

## IS4310: I2C Modbus RTU Slave Stack

### 500 Holding Registers

#### Main Advantages

- Eliminates engineering time and costs for protocol implementation and testing.
- Simple and easy to use solution.
- Reduces product time-to-market (TTM).
- Reduces microcontroller CPU load.
- Reduces impact on microcontroller peripherals (no need for timers or UARTs).
- Saves microcontroller pins with a shared I2C.
- Features a small, easy-to-solder SO8N package.
- Provides a low-cost solution.
- Makes the Modbus protocol transparent.
- I2C Speeds: 100kHz, 400kHz, and 1MHz.

#### Applications

- Modbus Sensors
- Modbus Actuators
- Custom Modbus Devices
- Communications between PCBs

#### Modbus Stack Characteristics

- 500 Holding Registers
- 4 Configuration Holding Registers:
  - Modbus Address ID
  - Baud Rate
  - Parity Bit
  - Stop Bits
- Implemented Function Codes:
  - 0x03 - Read Holding Registers
  - 0x06 - Write Single Register
  - 0x10 - Write Multiple Registers

#### General Description

The IS4310 is a chip that integrates a Modbus RTU Slave stack. It features an internal memory of 500 Holding Register. These registers can be accessed for reading and writing both by a microcontroller (via I2C) and by the Modbus Master device (such as PLC, computer, etc.).

The IS4310 features a UART port that can be connected to the desired electrical interface transceiver: RS485, RS422, RS232, etc.

The aim of the IS4310 is to save engineering time and costs associated with implementing and testing the Modbus RTU communication protocol, providing a reliable solution that reduces the time-to-market (TTM) of your product.

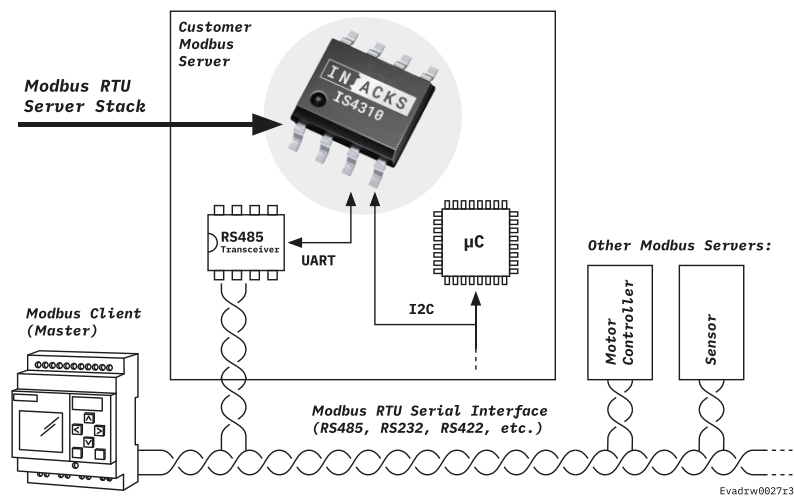
The IS4310 also brings benefits to your microcontroller: it utilizes I2C, eliminating the need for dedicated pins since I2C can be shared with other peripherals. Additionally, it eliminates the need for timers and decreases the CPU load on the microcontroller.

The device operates at 3.3V, and its I/O pins are 5V tolerant, allowing the use of either 3.3V or 5V transceivers. It is available in two temperature ranges: Industrial (-40°C to +85°C) and Extended (-40°C to +125°C).

Part Number	Package	Op. Temperature
IS4310-S8-I	SO8N	-40°C to +85°C
IS4310-S8-E	SO8N	-40°C to +125°C

SDA	1	8	SCL
VDD	2	7	I2CSPD
VSS	3	6	DIR
TX	4	5	RX

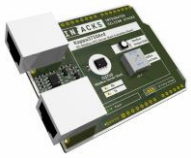



## Product Selection Guide

Part Number	Form Factor	Physical Layer	Stack	Description
-------------	-------------	----------------	-------	-------------

<b>Only Stack</b>	 <b>IS4310-S8</b>	SO8N	UART	Modbus RTU Server	Modbus RTU Slave Stack Chip.
-------------------	---	------	------	-------------------	------------------------------

<b>Stack with Physical Layer</b>	 <b>IS4310-485M2</b>	Castellated Holes Module	RS485	Modbus RTU Server	IS4310 with RS485 Transceiver. Industrial communications.
	 <b>IS4310-ISO485M6</b>	Castellated Holes Module	Isolated RS485	Modbus RTU Server	IS4310 with Isolated RS485 Transceiver. The isolation offers more robust communications and longer RS485 bus distances.
	 <b>IS4310-422M3</b>	Castellated Holes Module	RS422	Modbus RTU Server	IS4310 with RS422 Transceiver.
	 <b>IS4310-232M4</b>	Castellated Holes Module	RS232	Modbus RTU Server	IS4310 with RS232 Transceiver.

<b>Evaluation Boards</b>	 <b>Kappa4310Ard</b>	Arduino Compatible	RS485	Modbus RTU Server	IS4310 Evaluation Board with RS485 Transceiver. Compatible with Arduino.
	 <b>Kappa4310Rasp</b>	Raspberry Pi Compatible	RS485	Modbus RTU Server	IS4310 Evaluation Board with RS485 Transceiver. Compatible with Raspberry Pi.

## 1. Electrical Specifications

### Absolute Maximum Ratings

Parameter		Symbol	Min	Nom	Max	Unit
Supply Voltage		$V_{DD}$	-0.3	-	4	V
Input Voltage at any I/O pin		$V_{I/O-IN}$	-0.3	-	5.5	
Current Consumption	$T_A = 25^\circ\text{C}$	$I_{DD}$	-	3.05	3.60	mA
	$T_A = 85^\circ\text{C}$		-	3.15	3.80	
	$T_A = 125^\circ\text{C}$		-	3.35	4.16	
Temperature	Operating Temperature	$T_{OP}$	-40	-	+85	°C
	Storage Temperature	$T_{STO}$	-65	-	+150	
Electrostatic Discharge ( $T_A = 25^\circ\text{C}$ )	Human-body model (HBM)	$V_{ESD-HBM}$	-2000	-	+1500	V
	Charged-device model (CDM)	$V_{ESD-CDM}$	-500	-	+500	

Exceeding the specifications outlined in the Absolute Maximum Ratings could potentially lead to irreversible harm to the device. It's important to note that these ratings solely indicate stress limits and don't guarantee the device's functionality under such conditions, or any others not specified in the Recommended Operating Conditions. Prolonged exposure to conditions at or beyond the absolute maximum ratings might compromise the reliability of the device.

### Recommended Operation Conditions

Parameter		Symbol	Min	Nom	Max	Unit
Supply Voltage		$V_{DD}$	2.0	3.3	3.6	V
Input Voltage at any I/O pin		$V_{I/O-IN}$	-0.3	-	5.5	
Source/Sink Current at any I/O Pin		$I_{I/O-SS}$	-	-	20	mA

### Electrical Characteristics

Parameter		Symbol	Min	Nom	Max	Unit
Standby Current Consumption ( $T_A = 25^\circ\text{C}$ )		$I_{SB}$	-	-	2.8	mA
Operating Current Consumption ( $T_A = 25^\circ\text{C}$ )		$I_{OP}$	-	-	3.15	mA
Input Voltage	Logical High-Level	$V_{IH}$	$0.7 \times V_{DD}$	-	-	V
	Logical Low-Level	$V_{IL}$	-	-	$0.3 \times V_{DD}$	
Input Hysteresis		$V_{HYST}$	-	0.2	-	

### Flash Memory Cell Characteristics

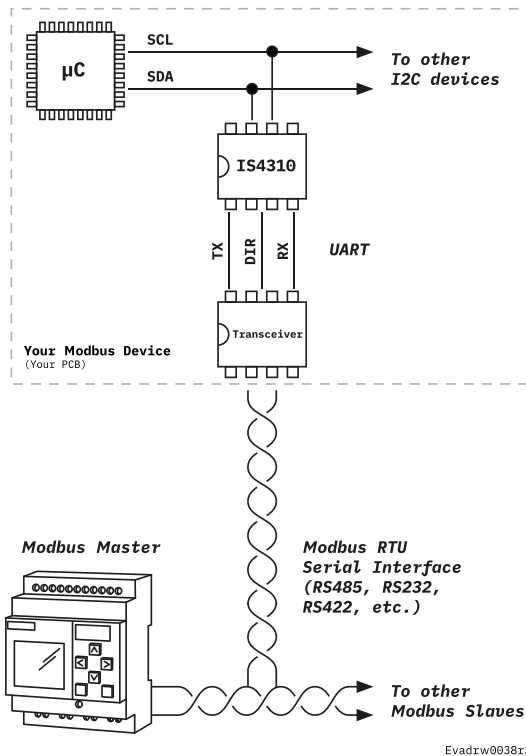
This memory stores the configuration of the Modbus communications: Slave ID (MBADR), Baud Rate (MBBDR), Parity (MBPAR), and Stop Bits (MBSTP).

Parameter		Min	Nom	Max	Unit
Write Cycles		10k	-	-	Cycles
Data Retention	$T_A = 85^\circ\text{C}$	30	-	-	Years
	$T_A = 105^\circ\text{C}$	15	-	-	
	$T_A = 125^\circ\text{C}$	7	-	-	
Programming time		-	-	25	ms

## 2. Detailed Description

### 2.1. IS4310 Description

The IS4310 is an integrated circuit running a Modbus RTU Slave Stack, providing an all-in-one and independent Modbus Slave solution ready for integration with a Microcontroller in customer applications.



