RTU-DI8 – 8 Channel Digital In
Modbus RTU Module

Documentation Issue 1.2

Features

- 8 Channel Opto-Isolated Digital Inputs
- Fast Opto-Coupler design capable of reading high speed pulses
- Wide Voltage input range (5-48V)
- Three modes of operation
    - High/Low Level Mode
    - Pulse Width Measurement Mode
    - Pulse Count Mode
- Software Modbus registers for
    - Channel High/Low Level State Mode
    - Channel 32bit Pulse Count totalizer (value also stored in Non-Volatile FRAM) Mode
    - Channel 32bit Pulse Count Offset Value
    - Current Channel Pulse Width Measurement (PWM) value
    - PWM 'Olympic' Averaging
    - *PWM Max channel reading
    - *PWM Min channel reading
    - Pulse count de-bounce period (default 10ms) configuration setting
    - PWM Average short/long configuration setting (selectable as over 6 or 10 readings)
    - Channel Mode configuration setting
    - Fast Modbus poll rates <100ms
    - Baud Rate
- Modbus Address selection via external "Push-On" jumper link setting
- Factory Reset Via "Push-On" link setting
- Integrated Watchdog and Power "Brown-Out" detect and correct
- 5V TTL Trigger Output Pin for Ultrasonic Sensors
- Regulated 5V Power supply pins for powering external sensors
- Optional DIN Rail mountable breakout board for Maxbotix ultrasonic sensors routing power and trigger signals for sequential daisy-chain operation providing maximum reading reliability.

**These threshold registers are user writeable so a reading can be taken, the registers written back to, either to zero out or set a new threshold, the system will check new readings against these values and overwrite if the threshold has been exceeded in the respective direction.*

Readings :

Pulse Count Mode keeps a tally of the number of pulses received from a given data source such as water meter or power meter. These pulses are usually fired by the data source to indicate a number of litres or kWh has been consumed and are cheaper to implement by the equipment manufacturer than a full digital interface.

The RTU unit will count pulses up to 100Hz with the default de-bounce setting, a higher frequency can be achieved if the user is able to supply a solid state input (avoiding relay contact bounce or other sources of interference).

Safety and ESD Precautions

Before first use, refer to this manual.

Before first use, make sure that all cables are connected properly

Please ensure proper working conditions, according to the device specifications
e.g. Supply voltage, ambient temperature, maximum power consumption requirements.

Ensure all wiring and connector terminals are securely fastened so as to avoid short circuits or other such damage.

Before making any modifications to wiring connections or PCB settings, turn off the power supply.

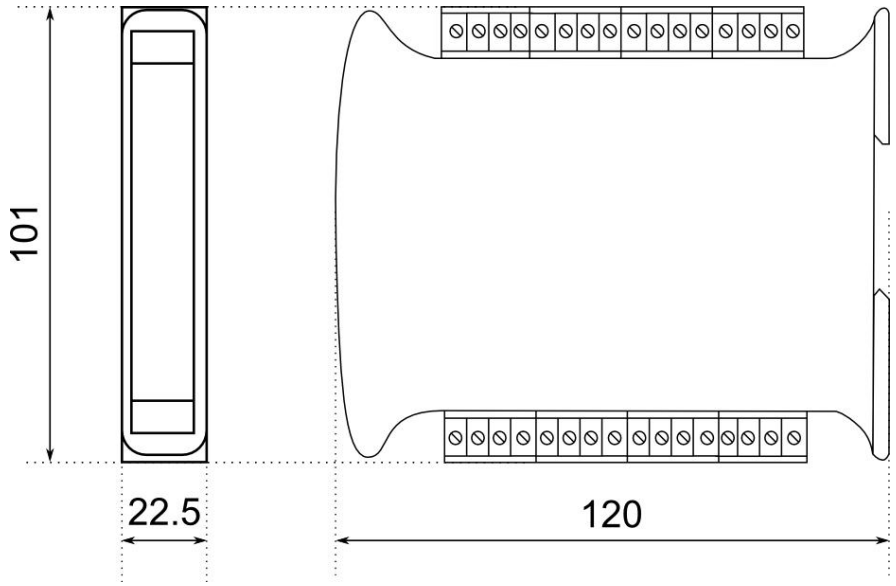
Caution - Component damage. Circuit boards contain electronic components that are extremely sensitive to static electricity. Ordinary amounts of static electricity from clothing or the work environment can destroy the components located on these devices.

