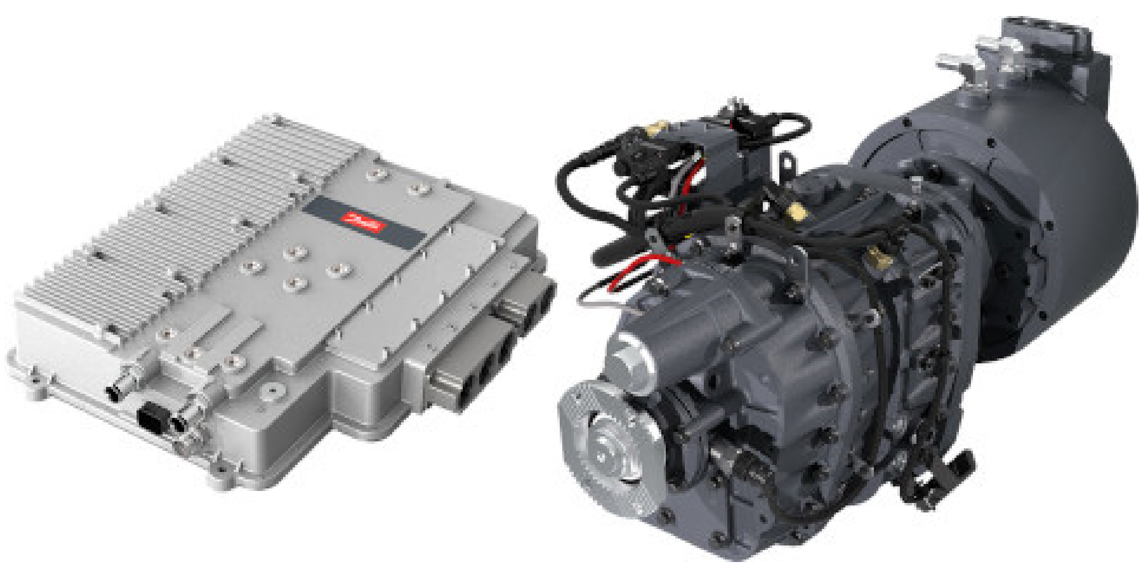


Table of Contents

List of Figures

List of Tables

<table>
<tr><th>Revision</th><th>Date</th><th>Author</th><th>Information</th></tr>
<tr><td>A</td><td>2018/12/19</td><td>Jesse C. Loggins</td><td>Initial Release</td></tr>
<tr><td>B</td><td>2019/04/16</td><td>Jesse C. Loggins</td><td>Increased minimum air pressure to implement shift

Added note to Air Pressure Out Of Range to reflect the minimum air pressure requirement

Added allowable tolerances on Max Sink and Max Source Currents Added limits to 24 V power supply for proper operation of the solenoid

Added notes to Upshift Failed and Downshift Failed stating the updated logic

Added notes in Section 7.1, 7.2.1.6 and 7.3.6.1 to reflect reverse operation in High gear

Added note to MCU CAN Active to reflect the observed discrepancy

Ensured a consistent 10A Fuse requirement throughout the Manual</td></tr>
<tr><td>C</td><td>2019/12/07</td><td>Jesse C. Loggins</td><td>Decreased minimum air pressure requirement to implement shift

Added Factory Diagnostic Message under TCU Status Message 2</td></tr>
<tr><td>D</td><td>2020/09/01</td><td>Jesse C. Loggins</td><td>Update to reflect change of ownership to Danfoss</td></tr>
</table>

1 Introduction

Thank you for your purchase of a Danfoss Power Solutions™ PowerPhase® DT2 Drive Train System Motor and Controller package. Notify Danfoss Power Solutions immediately if any damage has occurred during shipment.

PLEASE READ THIS ENTIRE MANUAL BEFORE APPLYING VOLTAGE TO THE SYSTEM.

This manual applies to any Drivetrain found in Table 1.1.

Table 1.1: ED-DT318B systems

Editron Product Model	Description Code	Description	Former UQM Designation
ED-DT / EDITRON SUB SOLUTIONS (Electric drivetrain system with transmission)			
ED-DT318B-PT2370E-360	ED-DT	Drivetrain Sub Solution	DT2 HD 220(+)
ED-DT318B-PT3050-600	ED-DT	Drivetrain Sub Solution	DT2 HD 250
ED-DT318B-PT3050E-600	ED-DT	Drivetrain Sub Solution	DT2 HD 250(+)

This state-of-the-art system is specifically designed for high performance drive applications. The shipped package consists of 2 parts:

- A high performance, liquid cooled, Brushless Permanent Magnet (PM) motor attached to a two speed pneumatically controlled transmission and a system level control processor referenced in this manual as the Transmission Control Unit or TCU.
- A high-power, liquid-cooled inverter with a full-featured digital signal processor (DSP) controller referenced in this manual as the Motor Control Unit (MCU), the controller or the inverter depending on the functionality being discussed.

This manual covers installation and operation of the PowerPhase® DT2 System. The system is ready to use, powerful, lightweight, rugged, reliable, and designed based upon Danfoss Power Solutions' years of experience developing and manufacturing motors and controllers for electric drive systems.

This manual also provides an overview of the CAN interface of a Danfoss Power Solutions Motor Control Unit (MCU) coupled to an Eaton 2 speed transmission with a Transmission Control Unit (TCU). It includes details of the CAN message layout and addressing schemes for command, feedback, and status messages.

The system provides many features required to develop a customized, high performance drive application. The system is capable of fully regenerative, four-quadrant, bi-directional torque-controlled operation.

The PowerPhase® DT2 system has been validated as a propulsion system. For applications other than propulsion systems, please contact Danfoss Power Solutions to determine if the PowerPhase® DT2 system is capable of operation in your desired application.

This guide gives a broad description of the motor, transmission, and controller package. We highly recommend that you read through these instructions to familiarize yourself with the operation and installation of the package before you begin installation. Please feel free to contact Danfoss Power Solutions if you have any questions regarding installation, application, or service.

⚠	**DANGER**	Dangerous voltages, currents, and energy levels exist in this product. Exercise extreme caution in the application of this equipment. Only qualified individuals should attempt to install, set-up, and operate this equipment.

⚠	**DANGER**	Incorrect motor and controller wiring can cause catastrophic failure. Proper connection of motor cables, signal cable, and DC cable are necessary for safe operation. Do not swap motor windings to reverse direction.

1.1 About this Guide

This installation guide provides instructions and guidelines for mounting, starting, testing, and operating your PowerPhase® DT2 system. These instructions are intended for an experienced audience with a high level of relevant knowledge.

This manual utilizes textual explanations, diagrams, photographs, computer-aided design (CAD) renderings, and interface control drawings (ICDs) to guide the user through installation and operation. The latest ICD drawings for the PowerPhase® DT2 system are available by contacting Danfoss Power Solutions.

This manual is organized as follows: (1)

- Section 1 is a general introduction to the PowerPhase® DT2 system
- Section 2 covers installation of the PowerPhase® DT2 system
- Section 3 covers electrical connections
- Section 4 covers cooling requirements for the motor and the inverter
- Section 5 discusses vehicle operation considerations
- Section 6 describes the hardware and protocols involved in system communications
- Section 7 contains the definitions of the CANbus message between the VCU and the TCU
- Section 8 describes the diagnostic software used to monitor the MCU
- Section 9 describes vibration test results
- Section 10 contains suggested response to status/error conditions.
- Section 11 contains a glossary of terms used in this document.
- Section 12 repeats all the safety notices contained within this document

1.1.1 Conventions

The **inverter/controller/Motor Control Unit** assembly may be referred to as the '**controller'**, the '**inverter**' or the '**MCU'** depending on the specific functionality being discussed.

You, the customer and reader of this manual, are referred to as 'the **user**.'

The **Signal Cable** (Cable E in Figure 1.1) may be referred to as **motor position** or **temperature cable**.

Clickable links to other sections in the manual, such as figures or appendices, are red.

1.1.2 Control Units

This manual makes extensive references to three control units with different areas of responsibility. These units are:

VCU: Vehicle Control Unit – The customer supplied unit which has overall control to the vehicle. The VCU sends commands to and receives status from the TCU

TCU: Transmission Control Unit – The vendor supplied unit which controls the amount of torque supplied to the vehicle's drivetrain. The TCU receives commands from and reports status to the VCU. In turn, the TCU uses the commands from the VCU to control the MCU.

MCU: Motor Control Unit – The vendor supplied unit which controls the vehicle's motor. The MCU receives commands from and reports status to the TCU. The MCU uses the commands from the TCU to control speed of the motor, the electricity to drive the motor and the electricity generated by the motor. The term MCU refers specifically to the DSP processor board located within the inverter.

1.1.3 Safety Information

The procedures described in this guide are highly technical and involve high voltage equipment which rotates at thousands of rpm. Accidents involving this equipment could result in severe injury or death. Please read and understand the entire guide before beginning to install the motor or controller.

The following notices signal possible hazardous situations or other important information:

DANGER	Indicates a hazardous situation that, if not avoided, will result in death or serious injury.
WARNING	Indicates a hazardous situation that, if not avoided, could result in death or serious injury, or catastrophic damage to the equipment.
CAUTION	Indicates a hazardous situation that, if not avoided, could result in minor or moderate injury or damage to the equipment.
NOTICE	Emphasizes important information or advice.

1.1.4 High Voltage Safety Information

DANGER

Exposure to high voltage can cause shock, burns, and even death.

Technicians with special training and knowledge are required to service the high voltage components in the vehicle.

High voltage components are identified by labels. Do not remove, open, take apart, or modify these components.

High voltage cable or wiring has an orange covering. Do not probe, tamper with, cut, or modify high voltage cable or wiring.

1.2 Packaging and Disassembly

The standard packaging for the PowerPhase® DT2 system will consist of the MCU/controller/inverter, the Drive Train (the motor and transmission), and the associated cables, connectors and pins. The total weight of the controller is 37 kg and motor/transmission is 176 kg.

WARNING Both the motor/transmission and controller are very heavy! Be careful while removing the products from packaging to avoid dropping the components and potentially damaging the products.

1.3 The following items are included in the packaging:

- The Controller/Inverter/MCU with a ship kit containing bolts for high voltage and bolts for cover.
- The Motor/Transmission/TCU with a ship kit containing mating connectors with pins/hardware for fabricating cable between the drivetrain interface connector (connector 3 in Figure 1.1) and the Vehicle Control Unit.
- The TCU to MCU Interface Cable (item C in Figure 1.1).
- The Signal Cable (item E in Figure 1.1).
- DC Cable (item F in Figure 1.1).
- The ship kit will also contain the connector housings and pins/hardware to fabricate cable between the Drivetrain Interface Connector (connector 3 in Figure 1.1) and DT2 Diagnostic Connector (connector 4 in Figure 1.1). Note: The customer is responsible for supplying the cabling between the VCU, the DT2 Diagnostic Connector, and the Drivetrain Interface Connector.

1.4 System Overview

The PowerPhase®DT2 system converts the High Voltage DC battery voltage into torque as an output from the transmission, and converts vehicle inertia as torque input to the transmission to electricity to charge the High Voltage DC battery. The system overview block diagram is shown below.

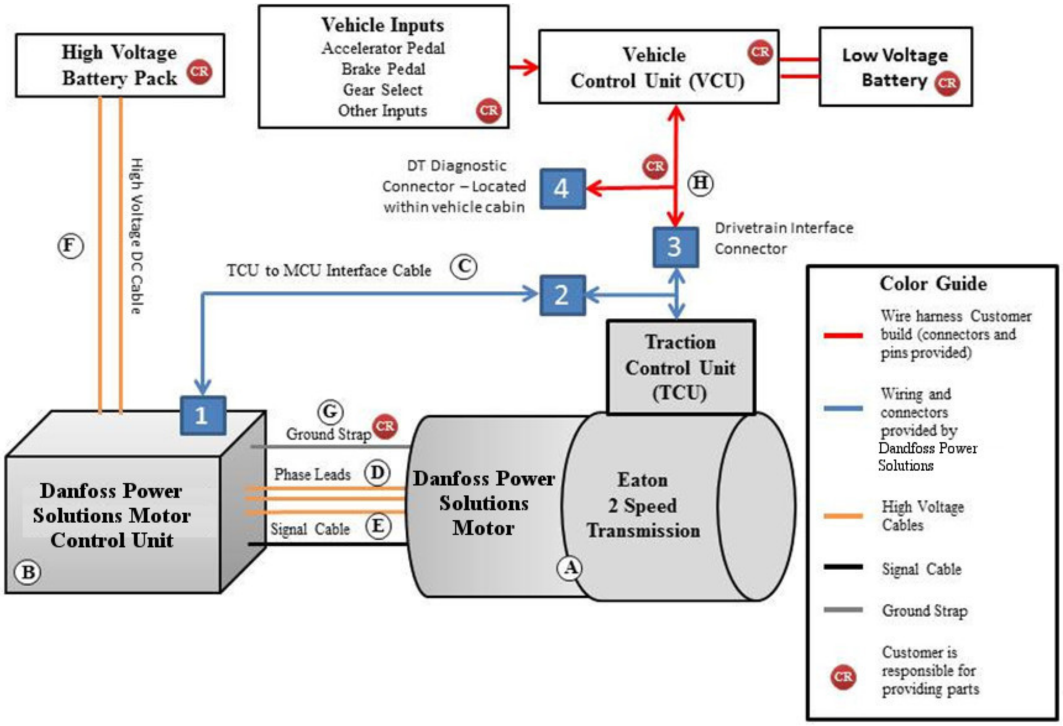


Figure 1.1: Block Diagram of the Total System

A. Motor & 2 speed transmission — Installation of the Motor & 2 speed transmission is defined in this user/installation manual.

B. Motor Controller (MCU) — Installation of the Controller is defined in this user/installation manual.

C. **TCU to MCU Interface Cable —** Danfoss Power Solutions supplies this Interface Cable. The cable length is defined as part of the purchase order (2.5 meters if not otherwise specified).

D. **Phase Cable —** Included as part of the motor. Danfoss Power Solutions supplies the Phase Cable. The cable length is defined as part of the purchase order (2 meters if not otherwise specified).

E. **Signal Cable —** Danfoss Power Solutions supplies this Position Cable. The cable length is defined as part of the purchase order (2.6 meters if not otherwise specified).

F. **High Voltage DC Cable —** See the documented ICD drawing. The cable length is defined as part of the purchase order (2 meters if not otherwise specified).

G. **Ground Strap** – Customer builds using 4 gage or larger wire. Braided ground strap wire is recommended.

H. **Drivetrain Control Cables** – Customer builds. The customer is responsible for all components including proper termination of CAN buses. The customer is responsible to ensure proper wire crimps are performed to the terminals.

1. 12-pin Deutsch connector – Connects the MCU to the TCU via the TCU to MCU interface Connector

2. **10-pin MCU Interface connector** – Connects the TCU to the MCU via the TCU to MCU interface Connector
3. **16-pin User Interface connector** – Connects the TCU to the VCU and provides access to the TCU to MCU CAN bus and the MCU's RS232 port.
4. **Diagnostic Connector** – Customer responsibility. Provides configuration and troubleshooting access to the TCU and MCU.

1.4.1 Vehicle Control Unit

The Danfoss Power Solutions system *requires* a vehicle level controller with the following expectations:

- PowerPhase® DT2 systems are designed to act as torque slaves within the vehicle system which receive torque, speed limit, and direction of travel commands from a vehicle level controller and react with appropriate torque to maintain direction of travel at or below the speed limit.
- The vehicle designer is responsible for providing the 24 V low voltage power for both the Traction Control Unit (TCU) and Motor Control Unit (MCU). Danfoss Power Solutions recommends that the VCU control the voltage supplied to the TCU & MCU. The current requirement for low voltage is 10 amps and the voltage supply line should be appropriately fused.
- The VCU is the system that takes various vehicle inputs (e.g., accelerator, brake pedals, and PRNDL), determines the desired action for the Danfoss Power Solutions system, and communicates the desired commands to the TCU.
- The vehicle control module must include hardware and software to ensure that accurate commands are issued to the TCU.
- It is the user's responsibility to determine and control the Danfoss Power Solutions system properly.
- The user is responsible for integrating the Danfoss Power Solutions system into the vehicle and must implement any regulatory requirements to ensure compliance.
- All vehicle level feedback and safety features are the responsibility of the vehicle system and NOT the Danfoss Power Solutions system.

2 Installation

This section provides information on mounting the drivetrain and controller in your vehicle. The installation process for the Danfoss Power Solutions system is fairly straightforward but requires planning and caution to avoid potential injury and/or damage to you or the equipment.

2.1 Avoiding Installation Problems

Please be aware of the following potential installation issues, which will cause damage or non-operational equipment:

WARNING Do not modify, or cut and re-solder, the Position cable length. If you need an alternate length, contact Danfoss Power Solutions.

WARNING Do not modify, or cut and re-solder, the Phase cable length. If you need an alternate length, contact Danfoss Power Solutions.

WARNING The DC cable length can be shortened if necessary. The customer is responsible for the termination to the battery system and for ensuring proper termination of the shielding is achieved.

WARNING Ensure that the motor shaft will remain unobstructed during acceleration.

WARNING Do not open the controller or motor housings.

CAUTION Ensure that there is sufficient liquid cooling and flow rate of coolant.

2.2 Installing the MCU/Controller

This section describes the guidelines for installing the controller for optimum performance and maximum life. Mounting dimensions of the liquid-cooled controller are shown in ICD drawing.

2.2.1 General Notes

The controller may be mounted in any orientation. Danfoss Power Solutions advises that the cable entry points are NOT located on the top of the assembly, to avoid fluids wicking into the controller via the signal cable or user interface cable. Secure the controller using four M10 bolts (user supplied), thru the mounting holes at the corners of the case. The mounting points should be flat within 0.25 mm. The user is responsible for determining the correct torque to apply to the M10 bolts. Controller is not to be mounted to the Motor Transmission Assembly or support structure for the Motor Transmission Assembly.

2.2.2 Vibration Considerations

The controller is to be mounted to the vehicle frame that is supported by the suspension system of the vehicle.

⚠	**CAUTION**	Vibration isolators at the mounting points of the controller are required when the vehicle vibration levels at the controller mounting location are in excess of typical automotive or commercial vehicle levels.

Danfoss Power Solutions has qualified the controller to the vibration levels stated in Appendix A**: Vibration Testing**. It is the responsibility of the integrator or vehicle manufacturer to determine the vibration levels in the application and when necessary, specify, install and maintain the vibration isolators.

2.2.3 Cable Routing

Route the cables in a way that avoids unnecessary binding and premature wear. Do not locate connections in close proximity to any surface or connector that could short the motor leads.

⚠	**CAUTION**	The customer must route and secure the Phase Cables, DC Cable, Signal Cable, and TCU to MCU Interface Cable and Drivetrain Control Cables in such a manner as to ensure that connector housings and sealing interfaces are not stressed during installation or operation.

2.2.4 Preparing the Coolant Loop for MCU and Motor

Danfoss Power Solutions requires that the controller be the first component in the coolant loop. The controller coolant ports function as either inlet or outlet. The performance of the system is not impacted by which controller coolant port is used for inlet or outlet. The temperature of the coolant going to the controller must not exceed 60°C to achieve full performance (reference the flow rates in ICD).

The coolant fittings on the controller are intended for a 20mm hose. The coolant must have a minimum flow of 10 LPM.

If the customer elects to use the Eaton 5586750 heat exchanger (oil to water) to cool the transmission lubrication fluid, the coolant supply to the cooler must **Not** be in line with the inverter or the motor.

⚠	**CAUTION**	Never allow the controller to operate unless the coolant is flowing at a minimum flow rate of 10 LPM.

There is no restriction on the maximum coolant flow. However, the system is designed for a maximum operating pressure of 30 PSI.

2.2.5 Routing the Signal Cable

The Signal Cable (cable E in Figure 1.1) contains information about the position of the rotor, and the temperatures of the motor's rotor and stator. The controller depends on that information to properly control the motor. The data integrity of the Signal Cable is necessary for optimum operation and care must be taken to ensure the reliability of these signals.

Please exercise care with the routing of this cables to prevent them from being scraped, damaged, cut, shorted, unplugged, or disturbed by high voltage noise fields. *Do not* route these cables near any DC power cables or the motor phase cables.

2.2.6 Routing the TCU to MCU Interface Cable

The TCU to MCU Interface Cable (cable C in Figure 1.1) provides 24 V power to the MCU, CAN signals from the TCU, and RS232 com signals from the Diagnostic Software (Section 8). As with the Signal Cable, insuring data integrity is required for optimum performance.

Please exercise care with the routing of this cables to prevent them from being scraped, damaged, cut, shorted, unplugged, or disturbed by high voltage noise fields. *Do not* route this cable near any DC power cables or the motor phase cables.

Note: When specifying a non-standard length for this cable, consideration must be given to the approximately 0.6 m distance from the face of the motor (the point of attachment for the Signal Cable) to the TCU mounting bracket (the attachment point for the TCU to MCU Interface Cable).

2.2.7 Applying Voltage

For safe operation of the PowerPhase® DT2 system, the TCU must have the 24 V system powered up and the TCU Enable (Section 7.2.1.5) and the MCU CAN Active (Section 7.3.2.15) signals must be set to true (1) before high voltage is applied. The 24 V power must remain on and TCU Enable must remain true as long as high voltage is applied.

If at any time either of these conditions is not met while the vehicle is in motion, the high voltage should be disconnected from the inverter and the vehicle should be brought to a complete stop before high voltage is reapplied to the inverter. Failure to do so may result in uncontrolled surges in high voltage which may damage the high voltage battery, the high voltage battery control unit or the inverter itself.

⚠	**CAUTION**	For proper solenoid operation, the 24 V supply must be no lower than 20.4 V and no higher than 28.8 V.

2.3 Installing the Motor & 2 Speed Transmission

The interface dimensions and tolerances of the PowerPhase® DT2 system can be found on the ICD drawing. Please discuss any other methods with Danfoss Power Solutions Engineering before implementing.

2.3.1 Connection of the driveline to the transmission output flange

The output flange (mounts to transmission) is XS type, ISO 8667 cross serrated. The functional limiting torque of the output flange is 14 kNm. The mating driveline flange mounts to output flange and is part of driveline assembly. It is an XS type flange and shall comply with ISO 12667 requirements for cross serrated flanges. The mounting fasteners used to join the output flange to the driveline flange will be supplied by customer and sized according to driveline requirements. Driveline assembly must conform to a balance quality grade of G16 as per ISO 1940-1-2003.

⚠	**WARNING**	Axial loading of the transmission output flange induced by the coupling system can result in premature transmission failure. Users of the system MUST ensure the output flange is not improperly loaded.

2.3.2 Mounting the Motor/Transmission into the vehicle

The customer is responsible for the design of motor / transmission mounting brackets. Refer to Figure 2.1 (left side) and Figure 2.2 (right side) for attachment points for bell housing (motor) mounting brackets. Mounting holes for bell housing mounting brackets are M12x1.75 X 24mm deep. The fastener thread engagement for bell housing mounting holes is 18mm (minimum) and 24mm (maximum). The torque specification for bell housing mounting holes is 80 – 105 Nm.

WARNING	The fastener thread engagement for bell housing mounting holes must not exceed 24mm.

The transmission housing mounting brackets will be attached to the transmission at the locations specified in Figure 2.1 and Figure 2.2. The customer is responsible for replacing existing fasteners with fasteners of comparable strength and of correct length to ensure full thread engagement of the M10x1.5 nut with the addition of their mounting brackets. The torque specification for M10x1.5 nuts is 60-70 Nm.

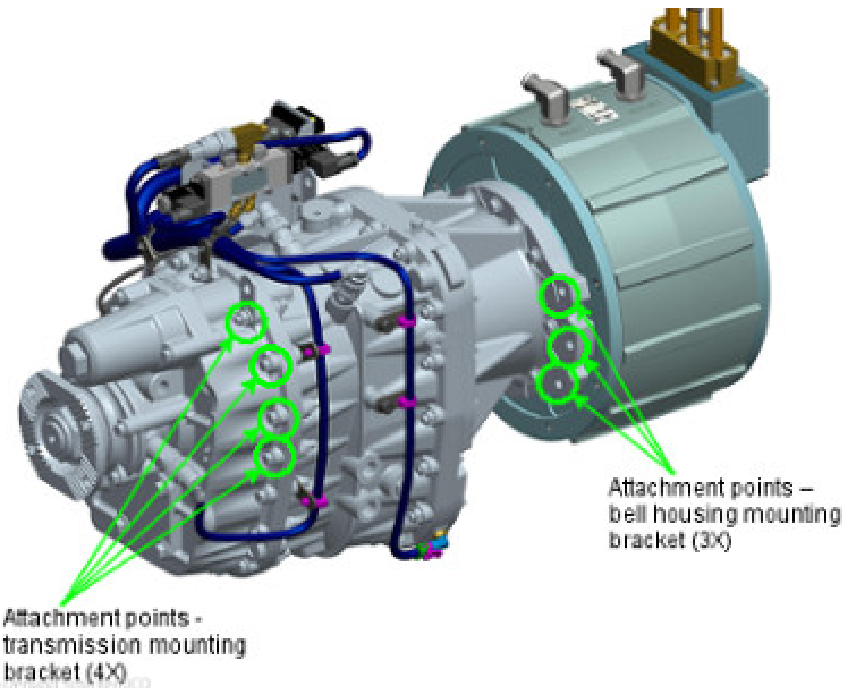


Figure 2.1: Left Side – attachment points for bell housing & transmission mounting brackets.

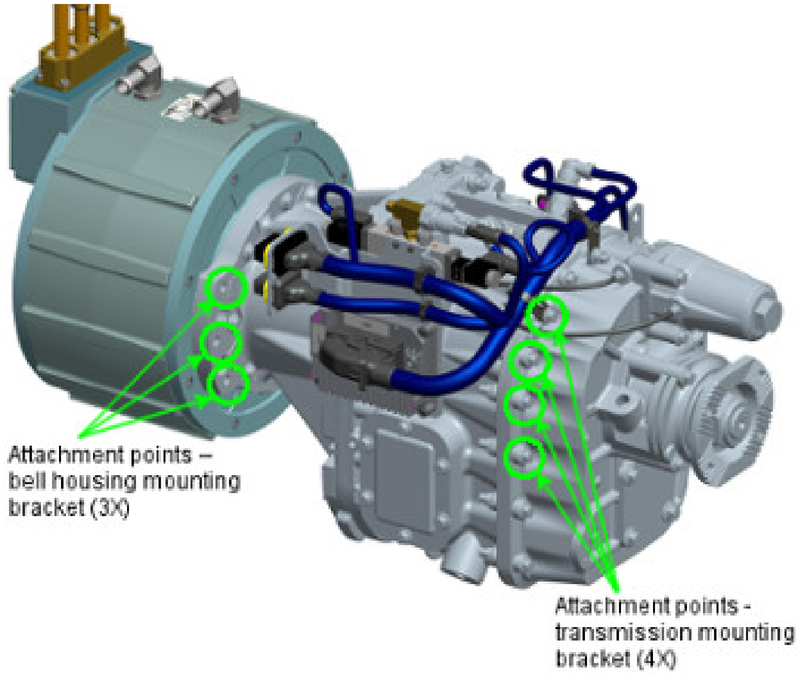


Figure 2.2: Right Side – attachment points for bell housing & transmission mounting brackets.

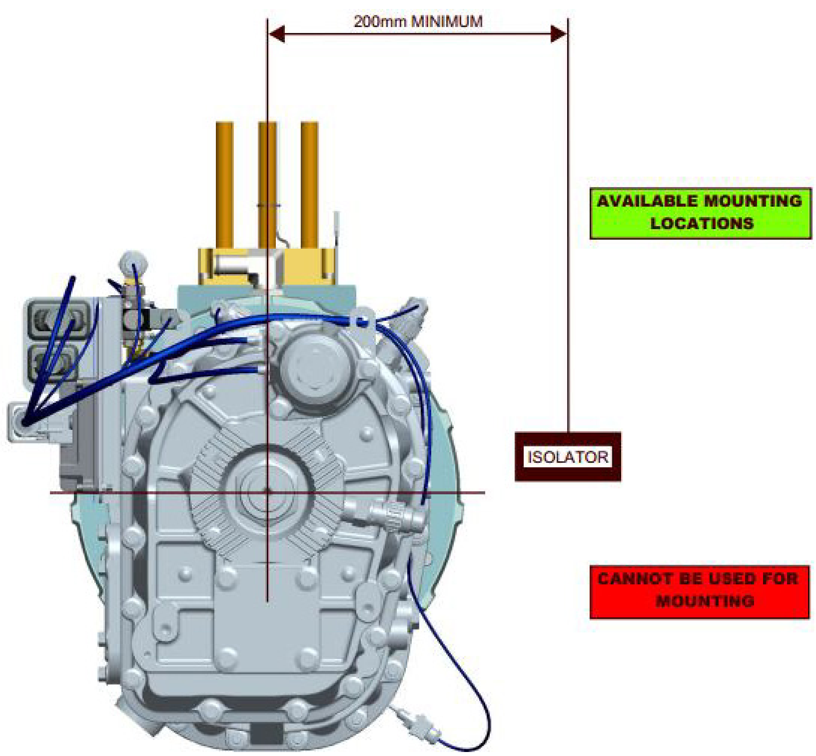


Figure 2.3: Approved location of vibration isolators.

If the fastener securing the wire harness to the transmission (at topmost transmission mounting point in Figure 2.2) is disrupted and used for a mounting bracket attachment point, it is the customer's responsibility to fasten the wire harness to the transmission in the same position as the original wire harness mounting scheme. The wire harness must be secured to alleviate any potential of rubbing on transmission housing and respective components, if this requirement is disregarded damage to harness may occur.

Each mounting bracket (4X) should incorporate an adequately sized vibration isolator.

The minimum distance from the isolator to the centerline of the transmission output shaft is 200mm; refer to Figure 2.3 for recommended location of isolators. The Danfoss Power Solutions recommended isolator is Hutchison 22003, 11, 12 or 13 and should be sized based on customer requirements. The customer should contact Hutchinson, Inc. directly at 1-508-417-7000 to discuss specific vehicle application requirements.

⚠	**WARNING**	The motor housing is not a structural member and is not intended to bear structural loads.

⚠	**WARNING**	Exercise care when mounting the motor and transmission to ensure that moving parts are not constrained and proper clearances are observed. All drive mechanisms mounted to the transmission shaft must be properly secured.

⚠	**WARNING**	Loads on the motor shaft induced by the coupling system can result in premature motor failure. Users of the motor MUST ensure the motor shaft is not improperly loaded.

⚠	**WARNING**	A separate ground wire must connect the motor case to the controller housing. High Voltage lines (positive or negative) must not be tied to the chassis, or the motor and controller/inverter cases. Please see Section 3.2 for more information on grounding requirements.

2.3.3 Overall Clearance Recommendation

- At least 19mm required clearance for powertrain package with surrounding structure
- Transmission shall be angled between 3 and 9.75 Degrees downward from level ground.

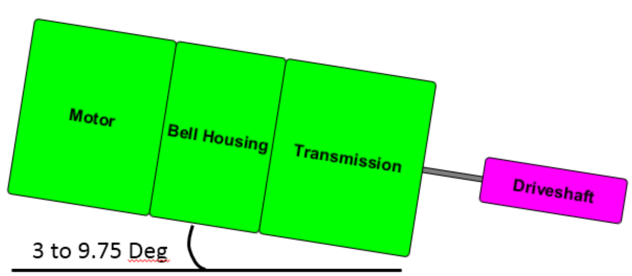


Figure 2.4: Mounting angle limits

- Looking into the output flange, the direction of rotation of the transmission in forward is CCW. The transmission's lubrication pump was designed for this direction of rotation; therefore, the direction of forward rotation cannot be changed without damaging the transmission. Note: for this reason, motion in reverse is limited to a cumulative time of 5 minutes without offsetting forward motion.

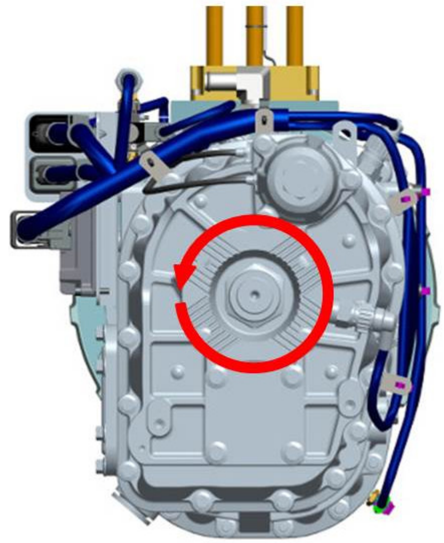


Figure 2.5: Direction of rotation in forward

2.3.4 Motor Coolant Connections

The motor coolant fitting location, hose size, and the inlet and outlet designation of the coolant fittings on the motor are referenced on the ICD drawings. Also reference the ICD drawing for the volume of coolant contained within the motor housing. The angular orientation of the coolant fittings can be changed by loosening the nut on the coolant fitting, rotating it to the desired angle, and tightening the nut to the torque specification on the ICD drawing. More details for making the coolant connections can be found in Section 4.

2.4 Transmission Initial set-up and requirements

2.4.1 Transmission oil/fluid

The customer is responsible for ensuring the transmission fluid is installed and maintained (both levels and changed per Eaton requirements).

The transmission will ship without fluid; therefore, the customer is responsible for filling the transmission before any operation of the drive train system. The estimated amount of fluid is 4.6 liters.

2.4.1.1 Lubrication recommendations

Eaton recommends the use of Eaton SAE 50 PS-164 Transmission Fluid. This and Eaton approved alternatives can be purchased from distributors listed at: www.roadranger.com.

In locations not covered by www.roadranger.com (e.g.: China) and where Eaton PS-164 is not available, BASF 2979 is the Eaton approved alternative. In the Chinese market, the BASF product is available from:

Dealer: 上海振威化工有限公司（Shanghai Zhenwei Chemical Co., Ltd)

Contact: 吴坚 (Wu Jian)

Cell Phone: 13661717371

Fluid Name: 2979

Eaton does not approve mineral oil lubricants by brand name.

Additives or friction modifiers which are not part of the original lubricant are not recommended.

The use of lubricants not meeting these requirements will affect warranty coverage.

Buy from a reputable dealer.

2.4.1.2 Lubrication Information

Proper lubrication procedures are the key to a good all-around maintenance program.

Eaton Transmissions are designed so that the internal parts operate in an oil circulating bath created by the motion of the gears and shafts.

All parts will be properly lubricated if these procedures are closely followed:

- Maintain oil level. Inspect regularly.
- Follow maintenance interval recommendations below.
- Use the brand recommended by the vehicle manufacturer.

2.4.1.3 Maintain Proper Oil Level

Make sure oil is level with the filler opening. Being able to reach oil with your finger does not mean oil is at proper level. The proper level is shown in Figure 2.6.

Never mix different brands of oil.

Figure 2.6: Proper lubricant level

2.4.1.4 Operating Temperature

It is important that the transmission operating temperature does not exceed 120°C (250°F) for an extended period of time. Operating temperatures above 120°C cause breakdown of the oil and shorten transmission life. The following conditions in any combination can cause operating temperatures of over 120°C:

- Operating consistently at road speeds under 32 km/h (20m.p.h.)
- High engine RPM
- High ambient temperature
- Restricted air flow around transmission
- High torque in low gear or reverse operation
- High power PTO operation for extensive periods while stationary

High operating temperatures may require more frequent oil change.

2.4.1.5 Maintenance Interval

The recommended transmission oil change interval is the lesser of 300,000 km or 3 years at vocational bus application

2.4.1.6 Transmission Operating Angles

The transmission operating angle should not exceed 20° from the horizontal (18% road slope at transmission installation angle of 9.8°)

2.4.1.7 Lubrication checking procedure

Oil Level

Before checking the oil level or refilling, ensure vehicle is on level ground. Make sure that the oil is level with the filler opening.

