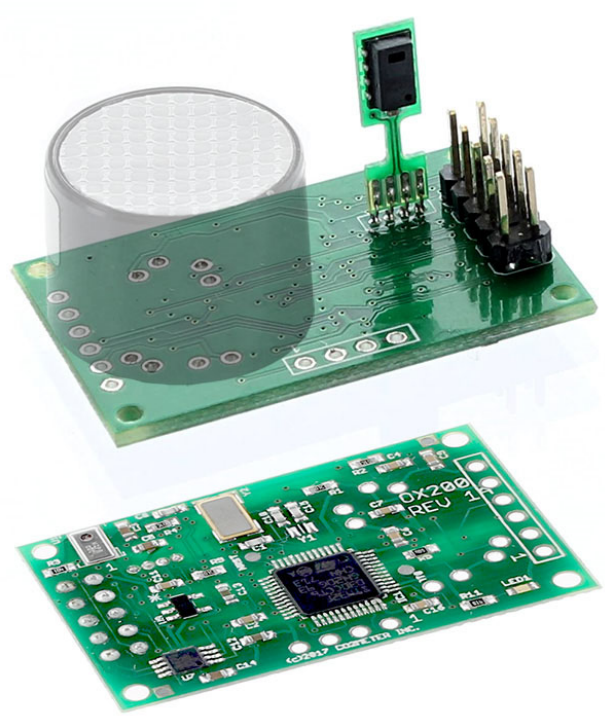
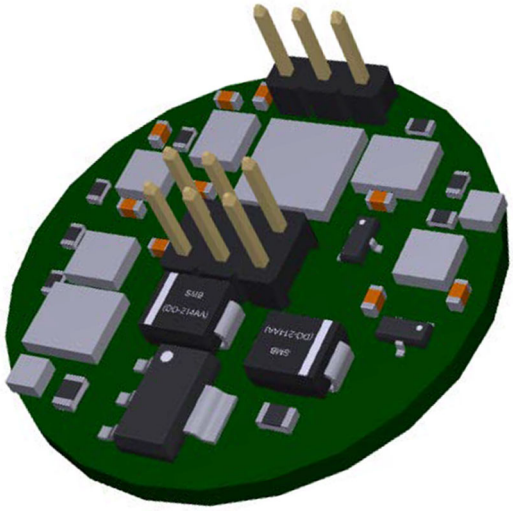
RS485 Modbus RTU Interface for MX/TX Boards

Revision F





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Document History

Date	Revision	Description
16 November 2018	A	Initial Draft
30 November 2018	A	Updated Draft
13 February 2019	B	Firmware version 4.0 Beta.
19 February 2019	C	Detail HR and IR registers.
10 June 2019	D	MX3/TX3 REV 4.4 Addition of model number reported to IR 30009. Clarification of dual use register TX, MX, location of Temp/ RH/ Barro sensors and allocation for second probe sensor for tube cap
19 June 2019	E	MX3/TX3 S/W REV. 4.4 . Documentation of addition of limiter for 4-20mA output. HR23 20mA level is limit of ADC value to drive 20mA signal.
04 December 2019	F	MX3/TX3 Rev 4.08

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Introduction

About this Manual

This document describes the implementation of the RS485 Modbus RTU protocol on sensors and controllers equipped with an RS485 Modbus RTU or an RS485 interface. It provides the information necessary to communicate with the sensors using this protocol.

RS485 Cable for EC/MX Sensor Boards

While not required to implement RS485, a custom FTDI USB - RS485 Cable with Molex connector that fits all GasLab EC and MX Smart Sensor Boards and Development Kits is available (part no. CBL-485) as an add-on part. This cable enables RS485 communication between our EC and MX Smart Sensor boards and development kits and our free GasLab software.

An RS485 cable is included with all TX sensor development kits.

Chapter 1 : Overview

This document is intended to serve as a technical reference for the RS485 Modbus or the RS485 Modbus RTU protocols as implemented on controllers including the MX, EC and TX sensor boards and development kits. It is intended to be used in conjunction with the Modbus references listed below.

