Effective: June 2019
Supersedes:

UTS User Manual

Universal Tilt Sensor

ENGINEERING YOUR SUCCESS.

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Publication History

The following table provides an overview of the changes made to this document over the course of its publication history

Revision	Description of Change
Rev. 001	First release of this document
Rev. 002	Formatting updates

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1 Safety

Do not perform the procedures in this manual unless you are experienced in the handling of electronic equipment.

Contact the manufacturer if there is anything you are not sure about or if you have any questions regarding the product and its handling or maintenance.

The term "manufacturer" refers to Parker Hannifin Corporation.

Safety Symbols

The following symbols are used in this document to indicate potentially hazardous situations:

- *Danger! Risk of death or injury.*
- *Warning! Risk of damage to equipment or degradation of signal.*

When you see these symbols, follow the instructions carefully and proceed with caution.

General Safety Regulations

Work on the hydraulics control electronics may only be carried out by trained personnel who are well-acquainted with the control system, the machine, and its safety regulations.

- Follow the manufacturer's regulations when mounting, modifying, repairing, and maintaining equipment. The manufacturer assumes no responsibility for any accidents caused by incorrectly mounted or incorrectly maintained equipment. The manufacturer assumes no responsibility for the system being incorrectly applied, or the system being programmed in a manner that jeopardizes safety.
- Do not use the product if electronic modules, cabling, or connectors are damaged or if the control system shows error functions.
- Electronic control systems in an inappropriate installation and in combination with strong electromagnetic interference fields can, in extreme cases, cause an unintentional change of speed of the output function
- This product can expose you to chemicals including **ANTIMONY TRIOXIDE,CARBON BLACK (AIRBORNE, UNBOUND PARTICLES OF RESPIRABLE SIZE)** which is known to the State of California to cause cancer and **4,4'-(PROPANE-2,2-DIYL)DIPHENOL, BPA, P,P'-ISOPROPYLIDENEBISPHENOL,** which is known to the State of California to cause birth defects or other reproductive harm. For more information go to www.P65Warnings.ca.gov

Welding After Installation

If welding is required for installation, complete as much as possible of the welding work before the installation of the system. If welding must be done afterwards, proceed as follows:

- Do not place the welding unit cables near the electrical wires of the control system
- If sensor has been installed and additional welding is required, remove the 4-pin connector from the sensor to avoid possible electrical damage to sensor

1. Disconnect the electrical connections between the system and external equipment
2. Disconnect the negative cable from the battery
3. Disconnect the positive cable from the battery
4. Connect the welder's ground wire as close as possible to the place of the welding

Construction Regulations

The vehicle must be equipped with an emergency stop which disconnects the supply voltage to the control system's electrical units. The emergency stop must be easily accessible to the operator. If possible, the machine must be built so that the supply voltage to the control system's electrical units is disconnected when the operator leaves the operator's station.

Safety During Installation

- Incorrectly positioned or mounted cabling can be influenced by radio signals, which can interfere with the functions of the system.

Safety During Start-Up

- *Danger! Risk of death or injury.* Do not start the machine's engine before the control system is mounted and its electrical functions have been verified.

  Do not start the machine if anyone is near the machine.

Safety During Maintenance and Fault Diagnosis

Before performing any work on the hydraulics control electronics, ensure that

- The machine cannot start moving
- Functions are positioned safely
- The machine is turned off
- The hydraulic system is relieved from any pressure
- Supply voltage to the control electronics is disconnected

2 Document Introduction

2.1 Scope

The purpose of this document is to detail installation recommendations and define CAN messages for the Universal Tilt Sensor v2 products. These instructions/guidelines are to be used as a reference tool for the manufacturer's design, production, and service personnel. The user of this manual should have basic knowledge in the handling of electronic equipment.

2.2 Terminology

The abbreviations and acronyms used in this manual are defined in the following table.

Table 2.2.1: Abbreviation List

Abbreviation	Explanation
UTS	Universal Tilt Sensor
CAN	Controller Area Network
EMI	Electromagnetic Interference
SAE	Society of Automotive Engineers
PGN	Parameter Group Number
MEMS	Micro Electro-Mechanical Systems
FIR	Finite Impulse Response
IIR	Infinite Impulse Response

3 Datasheet

3.1 Characteristics

Table 3.1.1: Physical and Electrical Characteristics

General	Purchasing Part Number	162703ECD	160736ECD	159456ECD
	Weight	0.14 kg	0.14 kg	0.14 kg
	Temperature (operating)	-40°C to 85°C	-40°C to 85°C	-40°C to 85°C
	Temperature (storage)	-40°C to 105°C	-40°C to 105°C	-40°C to 105°C
	Number of axes[1]	2	2	3
	Angular range[1]	±10°	±90°	±90°
	Mounting	Tripod	Tripod	Tripod
Mechanical Characteristics	Mounting bolt	1/4”-20 UNC or M6x1.0	1/4”-20 UNC or M6x1.0	1/4”-20 UNC or M6x1.0
	Mounting torque	135 in-lb max	135 in-lb max	135 in-lb max
	Mounting surface flatness	.010”	.010”	.010”
	Connector	Deutsch DT	Deutsch DT	Deutsch DT
Communication	CAN protocol	SAEJ1939	SAEJ1939	SAEJ1939
	CAN messages	see part drawing	see part drawing	see part drawing
	CAN bus speed	250 kbps	250 kbps	250 kbps
	Data broadcast rate	10 Hz	50 Hz	50 Hz
	CAN source address	0xE2	0xE2	0xE2
Electrical Specifications	Operating voltage	6.5 - 48 Vdc	6.5 - 48 Vdc	6.5 - 48 Vdc
	Reverse polarity	-48 Vdc	-48 Vdc	-48 Vdc
	Short circuit protection	32 Vdc or ground	32 Vdc or ground	32 Vdc or ground
	Current draw	9.0 mA (12 V); 6.0 mA (24 V)	9.0 mA (12 V); 6.0 mA (24 V)	9.0 mA (12 V); 6.0 mA (24 V)
	Resolution	0.02°	0.02°	0.02°
	Repeatability	0.05°	0.05°	0.05°
	Linearity (typical)	±0.4°	±0.3° + 1% of tilt from horizontal	±0.3° + 1% of tilt from horizontal
Environmental Protection	EMI	ISO 11452-2	100 V/m	
		ISO 7637-2 and -3	transients	
	ESD	ISO 10605:2008	±15 kV	
	Mechanical	Shock	1m drop	
		Vibration	40 Gs	
	Climate	Sealing	IP68/IP69K (with rear connector protection)	
	Chemical	Liquids (resistance)	standard automotive	