Note: This schematic is simplified for clarity and should not be used for technical reference.

The IS4310 features two communication buses: a TTL UART for Modbus and an I2C-Serial Interface for the Microcontroller.

The Modbus-UART can connect with different types of transceivers, such as RS485, RS422, RS232, fiber

and radio, with RS485 being the most typical. The I2C-Serial Interface can connect to a Microcontroller, microprocessor, single board computer like Raspberry Pi, or development boards like Arduino.

The IC contains 504 Holding Registers (from address 0 to 503), each 16 bits long. Of these, 500 registers are available for the customer's application and utilize RAM as their memory type. Four registers are dedicated to the Modbus configuration: Modbus Address ID, Baud Rate, Parity and Stop Bits.

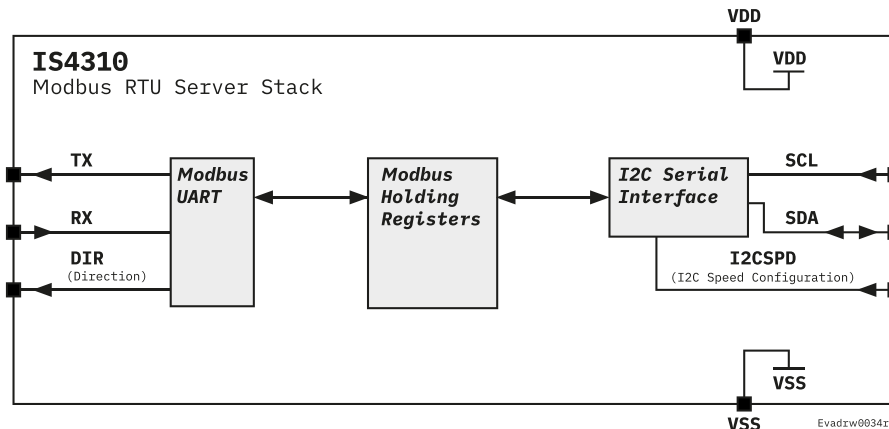
The Holding Registers is where the PLC (Modbus Master) and the Microcontroller (customer application) will exchange information.

In a motor controller application, for example, the PLC can write the desired motor speed to specific Holding Registers and read the motor's power consumption from others. These registers act as a shared memory bank where information is exchanged between the two components of the Modbus communication system: the Master and the Slave.

Essentially, the IS4310 operates as an I2C memory device integrated with the Modbus protocol, featuring a memory map that represents the Holding Registers. This map allows both the PLC and the Microcontroller to read from and write to the registers as needed.

It is available in Industrial (-40°C to +85°C) and Extended Temperature Range (-40° to +125°C).

This company and the products provided herein are developed independently and are not affiliated with, endorsed by, or associated with any official protocol or standardization entity. All trademarks, names, and references to specific protocols remain the property of their respective owners.



## 2.1.1. Function Codes

Following Function Codes are available on the IS4310 (Modbus Slave):

- 0x03 - Read Holding Registers
- 0x06 - Write Single Register
- 0x10 - Write Multiple Registers

If the PLC (Modbus Master) attempts to execute a query with a Function Code not listed above, the IS4310 (Modbus Slave) will respond with Exception Code 1.

## 2.1.2. Exception Codes

There are scenarios where the PLC can issue invalid queries to the IS4310 (Modbus Slave). In such cases, the IS4310 will respond to the PLC (Modbus Master) with one of the following Modbus Exception Codes:

### Code 1: ILLEGAL FUNCTION

The Modbus Master queried a non-valid Function Code to the IS4310 (Modbus Slave). Valid Function codes are 0x03, 0x06, 0x10.

### Code 2: ILLEGAL DATA ADDRESS

The Modbus Master attempted to read or write one or more Holding Registers higher than 503.

Alternatively, the query's starting register was valid, but the total number of registers requested exceeded 503.

### Code 3: ILLEGAL DATA VALUE

The query performed by the PLC has errors.

## 2.2. IS4310 Advantages

The use of the IS4310 brings the following benefits:

1. Eliminates engineering time and costs for protocol implementation and testing.
2. Reduces product time-to-market (TTM).
3. Increased product reliability
4. Saved microcontroller pins
5. Reduced microcontroller CPU load

The IS4310 significantly reduces engineering time by eliminating the need to manually implement and test the Modbus protocol. This time saving allows engineers to allocate resources more efficiently towards other critical aspects of product development. Additionally, this efficiency facilitates a faster time-to-market (TTM) and shortens the time to develop a minimum viable product (MVP). The streamlined development process enables companies to accelerate their product launch timelines, meeting market demands swiftly and effectively.

Using the IS4310 solution enhances customer application reliability. With the Modbus protocol already embedded and tested, there are fewer bugs and issues in the customer application, leading to a more robust and reliable product in the field. This also reduces the need for releasing firmware updates to patch undetected bugs and issues related to the Modbus communication protocol.

Additionally, using the IS4310 can reduce Microcontroller pin requirements by saving three dedicated UART pins (Rx, Tx, and direction) and utilizing a shared bus like I2C.

Furthermore, offloading the Modbus protocol processing to the IS4310 saves Microcontroller CPU load, Flash, RAM memory, and TMR resources. This efficiency enhancement allows the Microcontroller to handle other tasks more effectively, contributing to overall system performance improvements and enabling the selection of a lower-end Microcontroller.

In conclusion, the usage of IS4310 not only streamlines development, enhances reliability, and accelerates time-to-market but also optimizes Microcontroller resources, making it a comprehensive solution for efficient product development and deployment.

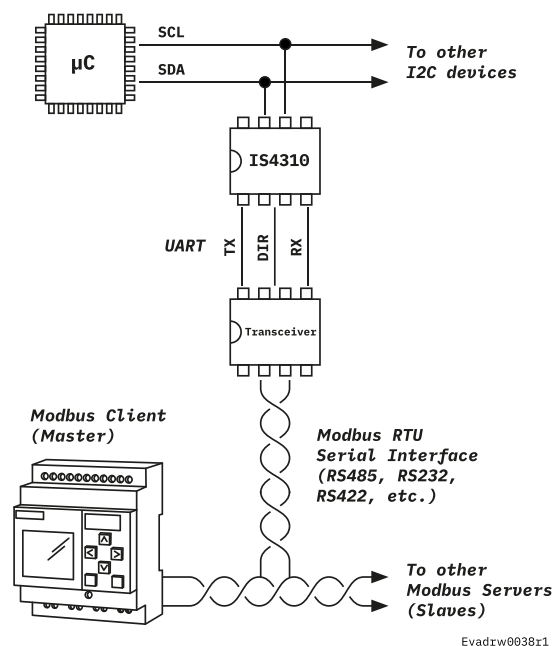
## 2.3. Modbus UART Port

The IS4310 is compatible with any Modbus RTU Serial Interface, including RS485, RS422, RS232, and others, thanks to its UART port. A transceiver matching the serial interface of the field bus (RS485, RS422, RS232, etc.) must be connected to the IS4310 UART port. This transceiver adapts the field bus voltage levels to 3.3V or 5V, ensuring proper operation with the IS4310.

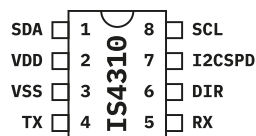
Note: Connecting field buses like RS485 or others directly to the IS4310 will not work and will permanently damage the device.

For example, if the customer application connects to an RS485 field bus, an RS485 transceiver such as the THVD1330 should be used.

Refer to chapter "Implementation Guide" for hardware design example.



### 3. Pin Description



Pin	Name	Type	Description
1	SDA	Open Drain 5V Tolerant	I2C-compatible Data pin. Open drain, it requires pull-up.
2	VDD	Supply	3.3V power supply pin. Bypass this pin to GND with a 100nF ceramic capacitor.
3	VSS	Ground	Ground reference pin.
4	TX	Digital Output Push-Pull	Modbus UART pins in TTL voltage levels. TX is the IS4310 transmit pin, RX the IS4310 receive pin.  Attention: Only digital 3.3V or 5V can be applied to this pin. Use the appropriate transceiver to connect the IS4310 with the desired bus. Do not connect field buses such as RS485, RS422, RS232 or other directly to this pin. Field buses voltages are not compatible with TTL.
5	RX	Digital Input 5V Tolerant	
6	DIR	Digital Output Push-Pull	Direction pin for the transceivers, used to control the data flow direction on the bus. This pin goes high only when the IS4310 is transmitting data. It goes low while receiving data or waiting for data.  Example: In an RS485 transceiver, the Receiver Output Enable (RE) and Driver Output Enable (DE) pins are connected to this pin.
7	I2CSPD	Analog Input 0 to 3.3V	I2C-Serial Interface Speed Selection pin. <ul style="list-style-type: none"> <li>For 100kHz pull to GND.</li> <li>For 400kHz make a voltage divider of VDD/2 (1.65V).</li> <li>For 1MHz pull to VDD (3.3V).</li> </ul> Attention: Voltage above 4V will damage the device.
8	SCL	Open Drain 5V Tolerant	I2C-compatible Clock pin. Open drain, it requires pull-up.

#### TX and RX Pins

Modbus UART Transmit and Receive Pins.

These pins handle UART transmit and receive functions for Modbus data and operate at TTL levels of 3.3V and they are 5V tolerant.

To interface with the field bus, these pins must connect to a suitable transceiver based on the field bus used: RS485, RS422, RS232, or others.