Scope

This document describes the general implementation for all MX, EC and TX sensor boards. The Modbus register assignments are described herein. Register assignments for other devices are also provided in the documentation for specific devices.

References

The following documents are referenced:

- Modicon Modbus Protocol Reference Guide PI-MBUS-300 Rev. J
- ANSI/TIA/EIA-485-A-1998

Chapter 2 : Communications Interface

General

The devices implement the RTU variant of the Modbus protocol. Modbus RTU is a packet-oriented protocol where a master device can communicate with multiple slave devices over a multi-drop line.

Physical Layer

The physical layer is a two-wire differential interface that conforms to EIA Standard RS485. This interface can operate at high speed over a single twisted pair. A common ground reference is required at each device. For cable lengths greater than about 6 feet, terminating resistors may be required at both ends of the cable.

The implementation defaults to 9600 baud, No Parity and 1 Stop Bit and is always 8 bits. The parity and stop bits can be changed in the configuration. When initially powered up, the controller will always listen with the default configuration, i.e. 9600 baud, No Parity, and 1 Stop Bit for 5 seconds. If a valid Modbus PDU is received, the controller will remain in the default configuration. If no PDU is received, the controller will switch to the programmed configuration. This is intended to ensure that the device can always be reconfigured when necessary.

Framing

Modbus RTU frames are bounded by marking intervals during which no characters are send. A frame begins with a transmitted character and ends 2.5-character times following the last transmitted character. At the end of the frame, a two-byte CRC value is checked and if not valid the frame is silently discarded. Note that there is never a response from the sensor unless a message with a valid CRC and Valid Address is received.

Device Address

Modbus uses a single byte to address slave devices. Address 0 is the broadcast address which permits a command to be set to all devices (to which no devices response).

Addresses 1 to 247 may be assigned to unique devices.

Address 254 is recognized as an any device address. This is an illegal address in the Modbus protocol and should never be used in an operational network. This device address is intended solely for configuration and test purposes where there is only a single device connected to the Modbus master.

Address 248 to 253, and 255 are always ignored.

The devices normally default to address 21 (0x15).

Registers

The Modbus RTU specifications define several types of registers including single bit registers ('coils' and 'discrete inputs') and 16-bit registers ('Input Registers' and 'Holding Registers').

All of these are numbered with a 16-bit value. Coils are number 01– 9999, Discrete Inputs are numbered 10001-19999, Input Registers are numbered from 30001 – 39999, and Holding Registers are numbered 40001 – 49999.

It is important to note the reference register numbers translate to 'addresses' in the Modbus message packets. These addresses are zero based. Register numbers 1 – 9999 translate to address 0 to 9998. Similarly, register numbers 30001 – 39999 translate to addresses 0 to 9998. The leading digit of the 5 digits in the register number is never used in the address and is implicit in the function code. For example, the read of an Input register always implies registers numbered 3XXXX.

Coils and Discrete inputs are not implemented.

Functions

Modbus Functions are used to read and write registers. The following functions are implemented.

- *Function3 (0x04) Read Input Registers*
- *Function 4 (0x03) Read Holding Registers*
- *Function 6 (0x06) Write Single Hold Register*
- *Function16 (0x10) Write Multiple hold Registers*

Device Commands

Holding Register 40032 (Address 0x1f) is used to initiate commands to the device for performing such functions as calibration and writing Holding Registers to FLASH. Holding Register 40031 (Address 0x1e) contains a parameter for those commands that require one.

Modbus function code 16 (0x10), Write Multiple Holding Registers, allows the parameter and command to be sent in a single PDU.

A command can only be sent to the device when it is not Busy. The Busy indication is provided as the most significant bit in the Status Register (Input Register 30001 at address 0).

If a command is not valid for a device, one of the Command Error bits will be set in the Status Register. Error bits are valid after the status returns to not busy.