4 Installation Quick Sheets

4.1 UTS Version 2

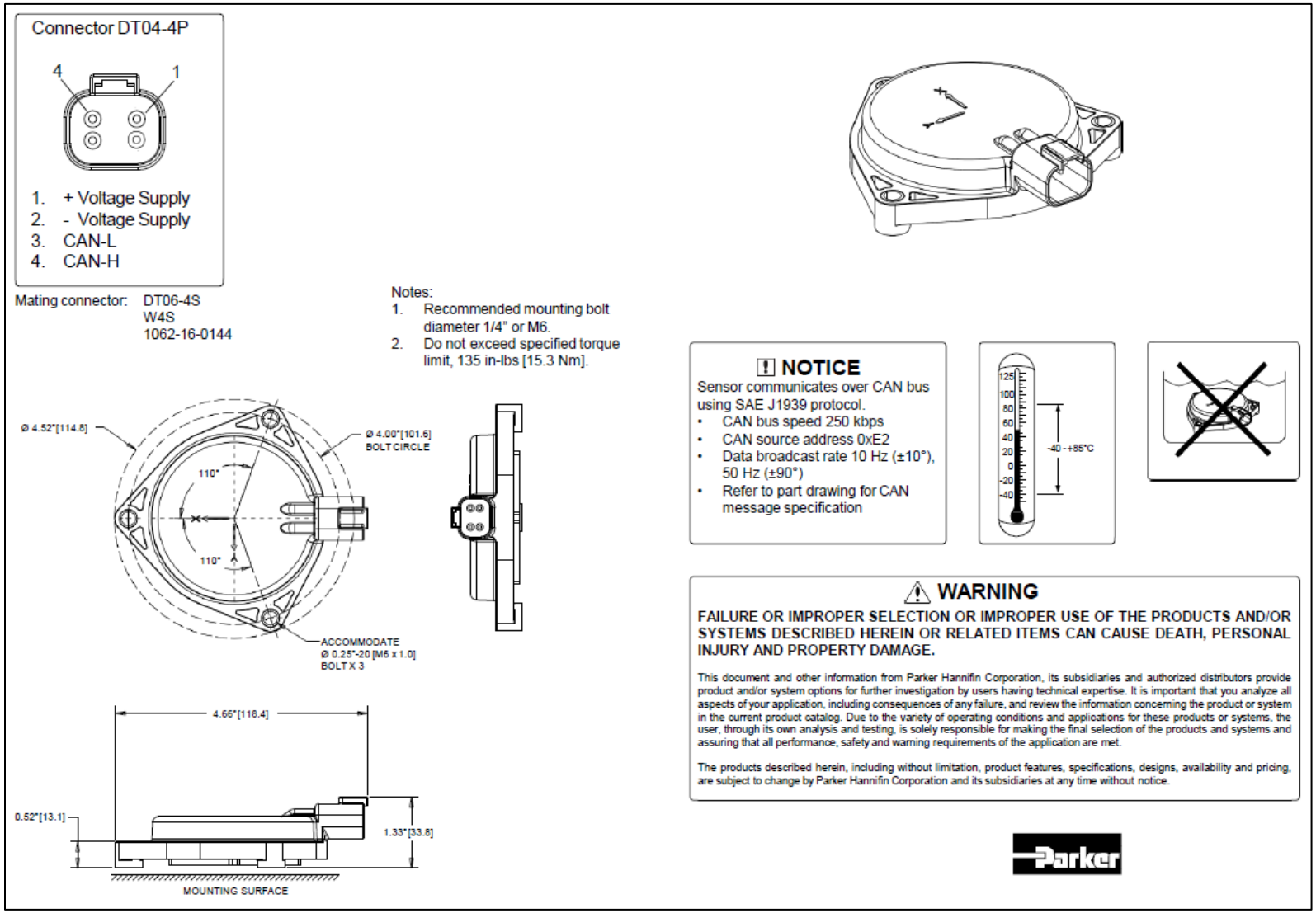

Figure 4.1.1: UTS Quick Sheet Page 1

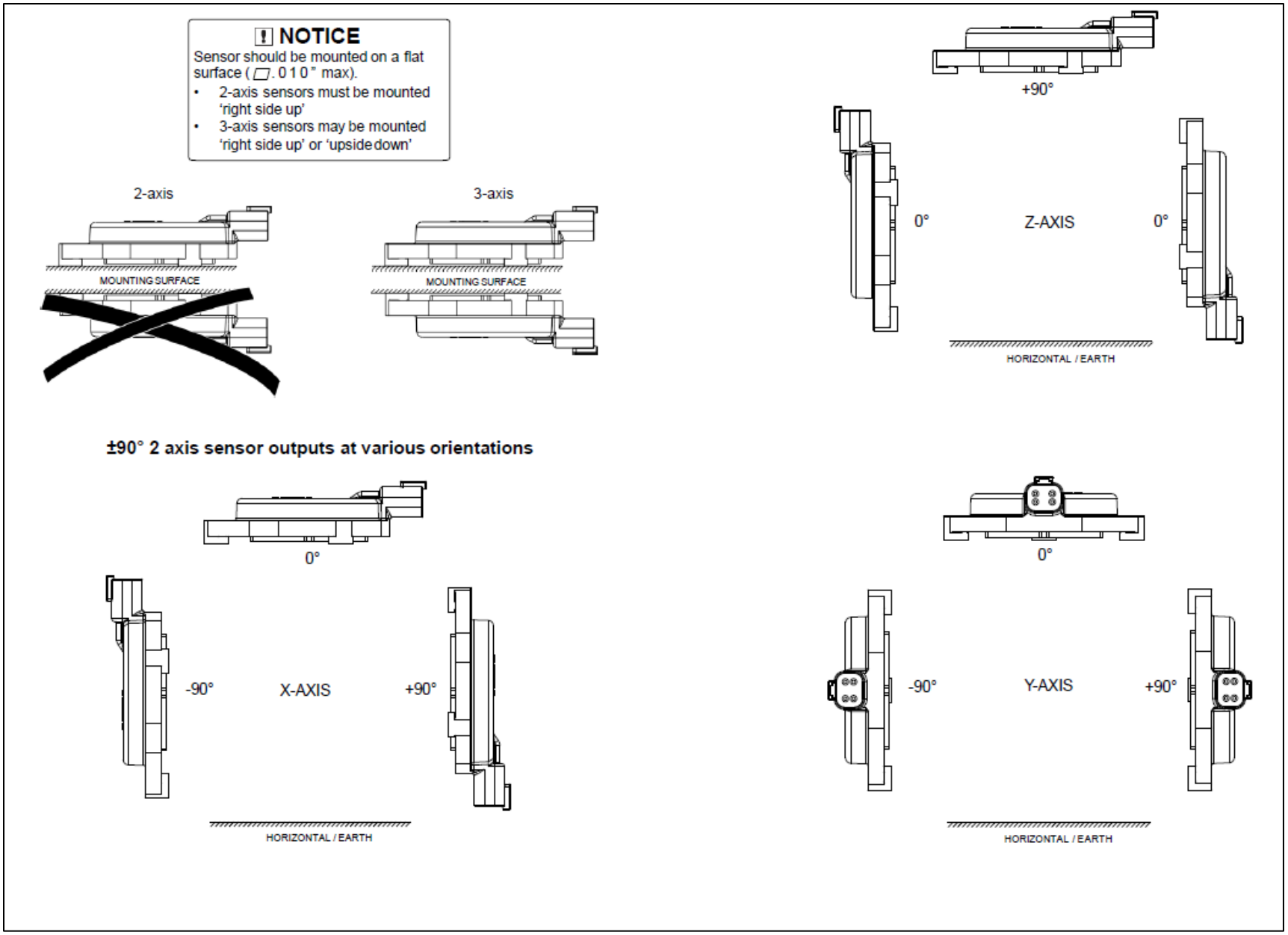

Figure 4.1.2: UTS Quick Sheet Page 2

5 Product Introduction

5.1 Overview

Application

The UTS uses MEMS technology to provide a multi-axis tilt sensor optimized for mobile hydraulic applications. Accelerometers are used to calculate changes in orientation with respect to gravity. The sensor communicates over CAN bus using SAE J1939 protocol and has an integral Deutsch connector.

Reliability

The UTS has a glass-filled, hybrid plastic construction for sturdiness and corrosion resistance. The sensor is very robust and able to withstand rugged applications. For moisture protection, the electronics are layered with a conformal coating, and the enclosure is sealed against harsh environments using spin-weld technology. These features give the sensor IP69k protection for exposed outdoor applications when mounted right side up and an IP68 rating when mounted up-side down. Additionally, the UTS design has a high level of EMI protection.

Installation

The UTS comes standard with two different operating angles: the ± 10° option with 2 axis' or the ± 90° option with 2 or 3 axis'. All options have three mounting holes in a tripod pattern to facilitate level installation and a 4-pin sealed Deutsch DT connector type designed for automotive use. These features provide for easy installation and removal, even in field conditions.

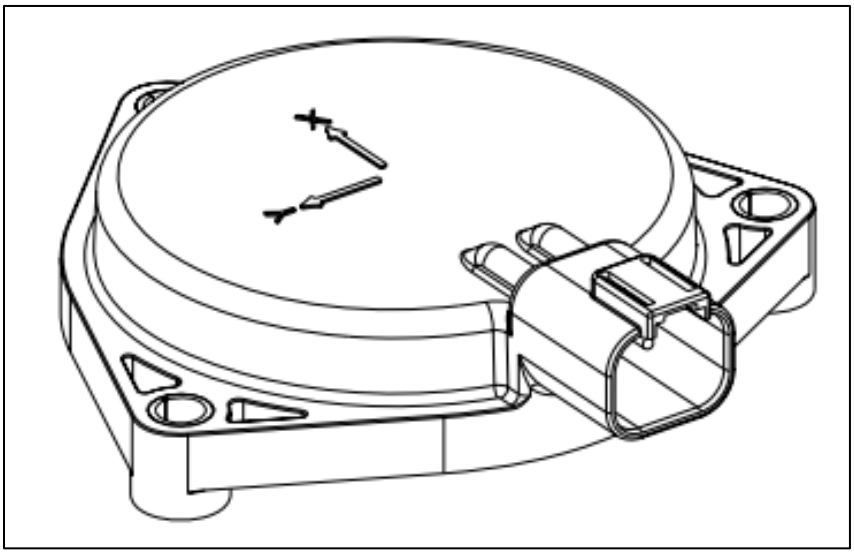

Figure 5.1.1: UTS with Deutsch DT04-4P Connector

5.2 UTS Filtering Description

The UTS has several different filtering options which are described below. Refer to Section 8.5 for examples on how to adjust these filters.

