Universal Tilt Sensor
J1939 protocol
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1 Introduction

These instructions are to be used as a reference tool for the vehicle manufacturer’s design, production, and service personnel. The user of these instructions should have basic knowledge in the handling of electronic equipment.

Overview
The UTS is a multi-axis tilt sensor that uses CAN messages to report its angular position. This document is intended to define the CAN messages supported by UTS v2 products.

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

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>UTS</td>
<td>Universal Tilt Sensor</td>
</tr>
<tr>
<td>CAN</td>
<td>Controller Area Network</td>
</tr>
<tr>
<td>PGN</td>
<td>Parameter Group Number</td>
</tr>
<tr>
<td>SAE</td>
<td>Society of Automotive Engineers</td>
</tr>
<tr>
<td>FIR</td>
<td>Finite Impulse Response</td>
</tr>
<tr>
<td>IIR</td>
<td>Infinite Impulse Response</td>
</tr>
</tbody>
</table>

Product documentation
The following publications are relevant for users of this product.

• UTS Catalog datasheet HY33-2374/US
• UTS Installation sheet HY33-2374-IS/US

All documentation may be found on our web pages, located at www.parker.com/ecd. 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.
2 Protocol description

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.

![The Universal Tilt Sensor (UTS).](image)

**Identifier Description**

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

- Bit 1-8 is *SA* Source Address
- Bit 9-24 is *PGN* Parameter Group Number
- Bit 25 is *DP* Data Page, default=Zero
- Bit 26 is *R* Reserved, default=Zero
- Bit 27-29 is *P* Priority

<table>
<thead>
<tr>
<th>Priority</th>
<th>R</th>
<th>DP</th>
<th>Parameter Group Number</th>
</tr>
</thead>
<tbody>
<tr>
<td>29</td>
<td>28</td>
<td>27</td>
<td>26</td>
</tr>
<tr>
<td>25</td>
<td>24</td>
<td>23</td>
<td>22</td>
</tr>
<tr>
<td>21</td>
<td>20</td>
<td>19</td>
<td>18</td>
</tr>
<tr>
<td>17</td>
<td>16</td>
<td>15</td>
<td>14</td>
</tr>
<tr>
<td>13</td>
<td>12</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>9</td>
<td>8</td>
<td>7</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>4</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

The identifier structure.

Each identifier has an associated 8-byte data field. The data field is built up as follows.

<table>
<thead>
<tr>
<th>DATA FIELD</th>
</tr>
</thead>
<tbody>
<tr>
<td>BYTE 8</td>
</tr>
<tr>
<td>8 7 6 5 4 3 2 1</td>
</tr>
</tbody>
</table>

The data field structure.
UTS Communications
The UTS uses two communication message types, Global and Specific Address.

Global message
This is the operational 'Broadcast mode’ message for all of 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.

CAN Message specification tables

Normal 'Broadcast Mode’ messages (Table 1)

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGN 0xEEFF (61183) - Address Claim Response</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>21 bits</td>
<td>Manufacturing serial number</td>
<td>21-bit unsigned integer</td>
</tr>
<tr>
<td>2.5</td>
<td>11 bits</td>
<td>Manufacturer code</td>
<td>11-bit unsigned integer (71 - Vansco)</td>
</tr>
<tr>
<td>4</td>
<td>1 byte</td>
<td>ECU instance, Function instance</td>
<td>Bits 0-2: ECU instance, Bits 3-7: Function instance (0x00)</td>
</tr>
<tr>
<td>5</td>
<td>1 byte</td>
<td>Function</td>
<td>8-bit unsigned integer (0x88 - Slope sensor)</td>
</tr>
<tr>
<td>6</td>
<td>1 byte</td>
<td>Reserved, Vehicle system</td>
<td>Bit 0: Reserved, Bits 1-7: Vehicle system (0x00)</td>
</tr>
<tr>
<td>7</td>
<td>1 byte</td>
<td>Sys. inst., Ind. group., Arb. addr.</td>
<td>Bits 0-3: System instance, Bits 4-6: Industry group, Bit 7: Arbitrary address (0x30)</td>
</tr>
</tbody>
</table>

PGN 0xFF00 (65280) to 0xFFFF (65535), excluding 0xFFB0 to 0xFFDF - Output Data Frame
(Specific PGN is configurable - see PGN 0xFFB2 in Table 3)