Note that some commands will execute immediately. In this case, by the time the host requests status the status will return non-busy the current error status. The error status is always valid for the last command when the device status indicates not busy.

Device Command 1 (0x0001) Error Reset
This command resets all error bits in the status word. Note that certain hardware errors may cause bits to be set again.

Device Command 2 (0x0002) Factory Use
This command is reserved for factory use.

Device Command 16 (0x0010) Save Holding Registers to Flash
This command saves the holding registers to Flash.

Device Command 17 (0x0011) Restore Factory Presets
This command will restore the factory presets to the holding registers. There are 7 groups of presets numbered 0 to 6. The command parameter indicates which group should be restored. Note that the retrieved values are not automatically saved to flash. To save the registers to flash, a separate Device Command 16 is required.

Device Command 32 (0x0020) Zero Calibration
This command set the zero value for the sensor. The sensor should be shown 100% nitrogen for approximately 1 minute prior to issuing this command.

Device Command 33 (0x0021) Calibrate to Span
This command calibrates the sensor based on the known concentration provided as the command parameter. This should be expressed in 10's of ppm. For example, for 20.9% the value should be 20900. Hold register are automatically saved upon execution.

Device Command 34 (0x0022) Calibrate to 400 PPM CO2
Calibrate CO2 sensor to 400 PPM GSS "G" Command.

Device Command 40 (0x0028) Suspend internal streaming GSS sensors only
Suspend streaming prior to calibrate CO2 sensor

Device Command 41 (0x0029) resume internal streaming GSS sensors only
Resume or start streaming operation after calibration.

Device Command 9985 (0x2701) Factory Use
This command is reserved for factory use.

Input Registers

There are 32 16-bit input registers. These registers are maintained by the controller during operation and can be read at any time. The “int” type is a signed quantity. The “uint” type is unsigned. The float type is an IEEE764 formatted number. The lower numbered register contains the 16 bit word with the exponent and upper bits of the significant. The higher numbered register contains the remaining bits of the significant.

The status bits are described separately in a following section.

Table 2-1 Input Registers (Read Only)

Reg	Addr	Type	Description
IR30001	0	int	Busy/Error Status (see below)
IR30002	1	int	Reserved
IR30003	2	int	O2 Concentration in 10’s of ppm CO2 filter concentration unscaled.
IR30004	3	int	O2 Partial Pressure in millibars. CO2 Raw unfiltered unscaled
IR30005	4	int	O2 sensor Temperature in 10ths degree C. CO2 Sensor T w/ local RHT (SHT) Temp. 10ths degree C; if no reports 1000
IR30006	5	int	O2 sensor Pressure in millibars from UVO2 sensor CO2 sensor RH w/ local RHT (SHT); if no reports 0
IR30007	6	uint	Error Status received from Sensor
IR30008	7	uint	Manufacturer ID Code35462 = CO2 meter
IR30009	8	uint	Model Number 1=TX 2=MX2 3=MX3 4=EC3
IR30010	9	uint	Software Build High-revision Low-build
IR30011	10	uint	Controller Serial Number
IR30012	11	uint	TX Received PDU Count
IR30013	12	uint	TX Received PDU Errors
IR30014	13	uint	TX Transmit PDU Count
IR30015	14	uint	TX Count of Received Measurements from Sensor
IR30016	15	int	O2% Raw as received from Sensor. CO2 NA
IR30017-18	16-17	float	O2 % Floating Point. CO2% Filtered
IR30019-20	18-19	float	O2 Floating Point Partial Pressure. CO2 unfiltered
IR30021-21	20-21	float	O2 Floating Point Temperature. CO2 Temperature
IR30023-24	22-23	float	O2 Floating Point Pressure. CO2 Relative humidity%
IR30025	24	uint	BME1 Temp, onboard
IR30026	25	uint	BME1 RH
IR30027	26	uint	BME1 Barro

Reg	Addr	Type	Description
IR30028	27	uint	BME2 Temp , Tube cap
IR30029	28	uint	BME2 RH, tube cap
IR30030	29	uint	BME2 Barro, Tube Cap
IR30031	30	uint	Reserved
IR30032	31	uint	TX Current DAC value to current loop (0 – 4095)

Holding Registers

There are 32 Holding Registers. The Holding Registers are read/write. They are initially loaded from non-volatile memory at power up. They may then be altered by the host.