FIR filter

The signal is first smoothed by a FIR filter. The FIR filter is a rolling average of the last *n* unfiltered measurements, where *n* is the number of FIR samples configured by PGN 0xFFB5 (set output filter settings). Increasing the number of FIR samples increases the signal dampening.

IIR filter

The IIR filter uses the resultant value of the FIR filter. The IIR filter is a weighted average of the current measurement from the FIR filter and the previous result from the IIR filter. The current measurement from the FIR filter is weighted by *x* %, where *x* is the IIR filter weight percent configured by PGN 0xFFB5 (set output filter settings), and the previous result from the IIR filter is weighted by (100 - *x*) %. Decreasing the IIR filter weight percent increases the signal dampening and reduces responsiveness. The IIR filter will reduce high frequency noise.

Heavy IIR filter

In some applications additional filtering may be desired to further reduce larger spikes in the output signal. The heavy IIR filter can be used to reduce larger spikes without burdening the rest of the signal with heavier dampening. When a spike induces a tilt angle rate of change (in °/s) more than the heavy IIR rate limit configured by PGN 0xFFB5 (set output filter settings) the heavy IIR filter weight percent is used in place of the normal IIR filter weight percent in the IIR filter. The heavier filtering reduces the spike. Once the tilt angle rate of change decreases below the heavy IIR rate limit the normal IIR filter weight percent is used again. In practice, the heavy IIR filter weight percent should be a lesser value than the IIR filter weight percent.

