Interface Protocol

Serial Interface

Devices: *iSYS-devices with serial Interface*

Revision: *22*

Date: *2020-12-04*

Table of content

0. History

Document revision	Date	Change log	Author
1	2016-01-25	– initial release	JW
2	2016-02-02	– Added quick start section – Added section with EEPROM functions – Added function code for reading the firmware version – Added function in C-code for target list decoding	JW
3	2016-02-29	Added following chapters: – Line filter 1 / 2 (0x00 00 / 0x00 01) – Enable output (0x0X 00) – Rising/falling delay (0x0X 01 / 0x0X 02) – Output setting 1 (0x0X 04) – Output setting 2 (0x0X 05) – Set/Get Potis (0x06 80) – Read digital output state (0xDB)	JW
4	2016-04-13	Added following chapters: – Read Raw Signals (0xE0) Added new devices: – iSYS-6007, iSYS-6008, iSYS-6203 Added new default RS485 addresses for iSYS-6xxx devices	JW
5	2016-04-20	Added following chapters: – Set default temperature threshold (0x01 33) – Measurement mode (0x00 10) – Temperature threshold (0x07 07)	JW
6	2016-11-28	Corrected following errors – Fixed error in chapter 2.2 (Target list request for newer firmware was wrong) – Removed device address restriction for iSYS-6003 (newer versions (firmware >= v0.400) don't have this restriction) Added new devices: – iSYS-4013, iSYS-5010 Added new commands: – RCS output enable/disable (0x08 53) – Target clustering enable/disable (0x08 80) – Get DSP hardware version (0x01 02) – Get RFE hardware version (0x01 03) – Get product information (0x01 04) – Get Bootloader version (0x02 20) Added table of supported commands for iSYS-5010	JW / DN
7	2017-01-09	Added table of supported commands – iSYS-4001, iSYS-4002, iSYS-4003, iSYS-4004 – iSYS-600x	JW/DN
8	2017-03-09	Corrected following errors: – Figure 192 contained error in number of samples per signal Removed devices: – iSYS-4009, iSYS-4011, iSYS-4012, iSYS-6008	JW

9	2017-03-13	Changed some section numbers for correct numbering Added new devices: – iSYS-5110	JW/TP
10	2017-05-10	Added note for clarifying setting of the alpha filter in section 3.3.5.13 Added devices – iSYS-6004, iSYS-6005 Added command for requesting fixed length target list in section 3.3.7	JW
11	2017-06-09	Added device - iSYS-6006	JW
12	2017-10-27	- Addition in section 3.3.5.13 to clarify implementation of alpha filter and usage - Added additional notes to clarify target list transmission in section 3.3.7 o transmission of variable data length frame using start delimiter SD3=0xA2 - added new sections with functions for iSYS-6203 o Range min/max extended (0x0X 19 / 0x0X 1A) o Set/Get mounting offset (0x05 06) o Range / temperature warning switch (0x07 09) o Set/get temperature warning threshold (0x07 0A) o Set/get range warning threshold (0x07 0B)	JW
13	2017-11-17	- Corrected some errors o Table 13 ▪ Values for sub function target direction (0x0X 0E) wrong o Figure 39 showed wrong request frame	JW
14	2017-11-30	- Added new command for iSYS-5010 o Moving target threshold sensitivity near range (0x08 28) o Moving target threshold sensitivity main range (0x08 29) o Moving target threshold sensitivity long range (0x08 2A)	JW
15	2017-12-20	Added device - iSYS-5020	ClB
16	2018-01-09	Added commands for iSYS-5110 stop bar zone	ClB
17	2018-05-07	Added command for iSYS-5020 o Target list interface (0x00 2C)	JW
18	2018-08-06	Changed information in section measurement mode for iSYS-6004 and iSYS-6005	TS / JW
19	2018-11-22	Added iSYS-5011 and iSYS-5021	JK
20	2019-01-07	Added Command for switching on/off iSYS-400x LED	TP / JW
21	2019-10-09	Removed command without function for iSYS-6xxx and iSYS-6005	JW

		- Threshold sensitivity left/right	
22	2020-12-04	Corrected wrong information for iSYS-40xx in Table 14	JW

1. Preface

This document describes the serial interface communication of the iSYS devices.

Numerical intervals in this documents do not imply the minimum and maximum values of the radar system.

The hardware description and pin assignment of the interface can found in the device specific datasheet.

List of iSYS devices using this protocol:

- iSYS-4001, iSYS-4002, iSYS-4003, iSYS-4004, iSYS-4013
- iSYS-5010, iSYS-5011, iSYS-5020, iSYS-5021, iSYS-5110
- iSYS-6003, iSYS-6004, iSYS-6005, iSYS-6006, iSYS-6007, iSYS-6203

2. Quick Start

This quick start shows how to request the device name and measured range from a connected device using the serial communication interface.

2.1. Read device name

Request the device name with the command specified in section 3.3.2:

68	03	03	68	80	01	D0	51	16

Figure 1: master request device name from device address 128 – command string in HEX format

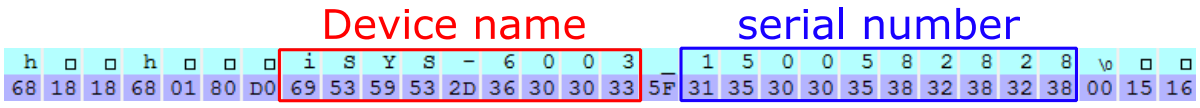


Figure 2: answer from device

68	03	03	68	64	01	D0	35	16

Figure 3: master requests device name from device address 100 (iSYS-6xxx with firmware >= 0.32) – command string in HEX format

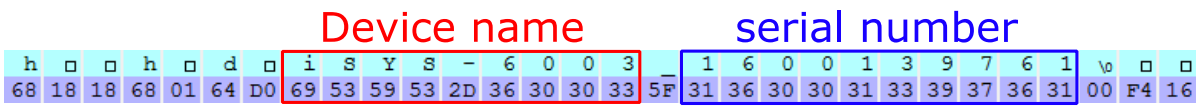


Figure 4: answer from device with device address 100

2.2. Read range measured by iSYS-6003

Request the measured range using command specified in section 3.3.7:

```
68 05 05 68 80 01 DA 01 20 7C 16
```

Figure 5: master requests range from iSYS-6003 with device address 128 – command string in HEX format

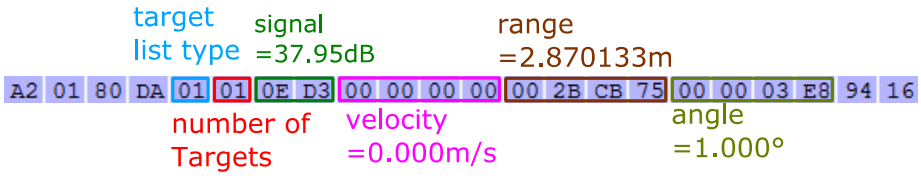


Figure 6: answer from iSYS-6003 – measured range = 2.870 m

```
68 05 05 68 64 01 DA 01 20 60 16
```

Figure 7: master requests range from iSYS-6003 with device address 100 (iSYS-6xxx with firmware >= 0.32) – command string in HEX format

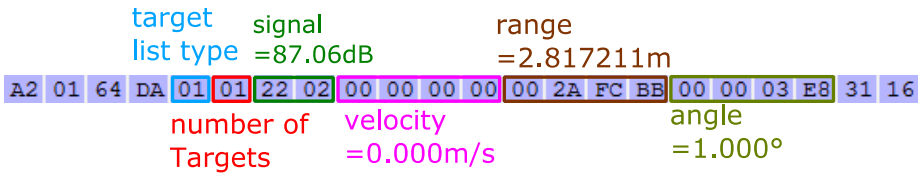


Figure 8: answer from iSYS-6003 (firmware >= 0.32) – measured range = 2.817 m

3. Communication workflow

3.1. Overview

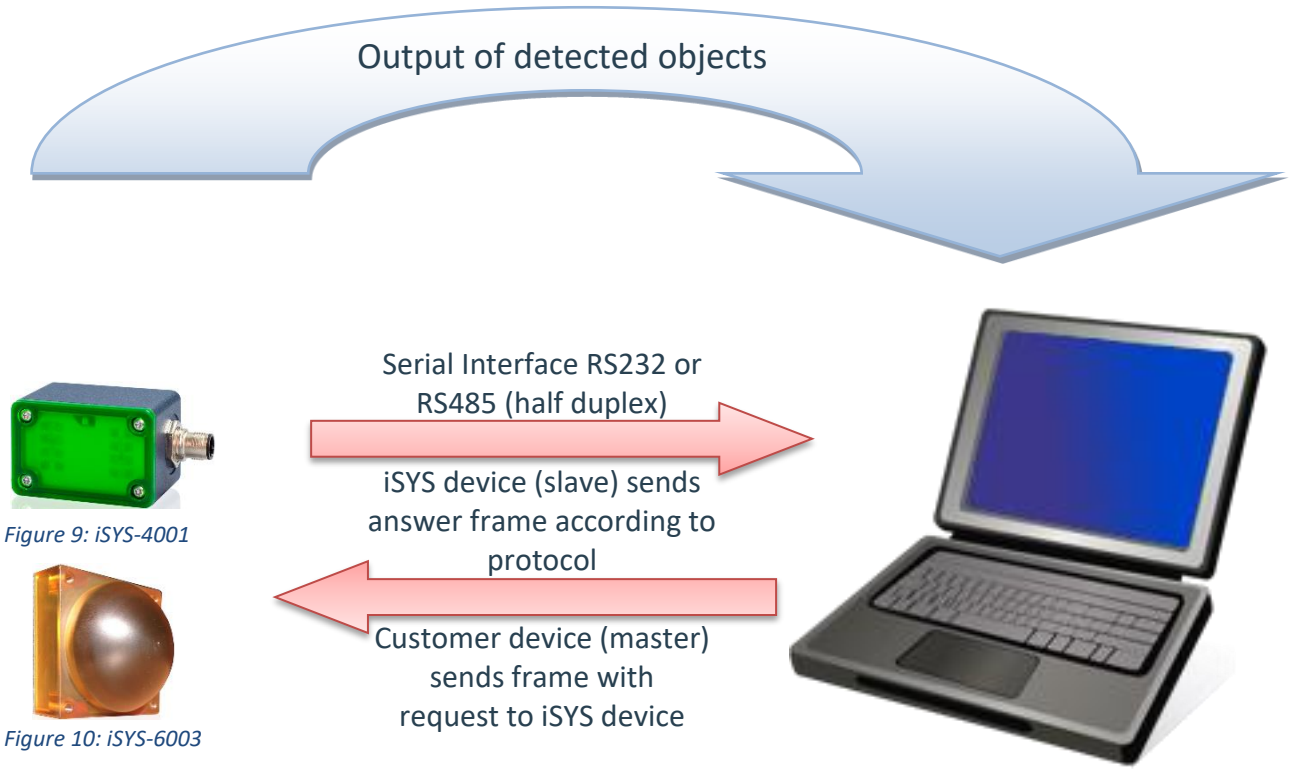


Figure 9: iSYS-4001

Figure 10: iSYS-6003

Figure 11: Customer device

3.2. Transmission

3.2.1.**Connection**

The iSYS devices have a serial interface connection according to UART and additional drivers for RS232 or RS485 2-wire standard. The interface configuration is defined in the device specific datasheets.

3.2.2.**Communication**

The communication uses the master/slave principle to support multiple slave devices (sensors) on one RS485 bus.

3.2.3.**Addressing**

The sensor device address is coded in one byte of each transmitted frame. This features 254 individual iSYS device addresses, the master device address and the broadcast address.

Each communication has to be initiated by the master device on address #1.

Frames send with the broadcast address (#0) as destination will be accepted from all connected devices on the bus. For determining the sensor address use the command specified in section 3.3.4.1 or the device specific data sheet.

Table 1: address range

Address	Description
0	Broadcast address
1	Master device address

2 to 255	Individual sensor slave addresses:
	default address:
	iSYS-4xxx = 128;
	iSYS-5X10 = 100
	iSYS-6XXX = 100;

3.2.4.Transmit format

8N1 transmission format: 1 start bit, 8 data bit, parity – none, 1 stop bit

3.2.5.Devices default baud rates

Table 2: default baudrates

Baud rate	devices
9.6 $\frac{kBit}{s}$	• iSYS-4003
57.6 $\frac{kBit}{s}$	• iSYS-4013
115.2 $\frac{kBit}{s}$	• iSYS-4001, iSYS-4002, iSYS-4004 • iSYS-5010, iSYS-5020, iSYS-5110 • iSYS-6003, iSYS-6004, iSYS-6007, iSYS-6203,
230.4 $\frac{kBit}{s}$	• iSYS-6005 • iSYS-6006

3.2.6.Transmit frames

The communication works by transmitting three different frame types, differentiated through different start delimiters. Each frame contains one of three start delimiters, the destination and source address, function code, checksum and end delimiter. The whole frame must be send slip free without breaks between the single bytes.

Table 3: frame without data

SD1	DA	SA	FC	FCS	ED
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5

Table 4: frame with variable data length

SD2	LE	LEr	SD2	DA	SA	FC	PDU	FCS	ED
Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5	Byte 6	Byte n+7	Byte n+8	Byte n+9

Table 5: frame with fixed data length

SD3	DA	SA	FC	PDU	FCS	ED
Byte 0	Byte 1	Byte 2	Byte 3	Byte n+4	Byte n+5	Byte n+6

SD: start delimiter to differ type of frame
1 = frame without data (SD1 = 0x10)
2 = frame with variable data length (SD2 = 0x68)
3 = frame with fixed data length (SD3 = 0xA2)
LE: length of the net data (data incl. DA, SA & FC appropriate byte 4 to byte n+7)
LEr: repetition of the net data length
DA: destination address
SA: source address
FC: function code
PDU: protocol data unit
FCS: frame checksum (addition of Bytes from Byte 4 to Byte n+7)
ED: end delimiter (ED = 0x16)

Incorrect or destroyed frames are cast away by the iSYS device without replying.

All accepted frames are acknowledged with a frame including the function code and possible requested data by the iSYS device.

Received frames which the iSYS device cannot execute are replied with the function code 0xFD (failure) as described in section 3.3.12.

A detailed description of the available function codes with working examples is included in section 3.3. All examples display the frame in hex format. The destination address and the frame checksum have to be changed if the address of your sensor differs from the one used in the example. For a table of supported commands of each iSYS devices refer to appendix 0 on page 70.

3.2.7. Receive frames

The answer frames from the iSYS use the same protocol described in section 3.2.6.

Some functions use the start delimiter SD3 = 0xA2 of a frame with fixed data length to transmit a frame with variable length. For example the 32-Bit resolution target list (section 3.3.7) transmits as target list with variable length using the start delimiter SD3=0xA2.

3.2.8. Error Management

The transmission reliability is based on a frame checksum which is generated from each transmitting device. After receiving a frame the device recalculates the checksum and compares it with the received checksum in the frame. If the checksums don't match, the frame is incorrect and must be cast away without replying.

Each frame has to be send as a continuous stream of data. When the time between two bytes exceeds the maximum delay time, the frame is discarded and the device waits for a new frame. InnoSenT devices use a maximum delay time of 10ms.

The master device (customer device) should use a pre-defined timeout to cancel transmissions. The user should set this time to values about 10% greater than the sensors measurement cycle time. For iSYS device with short cycle times (e.g. iSYS-400x or iSYS-6005) a minimum timeout about 20ms greater than the measurement cycle time is recommended. For example timeout values refer to Table 6.

Table 6: recommended timeout values

Sensor	Measurement cycle time	recommended minimum timeout value
• iSYS-400x	75 ms	100 ms
• iSYS-4003	300 ms	330 ms
• iSYS-4013	750 ms	825 ms
• iSYS-5010, iSYS-5020, iSYS-5110	100 ms	110 ms
• iSYS-6003, iSYS-6007, iSYS-6203	200 ms	220 ms
• iSYS-6004	1200ms	1400ms
• iSYS-6005	50ms	70ms
• iSYS-6006	15ms or 30ms	50ms

3.2.9. Calculation of the frame checksum

The frame checksum is calculated by adding all bytes of source address, destination address, function code and protocol data unit. Overruns during the addition of the bytes are ignored

The bytes used for checksum calculation are highlighted green in Table 7. Byte 1 to 3 (highlighted red) are SD2 exclusive and not used for checksum calculation.

$$Checksum = 0x01 + 0x80 + 0xD2 + 0x00 + 0x80 = 0x1D3 \rightarrow FCS = 0xD3$$

Table 7: Example frame (data used for checksum calculation are highlighted in green)

SD: 0x68	LE: 0x05	LEr: 0x05	SD: 0x68	DA: 0x01	SA: 0x80	FC: 0xD2	PDU: 0x00 0x80	FCS: 0xD3	ED: 0x16

3.3. Application protocol

3.3.1. Function code overview

Table 8: availible function codes

Function code	Function	Example
0xD0	Read Device name	Read device name as ASCII string
0xD1	Commands	Commands, e.g. start/stop measurement
0xD2	Read sensor settings	Read sensor parameters, e.g. sensor address
0xD3	Write sensor settings	Write sensor parameters, e.g. sensor address
0xD4	Read application settings	Read application parameters, e.g. min/max range
0xD5	Write application settings	Write application parameters, e.g. min/max range
0xD6	Read calibration settings	Read calibration settings, e.g. firmware version
0xDA	Read target list	Read target-list, e.g. 16-bit target list, 32-bit target list
0xDB	Read digital output state	Reads the output state of the digital outputs
0xDF	EEPEOM	EEPROM functions, e.g. set factory default, save sensor/application settings
0xE0	Read raw signal	iSYS sends the sampled raw data of one measurement / modulation cycle
0xE1	Read range list	Reads range list consisting of different range values calculated by the modulation scheme and additional statistical values (only iSYS-600x, iSYS-6203)
0xFD	Failure	Failure

Some functions use additional sub-function codes. This splits the function code down to access single parameters. The sub function codes are the first two data bytes. Sub functions are explained in the following sections if available.

