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User Manual

# EE895

## MINIATURE SENSOR MODULE FOR $CO_2$, TEMPERATURE AND BAROMETRIC PRESSURE

YOUR PARTNER IN SENSOR TECHNOLOGY
E+E ELEKTRONIK® Ges.m.b.H.

## EMC note USA (FCC):

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

## EMC note Canada (ICES-003):

CAN ICES-3 (A) / NMB-3 (A)

# CONTENTS

# 1 Introduction

## 1.1 General

This user manual serves for ensuring proper handling and optimal functioning of the device. It shall be read before commissioning and it shall be provided to all staff involved in transport, installation, operation, maintenance and repair.
The user manual may not be used for the purposes of competition without the written consent of E+E Elektronik® and may not be forwarded to third parties. Copies may be made for internal purposes. All information, technical data and diagrams included in the manual are based on the information available at the time of writing.

**Intended Use**
The EE895 miniature sensor module measures the $CO_2$ concentration, the temperature (T) and the absolute barometric pressure (p). It is intended to be used as sensor module in devices for diverse uses in non-condensing environments. Applications can be , e.g., in building automation, demand controlled ventilation and process control.
The sensor module can be mounted using several mounting methods. Please observe chapter 3 for mounting recommendations and descriptions. The use of the EE895 other than described in this manual is not recommended.
The manufacturer cannot be held responsible for damages as a result of incorrect handling, installation and maintenance of the device. Unauthorized modifications of the product lead to loss of all warranty claims. The device may only be powered with safety extra-low voltage (SELV).

**Disclaimer**
The manufacturer or his authorized agent can only be held liable in case of willful or gross negligence. In any case, the scope of liability is limited to the corresponding amount of the order issued to the manufacturer. The manufacturer assumes no liability for damages incurred due to failure to comply with the applicable regulations, operating instructions or the operating conditions. Consequential damages are excluded from the liability.

## 1.2 Explanation of Symbols

**This symbol indicates safety information.**
It is essential that all safety information is strictly observed. Failure to comply with this information can lead to personal injuries or damage to property. E+E Elektronik® assumes no liability if this happens.

**This symbol indicates instructions.**
The instructions shall be observed in order to reach optimal performance of the device.

**This symbol indicates ESD (electrostatic discharge) specific notes.**
Non-observance can result in damage to the device.

### 1.2.1 General Safety Instructions

- Use the EE895 only as intended and observe all technical specs.
- This device is not appropriate for safety, emergency stop or other critical applications where device malfunction or failure could cause injury to human beings.

## 1.3 Environmental Aspects

Products from E+E Elektronik® are developed and manufactured observing of all relevant requirements with respect to environment protection. Please observe local regulations for the device disposal.

The individual components of the device shall be disposed of according to local recycling regulations. The electronics shall be disposed of correctly as electronics waste.

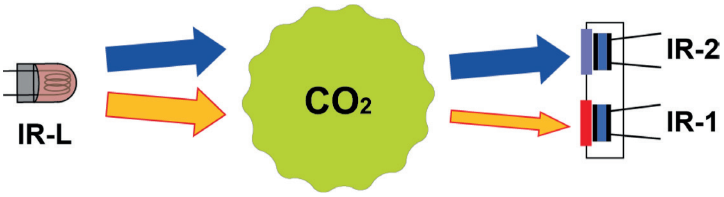
## 1.4 Product Description

Beside $CO_2$ concentration up to 10.000 ppm, the EE895 measures temperature (T) and absolute barometric pressure (p). The active pressure and temperature compensation minimizes the impact of altitude and ambient conditions on the $CO_2$ measured data.
The $CO_2$, T and p measured data is available on I²C or UART digital interfaces. The solder pads, the plated half-holes and the through-holes allow for various mounting options.

## 1.5 Operating Principle $CO_2$ Measurement

The $CO_2$ measurement is based on the dual wavelength Non Dispersive Infra-Red (NDIR) technology which compensates for ageing effects, is highly insensitive to pollution and offers outstanding long term stability.

The infrared detector 1 (IR-1) is tuned to 4.2 µm, which is the wavelenght absorbed by $CO_2$, the infrared detector 2 (IR-2) is tuned to 3.9 µm, which is not affected by any gas. For every single flash of the infrared lamp (IR-L), the device calculates the $CO_2$ concentration from the outputs of both infrared detectors IR-1 and IR-2. The measuring interval is user selectable (factory default: 15 s).




# 2 Handling Instructions

EE895 is an ESD sensitive device and must be handled with corresponding precautions. Protect the sensor outside the EPA (Electrostatic Protected Area) using ESD protective packaging.
The EE895 is packed in stacks of ESD trays with 50 pieces each. The tray dimension is 354.2 x 278.6 x 23.8 mm (13.94 x 10.97 x 0.94 inch).

Operating and storage conditions: -40…60 °C (-40…140 °F)
0…95 % RH (non-condensing)
700...1100 mbar (10.15...15.95 psi)

The EE895 housing and the circuit board shall not be exposed to unneccessary mechanical stress during installation and operation. The forces exerted shall not exceed 50 N.
The sensor module deploys a fine dust filter for sensing element protection. If the EE895 is deployed in a device which is designed for harsh environments, the device shall deploy a filter as well.

# 3 Hardware

## 3.1 Dimensions in mm (inch)

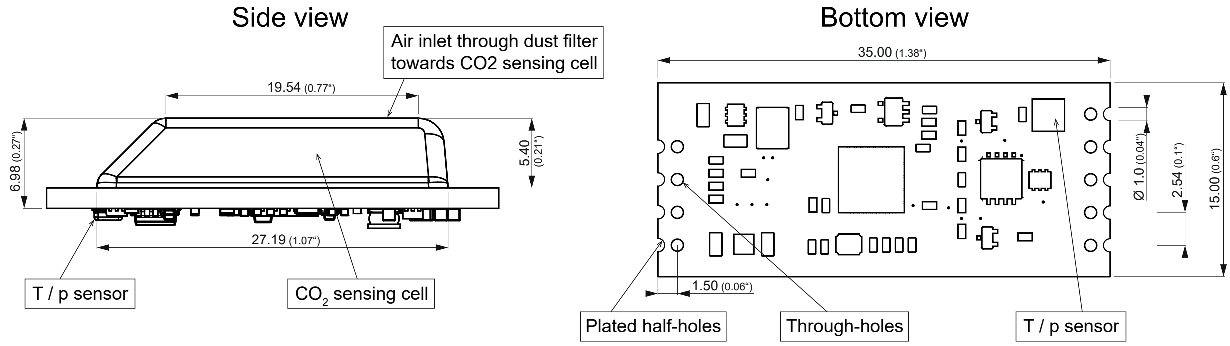



*Fig. 1 Dimensions*

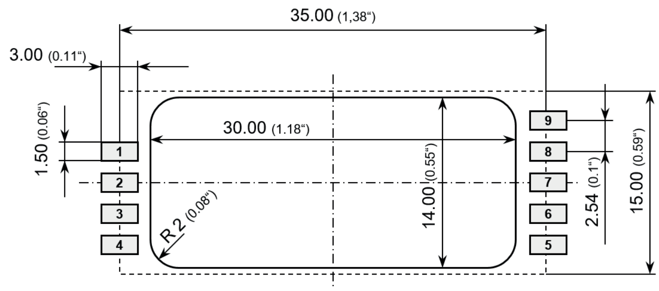



*Fig. 2 Recommended PCB footprint*

## 3.2 Mounting Recommendation

The EE895 is not intended for reflow soldering and consequently it does not feature a moisture sensitivity level rate (MSL). Nevertheless, for storage and handling it shall be regarded as compatible with MSL 1.