Draining Oil

Drain transmission while oil is warm. To drain oil remove the drain plug at the bottom of the case, or Remove strainer from the intermediate case (Figure 2.7). Clean the drain plug with kerosene before refitting.

Before draining the oil, ensure that oil is warm and the vehicle is on level ground.

To drain the oil, remove the drain plug from the left-hand side bottom of the intermediate case.

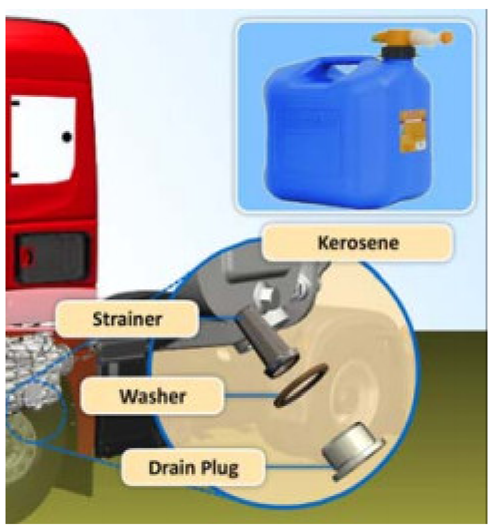


Figure 2.7: Transmission lubricant drain

Refilling transmission

Before refilling the transmission:

- Remove and clean the oil strainer. Clean the strainer in kerosene (paraffin) or suitable solvent and dry thoroughly. Renew the washer and the O-ring if necessary. When refitting, tighten to the torque (40 to 47 Nm).

- Dry the strainer thoroughly.
- Clean the drain plug.
- Inspect the washer and replace if necessary

Before checking the oil level or refilling, ensure that:

- Vehicle is on level ground.
- Lubricant temperature is between 20°C and 50°C.
- Lubricant is at the level of the filler plug hole opening.

The oil drain intervals should be as per the OEM recommendation.

Refill the oil to the level of the filler opening. During oil refill, do not over fill. This causes the oil to be forced out of the front and rear seals.

Do not mix different types of oil.

While adding the oil, it is recommended that different types and brands of oil are not intermixed because of possible incompatibility.

⚠	**WARNING**	When filling with lubricant – Do Not Overfill. This causes oil to be forced out of the front and rear seals.

2.4.1.8 Towing

Before towing the vehicle, place the transmission in neutral, and lift the rear wheels off the ground, or remove the axle shafts, or disconnect the driveline to avoid damage to the transmission during towing

⚠	**WARNING**	Lift drive whiles off the ground or disconnect the driveline from the transmission to avoid damage to the transmission during towing

2.4.2 Transmission Oil cooler

The vehicle manufacturer is responsible for providing the hardware and connections to the transmission for cooling the transmission oil to ensure the oil is maintained within the specified temperatures of between 80° C – 100° C. The transmission bulk oil temperature should not exceed 120ºC for more than 1 hour in any 12 hour period. To enforce these requirements, the TCU will set the Transmission Temperature Warning signal (Section 7.3.2.22) when the transmission temperature reaches or exceeds 120° C. If the temperature stays at or above 120° C for 30min or reaches 125° C, the TCU will set the Transmission Temperature Error signal (Section 7.3.2.23) and will limit torque production to 0 Nm. In addition, if the temperature reaches 120.5° C, the TCU will set the Transmission Temperature Limiting signal (Section 7.3.2.24) signal and will reduce the maximum allowed torque by 10% for each 0. 5° C rise in temperature above 120° C.

The transmission is equipped with an oil pump suitable to application of oil cooler. Oil cooler should be installed as close to transmission as possible. 1 meter is reasonable distance. Actual length will depend on back pressure created by cooler and hoses. Maximum back pressure of the system (cooler + hoses + adapters) should be below 0.6bar (checked with motor speed corresponding to top vehicle speed).

Depending on operation conditions and availability of sufficient air flow to provide cooling, the customer may find that the oil to air cooler is not needed (test in vehicle required).

The port locations on the transmission are shown in Figure 2.8 and Figure 2.9.

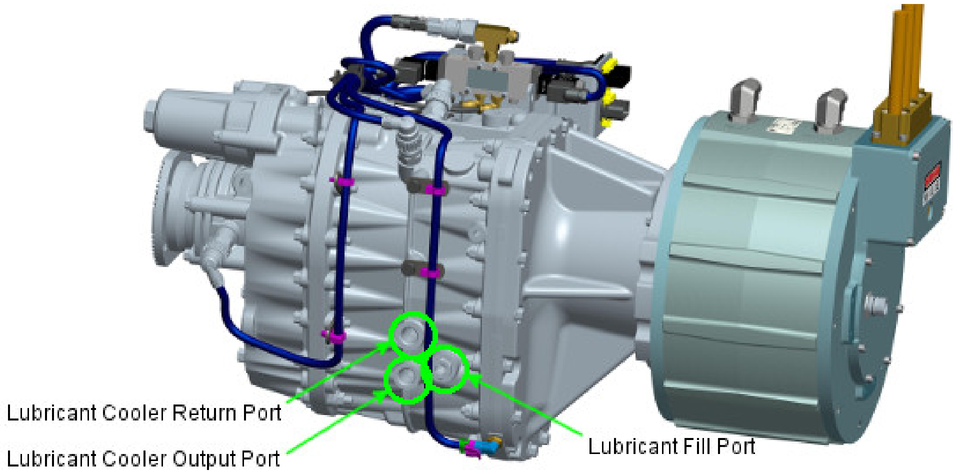


Figure 2.8: Eaton Transmission Lubricant Ports

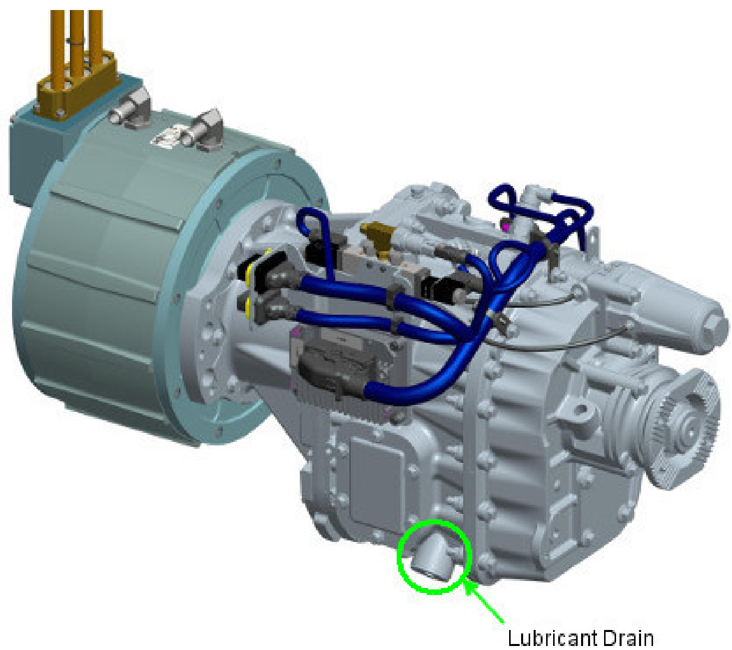


Figure 2.9: Lubricant Drain Port

If an external cooler is required, the customer must supply Metric Straight Thread O-ring Port M22x1.5 X 22mm Deep fittings appropriate to the chosen cooler.

2.4.3 Eaton recommended coolers

2.4.3.1 Eaton 18025 oil to air cooler

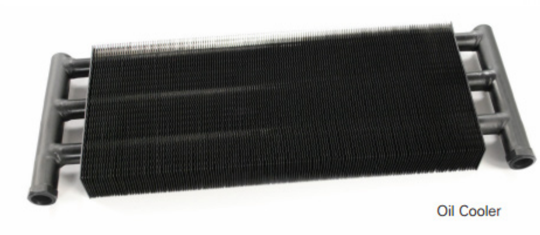


Figure 2.10: Eaton 18025 oil to air cooler

- Typical transmission application
    - 27° C (80° F) ambient
    - 121° C (250° F) oil
    - 77° C (170° F) temperature differential
    - Actual application capacity is 1.7 x graph
- Drastic changes in oil flow have small effect on heat capacity (10:1)
- Air flow changes are more significant (5:1)
- Temperature differential is most significant (1:1)

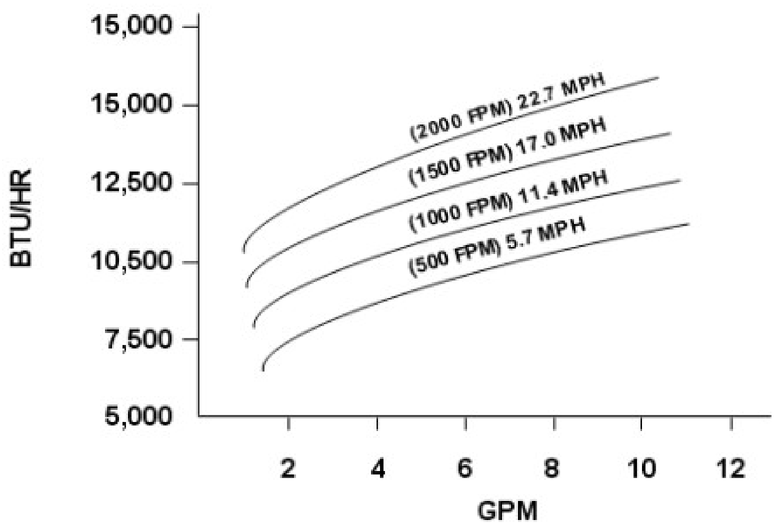


Figure 2.11: Eaton 18025 cooler heat transfer based on 38° C (100° F) temperature differential

Advantages

- Adds no heat to engine
- No potential of cooler failure affecting engine
- No coolant hoses required

Disadvantages

- Requires good location in cool air
- May “overcool” transmission in cold weather
- Requires longer hoses
- Sensitive to vehicle speed
- Requires installation evaluation & lubrication check

Note: Eaton OEM part 18025 oil to air cooler is not available in China

2.4.3.2 Eaton 5586750 oil to water heat exchanger

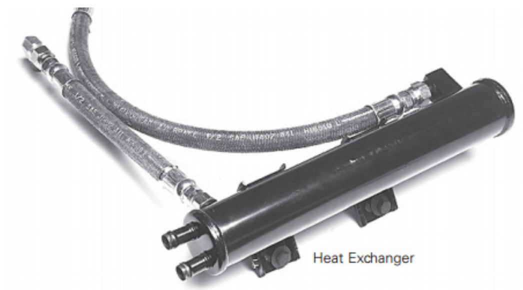


Figure 2.12: Eaton 5586750 oil to water heat exchanger

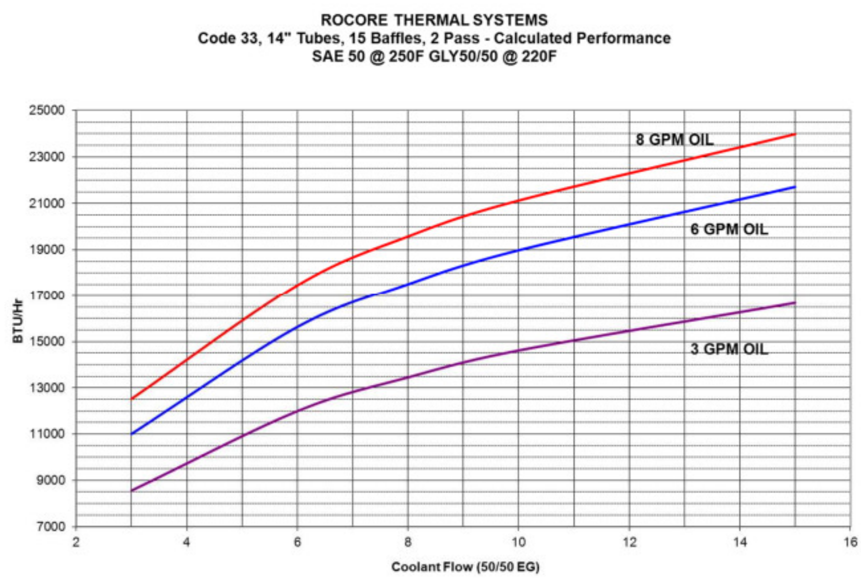


Figure 2.13: Eaton 5586750 heat exchanger heat transfer

Requirements

- 19mm (¾ inch) I.D. cooler lines
- 8 GPM system flow at 1500 RPM

Advantages

- Cooler mounting flexibility
- Convenient chassis location
  - Direct mount on transmission
  - In radiator mounting
- Not sensitive to vehicle speed

Disadvantages

- Adds heat load to total motor cooling system
- Requires coolant connection to radiator
- Requires installation evaluation & lubrication check

Note: If this option is used, the coolant loop must NOT be in line with the e-motor and controller/inverter coolant loop. The transmission coolant loop must be separate from the e-motor and MCU coolant loop.

Note: Eaton OEM part 5586750 oil to water cooler is available in China

2.4.4 Air supply to the transmission

The transmission requires an air supply for shifting. The requirements for the air supply to the transmission are:

- Operating pressure range at transmission to be within 7.5 bar to 8.3 bar. Minimum is 7 bar to support High/Low or Low/High gear shifts.
- High/Low and Low/High gear shifts will not be executed if the pressure is between 3.5 and 7 bar. The system will maintain the gear that it is in when loss of pressure occurs until it is commanded to the Neutral gear position.
- Gear disengagement may occur at pressure ~3.5 bar. Below 7 bar, the system will attempt to maintain gear engagement by applying the minimum torque required to prevent disengagement until it is commanded to the Neutral gear position.
- Flow 300 to 500 dm^3/min at pressure 7 bar.
- Minimum flow through exhaust 8dm^3/sec.
- Filter air contamination between 15 and 30 microns.

Note: 6.35mm (1/4") tube OD push-to-connect fitting is installed on valve. To use 6mm tube, customer must replace with compatible fitting for proper assembly.

The vehicle manufacturer is responsible for the air supply and the connections to the transmission

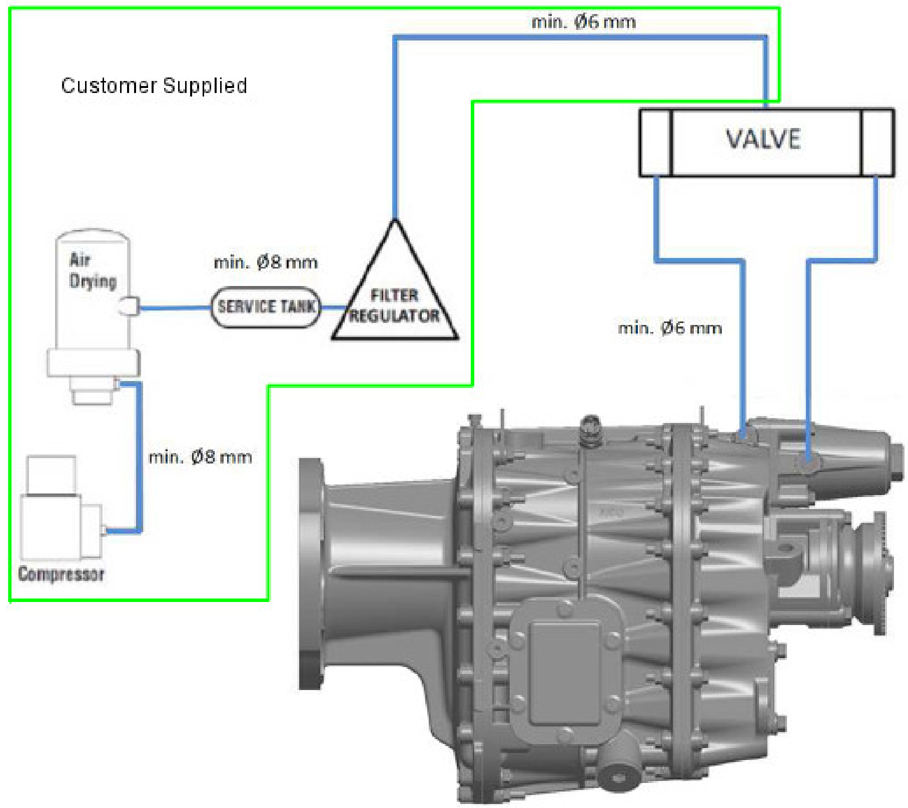


Figure 2.14: Pneumatic system

2.5 Electro-Magnetic Interference and Compatibility

Danfoss Power Solutions has tested the system for Electro-Magnetic Interference (EMI), susceptibility, and electrostatic discharge (ESD). The drive system has a built in EMI filter and comes with shielded phase leads to help in reducing the level of electromagnetic emissions generated. However, please note that due to application-specific routing of the wires and shielding required for installation into a vehicle, Danfoss Power Solutions cannot guarantee compliance with vehicle level testing that must occur.

Some precautions can reduce the level of electromagnetic emissions and compatibility issues from the drive system once the ED-DT318B system is installed into a vehicle. They include, but are not limited to, the following suggestions:

- Keep the controller and the drive motor as close as possible to one another in the installation. This reduces the power conductor length, thus reducing the length of the radiating antenna.
- Keep all of the high-power, motor phase leads as close together as possible in the routing from the controller to the motor. This reduces the open loop area of the radiating element.
- When routing the high-power DC conductors, run them side-by-side. This reduces the loop area and length, and thus reduces emissions.
- Most importantly, remember that the high-power DC and motor phase leads, to and from the controller, are moving several hundred amperes. Routing of any of these wires next to other control or signal wires will provide a coupling path for emissions from these wires. Use proper grounding and shielding techniques when building a vehicle.

2.5.1 CAN and RS232 Shielding

- For the CAN connection on the user interface connector, use a high quality, insulated, shielded, twisted pair cable (refer Danfoss Power Solutions p/n 14020-019, page 27. Do not allow the shield to touch the motor or controller housing. (See Section 6 for information on placement of termination resistors).
- When using CAN, ensure that you have a ground connection on the user interface connector CAN_COM to the same source as the CAN signal, using the CAN shield or a separate ground connection. The CAN circuits within the Danfoss Power Solutions controller are isolated from the 24 V system as well as the high voltage. Providing the ground connection from CAN_COM to a ground of your upper level controller allows the CAN signal reference to be the upper level controller ground.
- For the RS232 cable, you can also use the same type of shielded, twisted, pair cable used on the CAN, and use the shield for the RS232_COM pin connection.
- Ensure that the MCU has a solid connection from the enclosure to the vehicle chassis. This can be done with a braided strap or by directly mounting the MCU to the chassis. This ensures a low impedance conduction path of the EMI noise.

3 Electrical Connections

The following sections describe the motor, controller and PowerPhase® DT2 system level connections. Ensure that the input voltage is not connected before making any connections.

DANGER	Dangerous voltages, currents, and energy levels exist in this product. Exercise extreme caution in the application of this equipment. Only qualified individuals should attempt to install and set-up this equipment.

DANGER	Ensure that the high voltage battery input is not connected before making any connections.

DANGER	Ensure that the 24 V battery input is not connected before making any connections.

3.1 Power Cables

Before connecting any cable to the controller, remove the terminal housing cover.

Figure 3.1 and Figure 3.2 show exploded views of the controller connections.

CAUTION	Ensure the O-Rings are in-place or installed before connection to the controller.

CAUTION	Ensure the O-Rings are not pinched or nicked during installation.

WARNING	Ensure that the power is off before connecting the power cables.

WARNING	Ensure that the phase cables and DC cables are routed and restrained to prevent insulation damage.

WARNING	Do not use Locktite® or similar products when securing the High Voltage DC or the 3 phase AC cables to the inverter. The use of Locktite® in these locations will increase the resistance of the connection and may result in melting of the overmolding.

DANGER	Failure to orient the power lug connections correctly can cause short to chassis.

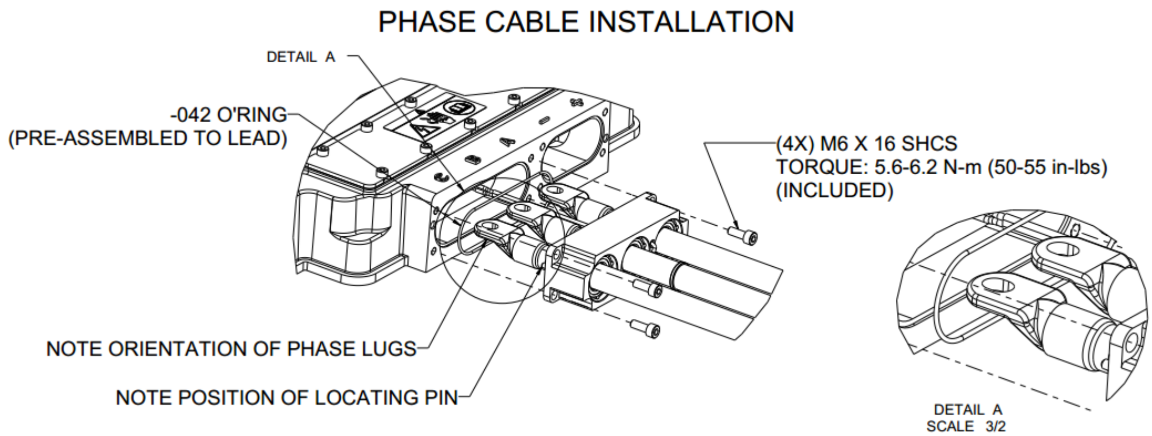


Figure 3.1: Controller Phase Connection

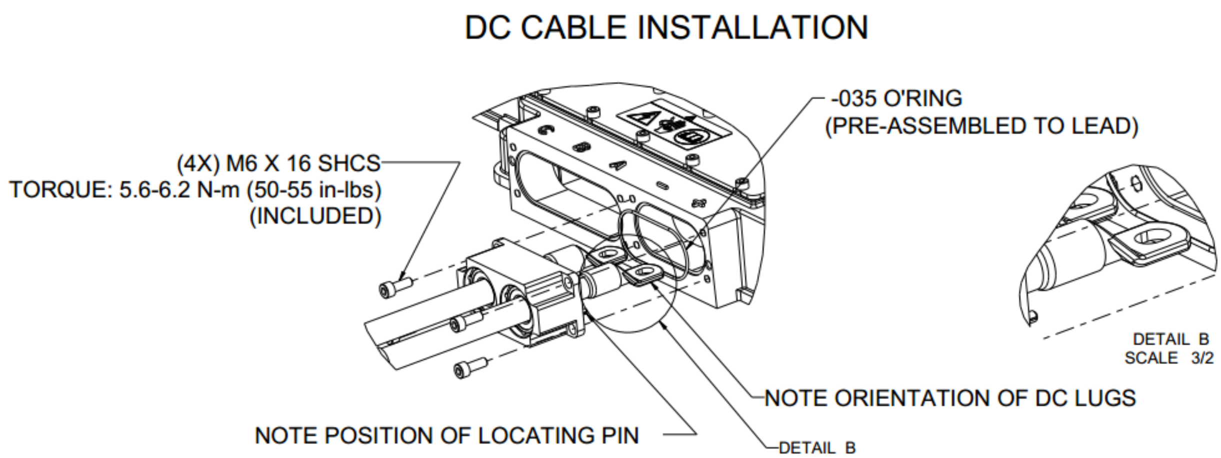


Figure 3.2: Controller Connections

NOTE: Ensure the O-Rings are in-place or installed before connection to the controller. Ensure the O-Rings are not pinched or nicked during installation.

DANGER Do not connect either the positive or negative high voltage bus to the chassis, motor cases, or controller. Catastrophic damage will occur. Provide sufficient insulation on all power terminals for safety.

3.1.1 Phase Cables (3 Phase AC cables)

The phase cables (Figure 1.1 cable D) supply three phase AC voltage from the inverter to the motor.

The motor ends of the phase cables are permanently attached to the motor at the factory. The controller electrical connections are shown in Figure 3.1. They are the block of 3 cables on the left side of the diagram. Before connecting the phase cables, remove the termination cover shown in Figure 3.4.

Install the phase cable housing (the metal block holding the phase cables together) to the controller housing and secure it using the included M6x1x16 socket head cap screws (SHCS) and tighten to the torque indicated in the ICD drawing.

The phase cable housing is keyed to the controller housing so it can only be installed in the correct orientation. After installation, the holes in the ring lugs at the end of the phase cables should line up with the threaded holes at the terminals of the controller.

Install three of the included M8-1.25 x20 flanged head bolts through the ring lug holes (Figure 3.1), and thread them into the holes in the controller terminals. Tighten to the indicated torque in the ICD drawing.

3.1.2 DC Cables

The DC Cables (Figure 1.1 cable F) supplies DC voltage from the high voltage power source to the inverter.

DC cables must have a dedicated set of contactors and fuses with appropriate ratings between the motor controller and the DC High voltage battery.

Install the DC cable housing (the metal block holding the DC cables together) to the controller housing and secure it using the included M6x1x16 socket head cap screws (SHCS) and tighten to the torque indicated in the ICD drawing.

The DC cable housing is keyed to the controller housing so it can only be installed in the correct orientation. After installation, the holes in the ring lugs at the end of the DC cables should line up with the threaded holes at the terminals of the controller.

Install two of the included M8-1.25 x20 flanged head bolts through the ring lug holes (Figure 3.2), and thread them into the holes in the controller terminals. Tighten to the indicated torque in the ICD drawing.

At rated peak power of the ED-DT318B system at the nominal voltage (both stated in the specific product specification sheet available through Danfoss Power Solutions sales); the Danfoss Power Solutions controller can draw over 650 Amps from the traction battery. Internal impedances inside the customer's battery can drop the voltage supplied to the Danfoss Power Solutions controller.

The ripple voltage on the high voltage power supply should be less than 10 V peak-to-peak at all current levels.

Before applying input high voltage, ensure that the shaft, and anything connected to the shaft, has sufficient area for rotation. Also make sure that the motor is secured to something that can handle the reactionary torque from the motor. As the rotor accelerates, the motor case attempts to torque in the opposite direction. Always disconnect input high voltage before making or removing any connections.

Due to the high inrush current of charging the controller's internal capacitors, the customer *must* ensure that the high voltage system has proper fusing and contactor configuration to ensure proper system start-up. Danfoss Power Solutions recommends some type of "soft start" circuit, which is the responsibility of the user and/or high voltage battery pack manufacturer.

NOTICE A soft start circuit is recommended for input voltages above 100 V High Voltage DC.

3.1.3 High Voltage Interlock Connection

The High Voltage Inter-Lock (HVIL) connections must be made for the system to operate safely.

The HVIL circuit is a continuity path "daisy chain" that starts at the User Interface connector, on the controller. The HVIL continues internally through the controller to the controller termination cover switch (closed when cover is on) then thru the position cable to the motor termination cover switch (closed when cover is on). From the switch in the motor back to the User Interface connector, see block diagram of the circuit (Figure 3.3).

Removal of the motor termination cover or the controller termination cover will open the HVIL circuit. If either the controller or motor termination covers are open, the Danfoss Power Solutions HVIL connection provides a signal to the vehicle system indicating that high voltage is exposed. It is the user's responsibility to take appropriate action with the Danfoss Power Solutions HVIL signal when either termination covers are op

Note: Your motor may have the HVIL connection coming thru the phase cable connection and needs to be connection inside the controller termination area.

For the DT2 system the MCU to TCU cable is provided and has a breakout on the TCU end with a two pin TE Deutsch connector for the user HVIL connection. The mating connector is provided in the ship kit, Danfoss Power Solutions part number 98010-039(Figure 3.8).

DANGER	It is the customer's responsibility to disable high voltage DC when the Danfoss Power Solutions HVIL indicates that either the inverter or the motor termination covers is open.

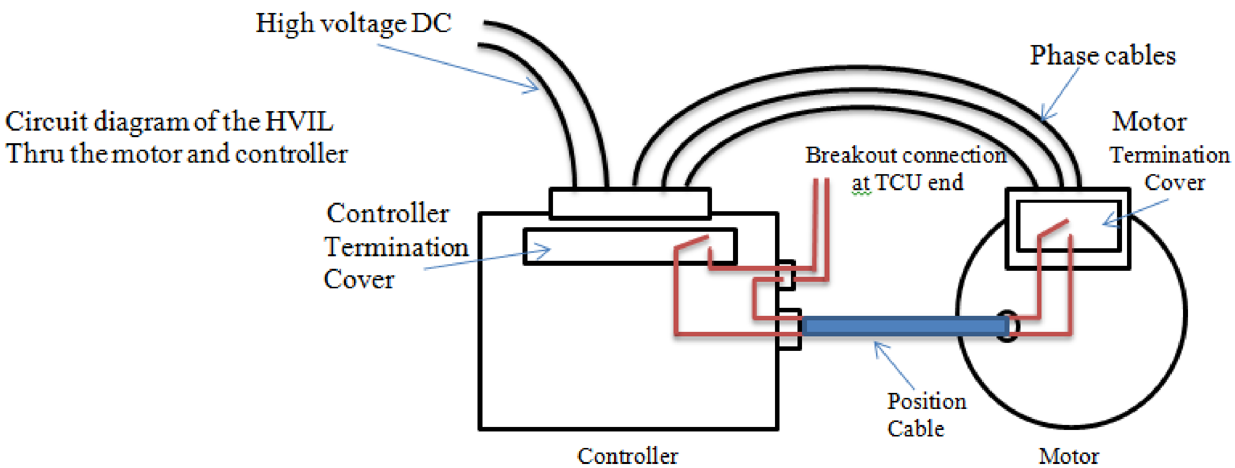


Figure 3.3: HVIL daisy chain routing thrugh the controller and motor

The User is responsible for:

- Connection of the HVIL on the User interface connector Pins 13 and 14
- Excitation voltage and current to monitor the continuity of the HVIL.
- Monitoring the continuity of the circuit, to ensure the HV connections are not exposed.

Additional details:

- There is no polarity on the HVIL connections Pins 13 and 14.
- Operating current; 1 amp maximum
- Operating voltage; 32 volts maximum

CAUTION	The user is responsible for proper HVIL actions and for disabling the DC high voltage power when the HVIL circuit is open.

3.1.4 Termination Cover Installation

After the DC and Phase cables are connected and bolts are properly torqued, install the small plastic cover with two M3 x 10mm plastite screws. Tighten to the indicated torque on the ICD drawing.

To seal the controller, place the O-ring (Item 6 in the ship kit) into the rectangular grove on the controller housing. Then, place the termination cover, making sure the O-ring remains within the grove. Install the terminal cover screws, M5 x16 HHCS (Item 7), into the 14 holes in the cover. Torque the screws to the torque specified on the ICD drawing.

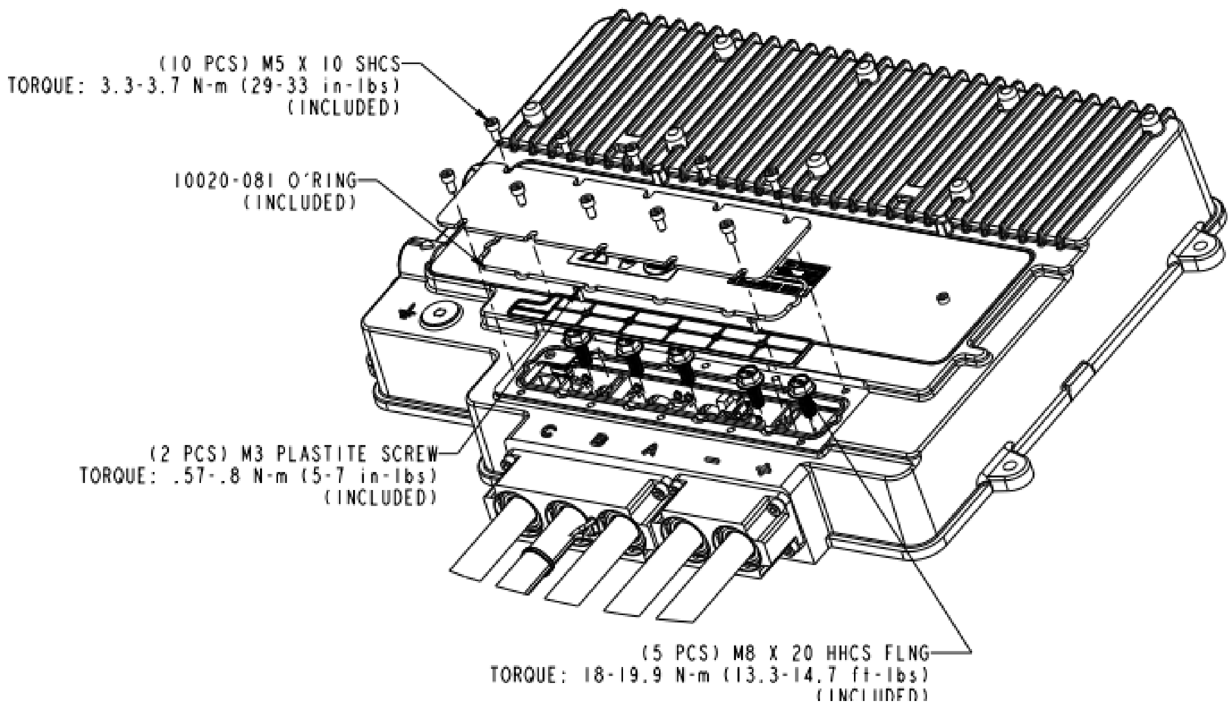


Figure 3.4 Exploded View of the Controller Connections

3.1.5 Phase Cable and DC Cable Routing and Air Flow Requirement

Take care in routing and attaching the Phase cables and DC cables such that there is no rubbing and abrasion of the outer insulation.

The customer is responsible for securing the cables to avoid insulation damage. In addition, it is recommended that the Phase and DC cables be routed such that air flow is directed over the cables for cooling.

The maximum outer jacket of cable temperature must be maintained below 130°C (for example a maximum rise of 80°C above an ambient temperature of 50°C is permitted). Application testing in maximum thermal conditions must be completed to ensure the cable temperature does not exceed this maximum cable jacket temperature.

The cable temperature rise will depend on many factors including, but not limited to: the average or RMS current flowing through the cables, (which will be determined by the vehicle drive cycle), air flow over the cables or thermal isolation of the cables in the application. See the applicable motor ICD drawing for minimum recommended air flow across the phase cables (this recommended air flow also applies to the DC cables).

When connecting the Phase cables and the DC cables, ensure that the O-Rings are installed on the cable housings before attaching to controller as shown in Figure 3.1. These O-Rings may be already attached the cable housings or shipped as part of the ship kit. Ensure the O-Rings are in-place or installed before connection to the controller. Ensure the O-Rings are not pinched or nicked during installation.

3.2 Grounding Requirements

The housings of the controller and motor must be wired together with large gauge copper wire (4 gauge or larger, stranded or braided is recommended) to ensure proper electrical ground. There is a stud on the coolant port side of the controller where the ground strap should be connected. The motor has a boss on the lead exit end bell for the ground strap connection. The motor and/or controller are typically in contact with the metal chassis of the vehicle, but this metal contact is not enough to provide the proper grounding path for the system.

WARNING The user is responsible for providing and installing a ground strap from the motor to the controller. Without a ground cable, erratic operation can occur.

3.3 Signal Cable

The signal cable (cable E in Figure 1.1) is the small shielded cable with a 17-pin Amphenol M23 style connector. Some of the wires in this cable are used for the rotor position signals. Others are used to send stator and rotor thermal information to the controller. Danfoss Power Solutions provides this cable as part of the PowerPhase® DT2 system, but the customer is responsible for connecting the signal cable from the motor to the inverter. Connectors are keyed to require one orientation.

This is the most critical and sensitive cable within the drive system, and it must be protected from any potential damage. It is also susceptible to loosening due to vibration if not properly torqued per instructions in Section 3.3. Erratic motor operation and even damage to the inverter may occur if this cable is allowed to loosen during operation due to not being properly torqued.

WARNING Do not attempt to lengthen or shorten the cable in any way. Contact Danfoss Power Solutions if the cable is too short or too long for the application.

WARNING Do not bundle the signal cable with the motor power leads. This may cause a controller failure.