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>2 bytes</td>
<td>Output data 1</td>
<td>16-bit signed integer, Angle: ° per bit set by PGN 0xFFB2, Rate: 0.015 °/s per bit, Acceleration: 0.05 mg per bit</td>
</tr>
<tr>
<td>2</td>
<td>2 bytes</td>
<td>Output data 2</td>
<td>16-bit signed integer, Angle: ° per bit set by PGN 0xFFB2, Rate: 0.015 °/s per bit, Acceleration: 0.05 mg per bit</td>
</tr>
<tr>
<td>4</td>
<td>2 bytes</td>
<td>Output data 3</td>
<td>16-bit signed integer, Angle: ° per bit set by PGN 0xFFB2, Rate: 0.015 °/s per bit, Acceleration: 0.05 mg per bit</td>
</tr>
<tr>
<td>6</td>
<td>2 bytes</td>
<td>Output data 4</td>
<td>16-bit signed integer, Angle: ° per bit set by PGN 0xFFB2, Rate: 0.015 °/s per bit, Acceleration: 0.05 mg per bit</td>
</tr>
</tbody>
</table>

Note: Output data parameters 1-4 are configured according to UTS drawing during manufacturing
### CAN Message specification tables

#### 2 Protocol description

**Generic acknowledge message (Table 2)**

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Generic acknowledge Message transmitted by UTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PGN 0xEEFF (61183) - Address Claim Request</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>PGN</td>
<td>0x00</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>PGN (PF)</td>
<td>0xEA (Address claim)</td>
</tr>
<tr>
<td>2</td>
<td>1 byte</td>
<td>PGN (PS)</td>
<td>UTS source address, valid range: 0x00 to 0xFE, must match the destination address in the PGN</td>
</tr>
</tbody>
</table>

Note: Data length in this message is expected to be 3 bytes

### Service Mode messages (Table 3)

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Service Mode enable/disable message received by UTS</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>PGN 0xFFB0 (65456) - Service Mode Enable / Disable</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>4 bytes</td>
<td>Service mode enable</td>
<td>0x9B4DE72A = service mode enabled, other = service mode disabled</td>
</tr>
<tr>
<td>5</td>
<td>3 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

Instruction book, UTS Protocol
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 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

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td><strong>PGN 0xFFB1 (65457) - Set Source Address</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>New source address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>2</td>
<td>6 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>PGN 0xFFB2 (65458) - Set Output PGN Settings</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>Output PGN broadcast interval</td>
<td>8-bit unsigned integer, 10ms per bit with 0ms offset, 20ms minimum</td>
</tr>
<tr>
<td>2</td>
<td>2 bytes</td>
<td>Output data frame PGN</td>
<td>16-bit unsigned integer, valid range: 0xFF00 to 0xFFAF and 0xFFFF to 0xFFFF</td>
</tr>
<tr>
<td>4</td>
<td>1 byte</td>
<td>Tilt angle data resolution</td>
<td>8-bit unsigned integer, 0.001° per bit, 0.006° minimum, resolution of angle data in output data frame</td>
</tr>
<tr>
<td>6</td>
<td>2 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>PGN 0xFFB3 (65459) - Set Offset Adjustment</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>Tilt selection</td>
<td>1 = X axis, 2 = Y axis, 3 = Z axis</td>
</tr>
<tr>
<td>2</td>
<td>2 bytes</td>
<td>Offset adjustment</td>
<td>16-bit signed integer, 0.006° per bit, positive value increases offset</td>
</tr>
<tr>
<td>4</td>
<td>4 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td><strong>PGN 0xFFB4 (65460) - Subscribe to Information Frame</strong></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>Subscription</td>
<td>1 = subscribe to information frame, other = unsubscribe from information frame</td>
</tr>
<tr>
<td>2</td>
<td>1 byte</td>
<td>Information broadcast interval</td>
<td>8-bit unsigned integer, 10ms per bit with 0ms offset, 20ms minimum</td>
</tr>
<tr>
<td>3</td>
<td>5 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>
### CAN Message specification tables

### Protocol description

**PGN 0xFFB5 (65461) - Set Output Filter Settings**

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>FIR samples</td>
<td>8-bit unsigned integer, valid range: 1 to 45, higher value increases FIR filtering</td>
</tr>
<tr>
<td>2</td>
<td>1 byte</td>
<td>IIR filter weight percent</td>
<td>8-bit unsigned integer, valid range: 1 to 100, lower value increases IIR filtering</td>
</tr>
<tr>
<td>3</td>
<td>2 bytes</td>
<td>Heavy IIR rate limit</td>
<td>16-bit unsigned integer, 0.015 °/s per bit with 0 °/s offset, tilt rate above which heavy IIR filter is applied</td>
</tr>
<tr>
<td>5</td>
<td>1 byte</td>
<td>Heavy IIR filter weight percent</td>
<td>8-bit unsigned integer, valid range: 1 to 100, lower value increases heavy IIR filtering</td>
</tr>
<tr>
<td>6</td>
<td>2 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

