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|   | Modbus – Ultraflex implementation | A5  | SDR-1MOD-537-250-00 |


# Modbus – Ultraflex implementation

## APPROVALS

| Title             | Name           | Signature | Date     |
|-------------------|----------------|-----------|----------|
| Original Author   | Stanimir Bonev |           | 07/12/17 |
| UPT Approval      |                |           |          |
| Customer Approval |                |           |          |


## REVISION HISTORY

| Revision | Date     | Author         | Description of Changes  |
|----------|----------|----------------|---|
| A1       | 07/12/17 | Stanimir Bonev | Original Issue  |
| A2       | 11/05/18 | Stanimir Bonev | Update register addresses, add errors   |
| A3       | 13/11/19 | Stanimir Bonev | Add Dew point, Humidity, Timer support, slave PA enable registers.                                  |
| A4       | 18/02/20 | Stanimir Bonev | Update errors list  |
| A5       | 15/01/21 | Stanimir Bonev | Update errors list, add change over switch related registers, add thermoregulator related registers |
|          |          |                |   |


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## PURPOSE

Purpose of this document is to specify the Modbus protocol implementation.


## PHYSICAL LAYER

### Electrical specification – RS485

- Bus polarization – master
- Bus termination – master and last slave in chain

### Timing specification

- Baud rate
  - 38400 default speed
- Data bits – 8
- Parity – None
- Stop bits – 1
- Direction control
  - Releasing to RX direction
    - Min 0 ms after stop bit of last byte
    - Max 2 ms after stop bit of last byte
  - Switch to TX direction – Master device
    - Min 10us before start bit of first byte
    - Max 1 bit time of current baud before start bit of first byte
  - Switch to TX direction – Slave device
    - Min 3 ms after stop bit of last received byte
  - Time out
    - Max 250msec
  - Idle
    - Min 3.5 character times

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## RTU FRAMING

In RTU mode, messages start with a silent interval of at least 3.5 character times. This is most easily implemented as a multiple of character times at the baud rate that is being used on the network (shown as T1–T2–T3–T4 in the figure below). The first field then transmitted is the device address.

- How the Address Field is Handled – **system default address 0x1**

The address field of a message frame contains eight bits (RTU). Valid slave device addresses are in the range of 0 – 247 decimal. The individual slave devices are assigned addresses in the range of 1 – 247.

- CRC – CRC-16, polynomial 0xA001

## SUPPORTED FUNCTION CODES

### Read coil status (0x01)

#### Description

Reads the ON/OFF status of discrete outputs in the slave.

#### Query


The query message specifies the starting coil and quantity of coils to be read.

|                   |         |                  |
|-------------------|---------|------------------|
| Function code     | 1 Byte  | 0x01             |
| Starting Address  | 2 Bytes | 0x1000 to 0x1004 |
| Quantity of coils | 2 Bytes | 1 to 5           |

#### Response

The coil status in the response message is packed as one coil per bit of the data field. Status is indicated as: 1 = ON; 0 = OFF. The LSB of the first data byte contains the coil addressed in the query. The other coils follow toward the high order end of this byte, and from 'low order to high order' in subsequent bytes.

If the returned coil quantity is not a multiple of eight, the remaining bits in the final data byte will be padded with zeros (toward the high order end of the byte). The Byte Count field specifies the quantity of complete bytes of data.

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|               |         |              |
|---------------|---------|--------------|
| Function code | 1 Byte  | 0x01         |
| Byte count    | 1 Byte  | N*           |
| Coil Status   | N Bytes | n = N or N+1 |

\*N = Quantity of Outputs / 8, if the remainder is different of 0 => N = N+1

#### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x81     |
| Exception code | 1 Byte | see p. 9 |

### Read input status (0x02)

#### Description

Reads the ON/OFF status of discrete inputs in the slave.

#### Query

The query message specifies the starting input and quantity of inputs to be read.


|                          |         |                  |
|--------------------------|---------|------------------|
| Function code            | 1 Byte  | 0x02             |
| Starting Address         | 2 Bytes | 0x0000 to 0x000A |
| Quantity of input status | 2 Bytes | 1 to 11          |

#### Response

The input status in the response message is packed as one input per bit of the data field. Status is indicated as: 1 = ON; 0 = OFF. The LSB of the first data byte contains the input addressed in the query. The other inputs follow toward the high order end of this byte, and from 'low order to high order' in subsequent bytes.

If the returned input quantity is not a multiple of eight, the remaining bits in the final data byte will be padded with zeros (toward the high order end of the byte). The Byte Count field specifies the quantity of complete bytes of data.



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|               |         |              |
|---------------|---------|--------------|
| Function code | 1 Byte  | 0x02         |
| Byte count    | 1 Byte  | N*           |
| Input status  | N Bytes | n = N or N+1 |

\*N = Quantity of Outputs / 8, if the remainder is different of 0 => N = N+1

#### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x82     |
| Exception code | 1 Byte | see p. 9 |

### Read holding registers (0x03)

#### Description

Reads the binary contents of holding registers in the slave.

#### Query


The query message specifies the starting register and quantity of registers to be read.

|                            |         |                  |
|----------------------------|---------|------------------|
| Function code              | 1 Byte  | 0x03             |
| Starting Address           | 2 Bytes | 0x3000 to 0x300C |
| Quantity of Hold registers | 2 Bytes | 1 to 16          |

#### Response

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.

|                     |              |        |
|---------------------|--------------|--------|
| Function code       | 1 Byte       | 0x03   |
| Byte count          | 1 Byte       | 2 x N* |
| Hold registers data | N* x 2 Bytes |        |

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\*N = Quantity of Registers

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x83     |
| Exception code | 1 Byte | see p. 9 |

### Read input registers (0x04)

#### Description

Reads the binary contents of input registers in the slave.