Please note that applying directly field bus (RS485, RS422, RS232, etc.) voltage levels to those pins will permanently damage the device.

For an RS485 fieldbus, use an RS485 transceiver, such as the THVD1330DR, to convert RS485 differential signaling to TTL/CMOS voltage levels. For an RS232 fieldbus, a transceiver like the MAX3221 can be used. Refer to the "Implementation" chapter for more details.

#### DIR Pin

Modbus Direction Pin.

This pin is typically used in transceivers to control the data flow (sending or receiving). For RS485 transceivers, it connects to the DE and  $\overline{RE}$  pins of the transceiver.

Modbus Over Serial Line is usually implemented on "Two-Wire" RS485 electrical interface, which operates in a half-duplex topology. Therefore, a direction pin is needed to indicate whether the transceiver should send or receive data. By default, the DIR pin is in a low state, which sets the transceiver to receive mode.

## SCL and SDA Pins

### I2C-Compatible Bus Interface Pins.

**SCL (Serial Clock Line):** This pin is used to synchronize data transfer between the IS4310 device and the Microcontroller or other CPU.

**SDA (Serial Data Line):** This bidirectional pin is used for both sending and receiving data between the IS4310 and the Microcontroller or other CPU.

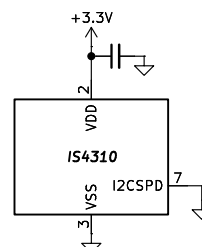
Both pins are open-drain and must be pulled up to 3.3V or 5V. The pull-up resistor value should be chosen based on the bus speed and capacitance. Typical values are 4.7kΩ for Standard Mode (100kbps) and 2.2kΩ for Fast Mode (400kbps) at both 3.3V and 5V.

## I2CSPD Pin

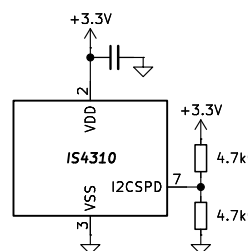
### I2C-Serial Interface Speed Selection Pin.

This pin configures the IS4310 internal I2C-Serial Interface timings and filters to properly work with the selected bus speed.

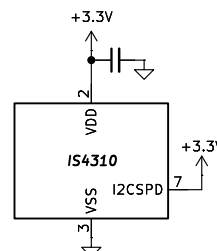
- For a **100kHz** setting, set the I2CSPD pin to VSS.



- For a **400kHz** setting, set the I2CSPD to 1.65V (VDD/2) using a balanced voltage divider. This can be achieved by placing two 4.7kΩ resistors from the I2CSPD pin: one to VDD and the other to VSS.



- For a **1000MHz** setting, set the I2CSPD pin to VDD.



### Important Remark:

A mismatch between the configured I2C speed and the actual operating I2C speed (e.g., configuring the bus for 100kHz but operating at 1MHz) can lead to an inconsistent state where some I2C messages are processed while others are not.

Ensure a proper match between the actual operating speed and the configured speed at the I2CSPD pin: If your bus works at 100kHz, ensure the I2CSPD pin is tied to VSS. If it works at 400kHz ensure the pin is at 1.65V. If it works at 1000MHz, ensure the pin is at 3.3V.

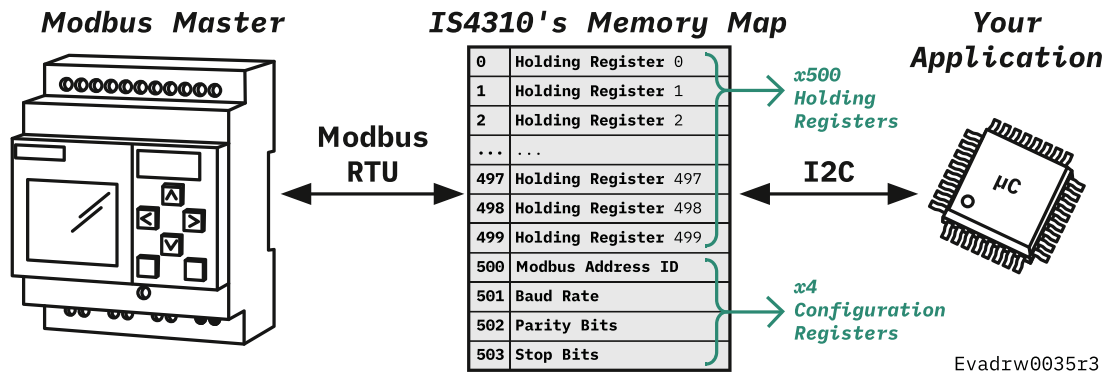


## 4. Memory Description

### 4.1. Memory Map Organization

The IS4310 is organized internally as a single page containing 504 registers, with addresses ranging from 0 to 503. These registers can be accessed individually or in blocks. Each register is 16 bits long, and there are two types: Holding Registers and

Configuration Registers. Both types are readable and writable and can be accessed by the Microcontroller via I2C or by the Modbus Master through a field bus (RS485, RS422, RS232, etc.).



#### Holding Registers

The Holding Registers consist of 500 volatile RAM registers, with addresses ranging from 0 to 499.

The Holding Registers (HOLDx) are available for your application. For example, if you are developing a gas sensor, these registers can store data such as gas concentration and the total operating hours of the sensor. The Microcontroller will continuously write to these registers, while the Modbus Master will read from them.

If you are developing an actuator, such as a relay module, these registers can store the state of the relays. In this case, the Microcontroller will continuously read from the registers, while the Modbus Master will write to them as needed.

You can also combine reading and writing operations within the same application. For example, when developing a Modbus motor controller, the Modbus Master can write the motor's speed and read its power consumption. In this case, the Microcontroller will continuously read from the registers assigned to the speed and write to the registers related to power consumption.

#### Configuration Registers

The Configuration Registers consist of four registers, with addresses ranging from 500 to 503. Any modifications to these registers are stored in the internal non-volatile memory. Upon power-up, the IS4310 retrieves the last saved configuration.

Four configuration registers are used to set the Modbus communication parameters: Modbus Address ID (MBADR), Baud Rate (MBBDR), Parity Bit (MBPAR), and Stop Bit (MBSTP).

Both the Modbus Master and the Microcontroller can write to these registers, and the changes take effect immediately.

#### Important Remark:

In a Modbus network, two slaves cannot have the same Address ID. Doing so will cause both devices to become unresponsive.

## 4.2. Memory Map Table

I2C Register Address	Modbus Register Address	Register Name	Register Description
0	0	HOLD0	Holding Register 0
1	1	HOLD1	Holding Register 1
2	2	HOLD2	Holding Register 2
3	3	HOLD3	Holding Register 3
4	4	HOLD4	Holding Register 4
5	5	HOLD5	Holding Register 5
...	...	(HOLD6 to HOLD493)	...
494	494	HOLD494	Holding Register 494
495	495	HOLD495	Holding Register 495
496	496	HOLD496	Holding Register 496
497	497	HOLD497	Holding Register 497
498	498	HOLD498	Holding Register 498
499	499	HOLD499	Holding Register 499
500	500	MBADD	Configuration Register, Slave Address Configuration
501	501	MBBDR	Configuration Register, Baud Rate Configuration
502	502	MBPAR	Configuration Register, Parity Bit Configuration
503	503	MBSTP	Configuration Register, Stop Bits Configuration

## 4.3. HOLDx Registers

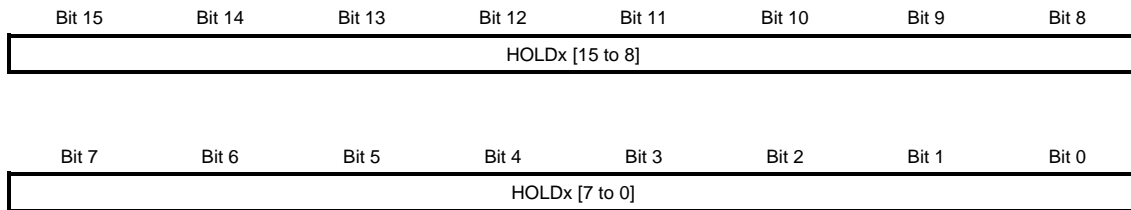
HOLDx Registers are Modbus Holding Registers available for use in your application. They can be accessed (read and written) by both the Modbus Master and the Microcontroller. The access can be individually or in block. Each register is 16 bits long and they are volatile RAM.

If your product is a sensor, these registers are typically written by the Microcontroller with sensed data, such as pressure, temperature, or humidity, and read by the Modbus Master.

If the product is an actuator, these registers are usually written by the Modbus Master with control data, such as relay states (on/off), motor speed, or solenoid valve positions, and read by the Microcontroller.

These registers can also serve as a bidirectional data exchange point, allowing both the Modbus Master and the Microcontroller to read and write data.

**Name:** HOLDx  
**Description:** Modbus Holding Registers  
**Address Range:** 0 to 499 (0x000 to 0x1F3)  
**Memory Type:** Volatile RAM  
**Allowed values:** 0 to 65535 (0x00 to 0xFFFF)  
**Reset value:** 0 (0x0000)



## 4.4. MBADR Register

This register represents the Slave Address of the device on the Modbus network. The value written to this register serves as the identifier for the Modbus device.