EE895 may only be soldered manually. A max. temperature of 360°C may be applied for max. 10s/solder point.

ESD precautions shall be observed while manually soldering the EE895.
The EE895 can be mounted facing either upwards or downwards.

### 3.2.1 Mounting via Solder Pads

The EE895 module can be mounted onto a pluggable female header or directly onto the electronics board by using a pin-header with 2.54 mm (0.1 inch) pitch.
The minimum clearance of 2 mm (0.08 inch) shall be strictly observed. This is necessary for free air flow around the $CO_2$ sensing cell and around the T/p sensor.

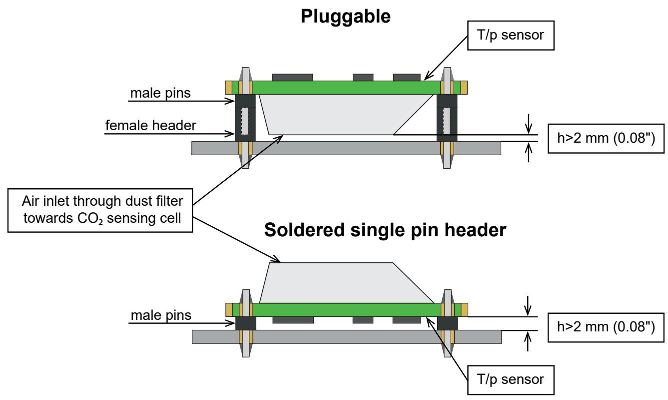



*Fig. 3 Mounting with soldered pin header*

### 3.2.2 Mounting via Side Plated Contacts

The EE895 can be mounted by manually soldering the plated half-holes onto the host board.

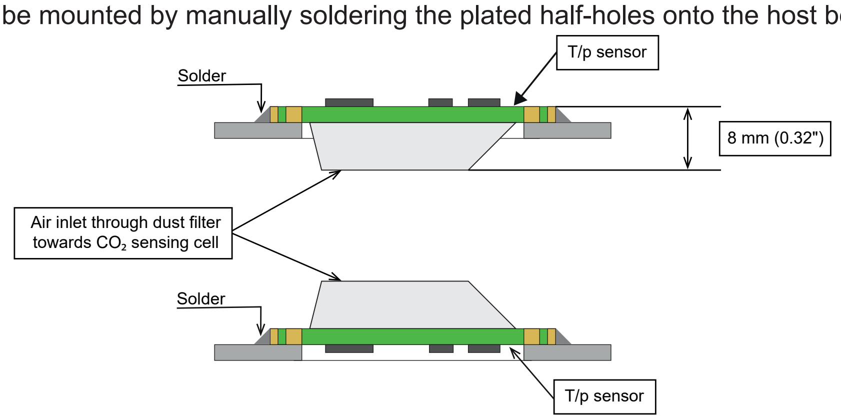



*Fig. 4 Mounting by soldering at the side plated contacts*

## 3.3 EE895 Block Diagram

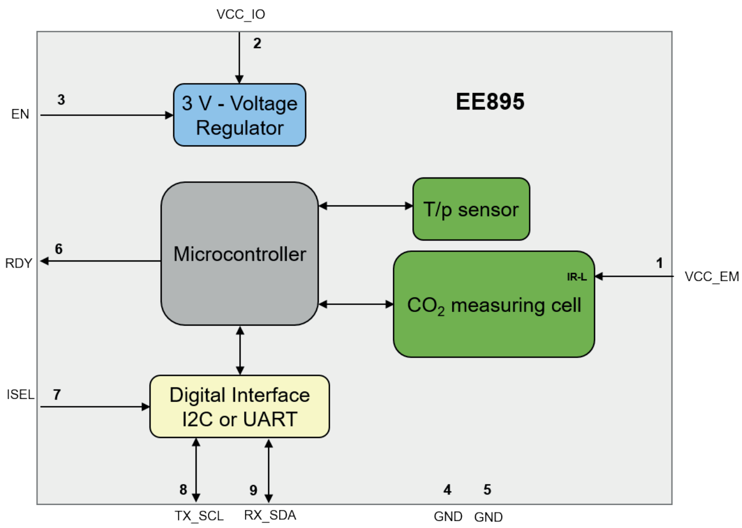



*Fig. 5 Block diagram*

## 3.4 Pin Assignment

Bottom view

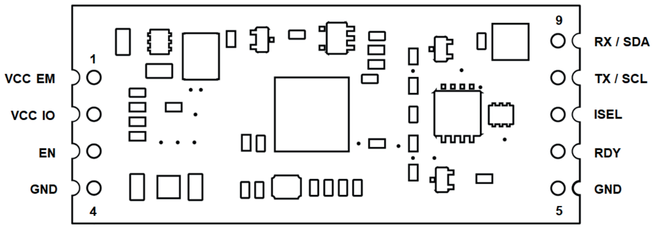



*Fig. 6 Pin assignment*

| Pin | Name | Type | Comment |
|---|---|---|---|
| 1 | VCC_EM | Power supply | Power supply emitter infra-led lamp (IR-L) |
| 2 | VCC_IO | Power supply | Power supply for the microcontroller |
| 3 | EN | Input | Enable the module. Tie to Vcc_IO for normal operation |
| 4 | GND | Power supply | Ground1) |
| 5 | GND | Power supply | Ground1) |
| 6 | RDY | Output | Data ready (open drain output) |
| 7 | ISEL | Input | Interface selection |
| 8 | TX / SCL | I/O | Transmission line (TX) / Serial Clock (SCL) |
| 9 | RX / SDA | I/O | Receive line (RX) / Serial Data (SDA) |