3.3.2. Read device name (0xD0)

This command requests the device name and the serial number to identify a device with an individual device number. The request is send by the master device within a frame with variable data length as shown in Figure 12. The slave device (sensor) sends the device name and serial number as a null-terminated ASCII string within a frame with variable data length. An example answer is shown in Figure 13.

Example:

68	03	03	68	80	01	D0	51	16

Figure 12: master device requests device name from sensor

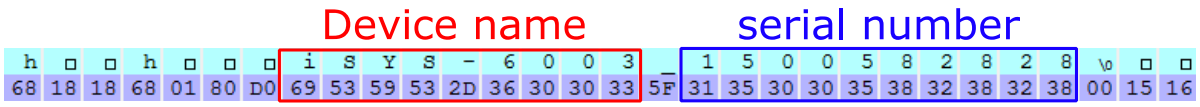


Figure 13: answer from sensor

3.3.3. Commands (0xD1)

The master device sends the function code with one available sub-function code from Table 9 in a frame with variable data length. The sensor acknowledges the command on success with the function code in a frame with variable data length.

Table 9: availible sub function codes

Sub-function codes	Description	Example
0x00 00	Start acquisition	Starts the sensor measurement
0x00 01	Stop acquisition	Stops the sensor measurement
0x01 33	Set default temperature threshold values (iSYS-6203 only)	Sets the default temperature threshold values OUT1: 55.00°C; OUT2: 60.00°C; OUT3: unused

3.3.3.1. Start/Stop acquisition (0x00 00 / 0x00 01)

This sub-function codes are used to start or stop the measurement of the iSYS sensor. Some functions are only available when acquisition is started or stopped.

Examples:

- Start acquisition

```
68 05 05 68 80 01 D1 00 00 52 16
```

Figure 14: master device requests start of acquisition

```
68 03 03 68 01 80 D1 52 16
```

Figure 15: acknowledge from sensor

- Stop acquisition

```
68 05 05 68 80 01 D1 00 01 53 16
```

Figure 16: master device requests stop of acquisition

```
68 03 03 68 01 80 D1 52 16
```

Figure 17: acknowledge from sensor device

3.3.3.2. Set default temperature threshold (0x01 33)

This sub-function code is used to set the default temperature threshold and **is only supported by the iSYS-6203**. This values are used to output a temperature warning or an alarm when the corresponding threshold temperature is exceeded. If the measured temperature falls 1.00°C below the threshold value the temperature warning on the output will be deactivated. The sensor returns the set threshold values within a frame with variable data length. From the three threshold values only the values for OUT1 and OUT2 are used. OUT3 is intended for future use and returns always 0x0000.

Example:

```
68 05 05 68 64 01 D1 01 33 6A 16
```

Figure 18: master device requests setting of default temperature threshold values (iSYS-6203)

```
                    OUT1  OUT2 OUT3
68 09 09 68 01 64 D1 15 7C 17 70 00 00 4E 16
```

Figure 19: acknowledge from sensor device with temperature threshold values (0x157C = 55.00°C, 0x1770 = 60.00°C)

3.3.4. Sensor settings (0xD2/0xD3)

The master device can read and write sensor settings from the connected iSYS.

For reading the different settings, the master sends the function code 0xD2 and the sub-function code within a frame with variable data length. The iSYS answers with the function code and the requested data within a frame with variable data length.

For writing data to the iSYS, the master sends a frame with function code 0xD3, the sub-function code and the data within a frame with variable data length.

Note: All writes are saved within volatile RAM on the sensor device. To save the sensor setting in non-volatile EEPROM use the commands specified in section 3.3.9.

Table 10 shows a list of supported sub-function codes.

Table 10: available sub-function codes

Sub-function code	Sub-function	Description	Data-bytes
0x00 01	Address	Read/write the RS485 bus address (allowed values 2-255)	2 (uint16_t)
0x00 04	Channel	Frequency channel of the sensor, if available (allowed values for writing 1-maxNrOfChannels[1][2])	2 (uint16_t)
0x00 0B	Minimum	Threshold minimum value in tenth of dB	2 (sint16_t)
0x00 10	Measurement Mode	Measurement mode of the iSYS-6003, iSYS-6006, iSYS-6007, iSYS-6203	2 (uint16_t)
0x00 16	Threshold Sensitivity left	Threshold sensitivity for left FFT-side in tenth of dB, e.g. iSYS-4001 positive velocities	2 (sint16_t)
0x00 17	Threshold sensitivity right	Threshold sensitivity for right FFT-side in tenth of dB, e.g. iSYS-4001 negative velocities	2 (sint16_t)
0x00 29	IP-Config	RADAR sensor IP configuration	13 (13x uint8_t)
0x00 2A	IP-Destination	Destination IP configuration	9 (5x uint8_t, 2x uint16_t)
0x00 2C	Target list interface	Interface for target list output	2 (2x uint8_t)
0x00 2D	LED Configuration	LED functionality set on, off or disabled blinking	1 (uint8_t)

[1] The max number of available channels depends on the used sensor type.
[2] Changing the frequency channel is only allowed in stop mode

3.3.4.1. Read/Write sensor address (0x00 01)

This sub-function code is used to read the sensor address or change the default sensor address. The request is send within a frame with variable data length. The following example changes the sensor address from 0x80 (128) to 0x81 (129). The sensor acknowledges the request after changing the device address with the function code and the new RS485 address as shown in Figure 21.

Note: The new address is saved in non-volatile memory on the sensor before acknowledging the command.

The address can be read from the sensor using the function code 0xD2 and sub-function code 0x00 01 within a frame with variable data length. This is usually used to determine the address from the connected sensor, e.g. device address was changed previously and is no longer known. In the example all connected sensors will answer the request, because the broadcast address (0x00) is used. Therefore only one sensor should be connected when using the broadcast address.

Examples:

- Set new sensor address

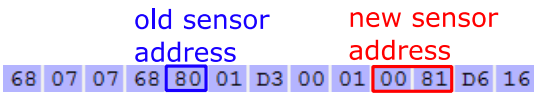


Figure 20: request from master device (only device with address 0x80)

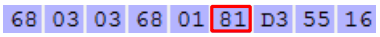


Figure 21: Acknowledge from sensor device

- Read sensor address

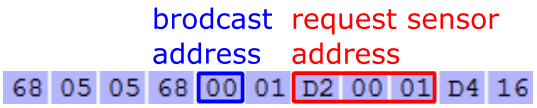


Figure 22: master requests sensor address

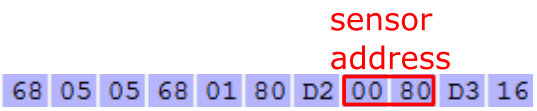


Figure 23: acknowledge from sensor device with address in data

3.3.4.2. Change frequency channel (0x00 04)

The frequency channel used by the sensor can be changed or read with this sub-function code. Table 11 show an overview of the maximum supported frequency channels of the different iSYS. Refer to the product specific data sheet for further information (e.g. channel frequencies). Changing the frequency channel is unavailable during measurement mode. To change the mode of the sensor see section 3.3.3. Requests with unsupported frequency channels or changes to frequency channel during measurement mode are replied with failure (0xFD). iSYS devices with only one frequency channel don't support this function and return failure for attempts to change the channel and channel 1 when reading the frequency channel.

Table 11: overview of maximum supported number of frequency channels

Device	Available # of frequency channels
• iSYS-4001, iSYS-4002, iSYS-4003, iSYS-4013	Channel 1, …, Channel 4 (firmware versions < v1.310) Channel 1, …, Channel 8 (firmware versions ≥ v1.310)
• iSYS-4004	Channel 1, Channel 2, Channel 3
• iSYS-5010, iSYS-5020, iSYS-5110	Channel 1, Channel 2
• iSYS-6003, iSYS-6004, iSYS-6005, iSYS-6006, iSYS-6007, iSYS-6203	Channel 1

Examples:

- set new frequency channel

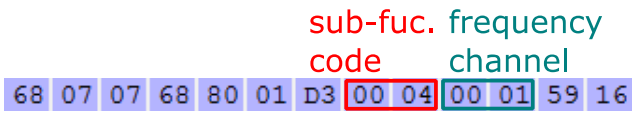


Figure 24: master requests new frequency channel 1

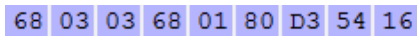


Figure 25: sensor device acknowledges command on success

- read current frequency channel

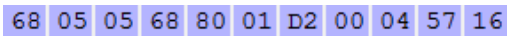


Figure 26: master requests frequency channel from iSYS

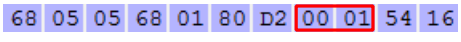


Figure 27: Sensor device acknowledes command with frequency channel 1 in PDU

3.3.4.3. Threshold minimum (0x00 0B)

This sub-function code allows to change the minimum value used for the threshold calculation. This is the same value used in the detection tab of the iSYS-GUI as shown in Figure 28. The value used by the sensor can also be read using the function code 0xD2. The value is transmitted as a sint16_t value in the third and fourth byte of the PDU for write operation and the first two bytes of the PDU during read operation in tenth of dB as shown in the following examples. Only writing of values between -30.0 dB and +30.0 dB is valid. Requesting invalid values is replied with failure.

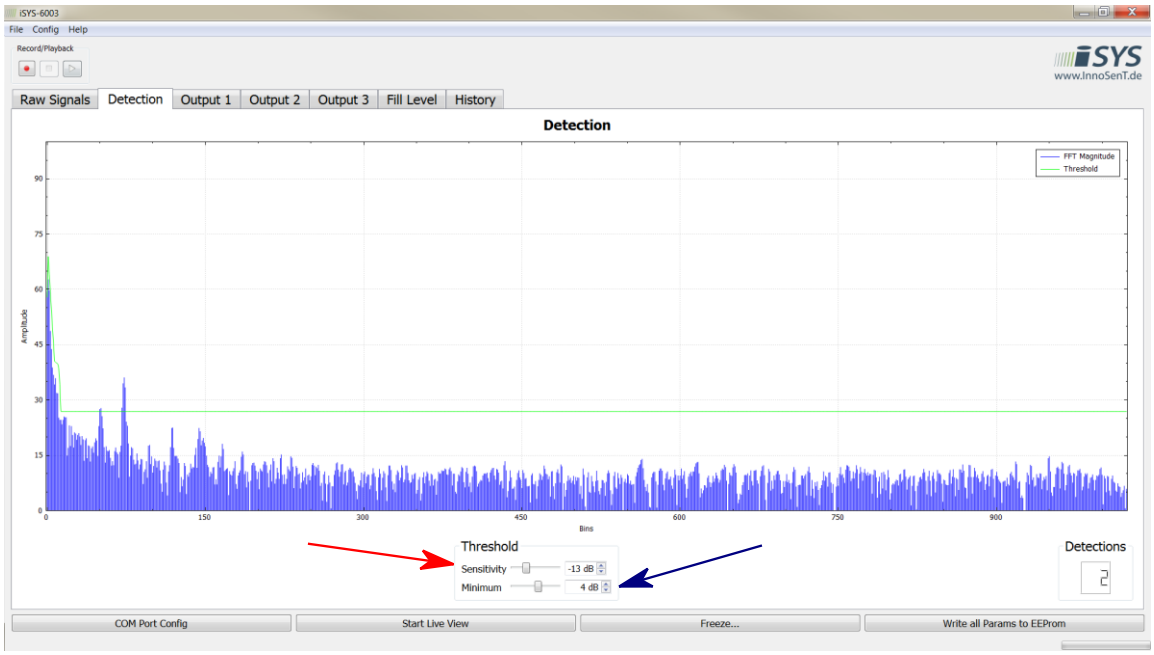


Figure 28: Detection tab from GUI

Examples

- Setting of new threshold min value

function and sub-func. code | new min value

68	07	07	68	80	01	D3	00	0B	00	64	C3	16

Figure 29: master requests new threshold min value (10dB)

68	03	03	68	01	80	D3	54	16

Figure 30: acknowledge from sensor device

- Read min value from sensor

68	05	05	68	80	01	D2	00	0B	5E	16

Figure 31: master device requests threshold min value from sensor

value from sensor

68	05	05	68	01	80	D2	00	64	B7	16

Figure 32: iSYS acknowledges with function code and min threshold value in PDU (10dB)

3.3.4.4. Measurement mode (0x00 10)

Most of the iSYS-6xxx devices with fmcw modulation support two measurement modes. One single target mode with a cycle time of 50ms (limited to only a single target output) and a multi-target mode with 200 ms cycle time and up to 30 target output. This sub-function code is used to change the measurement mode or read the mode from the sensor. For successfully executing this command measurement of the iSYS-6xxx has to be stopped. For stopping the iSYS measurement refer to section 3.3.3. The Table 12 shows the devices which support the setting of the measurement mode.

Changes to the measurement mode are stored in volatile memory. For saving the mode to nonvolatile memory use the command "**save Sensor and Application settings"** described in section 3.3.9.2.

Notes:

- *Saving the measurement mode to nonvolatile memory is only supported in firmware version higher than v0.36. Lower versions only support the setting in volatile memory.*
- *For iSYS-6004 and iSYS-6005 only read measurement mode (0xD2) is supported.*

Table 12: overview of devices which support this command

Device	**Fast measurement mode (single target only) PDU: 0x00 00**	**Multi target mode PDU: 0x00 01**
• iSYS-6003, iSYS-6007, iSYS-6203	50 ms cycle time	200 ms cycle time
• iSYS-6004	Not supported	1200 ms cycle time
• iSYS-6005	50 ms cycle time (multi target with fixed length target list)	Not supported
• iSYS-6006	15 ms cycle time	30 ms cycle time

Examples:

- set measurement mode fast

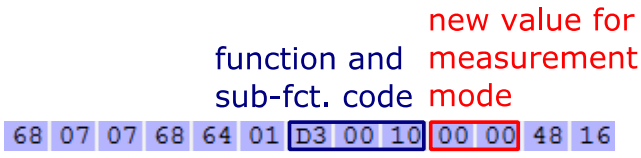


Figure 33: master requests fast measurement mode (0x00 00)

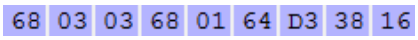


Figure 34: acknowledge from sensor

- Read measurement mode

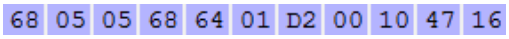


Figure 35: master requests measurement mode from sensor

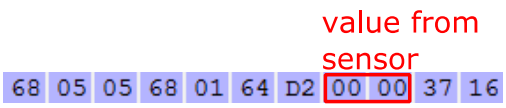


Figure 36: iSYS acknowledges with function code and measurement mode value (0x00 00: fast mode)

3.3.4.5. Threshold sensitivity left/right (0x00 16/ 0x00 17)

This sub-function codes allow to change the sensitivity of the filter used for the threshold calculation. These are the same values used in the iSYS-GUI shown in Figure 32. Both values are set to the same value through the GUI. Threshold sensitivity left is used for the left FFT-side. Reading or writing of threshold sensitivity right works similar to the right FFT-side. For the iSYS-4001 the left FFT-side corresponds to positive velocities and the right side to negative velocities. If only one side of the FFT is used in the sensor the other value is don't care and can be ignored. The iSYS-6003 for example only uses the left side of the FFT.

The values are transmitted as sint16_t data type in tenth of dB. Only writing of values between -30.0 dB and +30.0 dB is valid. Requesting invalid values is replied with failure.

