Doc name:			
Protocol specification Homing			
Doc. num: 240120OYG01	Last saved: 16.09.20	Project: 2kW Coupler	Comment:

Rev.	Comment:	Issued by:	Reviewed by:	Approved by:
0.2	Defined parameter range for HS command and added 0xFFFF as data invalid in HS response	OYG/15.04.2020	KTH/15.04.2020	KTH/15.04.2020
0.1	First release	OYG/24.01.2020	KTH/24.01.2020	KTH/24.01.2020

Contents

1. Introduction

This document is the specification of the communication protocol used to control the Homing sensor functionality at the inductive coupler products.

The protocol is communication bearer independent. For now, the Ethernet connection to the coupler is used. The protocol may also use a RS232/RS485 communication bearer.

2. Definitions

Message	A packet of bytes to be transmitted.
Master	The one of the two communication parts that controls the communication. Master can start to transmit whenever master wants to. External unit (superior system) is always master.
Slave	Slave shall always be ready to receive from master. Slave can never start transmitting on its own initiative, transmit can only be performed after receiving a message that require response. The coupler will always be a slave.
Command and Response	The content of a message is a command when it is sent from master to slave and a response when it is sent from slave to master. When receiving a command, the slave must perform needed actions to fulfil the command and return a proper response.

3. Protocol

3.1 Communication format

All bytes in a message will normally be sent continuously with no (or a very short) pause between bytes. Maximum time between bytes within a message is 50ms. If a longer pause occur, the message is considered corrupt. For more information regarding timing for responses, see chapter 3.6 "Timing and retransmission".

Communication is point-to-point with one master and one slave.

3.1.1 Ethernet

Couplers supporting configuration over Ethernet is TCP telnet server based. A TCP client must connect to port 5000 and issue commands as described below. There is no welcome message or other indication of connection.

3.1.2 Serial line, RS232/RS485

Coupler supporting configuration over serial line communicates at 19200 bps, 8 data bit, odd parity and 1 stop bit. There is no flow control. This setup can be changed based on HW/SW setup. Please see individual coupler description.

3.2 Message format

Each message consists of three parts, a "header" with ASCII character STX, address and message ID, a "container" with a byte count and data, and a "footer" containing a checksum for the message. A message is either a command or a response.

3.2.1 Command format

All commands will always have these parts:

STX	ADDR	CMD	NO	DATA	DATA	. . .	DATA	CHS
0x02	Address	Command ID	Number of bytes	1. byte	2. byte	. . .	n. byte	Check sum

Some commands do not have any DATA bytes in the container. These commands will have the byte count value of zero.

Explanation of each part:

Abbr.	Name	Size	Description
STX	Start of message	1 byte	STX character, 0x02.
ADDR	Address	1 byte	Reserved for future address information, set to 0x00.
CMD	Command identification	2 byte	This is an explicit identification of each command type. Possible value for each byte is any ASCII characters in upper case from 'A' (0x41) to 'Z' (0x5A).
NO	Number of bytes	1 byte	Byte count including all DATA bytes in the container part of the command.
DATA	Data	0-255 byte	Data needed to fulfill the command. NOTE: Data values are coded with MSB first.
CHS	Checksum	2 byte	Checksum for the message.

3.2.2 Response format

The response message format is almost the same as the command message format, and will always have these parts:

STX	ADDR	RSP	NO	DATA	DATA	. . .	DATA	CHS
0x02	Address	Response ID	Number of bytes	1. byte	2. byte	. . .	n. byte	Check sum

Some responses do not have any DATA bytes in the container. These responses will have the byte count value of zero.

Explanation of the specific response parts:

Abbr.	Name	Size	Description
STX	Start of message	1 byte	STX character, 0x02.
ADDR	Address	1 byte	Reserved for future address information, set to 0x00.
RSP	Response identification	2 byte	The same characters as for the command, but in lower case.
NO	Number of bytes	1 byte	Byte count including all DATA bytes in the container part of the response.
DATA	Data	0-255 byte	Response data. NOTE: Data values are coded with MSB first.
CHS	Checksum	2 byte	Checksum for the message.

3.3 Addresses

For current use no address information is really needed, since the communication bearer is always a point-to-point connection and there are no bridging or other functionality requiring an address system. However, to be able to use the product in future applications an address field is included in the message. The address shall for now be set to 0.

3.4 Checksum

All bytes in the header part and the container part (not the footer part) of a message are included when calculating checksum. The algorithm used is CRC-16 with polynomial 0xa001, initialized to 0xffff. Checksum is included in message with MSB first.

Checksum example in c code:

```
uint16_t Crc16(uint8_t *MsgToCalc, uint16_t DataLen)
{
  uint16_t Crc = 0xffff;
  uint8_t i;

  while (DataLen--)
  {
    Crc ^= *MsgToCalc++;
    for (i = 0; i < 8; i++)
    {
      if (Crc & 0x0001)
        Crc = (Crc >> 1) ^ 0xa001;
      else
        Crc >>= 1;
    }
  }
  return Crc;
}
```

3.5 Unknown messages and messages with checksum error

When receiving a message with unknown message ID, a message with checksum error or a message that do not fulfill the protocol, the message shall be rejected. The slave takes no action with such messages. If the master receives a response with any error, the master may retransmit previous command.

3.6 Timing and retransmission

Although the protocol supports a full duplex connection, timing and retransmission system are set to meet the requirements for typical half duplex communication bearer as RS485, radio etc.

When the protocol is using a half-duplex communication bearer, there are to be a pause of at least 10ms between all messages. That is, the slave will wait at least 10ms before sending the response, and master should wait at least 10ms after receiving response before sending next command. On Ethernet based connections such a pause is optional.