1) pins 4 and 5 shall be connected to the same potential

*Tab. 1 Pin assignment*

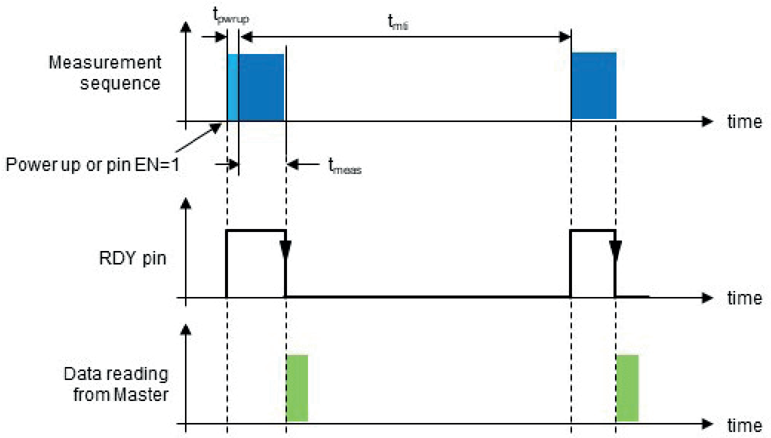
## 3.5 Pin Description

**Pin 1 - VCC_EM**
Power supply for the infrared lamp (IR-L). For optimizing of the energy consumption such as in battery-powered devices, the IR-L can be powered separately.
The IR-L does not have to be powered continuously, as it needs power supply during the measurement cycle $t_{meas}$ only, see Figure 6. Between the measurement cycles the current consumption of IR-L is approx. 0.1 µA.

**Pin 2 - VCC_IO**
Power supply for the microcontroller and the digital functional blocks.

**Pin 3 – EN (Enable)**
For battery-powered devices the user can optimize the energy consumption controlling the status of the EN pin by an external host controller.
When the EN pin is pulled-down to the logic Low 0 (≤0.4 V), the internal voltage regulator of EE895 is switched off and the current consumption is typically 1 µA (max 2 µA).
When pulled-up to the logic state High (≥0.9 V), the EE895 operates normally.
If the energy consumption of EE895 is not relevant, the EN pin shall be connected to VCC_IO.
The EN pin may not be left open.

**Pin 6 – RDY (Data ready)**
During the measurement cycle ($t_{meas}$), when $CO_2$, T and p are measured and processed, the pin RDY is in logic state High. As soon as data is available for read out, the pin RDY goes to logic state Low. The falling edge at this pin indicates that measured data is available for reading, see Figure 6.
If used, an external pull-up resistor is required. If not used, the RDY pin may be left open.




| | |
|---|---|
| $t_{pwrup}$ | power up time, approx. 150 ms |
| $t_{meas}$ | measurement cycle ($CO_2$, RH, T,p) , approx. 300 ms warm-up + 300 ms IR lamp pulse |
| $t_{mi}$ | measurement interval, user selectable 10…3600 s, +/-25 % (default: 15 s) |

*Fig. 7 Timing details (see chapter 4.4.3: „$CO_2$ Parameter Settings“)*

**Pin 7 – ISEL (Interface selection)**
The EE895 features I²C and UART interfaces.
Interface selection:

| ISEL logic state | EE895 interface |
|---|---|
| Low (0…0.9 V) | I²C |
| High (2.1…5.5 V) or not connected | UART |

*Tab. 2 Interface selection*

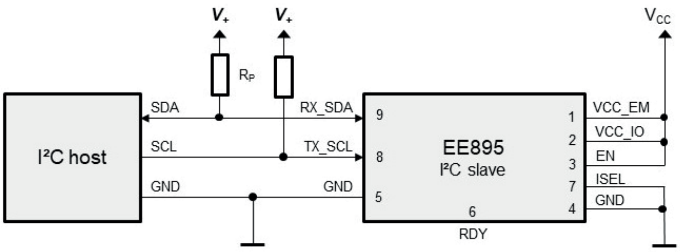
**Serial interface pins:**
**Pin 8 – TX_SCL** Transmission data / Serial clock
**Pin 9 – RX_SDA** Receiving data / Serial data
The function of pins 8 and 9 depends on the interface selected with pin 7 ISEL:

Pin 7 – ISEL connected to ground: EE895 features I²C interface:

| Pin | Mode | Note |
|---|---|---|
| 8 | SCL (serial clock) | External pull-up resistor to V+ (bus high voltage level) is required. |
| 9 | SDA (serial data) | External pull-up resistor to V+ (bus high voltage level) is required. |

*Tab. 3 Pin assignement I²C interface*

Example:




- $V_{CC}$ = EE895 supply voltage: 3.3 – 5.5 V
- $V_+$ = Bus high voltage, typical 3.3 - 5.5 V
- Rp = I²C pull-up resistors, typical 10 kΩ
- $V_+$ and $V_{CC}$ are independent but may be connected together
- Independently of $V_{CC}$, RX_SDA and TX_SCL pins are 5 V tolerant (max 5.5V)

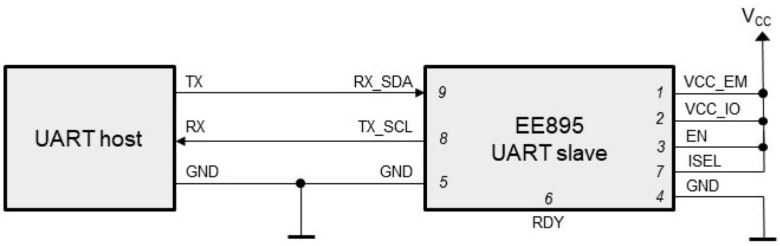
*Fig. 8 Example I²C interface*

Pin 7 – ISEL connected to $V_{CC}$ or left open: EE895 features UART interface:

| Pin | Mode | Note |
|---|---|---|
| 8 | TX (transmission line) | CMOS compatible ($V_{OutLowMax}$ 0.4 V; $V_{OutHighMin}$ 2.6 V) |
| 9 | RX (receive line) | CMOS compatible ($V_{InputLowMax}$ 0.9 V; $V_{InputHighMin}$ 2.1 V) |

*Tab. 4 Pin assignement UART interface*

Example:




- $V_{CC}$ = EE895 supply voltage: 3.3 – 5.5 V
- Independently of $V_{CC}$, RX_SDA pin is 5 V tolerant (5.5 V max)
- EE895 internal microcontroller uses 3 V supply
- RX_SDA / TX_SCL pins are CMOS compatible:
  - RX_SDA $V_{InputLowMax}$ = 0.9 V; $V_{InputHighMin}$ = 2.1 V
  - TX_SCL $V_{OutLowMax}$ = 0.4 V; $V_{OutHighMin}$ = 2.6 V @ 8 mA

*Fig. 9 Example UART interface*

## 3.6 Electrical Characteristics

| Signal | Unit | Min | Max | Note |
|---|---|---|---|---|
| VCC_EM | mA | | 95 mA @ 3.3V<br>61 mA @ 5 V | during IR lamp pulse only (300 ms) |
| VCC_IO | mA | | 9 mA @ 3.3 V<br>9 mA @ 5 V | during $CO_2$ measurement (600 ms) and communication only;<br>else 200 µA |
| Clock frequency | Hz | 500 | 100000 | |
| Pull-up resistor | kΩ | 4.7 | 100 | Typical 10 KΩ |