Examples:

- Write threshold sensitivity left

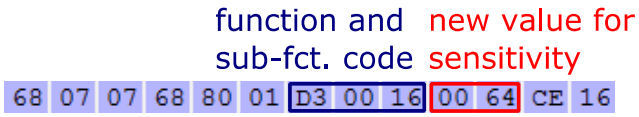


Figure 37: master requests new threshold sensitivity left value (10dB)

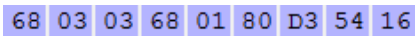


Figure 38: acknowledge from sensor

- Read threshold sensitivity left

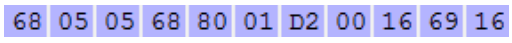


Figure 39: master requests threshold sensitivity left value from sensor

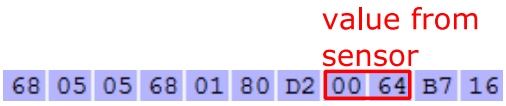


Figure 40: iSYS acknowledges with function code and threshold sensitivity value in PDU (10dB)

3.3.4.6. IP configuration (0x00 29)

This sub-function code changes the IP configuration of a RADAR sensor. Stop acquisition first (3.3.3.1) before write an IP configuration. Following configuration parameters available:

- Save location (uint8_t; 0=RAM, 1=EEPROM)
- IP-Address (4x uint8_t)
- Subnet-Mask (4x uint8_t)
- Gateway (4x uint8_t)

Examples:

- Write IP configuration

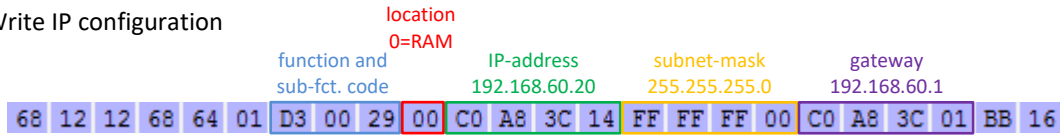


Figure 41: master writes IP configuration to RADAR sensor

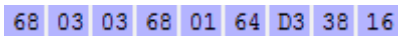


Figure 42: iSYS acknowledge

- Read IP configuration

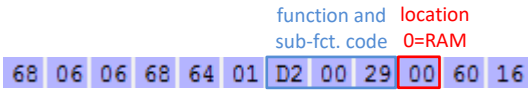


Figure 43: master reads IP configuration from RADAR sensor

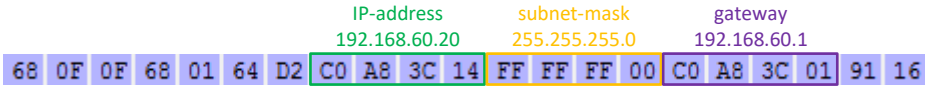


Figure 44: iSYS acknowledge with IP configuration

3.3.4.7. IP destination (0x00 2A)

This sub-function code changes the IP address and ports of the RADAR sensor destination. Stop acquisition first (3.3.3.1) before write an IP destination. Following parameters available:

- Save location (uint8_t; 0=RAM, 1=EEPROM)
- IP-Address (4x uint8_t)
- Target list port (uint8_t)
- Record data port (uint8_t)

Examples:

- Write IP destination

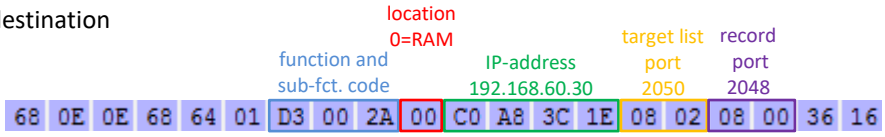


Figure 45: master writes IP destination to RADAR sensor

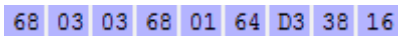


Figure 46: iSYS acknowledge

- Read IP destination

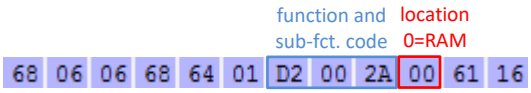


Figure 47: master reads IP destination from RADAR sensor

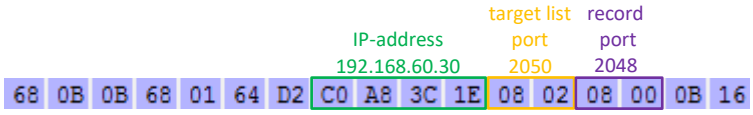


Figure 48: iSYS acknowledge with IP destination

3.3.4.8. Target list interface (0x00 2C)

This sub-function codes allow to select the interface for the target list output. The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM stores the parameter in non-volatile EEPROM. Another way for saving the value to EEPROM is using the command **"Save application and sensor settings"** as described in section 3.3.9.2. Byte 4 contains the target list interface. Successful writes are replied with the function code within a frame with variable data length.

For read request the first data byte of the answer frame contains the used target list interface of the sensor.

Setting	Description
0 = off	The target list output is disabled
1 = SPI	The iSYS sends the target list via SPI interface
2 = ETH	The iSYS sends the target list via Ethernet interface

Examples:

- Write target list interface

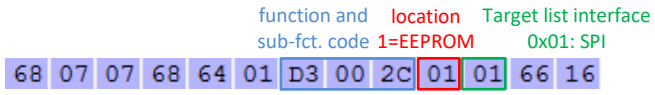


Figure 49: master writes target list interface (0x01: SPI) to the RADAR sensor

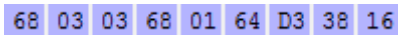


Figure 50: iSYS acknowledge

- Read target list interface

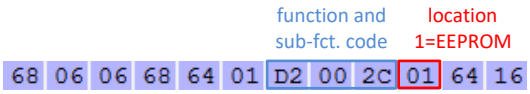


Figure 51: master reads the target list interface from the RADAR sensor

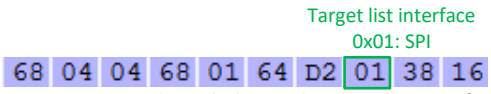


Figure 52: iSYS acknowledge with target list interface

3.3.4.9. Switching LED functionality on/off (0x00 2D)

If the LED light seems to have a disruptive behavior in the desired application, it can be configured to different functionalities. The functionality is saved in the EEPROM.

The frame PDU contains the sub-function in the first two bytes. The third byte contains the configured LED functionality state.

Functionality	Description
0 = off	LED off in all cases either target available or not
1 = on	LED on (default) • Target approaching – LED flashes red • Target receding – LED flashes green • No Target available – **LED is yellow blinking**
2 = blinking off	LED blinking off • Target approaching – LED flashes red • Target receding – LED flashes green • No Target available – **LED off**

Examples:

- Write LED functionality

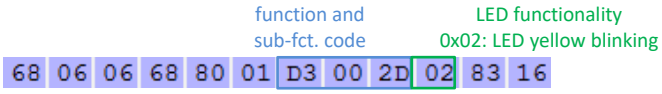


Figure 53: master writes LED functionality (0x02: Led yellow blinking of) to the RADAR sensor

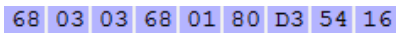


Figure 54: iSYS acknowledge

- Read LED functionality

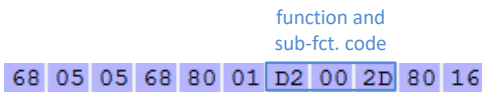


Figure 55: master reads LED functionality from the RADAR sensor

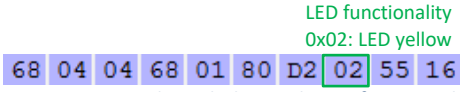


Figure 56: iSYS acknowledge with LED functionality

3.3.5. Application settings (0xD4/0xD5)

The master device can read and write application settings to adapt the iSYS functionality to the desired application. A list of the available settings on the different iSYS is shown in Table 14.

For reading the different settings, the master sends a frame with function code (0xD4) and sub function code. The iSYS answers with the function code and the requested data.

For writing data to the iSYS, the master sends a frame with function code (0xD5), sub-function code and the data.

In both cases the requests are send within a frame with variable data length and sub-function code within the first two bytes of the PDU.

The following table lists the available sub-function codes used for the configuration of the three different digital outputs. The "X" in the sub-function codes refers to the number of the digital output. [1, 2, 3].

A more detailed description for each sub-function with working examples for output 1 follows in the next subsections.

Note: This settings are only stored in volatile RAM on the iSYS. Use the EEPROM save application data command described in section 3.3.9.

Table 13: available sub-function codes

Sub-function code	Sub-function	Description	Data-bytes
0x00 00	Line filter 1	Line filter 1 setting 1. Uint16_t: Enable (0= off, 1 = on) 2. Uint16_t: frequency in Hz 3. Uint16_t: offset in tenth of dB	6 (3 x uint16_t)
0x00 01	Line filter 2	Line filter 2 setting 1. Uint16_t: Enable (0= off, 1 = on) 2. Uint16_t: frequency in Hz 3. Uint16_t: offset in tenth of dB	6 (3 x uint16_t)
0x0X 00	Enable	Digital output enable • 0 = off • 1 = digital • 2 = pwm	2 (uint16_t)
0x0X 01	Rising delay	Rising delay in multiples of cycle time	2 (uint16_t)
0x0X 02	falling delay	falling delay in multiples of cycle time	2 (uint16_t)
0x0X 04	Setting1	Setting 1 for the digital outputs • 0 = active low side • 1 = active high side • 2 = totem pole	2 (uint16_t)
0x0X 05	Setting2	Setting 2 for the digital outputs • 0 = normally open	2 (uint16_t)

		• 1 = normally closed	
0x0X 06	Angle min	Min possible angle (value in tenth of degree)	2 (sint16_t)
0x0X 07	Angel max	max possible angle (value in tenth of degree)	2 (sint16_t)
0x0X 08	Range min	Min possible range (value in tenth of m)	2 (sint16_t)
0x0X 09	Range max	Max possible range (value in tenth of m)	2 (sint16_t)
0x0X 0A	Signal min	Min possible signal strength (value in tenth of dB)	2 (sint16_t)
0x0X 0B	Signal max	Max possible signal strength (value in tenth of dB)	2 (sint16_t)
0x0X 0C	Velocity min	Min possible velocity (value in tenth of $\frac{m}{s}$)	2 (sint16_t)
0x0X 0D	Velocity max	Max possible velocity (value in tenth of $\frac{m}{s}$)	2 (sint16_t)
0x0X 0E	Direction	Moving direction of detect • 1=approaching • 2=receding • 3=both directions *Note: only available for sensors with velocity measurement function*	2 (sint16_t)
0x0X 15	Output filter	Type of single target filter • 0=highest amplitude • 1=mean • 2=median • 3=min • 4=max	2 (uint16_t)
0x0X 16	Output filter signal	Signal for single target filter • 0=off • 1=velocity radial • 2=range radial	2 (uint16_t)
0x0X 17	Alpha filter velocity	Alpha-filter parameter for velocity set between 0 and 100 in percent	2 (uint16_t)
0x0X 18	Alpha filter range	Alpha-filter parameter for range Set between 1 and 100 in percent	2 (uint16_t)
0x0X 19	Range min extended	Min possible range (value in centimeter (0.01m))	2 (sint16_t)
0x0X 1A	Range max extended	Max possible range (value in centimeter (0.01m))	2 (sint16_t)

0x05 06	Mounting offset (iSYS-6203 only)	Set an additional mounting offset in mm	4 (uint32_t)
0x06 80	Potis	Reads/Writes the amplification potentiometer values	2 (uint16_t)
0x07 07	Temperature threshold (iSYS-6203 only)	Sets the temperature threshold for the temperature warning/alarm outputs OUT1 and OUT2	7 (3 x uint16_t + 1)
0x07 09	Range/ temperature warning switch (iSYS-6203 only)	Switch output between temperature and range warning	3 (3 x uint8_t)
0x07 0A	Temperature threshold value iSYS-6203 only)	Set/get temperature warning threshold	4 (2x uint8_t + sint16_t)
0x07 0B	range threshold value iSYS-6203 only)	Set/get range warning threshold	6 (2x uint8_t + uint32_t)
0x08 28	Threshold margin parameter for moving targets: near range	Set/get the sensitivity margin for moving targets in near range (up to 2.7m)	3 (uint8_t + sint16_t)
0x08 29	Threshold margin parameter for moving targets: main range	Set/get the sensitivity margin for moving targets in the main range (2.7m to 40.7 m)	3 (uint8_t + sint16_t)
0x08 2A	Threshold margin parameter for moving targets: long range	Set/get the sensitivity margin for moving targets in near range (above 40.7m)	3 (uint8_t + sint16_t)
0x08 53	Rcs output enable	Enables / disables the rcs output	2 (2 x uint8_t)
0x08 80	Detection clustering	Enables / disables the detection clustering	2 (2 x uint8_t)
0x08 A0	Stop bar zone enable	Enables / disables stop bar zone	3 (3 x uint8_t)
0x08 A1	Stop bar zone range	Set/get the minimum and maximum range	4 (2 x uint8_t + 2 x sind16_t)
0x08 A2	Stop bar zone angle	Set/get the minimum and maximum angle	4 (2 x uint8_t + 2 x sind16_t)

Table 14: supported settings of the different iSYS devices

device	Angle (min/max)	Range (min/max)	Signal (min/max)	Velocity (min/max)	Velocity direction	Output signal target filter	Alpha filter
iSYS-6003, iSYS-6005, iSYS-6007, iSYS-6203	No	Yes (0-20.0m)	Yes (0dB-255.0dB)	No	-	Yes	Yes
iSYS-6004	No	Yes (0-15.0m)	Yes (0dB-255.0dB)	No	-	Yes	Yes
iSYS-6006	No	Yes (0-10.0m)	Yes (0dB-255.0dB)	No	-	Yes	Yes
iSYS-4001, iSYS-4002,	No	Yes (0m-150.0m)	Yes (0dB-250.0dB)	Yes $\left(0 - 70\frac{m}{s}\right)$	Yes	Yes	Yes
iSYS-4003	No	Yes (0m-50.0m)	Yes (0dB-250.0dB)	Yes $\left(0 - 12.5\frac{m}{s}\right)$	Yes	Yes	Yes
iSYS-4013	No	No	Yes (0dB-250.0dB)	Yes $\left(0 - 12.5\frac{m}{s}\right)$	Yes	Yes	Yes
iSYS-4004	No	Yes (0m-35.0m)	Yes (0dB-250.0dB)	No	-	Yes	Yes

3.3.5.1. Line filter 1 / 2 (0x00 00 / 0x00 01)

The line filters are two filters for suppressing frequencies caused by e.g. the supply voltage (Europe 50/100 Hz, USA 60/120 Hz). Both filters are identical and can be configured to increase the threshold used for detection in the environment of those frequencies by the supplied offset in tenth of dB. The data section of the frame contains three uint16_t word to determine the setting of the line filter. The first word is the enable of the selected line filter (0=off, 1=on). The second word is the frequency in Hz which the line filter suppresses. Allowed frequency values are between 0 and 50 kHz. The third word is the offset value of the line filter in dB. Values between 0 and 1000 dB are possible.

Note: Line filters are only supported by iSYS-4001, iSYS-4002, iSYS-4003 and iSYS-4013.

Examples:

- The following example sets line filter 1 with a frequency of 50 Hz and 5dB attenuation (offset)

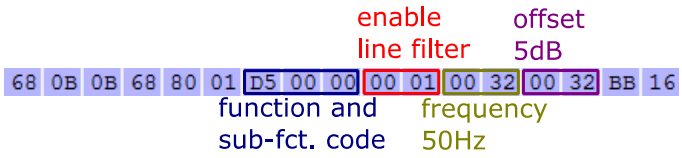


Figure 57: master sends write request line filter 1 settings (filter enabled, 50Hz, 5dB attenuation)

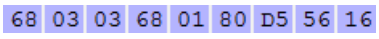


Figure 58: Acknowledge after sucessfull write request from iSYS

- The following example shows the read request for the line filter 1 settings

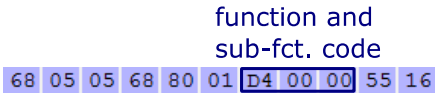
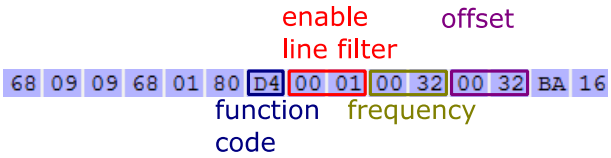


Figure 59: master sends read request for the line filter 1 settings



3.3.5.2. Enable output (0x0X 00)

This setting determines the output mode of the selected digital output. The number of the output is coded in the first byte of the sub function code (0x0X 00). Three possible settings are available. Unsupported settings are answered with failure by the iSYS.

Table 15: availible output enable states

Enable state	**description**
0 = output off	
1 = digital output.	Mode determined via output setting 1 (section 3.3.5.4) and output setting 2 (section 3.3.5.5)
2 = pwm coded output	The range of the nearest target is outputted via a pwm (not implemented on iSYS-6xxx). The duty cycle of the pwm corresponds to the measured distance. The duty cycle (DC) of the pwm is calculated according to following equation: $$DC = \frac{measuredRange - minRange}{maxRange - minRange} * 100$$ The min/max Range values can be changed via the output filter as described in section 3.3.5.7.