#### Query

The query message specifies the starting register and quantity of registers to be read.

|                             |         |                  |
|-----------------------------|---------|------------------|
| Function code               | 1 Byte  | 0x04             |
| Starting Address            | 2 Bytes | 0x2000 to 0x2015 |
| Quantity of Input Registers | 2 Bytes | 1 to 26          |

#### Response

The register data in the response message are packed as two bytes per register, with the binary contents right justified within each byte. For each register, the first byte contains the high order bits and the second contains the low order bits.


|                |              |        |
|----------------|--------------|--------|
| Function code  | 1 Byte       | 0x04   |
| Byte count     | 1 Byte       | 2 x N* |
| Input register | N* x 2 Bytes |        |

\*N = Quantity of Registers

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x84     |
| Exception code | 1 Byte | see p. 9 |

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## Force single coil (0x05)

### Description

Forces a single coil to either ON or OFF.

### Query

The query message specifies the coil reference to be forced.

The requested ON/OFF state is specified by a constant in the query data field. A value of FF 00 hex requests the coil to be ON. A value of 00 00 requests it to be OFF. All other values are illegal and will not affect the coil.

|                |         |                  |
|----------------|---------|------------------|
| Function code  | 1 Byte  | 0x05             |
| Output Address | 2 Bytes | 0x1000 to 0x1004 |
| Output value   | 2 Bytes | 0x0000 or 0xFF00 |

### Response


The normal response is an echo of the query, returned after the coil state has been forced.

|                |         |                  |
|----------------|---------|------------------|
| Function code  | 1 Byte  | 0x05             |
| Output Address | 2 Bytes | 0x1000 to 0x1004 |
| Output value   | 2 Bytes | 0x0000 or 0xFF00 |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x85     |
| Exception code | 1 Byte | see p. 9 |

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## Write Single Register (0x06)

### Description

Write Single Register in a remote device..

### Query

The query message specifies the hold register references to be written.

|                |         |                  |
|----------------|---------|------------------|
| Function code  | 1 Byte  | 0x06             |
| Output Address | 2 Bytes | 0x3000 to 0x300C |
| Register value | 2 Bytes |                  |

### Response


The normal response is an echo of the query, returned after the hold register state has been written.

|                |         |                  |
|----------------|---------|------------------|
| Function code  | 1 Byte  | 0x06             |
| Output Address | 2 Bytes | 0x3000 to 0x300C |
| Output value   | 2 Bytes |                  |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9.

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x86     |
| Exception code | 1 Byte | see p. 9 |

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## Force multiple coils (0x0F)

### Description

Forces each coil in a sequence of coils to either ON or OFF.

### Query

The query message specifies the coil references to be forced. The requested ON/OFF states are specified by contents of the query data field. A logical '1' in a bit position of the field requests the corresponding coil to be ON. A logical '0' requests it to be OFF.

|                     |          |               |
|---------------------|----------|---------------|
| Function code       | 1 Byte   | 0x0F          |
| Starting Address    | 2 Bytes  | 0x1000-0x1004 |
| Quantity of Outputs | 2 Bytes  | 1-5           |
| Byte Count          | 1 Byte   | N*            |
| Outputs Value       | N* Bytes |               |

### Response


The normal response returns the function code, starting address, and quantity of coils forced.

|                     |         |               |
|---------------------|---------|---------------|
| Function code       | 1 Byte  | 1 Byte        |
| Starting Address    | 2 Bytes | 0x1000-0x1004 |
| Quantity of Outputs | 2 Bytes | 1-5           |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x8F     |
| Exception code | 1 Byte | see p. 9 |

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## Preset multiple hold registers (0x10)

### Description

Presets values into a sequence of holding registers.

### Query

The query message specifies the register references to be preset. The requested preset values are specified in the query data field.

|                       |              |               |
|-----------------------|--------------|---------------|
| Function code         | 1 Byte       | 0x10          |
| Starting Address      | 2 Bytes      | 0x3000-0x300C |
| Quantity of registers | 2 Bytes      | 1-16          |
| Byte Count            | 1 Byte       | 2 x N*        |
| Outputs Value         | N* x 2 Bytes | value         |

\*N = Quantity of Registers

### Response


The normal response returns the slave address, function code, starting address, and quantity of registers preset.

|                      |         |               |
|----------------------|---------|---------------|
| Function code        | 1 Byte  | 0x10          |
| Starting Address     | 2 Bytes | 0x3000-0x300C |
| Quantity of Register | 2 Bytes | 1-16          |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x90     |
| Exception code | 1 Byte | see p. 9 |

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## Diagnostics (0x08)

### Description

Checking the communication system between a client device and a server, for more details see p. 7

### Query

|               |             |      |
|---------------|-------------|------|
| Function code | 1 Byte      | 0x08 |
| Sub-function  | 2 Byte      |      |
| Data          | N x 2 Bytes |      |


### Response

|               |             |      |
|---------------|-------------|------|
| Function code | 1 Byte      | 0x08 |
| Sub-function  | 2 Byte      |      |
| Data          | N x 2 Bytes |      |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x88     |
| Exception code | 1 Byte | see p. 9 |

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## Encapsulated Interface Transport (0x2B)