Signal cable connector assembly instructions

Note: These assembly instructions are only needed for the M23 screw type connector and not needed if your system has the Bayonet type connector.

1. Orient rotor position cable connector to the mating connector on the motor or the controller and rotate cable until keyway allows insertion.

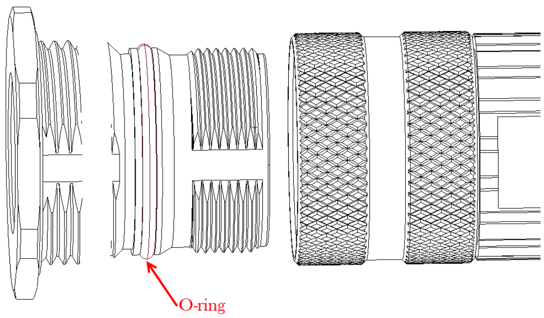


Figure 3.5: Signal Cable Connection – Insertion

2. Screw knurled connection nut clockwise. At about 3 turns some resistance will be felt. This is the nut coming into contact with the sealing O-ring. The connector is not fully seated.

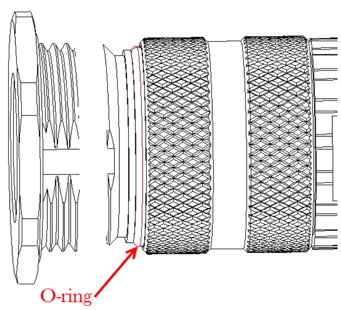


Figure 3.6: Signal Cable Connection – Tightening

3. Continue to tighten knurled nut until O-ring is covered, and increased torque is required, (about 2 turns) this is the point when the cable connector is fully seated to the mating connector.

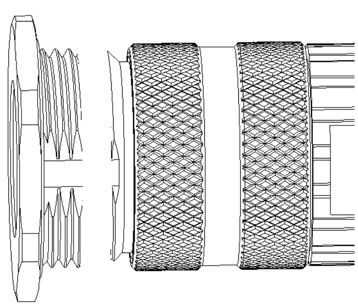


Figure 3.7: Signal Cable Connection – Final Torque

4. Torque the mated connector to 20-30 in lbs. This is about 2-3X the torque that can be achieved by hand.

WARNING Do not attempt to tighten the signal cable connector without the aid of a torque strap. Finger tight is not sufficient to maintain contact.

CAUTION Do not over-tighten or under-tighten the signal cable connector.

3.4 TCU to MCU Interface Cable

The TCU to MCU Interface Cable (Cable C in Figure 1.1) provides the TCU to MCU CAN connection. It also provides the 24 V battery power to the MCU and the MCU RS232 serial connection from the MCU to the Drivetrain Interface connection (Connector 3 in Figure 1.1 and Figure 3.8).

The TCU to MCU Interface cable is provided as part of the PowerPhase® DT2 system. It has a 12 pin Deutsch connector at one end and a 10 pin connector at the other. The customer is responsible for insuring that the cable is firmly connected from the inverter's Deutsch connector (Connector 1 in Figure 1.1) to the 10-pin MCU Interface connector (Connector 2 in Figure 1.1 and Figure 3.8).

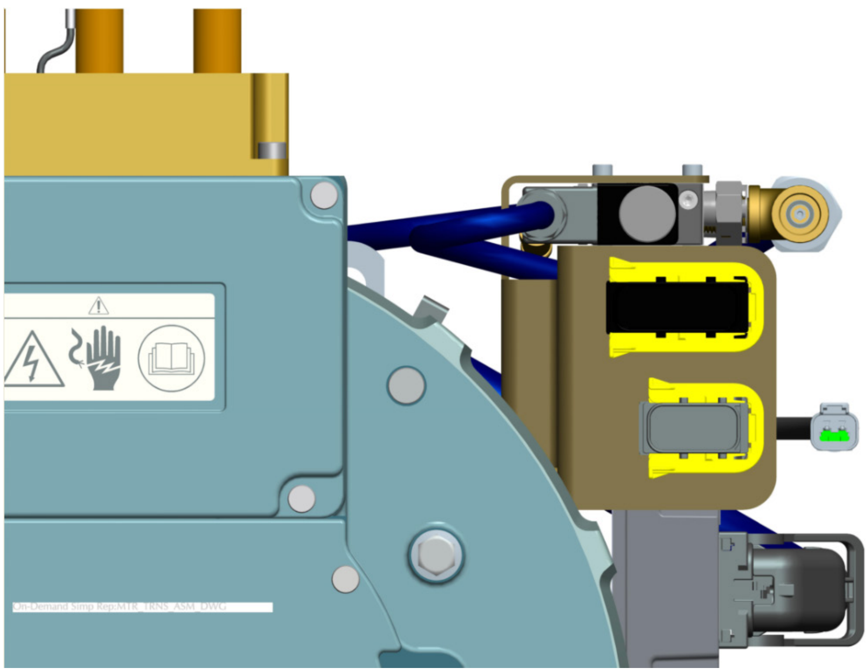


Figure 3.8: Connector Bracket

3.5 Drivetrain Interface Connector

The Drivetrain Interface Connector (connector 3 in Figure 1.1 and Figure 3.8) provides access for the VCU control CAN as well as the ability to monitor the TCU to MCU CAN bus and the MCU RS232 diagnostic bus. The TCU to MCU CAN bus is also used to upgrade the TCU code, the TCU configuration, and the MCU code. The MCU RS232 diagnostic bus allows access to the MCU for the Motor Diagnostic Software (Section 8).

When routing the VCU CAN Bus, note that the CAN bus connecting the VCU to the TCU has two sets of leads in the Drivetrain Interface Connector: VCU CAN Leg A (pins 1, 2 & 3) and VCU CAN Leg B (pins 4, 5 & 6). Both should be used as they are provided to preserve the integrity of the daisy chain for that bus. If the user elects to place the TCU at the end of the daisy chain, the 120Ω terminating resistor should be connected to the unused signal pins. If the user does not wish to place the MCU at the end of the daisy chain, both sets of signal pins should be used. The user should not splice to one set of pins and leave the other open. Figure 3.12 shows the allowed VCU CAN bus configurations.

The User Interface Connector also provides the 24 V battery voltage used to power the TCU and the MCU.

The pin assignments and wire sizes for the User Interface Connector are defined in Table 3.1.

Danfoss Power Solutions recommends that the 24 volt supply voltage be controlled by the VCU and that it be fused using an automotive rated 10 amp fuse between on the low voltage lines to the controller/invertor. Treat this low voltage 24V supply as you would the ignition source for a gasoline powered vehicle. The 24V line must be at least 14 gauge wire to avoid a voltage drop in the wire supplying LV to the controller. Note that the kit (Danfoss Power Solutions part # 98010-022) supplied with the PowerPhase® DT2 system provides terminals (Danfoss Power Solutions part # 15010-083) and wire seals (Danfoss Power Solutions part # 15010-019) appropriate for use with 14 G wire.

Danfoss Power Solutions recommends that the CAN and RS232 serial cables be 18 gauge, 2 conductor, shielded stranded twisted pair wire equivalent to the Danfoss Power Solutions part number 14020-019 as specified in Figure 3.10.

Please note that all user interface control signals are isolated from the high voltage DC bus and should not be referenced in any way to the high voltage DC bus supply.

⚠ **WARNING**	CYCLING THE +24V OR ENABLE SIGNAL WHILE THE MOTOR IS IN MOTION SHOULD BE AVOIDED IF AT ALL POSSIBLE. Cycling either of these signals will cause the inverter CPU to shut down and restart – which may result in unpredictable current surges.

⚠ **DANGER**	Your system may be configured for rotation when input voltage is applied. Before applying input voltage, ensure that the shaft and/or anything connected to the shaft has sufficient area for rotation. Always disconnect input voltage before making or removing any other connections.

⚠ **DANGER**	Do not connect either the positive or negative high voltage bus to the chassis, motor cases, or controller. Catastrophic damage may occur. Provide sufficient insulation on all power terminals for safety.

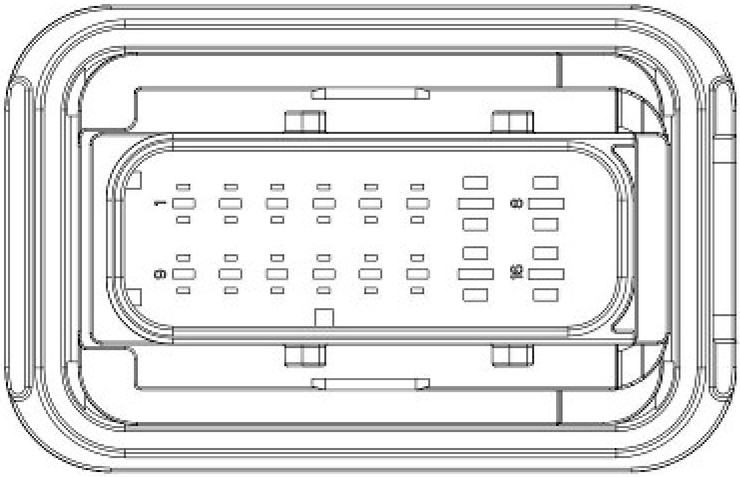


Figure 3.9: Drivetrain Interface Connector (connector 3)

Table 3.1: Drivetrain Interface Connector (connector 3) pinout

Pin Assignment	Kit	Terminal	Wire Seal	Wire	Pin #	Signal Source
VCU CAN Leg A +	98010-022	15010-084	16040-020	14020-019	1	VCU
VCU CAN Leg A -	98010-022	15010-084	16040-020	14020-019	2	VCU
VCU CAN Leg A Shield	98010-022	15010-084	16040-020	14020-019	3	VCU
VCU CAN Leg B +	98010-022	15010-084	16040-020	14020-019	4	Common to pin 1
VCU CAN Leg B -	98010-022	15010-084	16040-020	14020-019	5	Common to pin 2
VCU CAN Leg B Shield	98010-022	15010-084	16040-020	14020-019	6	Common to pin 3
Ignition Switch (TCU)	98010-021	15010-093	16040-025	18 AWG	7	VCU
Vgnd (TCU)	98010-020	15010-083	16040-019	14 AWG	8	Vehicle Ground
MCU CAN +	98010-022	15010-084	16040-020	14020-019	9	TCU/MCU
MCU CAN -	98010-022	15010-084	16040-020	14020-019	10	TCU/MCU
MCU CAN Shield	98010-022	15010-084	16040-020	14020-019	11	TCU/MCU
RS232 Transmit TxD	98010-022	15010-084	16040-020	14020-019	12	Diag SW
RS232 Receive RxD	98010-022	15010-084	16040-020	14020-019	13	Diag SW
RS232 Shield	98010-022	15010-084	16040-020	14020-019	14	Diag SW

Pin Assignment	Kit	Terminal	Wire Seal	Wire	Pin #	Signal Source
FEPS	98010-021	15010-093	16040-025	18 AWG	15	TCU Programing
Vbatt (TCU)	98010-020	15010-083	16040-019	14 AWG	16	Vehicle Battery

Note: The terminals and wires seals will be packaged in 3 different bags corresponding to the different wire sizes as defined.

14020-019

mfr p/n: 45162

AlphaWire

Alpha Wire | 711 Lidgerwood Avenue, Elizabeth, NJ 07207
Tel: 1-800-52 ALPHA (25742), Web: www.alphawire.com

Request a Sample

Customer Specification

PART NO. 45162

length options:
mfr p/n 45162 BK005 = 100'
mfr p/n 45162 BK001 = 1000'

Construction

				Diameters (In)	
1) Component 1		2 X 1 COND			
a) Conductor		18 (16/30) AWG Tinned Copper		0.047	
b) Insulation		0.016" Wall, Nom. TPE		0.079	
(1) Color Code		Alpha Wire Color Code D			
Cond	Color	Cond	Color	Cond	Color
1	BLACK	2	RED		
2) Cable Assembly		2 Components Cabled			
a) Twists:		6.9 Twists/foot (min)			
b) Core Wrap		Nonwoven Polyester Tape, 25% Overlap, Min.			
3) Shield:		A/P/A Tape, 25% Overlap, Min.			
a) Drain Wire		18 (16/30) AWG Tinned Copper			
b) Braid		Tinned Copper,70% Coverage, Min.			
4) Jacket		0.045" Wall, Nom.,TPE		0.280 (0.291 Max.)	
a) Color(s)		Slate, Black, Yellow, Orange, Blue, Green, Red, Sand Beige, White			
b) Ripcord		1 End 810 Denier Nylon			
c) Print		ALPHA WIRE-* P/N 45162 2C 18 AWG XTRAGUARD(R) 4 (UL) TYPE PLTC 105C SUN RES OR AWM 20237/21918 125C 300 V OR CRU AWM I/II A/B 125C 300 V FT1 P-07-KA140023-MSHA CE ROHS (SEQ FOOTAGE) * = Factory Code			

Figure 3.10: Danfoss Power Solutions Specification for 2 lead twisted pair shielded wire

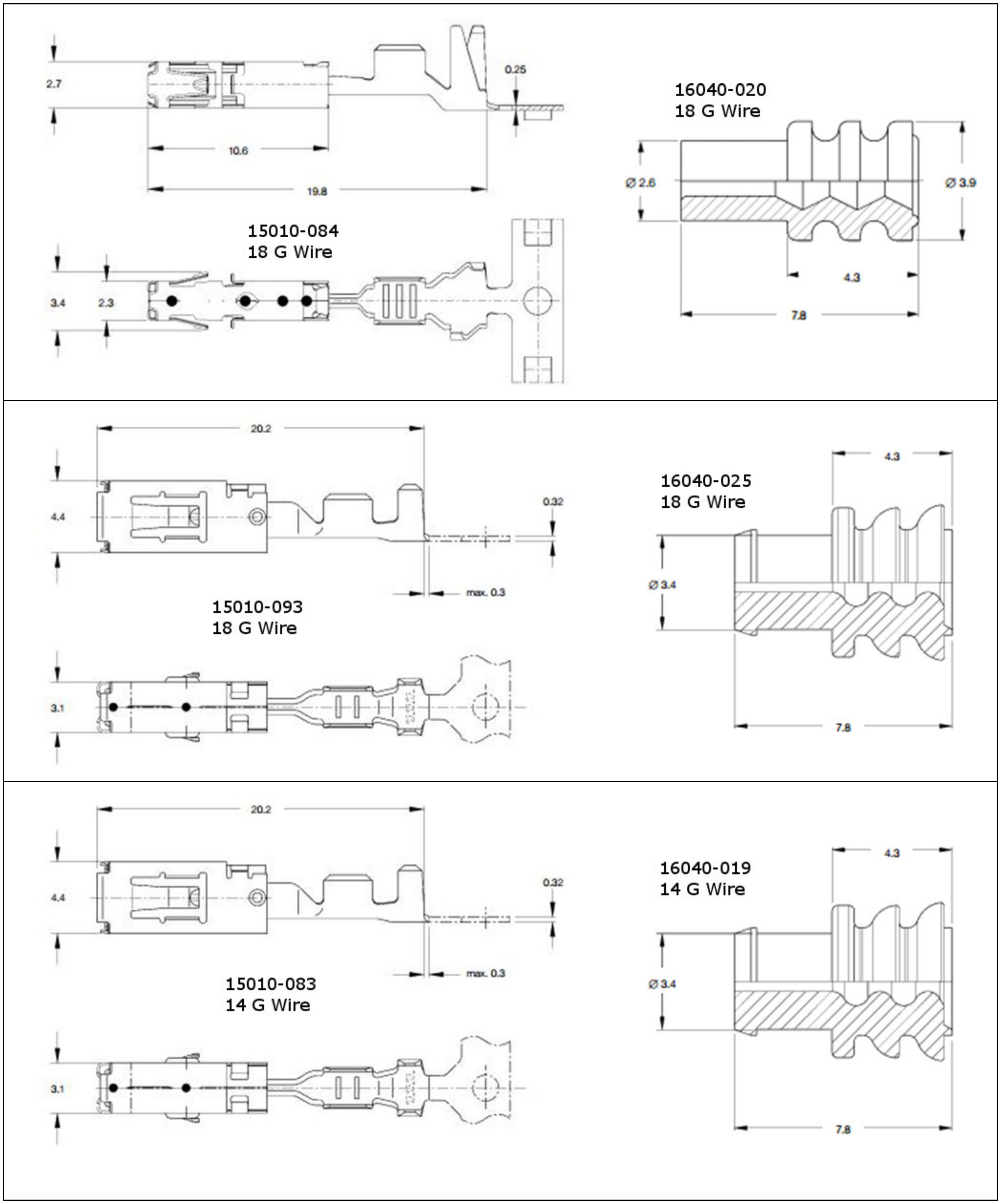


Figure 3.11: Drivetrain Interface Connector terminals and wire seals

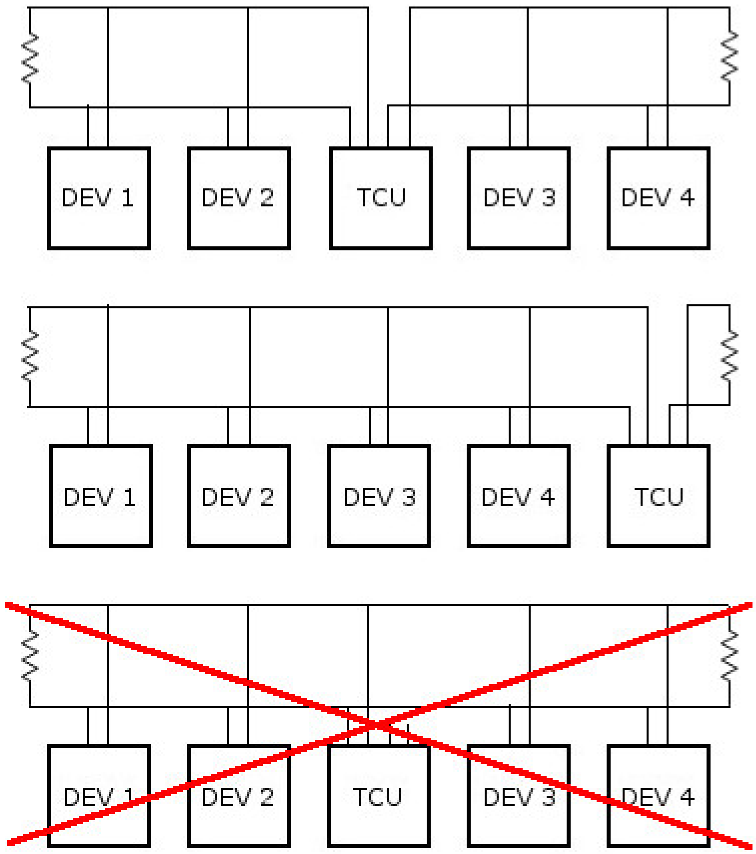


Figure 3.12: Allowed VCU to TCU CAN Bus Configurations

3.6 DT2 Diagnostic Connector

The DT2 Diagnostic Connector (Connector 4 in Figure 1.1) provides diagnostic access to the VCU to TCU CAN bus, the TCU to MCU CAN bus, and the MCU RS232 diagnostic bus for the Motor Diagnostic Software (Section 8).

Access to the VCU to TCU CAN buss allows the messages being passed on that but to be monitored and correlated to system activity.

Access to the TCU and MCU CAN bus allows monitoring of communications between the TCU and MCU. It also used to update TCU and MCU firmware and TCU configuration data. The MCU configuration is updated via the RS232 port documented below.

Danfoss Power Solutions provides one TCU to MCU CAN bus termination resistor, which is located within the body of the Danfoss Power Solutions inverter. The customer is responsible for the second termination resistor, which should be located at Diagnostic Connector. See Figure 3.13 for the recommended layout of the TCU to MCU CAN bus. Note that the wiring from the MCU to the TCU is provided by Danfoss Power Solutions via the TCU to MCU Interface Cable. The customer is responsible for the wiring from the Drivetrain Interface Connector to the Diagnostic Connector.

The Danfoss Power Solutions Motor Diagnostic Software (Section 8) communicates to the motor system through the RS232 communication pins (7, 15 & 8) of the Diagnostic Connector.

Communications with the MCU conforms to the RS232 signal protocol. When wiring from the Diagnostic Connector to a 9pin D connector, the user must ensure that the pin assignments in Table 3.2 are followed.

Table 3.2: RS232 Communications pinout

RS232 9 pin D Connector	
Signal	Pin
Rx	2
Tx	3
Ground	5

When deciding where to position the Diagnostic Connector the user should take into consideration that, when in operation, the technician using the port will require cabling from the port to a laptop computer. An additional consideration is that voltage from the vehicles low 24 V electrical system will be present on pin 16 of the Diagnostic Connector.

Therefore, the Connector should be positioned inside the vehicle's cabin in a location that will provide easy access while the vehicle is in motion, but will not interfere with the driver or passengers while in use and will protect the driver and passengers from the possibility of electrical shocks.

Table 3.3: DT2 Diagnostic Connector (Connector 4) pinout

Pin Assignment	Wire	Connector 3	Note
MCU CAN Shield	14020-019	11	
MCU CAN +	14020-019	9	120Ω Termination to MCU CAN -
Vgnd (TCU)	18 AWG		24 V Battery negative
VCU CAN +	14020-019	1 or 4	
RS232 Transmit TxD	14020-019	12	
RS232 Shield	14020-019	14	
MCU CAN -	14020-019	10	120Ω Termination to MCU CAN +
FEPS	18 AWG	15	
VCU CAN Shield	14020-019	3 or 6	
VCU CAN -	14020-019	2 or 5	
RS232 Receive RxD	14020-019	13	
Vbatt (TCU)	18 AWG		24 V Battery positive – use of a 10A fuse is recommended

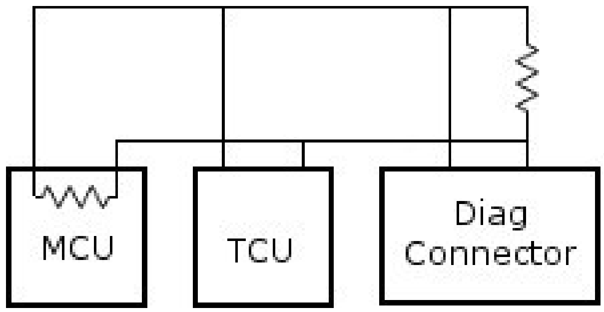


Figure 3.13: TCU to MCU CAN bus

4 Liquid Cooling MCU and Motor

The Electric Vehicle Driveline package requires a liquid-cooling system. The recommended liquid-cooling setup is shown in Figure 4.1 below.

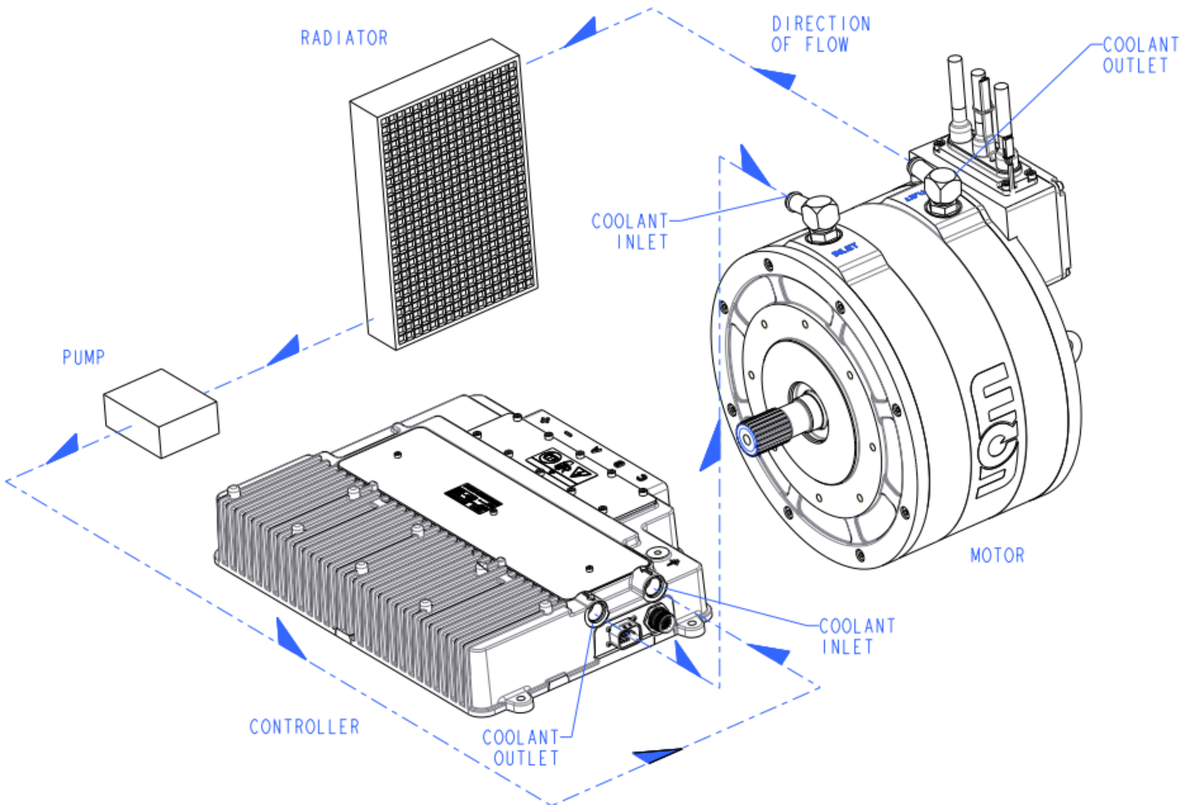


Figure 4.1: Recommended Liquid Cooling Setup

4.1 Coolant Loop Requirements

⚠	**CAUTION**	The coolant should never run in parallel paths. The coolant hoses between the controller and the motor should be in series, as the thermal algorithms used in the software depend upon the coolant flowing at the same rate through both components.

⚠	**CAUTION**	The coolant loop for the transmission MUST be on a SEPARATE coolant loop than the MCU and Motor.

The coolant for the Danfoss Power Solutions system must be designed and specified by the user or vehicle integrator. The heat rejection for the system is dependent upon the drive cycle; therefore, the customer must size the coolant system based on the drive cycle power requirements in the application. The losses can be determined from the efficiency maps for the propulsion system.

The motor and controller coolant fittings are attached to the respective devices via an O-ring port specified by SAE J1926-10. The controller and motor have 90° elbows that adapt to the hoses and rotate to meet with the particular application. The coolant fittings can be unscrewed and changed to meet the requirements of the application. Many different fittings are available that fit the SAE J1926-10 O-ring boss.

For proper performance and to achieve rated power, the coolant loop must meet the following requirements:

Table 4.1: Liquid Cooling System Requirements

Requirement	Specification
Coolant Type	50/50 water to glycol
Maximum Inlet Coolant Temperature (full performance)	60° C
Minimum Coolant Flow Rate	10 liters per minute (LPM)

Coolant volume for the controller and motor can be found on the ICD drawing or by contacting Danfoss Power Solutions.

A coolant flow rate of 10.0 liters per minute will have a pressure drop of approximately 8.5 kPa total from just the controller and motor. This does not include additional fittings, valves, or plumbing.

Note in Figure 4.1 that the coolant should go from the radiator, through the pump, and on to the controller. Then, it should move from the controller, to the motor, and back to the radiator. The controller is more heat sensitive than the motor and needs the coolant to be as cool as possible. While the system can operate at maximum rated coolant temperatures, the operating life of the controller will be extended if the coolant is kept below the maximum operating temperature.

To make loading the coolant into the system easier, make sure the radiator fill port is higher than the motor and controller, which allows air to flow out of the coolant system more easily.

4.2 Flow Rate vs. Pressure Drop

The total pressure drop in the system is the summation of the pressure drop across the controller, motor, and all customer installed hosing and fittings. The flow rate data is included on the ICD drawings.

5 Electric Vehicle System Operation

5.1 Electric Vehicle System Overview

The Danfoss Power Solutions system is the main drive component of an Electric Vehicle System. The major items are shown below.

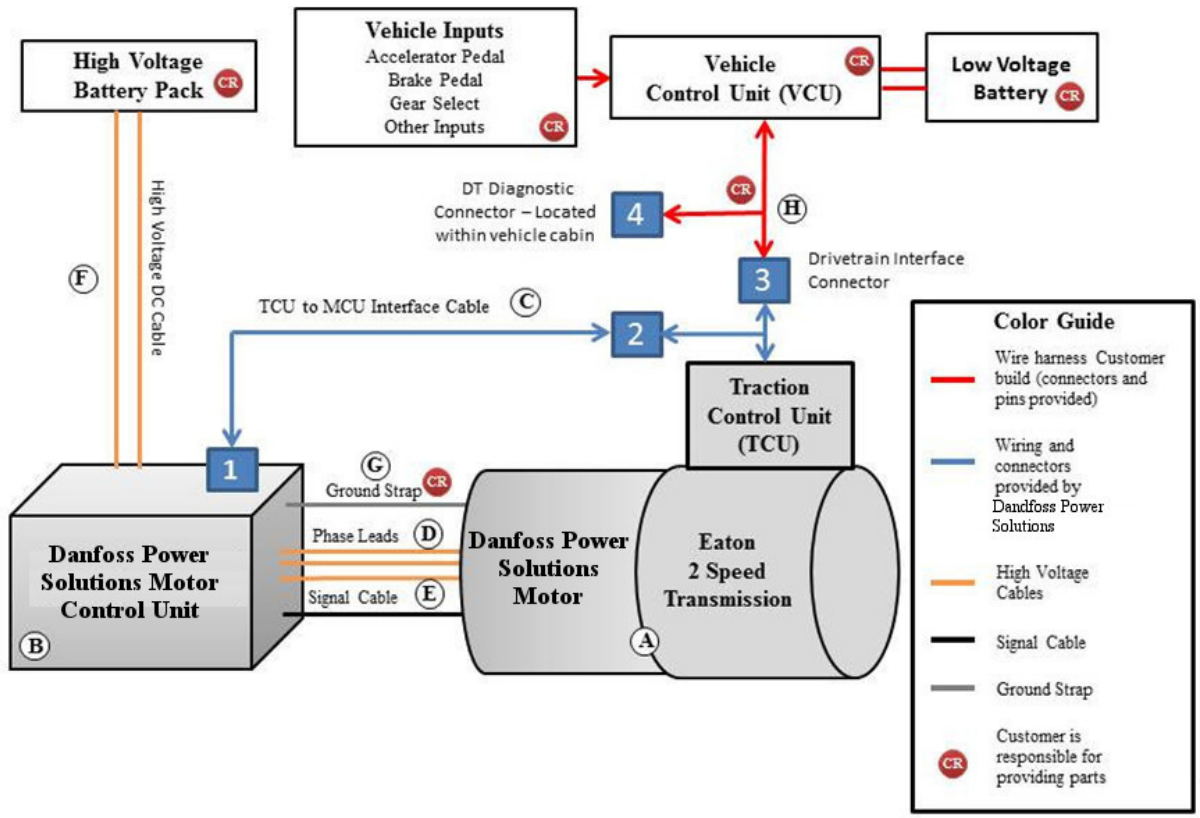


Figure 5.1: Block Diagram of Electric Vehicle Drive System

The customer must supply the Vehicle Control Module. Typically, it performs the following functions:

- Monitors the accelerator, brake pedal, and PRNDL inputs
- Monitors the High Voltage Battery
- Sends a Hardware Enable signal to the Danfoss Power Solutions TCU and MCU controllers
- Sends valid CAN torque commands to the Danfoss Power Solutions TCU controller as appropriate for the accelerator, brake pedal, PRNDL gear selector, and High Voltage Battery inputs

CAUTION It is not recommended to operate the system with the driveline disconnected from the transmission.

⚠ **WARNING**	DO NOT FLAT TOW the vehicle. While towing the vehicle, the drive wheels MUST NOT ROTATE, or damage will result when the motor system is not operational. If needed, the drive shaft should be disconnected from the transmission output flange.

⚠ **WARNING**	DO NOT RE-ENABLE BATTERY VOLTAGE TO A MOVING VEHICLE. *It is strongly recommended that if a condition occurs which requires power cycling the system, the vehicle should be at a full stop before battery power is enabled. Applying battery voltage while the motor is moving may result in serious damage to the system.*

5.2 Valid Control Modes via CAN

The only Control Mode in the Danfoss Power Solutions PowerPhase® DT2 System is CANbus Control. Control commands are issued by the VCU to the TCU via the CANbus. The TCU only recognizes one mode of operation: torque production with a speed limit.

5.2.1 Special Features

The MCU has a number of special features which can simplify vehicle control, improve system efficiency, and help with electric vehicle ride comfort. In the following section acceleration limiting will be discussed.

5.2.2 Acceleration Control

While fast acceleration is desirable, too much acceleration can cause poor riding comfort and excessive mechanical stress. All vehicles have a natural maximum acceleration limit due to the mechanical systems themselves and their environment. In addition, some applications have mandated limits to the acceleration experienced by vehicle riders.

Danfoss Power Solutions' Acceleration Limit feature attempts to control the acceleration of the electric motor to a user-defined level, allowing simplification of the vehicle control algorithms during terrain changes. With the same command sequence, more torque can be used going uphill and less torque be used going downhill, providing the vehicle occupants with identical experiences in both cases.

The Acceleration Limit is set dynamically through a CANbus command (see the Section 7 for details).

Acceleration Limit causes the Danfoss Power Solutions controller to use less torque if motor acceleration exceeds the user-defined level. Note that it can only *remove* torque. It does not try to maintain the acceleration rate unless too much torque is requested. Thus, a controlled deceleration requires a negative torque (regen) request, and a controlled acceleration requires a positive torque request.

For example, if an Acceleration Limit of 150 RPM/sec is set and a full torque request is issued to the Danfoss Power Solutions controller while the motor is at rest, then the Danfoss Power Solutions controller could deliver up to full torque to get the motor spinning. As the motor begins to spin, the controller will lessen the torque delivered to maintain an acceleration of 150 RPM/sec. The controller maintains this acceleration *while the torque request is greater than required to achieve an acceleration rate of 150rpms.*

If the torque request drops to zero, torque will immediately be removed. If a negative torque request is issued at this point, the Danfoss Power Solutions controller will deliver the requested regeneration torque (or less) in order to maintain a 150 rpms deceleration.

5.3 Safety Features

The Danfoss Power Solutions motor system provides built-in features to minimize hazardous conditions such as over motor current, over/under battery voltage, or over motor speed, with configurable values. It also has features to protect against battery disconnect, conditions causing stall, and hardware failures. These are discussed in the sections below, beginning with an explanation of limits. In general, these safety features are provided through limits that regulate the command torque when a problem is detected.

5.3.1 Limits

Limits regulate the torque production when a system condition is close to its limit, such as over motor current, over/under battery voltage, or over motor speed. The Danfoss Power Solutions Motor Diagnostic Software (see Section 8) shows the limitations acting on the torque whenever they are below 100%. The limitations can take away significant amounts of the deliverable torque of the system. The following table shows the conditions and the maximum limit that can occur to motoring torque requests and regeneration torque requests.

These limits will be conveyed to the VCU as the Max Drive Torque Allowed (Section 7.3.4.1) and Max Regen Torque Allowed (Section 7.3.4.2) CAN signals.