Examples:

- The following example sets the digital output 1 to digital output mode

```
68 07 07 68 80 01 D5 01 00 00 01 58 16
```

Figure 60: sets output1 to digital output.

```
68 03 03 68 01 80 D5 56 16
```

Figure 61: Acknowledge after sucessfull write request from iSYS

- The following example reads the output enable state from output 1

```
68 05 05 68 80 01 D4 01 00 56 16
```

Figure 62: master sends read request for the digital output 1 enable state

```
68 05 05 68 01 80 D4 00 01 56 16
```

Figure 63: iSYS sends requested output enable state (0x00 01 = digital output)

3.3.5.3. Rising/falling delay (0x0X 01 / 0x0X 02)

This settings are used for an on (rising)/off (falling) delay of the detected targets. The values written for rising delay determine the number of consecutive detections for one target until the target is outputted in the target list. The falling delay similarly determines the number of missing detections until a previous detected target is cleared from the target list. The values for rising and falling delay are measured in number of measurement cycles. For the measurement cycle time refer to the datasheet of the used iSYS device or Table 6. Allowed values are between 0 and $(2^{16} - 1)$.

Examples:

- The following example sets the rising delay to 10 measurement cycles. The falling delay can be set similar using the sub function code 0x01 02 and changing the frame checksum according.

```
68 07 07 68 80 01 D5 01 01 00 0A 62 16
```

Figure 64: sets output1 rising delay to 10 measurement cycles

```
68 03 03 68 01 80 D5 56 16
```

Figure 65: Acknowledge after sucessfull write request from iSYS

- The following example reads the rising delay for output 1. The falling delay can be read using the sub function code 0x01 02 and changing the frame checksum of the request according.

```
68 05 05 68 80 01 D4 01 01 57 16
```

Figure 66: master sends read request for the digital output 1 enable state

```
68 05 05 68 01 80 D4 00 0A 5F 16
```

Figure 67: iSYS sends requested output enable state (0x00 0A = 10 cycles rising delay)

3.3.5.4. Output setting 1 (0x0X 04)

The functionality of the three digital outputs can be configured using this sub function code and the sub function code from section 3.3.5.5. The three output settings from Table 16 determine the drive state of the selected digital output. The selected output (OUT1 (0x01) to OUT3 (0x03)) is coded in the first byte of the sub function code. The third and fourth byte contain during write commands the new output setting 1 value.

Table 16: available drive states for the iSYS devices

Setting	Description
0 = active low side	The iSYS drives the selected output between **GND** and **High impedance**
1 = active high side	The iSYS drives the selected output between **VCC** and **High impedance**
2 = totem pole	The iSYS drives the selected output between **GND** and **VCC**

Examples:

- The following example sets digital output 1 to totem pole

```
68 07 07 68 80 01 D5 01 04 00 02 5D 16
```

Figure 68: sets output1 setting 1 for totem pole

```
68 03 03 68 01 80 D5 56 16
```

Figure 69: Acknowledge after sucessfull write request from iSYS

- The following example reads the setting 1 for output 1

```
68 05 05 68 80 01 D4 01 04 5A 16
```

Figure 70: master sends read request for the digital output 1 drive state

```
68 05 05 68 01 80 D4 00 02 57 16
```

Figure 71: iSYS sends requested setting 1 for output 1 (2 = totem pole)

3.3.5.5. Output setting 2 (0x0X 05)

This function code determines the digital output state of the selected output if no target was detected or the output is disabled with the sub function code from section 3.3.5.2. Two settings are possible for each digital output:

- 0 = normally open
- 1 = normally closed

The first byte of the sub function code contains the coded output number (OUT1 (0x01) to OUT3 (0x03)). The third data byte contains the desired output 2 setting. Unsupported settings are replied with failure by the sensor device.

Examples:

- The following example sets digital output 1 to normally closed (output setting 2 = 1)

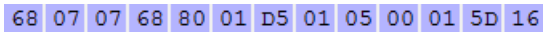


Figure 72: sets output1 setting 2 to normally closed

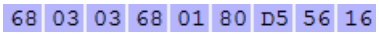


Figure 73: Acknowledge after sucessfull write request from iSYS

- The following example reads the output setting 2 for output 1

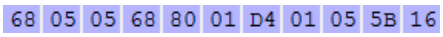


Figure 74: master sends read request for the digital output 1 default output state

Figure 75: iSYS sends requested setting 2 for output 1 (1 = normally closed)

3.3.5.6. Angle min/max (0x0X 06 / 0x0X 07)

This sub-function codes are used to set the angle boundaries of the detection area for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The angle value is transmitted as sint16_t in tenth of degree within the third and fourth PDU byte of a frame with variable data length. Write attempts of unsupported values are replied with failure by the iSYS. For sensors without angle measurement functionality this sub-function codes should not be used to change the default values on the sensor.

Examples:

- To set the detection area for output 1 between $\pm 10°$ following frames are send from the master to the iSYS. Both are replied with the function code as shown in Figure 78.

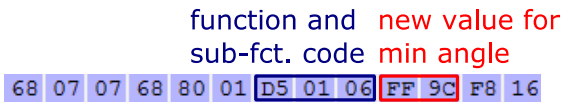


Figure 76: master sends write request with new min angle value (-10°)

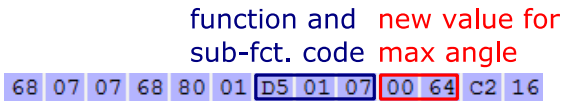


Figure 77: master sends write request with new max angle value (10°)

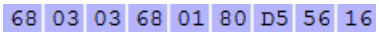


Figure 78: Acknowledge after sucessfull write requests from iSYS

The frames send to read the angle boundary values from the iSYS for output 1 are illustrated in the following figures.

- Min angle value

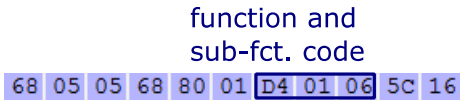


Figure 79: master sends read request for min angle value to iSYS

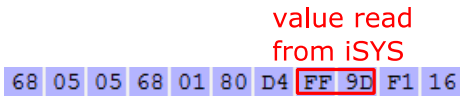


Figure 80: iSYS sends min angle value (-10°) in SD2 frame with function code 0xD4

- Max angle value

68 05 05 68 80 01 D4 01 07 5D 16

Figure 81: master sends read request for max angle value to iSYS

68 05 05 68 01 80 D4 00 64 B9 16

Figure 82: iSYS sends max angle value (10°) in SD2 frame with function code 0xD4

3.3.5.7. Range min/max (0x0X 08 / 0x0X 09)

This sub-function codes are used to set the range boundaries of the detection area for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The range value is transmitted as sint16_t in tenth of meter within the third and fourth PDU byte of a frame with variable data length. Write attempts of unsupported values are replied with failure by the iSYS. For sensors without range measurement functionality this sub-function codes should not be used to change the default values on the sensor.

Examples:

- To set the detection area for output 1 between 1m and 10m following frames are send from the master to the iSYS. Both are replied with the function code as shown in Figure 85.

68 07 07 68 80 01 D5 01 08 00 0A 69 16

Figure 83: master sends write request with new min range value (1m)

68 07 07 68 80 01 D5 01 09 00 64 C4 16

Figure 84: master sends write request with new max range value (10m)

68 03 03 68 01 80 D5 56 16

Figure 85: Acknowledge after sucessfull write requests from iSYS

- The frames send to read the range boundary values from the iSYS for output 1 are illustrated in the following figures.

    - Min range value

```
68 05 05 68 80 01 D4 01 08 5E 16
```

Figure 86: master sends read request for min range value to iSYS

```
68 05 05 68 01 80 D4 00 0A 5F 16
```

Figure 87: iSYS sends min range value (1m) in SD2 frame with function code 0xD4

    - Max range value

```
68 05 05 68 80 01 D4 01 09 5F 16
```

Figure 88: master sends read request for max range value to iSYS

```
68 05 05 68 01 80 D4 03 E8 40 16
```

Figure 89: iSYS sends max range value (10m) in SD2 frame with function code 0xD4

3.3.5.8. Signal min/max (0x0X 0A / 0x0X 0B)

This sub-function codes are used to set the signal strength boundaries of the detection area for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The signal value is transmitted as sint16_t in tenth of dB within the third and fourth PDU byte of a frame with variable data length. Write attempts of unsupported values are replied with failure by the iSYS.

Examples:

- To set the detection area for output 1 between 20dB and 100dB following frames are send from the master to the iSYS. Both are replied with the function code as shown in Figure 92.

```
68 07 07 68 80 01 D5 01 0A 00 C8 29 16
```

Figure 90: master sends write request with new min signal value (20dB)

```
68 07 07 68 80 01 D5 01 0B 03 E8 4D 16
```

Figure 91: master sends write request with new max signal value (100dB)

```
68 03 03 68 01 80 D5 56 16
```

Figure 92: Acknowledge after sucessfull write requests from iSYS

- The frames send to read the signal boundary values from the iSYS for output 1 are illustrated in the following figures.
    - Min signal value

68 05 05 68 80 01 D4 01 0B 61 16

Figure 93: master sends read request for min signal value to iSYS

68 05 05 68 01 80 D4 00 C8 1D 16

Figure 94: iSYS sends min signal value (20dB) in SD2 frame with function code 0xD4

    - Max signal value

68 05 05 68 80 01 D4 01 0B 61 16

Figure 95: master sends read request for max signal value to iSYS

68 05 05 68 01 80 D4 03 E8 40 16

Figure 96: iSYS sends max signal value (100dB) in SD2 frame with function code 0xD4

3.3.5.9. Velocity min/max (0x0X 0C / 0x0X 0D)

This sub-function codes are used to set the velocity boundaries of the detection area for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The velocity value is transmitted as sint16_t in tenth of meter per second within the third and fourth PDU byte of a frame with variable data length. Only positive velocity values are accepted by the iSYS. The direction of the velocity is set through a separate parameter. Write attempts of unsupported values are replied with failure by the iSYS. For sensors without velocity measurement functionality this sub-function codes should not be used to change the default values on the sensor.

Examples:

- To set the detection area for output 1 between $4\frac{m}{s}$ and $10\frac{m}{s}$ following frames are send from the master to the iSYS. Both are replied with the function code as shown in Figure 99.

68 07 07 68 80 01 D5 01 0C 00 28 8B 16

Figure 97: master sends write request with new min velocity value ($4\frac{m}{s}$)

68 07 07 68 80 01 D5 01 0D 00 64 C8 16

Figure 98: master sends write request with new max velocity value ($10\frac{m}{s}$)

68 03 03 68 01 80 D5 56 16

Figure 99: Acknowledge after sucessfull write requests from iSYS

- The frames send to read the velocity boundary values from the iSYS for output 1 are illustrated in the following figures.
    - Min velocity value

```
68 05 05 68 80 01 D4 01 0C 62 16
```

Figure 100: master sends read request for min velocity value to iSYS

```
68 05 05 68 01 80 D4 00 28 7D 16
```

Figure 101: iSYS sends min velocity value ($4\frac{m}{s}$) in SD2 frame with function code 0xD4

    - Max velocity value

```
68 05 05 68 80 01 D4 01 0C 62 16
```

Figure 102: master sends read request for max velocity value to iSYS

```
68 05 05 68 01 80 D4 00 64 B9 16
```

Figure 103: iSYS sends max velocity value ($10\frac{m}{s}$) in SD2 frame with function code 0xD4

3.3.5.10. Velocity direction (0x0X 0E)

This sub-function code sets the direction for the velocity min/max filter for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The direction is coded in the third and fourth PDU byte of a frame with variable data length. The supported values are shown in Table 17. Write attempts of unsupported values are replied with failure by the iSYS.

Table 17: values for setting target velocity direction

Value	Direction
0x00 01	Approaching
0x00 02	Receding
0x00 03	Both directions

Examples:

- To set up the iSYS for the detection of only approaching targets following frames are send from the master to the iSYS device. Both are replied with the function code shown in Figure 105.

```
68 07 07 68 80 01 D5 01 0E 00 01 66 16
```

Figure 104: master sends write request with new velocity direction value (0x00 01 = approaching)

```
68 03 03 68 01 80 D5 56 16
```

Figure 105: Acknowledge after sucessfull write requests from iSYS

- The frame send to read the velocity direction from the iSYS device for output 1 is illustrated in the following figure.

```
68 05 05 68 80 01 D4 01 0E 64 16
```

Figure 106: master sends read request for velocity direction value to iSYS

```
68 05 05 68 01 80 D4 00 01 56 16
```

Figure 107: iSYS sends velocity direction value (0x00 01 = approaching) in SD2 frame with function code 0xD4

3.3.5.11. Output single target filter type (0x0X 15)

This sub-function code set the single target filter type for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The filter type is coded in the third and fourth PDU byte of a frame with variable data length. The supported values are shown in Table 18. Write attempts of unsupported values are replied with failure by the iSYS.

Table 18: values for setting single target filter type (sub-function code 0x0X 15)

Value	Direction
0x00 00	Highest amplitude
0x00 01	mean
0x00 02	median
0x00 03	min
0x00 04	max

Examples:

- The following example sets the single target filter type for minimum. The frame is replied on success with the function frame shown in Figure 113.

```
68 07 07 68 80 01 D5 01 15 00 03 6F 16
```

Figure 108: master sends write request with new output filter (0x00 03 = min filter)

```
68 03 03 68 01 80 D5 56 16
```

Figure 109: Acknowledge after sucessfull write requests from iSYS device

- The following frame is send to read the single target filter type from the iSYS device for output 1.

```
68 05 05 68 80 01 D4 01 15 6B 16
```

Figure 110: master sends read request for single filter type to iSYS device

```
68 05 05 68 01 80 D4 00 03 58 16
```

Figure 111: iSYS sends output target filter setting for the filter (0x00 03 = min filter) in SD2 frame with function code 0xD4

3.3.5.12. Output single target filter signal (0x0X 16)

This sub-function code sets the single target filter signal for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The filter signal is coded in the third and fourth PDU byte of a frame with variable data length. This function code together with the output filter type determines the used single target filter. For example setting the filter type to min and the filter signal to range radial configures the iSYS to use a min range single target filter which returns the nearest detected target within the detection area.

The supported values are shown in Table 19. Write attempts of unsupported values are replied with failure by the iSYS. Setting the filter signal to 0x00 00 disables the single target filter for the selected output and all targets within the detection window are outputted. Use this to output an unfiltered target list.

Table 19: values for setting single target filter signal (sub-function code 0x0X 16)

Value	Direction
0x00 00	Off
0x00 01	Velocity radial
0x00 02	Range radial

Examples:

- The following example set the single target filter signal for range radial. The frame is replied on success with the frame shown in Figure 113.

```
68 07 07 68 80 01 D5 01 16 00 02 6F 16
```

Figure 112: master sends write request with new output signal for filter (0x00 02 = range radial)

```
68 03 03 68 01 80 D5 56 16
```

Figure 113: Acknowledge after sucessfull write requests from iSYS

- The following frame is send to read the single target filter signal from the iSYS device for output 1.

```
68 05 05 68 80 01 D4 01 16 6C 16
```

Figure 114: master sends read request single target filter signal to iSYS

```
68 05 05 68 01 80 D4 00 02 57 16
```

Figure 115: iSYS sends output signal setting for the filter (0x00 02 = range radial) in SD2 frame with function code 0xD4

3.3.5.13. Alpha filter velocity/range (0x0X 17 / 0x0X 18)

This sub-function codes set the value used for an alpha smoothing filter of the single target filter output value of the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The alpha filter value is transmitted as uint16_t in percent within the third and fourth byte of a frame with variable data length. Write attempts of unsupported values are replied with failure by the iSYS.

The alpha filter value determines the percentage of the new measurement value from the current cycle in the in the finial output value in the target list according to following formula:

$$\boldsymbol{Value_{new} = Value_{old} + \alpha \cdot (Value_{new,measured} - Value_{old})}$$

$Value_{new}$: New output value in the target list

$Value_{old}$: Old filtered value from the last measurement cycle

$Value_{new,mesured}$: New measurement value

α: settable parameter of the alpha filter ($0 < \alpha \leq 1$),
protocol transmits value as percent ($0 < \alpha_{percent} \leq 100$)

Note: The transmitted values is the inverted values of the alpha filter strength. This means sending a value of 100% (0x64) deactivates the alpha filter and a value of 0% (0x00) sets the filter to maximum strength.

Examples:

- The following examples show the setting of the alpha filter to 50%. The request is in both cases replied on success with the function code shown in Figure 118.

```
68 07 07 68 80 01 D5 01 17 00 32 A0 16
```

Figure 116: master sends write request with new value alpha filter velocity (0x00 32 = 50%)

```
68 07 07 68 80 01 D5 01 18 00 32 A1 16
```

Figure 117: master sends write request with new range alpha filter value (0x00 32 = 50%)

```
68 03 03 68 01 80 D5 56 16
```

Figure 118: Acknowledge after sucessfull write requests from iSYS

- The frames send to read the alpha filter settings from the iSYS for output 1 are illustrated in the following figures.
    - velocity alpha filter value

```
68 05 05 68 80 01 D4 01 17 6D 16
```

Figure 119: master sends read request for velocity alpha filter value to iSYS

```
68 05 05 68 01 80 D4 00 32 87 16
```

Figure 120: iSYS sends velocity alpha filter value (50%) in SD2 frame with function code 0xD4

    - range alpha filter value

```
68 05 05 68 80 01 D4 01 18 6E 16
```

Figure 121: master sends read request for range alpha filter value to iSYS

```
68 05 05 68 01 80 D4 00 32 87 16
```

Figure 122: iSYS sends range alpha filter value (50%) in SD2 frame with function code 0xD4

3.3.5.14. Range min/max extended (0x0X 19 / 0x0X 1A)

This sub-function codes are used to set the range boundaries of the detection area for the selected output [1, 2, or 3]. The output number is coded in the first byte of the sub-function code. The range value is transmitted as uint16_t in [cm] within the third and fourth PDU byte of a frame with variable data length. Write attempts of unsupported values are replied with failure by the iSYS. For sensors without range measurement functionality this sub-function codes should not be used to change the default values on the sensor.