Do not touch the components without antistatic precautions, especially along the connector edges.

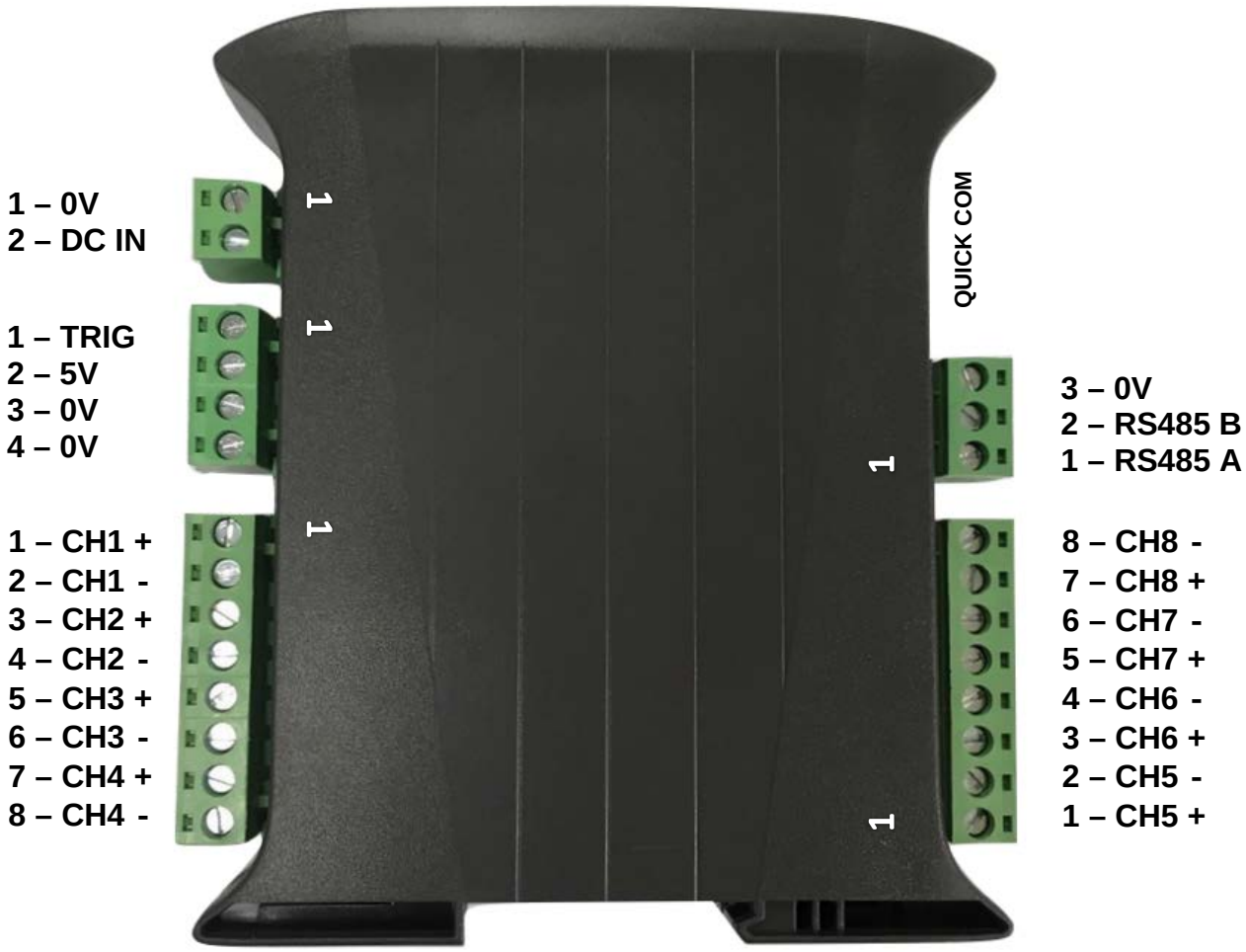
Note: This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment 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.