Table 5.1: Potential Limitations

Cause	Maximum Motoring Limits	Maximum Regeneration Limits
Motor velocity over Customer Speed	0% or -100%[1]	NA
Coolant loss detected	0%	0%
No CAN communication	0%	0%
Over temperature (Inverter/Stator/Rotor)	0%	0%
Position bad	0%	0%
Power supply out of specification	0%	0%
System halted	0%	0%
Torque producing current too noisy	0%	0%
Bus current too noisy	0%	0%
Raw bus current too large	0%	0%
Unreliable bus current measurement	0%	0%
Power switch hardware failure	0%	0%
Bus Voltage over Safety Voltage	NA	1%
Bus Voltage over Customer Battery Max	NA	2%

Cause	Maximum Motoring Limits	Maximum Regeneration Limits
Bus Voltage under Customer Battery Min	3%	NA
Stall conditions	10%	10%
Bus current over Positive Current	26%	NA
Bus current under Negative Current	NA	24%
Disconnected Temperature Sensor	50%	50%
Inverter Fault	50%	50%
Bad switch safety	50%	50%
Incorrect position offset	50%	50%
Over Positive Phase Advance limit	50%	50%
Under Negative Phase Advance limit	50%	50%
Variable Back EMF saturated high	50%	50%
Variable Back EMF saturated low	50%	50%
Bad controller calibration	51%	51%
Motor Leg current Over Current	51%	51%
Invalid Sensor voltage	52%	52%
Apparent Rotor Movement	52%	52%
Error with leg current sensors	53%	53%
Current Transducer Fault	53%	53%

1. If the “Allow Braking” box in the System Configuration is checked, the system will be able to apply regeneration torque to slow down the motor. Otherwise, the limit will be 0%.

When more than one limiting factor is present, the lowest limitation dominates. The most serious motoring limitation is Over Speed. If configured to do so, this limitation can actually cause motor regeneration in order to slow down the speed. The most serious regeneration limitation is Over Safety Voltage. This limitation can actually change the motor’s control mode while the condition exists because the inverter will be destroyed if the voltage remains above the allowable value. This control mode, called Forced Voltage Control, takes priority over any other limit.

5.3.2 Forced Voltage Control

Forced voltage control ensures the bus voltage of the inverter does not exceed the limits of the inverter's components. This condition may occur if the high voltage path is suddenly removed, for example, if a battery contactor opens.

If the motor is regenerating when the high voltage path is suddenly removed, then the bus voltage experienced by the inverter can rise very rapidly, endangering inverter components. This is detected as a **Disconnected Battery Event**. It will occur if, over a 2 millisecond period, the bus current is very small but the voltage change indicates that significant currents are flowing into the inverter's capacitors.

If the motor is motoring when the high voltage path is suddenly removed, the bus voltage experienced by the inverter can fall very rapidly, threatening a power device shutdown. This is detected as a **Low Forced Voltage Event**. It will occur if all of the following are happening: bus current is small, the bus voltage is less than the minimum allowed battery value and dropping fast, and the inverter is seeing large motor currents OR the speed is above base speed.

Danfoss Power Solutions inverters monitor for these conditions and enter the control mode "Forced Voltage Control" in order to control the bus voltage by motoring or regenerating rapidly. While in control, Forced Voltage Control maintains the voltage 10 V below the maximum battery voltage defined in the System Configuration. Note that if the regen switch is open then it will control the voltage to a higher value. This control mode is only allowed to use 10% of the motoring and regeneration capabilities of the Danfoss Power Solutions motor. The mode releases control within 128 milliseconds if conditions indicate that the battery is still connected. This condition is reported through the Diagnostic Software described in Section 8 of this manual, and also through the MCU Limp Home Mode signal (Section 7.3.3.5).

5.3.3 Stall

If the motor's rotor does not move when high torque is commanded, the result is a stalled condition in the motor. A rotor locked in this way can cause the current through the inverter to exceed safe limits. If unchecked, these high currents will cause the failure of an IGBT power device in the inverter. To protect against a prolonged stall condition (locked rotor); Danfoss Power Solutions controllers contain a complex algorithm to deliver the requested torque for as long as possible without damaging the power devices. The amount of time is variable and contingent on the amount of torque requested. It can range from many seconds down to 600 milliseconds. Once this time has elapsed, the Stall Limit will report a stall condition and limit the torque to 10% for 30 seconds. This condition is reported through the Diagnostic Software described in Section 8 of this manual, and also through the MCU Stall Condition Active signal (Section 7.3.2.36).

5.3.4 Forced Open Loop

In normal operation, the controller uses measured values from the motor to tune and improve control. In the case of detected measurement failure, control is managed with open loop values. The conditions that cause this include Invalid Sensor voltage, Error with leg current sensors, Current sensors appear disconnected, and bad controller calibration. Each significantly limits torque output, but the motor is allowed to operate in a "limp-home" mode. This condition is reported through the Diagnostic Software described in Section 8 of this manual, and also through the MCU Forced Open Loop signal (Section 7.3.2.37).

5.3.5 Software Watchdog Timer

In addition to all limit protections discussed above, a software watchdog timer is also enabled. If the watchdog timer is not maintained properly by the inverter's firmware, the system will be reset automatically.

5.4 Vehicle responses to Danfoss Power Solutions CAN Status Messages

The customer and/or vehicle integrator is responsible verifying that the configuration data in TCU Status Message 1 (Section 7.3.1) match those for which the vehicle was designed.

The customer and/or vehicle integrator is responsible for proper responses to the Danfoss Power Solutions CAN Status and Error signals contained in TCU Status Message 2 (Section 7.3.2) and TCU Status Message 3 (Section 7.3.3).

TCU Status Message 4 (Section 7.3.4), TCU Status Message 5 (Section 7.3.5), TCU Status Message 6 (Section 7.3.6), and TCU Status Message 7 (Section 7.3.7) provide feedback signals to be used to control the system.

The Vehicle Control Unit/Module will need to determine the appropriate actions to these messages. Danfoss Power Solutions is providing the status and error messages so that appropriate actions are taken at the vehicle level. Danfoss Power Solutions assumes no liability if the vehicle does not respond to our status and error messages.

For a typical electric vehicle application, the actions should be considered as part of the vehicle integration. See the detailed list in Appendix B (Section 10).

6 Communications

This section covers the CAN communications required for normal motor operations and RS232 communications required by the diagnostic software.

6.1 VCU to TCU CAN Communications

The user is responsible for connecting the CAN communication from the VCU to the TCU and the Diagnostic Connector (see Table 3.1 for the Drivetrain Interface Connector pinout and Table 3.3 for the Diagnostic Connector pinout).

Please follow the typical CAN setup procedures according to J1939.

Note that the CAN bus connecting the VCU to the TCU has two sets of leads in the Drivetrain Interface Connector: VCU CAN Leg A (pins 1, 2 & 3) and VCU CAN Leg B (pins 4, 5 & 6). Both should be used as they are provided to preserve the integrity of the daisy chain for that bus. If the user elects to place the TCU at the end of the daisy chain, the 120Ω terminating resistor should be connected to the unused signal pins (I.e.: if all of the other devices on the CAN bus are connected to VCU CAN Leg A, the termination resistor should be connected between VCU CAN Leg B + and VCU CAN Leg B -). If the user does not wish to place the MCU at the end of the daisy chain, both sets of signal pins should be used. The user should not splice to one set of pins and leave the other open. Figure 3.12 shows the allowed CAN bus configurations.

The VCU to TCU CAN Bus can support the following configurations:

Baud Rate

- 250 kbps
- 500 kbps

Message Format

- PDU1 (29 bit)
- PDU2 (29 bit)
- CANOpen (11 bit)

Bit Order

- Little Endian

The default configuration is 250 kbps, PDU1, Little Endian. If another combination is needed, please contact your Danfoss Power Solutions representative to obtain a customer specific TCU configuration and matching dbc file.

6.2 TCU to MCU CAN monitor

Danfoss Power Solutions also provides access to the TCU to MCU CAN bus via the Diagnostic Connector. This access allows monitoring of communications between the TCU and MCU. It also used to update TCU and MCU firmware and TCU configuration data. The MCU configuration is updated via the RS232 port documented below.

TCU to MCU CAN bus. Note that the wiring from the MCU to the TCU is provided by Danfoss Power Solutions via the TCU to MCU Interface Cable (Cable C in Figure 1.1). The customer is responsible for the wiring from the Drivetrain Interface Connector to the Diagnostic Connector.

The CAN configuration for the TCU to MCU CAN bus is 500 kbps, PDU1, Little Endian.

6.3 RS232 Communications

The Danfoss Power Solutions Motor Diagnostic Software (Section 8) communicates to the motor system through the RS232 communication pins (7, 15 & 8) of the DT2 Diagnostic Connector (Connector 4 in Figure 1.1). As with the TCU to MCU CAN bus, the RS232 serial bus is routed to the 16 pin User Interface connector (Connector 3 in Figure 1.1) via the TCU to MCU Interface Cable (Cable C in Figure 1.1). The customer is responsible for the wiring from the Drivetrain Interface Connector to the DT2 Diagnostic Connector.

6.4 DT2 Diagnostic Connector

The DT2 Diagnostic connector provides access to the CAN busses used by the PowerPhase® DT2 system for monitoring bus traffic, configuring the TCU, updating TCU and MCU software, and use in diagnosing issues with the TCU. It also provides an RS232 compliant connection to the MCU for diagnostic and configuration purposes.

Wiring for the Diagnostic Connector is covered in Section 3.6.

7 VCU to TCU CAN Bus

7.1 CAN Messages

CAN Messages are of two types.

- VCU to TCU Command Messages
- TCU to VCU Status Message

VCU to TCU Command Messages are messages that the VCU sends to the TCU to command operations. These messages are documented in Section 7.2.

In so far as is possible, these commands will be followed. However, there are limits to how closely these commands control the system. Some exceptions are:

- Torque production will not exceed the limits communicated by the status message.
- Speed in Low Gear or Reverse will not exceed 1360 rpm and may be lower depending on the limits of the selected MCU system.
- Speed in High Gear will not exceed 4800 rpm and may be lower depending on the limits of the selected MCU system.
- The TCU will have total control of torque and MCU speed during High/Low and Low/High gear shifts. Control will be returned to the VCU once the shift is complete
- The TCU will only respond to Forward/Reverse shift commands at very low speeds and will only allow a shift to Reverse Gear while in High Gear if it encounters a shift failure in Low Gear.
- Drive Torque commands will produce Regen torque if the vehicle is moving in reverse while in Forward gear or forward while in Reverse gear.

TCU to VCU Status Messages are messages the TCU sends to the VCU to communicate the status of the TCU and MCU. These messages are documented in Section 7.

The documentation both VCU to TCU Command Messages and TCU to VCU Status Messages use the following conventions:

7.1.1 Abbreviations

kbps: kilobits per second

Nm: Newton meters

mb: millibars

rpm: revolutions per minute

rpm/s: revolutions per minute per second (rate of acceleration)

˚C: degrees Celsius

VDC: Volts DC

A: Amperes

lsb: least significant bit

msb: most significant bit

lsn: least significant nibble

msn: most significant nibble

lsB: least significant byte

msB: most significant byte

rrss: receiver CAN address (rr) sender CAN address (ss) for PDU1 message

gess: message group extension (ge) sender CAN address (ss) for PDU2 message

xss: priority (x) sender CAN address (ss) for CANOpen message

7.1.2 Boolean Values

0: False

1: True

7.1.3 Hexadecimal Values

Hexadecimal values are denoted by a subscript of 16. E.g.: 255 = FF_{16}

7.2 VCU to TCU Command Messages

7.2.1 TCU Command Message 1

ID: PDU1: $04EErrss_{16}$

PDU2: $04FFgess_{16}$

11 bit: $xrr1_{16}$

From: VCU

To: TCU

Msg Rate: 50ms

64	63	62	61	60	59	58	57
TCU CAN Message Error	TCU CAN Active	TCU CAN Watchdog Timeout		VCU Watchdog Counter 1			
56	55	54	53	52	51	50	49
TCU Enable				Transmission Mode			
48	47	46	45	44	43	42	41
Speed Limit msB							
40	39	38	37	36	35	34	33
Speed Limit lsB							
32	31	30	29	28	27	26	25
Requested Torque msB							
24	23	22	21	20	19	18	17
Requested Torque 2nd msB							
16	15	14	13	12	11	10	9
Requested Torque 3rd msB							
8	7	6	5	4	3	2	1
Requested Torque lsB							

7.2.1.1 TCU CAN Message Error

dbc ref: TCUCmd1_TCU_CANMessageError

lsb: 64

msb: 64

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The VCU has detected 1 of 3 indications that a message has been missed:

- The VCU has received 1 or more **Status Message 1** messages from the TCU in which the **Watchdog Counter** is out of sequence.
- The VCU has not received a **Status Message 1** messages from the VCU in 150% of the normally allotted time.
- The VCU received a valid **Status Message 1** that was not followed by an immediate sequence of **Status Message 2**, **Status Message 3**, **Status Message 4**, **Status Message 5** and **Status Message 6** before receiving the next **Status Message 1**.

False The TCU has received the last 3 commands from the VCU within 150% of the normally allotted time and in each of the messages the **Watchdog Counter** is in sequence and they were immediately followed by the sequence of **Status Message 2**, **Status Message 3**, **Status Message 4**, **Status Message 5** and **Status Message 6**.

Note: At startup, this bit will be True until the VCU receives 3 series of status messages from the TCU within 150% of the normally allotted time and in each of the **Status Message 1** the **Watchdog Counter** is in sequence.

7.2.1.2 TCU CAN Active

dbc ref: TCUCmd1_TCU_CANActive

lsb: 63

msb: 63

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True Normal communication has been established between the VCU and the TCU.

False VCU is unable to communicate with the TCU.

Note: During TCU startup, this value will be false until communication with the VCU and TCU has been established. The **Transmission Mode** should always be Neutral when **TCU CAN Active** is False.

7.2.1.3 TCU CAN Watchdog Timeout

dbc ref: TCUCmd1_TCU_CANWatchdogTimeout

lsb: 62

msb: 62

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

True — The VCU has not received a complete and properly sequenced set Status Messages 1 through 7 within the last second.

False — The VCU has received a complete and properly sequenced set Status Messages 1 through 7 within the last second.

Note: This bit will be True at startup. Once this bit is set to True, it will be held True until he VCU has received 3 complete and properly sequenced sets Status Messages 1 through 7 without detecting a **TCU CAN Message Error**.

7.2.1.4 VCU Watchdog Counter 1

dbc ref: TCUCmd1_VCUWatchdogCounter_1

lsb: 57

msb: 60

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 15

Units: Rolling Count

Description: The Watchdog count is used to detect missed message and to detect issues with VCU messaging procedures.

In each successive **Traction Control Command**, the **Watchdog Count** will be the **Watchdog Count** of the previous **Traction Control Command** + 1. If the **Watchdog Count** of the previous **Traction Control Command** was 15, the **Watchdog Count** will be reset to 0.

If the **Watchdog Count** for a **Traction Control Command** does not equal the **Watchdog Count** of the previous **Traction Control Command** + 1. The TCU will report a **Traction Control Command Message Error**. If TCU does not receive a **Traction Control Command** for 1 second, or it takes more than 1 second to receive at least three successive **Traction Control Command** messages in which the **Watchdog Count** conforms to the requirement, the TCU will report **Traction Control Command Watchdog Timeout** and will instruct the MCU to stop producing torque.

7.2.1.5 TCU Enable

dbc ref: TCUCmd1_TCUEnable

lsb: 56

msb: 56

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The TCU will follow torque, speed and gear instructions from the VCU.

False The TCU will remain in Neutral and will disable the MCU.

Note: The TCU will treat this condition as False if it does not have CAN communication with the MCU.

7.2.1.6 Transmission Mode

dbc ref: TCUCmd1_TransmissionMode

lsb: 49

msb: 52

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 6

Units: Enumerated

Description: VCU to TCU Directed Mode of operation.

0: Neutral
Transmission is decoupled from the drive train and the motor is disabled

1: Reverse
The transmission does not have an explicit reverse gear. Reverse is achieved by placing the transmission in Low gear and driving the motor in the reverse direction.

2: Forward Automatic
The TCU controls whether the transmission is in high or low (most common mode of operation).

3: Forward Low
The transmission is held in Low gear.

Note 1: The TCU will behave as if this field is Neutral if it does not have CAN communication with the MCU.

Note 2: The TCU should be the Neutral state when voltage is not being supplied to the MCU. The TCU should not exit the Neutral state until the power-up sequence is completed and the TCU is reporting MCU status to the VCU.

Note 2: Transition to and from Reverse should only be allowed at extremely slow vehicle speeds (transmission output speed <50 rpm).

Note 3: When the transmission is in low gear, motor speed should never be allowed to exceed 6000 rpm.

Note 4: When the transmission is in high gear, motor speed should never be allowed to exceed 4800 rpm.

Note 5: The transmission will achieve reverse operation in High Gear if and only if it encounters a shift failure from High to Low gear.

7.2.1.7 Speed Limit

dbc ref: TCUCmd1_SpeedLimit

lsb: 33

msb: 48

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 4800

Units: rpm

Description: The maximum speed, in rpm, to be delivered by the transmission to the driveshaft.

When the **Transmission Mode** is Neutral, this value will be treated as if it is 0.

When the **Transmission Mode** is Reverse, Forward Low, Forward High or Forward Automatic: this is the maximum speed the transmission will supply to the driveshaft. The actual speed will be controlled by the **Drive Torque** as long as it does not result in speeds in excess of the **Speed** value

When the **Transmission Mode** is either Reverse or Forward Low, values that exceed

$$\frac{\text{the lessor of 6000 rpm or the maximum speed allowed by the MCU}}{3.529}$$

will be treated as if they were that value.

When **Transmission Mode** is either Forward High or Forward Automatic, values that exceed 4800 rpm will be treated as if they were that value.

7.2.1.8 Requested Torque

dbc ref: TCUCmd1_RequestedTorque

lsb: 1

msb: 32

Offset: 0 (Signed int)

Scale Factor: 0.1

Min Value: -6425.6

Max Value: 6425.5

Units: Nm

Description: The amount of torque the VCU is requesting the system deliver to the driveshaft.

When the **Transmission Mode** is Neutral, this value will be ignored.

When the **Transmission Mode** is Reverse or Forward Low Forward High or Forward Automatic: this value will control the torque the TCU commands the MCU to produce to accelerate or decelerate the vehicle.

In all modes, when this value exceeds the **Maximum Allowed Drive Torque**, it will be treated as if it were that value. Likewise, if it exceeds **Maximum Allowed Regen Torque**, it will be treated as if it were that value.

Note: This value will control the amount of torque the motor will attempt to produce, but may or may not be equal to it.
The high gear ratio is 1:1, so the motor will attempt to produce the same amount of torque as is **Requested Torque**.
The low gear ratio is 3.529:1, so the motor will attempt to produce the amount of torque equivalent to **Requested Torque** divided by 3.529. The multiplying effect of the gear ratio will result in the requested torque being supplied to the driveshaft.

7.2.2 TCU Command Message 2

Message: Control Parameters

ID: PDU1: 08EErrss$_{16}$

PDU2: 08FFgess$_{16}$

11 bit: xrr1$_{16}$

From: VCU

To: TCU

Msg Rate: 50ms

64	63	62	61	60	59	58	57
				VCU Watchdog Counter 2			
56	55	54	53	52	51	50	49
Acceleration Limit msB							
48	47	46	45	44	43	42	41
Acceleration Limit lsB							
40	39	38	37	36	35	34	33
Max Source Current							
32	31	30	29	28	27	26	25
Max Sink Current							
24	23	22	21	20	19	18	17
16	15	14	13	12	11	10	9
Driveshaft Speed msB							
8	7	6	5	4	3	2	1
Driveshaft Speed lsB							

7.2.2.1 VCU Watchdog Counter 2

dbc ref: TCUCmd2_VCUWatchdogCounter_2

lsb: 57

msb: 60

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 15

Units: Rolling Count

Description: The Watchdog count is used to detect missed message and to detect issues with VCU messaging procedures.

In each successive **Traction Control Parameters Command**, the **Watchdog Count** will be the **Watchdog Count** of the previous **Traction Control Parameters Command** + 1. If the **Watchdog Count** of the previous **Traction Control Parameters Command** was 15, the **Watchdog Count** will be reset to 0.

If the **Watchdog Count** for a **Traction Control Parameters Command** does not equal the **Watchdog Count** of the previous **Traction Control Parameters Command** + 1. The TCU will report a **Traction Control Parameters Command Message Error**. If TCU does not receive a **Traction Control Command** for 1 second, or it takes more than 1 second to receive at least three successive **Traction Control Parameters Command** messages in which the **Watchdog Count** conforms to the requirement, the TCU will report **Traction Control Parameters Command Watchdog Timeout** and will instruct the MCU to stop producing torque.

7.2.2.2 Acceleration Limit

dbc ref: TCUCmd2_AccelerationLimit

lsb: 41

msb: 56

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 32128

Units: rpm/s

Description: The maximum allowed rate of controlled acceleration/deceleration of the transmission output speed.

Values less than 50 will be ignored. If this field never contains a value equal to or greater 50, the TCU will allow the MCU to use its configured default value.

If value of this field exceeds 50, that value will be conveyed to the MCU. If this value is later set to a value less than 50, the previously written value will remain in effect.

Note 1: The Limits Command Message to the MCU should only be sent when the Acceleration Limit, Max Source Current, or Max Sink Current values are changed.

Note 2: To avoid perturbations due to fluctuating limits, the command to the MCU will only be updated at a 1s interval.

7.2.2.3 Max Source Current

dbc ref: TCUCmd2_MaxSourceCurrent

lsb: 33

msb: 40

Offset: 0

Scale Factor: 5

Min Value: 0

Max Value: 1275

Units: Amps

Description: The maximum current the MCU is allowed to source to the battery when in regen.

Note 1: When this value is set to 0, the MCU reverts to its configured default value.

Note 2: The Limits Command Message to the MCU should only be sent when the Acceleration Limit, Max Source Current, or Max Sink Current values are changed.

Note 3: The actual currents are expected to be on the order of ±10 A below 100 A or ±10% above 100 A with some larger short term surges possible during large rapid torque changes.

Note4: To avoid perturbations due to fluctuating limits, the command to the MCU will only be updated at a 1s interval.

7.2.2.4 Max Sink Current

dbc ref: TCUCmd2_MaxSinkCurrent

lsb: 25

msb: 32

Offset: 0

Scale Factor: 5

Min Value: 0

Max Value: 1275

Units: Amps

Description: The maximum current the MCU is allowed to sink from the battery to drive the motor.

Note 1: When this value is set to 0, the MCU reverts to its configured default value.

Note 2: The Limits Command Message to the MCU should only be sent when the Acceleration Limit, Max Source Current, or Max Sink Current values are changed.

Note 3: The actual currents are expected to be on the order of ±10 A below 100 A or ±10% above 100 A with some larger short term surges possible during large rapid torque changes.

Note4: To avoid perturbations due to fluctuating limits, the command to the MCU will only be updated at a 1s interval.

7.2.2.5 Driveshaft Speed

dbc ref: TCUCmd2_DriveshaftSpeed

lsb: 1

msb: 16

Offset: 0 (signed int)

Scale Factor: 1

Min Value:	-16384
Max Value:	16383
Units:	rpm
Description:	The rotational speed of the driveshaft. If the **Driveshaft Speed** significantly diverges from the **Transmission Output Speed**, the TCU will report a **Driveshaft Speed Mismatch Error**.

7.3 TCU to VCU Status messages

7.3.1 TCU Status Message 1

ID: PDU1: 04EErrss$_{16}$

PDU2: 04FFgess$_{16}$

11 bit: xrr1$_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

64	63	62	61	60	59	58	57
MCU System Type				TCU Watchdog Counter			
56	55	54	53	52	51	50	49
TCU System Type – msB							
48	47	46	45	44	43	42	41
TCU System Type – lsB							
40	39	38	37	36	35	34	33
TCU System Type Revision							
32	31	30	29	28	27	26	25
TCU Major Version				TCU Minor Version – msn			
24	23	22	21	20	19	18	17
TCU Minor Version – lsn				TCU Sub Version			
16	15	14	13	12	11	10	9
MCU Major Version				MCU Minor Version – msn			
8	7	6	5	4	3	2	1
MCU Minor Version – lsn				MCU Sub Version			

7.3.1.1 MCU System Type

dbc ref: TCUStat1_MCUSystemType

lsb: 61

msb: 64

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 15

Units: Enumeration

Description: The system type of the MCU

	Danfoss Part	Former UQM Part	Description
0:	Unknown		
1:	EM-PMI318-T350-255V	PowerPhase® HD-220	HD1 & 2 turn motor
2:	EM-PMI318-T360-425V	PowerPhase® HD-250	HD1 & 3 turn motor
3:	EM-PMI318-T400-255V	PowerPhase® HD-950T	HD1 & 3 turn motor (Low Voltage)
4:	EM-PMI318B-T440E-255V	PowerPhase® HD-225	HD2 & 2 turn motor
5:	EM-PMI318B-T520E-465V	PowerPhase® HD-255	HD2 & 3 turn motor
6:	Undefined		
7:	EM-PMI318B-T360-465V	PowerPhase® HD-251	HD2 & 3 turn varnished motor
8-15:	Undefined		

7.3.1.2 Watchdog Counter

dbc ref: TCUStat1_TCUWatchdogCounter

lsb: 57

msb: 60

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 15

Units: Rolling Count

Description: The **Watchdog Counter** is used to detect missed messages from the TCU to the VCU and to detect issues with VCU messaging procedures.

In each successive **Status 1 Message**, the **Watchdog Counter** will be the **Watchdog Counter** of the previous **Status 1 Message** + 1. If the **Watchdog Counter** of the previous **Status 1 Message** was 15, the **Watchdog Counter** will be reset to 0.

The VCU should monitor **Watchdog Counter** for any irregularities and react accordingly.

7.3.1.3 TCU System Type

dbc ref: TCUStat1_TCUSystemType

lsb: 41

msb: 56

Offset: 0

Scale Factor: 1

Min Value: 0 ("Unknown System Type")

Max Value: 65535

Units: Enumeration

Description: The value of this enumeration is defined by the customer specific configuration. It will be matched to the MCU. If the MCU is not of the appropriate type, TCU System Type will be set to "Unknown" (0).
The VCU should verify that the TCU System Type and VCU System Type Revision are correct for the VCUs configuration.

7.3.1.4 TCU System Type Revision

dbc ref: TCUStat1_TCUSystemTypeRev

lsb: 33

msb: 40

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 255

Units: Enumeration

Description: The value of this enumeration is defined by the number of changes that have been made to the system configuration.
The VCU should verify that the TCU System Type and VCU System Type Revision are correct for the VCUs configuration.

7.3.1.5 TCU Major Version

dbc ref: TCUStat1_TCUMajorVersion

lsb: 29

msb: 32

Offset: 0

Scale Factor: 1

Min Value: 1

Max Value: 15

Units: Integer

Description: TCU Code Major Version Number.

7.3.1.6 TCU Minor Version

dbc ref: TCUStat1_TCUMinorVersion

lsb: 21

msb: 28

Offset: 0

Scale Factor: 1

Min Value: 1

Max Value: 255

Units: Integer

Description: TCU Code Minor Version Number.

7.3.1.7 TCU Sub Version

dbc ref: TCUStat1_TCUSubVersion

lsb: 17

msb: 20

Offset: 0

Scale Factor: 1

Min Value: 1

Max Value: 15

Units: Integer

Description: TCU Code Sub Version Number.

7.3.1.8 MCU Major Version

dbc ref: TCUStat1_MCUMajorVersion

lsb: 13

msb: 16

Offset: 0

Scale Factor: 1

Min Value: 1

Max Value: 15

Units: Integer

Description: MCU Code Major Version Number.

7.3.1.9 MCU Minor Version

dbc ref: TCUStat1_MCUMinorVersion

lsb: 5

msb: 12

Offset: 0

Scale Factor: 1

Min Value: 1

Max Value: 255

Units: Integer

Description: MCU Code Minor Version Number.

7.3.1.10 MCU Sub Version

dbc ref:	TCUStat1_MCUSubVersion
lsb:	1
msb:	4
Offset:	0
Scale Factor:	1
Min Value:	1
Max Value:	15
Units:	Integer
Description:	MCU Code Sub Version Number.

7.3.2 TCU Status Message 2

ID: PDU1: 08EErrss$_{16}$

PDU2: 08FFgess$_{16}$

11 bit: xrr1$_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

Note: The TCU will transmit this message immediately following the transmission of the **Status Message 1**. The VCU will detect whether or not the message is received and will react as appropriate.

64	63	62	61	60	59	58	57
Current Transmission Mode				Selected Gear		Upshift In Progress	Downshift In Progress
56	55	54	53	52	51	50	49
Upshift Failed	Downshift Failed	Slow Upshift	Slow Downshift	Shift Disabled	Max Shift Speed Delta Exceeded	Air Pressure Out of Range	Forced Gear Engage Torque
48	47	46	45	44	43	42	41
Motor Speed Mismatch Error	Driveshaft Speed Mismatch Error	MCU CAN Active	MCU CAN Timeout	MCU Watchdog Error	TCU Command Message 1 Error	TCU Command Message 1 Watchdog Timeout	TCU Command Message 2 Error
40	39	38	37	36	35	34	33
TCU Command Message 2 Watchdog Timeout	Trans Temp Warning	Trans Temp Error	Trans Temp Limiting	Trans Temp Read Error	MCU Inverter Temp Read Error	MCU Stator Temp Read Error	MCU Rotor Temp Read Error
32	31	30	29	28	27	26	25
MCU Regen Type Error	Factory Diagnostic Message msb						
24	23	22	21	20	19	18	17
Factory Diagnostic Message lsb							
16	15	14	13	12	11	10	9

MCU Power Switches Off	MCU Invalid Power Supply	MCU Bad Switch	MCU Bad Position Signal	MCU Phase Current Sensor Error	MCU Stall Condition Active	MCU Forced Open Loop	MCU Turbo Mode
8	7	6	5	4	3	2	1
MCU Using Raw Speed	MCU Accel Limited	MCU Current Trip Fault Ileg/Ibus		MCU ABC Phase Order	MCU System Disabled In Motion	MCU CAN Limits Active	MCU Forced Voltage Control

7.3.2.1 Current Transmission Mode

dbc ref: TCUStat2_CurrentTransmissionMode

lsb: 61

msb: 64

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 6

Units: Enumerated

Description: TCU Current Mode of operation.

See **Transmission Mode** in **Traction Control Command** for details.

Note: This is not simply an echo of the **Transmission Mode** commanded by the **Traction Control Command**. Operational conditions may delay or prevent a mode change.

7.3.2.2 Selected Gear

dbc ref: TCUStat2_SelectedGear

lsb: 59

msb: 60

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 2

Units: Enumeration

Description: The currently selected gear.

0: Neutral
1: Low

2: High
3: Shift in progress

Note: The Error state indicates that the TCU is unable to determine the state of gear engagement

7.3.2.3 Upshift In Progress

dbc ref:	TCUStat2_UpshiftInProgress	
lsb:	58	
msb:	58	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	Gear shift to High gear is in progress
	False	Gear shift to High gear is not in progress

7.3.2.4 Downshift In Progress

dbc ref:	TCUStat2_DownshiftInProgress	
lsb:	57	
msb:	57	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	Gear shift to Low gear is in progress
	False	Gear shift to Low gear is not in progress

7.3.2.5 Upshift Failed

dbc ref:	TCUStat2_UpshiftFailed
lsb:	56
msb:	56
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	1
Units:	Boolean

Description: True The previous attempted shift to High gear failed

False The previous attempted shift to High gear was successful

Note 1: The Upshift Failed flag is True as long as the Air Pressure Out Of Range Flag is True. This will NOT set or reset the failed shift flags. However, once the Air Pressure is within desired limits the failed shift flag will disappear when the Air Pressure Out Of Range flag is False.

Note 2: The Upshift Failed logic will go True for 1 sec when there is unsuccessful upshift fail flag for Neutral to Low or Neutral to High.

Note 3: The Upshift Failed flag will be set to True if the transmission sets both the unsuccessful upshift fail Neutral to Low and Neutral to High flags to True. This flag can only reset on Power Cycle.

Note 4: The system will hold the current gear once it has encountered an upshift fail (Limp Home Mode) irrespective of the commanded transmission mode.

7.3.2.6 Downshift Failed

dbc ref: TCUStat2_DownshiftFailed

lsb: 55

msb: 55

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The previous attempted shift to Low gear failed

False The previous attempted shift to Low gear was successful

Note 1: The Downshift Failed flag is True as long as the Air Pressure Out Of Range Flag is True. This will NOT set or reset the failed shift flags. However, once the Air Pressure is within desired limits the failed shift flag will disappear when the Air Pressure Out Of Range flag is False.

Note 2: The Downshift flag will be set to True if either the unsuccessful downshift fail Low to Neutral or the unsuccessful High to Neutral flag is True. This flag can only reset on Power Cycle.

Note 3: The system will hold the current gear once it has encountered a downshift fail irrespective of the commanded transmission mode.

7.3.2.7 Slow Upshift

dbc ref: TCUStat2_SlowUpshift

lsb: 54

msb: 54

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The previous shift to High shift required an excessive amount of time

False The previous attempted shift to High gear was accomplished in a normal amount of time

7.3.2.8 Slow Downshift

dbc ref: TCUStat2_SlowDownshift

lsb: 53

msb: 53

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The previous shift to Low gear required an excessive amount of time

False The previous attempted shift to Low gear was accomplished in a normal amount of time

7.3.2.9 Shift Disabled

dbc ref: TCUStat2_ShiftDisabled

lsb: 52

msb: 52

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The ability to change from High to Low gear, from Low to High, or from Neutral to either Low or High is disabled.

False The ability to change gears is not disabled

Note: Once gear shifting is disabled, it will not be reenabled until the entire system has been power cycled.

Warning: the system should never be power cycled while the vehicle is in motion.

7.3.2.10 Max Shift Speed Delta Exceeded

dbc ref: TCUStat2_MaxShiftSpeedDeltaExceeded

lsb: 51

msb: 51

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

Description:	True	Gear Shift is disabled because excessive driveshaft speed has been detected while the vehicle is in Neutral
	False	Gear Shift is not disabled because excessive driveshaft speed has been detected while the vehicle is in Neutral
	Note:	When the vehicle comes to a full stop and the TCU is commanded to neutral, the TCU cannot reliably detect the direction of travel – therefore it cannot reliably match the transmission output speed and with sufficient accuracy to successfully change gears.

7.3.2.11 Air Pressure Out of Range

dbc ref: TCUStat2_AirPressureOutOfRange

lsb: 50

msb: 50

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:	True	Pneumatic pressure to operate the gear shift solenoids is out of range
	False	Pneumatic pressure to operate the gear shift solenoids is in normal operating range
	Note:	Loss of pneumatic pressure will result in the loss of ability to shift into either high or low gear, and **Shift Disabled** will be set to True. The ability to shift to Neutral will not be affected.

7.3.2.12 Forced Gear Engagement Torque

dbc ref: TCUStat2_ForcedGearEngagementTorque

lsb: 49

msb: 49

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

True — The TCU is imposing a minimum torque requirement to maintain gear engagement

False — The TCU is not imposing a minimum torque requirement to maintain gear engagement

Note: If pneumatic pressure drops below the minimum to maintain gear engagement and the torque drops below 20Nm, the transmission will fail to the Neutral position. In order to maintain control of the vehicle, the TCU will maintain a minimum torque required to prevent gear disengagement until the VCU commands a shift to Neutral.

7.3.2.13 Motor Speed Mismatch Error

dbc ref: TCUStat2_MotorSpeedMismatchError

lsb: 48

msb: 48

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

True — There is a significant mismatch between the **Motor Speed** reported by the MCU and the **Transmission Output Speed** reported by the Transmission Speed Sensor.

False — The difference between the motor speed reported by the MCU and the **Transmission Output Speed** reported by the Transmission Speed Sensor is within the normal tolerances.

Note: Detection of a significant mismatch between the motor speed and the **Transmission Output Speed** will result in the **Current Transmission Mode** being changed to Neutral, **Selected Gear** will be changed to Neutral, and **Shift Disabled** will be set to True.

7.3.2.14 Driveshaft Speed Mismatch Error

dbc ref: TCUStat2_DriveshaftSpeedMismatchError

lsb: 47

msb: 47

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

True — There is a significant mismatch between the **Transmission Output Speed** reported by the Transmission Speed Sensor and **Driveshaft Speed** reported by the VCU.

False — The difference between the **Transmission Output Speed** reported by the Transmission Speed Sensor and the **Driveshaft Speed** reported by the VCU is within the nominal tolerances.