### Description

The MODBUS Encapsulated Interface (MEI) transport is a mechanism for tunneling service requests and method invocations, as well as their returns, inside MODBUS PDUs for more details see p. 8

### Query

|                        |         |      |
|------------------------|---------|------|
| Function code          | 1 Byte  | 0x2B |
| MEI Type*              | 1 Byte  | 0x0E |
| MEI type specific data | N Bytes |      |

### Response

|                        |         |                             |
|------------------------|---------|-----------------------------|
| Function code          | 1 Byte  | 0x2B                        |
| MEI Type*              | 1 Byte  | echo of MEI Type in Request |
| MEI type specific data | N Bytes |                             |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0xA8     |
| Exception code | 1 Byte | see p. 9 |

## DIAGNOSTICS (08)


### Return query data (Sub-function code - 0x0000)

The data passed in the request data field is to be returned (looped back) in the response. The entire response message should be identical to the request.

### Restart communication option (Sub-function code - 0x0001)

The remote device serial line port must be initialized and restarted, and all of its communications event counters are cleared. If the port is currently in Listen Only Mode, no response is returned. This function is the only one that brings the port out of Listen Only Mode. If the port is not currently in Listen Only Mode, a normal response is returned. This occurs before the restart is executed.



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### Query

A request data field contents of 0xFF00 hex causes the port's Communications Event counters to be cleared also. Contents of 0x00000 leave the event counters as it was prior to the restart.

|               |         |                  |
|---------------|---------|------------------|
| Function code | 1 Byte  | 0x08             |
| Sub-function  | 2 Byte  | 0x0001           |
| Data          | 2 Bytes | 0x0000 or 0xFF00 |

### Response

|               |         |                  |
|---------------|---------|------------------|
| Function code | 1 Byte  | 0x08             |
| Sub-function  | 2 Byte  | 0x0001           |
| Data          | 2 Bytes | 0x0000 or 0xFF00 |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9


|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x88     |
| Exception code | 1 Byte | see p. 9 |

### Return diagnostic register (Sub-function code - 0x0002)

The contents of the remote device's 16-bit diagnostic register are returned in the response. Diagnostic register bit fields are described in section 10.

### Query

|               |         |        |
|---------------|---------|--------|
| Function code | 1 Byte  | 0x08   |
| Sub-function  | 2 Byte  | 0x0002 |
| Data          | 2 Bytes | 0x0000 |

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### Response

|               |         |                          |
|---------------|---------|--------------------------|
| Function code | 1 Byte  | 0x08                     |
| Sub-function  | 2 Byte  | 0x0002                   |
| Data          | 2 Bytes | register value see p. 10 |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x88     |
| Exception code | 1 Byte | see p. 9 |

### Force listen only mode (Sub-function code - 0x0004)

Forces the addressed remote device to its Listen Only Mode for MODBUS communications. This isolates it from the other devices on the network, allowing them to continue communicating without interruption from the addressed remote device. No response is returned.


When the remote device enters its Listen Only Mode, all active communication controls are turned off. The **Ready watchdog timer is allowed to expire, locking the controls off, after 10sec.** While the device is in this mode, any MODBUS messages addressed to it is monitored, but no actions will be taken and no responses will be sent.

### Query

|               |         |        |
|---------------|---------|--------|
| Function code | 1 Byte  | 0x08   |
| Sub-function  | 2 Byte  | 0x0004 |
| Data          | 2 Bytes | 0x0000 |

### Response

No Response Returned

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### Clear counters (Sub-function code - 0x0010)

The goal is to clear all counters and the diagnostic register. Counters are also cleared upon power-up.

#### Query

|               |         |        |
|---------------|---------|--------|
| Function code | 1 Byte  | 0x08   |
| Sub-function  | 2 Byte  | 0x0010 |
| Data          | 2 Bytes | 0x0000 |

#### Response

Echo Request Data

#### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9


|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x88     |
| Exception code | 1 Byte | see p. 9 |

### Return bus message count (Sub-function code - 0x0011)

The response data field returns the quantity of messages that the remote device has detected on the communications system since its last restart, clear counters operation, or power-up. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

#### Query

|               |         |        |
|---------------|---------|--------|
| Function code | 1 Byte  | 0x08   |
| Sub-function  | 2 Byte  | 0x0011 |
| Data          | 2 Bytes | 0x0000 |

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### Response

|               |         |                  |
|---------------|---------|------------------|
| Function code | 1 Byte  | 0x08             |
| Sub-function  | 2 Byte  | 0x0011           |
| Data          | 2 Bytes | 0x0000 to 0xFFFF |

### Error Response

Function code + 0x80, exertion byte, see Exception Responses p.9

|                |        |          |
|----------------|--------|----------|
| Function code  | 1 Byte | 0x88     |
| Exception code | 1 Byte | see p. 9 |

### Return bus communication error count (Sub-function code - 0x0012)

The response data field returns the quantity of CRC errors encountered by the remote device since its last restart, clear counters operation, or power-up. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

### Return bus exception error count (Sub-function code - 0x0013)

The response data field returns the quantity of MODBUS exception responses returned by the remote device since its last restart, clear counters operation, or power-up. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

### Return slave message count (Sub-function code - 0x0014)


The response data field returns the quantity of messages addressed to the remote device, that the remote device has processed since its last restart, clear counters operation, or power-up. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

### Return slave NAK count (Sub-function code - 0x0016)

The response data field returns the quantity of messages addressed to the remote device for which it returned a Negative Acknowledge (NAK) exception response, since its last restart, clear counters operation, or power-up. Exception responses are described and listed in section 9. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