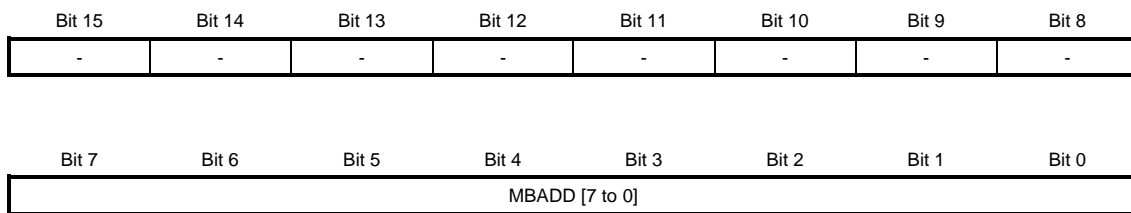
The default value is 1. Each Slave must have a unique address, as two Slaves with the same address will cause both devices to become unresponsive.

The allowed address range is from 1 to 247. Attempting to write an address outside this range will have no effect.

This register is placed at the end of the Holding Register section to minimize the risk of accidentally overwriting the Modbus configuration registers.

Any modifications to this register will be saved in the internal non-volatile memory, which supports up to 10,000 cycles. A write cycle occurs only if the written data differs from the previous value. The write process takes 25ms. Upon power-up, the IS4310 automatically retrieves the last saved configuration.

**Name:** MBADR  
**Description:** Slave Address Configuration  
**Address:** 500 (0x1F4)  
**Memory Type:** Non-Volatile RAM  
**Allowed values:** 1 to 247 (0x0000 to 0x00F7)  
**Default value:** 1 (0x0001)



## 4.5. MBBDR Register

The MBBDR register stores the Modbus Baud Rate configuration. The default value is 113, representing 19200 bps, which is the default Modbus speed.

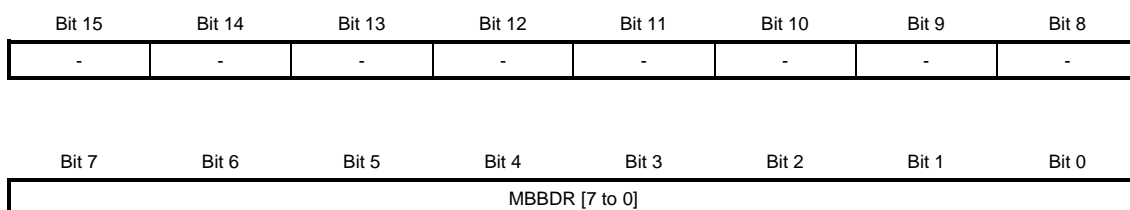
Allowed configuration values range from 110 to 115; attempting to write any other values will not have any effect.

- Value 110 sets a Modbus speed of 1200bps.
- Value 111 sets a Modbus speed of 2400bps.
- Value 112 sets a Modbus speed of 9600bps.
- Value 113 (default) sets a Modbus speed of 19200bps.
- Value 114 sets a Modbus speed of 57600bps.
- Value 115 sets a Modbus speed of 115200bps.

This register is placed at the end of the Holding Register section to minimize the risk of accidentally overwriting the Modbus configuration registers.

Any modifications to this register will be saved in the internal non-volatile memory, which supports up to 10,000 cycles. A write cycle occurs only if the written data differs from the previous value. The write process takes 25ms. Upon power-up, the IS4310 automatically retrieves the last saved configuration.

**Name:** MBADD  
**Description:** Baud Rate Configuration  
**Address:** 501 (0x1F5)  
**Memory Type:** Volatile RAM  
**Allowed values:** 110 to 115 (0x006E to 0x0073)  
**Default value:** 113 (0x0071)



## 4.6. MBPAR Register

The MBDR register stores the Modbus Parity Bit configuration. The default value is 122, representing Even Parity, which is the default Modbus Parity.

Allowed configuration values range from 110 to 115; attempting to write any other values will not have any effect.

- Value 120 represents No Parity.
- Value 121 represents Odd Parity.
- Value 122 (default) represents Even Parity.

This register is placed at the end of the Holding Register section to minimize the risk of accidentally overwriting the Modbus configuration registers.

Any modifications to this register will be saved in the internal non-volatile memory, which supports up to 10,000 cycles. A write cycle occurs only if the written data differs from the previous value. The write process takes 25ms. Upon power-up, the IS4310 automatically retrieves the last saved configuration.

**Name:** MBPAR  
**Description:** Parity Bit Configuration  
**Address:** 502 (0x1F6)  
**Memory Type:** Volatile RAM  
**Allowed values:** 120 to 122 (0x0078 to 0x007A)  
**Default value:** 122 (0x007A)

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
-	-	-	-	-	-	-	-

Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-	-	-	-	-	-	MBPAR [1 to 0]	

## 4.7. MBSTP Register

The MBBDR register contains the Modbus Parity Bit configuration. The default value is 131, representing One Stop Bit, which is the default Modbus Sop Bit.

Allowed configuration values range from 131 to 132; attempting to write any other values will not have any effect.

- Value 131 (default) One Stop bit (default).
- Value 132 Two Stop bit.

This register is placed at the end of the Holding Register section to minimize the risk of accidentally overwriting the Modbus configuration registers.

Any modifications to this register will be saved in the internal non-volatile memory, which supports up to 10,000 cycles. A write cycle occurs only if the written data differs from the previous value. The write process takes 25ms. Upon power-up, the IS4310 automatically retrieves the last saved configuration.

**Name:** MBSTP  
**Description:** Stop Bits Configuration  
**Address:** 503 (0x1F7)  
**Memory Type:** Non-Volatile RAM  
**Allowed values:** 131 and 132 (0x0083 and 0x0084)  
**Default value:** 131 (0x0083)

Bit 15	Bit 14	Bit 13	Bit 12	Bit 11	Bit 10	Bit 9	Bit 8
-	-	-	-	-	-	-	-
Bit 7	Bit 6	Bit 5	Bit 4	Bit 3	Bit 2	Bit 1	Bit 0
-	-	-	-	-	-	MBPAR [1 to 0]	

## 5. I2C-compatible Bus Description

### 5.1. Overview

The IS4310 operates as a slave in the I2C-Serial Interface. It supports Standard Mode (100kHz), Fast Mode (400kHz), and Fast Mode Plus (1MHz). The I2C-master device, typically a microcontroller or a single board computer, initiates and manages all read and write operations to the Slave.

Pull-up resistors are required on the SCL and SDA lines for proper operation. The resistor values depend on the bus capacitance and operating speed. Typical values are 10kΩ for Standard Mode (100kHz) and 2kΩ for Fast Mode and Fast Mode Plus (400kHz and 1MHz).

The IS4310's high state can be either 3.3V or 5V. A logical '0' is transmitted by pulling the line low, while a logical '1' is transmitted by releasing the line, allowing it to be pulled high by the pull-up resistor. The Master controls the Serial Clock (SCL) line, which generates the synchronous clock used by the Serial Data (SDA) line to transmit data.

A Start or Stop condition occurs when the SDA line changes during the High period of the SCL line. Data on the SDA line must be 8 bits long and is transmitted Most Significant Bit First and Most Significant Byte First. After the 8 data bits, the receiver must respond with either an acknowledge (ACK) or a no-acknowledge (NACK) bit during the ninth clock cycle, which is generated by the Master. To keep the bus in an idle state, both the SCL and SDA lines must be released to the High state.

The operability of the Read and Write commands of the IS4310 is very similar to an EEPROM memory. Thinking of the IS4310 as an EEPROM memory is a good analogy to quickly understand how to communicate with the device.

#### Summary

- I2C Device Address: 17 (0x11)
- Compatible I2C Speeds:
  - Standard Mode (100kHz)
  - Fast Mode (400kHz)
  - Fast Mode Plus (1MHz)



## 5.2. Read Operations

### 5.2.1. Single Word Read

Reading a single word is an action performed by the Microcontroller (I2C-Master) to access any register within the IS4310 memory (I2C-Slave), regardless of the last read or written position. To perform this action, the microcontroller must first load the address of the IS4310 register to be read into the IS4310's internal Pointer Register. Once the address is set, the microcontroller can retrieve the data from the specified register.

To initiate the Single Word Read operation, the microcontroller begins by pulling down the SDA while the SCL is high to create a Start Condition. It then sends the IS4310 I2C device address (0x11) with the

R/W bit set to '0' (write). Upon receiving the device address, the IS4310 acknowledges it. Subsequently, the microcontroller sends the two bytes of the Pointer Register address: the most significant byte first, followed by the less significant byte, each acknowledged by the IS4310. This sets the address of the next word to be read in the Pointer Register.

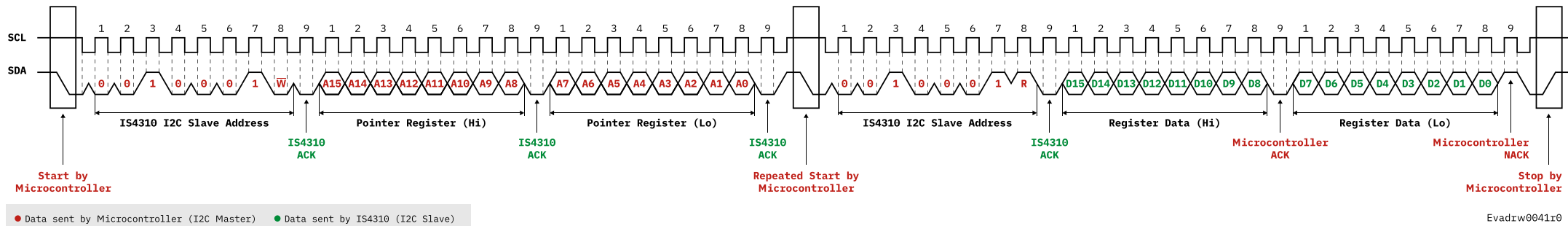
Next, the content of the Pointer Register, which is a word (two bytes), needs to be read.