Note: Detection of a significant mismatch between the motor speed reported by the MCU and the **Transmission Output Speed** reported by the Transmission Speed Sensor will result in the **Current Transmission Mode** being changed to Neutral, **Selected Gear** will be changed to Neutral, and **Shift Disabled** will be set to True.

7.3.2.15 MCU CAN Active

dbc ref: TCUStat2_MCU_CANActive

lsb: 46

msb: 46

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True Normal communication has been established between the TCU and the MCU.

False TCU is unable to communicate with the MCU.

Note 1: During TCU startup, this value will be false until communication with the MCU has been established. The TCU **Transmission Mode** should always be Neutral when **MCU CAN Active** is False.

7.3.2.16 MCU CAN Timeout

dbc ref: TCUStat2_MCU_CANTimeout

lsb: 45

msb: 45

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True TCU has timed-out waiting for status from the MCU.

False TCU has received a status message from the MCU within the allotted time.

7.3.2.17 MCU Watchdog Error

dbc ref: TCUStat2_MCUWatchdogError

lsb: 44

msb: 44

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU is reporting a Watchdog timeout to the TCU.

False The MCU is not reporting a Watchdog timeout to the TCU.

7.3.2.18 TCU Command Message 1 Error

dbc ref: TCUStat2_TCUCommandMessage_1_Error

lsb: 43

msb: 43

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The TCU has detected 1 of 2 indications that a message has been missed:

- The TCU has received 1 or more **TCU Command Message 1** messages from the VCU in which the **VCU Watchdog Counter 1** is out of sequence.
- The TCU has not received a **TCU Command Message 1** messages from the VCU in 150% of the normally allotted time.

False The MCU has received the last 3 commands from the VCU within 150% of the normally allotted time and in each of the messages the **VCU Watchdog Counter 1** is in sequence.

Note: At startup, this bit will be True until the MCU receives 3 commands from the VCU within 150% of the normally allotted time and in each of the messages the **Watchdog Counter** is in sequence.

7.3.2.19 TCU Command Message 1 Watchdog Timeout

dbc ref: TCUStat2_TCUCommandMessage_1_WatchdogTimeout

lsb: 42

msb: 42

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has not received a **TCU Command Message 1** message within the last second.

False The MCU has received a **TCU Command Message 1** message within the last second.

Note: This bit will be True at startup. Once this bit is set to True, it will be held True until **TCU Command Message 1 Error** is set to False.

7.3.2.20 TCU Command Message 2 Error

dbc ref: TCUStat2_TCUCommandMessage_2_Error

lsb: 41

msb: 41

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has detected 1 of 2 indications that a message has been missed:

- The MCU has received 1 or more **TCU Command Message 2** messages from the VCU in which the **VCU Watchdog Counter 2** is out of sequence.
- The MCU has not received a **TCU Command Message 2** messages from the VCU in 150% of the normally allotted time.

False The MCU has received the last 3 commands from the VCU within 150% of the normally allotted time and in each of the messages the **VCU Watchdog Counter 2** is in sequence.

Note: At startup, this bit will be True until the MCU receives 3 commands from the VCU within 150% of the normally allotted time and in each of the messages the **VCU Watchdog Counter 2** is in sequence.

7.3.2.21 TCU Command Message 2 Watchdog Timeout

dbc ref: TCUStat2_TCUCommandMessage_2_WatchdogTimeout

lsb: 40

msb: 40

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has not received a **TCU Command Message 2** message within the last second.

False The MCU has received a **TCU Command Message 2** message within the last second.

Note: This bit will be True at startup. Once this bit is set to True, it will be held True until **TCU Command Message 2 Error** is set to False.

7.3.2.22 Transmission Temperature Warning

dbc ref: TCUStat2_TransmissionTemperatureWarning

lsb:	39	
msb:	39	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	The transmission lubricant temperature is equal to or greater than 120˚C.
	False	The transmission lubricant temperature is within normal operating range.

7.3.2.23 Transmission Temperature Error

dbc ref:	TCUStat2_TransmissionTemperatureError	
lsb:	38	
msb:	38	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	The transmission lubricant temperature has exceeded 120˚C for 30 minutes in the last hour or the transmission lubricant temperature has exceeded 125˚C.
	False	The transmission lubricant temperature has been within normal operating range for more than 30 minutes in the last hour.
	Warning:	Excessive operation at lubricant temperatures in excess of 120˚C (1 hour in any 12 hour period) risks damage to the transmission.

7.3.2.24 Transmission Temperature Limiting

dbc ref:	TCUStat2_TransmissionTemperatureLimiting	
lsb:	37	
msb:	37	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	The TCU is limiting the maximum torque allowed due to excessive transmission lubricant temperature.

	False	The TCU is not limiting the maximum torque allowed due to excessive transmission lubricant temperature.

7.3.2.25 Transmission Temperature Read Error

dbc ref: TCUStat2_TransmissionTemperatureReadError

lsb: 36

msb: 36

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:	True	The TCU detected either an open or a short in the transmission lubricant temperature sensor.
	False	The transmission lubricant temperature sensor is working properly.

7.3.2.26 MCU Inverter Temperature Read Error

dbc ref: TCUStat2_MCUInverterTemperatureReadError

lsb: 35

msb: 35

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:	True	The TCU detected either an open or a short in the MCU Inverter temperature sensor.
	False	The MCU Inverter temperature sensor is working properly.

7.3.2.27 MCU Stator Temperature Read Error

dbc ref: TCUStat2_MCUStatorTemperatureReadError

lsb: 34

msb: 34

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The TCU detected either an open or a short in the MCU Stator temperature sensor.

False The MCU Stator temperature sensor is working properly.

7.3.2.28 MCU Rotor Temperature Read Error

dbc ref: TCUStat2_MCURotorTemperatureReadError

lsb: 33

msb: 33

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The TCU detected either an open or a short in the MCU Rotor temperature sensor.

False The MCU Rotor temperature sensor is working properly.

7.3.2.29 MCU Regen Type Error

dbc ref: TCUStat2_MCURegenTypeError

lsb: 32

msb: 32

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: 0: MCU is configured for New Style Regen
1: MCU is not configured for New Style Regen

In Old Style Regen, the MCU will continue to produce regen torque until speed equals 0rpm

In New Style Regen, the MCU will only produce regen torque if the motor speed exceeds the Forward or Reverse speed limits.

The default setting for the MCU is new style regen. The TCU is designed to operate with New Style Regen, therefore the TCU will not operate if the system is in Old Style Regen.

7.3.2.30 Factory Diagnostic Message

dbc ref: TCUStat2_FTYDiagnosticMessage

lsb: 17

msb: 31

Offset: 0

Scale Factor:	1
Min Value:	0
Max Value:	32767
Units:	Integer
Description:	This 15-bit message is used for factory diagnosis only Note: This message does not affect the control strategy in supervisory controller and should be ignored for all control applications

7.3.2.31 MCU Power Switches Off

dbc ref:	TCUStat2_MCUPowerSwitchesOff
lsb:	16
msb:	16
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	1
Units:	Boolean
Description:	True The system IGBT switches have been shut down. False The system IGBT switches are operating normally

This bit indicates that the system's power switches have shut down to protect the operator and the Danfoss Power Solutions controller.

During startup, the switches will not be turned on until High Voltage reaches a minimum value.

The switches will be turned off if the High Voltage drops below a minimum value. When the voltage rises above the minimum value, they will be turned back on. This will correspond with "Under Voltage Warning" being set to true.

If this is the case, the switches will be turned back on when High Voltage exceeds the minimum value and a restart is not required.

Otherwise: Power Switches Off will correspond to the following messages in the Event Log (See the Danfoss Power Solutions User Manual for information on the Event Log).

- Phase Driver Fault
- Iq Noise too big
- Leg dangerously over current
- Position error is too large
- Position signal is bad
- Untrustworthy voltage measurement occurred
- Ibus Noise too big
- Ibus Raw too big
- Overspeed Shutdown
- LoopOverRun Shutdown
- Phase A switch problem
- Phase A switches problem

- Phase B switch problem
- Phase B switches problem
- Phase C switch problem
- Phase C switches problem
- Bad switch occurred
- Bad switches occurred
- CTFault safety ON
- Inverter Temp Shutdown
- Rotor Temp Shutdown
- Stator Temp Shutdown
- Inverter Fault ON
- Apparent rotor movement occurred
- Leg sums not zero
- Unreliable bus current measurement occurred
- Bad rotor temperature occurred

In these cases, a power cycle is required to clear the error.

Note: When this situation occurs, the TCU will shift to Neutral.

7.3.2.32 MCU Invalid Power Supply

dbc ref: TCUStat2_MCUInvalidPowerSupply

lsb: 15

msb: 15

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU's internal power supply is operating in an out of specification condition.

False The MCU's internal power supply is operating normally.

When this occurs, the MCU will enter the open loop mode of operation and severely limits the amount of torque the motor will produce.

7.3.2.33 MCU Bad Switch

dbc ref: TCUStat2_MCUBadSwitch

lsb: 14

msb: 14

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has detected an IGBT switch failure.

False The MCU has not detected any IGBT switch failures.

When an IGBT switch fails, the MCU can no longer safely operate.

7.3.2.34 MCU Bad Position Signal

dbc ref: TCUStat2_MCUBadPositionSignal

lsb: 13

msb: 13

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has detected an error in the leg current sensor.

False The MCU has not detected any errors in the leg current sensor.

This situation may be transitory or persistent. If this situation is persistent, the MCU is unable to determine the motor's position and will cease producing torque. When this occurs, the TCU will shift to Neutral and cease supplying torque to the vehicle.

7.3.2.35 MCU Phase Current Sensor Error

dbc ref: TCUStat2_MCUPhaseCurrentSensorError

lsb: 12

msb: 12

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has detected an error in the leg current sensor.

False No error has been detected in the leg current sensor.

When this occurs, the MCU will enter the open loop mode of operation and severely limits the amount of torque the motor will produce.

7.3.2.36 MCU Stall Condition Active

dbc ref: TCUStat2_MCUStallConditionActive

lsb: 11

msb: 11

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has detected a stall condition.

False There is no current active stall condition.

A stall condition occurs when the motor is producing large amounts of torque, but the vehicle is not moving. This creates a condition in which the IGBT switches are in danger of being damaged by overheating.

The MCU handles this situation by limiting the output torque to 10% of its normal value for 30 seconds. It then allows normal torque until the stall conditions are met again.

The probability of encountering this situation is greatly reduced by configuring the MCU to use a low PWM frequency (see the Stall data in the EC-C1200F + EM-PMI318B User's Manual for more details).

7.3.2.37 MCU Forced Open Loop

dbc ref: TCUStat2_MCUForcedOpenLoop

lsb: 10

msb: 10

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU is operating in an open loop configuration.

False The MCU is operating in a closed loop configuration.

When the MCU detects certain errors in its feedback control loops (usually a problem with sensors or circuitry), it maintains the ability to provide some drive power to the vehicle but severely limits the amount of torque it will make available.

7.3.2.38 MCU Turbo Mode

dbc ref: TCUStat2_MCUTurboMode

lsb: 9

msb: 9

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU is operating in Turbo Mode.

False The MCU is operating in FOC Mode.

FOC is the most common mode of operation for DC electric motors. The MCU uses this mode of operation at lower motor speeds. At higher motor speeds, the MCU uses a Danfoss Power Solutions proprietary algorithm known as Turbo Mode.

7.3.2.39 MCU Using Raw Speed

dbc ref: TCUStat2_MCUUsingRawSpeed

lsb: 8

msb: 8

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU is using unfiltered speed values.

False The MCU is using filtered speed values

The MCU derives speed from motor position signals. It normally filters those signals to reduce the signal noise. The result of the filtering is that the speed used by the MCU slightly lags the actual motor speed.
During normal operations, the lag is not enough to be significant. But, during a gear shift, the lag is enough to cause a delay. The TCU eliminates the lag by signaling the MCU to use the unfiltered position signals while a gear shift is in progress.

7.3.2.40 MCU Acceleration Limited

dbc ref: TCUStat2_MCUAccelerationLimited

lsb: 7

msb: 7

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True Acceleration has reached its configured limit.

False Acceleration has not reach its configured limit.

Torque will be reduced to prevent Acceleration from exceeding the configured limit. The Acceleration Limit will be provided from one of two sources:

- An internal limit imposed by the MCU's configuration
- An external limit that the TCU will derive from the **Acceleration Limit** field in the **Traction Control Parameters Command**.

7.3.2.41 MCU Current Trip Fault Ileg/Ibus

dbc ref: TCUStat2_MCUCurrentTripFaultIleg_Ibus

lsb: 6

msb: 6

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True A Current Trip Fault condition has been detected by the MCU.

False No Current Trip Fault condition has been detected by the MCU.

This bit indicates that the MCU has detected unreliable current readings from either the power switch or bus current sensors. When this bit is True, the MCU will limit torque to 50% of its rated value at the current motor speed.

7.3.2.42 MCU ABC Phase Order

dbc ref: TCUStat2_MCU_ABCPhaseOrder

lsb: 4

msb: 4

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Enumeration

Description: The motor's direction of rotation.

0: Reverse
1: Forward

7.3.2.43 MCU System Disabled In Motion

dbc ref: TCUStat2_MCUSystemDisabledInMotion

lsb: 3

msb: 3

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU has detected movement in the motor when MCU is disabled by a command from the TCU.

False The MCU has not detected movement in the motor when MCU is disabled by a command from the TCU. The bit will be in this state when the MCU is enabled by the TCU.

This bit indicates that a non-zero motor speed is detected while the Enable bit in the Control Parameters signal of the UniversalCommand Message is not set. This implies that the motor is being spun by an external force.

7.3.2.44 MCU CAN Limits Active

dbc ref: TCUStat2_MCUCANLimitsActive

lsb: 2

msb: 2

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True Output is being limited due to limits sent by the VCU.

False Output is not being limited due to limits sent by the VCU.

This motor's output is being limited by limits imposed by the VCU or TCU. E.g. this bit would be set if the motor speed reaches the speed limit derive from the **Speed** value in the **Traction Control Command**.

7.3.2.45 MCU Forced Voltage Control

dbc ref: TCUStat2_MCUForcedVoltageControl

lsb: 1

msb: 1

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:	True	MCU is in Forced Voltage Control Mode.
	False	MCU is not in Forced Voltage Control Mode.
	The MCU will only operate in in Forced Voltage Control Mode when a dangerous over voltage condition is detected. In this case, the MCU switches to Voltage Control Mode in an attempt to reduce the bus voltage. However, this mode is severely power limited to prevent a runaway vehicle condition.	

7.3.3 TCU Status Message 3

Message: Name goes here

ID: PDU1: $0CEErrss_{16}$

PDU2: $0CFFgess_{16}$

11 bit: $xrr1_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

Note: The TCU will transmit this message immediately following the transmission of the **Status Message 2**. The VCU will detect whether or not the message is received and will react as appropriate.

64	63	62	61	60	59	58	57
MCU Inverter Fault	MCU Inverter Fault History	MCU Inverter Fault Latched	MCU Inverter Fault Latched History	MCU Limp Home Mode	MCU Limp Home Mode History	MCU ADC Calibration Problem	MCU ADC Calibration Problem History
56	55	54	53	52	51	50	49
MCU Over Voltage Alarm	MCU Over Voltage Alarm History	MCU Over Speed Alarm	MCU Over Speed Alarm History	MCU Over Voltage Warning	MCU Over Voltage Warning History	MCU Over Speed Warning	MCU Over Speed Warning History
48	47	46	45	44	43	42	41
MCU Inverter Over Temp	MCU Inverter Over Temp History	MCU Stator Over Temp	MCU Stator Over Temp History	MCU Rotor Over Temp	MCU Rotor Over Temp History	MCU Under Voltage Warning	MCU Under Voltage Warning History
40	39	38	37	36	35	34	33
MCU Over Phase Advance	MCU Over Phase Advance History	MCU Over Bus Current	MCU Over Bus Current History	MCU Over Leg Current	MCU Over Leg Current History	MCU Not Enabled	MCU Not Enabled History
32	31	30	29	28	27	26	25
Transmission Output Speed msB							
24	23	22	21	20	19	18	17
Transmission Output Speed lsB							

16	15	14	13	12	11	10	9
MCU Motor Speed msB							
8	7	6	5	4	3	2	1
MCU Motor Speed lsB							

7.3.3.1 MCU Inverter Fault

dbc ref: TCUStat3_MCUInverterFault

lsb: 64

msb: 64

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

True An MCU Inverter Fault is occurring.

False No MCU Inverter Fault is occurring.

MCU inverter faults are power switch protection events. Too much heat or too much current can damage the switches, so the MCU protects them and sets this bit while it is doing so. Too much heat normally means that coolant loss has occurred, and the controller turns off the switches in response. Too much current causes the controller to limit its torque by half.

7.3.3.2 MCU Inverter Fault History

dbc ref: TCUStat3_MCUInverterFaultHistory

lsb: 63

msb: 63

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description:

True **MCU Inverter Fault** has been set to True at some point since the last time MCU power was cycled.

False **MCU Inverter Fault** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.3 MCU Inverter Fault Latched

dbc ref:	TCUStat3_MCUInverterFaultLatched	
lsb:	62	
msb:	62	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU Inverter Fault** has been set to True at some point since the last time MCU power was cycled.
	False	**MCU Inverter Fault** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.4 MCU Inverter Fault Latched History

dbc ref:	TCUStat3_MCUInverterFaultLatchedHistory	
lsb:	61	
msb:	61	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU Inverter Fault Latched** has been set to True at some point since the last time MCU power was cycled.
	False	**MCU Inverter Fault Latched** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.5 MCU Limp Home Mode

dbc ref:	TCUStat3_MCULimpHomeMode
lsb:	60
msb:	60
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	1
Units:	Boolean

Description: True The MCU is operating in the Limp Home Mode.

False The MCU is not operating in the Limp Home Mode.

When the MCU detects a serious impairment to its normal operation (inaccurate position signal, IGBT switch problems, etc.), it enters Limp Home Mode. Limp Home Mode allows continued but reduced operation as safely as possible given the impairment. The torque delivered will be limited by the Limp Home Percentage, which is a percentage of the maximum torque possible at each speed and voltage point. See the Danfoss Power Solutions EC-C1200F + EM-PMI318B User Manual for more details.

7.3.3.6 MCU Limp Home Mode History

dbc ref: TCUStat3_MCULimpHomeModeHistory

lsb: 59

msb: 59

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Limp Home Mode** has been set to True at some point since the last time MCU power was cycled.

False **MCU Limp Home Mode** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.7 MCU ADC Calibration Problem

dbc ref: TCUStat3_MCU_ADCCalibrationProblem

lsb: 58

msb: 58

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU's ADC calibration integrity check failed.

False The MCU's ADC calibration integrity check passed.

This test is performed only at power up. Upon failure, the MCU uses default calibration data and severely limits torque output capability. A power cycle is required to clear this error

7.3.3.8 MCU ADC Calibration Problem History

dbc ref: TCUStat3_MCU_ADCCalibrationProblemHistory

lsb:	57	
msb:	57	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU ADC Calibration Problem** has been set to True at some point since the last time MCU power was cycled.
	False	**MCU ADC Calibration Problem** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.9 MCU Over Voltage Alarm

dbc ref:	TCUStat3_MCUOverVoltageAlarm	
lsb:	56	
msb:	56	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	The High Voltage DC bus voltage is greater than the high voltage alarm threshold.
	False	The High Voltage DC bus voltage is less than the high voltage alarm threshold.

If this condition is detected by the MCU, it will attempt to reduce the voltage by switching to the Forced Voltage Control mode and severely limiting the available regeneration torque.

7.3.3.10 MCU Over Voltage Alarm History

dbc ref:	TCUStat3_MCUOverVoltageAlarmHistory	
lsb:	55	
msb:	55	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU Over Voltage Alarm** has been set to True at some point since the last time MCU power was cycled.

False **MCU Over Voltage Alarm** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.11 MCU Over Speed Alarm

dbc ref: TCUStat3_MCUOverSpeedAlarm

lsb: 54

msb: 54

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True Motor speed is greater than the high speed alarm threshold.

False Motor speed is less than the high speed alarm threshold.

This indicates that the motor speed has exceeded maximum forward or reverse speed limit by at least 300 rpm. The MCU does not allow motoring torque until the speed has been reduced to less than the relevant threshold

7.3.3.12 MCU Over Speed Alarm History

dbc ref: TCUStat3_MCUOverSpeedAlarmHistory

lsb: 53

msb: 53

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Over Speed Alarm** has been set to True at some point since the last time MCU power was cycled.

False **MCU Over Speed Alarm** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.13 MCU Over Voltage Warning

dbc ref: TCUStat3_MCUOverVoltageWarning

lsb: 52

msb: 52

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The High Voltage DC bus voltage is greater than the maximum for which the Danfoss Power Solutions system is configured.

False The High Voltage DC bus voltage is less than the maximum for which the Danfoss Power Solutions system is configured.

If this condition is detected by the MCU, it will attempt to reduce the voltage by switching to the Forced Voltage Control mode and limiting the available regeneration torque.

7.3.3.14 MCU Over Voltage Warning History

dbc ref: TCUStat3_MCUOverVoltageWarningHistory

lsb: 51

msb: 51

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Over Voltage Warning** has been set to True at some point since the last time MCU power was cycled.

False **MCU Over Voltage Warning** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.15 MCU Over Speed Warning

dbc ref: TCUStat3_MCUOverSpeedWarning

lsb: 50

msb: 50

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True Motor speed is greater than the high speed warning threshold.

False Motor speed is less than the high speed warning threshold.

If this condition is detected by the MCU, it will attempt to limit the speed by reducing the amount of torque available.

7.3.3.16 MCU Over Speed Warning History

dbc ref: TCUStat3_MCUOverSpeedWarningHistory

lsb: 49

msb: 49

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Over Speed Warning** has been set to True at some point since the last time MCU power was cycled.

False **MCU Over Speed Warning** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.17 MCU Inverter Over Temperature

dbc ref: TCUStat3_MCUInverterOverTemperature

lsb: 48

msb: 48

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The MCU’s inverter temperature exceeds normal operating limits.

False The MCU’s inverter temperature is within normal operating limits.

When this condition occurs, the MCU attempts to lower the maximum torque the system can produce until it reaches a point at which the temperature no longer exceeds the limit. The MCU will then produce as much torque as it can while keeping the temperature at or just below the limit.

7.3.3.18 MCU Inverter Over Temperature History

dbc ref: TCUStat3_MCUInverterOverTemperatureHistory

lsb: 47

msb: 47

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Inverter Over Temperature** has been set to True at some point since the last time MCU power was cycled.

False **MCU Inverter Over Temperature** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.19 MCU Stator Over Temperature

dbc ref: TCUStat3_MCUStatorOverTemperature

lsb: 46

msb: 46

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True The motor's stator temperature exceeds normal operating limits.

False The motor's stator temperature is within normal operating limits.

When this condition occurs, the MCU attempts to lower the maximum torque the system can produce until it reaches a point at which the temperature no longer exceeds the limit. The MCU will then produce as much torque as it can while keeping the temperature at or just below the limit.

Note: High Voltage DC bus voltage, inverter temperature, stator temperature, and rotor temperature are the most common reasons for torque limitations.

7.3.3.20 MCU Stator Over Temperature History

dbc ref: TCUStat3_MCUStatorOverTemperatureHistory

lsb: 45

msb: 45

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Stator Over Temperature** has been set to True at some point since the last time MCU power was cycled.

False **MCU Stator Over Temperature** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.21 MCU Rotor Over Temperature

dbc ref:	TCUStat3_MCURotorOverTemperature
lsb:	44
msb:	44
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	1
Units:	Boolean

Description:

True	The motor's rotor temperature exceeds normal operating limits.
False	The motor's rotor temperature is within normal operating limits.

When this condition occurs, the MCU attempts to lower the maximum torque the system can produce until it reaches a point at which the temperature no longer exceeds the limit. The MCU will then produce as much torque as it can while keeping the temperature at or just below the limit.

7.3.3.22 MCU Rotor Over Temperature History

dbc ref:	TCUStat3_MCURotorOverTemperatureHistory
lsb:	43
msb:	43
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	1
Units:	Boolean

Description:

True	**MCU Rotor Over Temperature** has been set to True at some point since the last time MCU power was cycled.
False	**MCU Rotor Over Temperature** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.23 MCU Under Voltage Warning

dbc ref:	TCUStat3_MCUUnderVoltageWarning
lsb:	42
msb:	42
Offset:	0
Scale Factor:	1
Min Value:	0

Max Value: 1

Units: Boolean

Description: True — The High Voltage DC bus voltage is less than the minimum for which the Danfoss Power Solutions system is configured.

False — The High Voltage DC bus voltage is greater than the minimum for which the Danfoss Power Solutions system is configured.

In this condition, the MCU severely limits the torque the system can produce.

7.3.3.24 MCU Under Voltage Warning History

dbc ref: TCUStat3_MCUUnderVoltageWarningHistory

lsb: 41

msb: 41

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True — **MCU Under Voltage Warning** has been set to True at some point since the last time MCU power was cycled.

False — **MCU Under Voltage Warning** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.25 MCU Over Phase Advance

dbc ref: TCUStat3_MCUOverPhaseAdvance

lsb: 40

msb: 40

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True — The motor requires excessive phase advance to produce the desired torque.

False — The motor is able to produce the desired torque without requiring excessive phase advance.

Note: When this condition occurs, the MCU will reduce the maximum torque the system will produce to that which it can produce without requiring excessive phase advance.

7.3.3.26 MCU Over Phase Advance History

dbc ref:	TCUStat3_MCUOverPhaseAdvanceHistory	
lsb:	39	
msb:	39	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU Over Phase Advance** has been set to True at some point since the last time MCU power was cycled.
	False	**MCU Over Phase Advance** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.27 MCU Over Bus Current

dbc ref:	TCUStat3_MCUOverBusCurrent	
lsb:	38	
msb:	38	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	The DC bus currents are exceeding their normal operating parameters.
	False	The DC bus currents are within their normal operating parameters.

7.3.3.28 MCU Over Bus Current History

dbc ref:	TCUStat3_MCUOverBusCurrentHistory	
lsb:	37	
msb:	37	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU Over Bus Current** has been set to True at some point since the last time MCU power was cycled.

	False	**MCU Over Bus Current** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.29 MCU Over Leg Current

dbc ref:	TCUStat3_MCUOverLegCurrent	
lsb:	36	
msb:	36	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	The motor phase currents are exceeding their normal operating parameters.
	False	The motor phase currents are within their normal operating parameters.

7.3.3.30 MCU Over Leg Current History

dbc ref:	TCUStat3_MCUOverLegCurrentHistory	
lsb:	35	
msb:	35	
Offset:	0	
Scale Factor:	1	
Min Value:	0	
Max Value:	1	
Units:	Boolean	
Description:	True	**MCU Over Leg Current** has been set to True at some point since the last time MCU power was cycled.
	False	**MCU Over Leg Current** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.31 MCU Not Enabled

dbc ref:	TCUStat3_MCUNotEnabled
lsb:	34
msb:	34
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	1

Units: Boolean

Description: True The MCU's Inverter is not enabled.

False The MCU's Inverter is enabled.

The motor will only be allowed to produce torque if the MCU's Inverter is enabled. If the MCU detects motor movement when the Inverter is not enabled, it will report a status of **MCU System Disabled In Motion**.

Note: When the VCU sets the TCU to Neutral, the TCU will disable the MCU's Inverter and **MCU Not Enabled** will be True.

7.3.3.32 MCU Not Enabled History

dbc ref: TCUStat3_MCUNotEnabledHistory

lsb: 33

msb: 33

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 1

Units: Boolean

Description: True **MCU Not Enabled** has been set to True at some point since the last time MCU power was cycled.

False **MCU Not Enabled** has not been set to True at any point since the last time MCU power was cycled.

7.3.3.33 Transmission Output Speed

dbc ref: TCUStat3_TransmissionOutputSpeed

lsb: 17

msb: 32

Offset: 0(signed int)

Scale Factor: 1

Min Value: -16384

Max Value: 16383

Units: rpm

Description: The transmission output speed to the driveshaft.

Note: Negative values indicate that the direction of travel is the opposite of the commanded direction of travel – i.e.: if the commanded direction of travel is forward, a negative value indicates that the vehicle is moving in the reverse direction and, if the commanded direction of travel is reverse, a negative value indicates that the vehicle is moving in the forward direction.

7.3.3.34 MCU Motor Speed

dbc ref: TCUStat3_MCUMotorSpeed

lsb: 16

msb: 1

msb: 56

Offset: 0(signed int)

Scale Factor: 1

Min Value: -16064

Max Value: 16064

Units: rpm

Description: The rotational speed of the motor.

Note 1: Negative values indicate that the direction of travel is the opposite of the commanded direction of travel – i.e.: if the commanded direction of travel is forward, a negative value indicates that the vehicle is moving in the reverse direction and, if the commanded direction of travel is reverse, a negative value indicates that the vehicle is moving in the forward direction.

Note 2: When the transmission is in high gear, **MCU Motor Speed** will be equal to **Transmission Output Speed**. When the transmission is in low gear (forward or reverse), **Motor Speed** will be equal to 3.529 * **Transmission Output Speed**. When the transmission is in Neutral, there is no correlation between **MCU Motor Speed** and **Transmission Output Speed**.

7.3.4 TCU Status Message 4

ID: PDU1: 10EErrss$_{16}$

PDU2: 10FFgess$_{16}$

11 bit: xrr1$_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

Note: The TCU will transmit this message immediately following the transmission of the **Status Message 3**. The VCU will detect whether or not the message is received and will react as appropriate.

64	63	62	61	60	59	58	57
Max Drive Torque Allowed msB							
56	55	54	53	52	51	50	49
Max Drive Torque Allowed lsB							
48	47	46	45	44	43	42	41
Max Regen Torque Allowed msB							
40	39	38	37	36	35	34	33
Max Regen Torque Allowed lsB							
32	31	30	29	28	27	26	25
VCU Torque Requested msB							
24	23	22	21	20	19	18	17
VCU Torque Requested 2nd msB							
16	15	14	13	12	11	10	9
VCU Torque Requested 3rd msB							
8	7	6	5	4	3	2	1
VCU Torque Requested lsB							

7.3.4.1 Max Drive Torque Allowed

dbc ref: TCUStat4_MaxDriveTorqueAllowed

lsb: 49

msb: 64

Offset: 0

Scale Factor: 0.1

Min Value: 0

Max Value: 6425.6

Units: Nm

Description: This is the maximum drive torque the system is capable of delivering to the driveshaft under current operating conditions.

This value is derived from the MCU's Max Drive Torque Allowed and is corrected for the Low/High gear ratio.

This value will also be derated by 10% for each increase of 0.5˚C above 120˚C in the temperature of the transmission lubricant temperature.

7.3.4.2 Max Regen Torque Allowed

dbc ref: TCUStat4_MaxRegenTorqueAllowed

lsb: 33

msb: 48

Offset: 0

Scale Factor: 0.1

Min Value: 0

Max Value: 6425.6

Units: Nm

Description: This is the maximum regen torque the system is capable of delivering to the driveshaft under current operating conditions.

This value is derived from the MCU's Max Regen Torque Allowed and is corrected for the Low/High gear ratio.

This value will also be derated by 10% for each increase of 0.5˚C above 120˚C in the temperature of the transmission lubricant temperature.

7.3.4.3 VCU Torque Requested

dbc ref: TCUStat4_VCUTorqueRequested

lsb: 1

msb: 32

Offset: 0 (signed int)

Scale Factor: 0.1

Min Value: -6425.6

Max Value: 6425.5

Units: Nm

Description: The amount of torque the TCU is requesting the system to deliver to the driveshaft. This is the amount of torque the VCU requested in TCU Command Message 1 after it has been limited to the Max Drive and Max Regen Torque Allowed.

Note 1: This value will not exceed Max Drive Torque Allowed or the Max Regen Torque Allowed.

Note 2: This value will be reported as 0 when the Transmission is in Neutral

7.3.5 TCU Status Message 5

ID: PDU1: 14EErrss$_{16}$

PDU2: 14FFgess$_{16}$

11 bit: xrr1$_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

Note: The TCU will transmit this message immediately following the transmission of the **Status Message 4**. The VCU will detect whether or not the message is received and will react as appropriate.

64	63	62	61	60	59	58	57
TCU Requested Torque msB							
56	55	54	53	52	51	50	49
TCU Requested Torque lsB							
48	47	46	45	44	43	42	41
MCU Desired Torque msB							
40	39	38	37	36	35	34	33
MCU Desired Torque lsB							
32	31	30	29	28	27	26	25
MCU Torque msB							
24	23	22	21	20	19	18	17
MCU Torque lsB							
16	15	14	13	12	11	10	9
TCU Torque msB							
8	7	6	5	4	3	2	1
TCU Torque lsB							

7.3.5.1 TCU Requested Torque

dbc ref: TCUStat5_TCURequestedTorque

lsb: 49

msb: 64

Offset: 0 (signed int)

Scale Factor: 0.1

Min Value: -3212.8

Max Value: 3212.8

Units: Nm

Description: The amount of torque the TCU is requesting the MCU to deliver to the transmission.

Note 1: Negative values denote regen torque.

Note 2 This is the value requested of the MCU by the TCU and is not corrected for the gear ratio.

Under most circumstances, this value will be calculated based on **VCU Drive Torque Requested** and **VCU Drive Torque Requested**, but will not necessarily be one of those values. The value will be modified by whether the system is in high or low gear and will be decoupled from those values while a gear shift is in progress

7.3.5.2 MCU Desired Torque

dbc ref: TCUStat5_MCUDesiredTorque

lsb: 33

msb: 48

Offset: 0 (signed int)

Scale Factor: 0.1

Min Value: -3212.8

Max Value: 3212.8

Units: Nm

Description: The amount of torque the MCU is will attempt to deliver to the transmission.

Note 1: Negative values denote regen torque.

Note 2: This value is related to **TCU Torque Requested** but it will be calculated based on the MCU's current operational limits. E.g.: **Acceleration Limit** will control the rate of change in this value and reaching the limiting speed will result in reduction of this value to what is needed to maintain that speed.

Note 3: This is the value reported by the MCU and is not corrected for the gear ratio.

7.3.5.3 MCU Torque

dbc ref: TCUStat5_MCUTorque

lsb: 17

msb: 32

Offset: 0 (signed int)

Scale Factor: 0.1

Min Value: -3212.8

Max Value: 3212.8

Units: Nm

Description: The amount of torque being produced by the motor.

Note 1: Negative values denote regen torque.

Note 2: This value is related to **MCU Desired Torque** but it will be calculated based on the amount of current being consumed or produced by the motor.

Note 3: This is the value reported by the MCU and is not corrected for the gear ratio.

7.3.5.4 TCU Torque

dbc ref: TCUStat5_TCUTorque

lsb: 1

msb: 16

Offset: 0 (signed int)

Scale Factor: 0.2

Min Value: -6425.6

Max Value: 6425.6

Units: Nm

Description: The amount of torque being delivered to the driveshaft via the transmission.

Note 1: Negative values denote regen torque.

Note 2: This value is related to **TCU Torque** but it will be calculated based on the current gear ratio.

7.3.6 TCU Status Message 6

ID: PDU1: $18EErrss_{16}$

PDU2: $18FFgess_{16}$

11 bit: $xrr1_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

Note: The TCU will transmit this message immediately following the transmission of the **Status Message 5**. The VCU will detect whether or not the message is received and will react as appropriate.