Notes:

- A positive offset adjustment value increases the zero-tilt reading (offset) while a negative value decreases the zero-tilt reading.
- The maximum number of FIR samples that can be averaged is 45 (0x2D).
- The FIR samples, IIR filter weight percent and heavy IIR filter weight percent cannot be zero.
- Setting the heavy IIR rate limit to the max value of 983.025 °/s (0xFFFF) disables the heavy IIR filter.
- Setting the FIR samples to 1 and the IIR filter weight percent to 100% yields an unfiltered output.

6 Installation Guidelines

6.1 Operating Conditions

The UTS should not be submerged under any liquid without added protection. The operating temperatures for the sensor are -40 to +85°C.

6.2 CAN

The UTS uses CAN messages to report its angular position. All messages are SAE J1939 Proprietary B PGN's except the address claim request and response which are SAE J1939 standards. The UTS is compatible with a 250 kbps CAN baud rate, qualifying it as a "High-Speed" CAN sensor. Per ISO 11898-2, the linear bus must be terminated with two 120 Ω resistors at the ends of the transmission lines. Termination resistors are not provided with the system. External CAN termination is required. Be sure to follow SAE J1939 standards when creating the harness that the sensor connects to.

For a list of the default settings of the UTS refer to Table 7.4.1.

6.3 Power Supply Requirements

Table 6.3.1 shows the power supply requirements for the UTS. The UTS operates in 12V or 24V systems and can operate from 6.5 V to 48 V with a regulated voltage supply.

Table 6.3.1: UTS Power Supply Requirements

Parameter	Value	
Operating Voltage	+6.5 to +48 Vdc	
Input Current	9 mA at 12V typical 6mA at 24V typical	
Circuit Protection	Reverse Polarity	-48 Vdc
	All Pins - Short to $+V_{BAT}$	+32 Vdc MAX
	Transients	See ISO 7637-2,-3

6.4 Connector

The UTS uses the Deutsch DT series connector type. Technical details are listed below.

Mating Connector:	DT06-4S W4S 1062-16-0144

Figure 6.4.1: UTS Mating Connector

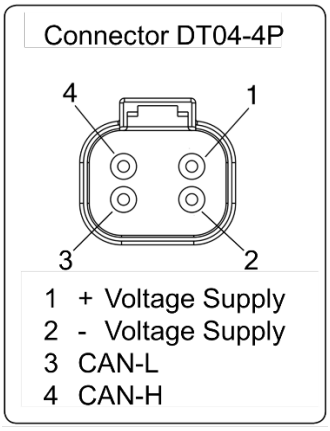

Figure 6.4.2: UTS Connector Diagram

6.5 Mounting Requirements

Mounting Torque

It is important to tighten the mounting fasteners enough to prevent vibration and loosening. Do not exceed 135 in-lbs (15.3 Nm).

- ⚠ Do not use an impact wrench as this type of device could damage the unit.

Mounting Surface

It is important for the mounting surface to be flat, clean, and clear of any imperfections that may cause false angle readings.

- ⚠ Do not mount to metal with surface flatness greater than .010” (.254mm).
- ⚠ Avoid mounting to metal less than 1/8” (3.175mm) thick as this can cause excess vibration.

Mounting Orientation

The 2-axis versions of the UTS must be mounted with horizontal earth underneath the sensor as shown in Figure 6.5.1.

The 3-axis version of the UTS must be mounted facing up or down with respect to horizontal earth as shown in Figure 6.5.1.

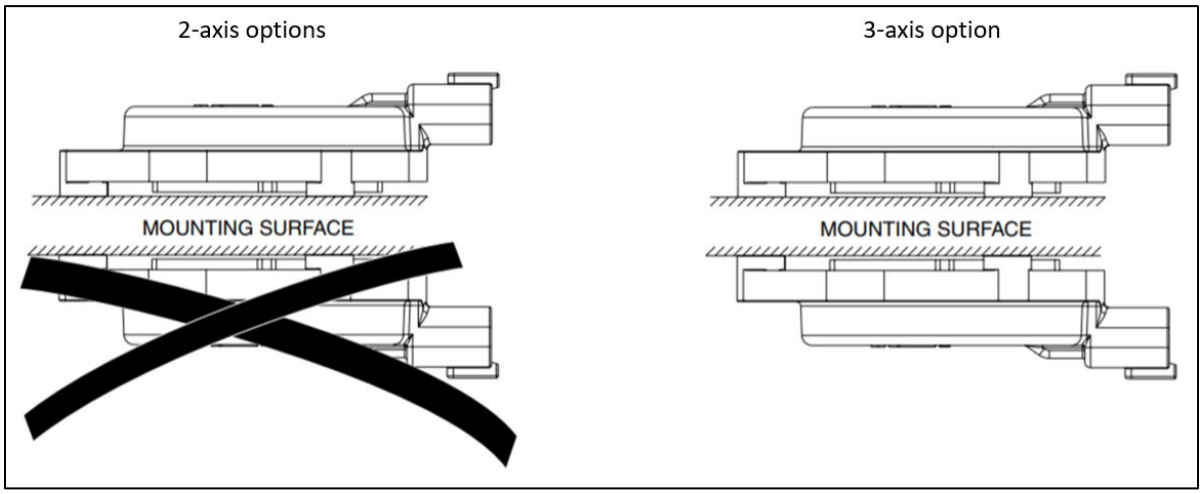

Figure 6.5.1: Supported 2-axis and 3-axis Mounting Configurations

6.6 Installation Validation

Due to manufacturing tolerances, evaluation is required to verify the output signal is of acceptable quality after the sensor is properly mounted. If the device is not level after installation, coordinate offsets can be made to account for this. Refer to Section 8.3 for an example on how to adjust offsets.

7 CAN Information

7.1 SAE J1939

The J1939 standards come from the international Society of Automotive Engineers (SAE) and were developed to provide a standard architecture by which multiple electronic systems on a vehicle can communicate. J1939 has been implemented in a broad range of vehicles and transportation systems and provides a reliable communication protocol over a high-speed CAN network.

The UTS uses this protocol to transmit its condition as a predefined set of outputs. All messages are SAE J1939 Proprietary B PGN's except the address claim request and response.