### Return slave busy count (Sub-function code - 0x0017)

The response data field returns the quantity of messages addressed to the remote device for which it returned a Server Device Busy exception response, since its last restart, clear counters operation, or power-up. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

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### Return overrun error count (Sub-function code - 0x0019)

The response data field returns the quantity of messages addressed to the remote device that it could not handle due to a character overrun condition, since its last restart, clear counters operation, or power-up. A character overrun is caused by data characters arriving at the port faster than they can be stored, or by the loss of a character due to a hardware malfunction. **The counter will be not overlapped (Max value 0xFFFF (65535)).**

## READ DEVICE IDENTIFICATION (0x0E)

### Read Device Identification sub code (0x0E)

This function code allows reading the identification and additional information relative to the physical and functional description of a remote device, only.

The Read Device Identification interface is modeled as an address space composed of a set of addressable data elements. The data elements are called objects and an object Id identifies them.

The interface consists only Basic device Identification of objects:

- Basic Device Identification. All objects of this category are mandatory: VendorName, Product code, and revision number.

Object ID 0: VendorName (ASCII String) – Ultraflex Power

Object ID 1: ProductCode (ASCII String) – 5537

Object ID 2: Revision (ASCII String) – 1.00


### Query

The query message

|                     |        |                   |
|---------------------|--------|-------------------|
| Function code       | 1 Byte | 0x2B              |
| MEI Type*           | 1 Byte | 0x0E              |
| Read Device ID code | 1 Byte | 0x01 (Basic only) |
| Object Id           | 1 Byte | 0x00-0x03         |

\*MEI = MODBUS Encapsulated Interface

### Response

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|                     |                     |  |
|---------------------|---------------------|--|
| Function code       | 1 Byte              | 0x2B   |
| MEI Type*           | 1 Byte              | 0x0E   |
| Read Device ID code | 1 Byte              | 0x01 (Basic only)  |
| Conformity level    | 1 Byte              | 0x01 (basic identification, stream access only)  |
| More Follows        | 1 Byte              | 0x00 - no more Object are available<br>or<br>0xFF - other identification Object are available and further MODBUS transactions are required |
| Next Object Id      | 1 Byte              | 0x00 - 0x03  |
| Number of Objects   | 1 Byte              | 0x01- 0x03   |
| List of             |                     |  |
| Object ID           | 1 Byte              |  |
| Object length       | 1 Byte              |  |
| Object Value        | Object length bytes | Depending on the object ID   |
| Next Object ID      |                     |  |

\* MEI = MODBUS Encapsulated Interface

#### **Object Id0**

Object Length – 0x0F

Object Value - “Ultraflex Power”

#### **Object Id1**


Object Length 1byte – 0x04

Object Value – “5537”

#### **Object Id2**

Object Length – 0x04

Object Value – “1.00”

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## EXCEPTION RESPONSES

| Code | Name                 | Meaning  |
|------|----------------------|--|
| 01   | ILLEGAL FUNCTION     | The function code received in the query is not an allowable action for the slave.  |
| 02   | ILLEGAL DATA ADDRESS | The data address received in the query is not an allowable address for the slave.  |
| 03   | ILLEGAL DATA VALUE   | A value contained in the query data field is not an allowable value for the slave.   |
| 04   | SLAVE DEVICE FAILURE | An unrecoverable error occurred while the slave was attempting to perform the requested action.  |
| 06   | SLAVE DEVICE BUSY    | The slave is engaged in processing a long–duration program command. The master should retransmit the message later when the slave is free. |
| 07   | NEGATIVE ACKNOWLEDGE | The slave cannot perform the program function received in the query.   |

## DIAGNOSTIC REGISTER

Bit 0 – Communication error (CRC validation fault) – set to 1, if communication error counter is not zero

bit 1 – Overrun error – set to 1, if overrun error counter is not zero

bit 2 – NAK error – set to 1, if NAK counter is not zero

bit 3 – Exception error – set to 1, if exception error counter is not zero

## DISCRETE INPUTS

### Configuration (0x0000)

0 – normal operation

1 – configuration mode – inhibit heat on

### Enable (0x0001)


0 – system is disable – inhibit heat on

1 – normal operation

### Heat (0x0002)

0 – idle

1 – heat on

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#### Top PA always on (0x0003)

- 1 – top PA is always on in heat on
- 0 - top PA is on depending of PA manager

#### Analog input enable(0x0004)

- 1 – enable analog SP input
- 0 – disable analog SP input

#### Ready (0x0005)

- 0 – system not ready, inhibit heat on
- 1 – system ready

#### Fault (0x0006)

- 1 – fault state, inhibit heat on
- 0 – normal operation

#### Firmware update (0x0007)

- 1 – firmware update in progress
- 0 – normal operation

#### Initialization (0x0008)

- 1 – system initialization, inhibit heat on
- 0 – normal operation

#### PA Ready (0x0009)

- 1 – All PAs(power amplifier) are ready
- 0 – one or more PAs(power amplifier) are not ready, inhibit heat on

#### Reset (0x000A)

- 1 – system reset
- 0 – reset is clear


#### Change over switch ready (0x000B)

- 1 – ready
- 0 – not ready (discard heat on request)

#### Change over switch side “A” feedback (0x000C)

- 1 – side “A” heat station is connected to generator output
- 0 – side “A” heat station is disconnected from generator output