The microcontroller generates a Repeated Start Condition, followed by the IS4310 I2C Slave address (0x11) with the R/W bit set to '1' (read), instructing the IS4310 to retrieve data. The IS4310

acknowledges and responds with the most significant byte, which the microcontroller acknowledges. Then, the IS4310 sends the less significant byte, which the microcontroller does not acknowledge (NACK). Finally, the microcontroller issues a Stop Condition by raising the SDA line while the SCL is high.

#### Invalid Memory Addressing

The valid memory range of the IS4310 goes from addresses 0 to 503. If a Read Operation is performed with a Pointer Register higher than 503, the read result will be 0xFFFF.



Evadriw0041r0

## 5.2.2. Multiple Word Read

Multiple Word Read functions similarly to Single Word Read but can read a block of up to 500 registers in a single operation. Remember, the registers are 16-bit words consisting of 2 bytes, so the number of registers retrieved should always be even.

To perform a Multiple Word Read, follow the same procedure as for a Single Word Read until the first data word is received. After receiving the first word, instead of generating a Not Acknowledge (NACK), the microcontroller should continue acknowledging

(ACK) each received data byte from the IS4310 for as many words as it intends to read. To conclude the read operation, after reading the last data word, the microcontroller should generate a Not Acknowledge (NACK) and a Stop Condition.

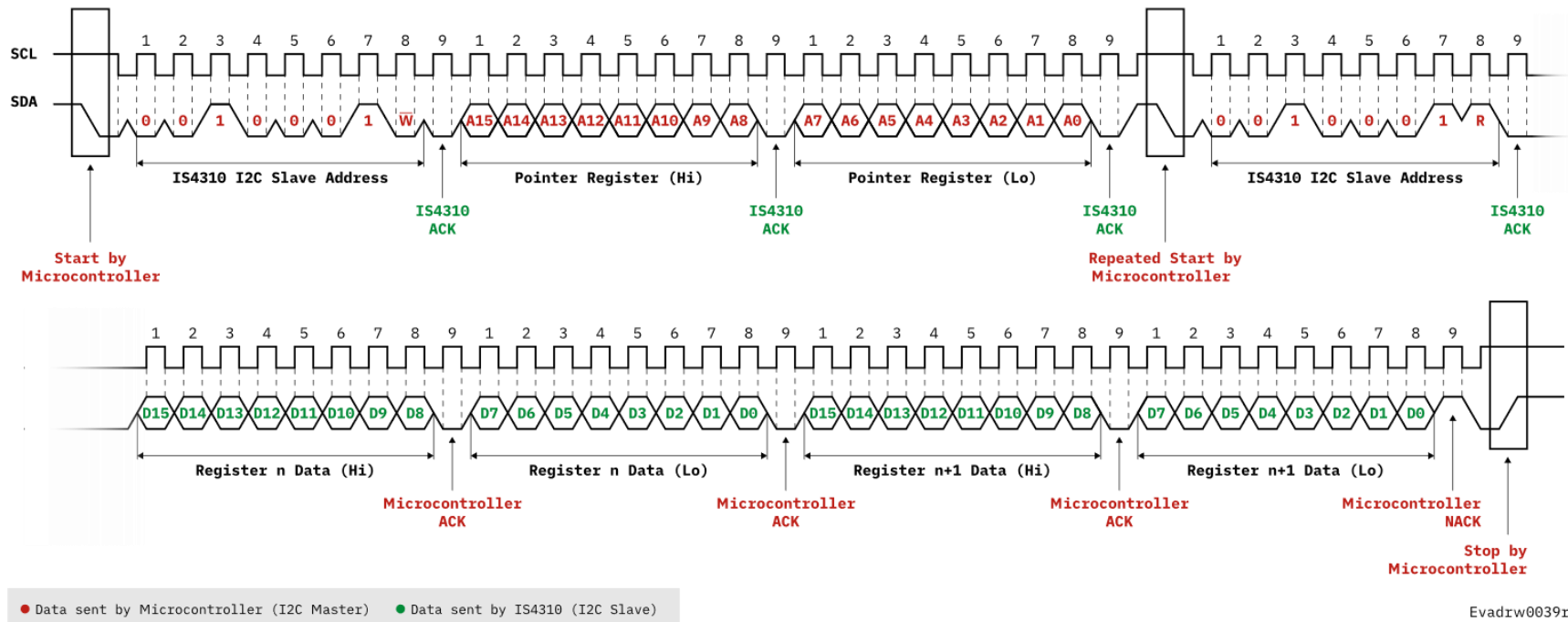
With each word read, the Pointer Register increments by one.

### Invalid Memory Addressing

The valid memory range of the IS4310 goes from addresses 0 to 503.

If the Read Operation is performed with a Pointer Register within the valid memory range (0 to 503), but the data retrieval extends beyond register 503, a rollover to position 0 will occur. For example, the value of register 504 will correspond to the content of register 0.

If a Read Operation is performed with a Pointer Register value higher than 503, the read result will be 0xFFFF.



## 5.3. Write Operations

### 5.3.1. Single Word Write

Writing a single word is an action performed by the Microcontroller (I2C-Master) to write data to any register within the IS4310 memory (I2C-Slave), regardless of the last read or written position. To perform this action, the Microcontroller must first load the address of the IS4310 register to be written into the IS4310's internal Pointer Register. Once the address is set, the Microcontroller can send the data to be stored.

To initiate the Single Word Write operation, the Microcontroller begins by pulling down the SDA line while the SCL line is high, creating a Start Condition. It then sends the IS4310 I2C device address (0x11) with the R/W bit set to '0' (write). Upon receiving the device address, the IS4310 acknowledges it.

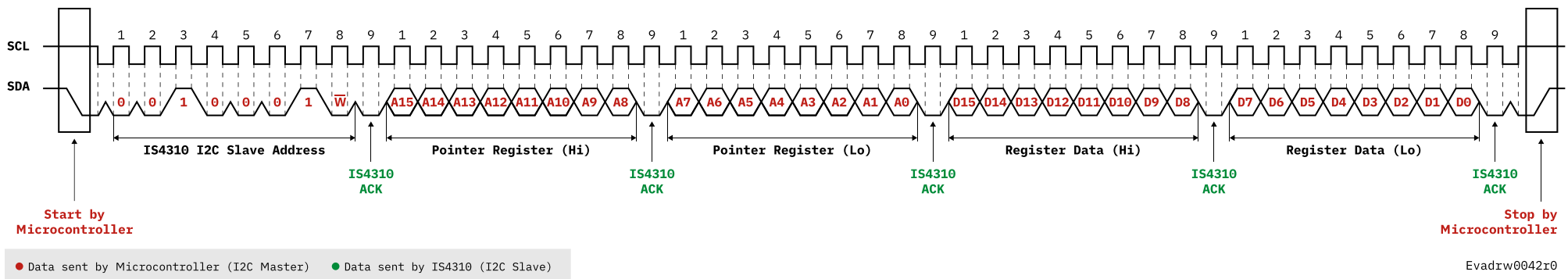
Subsequently, the Microcontroller sends the two bytes of the Pointer Register address: the most significant byte first, followed by the least significant byte, each acknowledged by the IS4310. This sets the address of the next word to be written in the Pointer Register, preparing the device to receive the data.

The Microcontroller then sends the most significant byte of the word to be written first, which the IS4310 acknowledges. The Microcontroller follows by sending the least significant byte of the word, which the IS4310 also acknowledges. Finally, the Microcontroller issues a Stop Condition by raising the SDA line while the SCL line is high.

After the Stop Condition, if any of the Modbus Configuration Registers (MBADR, MBBDR, MBPAR, MBSTP) are written with a value different from the previous one, a 25 millisecond Flash Memory write cycle will begin.

#### Invalid Memory Addressing

The valid memory range of the IS4310 goes from addresses 0 to 503. If a Write Operation is performed with a Pointer Register higher than 503, the IS4310 will answer with a NACK on the first received byte of the word.



## 5.3.2. Multiple Word Write

A Multiple Word Write performs a similar operation to a Single Word Write, but instead of writing to only one register, it can write to a block of up to 500 registers in a single operation.

To perform a Multiple Word Write, follow the same procedure as for a Single Word Write until the first data word is received. After receiving the first word, instead of generating a Stop Condition, the Microcontroller should continue sending data words. To conclude the write operation, after sending the last data word, the Microcontroller should generate a Stop Condition.

With each word written, the Pointer Register increments by one.