64	63	62	61	60	59	58	57
MCU Acceleration Limit msB							
56	55	54	53	52	51	50	49
MCU Acceleration Limit lsB							
48	47	46	45	44	43	42	41
MCU Voltage msB							
40	39	38	37	36	35	34	33
MCU Voltage lsB							
32	31	30	29	28	27	26	25
MCU Current msB							
24	23	22	21	20	19	18	17
MCU Current lsB							
16	15	14	13	12	11	10	9
MCU Leg Current msB							
8	7	6	5	4	3	2	1
MCU Leg Current lsB							

7.3.6.1 MCU Acceleration Limit

dbc ref: TCUStat6_MCUAccelerationLimit

lsb: 49

msb: 64

Offset: 0

Scale Factor: 1

Min Value: 0

Max Value: 32768

Units: rpm/s

Description: The maximum allowed rate of controlled acceleration/deceleration.

If this value is 0, the MCU will use its configured default value.

If the VCU commands a value greater than 50, the MCU will use that value instead of the configured default.

If the VCU commands a value greater than 50 and then commands a value less than 50, the greater value will remain in effect and will be reflected in this value.

Note: this value is the acceleration limit seen at the transmission output. Therefore the limit reported by the MCU will be divided by 3.529 when in low gear or reverse operation in low gear.

7.3.6.2 MCU Voltage

dbc ref: TCUStat6_MCUVoltage

lsb: 33

msb: 48

Offset: 0 (signed int)

Scale Factor: 0.1

Min Value: -3212.8

Max Value: 3212.8

Units: VDC

Description: The DC bus voltage available at the DC input terminals of the MCU.

7.3.6.3 MCU Current

dbc ref: TCUStat6_MCUCurrent

lsb: 17

msb: 32

Offset: 0 (signed int)

Scale Factor: 0.1

Min Value: -3212.8

Max Value: 3212.8

Units: A

Description: The DC bus current being consumed (motoring) or produced (regeneration) by the MCU. Positive values indicate motoring, while negative values indicate regeneration operation.

7.3.6.4 MCU Leg Current

dbc ref: TCUStat6_MCULegCurrent

lsb:	1
msb:	16
Offset:	0
Scale Factor:	1
Min Value:	0
Max Value:	32128
Units:	A
Description:	The absolute value of the peak currents passing through the motor's phase leads (the large cables between the inverter and the motor). The value is equal to the largest Leg Current value detected between successive MCU status report messages. It is representative of the currents driving the motor when it is motoring, or being produced by the motor when it is generating.

7.3.7 TCU Status Message 7

ID: PDU1: $1CEErrss_{16}$

PDU2: $1CFFgess_{16}$

11 bit: $xrr1_{16}$

From: TCU

To: VCU

Msg Rate: 50ms

Note: The TCU will transmit this message immediately following the transmission of the **Status Message 6**. The VCU will detect whether or not the message is received and will react as appropriate.

64	63	62	61	60	59	58	57
MCU Stall Safety Percentage							
56	55	54	53	52	51	50	49
TCU Lubricant Temperature							
48	47	46	45	44	43	42	41
MCU Inverter Temperature							
40	39	38	37	36	35	34	33
MCU Stator Temperature							
32	31	30	29	28	27	26	25
MCU Rotor Temperature							
24	23	22	21	20	19	18	17
MCU Max Source Current							
16	15	14	13	12	11	10	9
MCU Max Sink Current							
8	7	6	5	4	3	2	1

7.3.7.1 MCU Stall Safety Percentage

dbc ref: TCUStat7_StallSafetyPercentage

lsb: 57

msb: 64

Offset: 0

Scale Factor: 0.4

Min Value: 0

Max Value: 100

Units: %

Description: When this value reaches 100%, the stall safety limit trips and the MCU limits itself to 10% of its rated torque for approximately 30 seconds.

Note: The likelihood of this occurring can be significantly reduced by configuring the MCU to use a low PWM frequency (see the Stall data in the EC-C1200F + EM-PMI318B User's Manual for more details).

7.3.7.2 TCU Lubricant Temperature

dbc ref: TCUStat7_TCULubricantTemperature

lsb: 49

msb: 56

Offset: -40

Scale Factor: 1

Min Value: -40

Max Value: 210

Units: ˚C

Description: The temperature of the transmission's lubricant.

Note: Excessive use of the transmission at temperatures above 120˚C (more than 1 hour in any 12 hour period) may result in permanent damage to the transmission.

Note 2: The TCU will reduce the maximum allowed torque by 10% for each 1˚C of transmission lubricant temperature above 125˚C.

7.3.7.3 MCU Inverter Temperature

dbc ref: TCUStat7_MCUInverterTemperature

lsb: 41

msb: 48

Offset: -40

Scale Factor: 1

Min Value: -40

Max Value: 210

Units: ˚C

Description: The temperature of the MCU Inverter.

Note: The MCU will limit motor torque to keep this temperature within acceptable limits.

7.3.7.4 MCU Stator Temperature

dbc ref: TCUStat7_MCUStatorTemperature

lsb: 33

msb: 40

Offset: -40

Scale Factor: 1

Min Value: -40

Max Value: 210

Units: ˚C

Description: The temperature of the motor stator.

Note: The MCU will limit motor torque to keep this temperature within acceptable limits.

7.3.7.5 MCU Rotor Temperature

dbc ref: TCUStat7_MCURotorTemperature

lsb: 25

msb: 32

Offset: -40

Scale Factor: 1

Min Value: -40

Max Value: 210

Units: ˚C

Description: The temperature of the motor rotor.

Note: The MCU will limit motor torque to keep this temperature within acceptable limits

7.3.7.6 MCU Max Source Current

dbc ref: TCUStat7_MCUMaxSourceCurrent

lsb: 17

msb: 24

Offset: 0

Scale Factor: 5

Min Value: 0

Max Value: 1275

Units: Amps

Description: The maximum current the MCU is allowed to source to the battery when in regen.

7.3.7.7 MCU Max Sink Current

dbc ref:	TCUStat7_MCUMaxSinkCurrent
lsb:	9
msb:	16
Offset:	0
Scale Factor:	5
Min Value:	0
Max Value:	1275
Units:	Amps
Description:	The maximum current the MCU is allowed to sink from the battery to drive the motor.

8 Motor Diagnostic Software

Danfoss Power Solutions provides diagnostic software with our systems. This software runs on Microsoft Windows XP and later, and provides an environment to monitor and record the motor system conditions. It also allows you to change motor system configuration settings. This section describes the functionality of the diagnostic software.

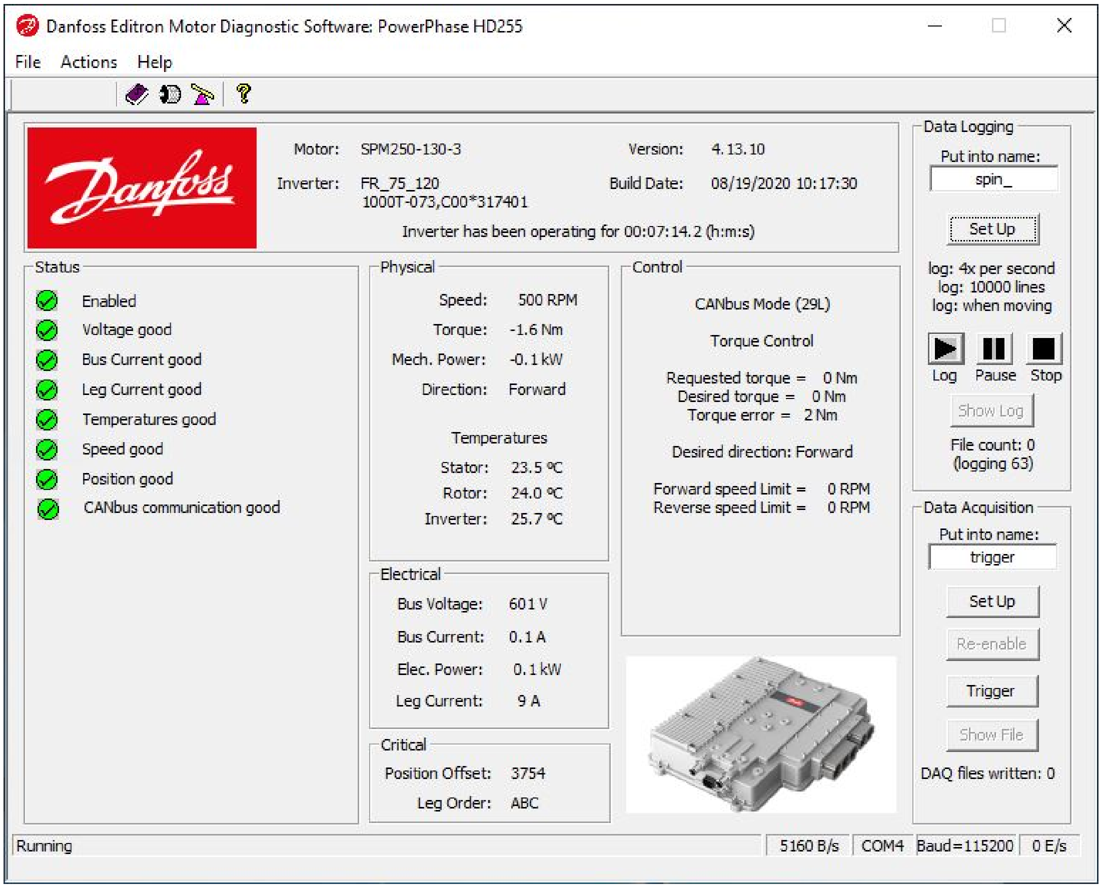


Figure 8.1: Danfoss Power Solutions Motor Diagnostic Software Front Panel

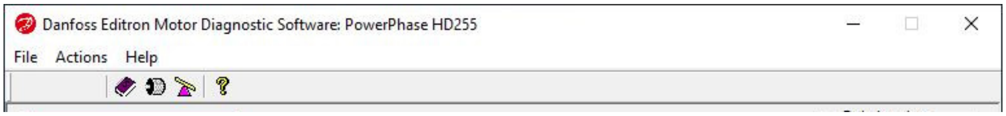


Figure 8.2: Menu Bar

Figure 8.3: General Group

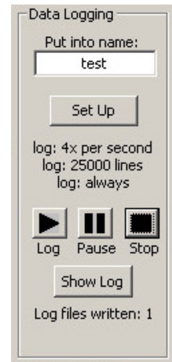


Figure 8.4: Data Logging Control

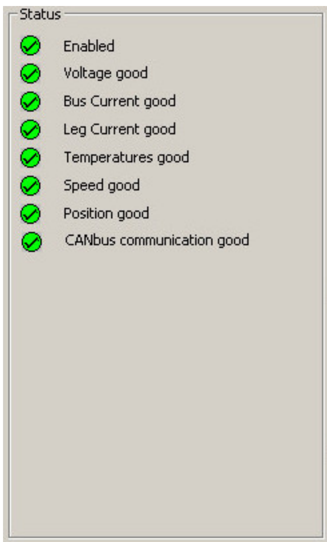


Figure 8.5: Status Group

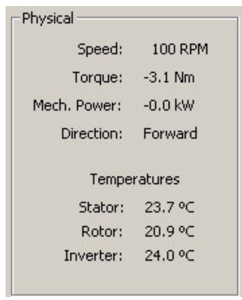


Figure 8.6: Physical Group

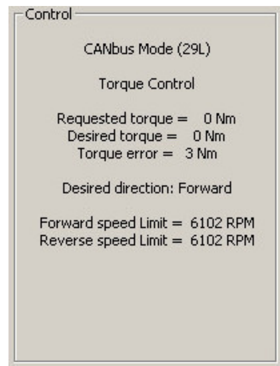


Figure 8.7: Control Group

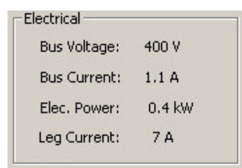


Figure 8.8: Electrical Group

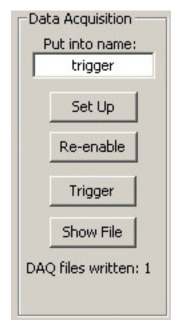


Figure 8.9: Data Acquisition (DAQ) Control

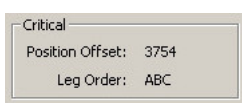


Figure 8.10: Critical Group

Figure 8.11: Status Bar

Classified as Business

8.1 Setting Up the Software

Danfoss Power Solutions Motor Diagnostic Software requires 10 Megabytes of hard disk space on a Microsoft Windows XP or later computer with a RS232 compliant COM port. A USB to RS232 Converter can be used to connect the COM port, but it must be installed before the Danfoss Power Solutions Motor Diagnostic Software.

Table 8.1: Components of a Danfoss Power Solutions Motor Diagnostic Software Installation

Start Menu Label	Description
Danfoss Power Solutions Motor Controller	The main diagnostic software described in this section of the manual. Connects to a Danfoss Power Solutions motor controller via an RS232 cable and provides an environment to monitor and record the motor system conditions.
PowerPhase®DT2 Manual	This document.
TCUtoVCU_PDU1_LE	dbc file for the PowerPhase®DT2 system. The default configuration is for PDU1 29bit headers and Little Endian

8.2 Starting the Software

After launching the Danfoss Power Solutions Motor Diagnostic Software, you are prompted (Figure 8.12) for the COM port number and for the fastest baud rate you desire. Using the default top speed of 115200 is recommended.

The software negotiates the baud rate with the controller each time it is started and finds the fastest baud rate that can be maintained, so it will not necessarily operate at the maximum rate of 115200 baud. You can, however, constrain it to a lower rate by setting that rate in the COM Port dialog box. Typically, this dialog box only appears the first time you launch the software. It stores these settings and uses them each time it is launched.

NOTICE	If the Danfoss Power Solutions Motor Diagnostic Software repeatedly asks you to choose a COM Port then it is unable to store the information. Move the UqmMotor directory to a location on your disk where the operating system allows the user to write.

If you want to change COM port or baud rate settings later, select **Actions > Choose COM Port** from the menu (Figure 8.12).

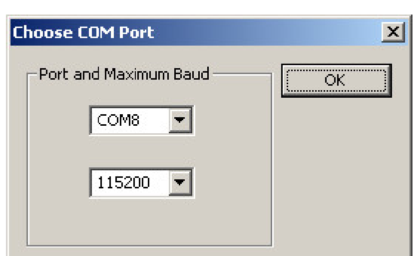


Figure 8.12: Choose COM Port Dialog Box

NOTICE Danfoss Power Solutions recommends that you save the original system configuration to a QSC file for each motor when you launch your software with that motor for the first time. This allows you to return to the configuration of your original shipped state at any time. See “Save to file” in Section 8.5 of this manual.

8.2.1 Status Bar

As the Danfoss Power Solutions Motor Diagnostic Software starts, it contacts the controller via the COM port. The Status Bar (Figure 8.13) at the bottom of the application window communicates all the details of the RS232 communication. It displays status messages, the current bytes-per-second rate, the COM port, the baud rate, and the current errors-per-second rate.

Figure 8.13: Status Bar

The Status Bar Communication Messages table (below) shows the communication messages that occur in the Status Bar (Figure 8.13).

When errors occur, the software provides additional information through message boxes or other dialog boxes. For example, if the software encounters a device that uses an older version of firmware, the software informs you and inquires if you wish to update or just run the application. Alternatively, if communication is not possible, the software either exits or returns to the “Choose COM Port” dialog box.

Table 8.2: Status Bar Communication Messages

Message	Description
Communication down, continuing to try...	Communication between the PC and the device has not yet been established or has failed. The PC will continue to try to establish communication every five seconds until you stop it via the “Choose COM Port” Action.
Have gotten the COM port	First message during initial contact.
Found device, initializing interface...	The device has answered; software is asking for identification.
Initializing Device...	Identification received; initializing communication with the device.
Negotiating baud...	Baud rate is being negotiated between the PC and the device. The highest supportable baud will be selected.
Reading Eerom...	The internal persistent memory is being read. This memory contains configuration, calibration, and error event data.

Message	Description
Running	Normal operation is occurring.
Fetching DAQ data	A DAQ trigger has occurred, and data is being moved from the device into a file.
Unable to communicate with device	Communication attempts have been unsuccessful.
Attached to a constantly talking device	A device has been encountered on the RS232 port that is outputting text all the time. Try connecting with Microsoft's HyperTerminal program to communicate with this device.
Bad DAQ directory	The software was unable to store a DAQ file in the present DAQ directory.
Cannot operate	An unrecoverable error has occurred.
Error count exceeded allowed. Letting go of COM port	Too many errors have occurred in the RS232 communication channel. The software is ending communication.

In normal operation, the software initializes the RS232 interface and retrieves the device's initialization information, negotiates the baud rate, reads the EEROM, checks to see if the firmware can be upgraded, and then begins operation. These activities do not disturb the normal operation of the Danfoss Power Solutions controller as it manages its electric motor. You can connect the diagnostic software to a Danfoss Power Solutions controller at almost any time.

We recommend that you save your system configuration to a file as soon as you begin using the software—this allows you to return to your original system configuration at any time. You can also save different system configurations as you make changes to the configurations. See Section 8.5 for further details on saving system configurations.

8.3 Diagnostic Software Operation

The Danfoss Power Solutions Motor Diagnostic Software consists of a front panel with menu, toolbar, and status bar. The status bar is described in Section 8.2.1 above. Table 8.3 gives general descriptions of each group on the front panel. Table 8.3 shows each of these groups.

Table 8.3: Front Panel Group Descriptions

Display Group	Description
General	The General Group (Figure 8.3) shows the motor, controller, build version, and date of the firmware in the controller. It also shows the elapsed time since the last controller power-up of the controller in hours:mins:secs.
Status	The Status Group (Figure 8.5) the current status of the motor system. Voltage, current, temperature, and rotor position conditions are monitored and problems are reported in this section. Further details are shown in Table 8.4.

Display Group	Description
	Indicates proper operation Indicates a cautionary or questionable situation Indicates a severely-limited or non-operation situation
Physical	The Physical Group (Figure 8.6) reports measurements for speed, torque, mechanical power, motor direction, and component temperatures. Any problem measurements are noted in the Status Group.
Electrical	The Electrical Group (Figure 8.8) reports measurements for DC bus voltage and current, electrical power, and the phase leg currents. Any problem measurements will be noted in the Status Group.
Critical	The Critical Group (Figure 8.10) reports the critical parameters of the position offset and the phase leg order. If these are incorrect, the situation is dangerous. This danger occurs if the motor is wired incorrectly to the controller.
Control	The Control Group (Figure 8.7) reports the current control mode and control parameters of the motor system.
Data Logging	Data Logging (Figure 8.4) controls the logging capabilities of the software. Data logging records motor system measurement data to a spreadsheet file in real time at second or multiple-second rates. The software can log data at these slow rates indefinitely. Details on logging are located in Section 8.4.
Data Acquisition	Data Acquisition (Figure 8.9) controls the data acquisition (DAQ) capabilities of the Danfoss Power Solutions controller. DAQ records motor system measurement data at millisecond rates. The data is limited in length, and is recorded into a spreadsheet file after the acquiring event has occurred. Significant time is required for extraction of the DAQ data from the controller. Details on DAQ are located in Section 8.5.
Status Bar	The Status Bar (Figure 8.11) displays the current condition of the RS232 communication port. Details of the operation of the Status Bar are covered in greater detail in Section 8.2.1.

8.3.1 Measurement Update Speed

In normal operation, the front panel (Figure 8.1) indicates the present operating conditions of the Danfoss Power Solutions Motor System. The measurements are updated four times per second at the higher baud rates. Slower rates, like 38400 and 19200, slow down the measurement rate to approximately twice a second.

Note that the measurement rate is slowed when a DAQ file is being retrieved because removal of the DAQ data is using almost all of the bandwidth of the RS232 port. One exception is if Data Logging at 4x per second is occurring. DAQ file retrieval is not maximized so that the requested logging rate is maintained. Front panel measurements are updated normally in this case.

8.3.2 Status Group

Figure 8.14: Status Group

The status group (Figure 8.14) is an important area of the front panel because it shows the status of the motor system at that moment. Conditions are monitored and problems are reported that are currently affecting the normal operation of the motor system. Whenever a red light is showing in the status group, the controller could be severely limited in operation. Table 8.4 shows the conditions that can cause red and yellow lights in the status group.

Table 8.4: Status Group Problems

RED LIGHT	
EEROM failed	The persistent memory on board the controller has failed or is not programmed. The controller cannot operate.
Bad System Configuration	The system configuration information in the persistent memory is unusable. The controller cannot operate.
Unit not Calibrated	The calibration data in the persistent memory is not present. The controller is severely limited in operation.
Bad ADC Calibration	The calibration values are out of specification. Default calibration values are being used, and the controller is severely limited in operation.
Sensor voltage invalid	The voltage that powers the current and temperature sensors is invalid. This is normal when high voltage is not present, but if high voltage is present then the controller is severely limited.
Inverter Faulted	One or more inverter/controller modules are presently faulted. This is normal when high voltage is not present. However, if high voltage is present, the controller is severely limited.

RED LIGHT	
Untrusted Voltage	The two measurements of voltage made by the controller have diverged unexpectedly. The controller cannot operate.
Over Voltage	Bus voltage is over the allowable limit. The controller is likely to have gone into forced voltage control to bring this condition under control. The controller is in danger of severe damage if this condition persists.
Over Speed	The motor is spinning faster than the allowable limit. Motoring is significantly limited, and the motor may be generating to try to slow itself down. If the over speed persists and is fast enough, the motor is in danger of damage.
Bus Current too large	Bus current is over the allowable limit. The controller imposes limitations on its output during this condition.
Leg Current too large	The motor's phase currents are exceeding limits. The controller is limiting torque.
Leg Currents sum not zero	The measured currents in the three motor phases should equal zero at any particular moment in time. If they do not, measurements are suspect, and the controller imposes limitations on its output during this condition. (Note that on average, the currents in the legs can be large, but sum to 0.)
Bad (A/B/C) Switch(es)	The controller has detected a problem on one or more of the three motor phases (A, B, or C) and assumes one or more IGBT switches are bad for the controller module in question. The controller imposes limitations on its output.
Phase limited	In high speed operation, the controller's phase adjustment has reached its allowable limit. The controller imposes limitations on its output during this condition.
Inverter/Stator/Rotor Temperature Disconnected	The inverter/controller has detected a disconnected temperature sensor. The controller imposes limitations on its output during this condition.
Inverter/Stator/Rotor/ Over Temperature	The temperature measurement is over the allowable limit. The temperature limits are given on the "About UqmMotor" dialog box. The controller imposes limitations on its output during this condition.
No position signal	There are no position sensor inputs detected. Ensure that the position signal cable is connected properly. The controller cannot operate.
Rotor movement	The controller has detected a condition that often indicates that the rotor or the position-sensing equipment has moved. The controller imposes limitations on its output.
Position signal is bad	The position signal is bad. The controller cannot operate and must be reset. Ensure that the position cable is properly connected.

RED LIGHT	
Position error too large	The amplitude of the error on the position signal has become too large so the position signal itself is suspect. The controller cannot operate.
Position problem	A position-sensing problem has occurred, and the motor is still limited in output because of it.
Position signals are noisy	Electrical noise has been detected within the position-sensing signals. If severe enough, this can cause limitations to motor output. A red light means that there has just been a noise event. A constant red light means noise is continually occurring.
Forced Open Loop	The controller is operating in forced open loop control and is limited in capability. This can occur because of bad sensor measurements.
CANbus communication error	The CANbus communication has ceased, and the controller is disabled. This is the CANbus watchdog error and must be reset via the heartbeat command through CAN. See the **CANbus Manual** for further details.
IBus CT Fault / ILeg CT Fault	The measurement sensors are untrustworthy, and the system cannot operate.
Limp Home happening	Indicates that the inverter has detected a condition that causes it to limit system torque to that specified by the **Limp Home Percentage**
Power switches off	Indicates that the inverter has detected a condition that causes it to shut down the IGBT Switches

YELLOW LIGHT	
Disabled	The controller is disabled. It can be disabled by the hardware enable line, through CANbus, through Key OFF, or through a number of conditions outlined in the RED LIGHT section of this table.
Fault Occurred	One or more controller modules has faulted, and the fault was cleared. The controller is limited in operation.
Motoring limited to x%	This caution appears whenever motoring ability has been limited to less than 100%. Besides the conditions outlined throughout this table, motoring can also be limited by a CANbus command.
Regen limited to x%	This caution appears whenever the motor's generation ability has been limited to less than 100%. Besides the conditions outlined throughout this table, generation can also be limited by a CANbus command.
Power close to or over limit	Electrical power is close to or over the allowable limit of the motor system. The controller will experience regeneration limitations.

YELLOW LIGHT	
Voltage Warning	Bus voltage is nearing its allowable limit. The controller will experience regeneration limitations.
Under Voltage	Bus voltage is too low to operate normally. Motoring is limited.
Voltage causing torque limitation	Bus voltage is below the nominal voltage for system operation. Maximum motoring and regen will be limited accordingly.
Speed Warning	The motor speed is near the allowable limit. Motoring will soon be limited in order to control the speed.
Unknown speed	There is no position-sensing input occurring. It is likely that the motor is not spinning.
Inverter/Stator/Rotor/ Temperature warning	The temperature measurement is approaching the allowable limit. The temperature limits are given on the “About UqmMotor” dialog box. The controller will soon impose limitations.
Position signals are noisy	Electrical noise was detected within the position-sensing signals. A yellow light indicates that a noise event has occurred in the last 15 seconds.
No CANbus communication	The controller is in CANbus control but no CANbus communication has yet been detected. The controller is disabled.
CANbus limit acting	Limits imposed through the CANbus commands are acting on the motor’s output.
Stall conditions	The motor is experiencing stall conditions, meaning that it is not spinning and large amounts of torque are being requested. While in stall condition, the motor is periodically limited in output to prevent damage to the controller modules.
Forced voltage control	The motor is in forced voltage control, a condition normally encountered when the motor is spun without a battery connected to it. Forced voltage control is entered to keep the voltage from going over the allowable controller limit, which would damage the hardware. The controller drops out of forced voltage control automatically when the battery is re-connected.
Leg current separation occurring	The motor’s phase legs have some current separation (vertical displacement from one phase to another). No limitation occurs with this message.
Direction mismatch	The desired direction in the CANbus command does not match the present direction of motor movement. This condition can exist when the motor is stopped because the directions were mismatched on the last movement of the motor as it came to a stop.

YELLOW LIGHT	
Torque matching problem	If this condition persists, the controller is indicating that it is unable to control the motor to the desired torque. This could be because the motor has partially demagnetized.
Limiting acceleration	Torque is being limited due to the acceleration limit in force.
Actively Damping	The Active Damping Control is altering the torque to damp out a drive train oscillation.
Regen disabled	The Regen Switch is open and regeneration power is impossible. The switch will close when the internal and external voltage measurements close to within 25V of each other
System Halt	The system is not operational. Voltage must rise to the minimum battery level before the system becomes operational.
ManuInfo invalid	The manufacturing information present in the inverter is invalid. This may mean that there is a problem with the inverter's EEROM.
Event Log disabled	The Event Log is inoperable. This does not affect motor operation.

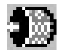
8.3.3 Menu Bar and Toolbar

The diagnostic software has a menu and toolbar to access other functionality beyond condition and measurement information. Table 8.5 describes the menu's choices and shows those that have Toolbar buttons.

Figure 8.15: Menu Bar and Toolbar

Table 8.5: Menu and Toolbar Descriptions

Menu Choice		Button	Description
File	Recent Files		Shows the four most recent log or DAQ files written by the software.
	Exit		Exits the diagnostic software.

Menu Choice		Button	Description
Actions	Show Event Log		Shows the attached motor's event log in a dialog box. See Event Log, Section 8.6 for more details.
	Date into Event Log		Marks the Event Log of the connected controller with today's date. The date is in the form yyyy/mm/dd. Only one marker is allowed per day.
	DAQ Configuration		Opens a pop-up menu with multiple DAQ configuration options. See DAQ, Section 8.5 for more details.
	Change COM port		Closes communication to the controller through the RS232 port and brings up the "Change COM Port" dialog box. Canceling this dialog box causes the diagnostic software to exit. See Section 8.2 for more details.
	Show CAN tests		Shows the CANbus Test dialog box. This dialog box generates and sends CANbus errors and status condition messages, so you can test whether your connecting software is responding correctly. See the **Danfoss Power Solutions CANbus Interface Manual** for more details.
	Allow PWMs at Stop		Normally, the pulse width modulation (PWM) the Danfoss Power Solutions controller uses to control its motor is not present when zero torque is requested and the motor is not spinning. This menu toggle (checked when true) causes the controller to PWM even when at rest. This is useful when you need to test your system's noise immunity to the PWM energy without actually operating the motor.
Help	User Manual		Shows the **Danfoss Power Solutions Motor System User Manual**. This is a PDF file.
	CAN Manual		Shows the **Danfoss Power Solutions CANbus Interface Manual**. This is a PDF file.
	About UqmMotor		Opens the "About UqmMotor" dialog box, showing the application's version number and the attached controller's temperature limits.

8.4 Logging Data

Data Logging is a powerful diagnostic tool that records motor system measurement data to a spreadsheet file in real time, at quarter-second to multiple-second rates. The diagnostic software can log data at these rates indefinitely, only limited by the disk drive space of your computer.

Log files are located and named via the logging set up dialog box. The files are numbered so that each name is unique and no data is lost. The naming convention includes the date. For example, two files taken on June 21st, 2013 with default settings would be named:

```
20150318LOG_test00.csv
```

`20150318LOG_test01.csv`

Note that the Data Logging feature also automatically saves a file with the extension "`.uqm`". This file contains additional log data that Danfoss Power Solutions can use in diagnosing issues. If you are experiencing problems, we usually request that you e-mail both the "`.csv`" log file and the "`.uqm`" file to Danfoss Power Solutions.

Logging is controlled via the right top corner of diagnostic software's front panel. Figure 8.1, Figure 8.16 and Table 3.1 show details of these controls.

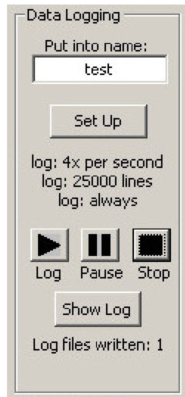


Figure 8.16: Front Panel Components of Logging

Table 8.6: Front Panel Logging Group Components

Label	Description
Put into name	The edit box is a shortcut to setting the name portion of a logging filename. Normally, this name is set in the logging Set Up, but it is sometimes more convenient to change the filename without going into the Set Up dialog box.
Set Up	Opens the Logging Set Up dialog box. This functionality is described in detail later in this section.
Log	Starts the logging of data into the log file. If a file is already logging, it closes that file and opens a new file. If a logging file is paused, it continues logging into the paused file.
Pause	Pauses the logging of data into the log file.
Stop	Stops logging and closes the log file.
Show Log	Starts your spreadsheet program with the last closed data log file. This feature will only work if you have a spreadsheet program has the file type associated for the CSV (comma-separated values) file format.

8.4.1 Logging Set Up

The Logging Setup dialog box controls where and how data logging occurs. Figure 8.17 illustrates this dialog box, invoked via the "Set Up" button in the Data Logging group. Table 8.7 describes each component of this dialog box.

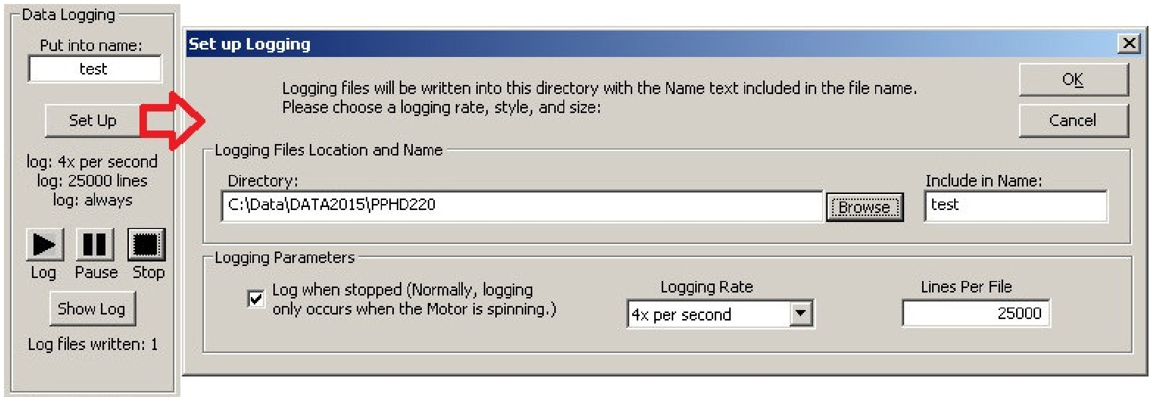


Figure 8.17: Logging Set Up Dialog Box

Table 8.7: Logging Set Up Components

Label	Description
Directory: Browse button	Enter the directory where Log files should be written. Browse brings up a File Open dialog box. Use it to point to the directory you want to use.
Include in Name	Text that you want included into the log filename. It includes the date, this text, and an incrementing number.
Log when stopped	Normally logging only occurs when the motor is spinning. If you want data to be logged at all times, then select this box.
Logging Rate	Select the rate that you want data logged.
Lines Per File	Enter the number of rows you want in each logging file. The diagnostic software will open a new file (incremented name) when this number of rows has been stored into a logging file.

In general, Data Logging stores one snapshot of measurement data every second or at an integer multiple of seconds. The fastest rate that data can be logged is four times a second. If you need faster data acquisition, then you should use the data acquisition feature of the Danfoss Power Solutions Motor System (see Section 8.5).

NOTICE *Logging at a four or two times per second rate will slow down the extraction of a data acquisition file.*

This data is stored in a spreadsheet file, with a snapshot of data measurements forming one row in the spreadsheet. The file format used is the comma-separated values (CSV) format. You can control the size of these files using the logging setup and the **Lines Per File** setting. By default, 25,000 rows of data are stored per file. Once a file is full, it is closed, and the next incremented file name is opened.

Data logging of measurements can be paused and continued into the same file using the **Pause** button. It is not possible to reopen a file and continue logging into it if that file has been closed. If you click on the **Log** button while the diagnostic software is actively logging, then the current log file is closed, and a new file is opened.

NOTICE Normally, the diagnostic software logs data into the file only when the motor is spinning. This means that you can start a log and have an active log file even when no data is being logged because the motor is quiescent. It begins automatically logging data when the speed reported by the motor is non-zero. If you want to log data even when the motor is motionless, open the Set Up dialog box and select the “Log when stopped” check box.

One row of data contains the measurements shown in Table 8.8.

Table 8.8: Logging and DAQ Measurement Columns

Column Label	Description
General	A column containing the motor and controller names, the firmware’s version number/build date, and the file storage date/time.
Index	An incrementing line number starting from zero.
SysErr History	This displays the controller’s System Error History. This is the on-going history of the System Error word. The first line shows the History as the file started. It is then cleared so that all subsequent snapshots show what has happened since the file was opened. Note that this field is present only in Data Logging files, not in DAQ files.
System Error	The controller’s System Error word in decimal format. See the Danfoss Power Solutions CAN Manual for further details.
Operating Time(secs)	This is the controller’s operating time: the number of seconds since the controller was last powered up, reset, or operated over 95 hours.
Speed (RPM)	The spinning speed of the motor in revolutions per minute. This number is a positive number no matter what direction it is going. The direction is indicated in the Motor Direction column.
FilteredSpeed	The filtered output of the motor speed, in revolutions per minute. This number multiplied by the value in the Motor Direction column is a signed speed value.
Actual Torque (Nm)	The torque in Newton meters, as calculated by the controller.
Friction (Nm)	The friction amount, in Newton meters, being used by the controller in its control calculations to overcome system friction.
Mech Power (W)	The mechanical power in watts, as calculated by the controller from the actual torque and speed.