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#### Change over switch side “B” feedback (0x000D)

- 1 – side “B” heat station is connected to generator output
- 0 – side “B” heat station is disconnected from generator output

#### Change over switch “A/B” switch request (0x000E)

- 1 – request to connected connect heat station side “A” to generator output
- 0 – request to connected connect heat station side “B” to generator output

#### Thermoregulator enable/disable status (0x000F)

- 1 – thermoregulator is enabled
- 0 – thermoregulator is disabled

### COILS

#### Configuration (0x1000)

- same as discrete input 0x0000

#### Enable (0x1001)

- same as discrete input 0x0001

#### Heat (0x1002)

- same as discrete input 0x0002

#### Top PA always enabled (0x1003)

- same as discrete input 0x0003

#### Analog input enable (0x1004)

- same as discrete input 0x0004

#### Analog input mode – 0-10V/4-20mA (0x1005)


- 1 – 4-20mA
- 0 – 0-10V

#### Change over switch enable (0x1006)

- 1 – enable
- 0 – disable

#### Change over switch mode (0x1007)

- 1 – external control
- 0 – control panel control

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Change over switch direction change request (0x1008)

same as discrete input 0x000E

## INPUT REGISTERS

Error ID (0x2000)

System error ID:

0x0000 – not error

0x0002 – overcurrent fault

0x0015 – resonance frequency is high

0x0016 – resonance frequency is low

0x001D – heat station water flow fault

0x001E – heat station over temperature fault

0x0020 – missing phase

0x0031 – Cabinet under temperature

0x003A – input water over temperature

0x003C – output water over temperature

0x0047 – Cabinet over temperature

0x0054 – input water under temperature

0x0055 – sensor of input water temperature fault

0x0056 – sensor of output water temperature fault

0x0057 – mains over voltage fault

0x0058 – mains under voltage fault

0x1001..8 – PAs(power amplifier) N(1..8) critical error (driver clocks fault (check LAN cables))

0x1011..8 – PAs(power amplifier) N(1..8) critical error (driver power supply fault)


0x1021..8 – PAs(power amplifier) N(1..8) critical error (transformer primary winding over temperature)

0x1031..8 – PAs(power amplifier) N(1..8) critical error (DC over current)

0x1041..8 – PAs(power amplifier) N(1..8) critical error (AC over current)

0x1051..8 – PAs(power amplifier) N(1..8) critical error (cabinet over temperature)

0x1061..8 – PAs(power amplifier) N(1..8) critical error (heat sink over temperature)

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0x1071..8 – PAs(power amplifier) N(1..8) critical error (mains supply over voltage)

0x1081..8 – PAs(power amplifier) N(1..8) critical error (mains supply under voltage)

0x1091..8 – PAs(power amplifier) N(1..8) error (safe mode AC over current (check current feedback))

0x1101..8 – PAs(power amplifier) N(1..8) unsupported power board

0x1111..8 – PAs(power amplifier) N(1..8) invalid logical address

0x1121..8 – PAs(power amplifier) N(1..8) cabinet over temperature

0x1131..8 – PAs(power amplifier) N(1..8) cabinet under temperature

0x1141..8 – PAs(power amplifier) N(1..8) heat sink over temperature

0x1151..8 – PAs(power amplifier) N(1..8) heat sink under temperature

0x1161..8 – PAs(power amplifier) N(1..8) coolant flow is low (check coolant filter)

0x1171..8 – PAs(power amplifier) N(1..8) missing phase

0x1181..8 – PAs(power amplifier) N(1..8) internal HW fault

0x1191..8 – PAs(power amplifier) N(1..8) internal HW fault

0x11A1..8 – PAs(power amplifier) N(1..8) internal HW fault

0x11B1..8 – PAs(power amplifier) N(1..8) internal HW fault

0x1201..8 – PAs(power amplifier) N(1..8) communication fault

0x1211..8 – PAs(power amplifier) N(1..8) FPGA to PA cable wrong position

0x1301..8 – PAs(power amplifier) N(1..8) unsupported PA type

0x1401..8 – PAs(power amplifier) N(1..8) firmware update fault

0x1501..8 – PAs(power amplifier) N(1..8) firmware update fault

0x1601..8 – PAs(power amplifier) N(1..8) firmware update fault

0x1701..8 – PAs(power amplifier) N(1..8) firmware update fault

0x1801..8 – PAs(power amplifier) N(1..8) firmware update fault


0x1901..8 – PAs(power amplifier) N(1..8) generic error

0x1B00 – Change over switch coolant flow is low

0x1B01 – Change over switch cabinet under temperature

0x1B02 – Change over switch cabinet over temperature

0x1B03 – Change over switch NTC1 sensor under temperature

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0x1B04 – Change over switch NTC1 sensor over temperature