Examples:

- To set the detection area for output 1 between 1.01m and 10.01m, the following frames are sent from the master to the iSYS. Both are replied with the function code as shown in Figure 125.

```
68 07 07 68 64 01 D5 01 19 00 65 B9 16
```

Figure 123: master sends write request with new min range value (1.01m)

```
68 07 07 68 64 01 D5 01 1A 03 E9 41 16
```

Figure 124: master sends write request with new max range value (10.01m)

```
68 03 03 68 01 64 D5 3A 16
```

Figure 125: Acknowledge after sucessfull write requests from iSYS

- The frames sent to read the range boundary values from the iSYS for output 1 are illustrated in the following figures.

  - Min range value

```
68 05 05 68 64 01 D4 01 19 53 16
```

Figure 126: master sends read request for min range value to iSYS

```
68 05 05 68 01 64 D4 00 65 9E 16
```

Figure 127: iSYS sends min range value (1.01m) in SD2 frame with function code 0xD4

  - Max range value

```
68 05 05 68 64 01 D4 01 1A 54 16
```

Figure 128: master sends read request for max range value to iSYS

```
68 05 05 68 01 64 D4 03 E9 25 16
```

Figure 129: iSYS sends max range value (10.01m) in SD2 frame with function code 0xD4

3.3.5.15. Set/Get mounting offset (0x05 06)

This sub function code is used to set an additional mounting offset. This offset is subtracted from all measured range values. The offset value is transmitted in [mm] in the third to sixth byte of the data section of a frame with variable data length. Writing invalid values is replied with failure. This function is only supported by iSYS-6203 with newer firmware versions.

A read request returns the value of the offset value within a frame with variable data length.

Examples:

- The following example sets the mounting offset to 1234mm

```
68 09 09 68 64 01 D5 05 06 00 00 04 D2 1B 16
```

Figure 130: master sets mounting offset to 1234mm

```
68 03 03 68 01 64 D5 3A 16
```

Figure 131: Acknowledge after sucessfull write request from iSYS

- The following example reads the current mounting offset value

```
68 05 05 68 64 01 D4 05 06 44 16
```

Figure 132: master sends read request for the mounting offset value

```
68 07 07 68 01 64 D4 00 00 04 D2 0F 16
```

Figure 133: iSYS sends requested value (0x00 00 04 D2 = 1234mm)

3.3.5.16. Set/Get Potis (0x06 80)

This function code is used to set the potentiometer values used for the NF-amplifier. The potentiometer value is transmitted in the third and fourth byte of the data section of a frame with variable data length. Only values between 0 and 255 are supported. Writing invalid values is replied with failure.

A read request returns the value of the amplifier potentiometer value within a frame with variable data length.

Examples:

- The following example sets the amplifier potentiometers to step 50

```
68 07 07 68 80 01 D5 06 80 00 32 0E 16
```

Figure 134: master sets amplifier potentiomerter to 50

```
68 03 03 68 01 80 D5 56 16
```

Figure 135: Acknowledge after sucessfull write request from iSYS

- The following example reads the current amplifier potentiometer value

```
68 05 05 68 80 01 D4 06 80 DB 16
```

Figure 136: master sends read request for amplifier potentiometer value

```
68 05 05 68 01 80 D4 00 32 87 16
```

Figure 137: iSYS sends requested value (0x00 32 = 50)

3.3.5.17. Temperature threshold (0x07 07)

This sub-function can be used to set the temperature threshold values **on the iSYS-6203**. A write request is send within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is using the command **"Save application and sensor settings"** as described in section 3.3.9.2. Byte 4 to 9 contain the threshold values for the three outputs in hundredth of degree Celsius. Threshold values between -20.00°C and 100.00°C are allowed for writing. Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the first data byte of the answer frame contains the location (0x00: RAM, 0x01: EEPROM) of the read value. Byte 2 to 7 contain the temperature threshold values in hundredth of degree Celsius.

Note: OUT3 is currently unused and intended for future use. It should always be written with 0x0000. A read request always return 0x0000 for this output.

Table 20: structure of PDU for temperature threshold write request

PDU[2] (uint8_t)	PDU[2,3] (sint16_t)	PDU[4,5] (sint16_t)	PDU[6,7] (sint16_t)
Location (0x00: RAM, 0x01:EEPROM)	Temperature threshold OUT1 (-20.00°C … 100.00°C)	Temperature threshold OUT2 (-20.00°C … 100.00°C)	Temperature threshold OUT3 (unused write 0x0000)

Examples:

- The following example sets the OUT1 to 50.00°C and OUT2 to 45.00°C and saves the settings to EEPROM

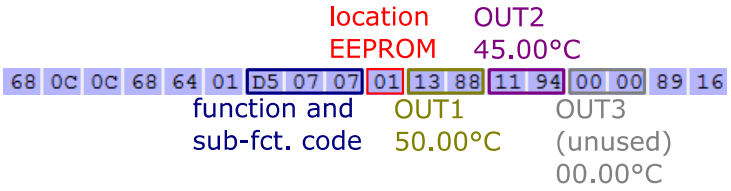


Figure 138: master sets temperature threshold values

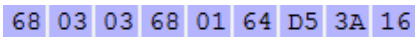


Figure 139: Acknowledge after sucessfull write request from iSYS-6203

- The following example reads the current temperature threshold values from EEPROM

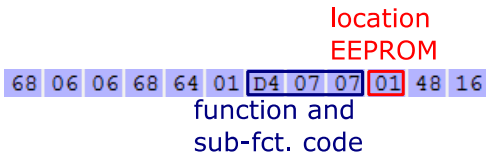


Figure 140: master sends read request for temperature threshold values

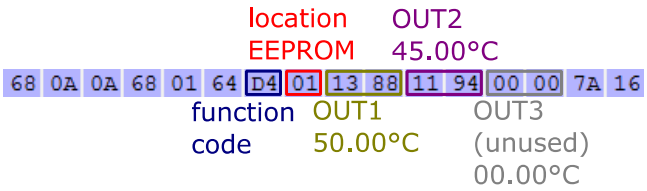


Figure 141: iSYS sends requested temperature threshold values (OUT1: 0x1388 = 50.00°C, OUT2: 0x1194 = 45.00°C)

3.3.5.18. Range / temperature warning switch (0x07 09)

This sub-function can be used to switch between temperature and range warning mode of the outputs **of the iSYS-6203**. A write request is sent within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is using the command **"Save application and sensor settings"** as described in section 3.3.9.2. The fourth byte contains the output (Out1: 1, Out2: 2). The fifth byte contains the warning mode (temperature: 1, range: 2). Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the first data byte of the answer frame contains the location (0x00: RAM, 0x01: EEPROM) and the output (Out1: 1, Out2: 2) of the read value. Byte 3 contains the warning mode.

Examples:

- The following example sets the OUT1 to range warning mode and saves the settings to EEPROM

```
68 08 08 68 64 01 D5 07 09 01 01 01 4D 16
```

Figure 142: master sets warning mode value (EEPROM: 0x01, Out1: 0x01, rangeWarning: 0x01)

```
68 03 03 68 01 64 D5 3A 16
```

Figure 143: Acknowledge after sucessfull write request from iSYS-6203

- The following example reads the warning mode for output 1 from EEPROM

```
68 07 07 68 64 01 D4 07 09 01 01 4B 16
```

Figure 144: master sends read request for temperature threshold values

```
68 06 06 68 01 64 D4 01 01 01 3C 16
```

Figure 145: iSYS sends requested temperature threshold values (warning mode range: 0x01)

3.3.5.19. Set/get temperature warning threshold (0x07 0A)

This sub-function can be used to set the temperature threshold for the temperature warning mode of the outputs **of the iSYS-6203**. A write request is sent within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is using the command **"Save application and sensor settings"** as described in section 3.3.9.2. The fourth byte contains the output (Out1: 1, Out2: 2). The fifth and sixth byte contains the temperature threshold in hundredths of degree. Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the first data byte of the answer frame contains the location (0x00: RAM, 0x01: EEPROM) and the output (Out1: 1, Out2: 2) of the read value. Byte three and four contains the read temperature threshold in hundredths of degree.

Examples:

- The following example sets the OUT1 temperature warning threshold to 50.00°C and saves the settings to EEPROM

```
68 09 09 68 64 01 D5 07 0A 01 01 13 88 E8 16
```

Figure 146: master sets warning mode value (EEPROM: 0x01, Out1: 0x01, temperature 50.00°C)

```
68 03 03 68 01 64 D5 3A 16
```

Figure 147: Acknowledge after sucessfull write request from iSYS-6203

- The following example reads the temperature warning threshold for output 1 from RAM

```
68 07 07 68 64 01 D4 07 0A 00 01 4B 16
```

Figure 148: master sends read request for temperature threshold values

```
68 07 07 68 01 64 D4 00 01 13 88 D5 16
```

Figure 149: iSYS sends requested temperature threshold values (temperature threshold: 50.00°C)

3.3.5.20. Set/get range warning threshold (0x07 0B)

This sub-function can be used to set the range threshold for the temperature warning mode of the outputs **of the iSYS-6203**. A write request is send within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is using the command **"Save application and sensor settings"** as described in section 3.3.9.2. The fourth byte contains the output (Out1: 1, Out2: 2). The fifth to eight byte contains the range threshold in millimeter with one decimal transmitted as uint32_t. Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the first data byte of the answer frame contains the location (0x00: RAM, 0x01: EEPROM) and the output (Out1: 1, Out2: 2) of the read value. Byte three to six contains the read range threshold in millimeter with one decimal transmitted as uint32_t.

Examples:

- The following example sets the OUT1 range warning threshold to 1234,5mm and saves the settings to EEPROM

```
68 0B 0B 68 64 01 D5 07 0B 01 01 00 00 30 39 B7 16
```

Figure 150: master sets warning mode value (EEPROM: 0x01, Out1: 0x01, range 1234,5mm)

```
68 03 03 68 01 64 D5 3A 16
```

Figure 151: Acknowledge after sucessfull write request from iSYS-6203

- The following example reads the range warning threshold for output 1 from RAM

```
68 07 07 68 64 01 D4 07 0B 00 01 4C 16
```

Figure 152: master sends read request for temperature threshold values

```
68 09 09 68 01 64 D4 00 01 00 00 30 39 A3 16
```

Figure 153: iSYS sends requested temperature threshold values (range threshold: 1234,5mm)

3.3.5.21. Moving target threshold sensitivity near range (0x08 28)

This sub function code is used to set the threshold sensitivity for moving target in the near range of the iSYS-5010. Targets in up to 2.7m are in the near range of the iSYS-5010.

A write request is send within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is first saving the value to RAM and then using the command **"Save application and sensor settings"** as described in section 3.3.9.2. The fourth and fifth byte contain the sensitivity value in tenth of dB transmitted as sint16_t.

Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the two data byte of the answer frame contain the read back sensitivity value in tenth of dB transmitted as sint16_t.

Examples:

- The following example sets the moving target threshold near range sensitivity in the RAM to 2,5dB (0x0019)

```
68 08 08 68 64 01 D5 08 28 00 00 19 83 16
```

Figure 154: master sets the near range sensitivity value (EEPROM: 0x00, value 0x00 19 (25 => 2,5dB))

```
68 03 03 68 01 64 D5 3A 16
```

Figure 155: Acknowledge from the iSYS-5010 after sucessfull write request

- The following example reads the near range sensitivity stored in RAM from the iSYS-5010

```
68 06 06 68 64 01 D4 08 28 00 69 16
```

Figure 156: master sends read request for the moving target threshold near range sensitivity

```
68 05 05 68 01 64 D4 00 19 52 16
```

Figure 157: iSYS sends requested sensitivity value (0x0019=25 => 2,5dB)

3.3.5.22. Moving target threshold sensitivity main range (0x08 29)

This sub function code is used to set the threshold sensitivity for moving target in the main range of the iSYS-5010. Targets between 2.7m and 40.7m are in the main range of the iSYS-5010.

A write request is send within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is first saving the value to RAM and then using the command **"Save application and sensor settings"** as described in section 3.3.9.2. The fourth and fifth byte contain the sensitivity value in tenth of dB transmitted as sint16_t.

Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the two data byte of the answer frame contain the read back sensitivity value in tenth of dB transmitted as sint16_t.

Examples:

- The following example sets the moving target threshold main range sensitivtiy in the RAM to 3,6dB (0x0024)

```
68 08 08 68 64 01 D5 08 29 00 00 24 8F 16
```

Figure 158: master sets the margin main range value (EEPROM: 0x00, value 0x00 24 (36 => 3,6dB))

```
68 03 03 68 01 64 D5 3A 16
```

Figure 159: Acknowledge from the iSYS-5010 after sucessfull write request

- The following example reads the main range sensitivity stored in RAM from the iSYS

```
68 06 06 68 64 01 D4 08 29 00 6A 16
```

Figure 160: master sends read request for the moving target threshold main range sensitivity

```
68 05 05 68 01 64 D4 00 24 5D 16
```

Figure 161: iSYS sends requested sensitivity value (0x00 24=36 => 3,6dB)

3.3.5.23. Moving target threshold sensitivity long range (0x08 2A)

This sub function code is used to set the threshold sensitivity for moving target in the long range of the iSYS-5010. Targets above 40.7m are in the long range of the iSYS-5010.

A write request is send within a frame with variable data length.
The frame PDU contains the sub-function in the first two bytes. The third byte contains the location for saving the value (0x00: RAM, 0x01: EEPROM). Both locations save the value to volatile RAM, but only the location EEPROM writes the threshold in non-volatile EEPROM. Another way for saving the value to EEPROM is first saving the value to RAM and then using the command **“Save application and sensor settings”** as described in section 3.3.9.2. The fourth and fifth byte contain the sensitivity value in tenth of dB transmitted as sint16_t.

Invalid values are replied with failure. Successful writes are replied with the function code within a frame with variable data length.

For read request the two data byte of the answer frame contain the read back sensititvity value in tenth of dB transmitted as sint16_t.

Examples:

- The following example sets the moving target threshold long range sensitivity in the RAM to 3,5dB (0x0023)

68 08 08 68 64 01 D5 08 2A 00 00 23 8F 16

Figure 162: master sets the sensitivity long range value (EEPROM: 0x00, value 0x00 23 (35 => 3,5B))

68 03 03 68 01 64 D5 3A 16

Figure 163: Acknowledge from the iSYS-5010 after sucessfull write request

- The following example reads the long range sensitivity stored in RAM from the iSYS

68 06 06 68 64 01 D4 08 2A 00 6B 16

Figure 164: master sends read request for the moving target threshold long range sensitivity

68 05 05 68 01 64 D4 00 23 5C 16

Figure 165: iSYS sends requested sensitivity value (0x00 23=35 => 3,5dB)

3.3.5.24. RCS output enable/disable (0x08 53)

This sub-function code activates or disables the RCS output in the target list. The configuration value is transmitted in the third byte of the data section of the frame. Only 0 and 1 are supported.

0 -> means output of the scaled signal strength in the target list

1 -> means output of the RCS value in the target list

A read request returns the current clustering configuration.

Examples:

- The following example turns the RCS output on and saves the configuration to RAM

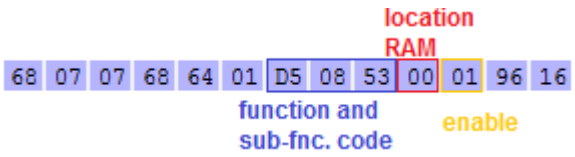


Figure 166 turning the RCS output configuration on

68 03 03 68 01 64 D5 3A 16

Figure 167: Acknowledge after sucessfull write request from iSYS-5010

- The following example reads the current RCS output configuration from RAM

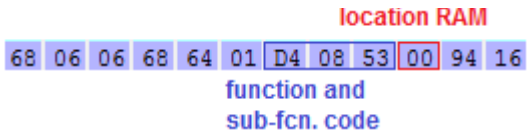


Figure 168: send read request to get the current RCS output configuration

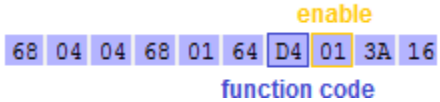


Figure 169: iSYS sends requested RCS output configuration (01 = RCS output on)

3.3.5.25. Target clustering enable/disable (0x08 80)

This sub-function code is used to enable or disable the target clustering. The configuration value is transmitted in the third byte of the data section of the frame. Only 0 (=disable) and 1 (=enable) are supported.