*Tab. 5 Electrical characteristics*

A DC/DC converter is used to flash the lamp (VCC_EM). Therefore, the supply current is reduced with higher voltage and vice versa. The microcontroller (VCC_IO) is supplied via a linear reglator, hence the supply current is constant.
The average current consumption at a sampling interval of 15 s (factory default) is 1.5 mA. For the maximum values, please compare Tab. 5

## 3.7 Typical Applications

### 3.7.1 EE895 Connected to USB Interface

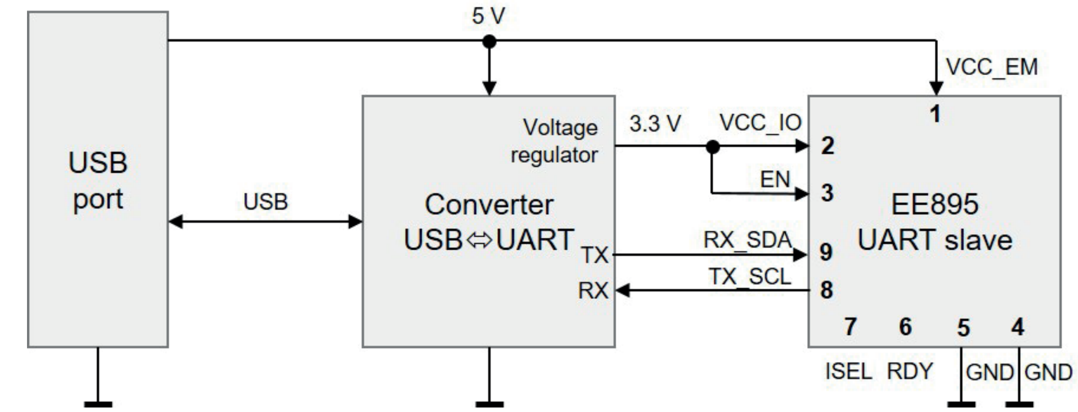



*Fig. 10 Example USB Interface*

Pin 7 - ISEL is not connected → the EE895 features UART interface.

VCC_EM is connected to the nominal 5 V from USB, the VCC_IO and EN are connected to 3.3 V voltage regulator.

The host can read the values at any time, pin 6 - RDY is not used.

### 3.7.2 EE895 in Battery Powered Devices

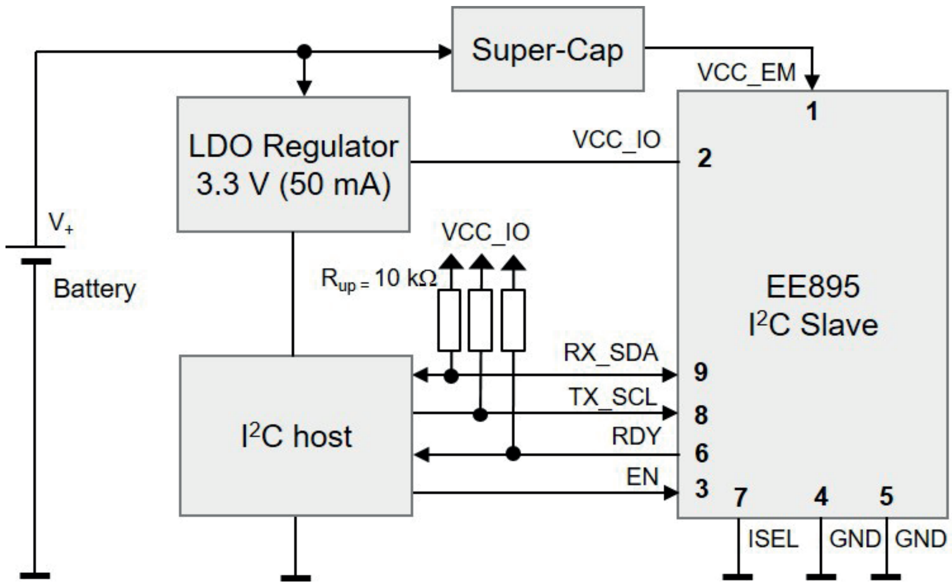



*Fig. 11 Example battery powerd devices*

Pin 7 - ISEL is connected to the ground → the EE895 features I²C interface.

VCC_EM is supplied by a low ESR super-capacitor and VCC_IO is connected to a typical low drop

3.3 V regulator.

The I²C host enables the EE895 with pin 3 - EN.

By checking the status of pin 6 - RDY (pulled up), the host can read the data as soon as available. After reading the data, EE895 can be disabled with pin 3.

### 3.7.3 EE895 Connected to a KNX Bus

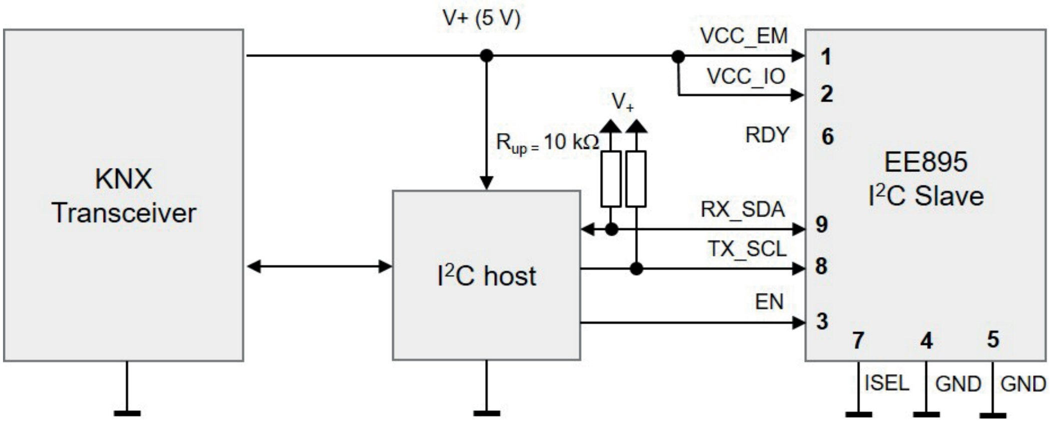



*Fig. 12 Example KNX Bus*

Pin 7 - ISEL is connected to the ground → the EE895 features I²C interface.
The VCC_EM and the VCC_IO are connected to the typical 5 V bus voltage.
The I²C host keeps the EE895 enabled with the pin 3 – EN and can read the values at any time, pin 6 - RDY is not used.

# 4 Digital Interface

The EE895 features standard I²C and UART interfaces.
The interface selection is made with pin 7 – ISEL, see Tab. 2 on page 8.
On both interfaces, I²C and UART, the data is encapsulated in Modbus Protocol Data Units (Modbus PDUs).