0x1B05 – Change over switch NTC2 sensor under temperature

0x1B06 – Change over switch NTC2 sensor over temperature

0x1B07 – Change over switch NTC3 sensor under temperature

0x1B08 – Change over switch NTC3 sensor over temperature

0x1B09 – Change over switch NTC4 sensor under temperature

0x1B0A – Change over switch NTC4 sensor over temperature

0x1B0B – Change over switch relay side “A” open

0x1B0C – Change over switch relay side “A” close

0x1B0D – Change over switch relay side “B” open

0x1B0E – Change over switch relay side “B” close

0x1B0F – Change over switch NTC1 sensor circuit open

0x1B10 – Change over switch NTC1 sensor circuit short

0x1B11 – Change over switch NTC2 sensor circuit open

0x1B12 – Change over switch NTC2 sensor circuit short

0x1B13 – Change over switch NTC3 sensor circuit open

0x1B14 – Change over switch NTC3 sensor circuit short

0x1B15 – Change over switch NTC4 sensor circuit open

0x1B16 – Change over switch NTC4 sensor circuit short

0x1B17 – Change over switch thermo switch open

0x1B18 – Change over switch unsupported HW

0x1B19 – Change over switch communication error

0x1B1A – Change over switch firmware update error


0x1B1B – Change over switch firmware update error

0x1B1C – Change over switch firmware update error


0x1B1D – Change over switch firmware update error

0x1B1E – Change over switch firmware update error


0x1B1F – Change over switch firmware generic error

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0x1B20 – Change over switch unexpected restart  
0x2000 – System firmware integrity check fault  
0x2001 – System boot fault  
0x2002 – System internal communication fault  
0x2003 – System restart request  
0x2004 – System internal error  
0x2005 – System internal error  
0x2006 – System internal error  
0x2007 – System internal error  
0x2008 – System HW fault  
0x2009 – System internal error  
0x200A – Missing current feedback  
0x200B – PAs fast error  
0x200C – Negative switching angle  
0x200D – FPGA/MCU communication queue full  
0x200E – FPGA single module local PA driver control error  
0x200F – FPGA init. programming signal asserted  
0x2100 – Fast frequency sweep fault  
0x2200 – Normal frequency sweep phase 1 load impedance fault  
0x2201 – Normal frequency sweep phase 1 over frequency fault  
0x2202 – Normal frequency sweep phase 1 time out  
0x2300 – Normal frequency sweep phase 2 time out  
0x2301 – Normal frequency sweep phase 2 load impedance fault  
0x2302 – Normal frequency sweep phase 2 under frequency fault  
0x2303 – Normal frequency sweep phase 2 over frequency fault  
0x2304 – Normal frequency sweep phase 2 resonance circuit open fault  
0x2305 – Normal frequency sweep phase 2 phase detector fault  
0x2307 – Normal frequency sweep phase 2 invalid feedback frequency

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0x3001..3 – Slave control board communication fault  
 0x3011..3 – Slave control board unsupported firmware  
 0x3021..3 – Slave control board firmware update fault  
 0x3031..3 – Slave control board firmware update fault  
 0x3041..3 – Slave control board firmware update fault  
 0x3051..3 – Slave control board firmware update fault  
 0x3061..3 – Slave control board not support firmware update  
 0x3071..3 – Slave control board generic fault  
 0x3101..3 – Slave control board input coolant temperature sensor fault  
 0x3111..3 – Slave control board output coolant temperature sensor fault  
 0x3121..3 – Slave control board humidity sensor fault  
 0x3131..3 – Slave control board dew point protection  
 0x3141..3 – Slave control board maximum air humidity protection  
 0x3151..3 – Slave control board cabinet under temperature fault  
 0x3161..3 – Slave control board cabinet over temperature fault  
 0x3171..3 – Slave control board input coolant under temperature fault  
 0x3181..3 – Slave control board input coolant over temperature fault  
 0x3191..3 – Slave control board output coolant over temperature fault  
 0x4001 – Heat on computing fault  
 0x4002 – Heat on computing fault  
 0x4003 – Heat on overloaded fault  
 0x4004 – Heat on overloaded fault  
 0x4005 – Heat on feedback of output current fault  
 0x4007 – Out of regulation  
 0x4008 – Dead time invalid time out  
 0x4009 – Safety fault  
 0x400A – Frequency lock fault  
 0x400B – Load impedance low

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0x400C – Tank capacitor overloaded by voltage

0x400D – Tank capacitor overloaded by current

0x400E – Tank capacitor overloaded by power

0x5000 – system HW error

0x5001 – system HW error

0x5002 – system SW error

0x5003 – system SW error

0x5004 – system HW error

0x5005 – unsupported HW fault

0x5006 – system HW error

0x5007 – system HW error

0x5008 – FW update error

0x5009 – system HW error

0x500A – system not ready – FW update

0x500B – system not ready – initialization

0x500C – system not ready – configuration mode

0x500D – system not ready – PA VDC not validation

0x500E – system not ready – SW disabled

0x5800 – PAs configuration fault

0x5801 – PAs switch to safe mode time out

0x5802 – PAs switch to regular mode time out

0x5803 – PAs not ready fault

0x5804 – PAs dew point protection

0x5900 – Change over switch unsupported type

0x5900 – Change over switch heat station side “A” coolant flow is low

0x5901 – Change over switch heat station side “B” coolant flow is low


0x5902 – Change over switch heat station side “A” over temperature

0x5903 – Change over switch heat station side “B” over temperature

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0x6000 – system configuration error  
0x6001 – system configuration error  
0x6002 – system configuration error  
0x6003 – system configuration error  
0x6004 – system configuration error  
0x6005 – system configuration error  
0x6006 – system configuration error  
0x6007 – system configuration error  
0x6008 – mains frequency out of range  
0x6009 – system configuration error  
0x600A – change over switch not ready  
0x6F00 – change over switch side “B” connect fault  
0x6F01 – change over switch side “B” disconnect fault  
0x6F02 – change over switch side “A” connect fault  
0x6F03 – change over switch side “A” disconnect fault  
0x7F80 – system internal error  
0x7F81 – system internal error  
0x7F82 – system internal error  
0x7F83 – system internal error  
0x7F84 – system internal error  
0x7F85 – system internal error  
0x7F86 – system internal error  
0x7F87 – system internal error  
0x7F88 – system internal error  
0x7F89 – system internal error  
0x7F8A – system internal error  
0x7F8B – system internal error  
0x7F8C – system internal error