Column Label	Description
Motor Direction	The direction of the motor. 1 is “Forward” and –1 is “Reverse.” This value multiplied by either Speed or FilteredSpeed provides signed speed values like those available through CANbus.
Stator Temp (°C)	The measured temperature of the stator of the motor in degrees Celsius.
Rotor Temp (°C)	The measured temperature of the rotor of the motor in degrees Celsius.
Inverter Temp (°C)	The measured temperature of the controller at its cooling block in degrees Celsius.
Bus Voltage (V)	The measured bus voltage in volts.
Bus Current (A)	The measured bus current in amperes.
Elec Power (W)	The electrical power in watts as calculated by the controller from the bus voltage and current.
Leg Current (A)	The measured envelope of the current motor’s phase legs.
Acceleration (RPM/sec)	The calculated rate of acceleration of the Danfoss Power Solutions motor. The maximum acceleration rate can be controlled by the .
Stall Percentage	The stall percentage value counts up from 0 to 100 as the motor approaches stall conditions. When the count reaches 100, a stall condition is detected, and the motor will limit torque to 10% of rated output for 30 seconds. For more information on stall conditions, please refer to Section 5.3.3.
RevCounter	Positive integer number of motor revolutions since the inverter was power up
AngularDistance	Total angular distance the motor has traveled since the inverter was powered up (1 count = 3.75°). Travel in the Forward direction is positive. Travel in the Reverse direction is negative.
Desired Direction	The requested direction of the motor. A 1 is “Forward” and –1 is “Reverse.”
Requested Torque (Nm)	This is the amount of torque requested by the user, in Newton meters. The values reported in this column come directly from the received CAN torque commands. This is useful in debugging because it allows the user to check whether the CAN commands contained the correct values and were received by the controller. In contrast, the *Desired Torque* column reports the torque that the controller intends to produce, after applying safeties and limits to the requested torque.

Column Label	Description
Desired Torque (Nm)	This is the amount of torque, in Newton meters, that the controller intends to produce. This column may differ from the *Requested Torque* column due to CAN limits or safety limitations. For example, if the user requests a large value of forward torque, but the motor is already spinning at its forward speed limit, the desired torque will be reduced to avoid exceeding the speed limit. Furthermore, the value in the *Desired Torque* column may differ slightly from the value in the *Actual Torque* column because the desired torque is the amount of torque that the motor intends to produce, whereas the actual torque is determined from measurements and best reflects the torque that the motor is truly producing.
Requested Speed (RPM)	This is the speed requested by the user, in revolutions per minute. The values reported in this column come directly from the received CAN speed commands. This is useful in debugging because it allows the user to check whether the CAN commands contained the correct values and were received by the controller. In contrast, the Desired Speed column reports the target speed of the controller, after applying safeties and limits to the requested value.
Desired Speed (RPM)	This is the speed that the controller aims to maintain, in revolutions per minute. If the controller is not in speed control, this number is meaningless. This column may differ from the *Requested Speed* column due to CAN limits or safety limitations. For example, if the torque limits in the CAN speed command are too restrictive, the controller will be unable to maintain the desired speed, and as a result the desired speed would be less than the requested speed. Note that the *Speed* and *FilteredSpeed* columns report the actual, measured speed of the motor, whereas *Desired Speed* reports the controller's target speed.
Desired Voltage (V)	The requested voltage demand in volts. If the inverter is not in voltage control, this number is meaningless.
Motoring Limit (%)	If any limits are acting on any motoring torque demand, this is a value below 100%.
Regen Limit (%)	If any limits are acting on any regeneration torque demand, this is a value below 100%.
HighestTorqAllowed (Nm)	The maximum motoring torque allowed at this moment. This value is affected by many limits (voltage, temperature, etc.) and command limits. Those limits are reflected by the Motoring Limit percentage.
LowestTorqAllowed (Nm)	The maximum regeneration torque allowed at this moment. Affected by many limits (voltage, temperature, etc.) and command limits. Those limits are reflected by the Regen Limit percentage.
Highest Power Allowed (kW)	The maximum motoring power allowed at this moment.
Lowest Power Allowed (kW)	The maximum regeneration power allowed at this moment

Column Label	Description
Accel Limit (RPM/sec)	The acceleration limit value that has been set as of this moment. It is the maximum expected rate of acceleration (in RPM per second) for the motor's application. The system will automatically reduce torque if this acceleration limit is exceeded.
Accel Surge (RPM)	The acceleration surge value that has been set as of this moment. It is the speed difference range (in RPM) that the motor's acceleration might be surging above the acceleration limit as the inverter tries to bring the acceleration under control.
Damping Torque (Nm)	The Active Damping corrective torque signal in Newton meters.
TorqueMatchingProblem	Displays a 1 if the desired and actual torques of the Danfoss Power Solutions motor are consistently not matching due to motor demagnetization or other factors. A 0 is displayed if it is matching consistently.
SwitchesOff	False (0) when power switches are active. True (any non 0 value) when power switches are not active.
RegenSwitchOpen	If there is a Regen Switch in the system, this would indicate that it is open with a 1.
Position Noise Level	Rate of noise on the position signal. 0 = No noise. Any non zero value indicates that there is noise on the position signal. 5 = max measurable noise level.
Noisy Positions	The count of noisy position events that have occurred since wake-up.
CAN Comm	A 1 indicates that CAN communication is active. A 0 indicates that it is not.
CAN Limiting	A 1 indicates that a CAN limit is in effect. A 0 indicates this is not the case.
Enabled	A 1 is displayed if the controller in enabled. A 0 indicates it is not.
Turbo Mode	A 1 is displayed if the controller is in Turbo Mode, a 0 if it is not. Turbo Mode is Danfoss Power Solutions' proprietary control algorithm that produces outstanding power and efficiency at high speeds.
Torque Control	A 1 is displayed if the controller is in torque control, a 0 if it is not.
Speed Control	A 1 is displayed if the controller is in speed control, a 0 if it is not.
Voltage Control	A 1 is displayed if the inverter is in voltage control, a 0 if it is not.
Forced Voltage Control	A 1 if the controller has entered forced voltage control (a safety response to dangerous voltage levels), a 0 if it is not.
Forced OL	A 1 if the controller is in forced open loop, a 0 if it is not.

Column Label	Description
Stalled	A 1 if the controller is responding to stall conditions, a 0 if it is not.
Accel Limiting	A 1 if the motor acceleration is being limited by the maximum acceleration safety; a 0 if it is not.
Bad Switch	If non-zero, indicates that a IGBT Switch error is occurring. A upper= 32 A lower = 16 B upper= 8 B lower = 4 C upper= 2 C lower = 1

8.5 Data Acquisition

Danfoss Power Solutions' data acquisition (DAQ) feature is a powerful diagnostic tool for your system design. The Danfoss Power Solutions Motor System measures the torque, voltage, current, and speed of your system. DAQ makes that information available to you with fast and accurately timed sampling rates. DAQ records motor system measurement data at sub-second rates. The data is limited in length, and is recorded into a spreadsheet file after the triggering event has occurred.

Significant time is required to extract the DAQ data from the Danfoss Power Solutions controller. The amount of time is dependent on the baud rate and whether Data Logging is also occurring. If your connection speed is 115200 baud and you are not logging, then a download takes approximately 50 seconds. If you are Data Logging at a four times per second rate, then an additional 20 seconds is added to the extraction time. Files take several minutes to extract when running at a baud rate of 19200.

The measurement data taken and stored in a data acquisition file is identical to the data stored in a data-logging file; it is simply taken at a faster rate and has a controlled length. See Table 8.8 for details of the measurements in a data acquisition file. In addition, a diagnostic Danfoss Power Solutions file is generated, useful to the Danfoss Power Solutions factory when advanced diagnostics are required.

DAQ Configuration is accessed via the menu choice **Actions > Daq Configuration**. Choices found in the pop-up menu accessed from this point are described in Table 8.9.

Table 8.9: DAQ Configuration Menu

Menu Choice	Button	Description
Edit Settings		Shows the Data Acquisition Set-up dialog box. See Figure 8.18 and Table 8.10 for more details.
Edit Levels		Shows the DAQ trigger levels dialog box. See Figure 8.18 and Table 8.10 for more details.
Save to file		Saves the current DAQ configuration settings to a QDC file.

Menu Choice	Button	Description
Load from file		Loads a DAQ configuration file into the Danfoss Power Solutions Motor controller.

In addition to menu access, complete Data Acquisition functionality is accessible from the lower right corner of the Diagnostic Software front panel itself. Figure 8.18 (below) and Table 8.10 illustrate these Data Acquisition group components.

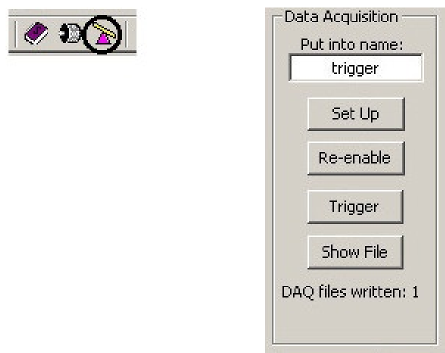


Figure 8.18: Front Panel Components of DAQ

Table 8.10: Front Panel DAQ Group Components

Label	Description
Put into name	This edit box is a shortcut to setting the name portion of a DAQ filename. Normally, this name is set in the DAQ Set Up, but when using the manual trigger it is more convenient to be able to change the filename without going into the Set Up dialog box.
Set Up	This button is the equivalent of the menu choice Actions > Daq Configuration > Edit Settings. It brings up the DAQ Set Up dialog box. This functionality is described in detail later in this section.
Re-enable	After a DAQ trigger, all triggers are disabled. This button quickly re-enables the last set of trigger settings. Alternatively, you can use the DAQ Set Up to re-enable them or change them. They can be automatically re-enabled as well.
Trigger/Cancel	When this button is labeled “Trigger,” it causes an immediate DAQ trigger following the settings already set in DAQ Set Up. While a DAQ file is being uploaded from the controller into the PC, this button’s label changes to “Cancel.” Clicking on it cancels the upload and clears the buffer. It also disables all triggers.
Show File	Starts your spreadsheet program with the last uploaded DAQ file. This feature will only work if you have a spreadsheet program that has registered itself for files with the CSV (comma-separated values) file format.

As noted, the data buffer length is limited, but DAQ has extensive triggering that allows you to capture the exact data that you need. Table 8.11 lists the triggers available.

Table 8.11: DAQ Trigger Descriptions

Trigger	Description
Absolute value of leg current exceeds specified level	Set an amperage level, and the trigger occurs when the composite leg current exceeds that level.
Acceleration exceeds trigger level	Set an acceleration level, and the trigger occurs when the Danfoss Power Solutions motor's acceleration exceeds that level.
Bus current reaches trigger level	Set an amperage level, and the trigger occurs when the bus current passes through that level from either direction.
Bus voltage reaches trigger level	Set a voltage level, and the trigger occurs when the bus voltage passes through that level from either direction.
CANbus changes the control mode	A trigger occurs when the controller's control mode (torque or speed) changes through the CANbus.
Desired Torque becomes dynamic	A trigger occurs when a significant change in desired torque is detected.
Desired Torque becomes steady state	A trigger occurs when no significant change in desired torque is detected over a period of time.
Direction (actual) changes	A trigger occurs when the motor's direction changes from forward to reverse, or reverse to forward.
Direction (desired) changes	A trigger occurs when the demanded direction changes from forward to reverse, or reverse to forward.
Electrical Power reaches trigger level	Set a wattage level, and the trigger occurs when the electrical power passes through that level from either direction.
Forced voltage control occurs	A trigger occurs when the controller is in forced voltage control, which is a safety mode entered only when bus voltage reaches a dangerous level.
Inverter fault occurs	A trigger occurs when any controller module faults. Over current and over temperature problems can cause these modules to fault when they are switching power. A drop in the 15 V supplying the modules also triggers a controller fault. It is also possible for a false trigger to occur when the bus voltage drops below the necessary level for controller module operation. This trigger is a default trigger.

Trigger	Description
Leg current exceeded within 16ms of bad position	A trigger occurs if a bad position signal event and an over leg current event occur within 16 milliseconds of each other.
Mechanical Power reaches trigger level	A mechanical power level is set, and a trigger occurs when the Danfoss Power Solutions motor's mechanical power exceeds this level.
Motoring is limited below trigger level percentage	A percentage level is set, and the trigger occurs when the limit acting on the motoring torque is below that level.
Over voltage	A trigger occurs when the bus voltage is over the maximum battery voltage.
Position signal is bad	A trigger occurs when the position signal is judged bad.
Position signal is searching	A trigger occurs if the position signal had been lost and the controller is attempting to re-sync to the position signal.
Position signals are noisy	A trigger occurs when electrical noise is detected on the position sensor signals.
Regen is limited below trigger level percentage	A percentage level is set, and the trigger occurs when the limit acting on the regeneration torque is below that level.
Regen switch changes	A trigger occurs when the state of the regen switch changes from open to closed or from closed to open.
Speed reaches trigger level	A signed RPM level is set, and the trigger occurs when the motor speed passes through that level from above or below. Remember that if spinning in reverse, then this value must be signed to cause a trigger.
Stall conditions occur	A trigger occurs when the controller begins limiting its output because it has detected stall conditions (also called locked rotor, when large torques are requested but the motor is not spinning).
Stall conditions stop	A trigger occurs when the controller begins limiting its output because it has detected stall conditions. See Stall conditions occur above.
Torque (actual) reaches trigger level	A Newton meter level is set, and the trigger occurs when the calculated torque passes through that level from either direction.
Torque (desired) reaches trigger level	A Newton meter level is set, and the trigger occurs when the demanded torque passes through that level from either direction.
Turbo Mode exits	A trigger occurs when Turbo Mode exits. Turbo Mode is Danfoss Power Solutions' proprietary control algorithm that produces outstanding power and efficiency at high speeds.

Trigger	Description
Turbo Mode occurs	A trigger occurs when the motor enters Turbo Mode. Turbo Mode is Danfoss Power Solutions' proprietary control algorithm that produces outstanding power and efficiency at high speeds.
Limp home mode occurring	A trigger occurs when the inverter detects a condition that required it to enter Limp Home Mode
Power switches off permanently	A trigger occurs when the inverter detects a condition that requires it to shut down the IGBT Switches

In addition to these triggering capabilities, DAQ allows you to specify the percentage of the data that is recorded on either side of the trigger event. By moving the slider shown in Figure 8.19 towards the left, the amount of data recorded before the trigger event is decreased, and the amount of data recorded after the trigger event is increased. The opposite can be achieved by moving the slider to the right. There are also six different sampling rates, from 80 microseconds to 6 milliseconds, allowing for a wide range of time windows.

Since the software monitors DAQ triggers and automatically uploads the DAQ event capture buffer on trigger completion, the CSV file is automatically generated. You can specify the directory it is placed in, and you can specify a name that will be included in the filename. By default, the name is "trigger" because this is the default trigger source. For example, a couple of inverter fault-triggered DAQ files, occurring in a row, on June 21st, 2013, would be named:

`20150318_trigger00.csv`

`20150318_trigger01.csv`

Note that the DAQ feature also automatically saves a file with the extension "`.uqm`". This file contains additional log data that Danfoss Power Solutions can use in diagnosing issues. If you are experiencing problems, we usually request that you e-mail both the "`.csv`" log file and the "`.uqm`" file to Danfoss Power Solutions.

8.5.1 DAQ Set Up

You must configure DAQ before using it. The configuration parameters of trigger events, fill line, sampling speed, file directory, and 'name to be included' in filename must all be set. The DAQ Set Up dialog box provides this functionality. Figure 8.19 shows this dialog box, and Table 8.12 lists the set up components with descriptions.

Note that the DAQ trigger settings and data spacing settings do not persist between resets. In other words, if you power cycle the inverter, you will have to enter your DAQ settings again. Fortunately, the Save/Load to Config File ("`.QDC`" file) feature makes it easy to restore settings. Please refer to the example in Section 8.5.1 for details.

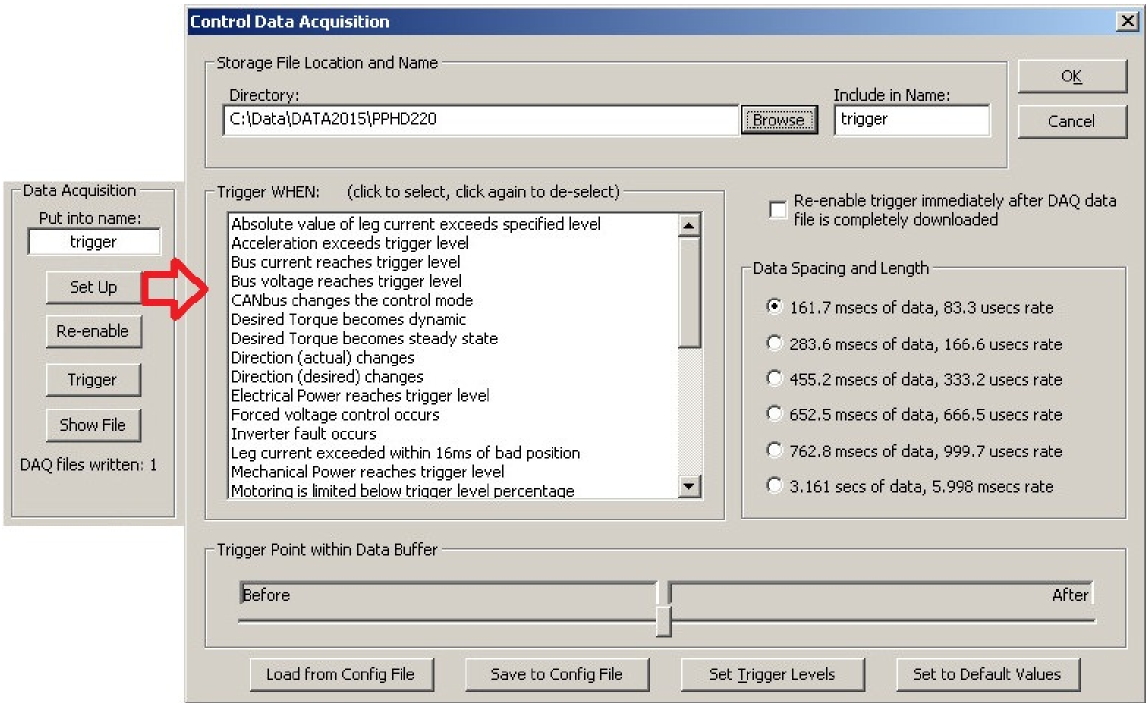


Figure 8.19: DAQ Setup

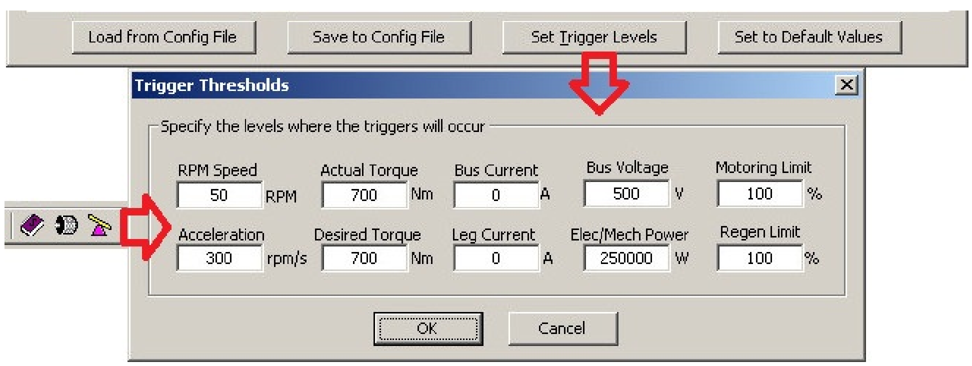


Figure 8.20: DAQ Trigger Thresholds

Table 8.12: DAQ Set Up Components

Label	Description
Directory: Browse button	Enter the directory where DAQ files should be written. Browse brings up a File Open dialog box. Use it to point to the directory you want to use.
Include in Name	Text that you want included into the DAQ filename. It will include the date, this text, and an incrementing number.
Trigger WHEN:	Select the triggers desired. If you select a trigger that depends on a trigger level then click on the Trigger Level button to set the value for that trigger.
Re-enable trigger	Re-enables the trigger immediately after a DAQ data file has been completely downloaded. NOTICE You must ensure that the triggers selected are not still active when the re-enable occurs. For example, a trigger of “Position signal is bad” if re-enabled immediately will also immediately cause another file to be gathered. This will continue until you manually cancel or until your disk is full.
Data Spacing and Length	Select the sampling rate from 80 microseconds, to 6 milliseconds. This also selects the total amount of time that data is collected, from 140.2 msec to 3.625 sec.
Trigger Point within Data Buffer	Move the slide bar to indicate how much of the data you want before the trigger event and how much after it.
Load from Config File	This button is the equivalent of the menu choice Actions > Daq Configuration > Load from File. It loads a QDC configuration file into the dialog box.
Save to Config File	Button is the equivalent of the menu choice Actions > Daq Configuration > Save to File. It saves the current configuration to a QDC file in the location you specify.
Set Trigger Levels	Button brings up the DAQ Trigger Level dialog box. It is also possible to reach the Trigger Level dialog box directly from the front panel through Action > Daq Configuration > Edit Levels. Figure 8.20 shows this dialog box.
Set to Default Values	Button resets all DAQ Configuration settings to their default values.

The “Trigger Thresholds” dialog box (Figure 8.20) sets the levels at which several triggers will occur. Note that the RPM Speed trigger is a SIGNED trigger level. If the motor is rotating in reverse, a positive trigger value can never cause a trigger.

8.5.2 DAQ Set Up Example

The DAQ feature of the Danfoss Power Solutions Motor Diagnostic Software is very useful when you need to diagnose a dynamic problem in your system. Because the Danfoss Power Solutions motor is connected to most of your system’s components, its measurements can help you find problems. For example, if your soft-start functionality is connecting and then disconnecting a short time later, Danfoss Power Solutions Motor’s DAQ can be used to trigger and collect fast data around this event so that you can see what your high voltage bus is doing during this time. In this example, you would set a trigger on the event of the voltage bus value reaching 250 V. You want several seconds of data, taken mostly after the triggering event occurs. To use the DAQ system to capture this event, perform the following steps:

1. Select the "Set up" on the front panel to bring up the "DAQ Set Up" dialog box.
2. Using the **Browse** button, select a directory where DAQ files should be placed.
3. Enter "softStart" in the "Include in Name" box.
4. Click on the trigger *when*: "Bus voltage reaches trigger level."
5. Click the **Trig Levels** button to enter the "Trigger Thresholds" dialog box.
6. Enter 250 in the Bus Voltage box, and select **OK** to close the Trigger Thresholds dialog box.
7. Select the last radio button in the "Data Spacing and Length" area that is labeled "3.625 secs of data, 6.240 msecs rate."
8. Drag the "Trigger Point within Data Buffer" slider bar to the left until it is close to the left side (it cannot get closer than 5% of the buffer).
9. Select **OK** on the DAQ Set Up dialog box.

You are now ready to begin the soft-start procedure. Once the bus voltage reaches 250 V, Danfoss Power Solutions' DAQ system triggers and captures the event. The data is extracted automatically by the Danfoss Power Solutions Motor Diagnostic Software and written to a file placed in the directory you selected.

During the extraction, the status message area (at the bottom of the front panel) shows the progress. Data extraction takes approximately one minute when running at 115200 baud rate. Once the file is finished, the **Show File** button becomes available. Clicking on it starts your spreadsheet program, opening the file last written by DAQ.

If the data points are too far apart when you look at the data, re-open the DAQ Set Up dialog box and change the "Data Spacing and Length" selection to a faster rate. (It will record over less time.) Select **OK** to close the dialog box and re-initiate the event in your system. Again, when the voltage reaches 250 V, data is captured, and a new file is written in the same directory with the same name, except for an incrementing number. It does not overwrite old data.

We recommend saving the useful DAQ configurations you have set up to a QDC file. With a QDC file, you can return the Danfoss Power Solutions Motor system to particular settings at any future time.

8.6 Event Log

Another helpful diagnostic tool in Danfoss Power Solutions Motor Systems is the Motor Event Log. The Danfoss Power Solutions controller tracks and stores all the system error events that occur and when they occurred into persistent memory. The diagnostic software provides access to this information through the "Event Log" dialog box illustrated in Figure 8.21, which is available through the menu choice **Actions > Show Event Log**, or its toolbar button.

The Event Log shows when error events occurred during operating time. It also logs the wake up condition of the controller. Table 8.13 lists the possible logging entries.

The dialog box consists of two lists: the event statistics and the event details. The statistics show which events have happened and how many times they have happened. The details show the order of the events from oldest to newest, and when they happened relative to controller turn-on. A line item in the statistics list can be used to find one entry in the details list by selecting it and pressing the **Find** button.

One feature specific to the Event Log is the revolution counter event. This feature logs an event into the Event Log representing that a user configurable number of motor revolutions have occurred. This can be thought of as a "mileage counter" when the number of revolutions equates to a distance.

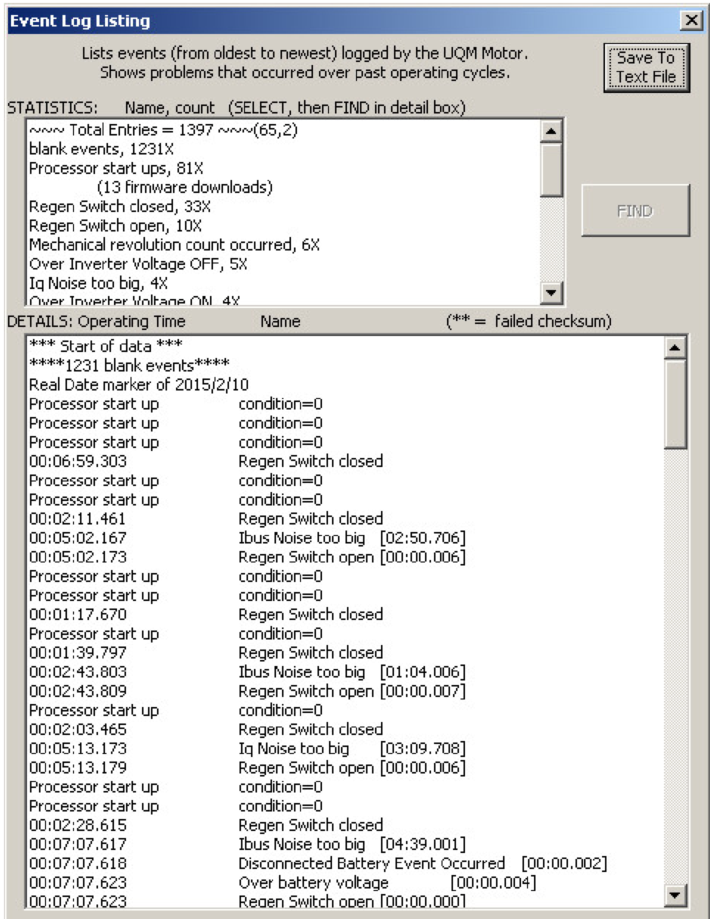


Figure 8.21: Event Dialog Box

Table 8.13: Possible Entries in Event Log

Entries	Description
*** Start of data ***	This marks the beginning of the oldest data.
****XX blank events****	Means that the Event Log is not yet full. Once it is full, then the oldest event is written over by the newest event, and there are no more blanks.
Processor start up	This marks that the controller went through a power up or a reset. The operating time is zero at this point.

Entries	Description
NEW FIRMWARE DOWNLOADED	This marks the point when the controller has just received new code. When new firmware is downloaded, older events may not be interpreted correctly in this listing. Always save the Event Log to a text file before downloading new firmware.
Real Date marker ofReal Time marker of	These mark the point when a date marker or a time marker were inserted. It shows the date in year/month/day format, and the time in hours:minutes:seconds format.
Inverter Fault ON Inverter Fault OFF	These events mark when an inverter fault occurred that affects the inverter's power switches. Over large motor phase currents or high temperatures can endanger the power switches.
Forced open loop ON Forced open loop OFF	These events mark when the controller has had to go into forced open loop because of sensor measurement problems.
Over mechanical danger speed Under mechanical danger speed Over speed occurred Over speed problem OFF	These events mark when speed problems have occurred.
Over Inverter Voltage ON Over Inverter Voltage OFF Over battery voltage Under battery voltage	These events mark when bus voltage problems occurred. Over inverter voltage means the inverter had to enter forced voltage control.
Untrustworthy voltage measurement occurred	The bus voltage measurement is suspect and the inverter shut down.
Sensor voltage invalid Sensor voltage good	These events mark when the voltage that powers the controller's sensors is not at an acceptable level and subsequently when the voltage has become good again.
CTFault safety ON	This event marks when a problem was detected with the current sensors of the controller.
Leg sums not zero Over Leg Current Leg significantly over current Leg dangerously over current Leg Current Separation ONCE	These events mark errors on the motor's phase legs.
Over Inverter Temperature ON Over Inverter Temperature OFF Over Stator Temperature ON Over Stator Temperature OFF Over Rotor Temperature ON Over Rotor Temperature OFF	These events mark when the temperatures reached unacceptable levels, and when they subsequently reached an acceptable level.

Entries	Description
Bad rotor temperature occurred	The rotor temperature sensor is suspect.
Inverter Temp Shutdown Rotor Temp Shutdown Stator Temp Shutdown	These events mark when temperatures exceeded limits, causing the power switches of the inverter to shut down.
Over Positive Phase Advance ONCE Under Negative Phase Advance ONCE	These events mark when the controller has encountered the phase limits of the motor.
Position signal is bad Position signal has come good Position error is too large Apparent rotor movement occurred	These events mark a problem or the resolution of a problem with the position sensor signals. Either a cable was removed or the position offset is suspect.
Mechanical revolution count occurred	The user configurable number of motor revolutions has occurred. This entry will be made each time that counter counts this number of revolutions.
CANbus watchdog occurred	CANbus commands ceased. This is sometimes seen benignly because the vehicle controller is powered off and is no longer communicating, but the motor controller has not yet been powered off.
Torque matching problem	The controller found that it was unable to control the motor to the desired torque. If this occurs regularly, this could be because the motor has partially demagnetized.
Back EMF saturated high Back EMF saturated low	The dynamic motor tuning control could not find the motor's Back EMF. Indicates that the wrong motor is connected.
Low Forced Voltage Control Occurred	The controller went into forced voltage control because of dangerous low voltage conditions.
Disconnected Battery Event Occurred	The controller detected conditions that indicated no power supply connection. This condition often results in forced voltage control.
Noisy position < 1 Hz Noisy position < 150 Hz Noisy position < 250 Hz Noisy position < 350 Hz Noisy position > 350 Hz	Electrical noise occurred on the position signals. This is a potentially dangerous condition because it could cause motor miscommutation if this rate is greater than 150 Hz.
Regen Switch closed Regen Switch open	Indicates the state of the 7th power switch in the inverter, called the Regen Switch. It isolates the inverter when high voltage or high regeneration current occurs.
Stalled OFF Stalled ON	These events mark when the controller severely limited torque while the motor could not spin.

Entries	Description
In Limp Home mode	The system torque is limited to the Limp Home Percentage
Iq Noise too big Ibus Noise too big Ibus Raw too big	Indicated that system current is operating outside of expected parameters
Redundant torque mismatch Redundant current mismatch	Indicated that system torque is operating outside of expected parameters
Phase A switch problem Phase A switches problem Phase B switch problem Phase B switches problem Phase C switch problem Phase C switches problem Bad switch occurred Bad switches occurred	Indicates IGBT switch failure
Torque Desired Osc warning ONCE Active Damping Osc warning ONCE	Indicates that Active damping and/or Torque Desired are oscillating due to rapid changes in torque requests
Unreliable bus current measurement occurred Bus current offset larger than expected	The bus current sensor value is not consistent with the expected value for existing operating conditions.

The word "ONCE" in an event log entry indicates that the event was logged the first time that the event occurred, but further such events will not be logged until the controller is reset.

The Event Log dialog box has a **Save to Text File** button that allows you to save a listing of the events to a text file. It is a good idea to save one of these text files occasionally. The button brings up a "File Save" dialog box. Select the directory and file name where the text file can be saved, then select **OK**. The file will be created and saved in the desired location with a ".txt" extension. A text file saves automatically if a firmware download is initiated.

Each time after completing an examination of the Event Log, you may want to mark the Event Log with the date. Since the Event Log is a circular buffer, older events disappear with time. An Event Log date marker will assist you on your next examination to know which events have occurred since your last examination. The Event Log data marker is available via the menu choice **Actions > Date Into Event Log**. Only one date entry is allowed per day.

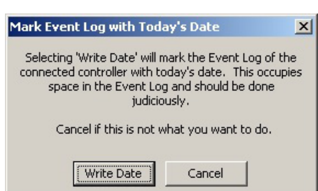


Figure 8.22 Mark Event Log with Today's Date dialog box

9 Appendix A: Vibration Testing

9.1 Controller Vibration Testing

Danfoss Power Solutions has qualified the controller to the vibration levels for both SAE J1455 and GB/T18488.1-2015 as stated in the Appendix. The vehicle integrator or manufacturer should ensure that the controller is not exposed to vibration levels above what has been qualified in testing. Exposure to vibrations above these qualified levels may lead to damage or failure of the controller.

Danfoss Power Solutions recommends that the vehicle integrator or manufacturer install vibration isolators on the controller to ensure that vibration levels of the controller are not in excess of the specifications tested throughout the vehicle's life. It is the responsibility of the integrator or manufacturer to specify the vibration isolators and install and maintain the vibration isolators.

9.1.1 SAE J1455 Vibration Test

The controller shall be mounted to the vibration fixture using the four corner mounting holes, with no vibration isolators. The electrical test equipment will be located next to the vibration table. The unit is unpowered throughout the test.

The assembly shall be exposed to 3 separate applications, of 3 hours duration, of 1 axis each random profile vibration per SAE J1455, Figure 10, Bobtail Vertical Mid Frame, Heavy Duty Truck, for a total of 9 hours. Figure 9.1 shows the axis orientation for the controller. Figure 9.2 shows the PSD profile of the vibration test.

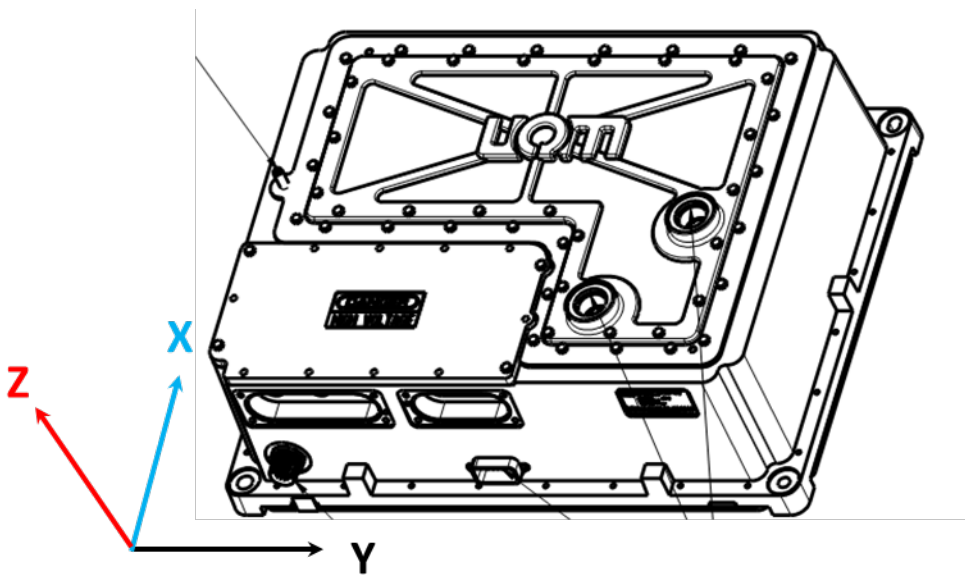


Figure 9.1: Controller Axis Orientation

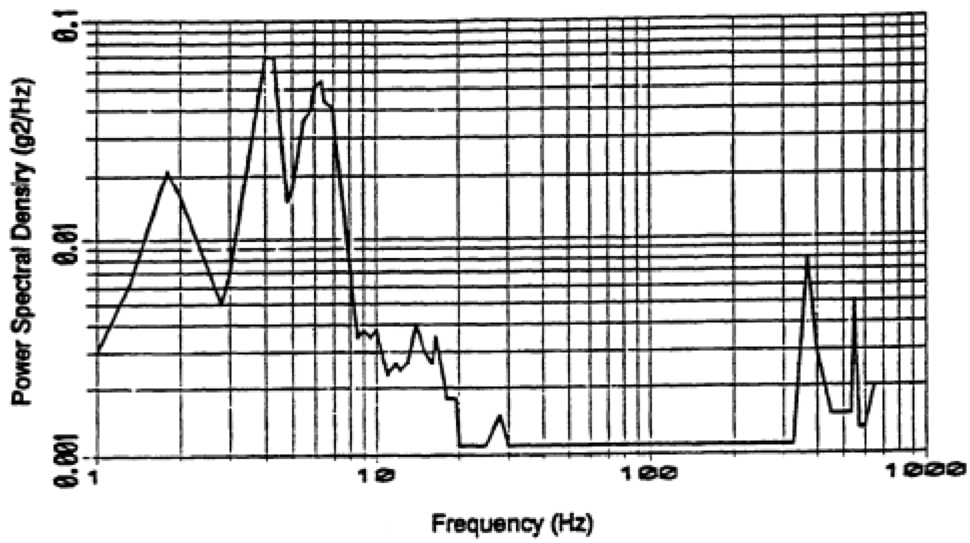


Figure 9.2: SAE J1455 PSD Bobtail vertical Mid frame, Heavy-duty Truck Profile

The order of testing Axes shall be:

1. Z axis (mounted with terminal cover and coolant ports on top)
2. Y axis
3. X axis

The unit shall be outfitted with the following:

- Phase cable
- DC cable
- Position feedback cable
- Coolant ports and hoses

All covers in place, sealed and screws torqued to manufacturing specifications.