The slave will execute the received command and build corresponding response immediately. Sending response shall start as soon as possible after the required pause of 10ms (optional for Ethernet connection). Maximum delay before sending first byte of response is 50ms after received last byte of the command.

The master should wait for the response of the previous command before sending next command. If the master did not receive at least the first byte of a response within 100ms after last byte of the command was sent, the master should consider that these messages are lost. The master may now retransmit the same command or send any other command.

4. Messages

All messages are built according to specified message format, see chapter 3.2.1 "Command format" and chapter 3.2.2 "Response format". In the tables below only the CMD, RSP, NO and DATA fields are pointed out. The STX, ADDR and CHS shall be added when building messages.

4.1 Homing control, PRI

<table>
<tr><th>Command</th><th></th><th>Values and comment</th></tr>
<tr><td>CMD</td><td>HP</td><td>Homing control, only applicable to PRI</td></tr>
<tr><td>NO</td><td>0x01</td><td>Number of bytes</td></tr>
<tr><td>DATA1</td><td>8 bit unsigned value</td><td>Homing set mode<table><tr><th>Value</th><th>Description:</th></tr><tr><td>0</td><td>Homing off</td></tr><tr><td>1</td><td>Homing on</td></tr><tr><td>2-255</td><td>Reserved</td></tr></table></td></tr>
<tr><td>Response</td><td></td><td></td></tr>
<tr><td>RSP</td><td>hp</td><td>Homing control status</td></tr>
<tr><td>NO</td><td>0x01</td><td>Number of bytes</td></tr>
</table>

<table>
<tr><td>DATA1</td><td>8 bit unsigned value</td><td>Operation mode status
<table>
<tr><th>Value</th><th>Description:</th></tr>
<tr><td>0</td><td>OK, homing is off</td></tr>
<tr><td>1</td><td>OK, homing is on</td></tr>
<tr><td>2</td><td>Homing operation cannot be started now</td></tr>
<tr><td>3-255</td><td>Reserved</td></tr>
</table></td></tr>
</table>

Table 1 Homing PRI control

4.2 Homing control, SEC

<table>
<tr><th>Command</th><th></th><th>Values and comment</th></tr>
<tr><td>CMD</td><td>HS</td><td>Homing control, only applicable to SEC</td></tr>
<tr><td>NO</td><td>0x02</td><td>Number of bytes</td></tr>
<tr><td>DATA1</td><td>8 bit unsigned value</td><td>Homing control
<table>
<tr><th>Value</th><th>Description:</th></tr>
<tr><td>0</td><td>Homing off</td></tr>
<tr><td>1</td><td>Homing on</td></tr>
<tr><td>2-255</td><td>Reserved</td></tr>
</table></td></tr>
<tr><td>DATA2</td><td>8 bit unsigned value</td><td>SEC push interval control.
This parameter controls the time interval between each response from SEC with sensor data. Push interval time is parameter value x 100ms.
Parameter range 2-30, for 200ms to 3sec push interval
Example:
Value 15 means 1500ms interval between each SEC response with sensor data</td></tr>
<tr><td>Response</td><td></td><td></td></tr>
<tr><td>RSP</td><td>hs</td><td>Homing status</td></tr>
<tr><td>NO</td><td>0x09</td><td>Number of bytes</td></tr>
<tr><td>DATA1</td><td>8 bit</td><td>Status information
<table>
<tr><th>BIT num</th><th>Description</th></tr>
<tr><td>0</td><td>0 – Pushing sensor data not started / ended (This will also be the value if command parameter is out of range)
1 – Pushing data started / continues</td></tr>
<tr><td>1</td><td>0 – No communication between PRI and SEC
1 – PRI and SEC communication OK
NOTE 1</td></tr>
<tr><td>2</td><td>Reserved</td></tr>
<tr><td>3</td><td>Reserved</td></tr>
<tr><td>4</td><td>Reserved</td></tr>
<tr><td>5</td><td>Reserved</td></tr>
<tr><td>6</td><td>Reserved</td></tr>
<tr><td>7</td><td>Reserved</td></tr>
</table></td></tr>
<tr><td>DATA2-3</td><td>16 bit unsigned value</td><td>Sensor A value in range 0-40000. 0xFFFF if data not available.
NOTE 2</td></tr>
<tr><td>DATA4-5</td><td>16 bit unsigned value</td><td>Sensor B value in range 0-40000. 0xFFFF if data not available.
NOTE 2</td></tr>
<tr><td>DATA6-7</td><td>16 bit unsigned value</td><td>Sensor C value in range 0-40000. 0xFFFF if data not available.
NOTE 2</td></tr>
<tr><td>DATA8-9</td><td>16 bit unsigned value</td><td>Sensor Z value in range 0-40000. 0xFFFF if data not available.
NOTE 2</td></tr>
</table>

Table 2 Homing SEC control

NOTE 1:
Response DATA 1, bit 1: Value 1 is set when PRI and SEC have established an internal communication link. This indicates that SEC are close to docking, distance is no more than a few cm.

NOTE 2:
Sensor A, B and C are placed outside and around the SEC coupler, with internal distance 120º. Sensor Z is actual the SEC main power coil.
The sensor values (A, B, C and Z) are direct readings of the magnetic field detected by the sensors. Values will increase when PRI and SEC are approaching each other and decrease when PRI and SEC are pulling apart. Values are not linear with distance, since magnetic field does not weaken linearly with distance.

Installation of other equipment, metal etc. that will influence the magnetic field, may also influence the sensor readings. Therefore, the same sensors and distance PRI-SEC may for installation at different AUV's give different sensor values.

The AUV must convert sensor values to distance based on learned values at known distances.