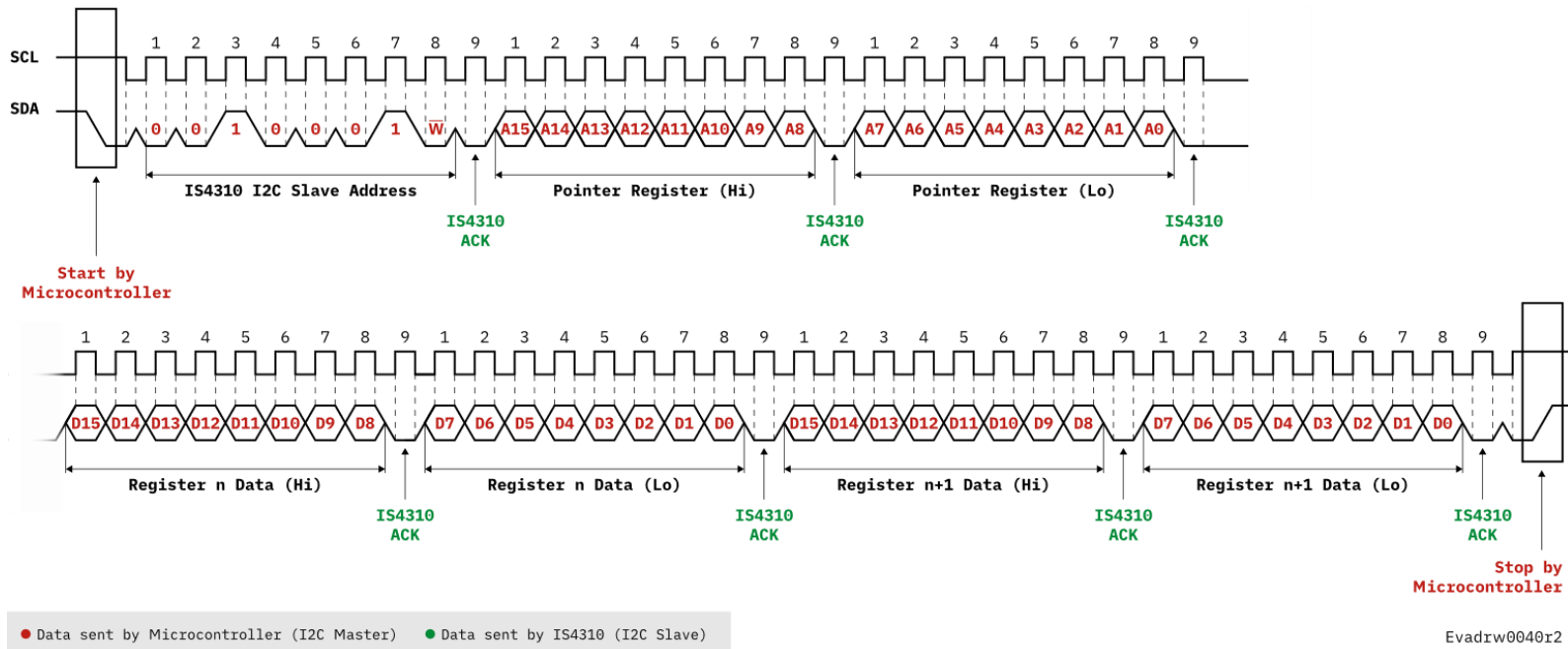
After the Stop Condition, if any of the Modbus Configuration Registers (MBADR, MBBDR, MBPAR, MBSTP) are written with a value different from the previous one, a 25 millisecond Flash Memory write cycle will begin.

### Invalid Memory Addressing

The valid memory range of the IS4310 goes from addresses 0 to 503.

If a Write Operation is performed with a Pointer Register within the valid memory range (0 to 503) but exceeds the last memory register (503), a rollover to position 0 will occur. For example, writing a value to register 504 will result in writing the value to register 0.

If a Write Operation is performed with a Pointer Register higher than 503, the IS4310 will answer with a NACK on the first received byte of the word.



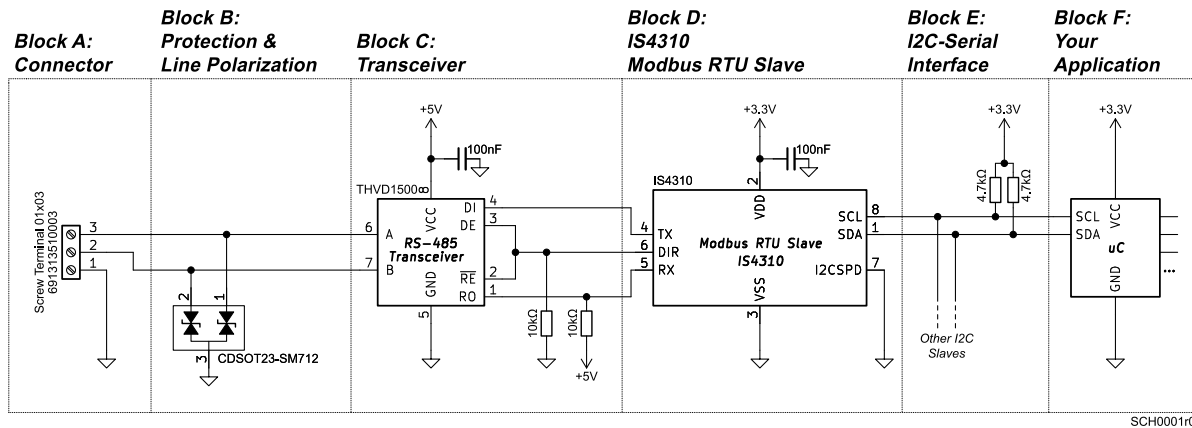
## 6. Implementation Guide

The following chapter represents an application design example for explanation proposals and is not part of the product standard. The customer must design his own solution, choose its most appropriate components and validate the final product according to the legislation and the Modbus specifications.

### 6.1. RS485 Example

This example shows the design of a Modbus over Serial Line working in RS485.

More examples can be found on the website.



#### Block A: Connector

Typical Modbus Serial Line connectors include Screw Terminals, RJ45, and D-Sub 9-pin (commonly known as DB9), among others. The device-side connector must be female, while the cable-side connector must be male.

The recommended connector is RJ45, but in the schematic, a screw terminal is used for simplicity. When selecting a connector, always choose the shielded version if available. RJ45 and DB9 connectors typically come with shielded options, while terminal blocks usually do not.

On the cable-side connector, make sure to connect the cable shield to the connector shield to ensure proper electrical continuity across all cable shields on the bus.

Do not connect the shield to the Common. All cable shields should be connected to Common and Protective Ground at a single point for the entire bus, ideally at the master device.

In the example, the connector has three positions: A, B, and Common. A and B are the differential lines for the transceiver, while Common serves as the reference point for the A and B signals. Common must be connected to the GND of your circuit.

Optionally, power can be supplied to your system through the Modbus connector. In this case, a four-position connector would be used for A, B, Common, and Power. In that case, the Common serves as the

reference for A and B signals as well as the return path for Power. The voltage should be within the 5V to 24V range.

#### Block B: Protection & Line Polarization

##### Protection

The protection stage is influenced by several factors, including the intrinsic robustness and protection features of the transceiver, the potential harshness of the fieldbus environment, the product's budget, and its required reliability, among other considerations. Refer to your transceiver's documentation to determine the appropriate protection requirements.

In the schematic, a bidirectional 400-W transient suppressor diodes are used to protect against surge transients.

##### Line Polarization

Line Polarization is the process of biasing the RS485 bus to a known state by pulling signal A down and pulling signal B to 5V using resistors in the range of 450 to 650Ω. This ensures that the bus has a defined idle state.

When there is no data activity on an RS-485 balanced pair, the lines are not actively driven and are therefore susceptible to external noise or interference. To ensure that the transceiver remains in a stable state when no data signal is present,

some transceivers require a biasing circuit. However, not all transceivers need this.

When selecting your transceiver, confirm in the datasheet whether line polarization is necessary or not. If it is necessary, you must document it in the product guide.

If polarization is needed, it should **ONLY** be implemented at one location on the bus, typically at the master device.

Bus polarization is a good technic to increase the resistance of the bus to external noise or interferences. However, it has the drawback of significantly reducing the number of devices that can support the bus.

## Block C: Transceiver

---

Modbus over Serial Line typically employs the RS485 electrical interface, which uses a transceiver to adapt RS485 fieldbus voltage levels to TTL voltage levels for the IS4310. Other electrical interfaces such as RS422 or RS232 can also be utilized.

A pull-down resistor on DE and RE will keep the transceiver in 'receiver' state by default, ensuring it does not disturb the fieldbus. Pull-up resistor on RO will keep the RX line clear.

Using a 5V transceiver is a good technic to increase the resistance of the bus to external noise or

interferences. 5V transceivers can be used with the IS4310 since TX, RX and DIR pins are 5V tolerant.

## Block D: IS4310 Modbus RTU Slave

---

The IS4310 is very simple to integrate into your design.

A decoupling capacitor should be placed on the power pins (VDD and VSS). It is recommended to use a 100nF, 10-25V low-ESR ceramic capacitor.

The I2CSPD pin defines the I2C speed. Connect this pin to GND for a speed of 100kHz. For 400kHz, it should be pulled to 1.65V, which is half of 3.3V. This can be achieved with a simple resistor voltage divider using 3.3V and GND. For 1MHz, the pin must be connected to 3.3V. This pin is not 5V tolerant.