9.1.1.1 Acceptance Criteria

After each axis test, the unit will be returned to Danfoss Power Solutions for end-of-line (EOL) test and inspection. Upon successful completion of the three axis' testing and inspection, the unit shall pass a Dynamometer screen test, specified by Danfoss Power Solutions.

9.1.2 GB/T 18488.1-2015 Vibration Test

The controller shall be mounted to the vibration fixture using the four corner mounting holes, with no vibration isolators. The electrical test equipment will be located next to the vibration table. The testing details are shown below.

9.1.2.1 Frequency sweep vibration

Drive motors and drive motor controllers shall be able to withstand frequency sweep vibration tests of three directions - X, Y, Z. If there is no special provision, according to installation position, severe grade of frequency sweep vibration test of drive motors and drive motor controllers shall meet regulations of Table 9.1.

Table 9.1: Severe Grade of Frequency Sweep Vibration Test

Product installation position	Frequency Hz	Amplitude mm	Accelerated speed m/s^2	Sweeping frequency speed oct/min	Test time for each direction h
In the engine	10~50	2.5		1	8
	50~200	0.16			
	200~500		250		
Other parts	10~25	1.2		1	8
	25~500		250		

Note 1: Amplitude and accelerated speed are used for “Z” direction; for the “X” and “Y”, its amplitude and accelerated speed can be divided by 2 in the table.

Note 2: Stipulated direction during vibration test shall be: parallel direction of engine cylinder-hole axis when products are installed at engine; parallel direction of the vertical direction of vehicles when product is installed at other parts.

Drive motors and drive motor controllers shall usually be inspected under the condition of not-energized. Checkpoints of vibration test generally are the junction of test fixture and test-bed. After vibration test, parts shall have no damage, fasteners shall not be loose; drive motors and drive motor controllers shall work properly under the rated voltage, continuous torque and continuous power.

9.1.2.2 Random vibration

Drive motors and drive motor controllers shall bear random vibration tests of three directions- X, Y, Z. If there is no special provision, according to installation position, severe degree limit of random vibration and test duration of motors and controllers shall comply with regulations of GB/T 28046.3-2011.

Drive motors and drive motor controllers shall usually be inspected under the condition of not-energized. Checkpoints of vibration test generally are the junction of test fixture and test-bed. After vibration test, parts shall have no damage, fasteners shall not be loose; drive motors and drive motor controllers shall work properly under the rated voltage, continuous torque and continuous power.

10 Appendix B: Vehicle responses to Danfoss Power Solutions' CAN Status Messages

10.1 Vehicle responses to Danfoss Power Solutions' CAN Status Messages

The customer and/or vehicle integrator is responsible verifying that the configuration data in TCU Status Message 1 (Section 7.3.1) match those for which the vehicle was designed.

The customer and/or vehicle integrator is responsible for proper responses to the Danfoss Power Solutions CAN Status and Error signals contained in TCU Status Message 2 (Section 7.3.2) and TCU Status Message 3 (Section 7.3.3).

TCU Status Message 4 (Section 7.3.4), TCU Status Message 5 (Section 7.3.5), TCU Status Message 6 (Section 7.3.6), and TCU Status Message 7 (Section 7.3.7) provide feedback signals to be used to control the system.

The Vehicle Control Unit/Module will need to determine the appropriate actions to these messages. Danfoss Power Solutions is providing the status and error messages so that appropriate actions are taken at the vehicle level. Danfoss Power Solutions assumes no liability if the vehicle does not respond to our status and error messages.

For a typical electric vehicle application, the following actions should be considered as part of the vehicle integration.

Table 10.1: System Status Signals

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU System Type Section 7.3.1.1	X	Insure that this value matches the vehicle's expected system type. The vehicle should never be operated with the wrong system type installed.	Check the MCU & Motor for the correct type. Replace MCU & Motor.
Watchdog Counter Section 7.3.1.2	X	Insure that the proper counting pattern is maintained and that TCU Status Message 1 is followed messages TCU Status Message 2-7 before the next TCU Status Message 1 is received. Note: An occasional dropped message may occur without affecting the system. If dropouts are frequent or continuous: check integrity of the CAN Bus connection between the VCU and the TCU	Check the integrity of the CAN Bus between the VCU and TCU. Replace the VCU to TCU CAN Bus wiring.
TCU System Type Section 7.3.1.3	X	Insure that this value matches the vehicle's expected TCU configuration. The vehicle should never be operated with the wrong configuration installed.	Check the TCU calibration for the correct type. Replace the PowerPhase®DT2 system with the correct type.
TCU System Type Revision Section 7.3.1.4	X	Insure that this value matches the vehicle's expected TCU configuration. The vehicle should never be operated with the wrong configuration installed.	Check the TCU for the correct version. Replace TCU.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
TCU Major Version Section 7.3.1.5	X	Nothing, informational only	X
TCU Minor Version Section 7.3.1.6	X	Nothing, informational only	X
TCU Sub Version Section 7.3.1.7	X	Nothing, informational only	X
MCU Major Version Section 7.3.1.8	X	Nothing, informational only	X
MCU Minor Version Section 7.3.1.9	X	Nothing, informational only	X
MCU Sub Version Section 7.3.1.10	X	Nothing, informational only	X
Current Transmission Mode Section 7.3.2.1	Immediate	Appropriate display to the driver	X
Selected Gear Section 7.3.2.2	X	Indicates the actual gear position, used in system control algorithms as appropriate	X
Upshift In Progress Section 7.3.2.3	X	Nothing, typical occurrence	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
Downshift In Progress Section 7.3.2.4	X	Nothing, typical occurrence	X
Upshift Failed Section 7.3.2.5	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Visual inspection of air lines. Replace transmission air solenoid. Replace transmission gear switch sensors. Replace transmission speed sensor. Send data log to Danfoss Power Solutions for analysis.
Downshift Failed Section 7.3.2.6	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Visual inspection of air lines. Replace transmission air solenoid. Replace transmission gear switch sensors. Replace transmission speed sensor. Send data log to Danfoss Power Solutions for analysis.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
Slow Upshift Section 7.3.2.7	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Visual inspection of air lines. Replace transmission air solenoid. Replace transmission gear switch sensors. Replace transmission speed sensor. Send data log to Danfoss Power Solutions for analysis.
Slow Downshift Section 7.3.2.8	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Visual inspection of air lines. Replace transmission air solenoid. Replace transmission gear switch sensors. Replace transmission speed sensor. Send data log to Danfoss Power Solutions for analysis.
Shift Disabled Section 7.3.2.9	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Visual inspection of air lines. Replace transmission air solenoid. Replace transmission gear switch sensors. Replace transmission speed sensor. Send data log to Danfoss Power Solutions for analysis.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
Max Shift Speed Delta Exceeded Section 7.3.2.10	X	Nothing, typical occurrence	X
Air Pressure Out of Range Section 7.3.2.11	Immediate	Check engine light	Verify air pressure minimum. Visual inspection of air lines.
Forced Gear Engagement Torque Section 7.3.2.12	X	Nothing, will only be seen when "Air Pressure Out of Range" is set	Verify air pressure minimum. Visual inspection of air lines.
Motor Speed Mismatch Error Section 7.3.2.13	Immediate	Check engine light Note: Will be accompanied by loss of power	Power-cycle PowerPhase®DT2 system. Verify air pressure minimum. Visual inspection of air lines. Replace transmission speed sensor.
Driveshaft Speed Mismatch Error Section 7.3.2.14	Immediate	Check engine light Note: Will be accompanied by loss of power	X
MCU CAN Active Section 7.3.2.15	X	Nothing, typical occurrence	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU CAN Timeout Section 7.3.2.16	Immediate	Check engine light if accompanied by loss of power or if recurrent. Note: It is possible that this may be seen occasionally without having great significance, but if it occurs frequently, contact Danfoss Power Solutions to investigate possible hardware issue.	Verify the MCU CAN settings. Check the integrity of the CAN Bus between the TCU and MCU. Replace the TCU to MCU CAN Bus wiring.
MCU Watchdog Error Section 7.3.2.17	Immediate	Check engine light Note 1: Will be accompanied by loss of power Note 2: Contact Danfoss Power Solutions to investigate possible hardware issue.	Verify the MCU CAN settings. Check the integrity of the CAN Bus between the TCU and MCU. Replace the TCU to MCU CAN Bus wiring.
TCU Command Message 1 Error Section 7.3.2.18	X	Little meaning if seen occasionally. If seen frequently, check integrity of the CAN Bus connection between the VCU and the TCU	Verify the MCU CAN settings. Check the integrity of the CAN Bus between the TCU and MCU. Replace the TCU to MCU CAN Bus wiring.
TCU Command Message 1 Watchdog Timeout Section 7.3.2.19	Immediate	Check engine light Note 1: Will be accompanied by loss of power Note 2: Check integrity of the CAN Bus connection between the VCU and the TCU	Verify the MCU CAN settings. Check the integrity of the CAN Bus between the TCU and MCU. Replace the TCU to MCU CAN Bus wiring.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
TCU Command Message 2 Error Section 7.3.2.20	X	Little meaning if seen occasionally. If seen frequently, check integrity of the CAN Bus connection between the VCU and the TCU	Verify the MCU CAN settings. Check the integrity of the CAN Bus between the TCU and MCU. Replace the TCU to MCU CAN Bus wiring.
TCU Command Message 2 Watchdog Timeout Section 7.3.2.21	Immediate	Check engine light Note 1: Will be accompanied by loss of power Note 2: Check integrity of the CAN Bus connection between the VCU and the TCU	Verify the MCU CAN settings. Check the integrity of the CAN Bus between the TCU and MCU. Replace the TCU to MCU CAN Bus wiring.
Transmission Temperature Warning Section 7.3.2.22	X	Temperature warning /check engine light per recommendations in TCU Lubricant Temperature below Note: Available power will be reduced as transmission temperature rises	Verify the transmission temperature sensor and wiring. Verify the transmission lubricant level.
Transmission Temperature Error Section 7.3.2.23	Immediate	Check engine light Note: Will be accompanied by loss of power	Verify the transmission temperature sensor and wiring. Verify the transmission lubricant level.
Transmission Temperature Limiting Section 7.3.2.24	X	Nothing, will only be seen when “Transmission Temperature Warning” is set	Verify the transmission temperature sensor and wiring. Verify the transmission lubricant level.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
Transmission Temperature Read Error Section 7.3.2.25	Immediate	Check engine light Note 1: Extended use of the system in this condition risks damage to the transmission Note 2: Contact Danfoss Power Solutions to investigate possible hardware issue.	Verify the transmission temperature sensor and wiring. Verify the transmission lubricant level.
MCU Inverter Temperature Read Error Section 7.3.2.26	Immediate	Check engine light Note 1: Extended use of the system in this condition risks damage to the MCU Note 2: Contact Danfoss Power Solutions to investigate possible hardware issue.	X
MCU Stator Temperature Read Error Section 7.3.2.27	Immediate	Check engine light Note 1: Extended use of the system in this condition risks damage to the Motor Note 2: Contact Danfoss Power Solutions to investigate possible hardware issue.	Verify the MCU signal wiring integrity.
MCU Rotor Temperature Read Error Section 7.3.2.28	Immediate	Check engine light Note 1: Extended use of the system in this condition risks damage to the Motor Note 2: Contact Danfoss Power Solutions to investigate possible hardware issue.	Verify the MCU signal wiring integrity.
MCU Regen Type Error Section 7.3.2.29	Immediate	Check engine light Note: System is inoperable because the MCU is not correctly configured for use in PowerPhase®DT2 systems	Verify the MCU configuration. Verify the MCU version and type.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Power Switches Off Section 7.3.2.30	Immediate	System inoperable	If High Voltage Power Supply is less than minimum operating voltage: Normal operation – do nothing If High Voltage Power Supply is greater than minimum operating voltage: Record data and contact Danfoss Power Solutions.
MCU Invalid Power Supply Section 7.3.2.32	Long	System inoperable	Record data and contact Danfoss Power Solutions.
MCU Bad Switch Section 7.3.2.33	Long	Check engine light	Record data and contact Danfoss Power Solutions.
MCU Bad Position Signal Section 7.3.2.34	Long	Check engine light	Verify the MCU signal wiring integrity Record data and contact Danfoss Power Solutions.
MCU Phase Current Sensor Error Section 7.3.2.35	Long	Check engine light	Record data and contact Danfoss Power Solutions.
MCU Stall Condition Active Section 7.3.2.36	Long/X	Customer dependent - hill too steep for motor torque and vehicle weight - Danfoss Power Solutions delivering 10% torque for 30 seconds	X
MCU Forced Open Loop Section 7.3.2.37	Long	Check engine light	Record data and contact Danfoss Power Solutions.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Turbo Mode Section 7.3.2.38	X	Nothing, typical occurrence	X
MCU Using Raw Speed Section 7.3.2.39	X	Nothing, typical occurrence	X
MCU Acceleration Limited Section 7.3.2.40	X	Nothing, typical occurrence	X
MCU Current Transducer Fault Ileg/Ibus Section 7.3.2.41	Long	Check engine light	Record data and contact Danfoss Power Solutions.
MCU ABC Phase Order Section 7.3.2.42	X	Nothing, typical occurrence	X
MCU System Disabled In Motion Section 7.3.2.43	Short	Customer dependent - Is customer enabling the Danfoss Power Solutions drive?	X
MCU CAN Limits Active Section 7.3.2.44	X	Nothing, typical occurrence	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Forced Voltage Control Section 7.3.2.45	Immediate	Check engine light Note 1: Regen switch will open and shifting will be disabled Note 2: Check for battery fuse blown, battery contactor opened, or high voltage battery problem	Verify DC bus operation. Record data and contact Danfoss Power Solutions.
MCU Inverter Fault Section 7.3.3.1	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Record data and contact Danfoss Power Solutions.
MCU Inverter Fault History Section 7.3.3.2	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Record data and contact Danfoss Power Solutions.
MCU Inverter Fault Latched Section 7.3.3.3	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Record data and contact Danfoss Power Solutions.
MCU Inverter Fault Latched History Section 7.3.3.4	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Record data and contact Danfoss Power Solutions.
MCU Limp Home Mode Section 7.3.3.5	Immediate	Check engine light	Power-cycle PowerPhase®DT2 system. Record data and contact Danfoss Power Solutions.
MCU Limp Home Mode History Section 7.3.3.6	X	Nothing, latched indication that MCU Limp Home Mode has occurred. Provided for trouble shooting.	Power-cycle PowerPhase®DT2 system. Record data and contact Danfoss Power Solutions.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU ADC Calibration Problem Section 7.3.3.7	Long	Check engine light	Record data and contact Danfoss Power Solutions.
MCU ADC Calibration Problem History Section 7.3.3.8	X	Nothing, latched indication that MCU ADC Calibration Problem has occurred. Provided for trouble shooting.	Record data and contact Danfoss Power Solutions.
MCU Over Voltage Alarm Section 7.3.3.9	Immediate	Check engine light Note 1: Regen switch will open and shifting will be disabled Note 2: Check for battery fuse blown, battery contactor opened, or high voltage battery problem	Verify DC bus operation. Record data and contact Danfoss Power Solutions.
MCU Over Voltage Alarm History Section 7.3.3.10	X	Nothing, latched indication that MCU Over Voltage Alarm has occurred. Provided for trouble shooting.	Verify DC bus operation. Record data and contact Danfoss Power Solutions.
MCU Over Speed Alarm Section 7.3.3.11	X	Customer dependent - over customer's limit or Danfoss Power Solutions upper limit	Verify VCU speed limit.
MCU Over Speed Alarm History Section 7.3.3.12	X	Nothing, latched indication that MCU Over Speed Alarm has occurred. Provided for trouble shooting.	X
MCU Over Voltage Warning Section 7.3.3.13	X	Customer dependent - over customer's limit or Danfoss Power Solutions upper limit	Verify DC bus operation.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Over Voltage Warning History Section 7.3.3.14	X	Nothing, latched indication that MCU Over Voltage Warning has occurred. Provided for trouble shooting.	X
MCU Over Speed Warning Section 7.3.3.15	X	Customer dependent - over customer's limit or Danfoss Power Solutions upper limit	Verify VCU speed limit.
MCU Over Speed Warning History Section 7.3.3.16	X	Nothing, latched indication that MCU Over Speed Warning has occurred. Provided for trouble shooting.	X
MCU Inverter Over Temp Section 7.3.3.17	X	Temperature warning /check engine light per recommendations in MCU Inverter Temperature below	Verify coolant circuit.
MCU Inverter Over Temp History Section 7.3.3.18	X	Nothing, latched indication that MCU Inverter Over Temp has occurred. Provided for trouble shooting.	Verify coolant circuit.
MCU Stator Over Temp Section 7.3.3.19	X	Temperature warning /check engine light per recommendations in MCU Stator Temperature below	Verify coolant circuit.
MCU Stator Over Temp History Section 7.3.3.20	X	Nothing, latched indication that MCU Stator Over Temp has occurred. Provided for trouble shooting.	Verify coolant circuit.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Rotor Over Temp Section 7.3.3.21	X	Temperature warning /check engine light per recommendations in MCU Rotor Temperature below	Verify coolant circuit.
MCU Rotor Over Temp History Section 7.3.3.22	X	Nothing, latched indication that MCU Rotor Over Temp has occurred. Provided for trouble shooting.	Verify coolant circuit.
MCU Under Voltage Warning Section 7.3.3.23	X	Customer dependent - under customer's limit	Verify DC Bus operation.
MCU Under Voltage Warning History Section 7.3.3.24	X	Nothing, latched indication that MCU Under Voltage Warning has occurred. Provided for trouble shooting.	Verify DC Bus operation.
MCU Over Phase Advance Section 7.3.3.25	X	Nothing, if error lasts under 10 seconds (See Notice below for persistent occurrences of this error).	Record data and contact Danfoss Power Solutions.
MCU Over Phase Advance History Section 7.3.3.26	X	Nothing, latched indication that MCU Over Phase Advance has occurred. Provided for trouble shooting.	Record data and contact Danfoss Power Solutions.
MCU Over Bus Current Section 7.3.3.27	X	Customer dependent - over customer's limit	Verify VCU DC Bus limits.

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Over Bus Current History Section 7.3.3.28	X	Nothing, latched indication that MCU Over Bus Current has occurred. Provided for trouble shooting.	Verify VCU DC Bus limits.
MCU Over Leg Current Section 7.3.3.29	X	Nothing, only occurs in highly dynamic situation	X
MCU Over Leg Current History Section 7.3.3.30	X	Nothing, latched indication that MCU Over Leg Current has occurred. Provided for trouble shooting.	X
MCU Not Enabled Section 7.3.3.31	X	Nothing, typical occurrence	X
MCU Not Enabled History Section 7.3.3.32	X	Nothing, latched indication that MCU Not Enabled has occurred. Provided for trouble shooting.	X
Transmission Output Speed Section 7.3.3.33	X	This value should have a consistent relationship with the vehicle speed Note: The VCU must take into consideration the ratio of any gearing between the transmission output and the wheels and the actual diameter of the wheels.	X
MCU Motor Speed Section 7.3.3.34	X	Nothing This is the actual motor speed before the transmission gearing is applied.	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
Max Drive Torque Allowed Section 7.3.4.1	X	Max drive torque the VCU is allowed to request. Drive torque requested by the VCU will be limited to this value	X
Max Regen Torque Allowed Section 7.3.4.2	X	Max regen torque the VCU is allowed to request. Regen torque requested by the VCU will be limited to this value	X
VCU Torque Requested Section 7.3.4.3	X	Customer dependent - this is torque that the system will attempt to deliver at the output of the driveshaft.	X
TCU Requested Torque Section 7.3.5.2	X	Nothing This is torque that the TCU actually requests from the MCU and is not corrected for transmission gear ratio. Provided for trouble shooting.	X
MCU Desired Torque Section 7.3.5.2	X	Nothing This is torque that the MCU will attempt to produce and is not corrected for transmission gear. Provided for trouble shooting.	X
MCU Torque Section 7.3.5.3	X	Nothing This is torque that the motor is producing at the input to the transmission and is not corrected for transmission gear ratio. Provided for trouble shooting.	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
TCU Torque Section 7.3.5.4	X	Customer dependent - this is torque that the system is delivering at the output of the driveshaft. It may be used as a feedback signal to generate the VCU torque request.	X
MCU Acceleration Limit Section 7.3.6.1	X	Customer dependent - this is acceleration limit in rpm/s at the output of the driveshaft. It may be used as a feedback signal to check compliance with the VCU acceleration limit.	X
MCU Voltage Section 7.3.6.2	X	Customer dependent - this is voltage that the MCU is either sinking (in drive) or sourcing (in regen). It may be used as a feedback signal to check compliance with the Battery Control Unit Voltage requirements.	X
MCU Current Section 7.3.6.3	X	Customer dependent - this is voltage that the MCU is either sinking (in drive) or sourcing (in regen). It may be used as a feedback signal to check compliance with the Battery Control Unit Current requirements.	X
MCU Leg Current Section 7.3.6.4	X	Nothing This is maximum current seen on any of the motor phase leads within the most recent reporting period. Provided for trouble shooting.	X
MCU Stall Safety Percentage Section 7.3.7.1	X	Customer dependent - this indicates how close the motor is to a stall situation with the stall becoming imminent as this number approaches 100. This is more significant in small Danfoss Power Solutions motors and has seldom been an issue with the larger motors used in PowerPhase®DT2 systems.	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
TCU Lubricant Temperature Section 7.3.7.2	Long	Transmission Temperature Warning will be set at 120°C Warning light at 120°C Check Engine light at 122°C Customer dependent - the VCU should reduce torque demands as this temperature approaches 120°C. The TCU will limit the torque allowed if this temperature exceed 120°C and will cease torque production if this temperature reaches 125°C. Note: Extended operation above 120°C may result in damage to the transmission.	X
MCU Inverter Temperature Section 7.3.7.3	Long	MCU Inverter Over Temp signal is set at 90° C Amber over temp light if over 93° C Red over temp light if over 98° C Note: Torque production is limited beginning at 90° C and reaches 0Nm at 100° C	X
MCU Stator Temperature Section 7.3.7.4	Long	MCU Stator Over Temp signal is set at 150° C Amber over temp light if over 156° C Red over temp light if over 166° C Note: Torque production is limited beginning at 150° C and reaches 0Nm at 170° C	X

Status Signal	Time period before reacting	Typical Vehicle Controller Unit (VCU) Expected Action	Recommended Service Action
MCU Rotor Temperature Section 7.3.7.5	Long	MCU Rotor Over Temp signal is set at 130° C Amber over temp light if over 136° C Red over temp light if over 146° C Note: Torque production is limited beginning at 130° C and reaches 0Nm at 150° C	X
MCU Max Source Current Section 7.3.7.6	X	Nothing – this value is set as the result of changes in the Max Source Current (Section 7.2.2.3). Note: The max value of this signal is defined by the MCU.	X
MCU Max Sink Current Section 7.3.7.7	X	Nothing – this value is set as the result of changes in the Max Sink Current (Section 7.2.2.4). Note: The max value of this signal is defined by the MCU.	X

NOTICE

If MCU **Over Phase Advance** is persistently detected over time, contact Danfoss Power Solutions for a motor specific Danfoss Power Solutions file (Section 8). Danfoss Power Solutions will require the serial number of the motor and a copy of the current QSC to process this request.

The QSC is for the specific motor. If the motor is replaced, revert to the original QSC or load the QSC for the replacement motor

Table 10.2: Error Response Delay Time

Length of time period before reacting	Typical Vehicle Controller Unit (VCU) Reaction Time
Immediate	0 seconds
Short	0.3 seconds
Long	1.0 seconds
X	Don't react

11 Appendix C: Glossary

Baud: The unit in which the information carrying capacity or signaling rate of a communication channel is measured. One baud is one symbol per second.

Brushless Permanent Magnet (PM) Motor: A synchronous electric motor that uses permanent magnet excitation.

Bus: A subsystem that transfers data or electric power between two or more components.

CANbus (Controlled Area Network): A broadcast, differential serial bus standard, originally developed in 1988 by Intel Corporation and Robert Bosch, for connecting electric controlled units. CAN is a communication system whereby multiple nodes connect to over a single connection medium called the Bus.

Capacitors: An electric current element used to store charge temporarily, consisting in general of two metallic plates separated and insulated from each other by a dielectric.

Controller: A mechanism that controls the operation of a machine.

DC/AC (direct current/alternating current): Unidirectional flow of electric charge to electrical current whose magnitude and direction vary cyclically.

DSP (Digital Signal Processor): A specialized microprocessor designed specifically for the study of signals in digital representation.

EMI/EMC (Electromagnetic Interference/Electromagnetic Compatibility): EMC is the branch of electrical science which studies the unintentional generation, propagation, and reception of electrical magnetic energy with reference to the unwanted effects (EMI) that such energy may induce.

Fault: A partial or total local failure in the insulation or continuity in the conductor or functioning of an electric system.

Firmware: Computer programming instructions that are stored in a read-only memory unit rather than being implemented through software.

Inverter: A device that converts direct current into alternating current.

Microprocessor: An integrated circuit that contains the entire central processing unit on a single chip.

Motor: A machine that converts electric energy into mechanical energy.

O-ring: A loop of elastomer with a round (o) shape, used as a mechanical seal or gasket.

Potentiometer: A variable tapped resistor that can be used as a voltage divider.

Regenerative: To magnify the amplification of, by relaying part of the output circuit power into the input circuit.

Ripple: The alternating current component from a direct current power supply arising from sources within the power supply.

Shaft: A rotating or oscillating round, straight bar for transmitting motion and torque, usually supporting on bearings and carrying gears, wheels, or the like, as a draft shaft of an engine.

Sine wave: A geometric waveform that oscillates periodically, as it is defined by the function y = sin x. In other words, it is an s-shaped smooth wave that oscillates above and below zero.

Soft Start: A term describing any circuit, which is current limited during initial power up.

Software Watchdog Timer: An independent parallel component, which detects software errors' and hardware errors' reliability.

Torque: Something that produces or tends to produce torsion or rotation; the moment of a force or system of forces tending to cause rotation.

11.1 Abbreviations

CCW: Counterclockwise

CW: Clockwise

CSV: A spreadsheet using the comma-separated values format

DAQ: Data Acquisition

ESD: Electrostatic Discharge

IGBT: Insulated-gate bipolar transistor

LPM: Liters per Minute; unit of volume equal to 1 cubic decimeter (dm^3)

MCU: Motor Control Unit

PRNDL: Gear selector (Park/Reverse/Neutral/Drive/Low)

TCU: Traction Control Unit

VCU: Vehicle Control Unit

VDC: Voltage direct current

12 Appendix D: Safety Notices

These safety notices are contained in the body of the document and are repeated here as a quick reference. If there are any questions about one or more of these notices, the appropriate section of this document should be reviewed.

Section 1

DANGER	Dangerous voltages, currents, and energy levels exist in this product. Exercise extreme caution in the application of this equipment. Only qualified individuals should attempt to install, set-up, and operate this equipment.

DANGER	Incorrect motor and controller wiring can cause catastrophic failure. Proper connection of motor cables, signal cable, and DC cable are necessary for safe operation. Do not swap motor windings to reverse direction.

Section 1.1.4

DANGER	Exposure to high voltage can cause shock, burns, and even death. Technicians with special training and knowledge are required to service the high voltage components in the vehicle. High voltage components are identified by labels. Do not remove, open, take apart, or modify these components. High voltage cable or wiring has an orange covering. Do not probe, tamper with, cut, or modify high voltage cable or wiring.

Section 1.2

WARNING	Both the motor/transmission and controller are very heavy! Be careful while removing the products from packaging to avoid dropping the components and potentially damaging the products.

Section 2.1

WARNING	Do not modify, or cut and re-solder, the Signal cable length. If you need an alternate length, contact Danfoss Power Solutions.

WARNING	Do not modify, or cut and re-solder, the Phase cable length. If you need an alternate length, contact Danfoss Power Solutions.

WARNING	The DC cable length can be shortened if necessary. The customer is responsible for the termination to the battery system and for ensuring proper termination of the shielding is achieved.

WARNING	Ensure that the motor shaft will remain unobstructed during acceleration.

WARNING	Do not open the controller or motor housings.

CAUTION	Ensure that there is sufficient liquid cooling and flow rate of coolant.

Section 2.2.2

CAUTION	Vibration isolators at the mounting points of the controller are required when the vehicle vibration levels at the controller mounting location are in excess of typical automotive or commercial vehicle levels.

Section 2.2.3

CAUTION	The customer must route and secure the Phase Cables, DC Cable, Signal Cable, and TCU to MCU Interface Cable and Drivetrain Control Cables in such a manner as to ensure that connector housings and sealing interfaces are not stressed during installation or operation.

Section 2.2.4

CAUTION	Never allow the controller to operate unless the coolant is flowing at a minimum coolant flow rate of 10 LPM.

Section 2.2.7

CAUTION	For proper solenoid operation, the 24 V supply must be no lower than 20.4 V and no higher than 28.8 V.

Section 2.3.1

WARNING	Axial loading of the transmission output flange induced by the coupling system can result in premature transmission failure. Users of the system MUST ensure the output flange is not improperly loaded.

Section 2.3.2

WARNING The fastener thread engagement for bell housing mounting holes must not exceed 24mm.

WARNING The motor housing is not a structural member and is not intended to bear structural loads.

WARNING Exercise care when mounting the motor and transmission to ensure that moving parts are not constrained and proper clearances are observed. All drive mechanisms mounted to the transmission shaft must be properly secured.

WARNING Loads on the motor shaft induced by the coupling system can result in premature motor failure. Users of the motor MUST ensure the motor shaft is not improperly loaded.

WARNING A separate ground wire must connect the motor case to the controller housing. High Voltage lines (positive or negative) must not be tied to the chassis, or the motor and controller/inverter cases. Please see Section 3.2 for more information on grounding requirements.

Section 2.4.1.7

WARNING When filling with lubricant – Do Not Overfill. This causes oil to be forced out of the front and rear seals.

Section 2.4.1.8

WARNING Lift drive whiles off the ground or disconnect the driveline from the transmission to avoid damage to the transmission during towing

Section 3

DANGER Dangerous voltages, currents, and energy levels exist in this product. Exercise extreme caution in the application of this equipment. Only qualified individuals should attempt to install and set-up this equipment.

DANGER Ensure that the high voltage battery input is not connected before making any connections.

DANGER Ensure that the 24 V battery input is not connected before making any connections.

Section 3.1

CAUTION	Ensure the O-Rings are in-place or installed before connection to the controller.

CAUTION	Ensure the O-Rings are not pinched or nicked during installation.

WARNING	Ensure that the power is off before connecting the power cables.

WARNING	Ensure that the phase cables and DC cables are routed and restrained to prevent insulation damage.

WARNING	Do not use Locktite® or similar products when securing the High Voltage DC or the 3 phase AC cables to the inverter. The use of Locktite® in these locations will increase the resistance of the connection and may result in melting of the overmolding.

DANGER	Failure to orient the power lug connections correctly can cause short to chassis.

DANGER	Do not connect either the positive or negative high voltage bus to the chassis, motor cases, or controller. Catastrophic damage will occur. Provide sufficient insulation on all power terminals for safety.

Section 3.1.3

DANGER	It is the customer's responsibility to disable high voltage DC when the Danfoss Power Solutions HVIL indicates that either the inverter or the motor termination covers is open.

CAUTION	The user is responsible for proper HVIL actions and for disabling the DC high voltage power when the HVIL circuit is open.

Section 3.2

WARNING	The user is responsible for providing and installing a ground strap from the motor to the controller. Without a ground cable, erratic operation can occur.

Section 3.3

WARNING	Do not attempt to lengthen or shorten the cable in any way. Contact Danfoss Power Solutions if the cable is too short or too long for the application.

WARNING	Do not bundle the signal cable with the motor power leads. This may cause a controller failure.

WARNING	Do not attempt to tighten the signal cable connector without the aid of a torque strap. Finger tight is not sufficient to maintain contact.

CAUTION	Do not over-tighten or under-tighten the signal cable connector.

Section 3.5

WARNING	CYCLING THE **+24V** OR **ENABLE** SIGNALS WHILE THE MOTOR IS IN MOTION SHOULD BE AVOIDED IF AT ALL POSSIBLE. Cycling either of these signals will cause the inverter CPU to shut down and restart – which may result in unpredictable current surges.

DANGER	Your system may be configured for rotation when input voltage is applied. Before applying input voltage, ensure that the shaft and/or anything connected to the shaft has sufficient area for rotation. Always disconnect input voltage before making or removing any other connections.

DANGER	Do not connect either the positive or negative high voltage bus to the chassis, motor cases, or controller. Catastrophic damage may occur. Provide sufficient insulation on all power terminals for safety.

Section 4.1

CAUTION	The coolant should never run in parallel paths. The coolant hoses between the controller and the motor should be in series, as the thermal algorithms used in the software depend upon the coolant flowing at the same rate through both components.

CAUTION	The coolant loop for the transmission MUST be on a SEPARATE coolant loop than the MCU and Motor.

Section 5.1

CAUTION	It is not recommended to operate the system with the driveline disconnected from the transmission.

WARNING	DO NOT FLAT TOW the vehicle. While towing the vehicle, the drive wheels MUST NOT ROTATE, or damage will result when the motor system is not operational. If needed, the drive shaft should be disconnected from the transmission output flange.

WARNING	DO NOT RE-ENABLE BATTERY VOLTAGE TO A MOVING VEHICLE. *It is strongly recommended that if a condition occurs which requires power cycling the system, the vehicle should be at a full stop before battery power is enabled. Applying battery voltage while the motor is moving may result in serious damage to the system.*

ENGINEERING TOMORROW

About Danfoss Editron

Danfoss Editron is the Electrification division in Danfoss Power Solutions. Danfoss Editron is composed of 3 Business Units: On Highway Electrification, Off-Highway Electrification and Marine Electrification. For more information please visit: https://www.danfoss.com/en-us/about-danfoss/our-businesses/power-solutions/danfoss-editron/

Fully-electric and hybrid EDITRON systems:

- Lower fuel and energy consumption
- Reduced carbon dioxide and small particle emissions
- Freedom of design thanks to lightweight and compact hardware

Easy integration into various different machines

Danfoss Editron
4120 Specialty Place
Longmont, CO.
+1.303.682.4900
Sales.uqm@danfoss.com