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0x7F8D – system internal error

0x7F8E – system internal error

0x7F8F – system internal error

0x7F90 – system internal error

0x7F91 – system internal error

0x7F92 – system internal error

0x8000..18 – PAs(power amplifier) N(1..24) critical error (driver clocks fault (check LAN cables))

0x8081..18 – PAs(power amplifier) N(1..24) critical error (driver power supply fault)

0x8101..18 – PAs(power amplifier) N(1..24) critical error (transformer primary winding over temperature)

0x8181..18 – PAs(power amplifier) N(1..24) critical error (DC over current)

0x8201..18 – PAs(power amplifier) N(1..24) critical error (AC over current)

0x8281..18 – PAs(power amplifier) N(1..24) critical error (cabinet over temperature)

0x8301..18 – PAs(power amplifier) N(1..24) critical error (heat sink over temperature)

0x8381..18 – PAs(power amplifier) N(1..24) critical error (mains supply over voltage)

0x8401..18 – PAs(power amplifier) N(1..24) critical error (mains supply under voltage)

0x8481..18 – PAs(power amplifier) N(1..24) error (safe mode AC over current (check current feedback))

0x8501..18 – PAs(power amplifier) N(1..24) critical error (AC over current)

0x8581..18 – PAs(power amplifier) N(1..24) unsupported power board

0x8601..18 – PAs(power amplifier) N(1..24) invalid logical address

0x8681..18 – PAs(power amplifier) N(1..24) cabinet over temperature

0x8701..18 – PAs(power amplifier) N(1..24) cabinet under temperature

0x8781..18 – PAs(power amplifier) N(1..24) heat sink over temperature

0x8801..18 – PAs(power amplifier) N(1..24) heat sink under temperature


0x8881..18 – PAs(power amplifier) N(1..24) coolant flow is low (check coolant filter)

0x8901..18 – PAs(power amplifier) N(1..24) missing phase

0x8981..18 – PAs(power amplifier) N(1..24) internal HW fault

0x8A01..18 – PAs(power amplifier) N(1..24) internal HW fault

0x8A81..18 – PAs(power amplifier) N(1..24) internal HW fault

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0x8B01..18 – PAs(power amplifier) N(1..24) internal HW fault  
0x8B81..18 – PAs(power amplifier) N(1..24) communication fault  
0x8C01..18 – PAs(power amplifier) N(1..24) wrong cables position  
0x8C81..18 – PAs(power amplifier) N(1..24) unsupported PA type  
0x8D01..18 – PAs(power amplifier) N(1..24) firmware update fault  
0x8D81..18 – PAs(power amplifier) N(1..24) firmware update fault  
0x8E01..18 – PAs(power amplifier) N(1..24) firmware update fault  
0x8E81..18 – PAs(power amplifier) N(1..24) firmware update fault  
0x8F01..18 – PAs(power amplifier) N(1..24) firmware update fault  
0x8F81..18 – PAs(power amplifier) N(1..24) generic fault  
0x9001..18 – PAs(power amplifier) N(1..24) unexpected restart

#### Reset ID (0x2001)


System reset ID:

0x0000 – not pending reset  
0x0001 – external reset  
0x0002 – power on reset  
0x0003 – brown out reset  
0x0004 – WDT reset  
0x0005 – SW reset  
0x0006 – FW update reset  
0x00FF – unknown reset

#### Analog input assignment (0x2002)

Analog input 4-20mA SP assignment.

0x0000 – Power regulator  
0x0001 – Current regulator

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#### Analog output assignment (0x2003)

Analog output 4-20mA SP assignment.

0x0000 – output power

0x0001 – output current

0x0002 – output voltage

#### PA enable mask (0x2004)

System PAs enable mask.

0 – disable

1 – enable

bit 0 – PA1

bit 1 – PA2

bit 2 – PA3

bit 3 – PA4

bit 4 – PA5

bit 5 – PA6

bit 6 – PA7

bit 7 – PA8

#### PA max working set (0x2005)

Number of simultaneously ON PAs.

#### 100% output power \*100 W (0x2006)

100% output power

Power = Value \* 100, [W]


range: 0..65535

#### 100% output current /10A (0x2007)

100% output current

Current = Value / 10, [A]

range – 0..65535

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#### 100% output voltage /10V (0x2008)

100% output voltage

Voltage = Value / 10, [V]

range: 0..65535

#### SP Iac /100% (0x2009)

Actual output current regulator SP percent – 0..100%, depending of analog input SP too.

SP[%] = Value / 100;

range: 0x0000 - 0x2710

#### SP Power /100% (0x200A)

Actual output power regulator SP percent – 0..100%, depending of analog input SP too.