## Block E: I2C-Serial Interface

---

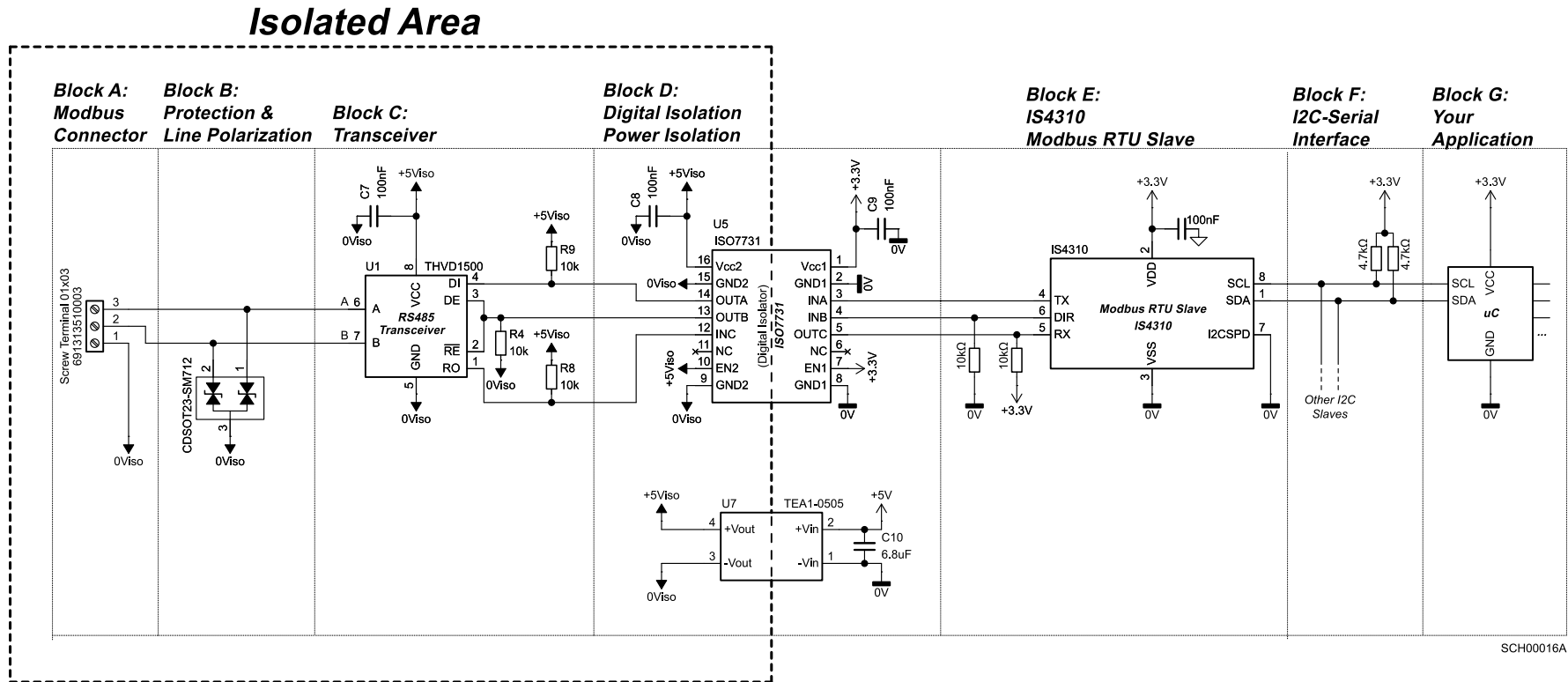
For proper operation of the I2C Serial Interface, pull-up resistors to 3.3V or 5V are necessary. Typical resistor values are 4.7k $\Omega$  for Standard Mode (100kHz) and 2.2k $\Omega$  for both Fast Mode (400kHz) and Fast Mode Plus (1MHz).

## Block F: Your Application

---

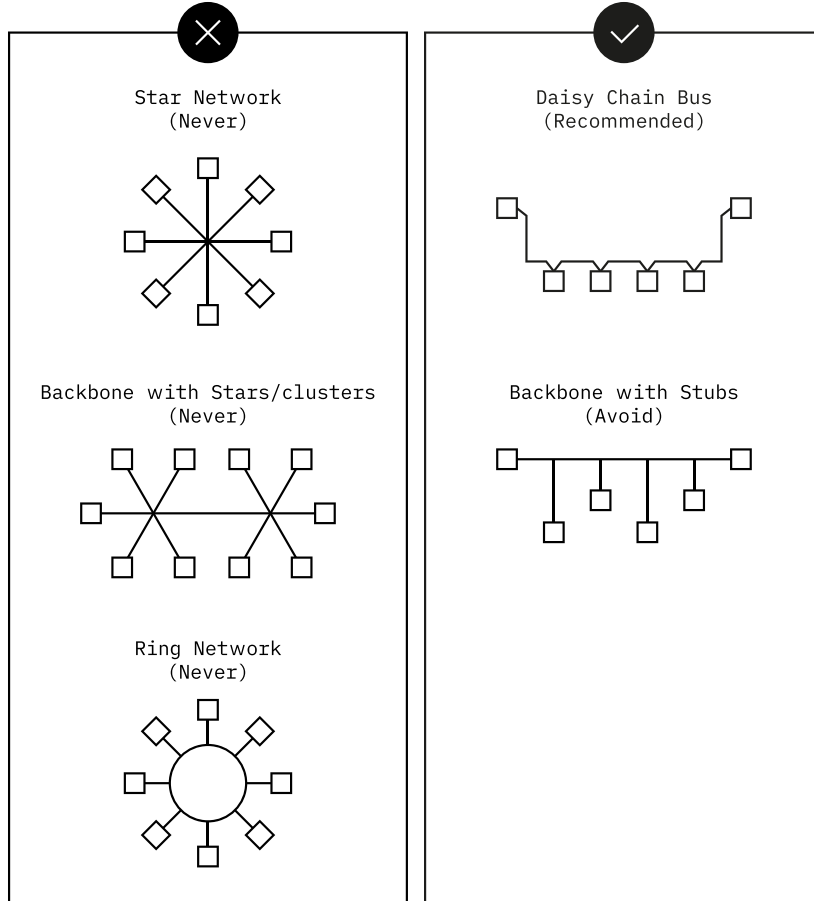
Here is the rest of your product design. Typically, a microcontroller interfaces with the IS4310, but a microprocessor or a single-board computer, such as a Raspberry Pi, can also be used as long as they are equipped with an I2C Serial Interface.

## 6.2. Isolated RS485 Example



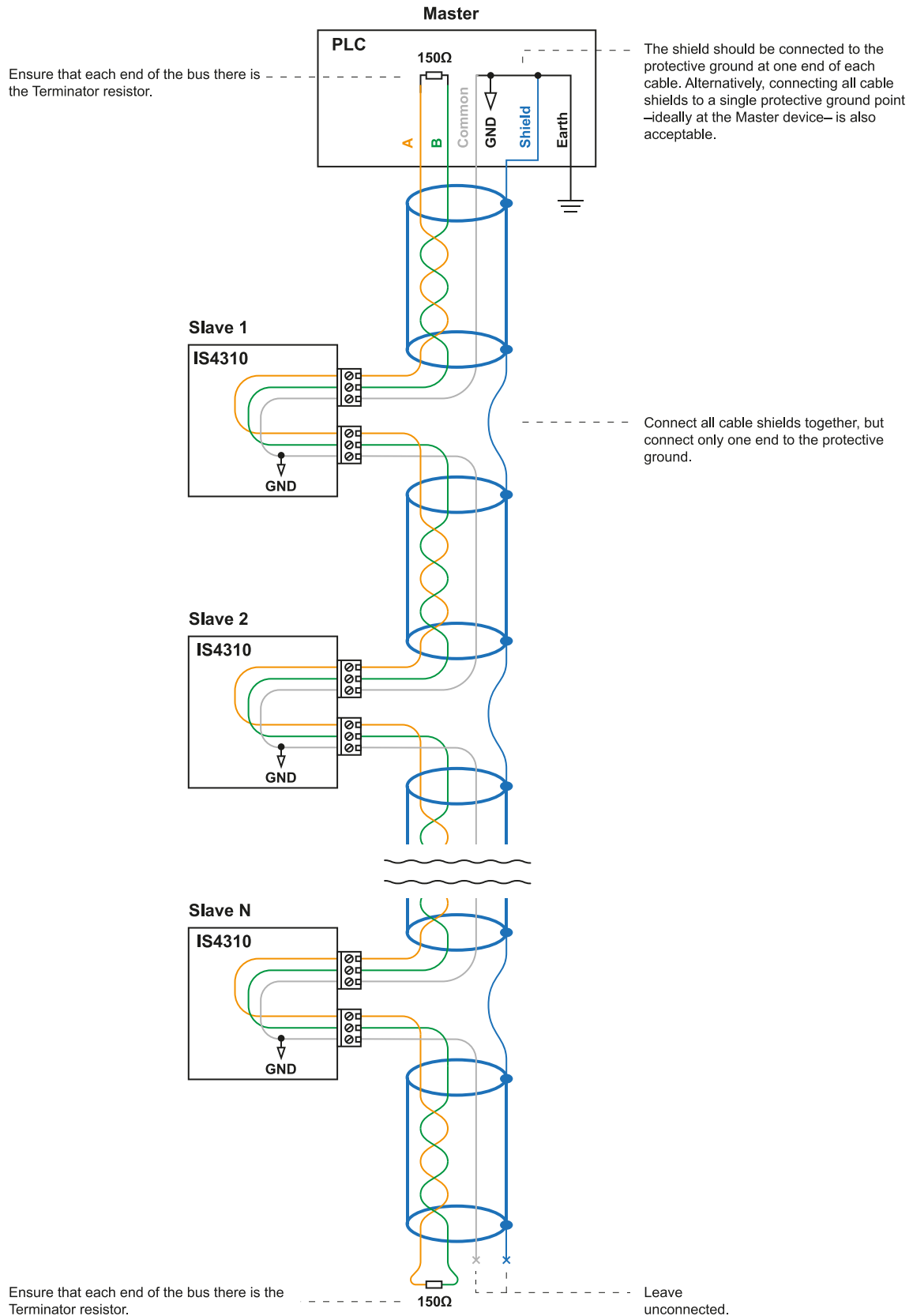
## 6.3. Bus Topology

In an RS485 setup without a repeater, a single trunk cable runs through the system, with devices connected in a daisy-chain manner. Short cables derivations (stubs) are also allowed but not recommended. Keep the derivation distance as short as possible. Other topologies are not allowed.