A read request returns the current clustering configuration.

Examples:

- The following example turns the clustering on and saves the setting to RAM

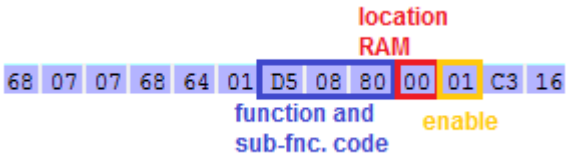


Figure 170: turn the clustering on

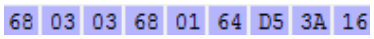


Figure 171: Acknowledge after sucessfull write request from iSYS-5010

- The following example reads the current clustering configuration from RAM

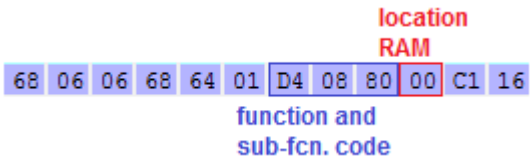


Figure 172: send read request to get the current clustering configuration

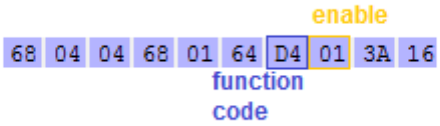


Figure 173: iSYS sends requested clustering configuration (01 = enabled)

3.3.5.26. Stop Bar Zone enable/disable (0x08 A0)

This sub-function code is used to enable or disable the stop bar zones. Only 0 (=disable) and 1 (=enable) are supported.

A read request returns the current stop bar zone status.

Table 21: structure of PDU for stop bar zone enable

PDU[2] (uint8_t)	PDU[3] (uint8_t)	PDU[4] (uint8_t)
Location (0x00: RAM, 0x01:EEPROM)	Zone number (0x00: Zone 1, 0x01: Zone 2)	enable (0x00: disable, 0x01: enable)

3.3.5.27. Stop Bar Zone Range set/get (0x08 A1)

This sub-function code is used set or get the range setting for a stop bar zone in meters.

A read request returns the current stop bar zone minimum and maximum range.

Table 22: structure of PDU for stop bar zone range

PDU[2] (uint8_t)	PDU[3] (uint8_t)	PDU[4,5] (sint16_t)	PDU[6,7] (sint16_t)
Location (0x00: RAM, 0x01:EEPROM)	Zone number (0x00: Zone 1, 0x01: Zone 2)	Minimum range (0x00 14: 20m, 0x00 32: 50m)	Maximum range (0x00 14: 20m, 0x00 32: 50m)

3.3.5.28. Stop Bar Zone Angle set/get (0x08 A2)

This sub-function code is used set or get the angle setting for a stop bar zone in degrees.
The angle precision is $1*10^{-1}$ °.

A read request returns the current stop bar zone minimum and maximum angle.

Table 23: structure of PDU for stop bar zone angle

PDU[2] (uint8_t)	PDU[3] (uint8_t)	PDU[4,5] (sint16_t)	PDU[6,7] (sint16_t)
Location (0x00: RAM, 0x01:EEPROM)	Zone number (0x00: Zone 1, 0x01: Zone 2)	Minimum angle (0x00 C8: 20.0°, 0x01 63: 35.5°)	Maximum angle (0x00 C8: 20.0°, 0x01 63: 35.5°))

3.3.6. Read calibration settings (0xD6)

This function code is used to read the calibration setting from a connected iSYS device. A list of the available sub function codes is shown in Table 24.

The master sends a frame with variable data length with function code (0xD6) and the sub function code. The iSYS device answers with the function code and the requested data or failure (see 0) within a frame with variable data length.

Table 24: available sub-function codes for function code 0xD6

Sub-function code	Sub-function	Description	Data-bytes
0x01 01	Firmware version	Returns the firmware version running on the connected iSYS device.	6 (3 x uint16_t)
0x01 02	DSP-Hardware version	Returns the dsp hardware version of the connected iSYS	6 (3 x uint16_t)
0x01 03	RFE-Hardware version	Returns the rfe hardware version of the connected iSYS	6 (3 x uint16_t)
0x01 04	Product info	Returns the product info (product code) of the connected iSYS	2 (1 x uint16_t)
0x02 20	Bootloader version	Returns the bootloader version of the connected iSYS device **Command only supported by devices with newer firmware:** – **iSYS-6xxx: firmware >=0.400** – **iSYS-4xxx: firmware >=2.000** – **iSYS-5xxx:**	6 (3 x uint16_t)

3.3.6.1. Firmware version (0x01 01)

This sub function code is used to read the version of the firmware running on the iSYS device. The three uint16_t values send by the sensor device in the data section of a frame with variable data length are used to determine the firmware version. The first uint16_t determines the major version before the decimal separator. The second uint16_t value determines the number of decimal places used for the firmware version. The third value contains the minor firmware version.

Example:

The following example show the frame send for requesting the firmware version and the decoding of the answer frame from the iSYS device.

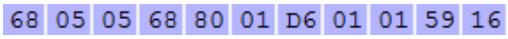


Figure 174: master device requests firmware version from the iSYS with device address 128

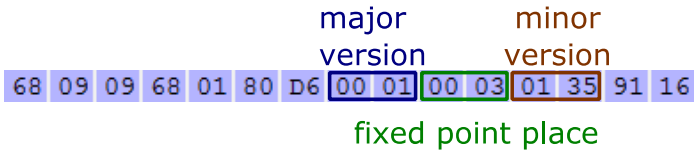


Figure 175: frame send with firmware version from the iSYS device

Decoding of the example answer frame:

Major version:	1
Fixed point place:	3
Minor version:	309
Firmware version:	**1.309**

3.3.6.2. Get DSP hardware version (0x01 02)

This sub-function code is used to read out the DSP hardware version of the sensor. The return value is transmitted as three uint16 values inside the data section of the frame. Byte one and two are the major version. Byte three and four are the fixed point place (this is used to determinate the length of the version). Byte five and six are the minor version.

Examples:

- The following example shows how the iSYS-device returns the requested DSP hardware version

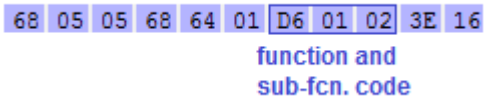


Figure 176: requesting the DSP hardware version from iSYS-device

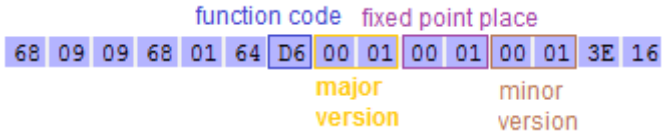


Figure 177: frame send with dsp hw version information from iSYS-device

3.3.6.3. Get RFE hardware version (0x01 03)

This sub-function code is used to read the RFE hardware version of the sensor. The return value is transmitted as three uint16 values inside the data section of the frame. Byte one and two are the major version. Byte three and four are the fixed point place (this is used to determinate the length of the version). Byte five and six are the minor version.

Examples:

- The following example shows how the iSYS-device returns the requested RFE hardware version

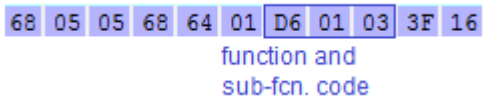


Figure 178: requesting the RFE hardware version from the iSYS-device

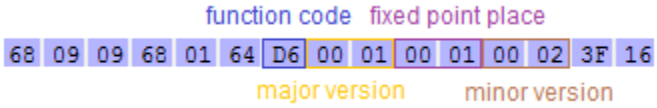


Figure 179: frame send with RFE hardware version information from iSYS-device

3.3.6.4. Get product information (0x01 04)

This function code is used to read the product information from the sensor. The return value is transmitted as uint16 value in the data section of the frame.

Examples:

- The following example shows how the iSYS-device returns the requested product information

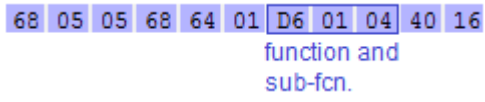


Figure 180: requesting the product information from the iSYS-device

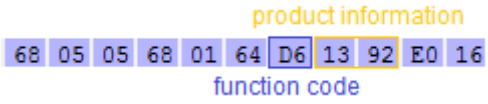


Figure 181: answer with the product information which was requested (0x13 0x92 = 5010)

3.3.6.5. Get Bootloader version (0x02 20)

This sub function code requests the version of the bootloader running on the iSYS device. The three uint16_t values send in the data section of a frame with variable data length represent the bootloader version. The first uint16_t determines the major version before the decimal separator. The second uint16_t value determines the number of decimal places right of the decimal separator. The third value contains the minor bootloader version. The iSYS devices answers with failure, if the command is not supported. Bootloader version 65535.65535 is send if the firmware supports the command, but no valid bootloader version could be read.

Example:

The following example show the frame send for requesting the bootloader version and the decoding of the answer frame from the iSYS device.

```
68 05 05 68 64 01 D6 02 20 5D 16
```

Figure 182: master device requests bootloader version from the iSYS with device address 100

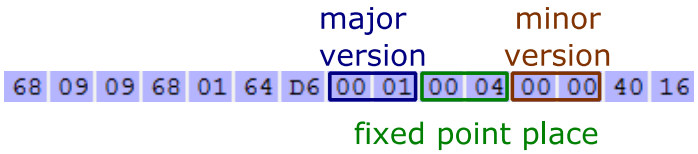


Figure 183: frame send with bootloader version from the iSYS device

Decoding of the example answer frame:

Major version:	1
Fixed point place:	4
Minor version:	0
Bootloader version:	**1.0000**

3.3.7. Read Target list (0xDA)

With this command the master device requests the target list of one measurement cycle. This is the target list processed from one measurement cycle filtered with the selected output filter. This command is only accepted by the iSYS during measurement mode. If the sensor is not in measurement mode, all target list request will be answered with failure. For changing the sensor mode refer to section 3.3.3.

The targets are sent one after another in the data section of the frame, the maximum number of targets in the list is limited to 35. Some iSYS may support only a shorter target list with fewer targets. When using low baud rates the target list may also be shortened to complete the transmission within the available time of one measurement cycle.

After completely receiving the target list a new target list can be requested. The iSYS sends the next target list immediately when it's available. You can request the target lists with the iSYS cycle time given Table 6 using this procedure.

Different target lists can be requested. The type of the target list is specified in the first two bytes of the PDU. The first byte in the PDU determines the parameters used for filtering the target list. Most iSYS support three configurable output filter parameter sets, which can be set individually as described in section 3.3.5. For an overview of the supported filter settings refer to Table 14. The second byte determines the requested resolution of the target list. The highest bit of the second byte is used as a flag to request a 16- or 32-Bit resolution target list with fixed frame length. The values for requesting a specific target list are shown in Table 25 and Table 26.

The request is transmitted within a frame with variable data length (SD2=0x68).

The target list from the iSYS is transmitted without a prior acknowledge within a frame with variable data length using start delimiter SD2=0x68 (16- Bit resolution) or SD3=0xA2 (32-Bit resolution).

Note: Not all target list resolutions are supported for all iSYS devices. For an overview of the supported target list resolutions of different iSYS devices refer to Table 27*. Requesting an unsupported target list is answered with failure by the device.*

Important Note: ***Despite using the start delimiter SD3=0xA2 of a fixed length frame the* 32-Bit resolution target list *from the iSYS is a frame with variable data length.***

Table 25: list number: values for requesting different target lists

Value PDU Byte[0]	Description
1	Target list filtered with parameters from output 1
2	Target list filtered with parameters from output 2
3	Target list filtered with parameters from output 3

Note: For requesting an unfiltered target list set the single target filter signal of one output filter to off as described in section 3.3.5.12 and request the target list from the output in the same way as describe in the following sections.

Table 26: resolution types for the target list

Value PDU Byte[1]	Description
Not available	Output of sint16_t variable types
16	Output of sint16_t variable types (16-Bit output)
32	Output of sin32_t variable types (32-Bit output)
0b1xxxxxxx	Flag for requesting target list with fixed frame length if supported by sensor

Table 27: supported target list resolutions of the different iSYS devices

Device	16-bit resolution		32-bit resolution	
	Variable frame length	Fixed frame length	Variable frame length	Fixed frame length
iSYS-4xxx	Yes	No	Yes	No
iSYS-6xxx	No	No	Yes	No
iSYS-6005	No	No	No	Yes

3.3.7.1. Format 16-Bit target list

In the first byte of the answer frame data section (PDU) the requested list is coded. The second byte specifies the number of targets. If a clipping error occurs, which makes the signal processing unnecessary this byte is set to 0xff (clipping flag). A frame with clipping doesn't have any targets.

Table 28: PDU for target list with one target and 16-bit resolution

PDU[0]	PDU[1]	PDU[2]	PDU[3, 4]	PDU[5, 6]	PDU[7, 8]
List number (number of output)	Number of targets	Signal target1	Velocity target1	Range target1	Angle target1

Table 29: resolution range of target data with 16-Bit target list

Parameter	Type	Range of values
Signal	unsigned integer 8 bit	0 … 255 [dB]
Velocity (v)	signed integer 16 bit	-327.68 … 327.67 [m/s]
Range I	signed integer 16 bit	-327.68 … 327.67 [m] **iSYS-4004:** -32.768 … 32.767 [m]
Angle (a)	signed integer 16 bit	-327.68 … 327.67 [°]

3.3.7.2. Format 32-Bit target list

In the first byte of the answer frame data section (PDU) the requested list is coded. The second byte specifies the number of targets. If a clipping error occurs, which makes the signal processing unnecessary this byte is set to 0xff (clipping flag). A frame with clipping doesn't have any targets.

Table 30: PDU for target list with one target and 32-Bit resolution

PDU[0]	PDU[1]	PDU[2…3]	PDU[4…7]	PDU[8…11]	PDU[12…15]
List number (number of output)	Number of targets	Signal target1	Velocity target1	Range target1	Angle target1

Table 31: resolution range of target data for 32-Bit resolution

Parameter	Type	Range of values
Signal	unsigned integer 16 bit	0 … 655.35 [dB]
Velocity (v)	signed integer 32 bit	-2,147,483,648 … 2,147,483,647 [mm/s]
Range I	signed integer 32 bit	-2,147,483,648 … 2,147,483,647 [µm]
Angle (a)	signed integer 32 bit	-2,147,483,648 … 2,147,483,647 [mill°]

3.3.7.3. Fixed length target list

The answer frame for the fixed length target list uses the same structure as the 16- and 32-Bit target lists described in section 3.3.7.1 and 3.3.7.2. Different to the normal 16- or 32-Bit target list the fixed length target list always transmits a fixed number of targets. For information on the number of targets in the fixed target list refer to the product specific data sheet. If fewer target as the number transmitted in the list the remaining targets are filled with zeros. For information which devices support the fixed length target list refer to section 4.3.

Examples:

The following example frames show the requesting of the target list with different resolution form output 1. The byte for selecting the output filter is highlighted green and the byte for selecting the resolution is highlighted red.

- Request target list with 16-Bit resolution for output 1
    - Without specified Resolution in PDU Byte[1]: 68 04 04 68 80 01 DA 01 5C 16
    - With 16-Bit resolution in PDU Byte[1]: 68 05 05 68 80 01 DA 01 10 6C 16
- Request target list with 32-Bit resolution for output 1
    - With 32-Bit resolution in PDU Byte[1]: 68 05 05 68 80 01 DA 01 20 7C 16

An example of a 32-Bit target list with one target is shown below

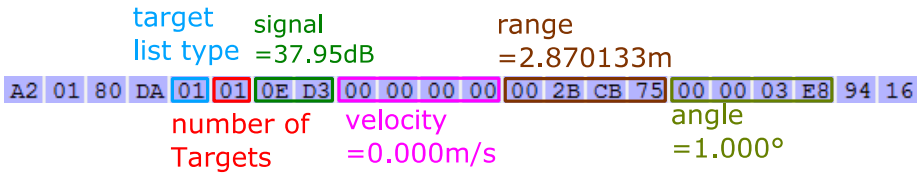


Figure 184: example target list with one target and 32-Bit resolution

The same target values from the 32-Bit target list, when transmitted within a 16-Bit target list would be send with the following PDU from the iSYS:

Table 32: example output of target list from Figure 184 with 16-Bit resolution

List / Output number	Number of targets	Signal target 1 (38dB)	Velocity target 1 (0 m/s)	Range target 1 (2.87m)	Angle target 1 (1.00°)
0x01	0x01	0x26	0x00 00	0x01 1F	0x00 64

The same target values from the 32-Bit target list, when transmitted within a 5 targets 32-Bit fixed length target list would be send with the following PDU from the iSYS device:

Table 33: example output of target list from Figure 184 with 32-Bit resolution and fixed length for 5 targets

List / Output number	Number of targets	Signal target 1 (38dB)	Velocity target 1 (0 m/s)	Range target 1 (2.87m)	Angle target 1 (1.00°)	Signal, Velocity, Range and Angle (Target 2 to 5)
0x01	0x01	0x0e D3	0x00 00 00 00	0x00 2B CB 75	0x00 00 03 E8	56 byte 0x00

3.3.7.4. C-function for easy decoding of the target list

For a C-code function to decode the target list refer to code in the appendix 4.2.