**PGN 0xFFFFB (65471) - Apply Configuration Settings** (Configuration settings written to UTS are not applied until PGN 0xFFFFB is received or power is cycled)

<p>| | | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>7 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

**Query Messages received by UTS:**

- The UTS only receives query messages when service mode is enabled using PGN 0xFFFFB0
- 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 0xFFFFDx)

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>PGN 0xFFC1 (65473) - Query Source Address</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>7 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

| PGN 0xFFC2 (65474) - Query Output PGN Settings |
| 0 | 1 byte | Target UTS address | 8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address |
| 1 | 7 bytes | Reserved |   |

| PGN 0xFFC3 (65475) - Query Offset Adjustment |
| 0 | 1 byte | Target UTS address | 8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address |
| 1 | 1 byte | Tilt selection | 1 = X axis, 2 = Y axis, 3 = Z axis |
| 2 | 6 bytes | Reserved |   |

| PGN 0xFFC4 (65476) - Query Information Frame |
| 0 | 1 byte | Target UTS address | 8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address |
| 1 | 7 bytes | Reserved |   |

| PGN 0xFFC5 (65477) - Query Output Filter Settings |
| 0 | 1 byte | Target UTS address | 8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address |
| 1 | 7 bytes | Reserved |   |
**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

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Source address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>7 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

**PGN 0xFFD2 (65490) - Output PGN Settings**

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Target UTS address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>7 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

**PGN 0xFFD3 (65491) - Offset Adjustment**

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Source address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>Tilt selection</td>
<td>1 = X axis, 2 = Y axis, 3 = Z axis</td>
</tr>
<tr>
<td>2</td>
<td>6 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

**PGN 0xFFD4 (65492) - Information Frame**

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>SW version type</td>
<td>ASCII Char ('P' for Production, 'B' for Beta)</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>SW version major</td>
<td>8-bit unsigned integer</td>
</tr>
<tr>
<td>2</td>
<td>1 byte</td>
<td>SW version minor</td>
<td>8-bit unsigned integer</td>
</tr>
<tr>
<td>3</td>
<td>3 bytes</td>
<td>Manufacturing serial number</td>
<td>21-bit unsigned integer (lowest 21 bits of 24-bit data)</td>
</tr>
<tr>
<td>6</td>
<td>1 byte</td>
<td>Temperature (°C)</td>
<td>8-bit signed integer, 1°C per bit</td>
</tr>
<tr>
<td>7</td>
<td>1 byte</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>

**PGN 0xFFD5 (65493) - Output Filter Settings**

<table>
<thead>
<tr>
<th>Start position</th>
<th>Length</th>
<th>Parameter name</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>1 byte</td>
<td>Source address</td>
<td>8-bit unsigned integer, valid range: 0x00 to 0xFE, 0xFE = NULL address</td>
</tr>
<tr>
<td>1</td>
<td>1 byte</td>
<td>FIR samples</td>
<td>8-bit unsigned integer, valid range: 1 to 45, higher value increases FIR filtering</td>
</tr>
<tr>
<td>2</td>
<td>2 bytes</td>
<td>Heavy IIR rate limit</td>
<td>16-bit unsigned integer, 0.015 °/s per bit with 0 °/s offset, tilt rate above which heavy IIR filter is applied</td>
</tr>
<tr>
<td>5</td>
<td>1 byte</td>
<td>Heavy IIR filter weight percent</td>
<td>8-bit unsigned integer, valid range: 1 to 100, lower value increases heavy IIR filtering</td>
</tr>
<tr>
<td>6</td>
<td>2 bytes</td>
<td>Reserved</td>
<td></td>
</tr>
</tbody>
</table>
3 Application examples

How do I...

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.
Change the broadcast interval (or rate) 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 broadcast interval and set the new output PGN settings - PGN 0xFFB2
4. Apply configuration settings - PGN 0xFFBF
5. Exit Service mode - PGN 0xFFB0

Example - Change the broadcast interval of the output data frame to 20 ms (UTS source address = 0x2E)
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
   2nd data byte is output data frame broadcast interval: 0xA = 10 bits x 10 ms per bit = 100 ms (10 Hz rate)

3. Send PGN 0xFFB2 (set output PGN settings) -
   Data bytes: E2 02 AB FF 06 06 FF FF
   UTS responds with PGN 0xFFBC (acknowledge) -
   Data bytes: E2 02 AB 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:
- The minimum broadcast interval of the output data frame is 20 ms (50 Hz rate).
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
   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.
Change the priority of the output data frame PGN