7.2 Identifier Description

The J1939 protocol uses a 29-bit identifier. The 29-bit identifier is built up as follows:

- Bit 0-7 is Source Address (**SA**)
- Bit 8-23 is Parameter Group Number (**PGN**)
- Bit 24 is Data Page (**DP**)
- Bit 25 is Reserved (**R**)
- Bit 26-28 is Priority (**P**)

Table 7.2.1: J1939 CAN Identifier Structure

	29-bit IDENTIFIER																											
	Priority			**R**	**DP**	**P**arameter **G**roup **N**umber														**S**ource **A**ddress							
						PDU Format								PDU Specific														
CAN 29 Bit ID Position	29	28	27	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1

Each identifier has an associated 8-byte data field. The data field is built up as shown in Table 7.2.2.

Table 7.2.2: The Data Field Structure

DATA FIELD																													
BYTE 1								BYTE 2								BYTE 3-7								BYTE 8							
7	6	5	4	3	2	1	0	7	6	5	4	3	2	1	0	7	6	…		1	0	7	6	5	4	3	2	1	0

The Data Field is structured as Little Endian within the bytes, and Big Endian for the Data Field. This is visualized in Table 7.2.2 above.

7.3 UTS Communications

The UTS uses two communication message types: Global and Specific Address.

- **Global Message:** This is the operational “Broadcast mode” message for all the axis tilt information on the sensor. In these messages the unit broadcasts the outgoing data (status of each axis) on the J1939 bus.
- **Specific Address Message:** This is the “Service mode” message for the sensor. In these messages the UTS receives write and query messages to its node address from the J1939 bus.
  - ⚠ Ensure there is no loss of power while making programming changes with the UTS in service mode

7.4 Protocol Defaults

The default UTS settings are adjustable. The table below lists the default settings the sensor ships with. Please refer to Section 8 for examples on how to adjust these parameters. Refer to the tables in Section 7.5 for CAN message details

Table 7.4.1: Default Product Messages and Setup

Parameter	**159456-CL(D) / 160736-CL(C) / 162703-CL(A)**					
Typical Broadcast Message	**Start Position**	**Length**	**Type**	**Default Setting**		
Identifier	**(bit)**					
Source Address	0	1 byte	-	0xE2		
PGN	8	2 bytes	-	0xFFAB		
Data Page	24	1 bit	-	0		
Reserved	25	1 bit	-	0		
Priority	26	3 bits	-	6		
Data Field	**(byte)**					
X-axis tilt angle resolution	1	2 bytes	Signed int	0.006° per bit, 0x06		
Y-axis tilt angle resolution	3	2 bytes	Signed int	0.006° per bit, 0x06		
Temperature data	5	1 byte	Signed int	1° per bit		
SW Version type	6	1 byte	ASCII Char	‘P’ for Production		
SW version Major	7	1 byte	Unsigned int	2		
SW version Minor	8	1 byte	Unsigned int	3		
General Acknowledge Message	**(bit)**					
PGN	8	2 bytes	-	0xFFBC (only change from broadcast)		
Acknowledge data	0	8 bytes	-	Echo of write message received by UTS		
Software Features				**159456**	**160736**	**162703**
Data Broadcast Rate		-	-	10 Hz	10 Hz	50Hz
FIR filter		1 byte	Unsigned int	5 samples		
IIR filter weight percent		1 byte	Unsigned int	20 %		
Heavy IIR Rate limit		2 bytes	Unsigned int	983.025 °/s		
Heavy IIR filter weight percent		1 byte	Unsigned int	20 %		
Inclinometer Settling Time*		-	-	1 s	1 s	3 s
IIR Filter Settling Time*		-	-	1 s	1 s	3 s
Power to Broadcast Delay		-	-	110 ms (typ.)		

Note: If the cells are not split up into three identifying sections, then the cell applies to all three sensors.

*Settling times will fluctuate if filtering settings are changed

7.5 CAN Message Specification Tables

Table 7.5.1: Normal Broadcast Messages

Start Position	Length	Parameter Name		Format
PGN 0xEEFF (61183) – Address Claim Response Default Source Address = 0xE2				
1.0	21 bits	Manufacturing serial number		21-bit unsigned integer
3.5	11 bits	Mfg code		11-bit unsigned integer (71)
5	1 byte	ECU instance, Funct. instance		Bits 0-2: ECU instance, Bits 3-7: Function instance (0x00)
6	1 byte	Function		8-bit unsigned integer (0x88 – Slope sensor)
7	1 byte	Reserved, Vehicle system		Bit 0: Reserved, Bits 1-7: Vehicle system (0x00)
8	1 byte	Sys. inst., Ind. grp., Arb. addr.		Bits 0-3: System instance, Bits 4-6: Industry group, Bit 7: Arbitrary address (0x30)
PGN 0xFFAB (65451) – Output Data Frame Configurable PGN (see PGN 0xFFB2 in Table 7.5.5 to configure PGN)				
1	2 bytes	X axis tilt		16-bit signed integer, 0.006° per bit
3	2 bytes	Y axis tilt		16-bit signed integer, 0.006° per bit
5	1 byte	Temperature (°C)		8-bit signed integer, 1°C per bit
6	1 byte	SW version	Type	ASCII Char (‘P’ by default)
7	1 byte		Major	8-bit unsigned integer
8	1 byte		Minor	8 bit unsigned integer
PGN 0xFFD4 (65492) - Information Frame (Must enable subscription - see PGN 0xFFB4 in Table 7.5.5)				
1	1 byte	SW version type		ASCII Char ('P' for Production, 'B' for Beta)
2	1 byte	SW version major		8-bit unsigned integer
3	1 byte	SW version minor		8-bit unsigned integer
4	3 byte	Manufacturing serial number		21-bit unsigned integer (lowest 21 bits of 24-bit data)
7	1 byte	Temperature (°C)		8-bit signed integer, 1°C per bit
8	1 byte	Reserved		
PGN 0xEA00 (59904) – 0xEAFE (60158) - Address Claim Request				
1	1 byte	PGN		0x00
2	1 byte	PGN (PF)		0xEA (Address claim)
3	1 byte	PGN (PS)		UTS source address, valid range: 0x00 to 0xFE, must match the destination address in the PGN
Note: Data length in this message is expected to be 3 bytes				