3.3.8. Read digital output state (0xDB)

This function codes requests the output of the digital output states within one frame. For requesting this output send following frame to the iSYS:

```
68 03 03 68 80 01 DB 5C 16
```

Figure 185: master request the digital output states of the sensor

Table 34: data section of the answer frame

Byte 0	Byte 1	Byte 2	Byte 3	Byte 4	Byte 5
OUT_1 high	OUT_1 low	OUT_2 high	OUT_2 low	OUT_3 high	OUT_3 low

3.3.8.1. Outputs configured as digital outputs

If the output is driven as digital output the value 0x0000 shows LOW and the value 0x0001 shows HIGH.

3.3.8.2. PWM coded output

If the output is driven as PWM coded signal the two bytes stand for a sint16_t value. The outputted values is determined by the selected target filter signal (see section 3.3.5.12). The value is outputted in hundredth of m or $\frac{m}{s}$.

Table 35: outputed values for pwm coded digital outputs

Parameter	Type	Range of values
Range radial	sint16_t	0 … 327,67m
Velocity radial	sint16_t	-327,68 … 327,67 $\left(\frac{m}{s}\right)$

3.3.9.EEPROM (0xDF)

These function code together with the sub-function codes in Table 36 are used to set the factory default settings of the sensor device or save changes to the sensor and application settings in non-volatile EEPROM on the Sensor device. All valid requests are answered by the iSYS device on success with the frame from Figure 186. Invalid request frames are answered with failure.

Table 36: EEPROM sub-function codes

Sub-function code	Sub-function	Description
0x01	Set factory settings	Restores the factory default settings of the iSYS device. This includes the complete sensor and application settings.
0x02	Save sensor settings	Saves the sensor settings stored in RAM to EEPROM, e.g. default frequency channel
0x03	Save application setting	Saves the application settings stored in RAM to EEPROM, e.g. threshold min values, threshold sensitivity, output filter parameters
0x04	Save sensor and application settings	Saves sensor and application settings form RAM to EEPROM.

```
68 03 03 68 01 80 DF 60 16
```

Figure 186: acknowlded send by the iSYS devices after successfull EEPROM command execution

3.3.9.1. Set factory settings

The **sub-function code 0x01** restores the factory default settings in EEPROM of the connected iSYS device. All changes to the sensor and application settings made by the user are overwritten. The request frame is shown in Figure 187.

```
68 04 04 68 80 01 DF 01 61 16
```

Figure 187: request frame for restoring the factory default settings of the iSYS device

3.3.9.2. Save sensor and application settings

This sub-function codes are used to save the setting changed with the commands described in section 3.3.4 (sensor settings) and section 3.3.5 (application) in nonvolatile memory on the sensor.

Note: The threshold settings are considered application setting even though the commands for reading/writing shares the function code of the sensor settings. The following example frames are used for saving the settings to EEPROM

Examples:

- Save sensor settings with **sub-function code 0x02**. This includes settings made with the commands in section 3.3.4 without the threshold settings.

```
68 04 04 68 80 01 DF 02 62 16
```

Figure 188: master devices requests saving of the sensor settings to EEPROM from the iSYS device

- Save application settings with **sub-function code 0x03**. This includes settings made with the commands from section 3.3.5 and the threshold settings from section 3.3.4.

```
68 04 04 68 80 01 DF 03 63 16
```

Figure 189: master devices requests saving of the application settings to EEPROM from the iSYS device

- Save sensor and application settings with **sub-function code 0x04**. This includes all settings made with the commands from section 3.3.4 and section 3.3.5.

```
68 04 04 68 80 01 DF 04 64 16
```

Figure 190: master devices requests saving of the sensor and application settings to EEPROM from the iSYS device

3.3.10. Read Raw Signals (0xE0)

With this command the iSYS sends the raw data of one measurement cycle. For successfully executing this command the iSYS has to be in measurement mode. For changing the measurement mode refer to section 3.3.3.

The raw data is send within a frame with fixed data length. The first byte of the data area contains the number of the transmitted signals, the second byte the length of one signal and the third byte the number of bytes used for one sample. The data bytes four to N contain the interleaved signal values. Table 37 and the examples below illustrate the structure of the transmitted frame.

When requesting the raw data the cycle time is expanded to allow the transmission of the complete sampled data. The timeout of the master devices (customer device) should be set to a greater values as described in Table 6 to allow the completion of the data transmission.

For example the transmission of four signals with 2048 samples using the default baud rate of 115200baud needs about 1.5 seconds to complete. In this example a minimal timeout value of about 2 seconds should be used.

For estimating the required time for the raw data transmission following formula can be used:

$$t_{rawDataTransmission} \approx \frac{Nr_{Samples} \cdot Nr_{BytesPerSample} \cdot (8+2) \cdot Nr_{signals}}{baud\ rate} \cdot 1.1$$

Table 37: structure of raw data output PDU

PDU Byte [0]	PDU Byte [1]	PDU Byte [2]	PDU Byte [3...6]	PDU Byte [7...(N-1)]
Number of signals	Length of of one signal (coded as 16 part of samples, e.g. 0x80 means 2048 samples per signal)	Data size (number of bytes per sample value)	Sample time in µs	Interleaved raw signals

Example:

The following example shows the requesting of the raw signals form an iSYS-6003. The request from Figure 191 is answered with the raw data frame shown in Figure 193 and Figure 192.

```
68 03 03 68 64 01 E0 45 16
```

Figure 191: master requests raw signals

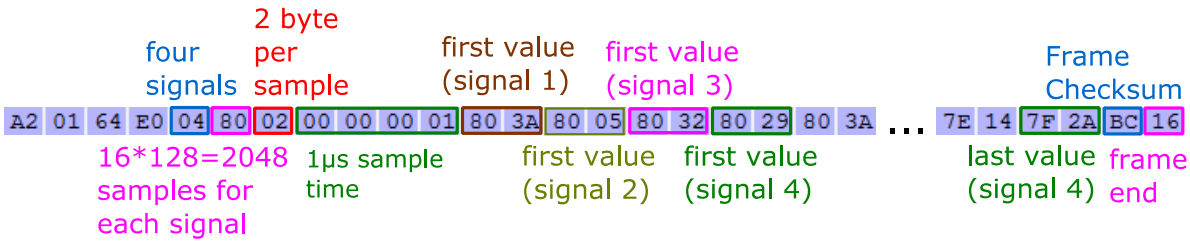


Figure 192: iSYS sends requested raw signals within a frame with fixed data length (part of answer from Figure 193)

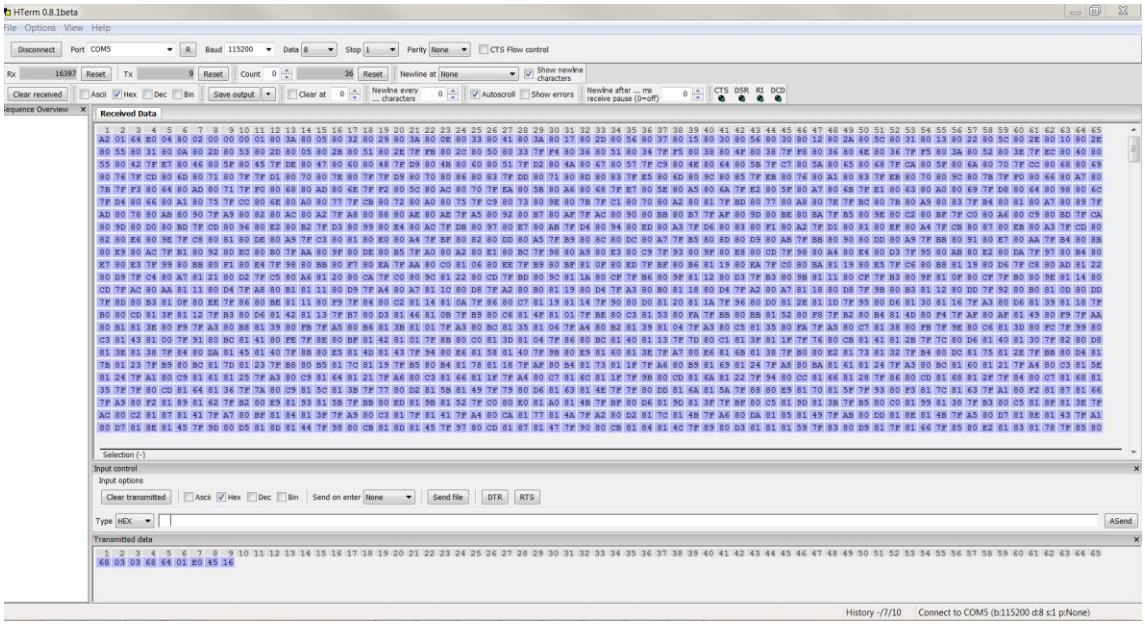


Figure 193: example communication for requesting raw data

3.3.11. **Read range list (0xE1) (iSYS-600x, iSYS-6203 only)**

This function code requests the output of the range list. The range list consists of the range value calculated by the modulation scheme and additional statistic values. This function is available for the iSYS-600x and iSYS-6203. The request is send within a frame with variable data length. The return frame PDU consists of the values shown in Table 38 and is send within a frame with variable data length as illustrated in Figure 195.

Table 38: structure of range list PDU

PDU Byte [0...3]	PDU Byte [4,5]	PDU Byte [6,7]	PDU Byte [8...11]	PDU Byte [12...15]	PDU Byte [16...19]	PDU Byte [20...23]
Range	Baseband amplitude	Sensor temperature	Standard deviation	Variance	Minimum	Maximum

68 03 03 68 80 01 E1 62 16

Figure 194: master requests range list

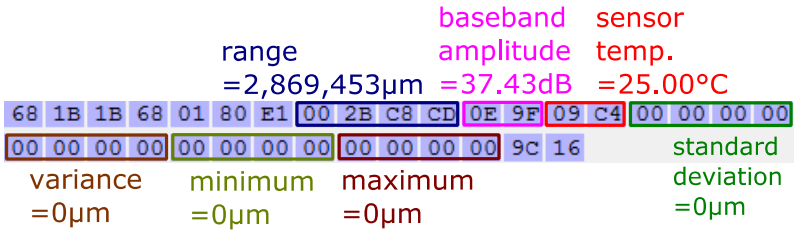


Figure 195: iSYS sends requested range list within a frame with variable data length

Table 39: Description of the transmitted values

Parameter	Type	Range of values	Description
Range	sint32_t	- 2,147,483,648 … +2,147,483,647 [µm]	Measured range
Baseband amplitude	sint16_t	-327.68 … 327.67 [dB]	Mean amplitude of all baseband signals
Sensor temperature	sint16_t	-327.68 … 327.67 [°C]	Temperature measured inside radar sensor housing
Standard deviation	sint32_t	- 2147483648 … +2147483647 [µm]	Statistical value over last 100 range combined values (unused by 6xxx)
Variance	sint32_t	- 2147483648 … +2147483647 [µm]	Statistical value over last 100 range combined values (unused by 6xxx)
Minimum	sint32_t	- 2147483648 … +2147483647 [µm]	Statistical value over last 100 range combined values (unused by 6xxx)
Maximum	sint32_t	- 2147483648 … +2147483647 [µm]	Statistical value over last 100 range combined values (unused by 6xxx)

3.3.12. Failure (0xFD)

This function code is send by the iSYS, if a correct transmitted frame cannot execute. This can happen for example, if the values of the transmitted data were out of range, the requested function code is not supported or the iSYS is not in the right measurement mode.

```
68 03 03 68 01 80 FD 7E 16
```

Figure 196: Frame send by iSYS if correct transmitted frame cannot execute

4. Appendix

The following C-code function can be used to decode the target list received from the iSYS device using the commands described in section 3.3.7.

4.1. General data types

The following definitions are provided for convenience and can be added if need

```
typedef unsigned char       uint8_t;
typedef unsigned int        uint16_t;
typedef int                 sint16_t;
typedef unsigned long       uint32_t;
typedef long                sint32_t;
typedef float               float32_t;
```

4.2. C-code for target list decoding

```
#include <string.h>             /* memset */

#define MAX_TARGETS         (0x23)

typedef enum iSYSResult
{
        ERR_OK                                  = 0x0000,
        ERR_FUNCTION_DEPRECATED                 ,
        ERR_DLL_NOT_FINISHED                    ,
        ERR_HANDLE_NOT_INITIALIZED              ,
        ERR_COMPORT_DOESNT_EXIST                ,
        ERR_COMPORT_CANT_INITIALIZE             ,
        ERR_COMPORT_ACCESS_DENIED               ,
        ERR_COMPORT_BAUDRATE_NOT_VALID          ,
        ERR_COMPORT_CANT_OPEN                   ,
        ERR_COMPORT_CANT_SET_FLOW_CONTROL       ,
        ERR_COMPORT_CANT_SET_PARITY             ,
        ERR_COMPORT_CANT_SET_STOP_BITS          ,
        ERR_COMPORT_CANT_SET_DATA_BITS          ,
        ERR_COMPORT_CANT_SET_BAUDRATE           ,
        ERR_COMPORT_ALREADY_INITIALIZED         ,
        ERR_COMPORT_EQUALS_NULL                 ,
        ERR_COMPORT_NOT_OPEN                    ,
        ERR_COMPORT_NOT_READABLE                ,
        ERR_COMPORT_NOT_WRITEABLE               ,
        ERR_COMPORT_CANT_WRITE                  ,
        ERR_COMPORT_CANT_READ                   ,
        ERR_COMMAND_NOT_WRITTEN                 ,
        ERR_COMMAND_NOT_READ                    ,
        ERR_COMMAND_NO_DATA_RECEIVED            ,
        ERR_COMMAND_NO_VALID_FRAME_FOUND        ,
        ERR_COMMAND_RX_FRAME_DAMAGED            ,
        ERR_COMMAND_FAILURE                     ,
        ERR_UNDEFINED_READ                      ,
        ERR_COMPORT_LESS_DATA_READ              ,
        ERR_COMPORT_SYSTEM_INIT_FAILED          ,
        ERR_COMPORT_SYSTEM_ALREADY_INITIALIZED  ,
        ERR_COMMAND_RX_FRAME_LENGTH             ,
        ERR_COMMAND_MAX_DATA_OVERFLOW           ,
        ERR_COMMAND_MAX_IQPAIRS_OVERFLOW        ,
        ERR_COMMAND_NOT_ACCEPTED                ,
```

```
        ERR_NULL_POINTER
} iSYSResult_t;

typedef enum iSYSTargetListError
{
        TARGET_LIST_OK                          = 0x00,
        TARGET_LIST_FULL                        = 0x01,
        TARGET_LIST_REFRESHED                   = 0x02,
        TARGET_LIST_ALREADY_REQUESTED           = 0x03,
        TARGET_LIST_ACQUISITION_NOT_STARTED     = 0x04
}iSYSTargetListError_t;


typedef struct iSYSTarget {

        float32_t velocity;             /* radial velocity in m/s */
        float32_t range;                /* range in m */
        float32_t signal;               /* signal indicator */
        float32_t angle;                /* angle of detected object [°] */

} iSYSTarget_t;

union iSYSTargetListError_u
{
        iSYSTargetListError_t iSYSTargetListError;
        uint32_t dummy;
};

typedef struct iSYSTargetList {
        union iSYSTargetListError_u error;
        uint8_t outputNumber;
        uint16_t nrOfTargets;
        uint32_t clippingFlag;
        iSYSTarget_t targets[MAX_TARGETS];
} iSYSTargetList_t;


/**********************************************************************
Function: decodes target list frame received from iSYS device.
Input arguments:
        -       Frame array:    array with from iSYS received target list frame
        -       nrOfElements:   number of bytes in the frame array
        -       productcode:    product code of the connected iSYS (e.g. 6003, 4001, …)
        -       bitrate:        resolution of the target list in the frame array (16-Bit or 32-Bit)
        -       targetList:     struct for decoded target list
Output arguments:
        -       targetList:     struct with decoded target list
Return value:
        -       ErrorCode
**********************************************************************/
iSYSResult_t decodeTargetFrame(unsigned char *frame_array, uint16_t nrOfElements,
                                        uint16_t productcode, uint8_t bitrate, iSYSTargetList_t *targetList){
        uint16_t ui16_fc;
        uint8_t output_number;
        uint8_t nrOfTargets;
        uint8_t *pData;
        sint16_t tmp;
        uint8_t i;

        if(frame_array[0] == 0x68)              /* check SD2 Frame */
        {
            ui16_fc = 6;                        /* set function code bit for variable length frames    */
        }
        else
        {
            ui16_fc = 3;                        /* set function code bit for fixed length frames       */
        }

        output_number = (uint16_t)(frame_array[ui16_fc+1] & 0x00ff);
        nrOfTargets = (uint16_t)(frame_array[ui16_fc+2] & 0x00ff);
        pData = &frame_array[ui16_fc+3];
```

```
if (frame_array[nrOfElements -1] != 0x16){                    /* check end of frame */
    return ERR_COMMAND_NO_VALID_FRAME_FOUND;
}

/* check for valid amount of targets */
if((nrOfTargets > MAX_TARGETS) && (nrOfTargets != 0xff)){
    return ERR_COMMAND_FAILURE;
}

if(nrOfTargets != 0xff){ //0xff → clipping
    for(i = 0; i < MAX_TARGETS ; i++){                        //Init Array
        targetList->targets[i].angle = 0;
        targetList->targets[i].range = 0;
        targetList->targets[i].signal = 0;
        targetList->targets[i].velocity = 0;
    }

    targetList->nrOfTargets = nrOfTargets;
    targetList->clippingFlag = 0;
    targetList->outputNumber = output_number;

    if (bitrate == 32){
        int tmp32;

        for(i=0; i < nrOfTargets;i++){
            tmp = (((*pData++)&0x00ff) << 8);
            tmp|=((*pData++)&0x00ff);
            targetList->targets[i].signal = (float)(tmp*0.01f);
            tmp32 = (((*pData++)&0x000000ff) << 24);
            tmp32|=(((*pData++)&0x000000ff) << 16);
            tmp32|=(((*pData++)&0x000000ff) << 8);
            tmp32|=((*pData++)&0x000000ff);
            targetList->targets[i].velocity = (float)tmp32*0.001f;
            tmp32 = (((*pData++)&0x000000ff) << 24);
            tmp32|=(((*pData++)&0x000000ff) << 16);
            tmp32|=(((*pData++)&0x000000ff) << 8);
            tmp32|=((*pData++)&0x000000ff);
            targetList->targets[i].range = (float)tmp32*1E-6f;
            tmp32 = (((*pData++)&0x000000ff) << 24);
            tmp32|=(((*pData++)&0x000000ff) << 16);
            tmp32|=(((*pData++)&0x000000ff) << 8);
            tmp32|=((*pData++)&0x000000ff);
            targetList->targets[i].angle = (float)tmp32*0.01f;
        }
    }

    if (bitrate == 16){
        for(i=0; i < nrOfTargets;i++){
            targetList->targets[i].signal = (float)((*pData++) & 0x00ff);

            tmp = (((*pData++)&0x00ff) << 8);
            tmp|=((*pData++)&0x00ff);
            targetList->targets[i].velocity = (float)tmp*0.01f;

            tmp = (((*pData++)&0x00ff) << 8);
            tmp|=((*pData++)&0x00ff);
            if(productcode == 4004 || productcode == 6003){
                    targetList->targets[i].range = (float)tmp*0.001f;
            }
            else{
                    targetList->targets[i].range = (float)tmp*0.01f;
            }

            tmp = (((*pData++)&0x00ff) << 8);
            tmp|=((*pData++)&0x00ff);
            targetList->targets[i].angle = (float)tmp*0.01f;
        }
    }
}
```

```
        else{
            targetList->clippingFlag = 1;
        }

        if(nrOfTargets == MAX_TARGETS){
            targetList->error.iSYSTargetListError = TARGET_LIST_FULL;
        }
        else {
            targetList->error.iSYSTargetListError = TARGET_LIST_OK;
        }
        return ERR_OK;
}
```