## 4.1 I²C Interface

The EE895 supports the standard I²C specification. For detailed information about the I²C interface, please refer to NXP document „I²C-bus specification and user manual“, Rev. 6, 4 April 2014: www.nxp.com/docs/en/user-guide/UM10204.pdf

The I²C interface simultaneously supports two protocols on two different slave addresses:
- Modbus over I²C address 0x5F
- I²C simplified address 0x5E

These addresses are fixed, they cannot be changed by the user.

### 4.1.1 Modbus Protocol Over I²C Interface

I²C slave address: 0x5F

The I²C interface encapsulates the data according Modbus PDU packets, including CRC:

| S | Slave Address | W | A | Request: Modbus PDU + Modbus CRC | P |
|---|---|---|---|---|---|

| S | Slave Address | R | A | Response: Modbus PDU + Modbus CRC | P |
|---|---|---|---|---|---|

Every byte of the Modbus PDU and the Modbus CRC must be acknowledged (according to I²C specification, not shown above).

The EE895 module supports repeated START or STOP conditions between the request packet and the response packet. If a START condition and an address match are detected, the EE895 will stay active until a STOP condition is received or an idle timeout of 500 ms occurs. This might increase the power consumption and self-heating. The I²C master shall ensure that the data is retrieved as soon as possible in case of a repeated START.

The CRC16 shall be calculated including the slave address. For the Modbus register map please refer to chapter 4.3, page 14. For Modbus specifications, please refer to Appendix 1, page 18.

Example of command reading the temperature (floating point value) T = 27.50 °C from the register 0x3EA:

**Request [Hex]: S BE 03 03 EA 00 02 E8 C5 P**

| START | Slave address 7-bit shifted | Function code | Starting address Hi | Starting address Lo | No. of register Hi | No. of register Lo | CRC | | STOP |
|---|---|---|---|---|---|---|---|---|---|
| S | BE | 03 | 03 | EA | 00 | 02 | E8 | C5 | P |

**Response [Hex]: S BF 03 04 00 00 41 DC 74 3F P**

| START | Slave address 7-bit shifted | Function code | Byte count | Register 1 value Hi | Register 1 value Lo | Register 2 value Hi | Register 2 value Lo | CRC | | STOP |
|---|---|---|---|---|---|---|---|---|---|---|
| S | BF | 03 | 04 | 00 | 00 | 41 | DC | 74 | 3F | P |

For decoding of float values stored according standard IEEE754, please refer to Appendix 1, page 18.

Example of Decoding:

**Response [Hex]:**

| Byte 1 (Register 2 - Hi) | Byte 2 (Register 2 – Lo) | Byte 3 (Register 1 - Hi) | Byte 4 (Register 1 - Lo) | Decimal value |
|---|---|---|---|---|
| 41 | DC | 00 | 00 | 27.50 |

**Please note:** For obtaining the correct value, both registers have to be read within the same reading cycle. The measured value can change between two Modbus requests, therefore, exponent and mantissa may get inconsistent.

### 4.1.2 I²C Simplified Protocol

I²C slave adress: 0x5E

This I²C protocol is intended for I²C master reading the measured values from EE895 in "EEPROM-like-mode".

The simplified I²C does not support any error detection (such as CRC) and provides the measured data in 8 subsequent registers, as 16 bit integers.

| Slave address | 0x00 | 0x01 | 0x02 | 0x03 | 0x04 | 0x05 | 0x06 | 0x07 |
|---|---|---|---|---|---|---|---|---|
| 0x5E | $CO_2$ high byte | $CO_2$ low byte | T high byte | T low byte | reserved*) high byte | reserved*) low byte | p high byte | p low byte |

*) reserved for future use

The read pointer is the first register to read. Additional bytes are answered by the EE895 module with NACK. If more bytes are read than the 8 registers, the EE895 answers with 0xFF (i.e. the SDA line is not pulled down). If a START condition and an address match are detected, the EE895 will stay active until a STOP condition is received or an idle timeout of 500 ms occurs.

The measured data is available as a 16 bit integer and is expressed in SI units:

| Measurand | Register pointer | Unit | Scale |
|---|---|---|---|
| $CO_2$ average | 0x00 | ppm | 1:1 |
| T | 0x02 | °C | 1:100 * |
| p | 0x06 | mbar | 1:10 ** |

* Example: 2575 means 25.75 °C
** Example: 10130 means 1013 mbar

*Tab. 6 Data availability from the EE895 Miniature Sensor Module*

Example for reading all measurands (7-bit address shifted):

**Request [Hex]: S BC 00 P**

| START | Slave address 7-bit shifted | Register pointer | STOP |
|---|---|---|---|
| S | BC | 00 | P |

**Response [Hex]: S BD 03 B0 0A B7 6 70 P**

| START | Slave address 7-bit shifted | $CO_2$ high byte | $CO_2$ low byte | T high byte | T low byte | res.*) high byte | res.*) low byte | p high byte | p low byte | STOP |
|---|---|---|---|---|---|---|---|---|---|---|
| S | BD | 03 | B0 | A0 | B7 | 80 | 00 | 26 | 70 | P |

*) reserved for future use

Conversion:

| Measurand | Response [Hex] | Response [Dec] | Value |
|---|---|---|---|
| $CO_2$ | 0x03B0 | 944 | 944 ppm |
| T | 0x0AB7 | 2743 | 27.43 °C |
| p | 0x2670 | 9840 | 984.0 mbar |

*Tab. 7 Interpretation of data from the response*

Example for reading the air pressure value (7-bit address shifted):

**Request [Hex]: S BC 06 P**

| START | Slave address 7-bit shifted | Register pointer | STOP |
|---|---|---|---|
| S | BC | 06 | P |

**Response [Hex]: S BD 26 70 P**

| START | Slave address 7-bit shifted | p high byte | p low byte | STOP |
|---|---|---|---|---|
| S | BD | 26 | 70 | P |

Conversion:

| Measurand | Response [Hex] | Response [Dec] | Value |
|---|---|---|---|
| p | 0x2670 | 9840 | 984.0 mbar |

*Tab. 8 Interpretation of data from the response*

## 4.2 UART Interface

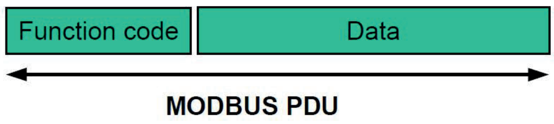
### 4.2.1 Modbus Protocol Over UART Interface

Modbus slave address: 0x5F
The interface settings are: Baud rate 9600, 8 Data, No parity, 1 Stop bit (9600 8 N 1)
The slave address and the interface settings are fixed, they cannot be changed by the user.

The EE895 module shall be addressed according to the specification “Modbus over serial line V1.02”, see [http://www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf](http://www.modbus.org/docs/Modbus_over_serial_line_V1_02.pdf) .