Table 7.5.2: General Acknowledge Message

Generic Acknowledge Message Transmitted by UTS			
Start Position	**Length**	**Parameter Name**	**Format**
PGN 0xFFBC (65468) - Generic Acknowledge			
1	8 bytes	Acknowledge data	Echo of write message (PGN 0xFFBx) data received by UTS, in original data format

Table 7.5.3: Service Mode Enable/Disable Message

Service Mode Enable Message			
Start Position	**Length**	**Parameter Name**	**Format**
PGN 0xFFB0 (65456) - Service Mode Enable / Disable **(Data received by the UTS is echoed back on generic acknowledge PGN 0xFFBC - see Table 7.5.2)**			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	4 bytes	Service mode enable	0x9B4DE72A = service mode enabled, other = service mode disabled
6	3 bytes	Reserved	

Table 7.5.4: Write Messages Received by UTS 1 – Set Source Address

Write Messages Received by UTS: • **The UTS only receives write messages when service mode is enabled using PGN 0xFFB0** • **Target UTS address is the CAN source address of the UTS that should receive the write message** • **Data received by the UTS is echoed back on generic acknowledge PGN 0xFFBC - see Table 7.5.2** • **Configuration settings written to the UTS in service mode are not applied until PGN 0xFFBF is received by the UTS or power is cycled**			
Start Position	**Length**	**Parameter Name**	**Format**
PGN 0xFFB1 (65457) - Set Source Address			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	New source address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
3	6 bytes	Reserved	

Table 7.5.5: Write Messages Received by UTS 2 – Configure PGN, Set Offset, Subscribe to Information

Start Position	Length	Parameter Name	Format
PGN 0xFFB2 (65458) - Configure Output PGN Settings			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	Output PGN broadcast interval	8-bit unsigned integer, 10ms per bit with 0ms offset, 20ms minimum
3	2 bytes	Output data frame PGN	16-bit unsigned integer, valid range: 0xFF00 to 0xFFAF and 0xFFE0 to 0xFFFF
4	1 byte	Output data frame PGN priority	8-bit unsigned integer, valid range: 0 (highest priority) to 7 (lowest priority)
5	1 byte	Tilt angle data resolution	8-bit unsigned integer, 0.001° per bit, 0.006° (0x06) minimum, resolution of angle data in output data frame.
7	2 bytes	Reserved	
PGN 0xFFB3 (65459) - Set Offset Adjustment			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	Tilt selection	1 = X axis, 2 = Y axis, 3 = Z axis
3	2 bytes	Offset adjustment	16-bit signed integer, 0.006° per bit, positive value increases offset
5	4 bytes	Reserved	
PGN 0xFFB4 (65460) - Subscribe to Information Frame			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	Subscription	1 = subscribe to information frame, other = unsubscribe from information frame
3	1 byte	Information broadcast interval	8-bit unsigned integer, 10ms per bit with 0ms offset, 20ms minimum
4	5 bytes	Reserved	

Table 7.5.6: Write Messages Received by UTS 3 – Output Filter, Apply Configuration

Start Position	Length	Parameter Name	Format
PGN 0xFFB5 (65461) - Set Output Filter Settings			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	FIR samples	8-bit unsigned integer, valid range: 1 to 45, higher value increases FIR filtering
3	1 byte	IIR filter weight percent	8-bit unsigned integer, valid range: 1 to 100, lower value increases IIR filtering
4	2 bytes	Heavy IIR rate limit	16-bit unsigned integer, 0.015 °/s per bit with 0 °/s offset, tilt rate above which heavy IIR filter is applied
6	1 byte	Heavy IIR filter weight percent	8-bit unsigned integer, valid range: 1 to 100, lower value increases heavy IIR filtering
7	2 bytes	Reserved	
PGN 0xFFBF (65471) - Apply Configuration Settings (Configuration settings written to UTS are not applied until PGN 0xFFBF is received or power is cycled)			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	

Note:

The UTS can have multiple commands sent to it while in service mode. An, “apply configuration settings” message (PGN 0xFFBF) must be sent after every configuration change command (except for source address changes)

Table 7.5.7: Query Messages Received by UTS

Query Messages Received by UTS:

- **The UTS only receives query messages when service mode is enabled using PGN 0xFFB0**
- **Target UTS address is the CAN source address of the UTS that should receive the query message**
- **The UTS replies with queried data on the corresponding reply message (PGN 0xFFDx)**

Start Position	Length	Parameter Name	Format
PGN 0xFFC1 (65473) - Query Source Address			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	
PGN 0xFFC2 (65474) - Query Output PGN Settings			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	
PGN 0xFFC3 (65475) - Query Offset Adjustment			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	Tilt selection	1 = X axis, 2 = Y axis, 3 = Z axis
3	6 bytes	Reserved	
PGN 0xFFC4 (65476) - Query Information Frame			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	
PGN 0xFFC5 (65477) - Query Output Filter Settings			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	

Table 7.5.8: Reply Messages Transmitted by UTS

Reply Messages Transmitted by UTS: • **The UTS only sends reply messages when service mode is enabled using PGN 0xFFB0** • **The UTS replies with queried data on PGN 0xFFDx when a corresponding query message is received on PGN 0xFFCx** • **Source address is the CAN source address of the responding UTS**			
Start Position	**Length**	**Parameter Name**	**Format**
PGN 0xFFD1 (65489) - Source Address			
1	1 byte	Source address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	
PGN 0xFFD2 (65490) - Output PGN Settings			
1	1 byte	Target UTS address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	7 bytes	Reserved	
PGN 0xFFD3 (65491) - Offset Adjustment			
1	1 byte	Source Address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	Output PGN broadcast interval	8-bit unsigned integer, 10ms per bit with 0ms offset, 20ms minimum
3	2 bytes	Output data frame PGN	16-bit unsigned integer, valid range: 0xFF00 to 0xFFAF and 0xFFE0 to 0xFFFF
5	1 byte	Output data PGN priority	8-bit unsigned integer, valid range: 0 (highest priority) to 7 (lowest priority)
6	1 byte	Tilt angle data resolution	8-bit unsigned integer, 0x001° per bit, 0.006° minimum (0x06), resolution of angle data in output data frame.
7	2 bytes	Reserved	
PGN 0xFFD4 (65492) - Information Frame			
1	1 byte	SW version type	ASCII Char ('P' for Production, 'B' for Beta)
2	1 byte	SW version major	8-bit unsigned integer
3	1 byte	SW version minor	8-bit unsigned integer
4	3 bytes	Manufacturing serial number	21-bit unsigned integer (lowest 21 bits of 24-bit data)
7	1 byte	Temperature (°C)	8-bit signed integer, 1°C per bit
8	1 byte	Reserved	
PGN 0xFFD5 (65493) - Output Filter Settings			
1	1 byte	Source address	8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address
2	1 byte	FIR samples	8-bit unsigned integer, valid range: 1 to 45, higher value increases FIR filtering
3	1 byte	IIR filter weight percent	8-bit unsigned integer, valid range: 1 to 100, lower value increases IIR filtering
4	2 bytes	Heavy IIR rate limit	16-bit unsigned integer, 0.015 °/s per bit with 0 °/s offset, tilt rate above which heavy IIR filter is applied
6	1 byte	Heavy IIR filter weight percent	8-bit unsigned integer, valid range: 1 to 100, lower value increases heavy IIR filtering
7	2 bytes	Reserved	