## 6.4. Cable Wiring



Evadnw0055r1

## 7. Mechanical

**S08N Package**

The drawing includes three views of the S08N package:

- Top View:** Shows a rectangular package with a width of 4.900 mm and a height of 6.000 mm. The distance between the top pins is 3.900 mm.
- Side View:** Shows the package height as 1.250 mm and the maximum height of the pins as 1.750 mm max. The distance between the pins is 1.270 mm.
- Lead View:** Shows the lead thickness as 0.230 mm, the lead width as 0.400 mm min, and a lead angle of 8°.

A 3D perspective view of the IS4310 chip, showing the IN ACKS logo and the part number IS4310 on the top surface.

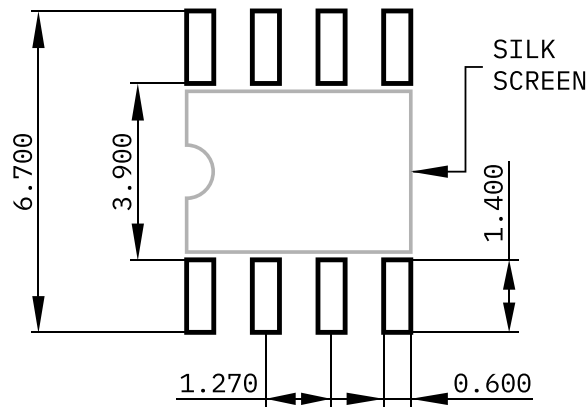
Units: millimeters

**Notes:**  
This drawing is for general information only.  
Drawing not to scale.

**IN ACKS**  
INTEGRATED SILICON STACKS

Evadrw0033r0

### S08N Recommended Footprint



Units: millimeters



**Notes:**  
This drawing is for general information only.  
Drawing not to scale.

Evadrw0025r2

## Content

IS4310: I2C Modbus RTU Slave Stack .....	1	5.2. Read Operations .....	17
Product Selection Guide .....	2	5.2.1. Single Word Read .....	17
1. Electrical Specifications .....	3	5.2.2. Multiple Word Read .....	18
2. Detailed Description .....	4	5.3. Write Operations .....	19
2.1. IS4310 Description .....	4	5.3.1. Single Word Write.....	19
2.1.1. Function Codes.....	5	5.3.2. Multiple Word Write .....	20
2.1.2. Exception Codes.....	5	6. Implementation Guide .....	21
2.2. IS4310 Advantages .....	5	6.1. RS485 Example .....	21
2.3. Modbus UART Port .....	6	6.2. Isolated RS485 Example.....	23
3. Pin Description.....	7	6.3. Bus Topology .....	24
4. Memory Description .....	9	7. Mechanical .....	26
4.1. Memory Map Organization .....	9	Content.....	28
4.2. Memory Map Table.....	10	Appendix .....	29
4.3. HOLDx Registers.....	11	Revision History .....	29
4.4. MBADR Register .....	12	Documentation Feedback.....	29
4.5. MBBDR Register .....	13	Sales Contact.....	29
4.6. MBPAR Register .....	14	Customization .....	29
4.7. MBSTP Register .....	15	Trademarks.....	29
5. I2C-compatible Bus Description .....	16	Disclaimer .....	30
5.1. Overview.....	16		

## Appendix

### Revision History

---

Date	Revision Code	Description
February 2025	ISDOC125B	Added "Cable Wiring" section.
February 2025	ISDOC125A	Initial Release

### Documentation Feedback

---

Feedback and error reporting on this document are very much appreciated.

[feedback@inacks.com](mailto:feedback@inacks.com)

### Sales Contact

---

For special order requirements, large volume orders, or scheduled orders, please contact our sales department at:

[sales@inacks.com](mailto:sales@inacks.com)

### Customization

---

INACKS can develop new products or customize existing ones to meet specific client needs. Please contact our engineering department at:

[engineering@inacks.com](mailto:engineering@inacks.com)

### Trademarks

---

All referenced brands, product names, service names and trademarks are the property of their respective owners.

## Disclaimer

Limited warranty and liability — Information in this document is believed to be accurate and reliable. However, INACKS does not give any representations or warranties, expressed or implied, as to the accuracy or completeness of such information and shall have no liability for the consequences of use of such information. INACKS takes no responsibility for the content in this document if provided by an information source outside of INACKS.

In no event shall INACKS be liable for any indirect, incidental, punitive, special or consequential damages (including - without limitation - lost profits, lost savings, business interruption, costs related to the removal or replacement of any products or rework charges) whether or not such damages are based on tort (including negligence), warranty, breach of contract or any other legal theory.

Notwithstanding any damages that customer might incur for any reason whatsoever, INACKS's aggregate and cumulative liability towards customer for the products described herein shall be limited in accordance with the Terms and conditions of commercial sale of INACKS.

Right to make changes — INACKS reserves the right to make changes to information published in this document, including without limitation specifications and product descriptions, at any time and without notice. This document supersedes and replaces all information supplied prior to the publication hereof.

Suitability for use — INACKS products are not designed, authorized or warranted to be suitable for use in life support, life-critical or safety-critical systems or equipment, nor in applications where failure or malfunction of an INACKS product can reasonably be expected to result in personal injury, death or severe property or environmental damage. INACKS and its suppliers accept no liability for inclusion and/or use of INACKS products in such equipment or applications and therefore such inclusion and/or use is at the customer's own risk.

Quick reference data — The Quick reference data is an extract of the product data given in the Limiting values and Characteristics sections of this document, and as such is not complete, exhaustive or legally binding.

Applications — Applications that are described herein for any of these products are for illustrative purposes only. INACKS makes no representation or warranty that such applications will be suitable for the specified use without further testing or modification.

Customers are responsible for the design and operation of their applications and products using INACKS products, and INACKS accepts no liability for any assistance with applications or customer product design. It is customer's sole responsibility to determine whether the INACKS product is suitable and fit for the customer's applications and products planned, as well as for the planned application and use of customer's third party customer(s). Customers should provide appropriate design and operating safeguards to minimize the risks associated with their applications and products.

INACKS does not accept any liability related to any default, damage, costs or problem which is based on any weakness or default in the customer's applications or products, or the application or use by customer's third party customer(s). Customer is responsible for doing all necessary testing for the customer's applications and products using INACKS products in order to avoid a default of the applications and the products or of the application or use by customer's third party customer(s). INACKS does not accept any liability in this respect.

Limiting values — Stress above one or more limiting values (as defined in the Absolute Maximum Ratings System of IEC 60134) will cause permanent damage to the device. Limiting values are stress ratings only and (proper) operation of the device at these or any other conditions above those given in the Recommended operating conditions section (if present) or the Characteristics sections of this document is not warranted. Constant or repeated exposure to limiting values will permanently and irreversibly affect the quality and reliability of the device.

Terms and conditions of commercial sale — INACKS products are sold subject to the general terms and conditions of commercial sale, as published at <http://www.inacks.com/commercialsale/terms>, unless otherwise agreed in a valid written individual agreement. In case an individual agreement is concluded only the terms and conditions of the respective agreement shall apply. INACKS hereby expressly objects to applying the customer's general terms and conditions with regard to the purchase of INACKS products by customer.

No offer to sell or license — Nothing in this document may be interpreted or construed as an offer to sell products that is open for acceptance or the grant, conveyance or implication of any license under any copyrights, patents or other industrial or intellectual property rights.

Export control — This document as well as the item(s) described herein may be subject to export control regulations. Export might require a prior authorization from competent authorities.

Non-automotive qualified products — This INACKS product is not suitable for automotive use. It is neither qualified nor tested in accordance with automotive testing or application requirements. INACKS accepts no liability for inclusion and/or use of non-automotive qualified products in automotive equipment or applications.

Protocol Guidance Disclaimer: The information provided herein regarding the protocol is intended for guidance purposes only. While INACKS strive to provide accurate and up-to-date information, this content should not be considered a substitute for official protocol documentation. It is the responsibility of the client to consult and adhere to the official protocol documentation when designing or implementing systems based on this protocol.

INACKS make no representations or warranties, either expressed or implied, as to the accuracy, completeness, or reliability of the information contained in this document. INACKS shall not be held liable for any errors, omissions, or inaccuracies in the information or for any user's reliance on the information.

The client is solely responsible for verifying the suitability and compliance of the provided information with the official protocol standards and for ensuring that their implementation or usage of the protocol meets all required specifications and regulations. Any reliance on the information provided is strictly at the user's own risk.

Certification and Compliance Disclaimer: Please be advised that the product described herein has not been certified by any competent authority or organization responsible for protocol standards. INACKS do not guarantee that the chip meets any specific protocol compliance or certification standards.

It is the responsibility of the client to ensure that the final product incorporating this product is tested and certified according to the relevant protocol standards before use or commercialization. The certification process may result in the product passing or failing to meet these standards, and the outcome of such certification tests is beyond our control.

INACKS disclaim any liability for non-compliance with protocol standards and certification failures. The client acknowledges and agrees that they bear sole responsibility for any legal, compliance, or technical issues that arise due to the use of this product in their products, including but not limited to the acquisition of necessary protocol certifications.