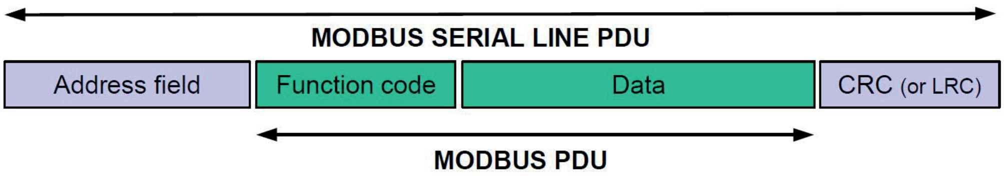
Modbus frame description (screenshot taken from the “Modbus overSerial Line Specification and Implementation Guide V1.02” mentioned above):

The MODBUS application protocol [1] defines a simple **P**rotocol **D**ata **U**nit (**PDU**) independent of the underlying communication layers:




MODBUS Protocol Data Unit

The mapping of MODBUS protocol on a specific bus or network introduces some additional fields on the **P**rotocol **D**ata **U**nit. The client that initiates a MODBUS transaction builds the MODBUS PDU, and then adds fields in order to build the appropriate communication PDU.




MODBUS frame over Serial Line

## 4.3 Modbus Register Map

Following Modbus register map is valid for both, the I²C and the UART interface. The measured data is saved as 32 bit floating point values (data type FLOAT) and as 16 bit signed integer values (data type INTEGER), please refer to Tab. 9 and Tab. 10 below:

| **FLOAT 32 bit** | | | |
|---|---|---|---|
| **Parameter** | **Unit** | **Register number¹⁾ [DEC]** | **Register address²⁾ [HEX]** |
| ***Read register: function code 0x03*** | | | |
| Temperature T | ° C | 1003 | 0x3EA |
| Temperature T | ° F | 1005 | 0x3EC |
| Temperature T | K | 1009 | 0x3F0 |
| $CO_2$ (average) | ppm | 1061 | 0x424 |
| $CO_2$ (raw) | ppm | 1063 | 0x426 |
| Pressure p | mbar | 1201 | 0x4B0 |
| Pressure p | psi | 1203 | 0x4B2 |

1) Register number starts from 1
2) Register address starts from 0

*Tab. 9 I²C and UART Modbus register map for 32 bit floating point values*

| INTEGER 16 bit | | | | |
|---|---|---|---|---|
| **Parameter** | **Unit** | **Scale[3]** | **Register number[1] [DEC]** | **Register address[2] [HEX]** |
| ***Read register: function code 0x03*** | | | | |
| Temperature T** | ° C | 100 | 4002 | 0xFA1 |
| Temperature T** | ° F | 50 | 4003 | 0xFA2 |
| Temperature T** | K | 50 | 4005 | 0xFA4 |
| $CO_2$ (average) | ppm | 1 | 4031 | 0xFBE |
| $CO_2$ (raw) | ppm | 1 | 4032 | 0xFBF |
| Pressure p* | mbar | 10 | 4101 | 0x1004 |
| Pressure p* | psi | 100 | 4102 | 0x1005 |

1) Register number starts from 1
2) Register address starts from 0
3) Examples: For scale 100, the reading of 2550 means a value of 25.5. For scale 50, the reading of 2550 means a value of 51.

*Tab. 10 I²C and UART Modbus register map for 16 bit signed integer values*

# 4.4 EE895 Commands

The following commands are available via Modbus over I²C and Modbus over UART.
**Please note:** I²C simplified does not support Modbus encapsulation. Therefore, no Modbus communication and no settings are possible.

## 4.4.1 Information

| Function code | Register address[1] [Hex] | Description | Note |
|---|---|---|---|
| 0x06 | 0x00 | Serial number | EE895 serial number, ASCII, 0 terminated |
| | 0x08 | FW-Version (Major, Minor) | High-Byte = Major Version<br>Low-Byte = Minor Version<br><br>Example:<br>0x011A = 1.26 [01=1; 1A=26] |
| | 0x09 | Sensor name | 2 ASCII characters for each Register (“EE895”)<br>String is 0-terminated |

1) Register address starts from 0

*Tab. 11 Available commands for I²C and UART*

**Please note:** When reading the serial number or the sensor name, it is always necessary to read all 8 registers, even if the desired information requires less.

## 4.4.2 General Settings

The following functions allow for EE895 settings. These are stored in the RAM, therefore they are volatile.

**Measuring mode:** continuous or single shot

| Function code | Register address[1] [Hex] | Note |
|---|---|---|
| 0x03 | 0x1F8 | [Bit 0] Default status = 0<br>0 = continuous. The EE895 measures at the regular interval set with the command “$CO_2$ measuring interval”, see 4.4.3.<br>1 = single shot. The EE895 measures only with the command “Measuring trigger”, see below.<br><br>[Bit 1..15]<br>reserved (must be written as 0) |

1) Register address starts from 0

*Tab. 12 Continuous or single shot measurement*

**Measuring status:** indicates when new single shot measurement is possible.

| Function code | Register address[1] [Hex] | Note |
|---|---|---|
| 0x03 | 0x1F9 | [Bit 0]: Data ready. The data are available for read out.<br>0 = busy, 1 = ready<br>[Bit 1]: Trigger ready. The EE895 is ready for new measurement cycle. The minimum time interval between two triggers is 10 s.<br>0 = trigger not possible<br>1 = ready for new trigger<br>[Bit 2..15]<br>reserved (do not use) |

1) Register address starts from 0

*Tab. 13 Single shot measurement possible*

**Measuring trigger:** command for the single shot measurement. For accurate measurement results, there are recommended six single shot measurements under stable temperature conditions.

| Function code | Register address[1] [Hex] | Note |
|---|---|---|
| 0x06 | 0x1FA | [Bit 0]: Measurement Trigger<br>0 = don't care<br>1 = Start new measurement cycle<br>[Bit 1..15]<br>reserved (must be written as 0) |

1) Register address starts from 0

*Tab. 14 Command single shot measurement*

### EE895 detailed status

| Function code | Register address[1] [Hex] | Note |
|---|---|---|
| 0x06 | 0x258 | [Bit 0]: $CO_2$ measurement too high<br>[Bit 1]: $CO_2$ measurement too low<br>[Bit 2]: T measurement too high<br>[Bit 3]: T measurement too low<br>[Bit 6]: p measurement too high<br>[Bit 7]: p measurement too low<br>[Bit 8…15]: reserved (do not use) |

1) Register address starts from 0

*Tab. 15 Status details*

## 4.4.3 $CO_2$ Parameter Settings

The $CO_2$ parameter settings are non-volatile since they are stored in the flash memory.

| Function code | Register address[1] [Hex] | Description | Note |
|---|---|---|---|
| 0x06 | 0x1450 | $CO_2$ measuring interval s | 16 bit integer unsigned<br>Scale 1:10. Example: 150 = 15 seconds<br>Range 100…36000<br>Default 15 s |
| | 0x1451 | $CO_2$ filter coefficient*) | 16 bit integer unsigned<br>Range 1…20<br>Default: 4 |
| | 0x1452 | $CO_2$ customer offset ppm | 16 bit integer signed<br>Range -32786…32785<br>Default: 0 ppm |

1) Register address starts from 0

*Tab. 16 $CO_2$ parameter settings*

*) The EE895 features an exponential moving average filter which to a certain degree suppresses the influence of short-term $CO_2$ variations onto the output $CO_2$ data. The filter coefficient is user selectable and affects the response time of the EE895. A higher filter coefficient leads to smoother output data and to longer response time, see figure 12. Figure 13 shows the number of samples required to reach 63% or 90% of a $CO_2$ step as function of the filter coefficient.