8 Application Examples/How Do I…

8.1 Transmitting a command

If the user is broadcasting messages through a tool, then it is possible that the entire 29-bit identifier needs to be set. In a case like this, the typical CAN extended (29-bit) identifier is broken down below

Table 8.1.1: CAN Extended Identifier Example

P/R/DP	PGN	SA
18	FFB0	FF

- **P/R/DP**: Priority, Reserved, Data Page – A value of **18** is typical for a broadcast message.
- **PGN**: Parameter Group Number – This section changes based on the command sent to the UTS.
- **SA**: Source Address – This section, set to **FF**, can be set to anything. FF was used as it is the SA of the tools used.

Using an Identifier of 18xxxxF0, with the x's replaced by the PGN specified in the examples can be used for the following examples.

8.2 Change the UTS source address

Instructions

1. Put UTS into Service mode – PGN 0xFFB0
2. Set UTS source address – PGN 0xFFB1
3. Exit Service mode – PGN 0xFFB0

EXAMPLE - CHANGE THE UTS SOURCE ADDRESS FROM 0XE2 TO 0XE3

1. Send PGN 0xFFB0 (service mode enable) –
   Data bytes: E2 2A E7 4D 9B FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 2A E7 4D 9B FF FF FF

2. Send PGN 0xFFB1 (set source address) –
   Data bytes: E2 E3 FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 E3 FF FF FF FF FF FF

3. Send PGN 0xFFB0 (service mode disable) –
   Data bytes: E3 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E3 FF FF FF FF FF FF FF

   Notes:
   - The UTS source address is changed immediately after receiving PGN 0xFFB1 (set source address) and does not require the use of PGN 0xFFBF (apply configuration settings).
   - 0xFE is the NULL address. The UTS will not broadcast the output data frame if the source address is changed to 0xFE.

8.3 Change the PGN of the output data frame

Instructions

1. Put UTS into Service mode - PGN 0xFFB0
2. Query the current output PGN settings from UTS - PGN 0xFFC2
3. Change the output data frame PGN and set the new output PGN settings - PGN 0xFFB2
4. Apply configuration settings - PGN 0xFFBF
5. Exit Service mode - PGN 0xFFB0

EXAMPLE - CHANGE THE PGN OF THE OUTPUT DATA FRAME TO 0XFFAC (UTS SOURCE ADDRESS = 0XE2)

1. Send PGN 0xFFB0 (service mode enable) –
   Data bytes: E2 2A E7 4D 9B FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 2A E7 4D 9B FF FF FF

2. Send PGN 0xFFC2 (query output PGN settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFD2 (output PGN settings) –
   Data bytes: E2 0A AB FF 06 06 FF FF
   The 3rd and 4th data bytes are the output data frame PGN: 3rd byte = 0xAB; 4th byte = 0xFF; PGN = 0xFFAB

3. Send PGN 0xFFB2 (set output PGN settings) –
   Data bytes: E2 0A AC FF 06 06 FF FF
   The 3rd and 4th data bytes are the output data frame PGN: 3rd byte = 0xAC; 4th byte = 0xFF; PGN = 0xFFAC
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 0A AC FF 06 06 FF FF

4. Send PGN 0xFFBF (apply configuration settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

5. Send PGN 0xFFB0 (service mode disable) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

   Notes:
   - Valid values for the PGN of the output data frame are 0xFF00 to 0xFFAF and 0xFFE0 to 0xFFFF.

8.4 Adjust the zero-tilt reading (offset) of the output data

Instructions

1. Put UTS into Service mode - PGN 0xFFB0
2. Query the current offset adjustment from UTS - PGN 0xFFC3
3. Add desired zero-tilt adjustment to current offset adjustment and set new offset adjustment - PGN 0xFFB3
4. Apply configuration settings - PGN 0xFFBF
5. Exit Service mode - PGN 0xFFB0

EXAMPLE - CHANGE THE PGN OF THE OUTPUT DATA FRAME TO 0XFFAC (UTS SOURCE ADDRESS = 0XE2)

1. Send PGN 0xFFB0 (service mode enable) –
   Data bytes: E2 2A E7 4D 9B FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 2A E7 4D 9B FF FF FF

2. Send PGN 0xFFC3 (query offset adjustment) –
   Data bytes: E2 01 FF FF FF FF FF FF
   2nd data byte is the tilt angle selection: 0x01 = X-axis (0x02 = Y-axis, 0x03 = Z-axis)
   UTS responds with PGN 0xFFD3 (offset adjustment) –
   Data bytes: E2 0A AB FF 06 06 FF FF
   The 3rd and 4th data bytes are the current offset adjustment: 3rd byte = 0xAB; 4th byte = 0xFF; offset adjustment = 0xFFAB = -85 bits X 0.006° per bit = -0.510°

3. Send PGN 0xFFB3 (set offset adjustment) –
   Data bytes: E2 01 8A FF FF FF FF FF
   Current X-axis reading is 0.2° too high, so desired zero-tilt adjustment is -0.2°
   New offset adjustment = -0.510° + (-0.2°) = -0.710° / 0.006° per bit = -118 bits = 0xFF8A (signed integer).
   The 3rd and 4th data bytes are the new offset adjustment: 3rd byte = 0x8A; 4th byte = 0xFF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 01 8A FF FF FF FF FF

4. Send PGN 0xFFBF (apply configuration settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

5. Send PGN 0xFFB0 (service mode disable) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

   Notes:
   - A positive offset adjustment value increases the zero-tilt reading (offset) while a negative value decreases the zero-tilt reading.