Table 2-2 Holding Registers (Read/Write)

Reg	Addr	Default	Description
HR40001	0	N/A	Checksum Value for FLASH Storage
HR40002	1	0	EC Output Mode Mask
HR40003	2	0	EC log mask Reserved
HR40004	3	0	EC Analog configuration Reserved
HR40005	4	5	MX EC "!" protocol Address default 5 Reserved
HR40006	5	0	EC log interval, MX stream interval 0=no log, No stream
HR40007	6	1	Gas Type 1=CO2 2=O2
HR40008	7	0	Zero Value, reported in zero calibration
HR40009	8	0	TX O2 K Value of calibration CONFIRM
HR40010	9	0	EX/ MX Calibration Concentration, Confirm written on calibration X
HR40011	10	0	EC / MX Full scale PWM Range
HR40012	11	0	EC 0-3V/ MX 0-3V/ TX 4-20 mA Full Scale Analog 25000 25% O2, 10000 100% CO2
HR40013	12	10	Multiplier to get to PPM
HR40014	13	0	EC Feature Configuration- Reserved BIT 0 TempCo 1=Disabled Bit 1 Pressure comp 0=Disabled Bit 2 Tube Cap AUX BME read only 1+present, set at power up
HR40015	14	5865	MX PWM time base =1 second
HR40016	15	21	MX/TX Modbus Address 1-247. 254 setup and discovery
HR40017	16	0	Comm Configuration (Stop bits and Parity)
HR40018	17	8	Baud Rate (Multiple of 1200)
HR40019	18	0	Reserved
HR40020	19	0	TX only Loop Test (when non-zero) 4-20 mA
HR40021	20	0	TX only Current Loop Scale Factor
HR40022	21	550	TX only Current Loop 4ma Level
HR40023	22	4720	TX only Current Loop 20ma Level and Limiter

Reg	Addr	Default	Description
HR40024	23	0	Reserved ADC EC-MX AIN 1
HR40025	24	0	Reserved ADC EC-MX AIN 2
HR40026	25	0	Reserved ADC EC-MX EC Sensor signal
HR40027	26	0	Reserved
HR40028	27	0	Reserved
HR40029	28	0	Reserved
HR40030	29	0	Reserved
HR40031	30	0	MX/TX MODBUS Command Parameter
HR40032	31	0	MX/TX MODBUS Command

Status Register (IR 30001) Bit Assignments

The Status Register indicates the current error status of the device. A 1 bit in the bit position indicates the presence of the error or condition. The bit assignments are as follows:

Bit 15 (MSB) Busy.
Bits 4-14 Reserved.
Bit 3 Command Failure.
Bit 2 Flash Error.
Bit 1 Invalid Command.
Bit 0 (LSB) Power Fail. (Set at Power Up)

All bits can be cleared by executing the "Error Reset" device command

Factory preset sensor parameters table

Sensor:	Label	1=CO22=O2	Zero	K factor	Cal Val	Range	4-20	scaler
Type 0:	Luminox 25%	2	0	32768	20900	25000	25000	10
Type 1:	Luminox 50%	2	0	32768	20900	50000	50000	10
Type 2:	GSS 1-2%	1	0	32768	10000	10000	1000	1
Type 3:	GSS 5%	1	0	32768	5000	5000	5000	10
Type 4:	GSS 20%	1	0	32768	10000	20000	20000	10
Type 5:	GSS 60%	1	0	32768	10000	60000	60000	10
Type 6:	GSS 100%	1	0	32768	10000	10000	10000	100