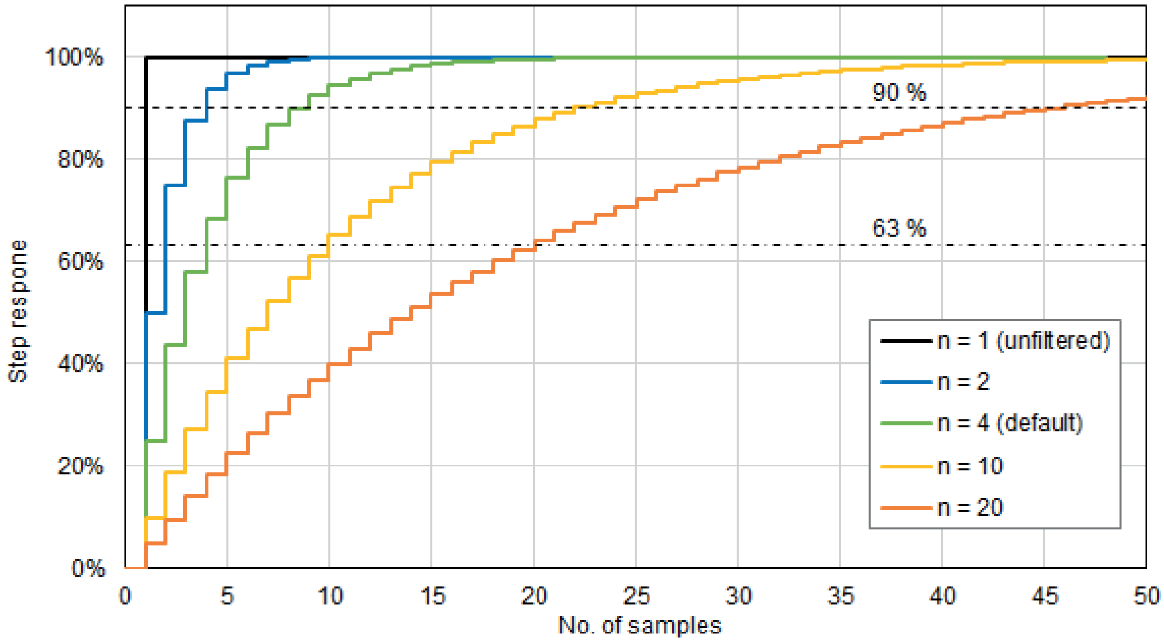



*Fig. 13 Step response vs. samples*

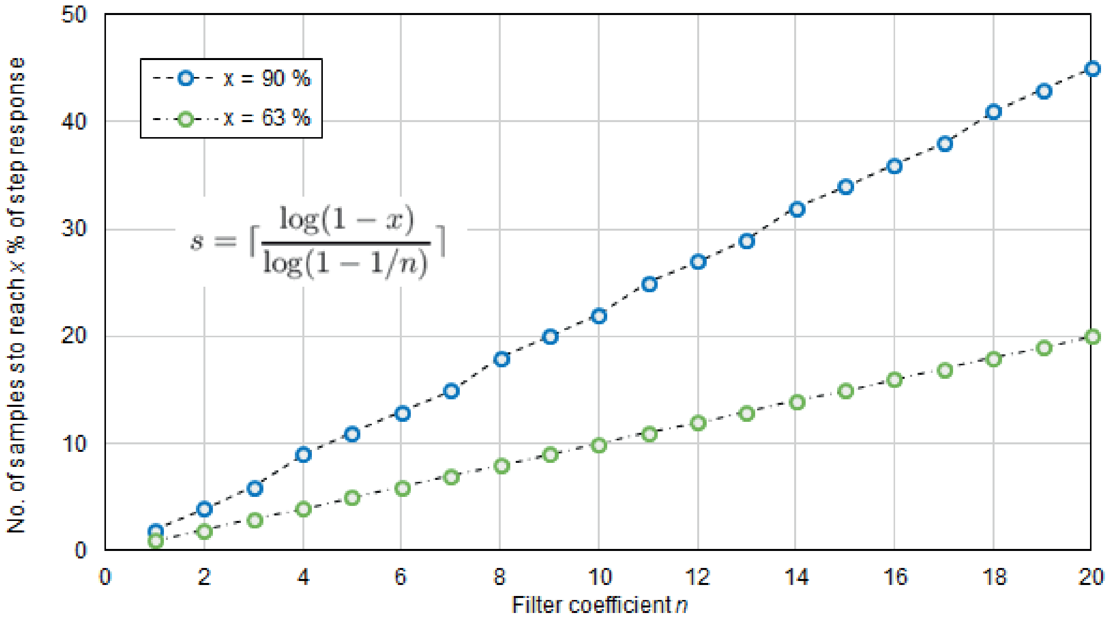



*Fig. 14 Step response vs. filter coefficient*

# APPENDIX 1 : APPLICATION NOTE AN0103

# 1 Supported Function Codes

Following function codes are supported:
- 0x01 Read Coil Register
- 0x03 Read Holding Registers
- 0x04 Read Input Registers
- 0x05 Write Coil Register
- 0x06 Write Single Register
- 0x10 Write Multiple Registers

The measured values can be read by using 0x03 and 0x04 codes. The register numbers and the corresponding physical quantities are listed in the datasheet and in the user manual of the specific E+E device.

# 2 Packet Format for Read Coil Code 0x01

**Request:**

| Modbus Address | Function Code | Communication Address | | Qunatity of Coils | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 01 | YY | YY | YY | YY | CC | CC |

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Byte Count | N * Coil Status | | CRC | |
|---|---|---|---|---|---|---|
| | | | HB | LB | LB | HB |
| YY | 01 | YY | YY | YY | CC | CC |

## 2.1 Example: Reading Status

This example demonstrates reading the device status from a desired address. The supported addresses can be found in the datasheet and in the user manual of the specific E+E device.