8.5 Enable the information frame to broadcast software version, serial number and temperature data

Instructions

1. Put UTS into Service mode - PGN 0xFFB0
2. Subscribe to the information frame - PGN 0xFFB4
3. Apply configuration settings - PGN 0xFFBF
4. Exit Service mode - PGN 0xFFB0

EXAMPLE – ENABLE THE INFORMATION FRAME WITH A BROADCAST INTERVAL OF 100 MS (UTS SOURCE ADDRESS = 0XE2)

1. Send PGN 0xFFB0 (service mode enable) –
   Data bytes: E2 2A E7 4D 9B FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 2A E7 4D 9B FF FF FF

2. Send PGN 0xFFB4 (subscribe to information frame) –
   Data bytes: E2 01 0A FF FF FF FF FF
   2nd data byte determines information frame subscription: 0x01 = subscribe (anything else = unsubscribe)
   3rd data byte is information frame broadcast interval: 0x0A = 10 bits X 10 ms per bit = 100 ms (10 Hz)

   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 01 0A FF FF FF FF FF

3. Send PGN 0xFFBF (apply configuration settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

4. Send PGN 0xFFB0 (service mode disable) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

Enabling the information frame will result in a repeated message with content resembling Table 8.4.1.

Table 8.5.1: Example Information Data Frame

Data Bytes	50	02	03	01 30 0D	19	01
Function	SW Version			Manufacturing Serial Number	Temp °C	Reserved
	Type	Major	Minor			
Value	P	2	3	77837	25	1

Notes:

- The minimum broadcast interval of the information frame is 20 ms (50 Hz).
- The sensor's software version, serial number and temperature are broadcast on PGN 0xFFD4.
- The source address of the sensor is 0xE2 by default.

8.6 Adjust the internal filtering of the UTS (Example 1)

Instructions

1. Put UTS into Service mode - PGN 0xFFB0
2. Query the current output filter settings from UTS - PGN 0xFFC5
3. Change the desired filter settings and set the new output filter settings - PGN 0xFFB5
4. Apply configuration settings - PGN 0xFFBF
5. Exit Service mode - PGN 0xFFB0

EXAMPLE 1 - INCREASE OUTPUT DAMPENING BY INCREASING FIR SAMPLES (UTS SOURCE ADDRESS = 0XE2)

1. Send PGN 0xFFB0 (service mode enable) –
   Data bytes: E2 2A E7 4D 9B FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 2A E7 4D 9B FF FF FF

2. Send PGN 0xFFC5 (query output filter settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFD5 (output filter settings) –
   Data bytes: E2 05 14 FF FF 14 FF FF
   2nd data byte is the number of FIR samples: FIR samples = 0x05 = 5 samples

3. Send PGN 0xFFB5 (set output filter settings) –
   Data bytes: E2 19 14 FF FF 14 FF FF
   2nd data byte is the number of FIR samples: FIR samples = 0x19 = 25 samples
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 19 14 FF FF 14 FF FF

4. Send PGN 0xFFBF (apply configuration settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

5. Send PGN 0xFFB0 (service mode disable) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

8.7 Adjust the internal filtering of the UTS (Example 2)

Instructions

1. Put UTS into Service mode - PGN 0xFFB0
2. Query the current output filter settings from UTS - PGN 0xFFC5
3. Change the desired filter settings and set the new output filter settings - PGN 0xFFB5
4. Apply configuration settings - PGN 0xFFBF
5. Exit Service mode - PGN 0xFFB0

EXAMPLE 2 - INCREASE OUTPUT RESPONSIVENESS BY INCREASING IIR FILTER WEIGHT PERCENT (UTS SOURCE ADDRESS = 0XE2)

1. Send PGN 0xFFB0 (service mode enable) –
   Data bytes: E2 2A E7 4D 9B FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 2A E7 4D 9B FF FF FF

2. Send PGN 0xFFC5 (query output filter settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFD5 (output filter settings) –
   Data bytes: E2 05 14 FF FF 14 FF FF
   3rd data byte is the IIR filter weight percent: IIR filter weight = 0x14 = 20%

3. Send PGN 0xFFB5 (set output filter settings) –
   Data bytes: E2 05 32 FF FF 14 FF FF
   3rd data byte is the IIR filter weight percent: IIR filter weight = 0x32 = 50%
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 05 32 FF FF 14 FF FF

4. Send PGN 0xFFBF (apply configuration settings) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

5. Send PGN 0xFFB0 (service mode disable) –
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFBC (acknowledge) –
   Data bytes: E2 FF FF FF FF FF FF FF

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9 Performance Considerations

The UTS is an angle sensor that uses an accelerometer to calculate changes in orientation. There are a few factors that may influence the operation.

Vibrations
Due to the use of high-resolution accelerometers, vibrations can cause interference in certain applications. Once the device is installed, it is recommended to operate all functions that may cause sudden vibrations/shock across the vehicle to ensure regular operation is not interrupted. These instances will be picked up by the UTS as angular changes and could have an adverse effect on regular operation depending on the application.

If it is determined that there is interference due to vibration, here are some solutions to investigate:

- Ensure consistency with mounting recommendations outlined in this document is maintained
- Increase programable filtering
- Reduce the output resolution
- Add vibration isolation (rubber dampeners)
- Increase thickness of mounting surface
- Reduce the vibrations from the source
- Relocate the sensor to an area of lower vibration
- Avoid installing the UTS in areas that are susceptible to large sonic vibrations

Operation at Extreme Linear Limits
It is recommended to avoid using extreme linear limits for critical angular measurements. Consider setting up an operated range that is enclosed by a diagnostic zone at the limits of angular range. It is common practice to allow 5-10% of the full range for these zones.

Signed Integers
The UTS broadcasts tilt angles using signed 16-bit integers.

Using multiple sensors on the same CAN bus system
Each UTS will need to have a unique source address.

10 FAQ

The FAQ for UTS can be found at http://blog.parker.com/faqs for additional product support.

MSG33-2374-UM 6/2019

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