4.3. Support commands

InnoSenT uses a companywide serial interface protocol for all iSYS systems. But each iSYS device uses only a small subset of the commands. This chapter shows the supported functions and sub-functions of the different devices.

4.3.1. **iSYS-4001, iSYS-4002, iSYS-4003**

Following listed all supported commands:

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Threshold minimum (0x00 0B)	3.3.4.3	20
0xD2 / 0xD3	Threshold sensitivity left/right (0x00 16/ 0x00 17)	3.3.4.5	22
0xD2 / 0xD3	Switching LED functionality on/off (0x00 2D)	3.3.4.9	26
0xD4 / 0xD5	Line filter 1 / 2 (0x00 00 / 0x00 01)	3.3.5.1	30
0xD4 / 0xD5	Enable output (0x0X 00)	3.3.5.2	31
0xD4 / 0xD5	Rising/falling delay (0x0X 01 / 0x0X 02)	3.3.5.3	32
0xD4 / 0xD5	Output setting 1 (0x0X 04)	3.3.5.4	33
0xD4 / 0xD5	Output setting 2 (0x0X 05)	3.3.5.5	33
0xD4 / 0xD5	Range min/max (0x0X 08 / 0x0X 09)	3.3.5.7	35
0xD4 / 0xD5	Signal min/max (0x0X 0A / 0x0X 0B)	3.3.5.8	36
0xD4 / 0xD5	Velocity min/max (0x0X 0C / 0x0X 0D)	3.3.5.9	37
0xD4 / 0xD5	Velocity direction (0x0X 0E)	3.3.5.10	38
0xD4 / 0xD5	Output single target filter type (0x0X 15)	3.3.5.11	39
0xD4 / 0xD5	Output single target filter signal (0x0X 16)	3.3.5.12	40
0xD4 / 0xD5	Alpha filter velocity/range (0x0X 17 / 0x0X 18)	3.3.5.13	41
0xD4 / 0xD5	Set/Get Potis (0x06 80)	3.3.5.16	43

0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55
0xDA	Read Target list (0xDA)	3.3.7	56
0xDB	Read digital output state (0xDB)	3.3.8	60
0xDF	Set factory settings	3.3.9.1	61
0xDF	Save sensor and application settings	3.3.9.2	62

4.3.2.**iSYS-4013**

Following listed all supported commands:

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Threshold minimum (0x00 0B)	3.3.4.3	20
0xD2 / 0xD3	Threshold sensitivity left/right (0x00 16/ 0x00 17)	3.3.4.5	22
0xD4 / 0xD5	Line filter 1 / 2 (0x00 00 / 0x00 01)	3.3.5.1	30
0xD4 / 0xD5	Enable output (0x0X 00)	3.3.5.2	31
0xD4 / 0xD5	Rising/falling delay (0x0X 01 / 0x0X 02)	3.3.5.3	32
0xD4 / 0xD5	Output setting 1 (0x0X 04)	3.3.5.4	33
0xD4 / 0xD5	Output setting 2 (0x0X 05)	3.3.5.5	33
0xD4 / 0xD5	Signal min/max (0x0X 0A / 0x0X 0B)	3.3.5.8	36
0xD4 / 0xD5	Velocity min/max (0x0X 0C / 0x0X 0D)	3.3.5.9	37
0xD4 / 0xD5	Velocity direction (0x0X 0E)	3.3.5.10	38
0xD4 / 0xD5	Output single target filter type (0x0X 15)	3.3.5.11	39
0xD4 / 0xD5	Output single target filter signal (0x0X 16)	3.3.5.12	40
0xD4 / 0xD5	Alpha filter velocity/range (0x0X 17 / 0x0X 18)	3.3.5.13	41
0xD4 / 0xD5	Set/Get Potis (0x06 80)	3.3.5.16	43
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55

0xDA	Read Target list (0xDA)	3.3.7	56
0xDB	Read digital output state (0xDB)	3.3.8	60
0xDF	Set factory settings	3.3.9.1	61
0xDF	Save sensor and application settings	3.3.9.2	62

4.3.3. **iSYS-4004**

Here are listed all commands which are compatible with the iSYS-4004.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Threshold minimum (0x00 0B)	3.3.4.3	20
0xD2 / 0xD3	Threshold sensitivity left/right (0x00 16/ 0x00 17)	3.3.4.5	22
0xD4 / 0xD5	Line filter 1 / 2 (0x00 00 / 0x00 01)	3.3.5.1	30
0xD4 / 0xD5	Enable output (0x0X 00)	3.3.5.2	31
0xD4 / 0xD5	Rising/falling delay (0x0X 01 / 0x0X 02)	3.3.5.3	32
0xD4 / 0xD5	Output setting 1 (0x0X 04)	3.3.5.4	33
0xD4 / 0xD5	Output setting 2 (0x0X 05)	3.3.5.5	33
0xD4 / 0xD5	Range min/max (0x0X 08 / 0x0X 09)	3.3.5.7	35
0xD4 / 0xD5	Signal min/max (0x0X 0A / 0x0X 0B)	3.3.5.8	36
0xD4 / 0xD5	Output single target filter type (0x0X 15)	3.3.5.11	39
0xD4 / 0xD5	Output single target filter signal (0x0X 16)	3.3.5.12	40
0xD4 / 0xD5	Alpha filter velocity/range (0x0X 17 / 0x0X 18)	3.3.5.13	41
0xD4 / 0xD5	Set/Get Potis (0x06 80)	3.3.5.16	43
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55
0xDA	Read Target list (0xDA)	3.3.7	56

0xDB	Read digital output state (0xDB)	3.3.8	60
0xDF	Set factory settings	3.3.9.1	61
0xDF	Save sensor and application settings	3.3.9.2	62

4.3.4.iSYS-5010

Here are listed all commands which are compatible with the iSYS-5010.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD4 / 0xD5	Moving target threshold sensitivity near range (0x08 28)	3.3.5.21	47
0xD4 / 0xD5	Moving target threshold sensitivity main range (0x08 29)	3.3.5.22	47
0xD4 / 0xD5	Moving target threshold sensitivity long range (0x08 2A)	3.3.5.23	48
0xD4 / 0xD5	RCS output enable/disable (0x08 53)	3.3.5.24	49
0xD4 / 0xD5	Target clustering enable/disable (0x08 80)	3.3.5.25	50
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55

4.3.1.**iSYS-5011**

Here are listed all commands which are compatible with the iSYS-5011.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55

4.3.2.iSYS-5020

Here are listed all commands which are compatible with the iSYS-5020.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Target list interface (0x00 2C)	3.3.4.8	25
0xD4 / 0xD5	Moving target threshold sensitivity near range (0x08 28)	3.3.5.21	47
0xD4 / 0xD5	Moving target threshold sensitivity main range (0x08 29)	3.3.5.22	47
0xD4 / 0xD5	Moving target threshold sensitivity long range (0x08 2A)	3.3.5.23	48
0xD4 / 0xD5	RCS output enable/disable (0x08 53)	3.3.5.24	49
0xD4 / 0xD5	Target clustering enable/disable (0x08 80)	3.3.5.25	50
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55

4.3.1.**iSYS-5021**

Here are listed all commands which are compatible with the iSYS-5021.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Target list interface (0x00 2C)	3.3.4.8	25
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55

4.3.2.**iSYS-5110**

Here are listed all commands which are compatible with the iSYS-5110.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	IP configuration (0x00 29)	3.3.4.6	23
0xD2 / 0xD3	IP destination (0x00 2A)	3.3.4.7	24
0xD4 / 0xD5	Stop Bar Zone enable/disable (0x08 A0)	3.3.5.26	51
0xD4 / 0xD5	Stop Bar Zone Range set/get (0x08 A1)	3.3.5.27	51
0xD4 / 0xD5	Stop Bar Zone Angle set/get (0x08 A2)	3.3.5.28	51
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55

4.3.3.**iSYS-6xxx**

Here are listed all commands which are compatible with the iSYS-6xxx.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD1	Set default temperature threshold (0x01 33)	3.3.3.2	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Threshold minimum (0x00 0B)	3.3.4.3	20
0xD2 / 0xD3	Measurement mode (0x00 10)	3.3.4.4	21
0xD4 / 0xD5	Enable output (0x0X 00)	3.3.5.2	31
0xD4 / 0xD5	Rising/falling delay (0x0X 01 / 0x0X 02)	3.3.5.3	32
0xD4 / 0xD5	Output setting 1 (0x0X 04)	3.3.5.4	33
0xD4 / 0xD5	Output setting 2 (0x0X 05)	3.3.5.5	33
0xD4 / 0xD5	Range min/max (0x0X 08 / 0x0X 09)	3.3.5.7	35
0xD4 / 0xD5	Signal min/max (0x0X 0A / 0x0X 0B)	3.3.5.8	36
0xD4 / 0xD5	Output single target filter type (0x0X 15)	3.3.5.11	39
0xD4 / 0xD5	Output single target filter signal (0x0X 16)	3.3.5.12	40
0xD4 / 0xD5	Alpha filter velocity/range (0x0X 17 / 0x0X 18)	3.3.5.13	41
0xD4 / 0xD5	Range min/max extended (0x0X 19 / 0x0X 1A)	3.3.5.14	42
0xD4 / 0xD5	Set/Get mounting offset (0x05 06)	3.3.5.15	43
0xD4 / 0xD5	Temperature threshold (0x07 07)	3.3.5.17	44
0xD4 / 0xD5	Range / temperature warning switch (0x07 09)	3.3.5.18	45
0xD4 / 0xD5	Set/get temperature warning threshold (0x07 0A)	3.3.5.19	45
0xD4 / 0xD5	Set/get range warning threshold (0x07 0B)	3.3.5.20	46
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53

0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55
0xDA	Read Target list (0xDA)	3.3.7	56
0xDF	Set factory settings	3.3.9.1	61
0xDF	Save sensor and application settings	3.3.9.2	62
0xE0	Read Raw Signals (0xE0)	3.3.10	63
0xE1	Read range list (0xE1) (iSYS-600x, iSYS-6203 only)	3.3.11	64

4.3.1.**iSYS-6004**

Here are listed all commands which are compatible with the iSYS-6004.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD1	Set default temperature threshold (0x01 33)	3.3.3.2	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Threshold minimum (0x00 0B)	3.3.4.3	20
0xD2 / 0xD3	Threshold sensitivity left/right (0x00 16/ 0x00 17)	3.3.4.5	22
0xD4 / 0xD5	Enable output (0x0X 00)	3.3.5.2	31
0xD4 / 0xD5	Rising/falling delay (0x0X 01 / 0x0X 02)	3.3.5.3	32
0xD4 / 0xD5	Output setting 1 (0x0X 04)	3.3.5.4	33
0xD4 / 0xD5	Output setting 2 (0x0X 05)	3.3.5.5	33
0xD4 / 0xD5	Range min/max (0x0X 08 / 0x0X 09)	3.3.5.7	35
0xD4 / 0xD5	Signal min/max (0x0X 0A / 0x0X 0B)	3.3.5.8	36
0xD4 / 0xD5	Output single target filter type (0x0X 15)	3.3.5.11	39
0xD4 / 0xD5	Output single target filter signal (0x0X 16)	3.3.5.12	40
0xD4 / 0xD5	Alpha filter velocity/range (0x0X 17 / 0x0X 18)	3.3.5.13	41
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55
0xDA	Read Target list (0xDA)	3.3.7	56
0xDF	Set factory settings	3.3.9.1	61
0xDF	Save sensor and application settings	3.3.9.2	62

0xE0	Read Raw Signals (0xE0) (signals transmitted as float32_t)	3.3.10	63
0xE1	Read range list (0xE1) (iSYS-600x, iSYS-6203 only)	3.3.11	64

4.3.1.iSYS-6005

Here are listed all commands which are compatible with the iSYS-6005.

Function code	Description	See Chapter	See Page
0xD0	Read device name (0xD0)	3.3.2	15
0xD1	Start/Stop acquisition (0x00 00 / 0x00 01)	3.3.3.1	16
0xD1	Set default temperature threshold (0x01 33)	3.3.3.2	16
0xD2 / 0xD3	Read/Write sensor address (0x00 01)	3.3.4.1	18
0xD2 / 0xD3	Change frequency channel (0x00 04)	3.3.4.2	19
0xD2 / 0xD3	Threshold minimum (0x00 0B)	3.3.4.3	20
0xD4 / 0xD5	Enable output (0x0X 00)	3.3.5.2	31
0xD4 / 0xD5	Rising/falling delay (0x0X 01 / 0x0X 02)	3.3.5.3	32
0xD4 / 0xD5	Output setting 1 (0x0X 04)	3.3.5.4	33
0xD4 / 0xD5	Output setting 2 (0x0X 05)	3.3.5.5	33
0xD4 / 0xD5	Range min/max (0x0X 08 / 0x0X 09)	3.3.5.7	35
0xD4 / 0xD5	Signal min/max (0x0X 0A / 0x0X 0B)	3.3.5.8	36
0xD4 / 0xD5	Output single target filter type (0x0X 15)	3.3.5.11	39
0xD4 / 0xD5	Output single target filter signal (0x0X 16)	3.3.5.12	40
0xD4 / 0xD5	Alpha filter velocity/range (0x0X 17 / 0x0X 18)	3.3.5.13	41
0xD6	Firmware version (0x01 01)	3.3.6.1	52
0xD6	Get DSP hardware version (0x01 02)	3.3.6.2	53
0xD6	Get RFE hardware version (0x01 03)	3.3.6.3	54
0xD6	Get product information (0x01 04)	3.3.6.4	54
0xD6	Get Bootloader version (0x02 20)	3.3.6.5	55
0xDA	Read Target list (0xDA) (support only fixed length 32-Bit target list)	3.3.7	56
0xDF	Set factory settings	3.3.9.1	61
0xDF	Save sensor and application settings	3.3.9.2	62
0xE0	Read Raw Signals (0xE0)	3.3.10	63

0xE1	Read range list (0xE1) (iSYS-600x, iSYS-6203 only)	3.3.11	64

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