SP[%] = Value / 100;

range: 0x0000 – 0x2710

#### Input water temperature /10K (0x200B)

Input water temperature

Temperature = Value/10, [K]

range: -1..32767

#### Output water temperature /10K (0x200C)

Output water temperature

Temperature = Value/10, [K]

range: -1..32767

negative value is invalid

#### Cabinet temperature /10K (0x200D)

Cabinet temperature

Temperature = Value/10, [K]


range: -1..32767

#### PA water flow /10 lps (0x200E)

Water flow through PA

WF = Value/10, [lps]

range: 0..65535

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#### Mains rectified voltage /10V (0x200F)

Actual mains rectified voltage

Voltage = Value / 10, [V]

range: 0..65535

#### Output limit by mask (0x2010)

Output limit by mask

bit0 – by angle

bit1 – by output current

bit2 – by tank capacitor voltage

bit3 – by output voltage

bit4 – by output power

bit5 – by min PWM

bit6 – by frequency

bit7 – derate by frequency

#### Output power \*100 W (0x2011)

Actual output power

Power = Value \* 100, [W]

range: 0..65535

#### Output current /10A (0x2012)

Actual output current

Current = Value / 10, [A]


range: 0..65535

#### Output voltage /10V (0x2013)

Actual output voltage

Voltage = Value / 10, [V]

range: 0..65535

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#### Resonance capacitor voltage /10V (0x2014)

Actual resonance capacitor voltage

Voltage = Value / 10, [V]

range: 0..65535

#### Frequency /100 Hz (0x2015)

Actual output frequency

Frequency = Value / 100, [Hz]

range: 0..65535

#### Dew point temperature /10K (0x2016)

PA heatsink dew point temperature

Tdp = Value / 10, [K]

range: -1..32767

#### Cabinet humidity % (0x2017)

Cabinet humidity

Humidity = Value, [%]

range: -1..100

#### Timer remain /10 sec (0x2018)

Timer remain

T = Value/10, [sec]

range: -1..32767

#### Slave cabinets PA enable mask (0x2019)

Slave cabinets PAs enable mask.

0 – disable

1 – enable


bit 0 – PA1 left cabinet

bit 1 – PA2 left cabinet

bit 2 – PA3 left cabinet

bit 3 – PA4 left cabinet

bit 4 – PA5 left cabinet

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bit 5 – PA6 left cabinet

bit 6 – PA7 left cabinet

bit 7 – PA8 left cabinet

bit 8 – PA1 right cabinet

bit 9 – PA2 right cabinet

bit 10 – PA3 right cabinet

bit 11 – PA4 right cabinet

bit 12 – PA5 right cabinet

bit 13 – PA6 right cabinet

bit 14 – PA7 right cabinet

bit 15 – PA8 right cabinet

#### Configuration change (0x201A)

Machine configuration change – on every change in machine configuration value is incremented by 1, when value reach 255 next change will set register value to 0

#### Thermoregulator regulation mode (0x201B)

0 – by current

1 – by power

#### Thermoregulator set point /10K (0x201C)

Thermoregulator temperature set point [K]

SP = Value / 10, [K]

range: -1..32767

#### Thermoregulator sensor temperature /10K (0x201D)

Thermoregulator sensor temperature [K]

Sensor\_t = Value / 10, [K]

range: -1..32767

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## HOLDING REGISTERS

### Error ID (0x3000)

write 0x0000 – clear fault

### Reset ID (0x3001)

write 0x0000 – clear reset

### Analog input assignment (0x3002)

see input register 0x2002

### Analog output assignment (0x3003)

see input register 0x2003

### PA enable mask (0x3004)

see input register 0x2004

### PA max working set (0x3005)

see input register 0x2005

### SP Iac \*100% (0x3006)

Output current regulator SP – 0..100%, resolution 0.01%

Value = SP[%] \* 100;

range : 0x0000 – 0x2710

### SP Power \*100% (0x3007)

Output power regulator SP – 0..100%, resolution 0.01%

Value = SP[%] \* 100;

range: 0x0000 – 0x2710

### Equal tank capacitor value /100 (0x3008)

Equal tank capacitor group value

Cap = Value/100 \* 10 ^ “value of 0x3009”, [F]

range: 0x0000 – 65535


### Equal tank capacitor exponent (0x3009)

Equal tank capacitor group exponent

Cap = “value of 0x3008”/100 \* 10 ^ Value, [F]

range: -12..-6



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#### Maximum equal tank capacitor voltage /10V (0x300A)

Maximum tank equal capacitor voltage

Voltage = Value / 10, [V]

range: 0..65535

#### Heat station transformer ratio /100 (0x300B)

Heat station ration

Value = (Primary/Secondary) \* 100

Ratio = Value/100

range: 0..65535

#### Nominal mains phase voltage /10V (0x300C)

Nominal mains phase voltage

Voltage = Value / 10, [V]

range: 0..65535

#### Maximum equal tank capacitor current A (0x300D)

Maximum equal tank capacitor current – negative or 0 – disable tank capacitor current limit

Voltage = Value, [A]

range: -1..32767

#### Timer set point, sec (0x300E)

Timer set point – negative or 0 – disable

Time = Value/10, [sec]

range: -1..32767

#### Slave cabinets PA enable mask (0x300F)

see input register 0x2019

#### Second heat station transformer ratio /100 (0x3010)


see hold register 0x300B

#### Maximum equal tank capacitor power \*10000VA (0x3011)

Maximum tank capacitor reactive power – negative or 0 – disable tank capacitor power limit

Power = Value \* 10000 [VA]

range: -1..32767

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Second heat station equal tank capacitor value /100 (0x3012)

see hold register 0x3008

Second heat station equal tank capacitor exponent (0x3013)

see hold register 0x3009

Second heat station maximum equal tank capacitor voltage /10V (0x3014)

see hold register 0x300A

Second heat station maximum equal tank capacitor current A (0x3015)

see hold register 0x300D

Second heat station equal tank capacitor power \*10000VA (0x3016)

see hold register 0x3011