1. SPI Protocol

This document reflects the Novotechnik sensor protocol implementation of the standard SPI protocol. A basic knowledge of the SPI bus is required for a proper understanding of this document.

1.1 Bus Topology

SPI communication with only 1 slave:

![Diagram of SPI communication with one slave]

SPI communication with more than 1 slave:

![Diagram of SPI communication with multiple slaves]
1.2 Electrical Characteristics
The serial protocol of Novotechnik Multi turn sensors is a three wires protocol (/SS, SCLK, MISO).

The rotary sensor is considered as a slave mode:
- /SS pin is a 3.3 V (5V tolerant) digital input
- SCLK pin is a 3.3 V (5V tolerant) digital input
- MISO pin is a 5V digital output

1.3 SPI Mode
Clock phase CPHA = 1 even clock changes are used to sample the data
Clock polarity CPOL = 0 active high clock
The positive going edge shifts a bit to the slave’s output stage and the negative going edge samples the bit at the master’s input stage.

1.4 MISO (Master In, Slave Out)
The MISO of the slave is a tri state output.

1.5 /SS Slave Select
The /SS pin enables a frame transfer (if CPHA = 1). It allows a re-synchronisation between slave and master in case of communication error.

1.6 Master Start-up
/SS, SCLK, MISO can be undefined during the master start-up as long as the slave is re-synchronized before the first frame transfer.

1.7 Slave Start-up
The slave start-up (after power-up or an internal failure) takes 15 ms. Within this time /SS and SCLK is ignored by the slave. The first frame can therefore be sent after 15 ms. MISO is high-impedant until the slave is selected by its /SS input.

1.8 Timing
To synchronize communication, the master deactivates /SS high for at least 1 µs. In this case, the slave will be ready to receive a new frame.

The master can re-synchronize at any time, even in the middle of a byte transfer.

1.9 Slave Reset
In case of internal failures the slave shows 0 for all bits.
Power off / on is necessary for a slave reset.

1.10 Data Frame Structure
A data frame consists of 2 data bytes (Data 16 – most significant byte first).
1.11 Data Structure
Data 16: Angle A [15:0] with (Angle Span) / 2^16

<table>
<thead>
<tr>
<th>Most Significant Byte</th>
<th>Least Significant Byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>A15</td>
<td>A14</td>
</tr>
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</table>

Data 16: Error
In case of internal failures the slave shows 0 for all bits

<table>
<thead>
<tr>
<th>Most Significant Byte</th>
<th>Least Significant Byte</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

1.12 Angle Calculation
All communication timing is independent (asynchronous) of the angle data processing. The angle is calculated continuously by the slave every 1 ms. The last angle calculated is held to be read by the master at any time.

1.13 Document Changes

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