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 priority and set the new output PGN settings - PGN 0xFFB2
4. Apply configuration settings - PGN 0xFFBF
5. Exit Service mode - PGN 0xFFB0

EXAMPLE - CHANGE THE PRIORITY OF THE OUTPUT DATA FRAME PGN TO 4 (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
   5th data byte is the output data frame PGN priority: PGN priority = 0x06 = 6

3. Send PGN 0xFFB2 (set output PGN settings) -
   Data bytes: E2 0A AB FF 04 06 FF FF
   5th data byte is the output data frame PGN priority: PGN priority = 0x04 = 4
   UTS responds with PGN 0xFFBC (acknowledge) -
   Data bytes: E2 0A AB FF 04 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 priority of the output data frame PGN are 0 (highest priority) to 7 (lowest priority).
Change the resolution of the tilt angle output data

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

EXAMPLE - CHANGE THE RESOLUTION OF THE TILT ANGLE OUTPUT DATA TO 0.01° (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
   6th data byte is the tilt angle data resolution: 0x06 = 6 bits X 0.001° per bit = 0.006°

3. Send PGN 0xFFB2 (set output PGN settings) -
   Data bytes: E2 0A AB FF 06 0A FF FF
   6th data byte is the tilt angle data resolution: 0x0A = 10 bits X 0.001° per bit = 0.01°
   UTS responds with PGN 0xFFBC (acknowledge) -
   Data bytes: E2 0A AB FF 06 0A 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
- The minimum resolution of the tilt angle output data is 0.006°.
How do I…

3  Application examples

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 - ADJUST X-AXIS FOR ZERO-TILT READING OF 0.2° (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 01 0C 00 FF FF FF FF
   The 3rd and 4th data bytes are the current offset adjustment: 3rd byte = 0x0C;
   4th byte = 0x00; offset adjustment = 0x000C = 12 bits X 0.006° per bit = 0.072°

3  Send PGN 0xFFB3 (set offset adjustment) -
   Data bytes: E2 01 EB 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 = 0.072° + (-0.2°) = -0.128° / 0.006° per bit = -21 bits = 0xFFEB
   (signed integer)
   The 3rd and 4th data bytes are the new offset adjustment: 3rd byte = 0xEB;
   4th byte = 0xFF
   UTS responds with PGN 0xFFBC (acknowledge) -
   Data bytes: E2 01 EB 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.
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 rate)
   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

Notes
• The minimum broadcast interval of the information frame is 20 ms (50 Hz rate).
• The sensor's software version, serial number and temperature are broadcast on PGN 0xFFD4.
Get software version, serial number and temperature without broadcasting the information frame

Instructions
1. Put UTS into Service mode - PGN 0xFFB0
2. Query the information frame - PGN 0xFFC4
3. Exit Service mode - PGN 0xFFB0

Example - Read the temperature by querying the information frame (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 0xFFC4 (query information frame) -
   Data bytes: E2 FF FF FF FF FF FF FF
   UTS responds with PGN 0xFFD4 (information frame) -
   Data bytes: 50 02 03 01 30 0D 19 01
   7th data byte is the temperature: 0x19 = 25 bits X 1°C per bit = 25°C
3. 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
• The sensor's software version, serial number and temperature are provided on PGN 0xFFD4.
Adjust the internal filtering of the UTS

Description of UTS filtering

- 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.

- 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.

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
How do I...

3 Application examples

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**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
**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 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
**EXAMPLE 3 - REDUCE LARGE NOISE SPIKES BY IMPLEMENTING THE HEAVY IIR FILTER (UTS SOURCE ADDRESS = 0x2E)**

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 14 FF FF
   *6th data byte is the heavy IIR filter weight percent: heavy IIR filter weight = 0x14 = 20%*
   *The 4th and 5th data bytes are the heavy IIR rate limit: 4th byte = 0xFF; 5th byte = 0xFF; heavy IIR rate limit = 0xFFFF = 65,535 bits X 0.015 °/s per bit = 983.025 °/s*

3. Send PGN 0xFFB5 (set output filter settings) -
   Data bytes: E2 05 14 4D 01 05 FF FF
   *6th data byte is the heavy IIR filter weight percent: heavy IIR filter weight = 0x05 = 5%*
   *The 4th and 5th data bytes are the heavy IIR rate limit: 4th byte = 0x4D; 5th byte = 0x01; heavy IIR rate limit = 0x014D = 333 bits X 0.015 °/s per bit = 4.995 °/s*
   UTS responds with PGN 0xFFBC (acknowledge) -
   Data bytes: E2 05 14 4D 01 05 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**

- 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 maximum 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.