**Request:**

| Modbus Address | Function Code | Communication Address | | Qunatity of Registers | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 01 | 00 | XX | 00 | 08 | CC | CC |

Quantity of Coils = 8…1 Byte (8Bit)

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Byte Count | Coils Status | CRC | |
|---|---|---|---|---|---|
| | | | | LB | HB |
| YY | 01 | 01 | YY | CC | CC |

# 3 Packet Format for Read Function Codes 0x03 and 0x04

**Request:**

| Modbus Address | Function Code | Communication Address | | Qunatity of Registers | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 03, 04 | YY | YY | YY | YY | CC | CC |

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Byte Count | N * Register | | CRC | |
|---|---|---|---|---|---|---|
| | | | HB | LB | LB | HB |
| YY | 03, 04 | YY | YY | YY | CC | CC |

## 3.1 Example: Reading Temperature

This example demonstrates reading the temperature (float value) from address 0x3A. A float value consists of 4 Bytes.

**Request:**

| Modbus Address | Function Code | Communication Address | | Qunatity of Registers | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 03 | 00 | 3A | 00 | 02 | CC | CC |

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Byte Count | 2 Registers (4 Byte) | | | | CRC | |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | LB | HB |
| YY | 03 | 04 | YY | YY | YY | YY | CC | CC |

# 4 Packet Format for Write Coil Code 0x05

**Request:**

| Modbus Address | Function Code | Communication Address | | Register Value | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 05 | YY | YY | YY | YY | CC | CC |

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Communication Address | | Register Value | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 05 | YY | YY | YY | YY | CC | CC |

The supported addresses can be found in the datasheet and in the user manual of the specific E+E device.

# 5 Packet Format For Write Function Code 0x06

**Request:**

| Modbus Address | Function Code | Communication Address | | Register Value | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 06 | YY | YY | YY | YY | CC | CC |

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Communication Address | | Register Value | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 06 | YY | YY | YY | YY | CC | CC |

# 6 Packet Format for Write Multiple Function Code 0x10

**Request:**

| Modbus Address | Function Code | Communication Address | | Qunatity of Registers | | Byte Count | N * Register Values | | CRC | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | | HB | LB | LB | HB |
| YY | 10 | YY | YY | YY | YY | YY | YY | YY | CC | CC |

**Response from the E+E Modbus device:**

| Modbus Address | Function Code | Communication Address | | Quantity of Registers | | CRC | |
|---|---|---|---|---|---|---|---|
| | | HB | LB | HB | LB | LB | HB |
| YY | 10 | YY | YY | YY | YY | CC | CC |

The supported addresses can be found in the datasheet and in the user manual of the specific E+E device.

# 7 Data Encoding of Float Values

The Modbus standard allows for flexible word order, values larger than 16 bits, such as floating point values (32 Bit).

## 7.1 IEEE 754 Format

The IEEE standard definition of floating point values:

| SEEEEEEE | EMMMMMMM | MMMMMMMM | MMMMMMMM |
|---|---|---|---|
| Byte 1 | Byte 2 | Byte 3 | Byte 4 |

S ... Sign
E ... Exponent
M ... 23 Bit Mantissa

## 7.2 Modbus Floating Point Format

E+E devices use the Modbus floating point format. The byte pairs 1, 2 and 3, 4 are inverted as follows.

| SEEEEEEE | EMMMMMMM | MMMMMMMM | MMMMMMMM |
|---|---|---|---|
| Byte 3 | Byte 4 | Byte 1 | Byte 2 |

# APPENDIX 2: TECHNICAL DATA

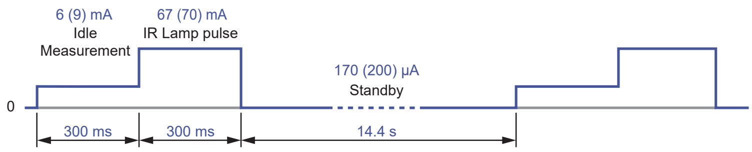
## Measurands

| | |
|---|---|
| **CO2** | |
| Measurement principle | Dual wavelength NDIR (non-dispersive infrared technology) |
| Working range | 0...2000 / 5000 / 10000 ppm |
| Accuracy at 25 °C and 1013 mbar[1)]<br>(77 °F and 14.69 psi) | 0...2000 ppm  < ± (50 ppm +2% of the measured value)<br>0...5000 ppm  < ± (50 ppm +3% of the measured value)<br>0...10000 ppm  < ± (100 ppm +5% of the measured value) |
| T and p compensation<br>of the $CO_2$ reading | with on-board sensors |
| Initialisation time (power on) | < 1s |
| Response time $t_{90}$ | 105 s with measured data averaging (smooth output)<br>60 s without measured data averaging |
| Temperature dependency, typ. | ± (1 + $CO_2$ concentration [ppm] / 1000) ppm/°C (-20...45 °C) (-4...113 °F) |
| Residual pressure dependency[2)] | 0.014 % of the measured value / mbar (ref. to 1013 mbar) |
| Calibration interval[3)] | > 5 years |
| Sampling interval | from 10 s up to 1 h, user selectable; factory setup = 15s |
| **Pressure** | |
| Working range | 700…1100 mbar (10.15...15.95 psi) |
| Accuracy at 25 °C (77 °F), typ. | ± 2 mbar (20…80 % RH) |
| Temperature dependency | ± 0.015 mbar/K |
| **Temperature** | |
| Working range | -40…60 °C (-40...140 °F) |
| Accuracy at 25 °C (77 °F), typ. | ± 0.5 °C (± 0.9 °F) |

## General

| | |
|---|---|
| **Digital interface (pin-selectable)** | |
| I²C | up to 100 kbit/s |
| UART | baud rate 9600, 8 bits, no parity, 1 stop bit |
| **Module control** | |
| Enable pin | continuous operation / power down |
| Data ready pin | indication of valid data |
| Supply voltage | 3.3...5 V DC ± 5 % |
| Average current consumption<br>@ VCC_EM + VCC_IO<br>Supply voltage 5 V<br>Values typ. (max.) | 1.6 (1.8) mA at 15 s sampling interval<br>177 (209) µA at 1h sampling interval with standby between measurements<br>7 (11) µA at 1h sampling interval with power down between measurements |
| Peak current (300 ms)<br>@ VCC_EM | 61 mA at 5 V supply<br>94 mA at 3.3 V supply |

Current profile $CO_2$ measurement
@ VCC_EM + VCC_IO
for 15 s sampling interval
Supply voltage 5 V
Values typ. (max.)




| | |
|---|---|
| Electrical connection | side plated contacts and solder pads |
| Working and storage conditions | -40...60 °C (-40...140 °F)<br>0...95 % RH (not condensating)<br>700...1100 mbar (10.15...15.95 psi) |

1) With data averaging for smooth output signal.
2) The pressure dependency of a device without pressure compensation: 0.14 % of measured value / mbar.
3) Recommended under normal operating conditions in building automation.

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