Specifications

Power Supply	Voltage	6-28 VDC
	Maximum Current	10mA @12V Max
Digital Inputs	No of inputs	8 (AC or DC Inputs)
	Input Range (Voltage Mode)	0–48V
	Low Level	0 - 3V
	High Level	>= 5V
	Input Resistor	6.8 KΩ
Environmental Conditions	Operating Temperature	-20°C to +70°C
	Storage Temperature	-40°C to +85°C
	Humidity	0 .. 90 % (non-condensing)
Isolation	Isolation	2500 Vrms (Between CPU/Power and Digital Inputs)
Dimensions	Height/ Length	120x101 mm
Communication	Protocol	Modbus RTU
	Baud	9600-57600 (19200 Factory Default)
	Address	1-31
EMC	Rating	Class A (Industrial)
	Immunity	EN 61000-6-2
	Emissions	EN 61000-6-4
IP	IP Rating	IP20

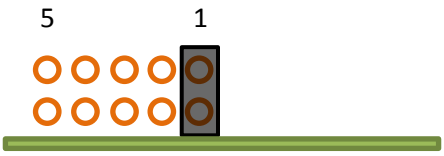


RTU Module Pin Out



Status LEDs & Modbus ID

Modbus Address ID Link Setting



Link No	Address Setting
1	Modbus Address +1
2	Modbus Address +2
3	Modbus Address +4
4	Modbus Address +8
5	Modbus Address +16
No Links	Use factory defaults*

Status LEDs

	Top	Bottom
Green	Power On	Modbus Rx
Red	-	Modbus Tx

* Factory Default setting :

- Address Id = 1
- Baud Rate = 19200 8N1

Modbus Address ID Selection Link

Addr	5	4	3	2	1
0*	**OFF**	**OFF**	**OFF**	**OFF**	**OFF**
1	OFF	OFF	OFF	OFF	ON
2	OFF	OFF	OFF	ON	OFF
3	OFF	OFF	OFF	ON	ON
4	OFF	OFF	ON	OFF	OFF
5	OFF	OFF	ON	OFF	ON
6	OFF	OFF	ON	ON	OFF
7	OFF	OFF	ON	ON	ON
8	OFF	ON	OFF	OFF	OFF
9	OFF	ON	OFF	OFF	ON
10	OFF	ON	OFF	ON	OFF
11	OFF	ON	OFF	ON	ON
12	OFF	ON	ON	OFF	OFF
13	OFF	ON	ON	OFF	ON
14	OFF	ON	ON	ON	OFF
15	OFF	ON	ON	ON	ON
16	ON	OFF	OFF	OFF	OFF
17	ON	OFF	OFF	OFF	ON
18	ON	OFF	OFF	ON	OFF
19	ON	OFF	OFF	ON	ON
20	ON	OFF	ON	OFF	OFF
21	ON	OFF	ON	OFF	ON
22	ON	OFF	ON	ON	OFF
23	ON	OFF	ON	ON	ON
24	ON	ON	OFF	OFF	OFF
25	ON	ON	OFF	OFF	ON
26	ON	ON	OFF	ON	OFF
27	ON	ON	OFF	ON	ON
28	ON	ON	ON	OFF	OFF
29	ON	ON	ON	OFF	ON
30	ON	ON	ON	ON	OFF
31	ON	ON	ON	ON	ON

* Invokes Factory Default setting:

- Address Id = 1
- Baud Rate = 19200 8N1

Pulse Width Measurement Mode

The auxiliary pulse width measurement interface connector allows for the integration, and daisy chaining, of sensors which require a low 5V voltage power supply and/or trigger pulse in order to initiate conversion/pulse generation. The width/length of the received pulse is then measured and stored in the respective Modbus register in microsecond units with a resolution of 4 µs (0.004ms) and an accuracy tolerance of ± 8 µs (0.008ms).

The functionality here has been specifically designed with Maxbotix ultrasonic range sensors in mind, although the interface is generic and can be used with any sensor providing a varying pulse width.

In addition the RTU module can optionally be paired with a breakout board specifically designed for daisy chaining up to 8 Maxbotix ultrasonic sensors; this gives maximum reliability and prevents "cross talk" between sensors if placed in close proximity.

Pulse width readings also have special averaging and peek max/min recorders for alarm sensing

PWM 'Olympic Average' Reading

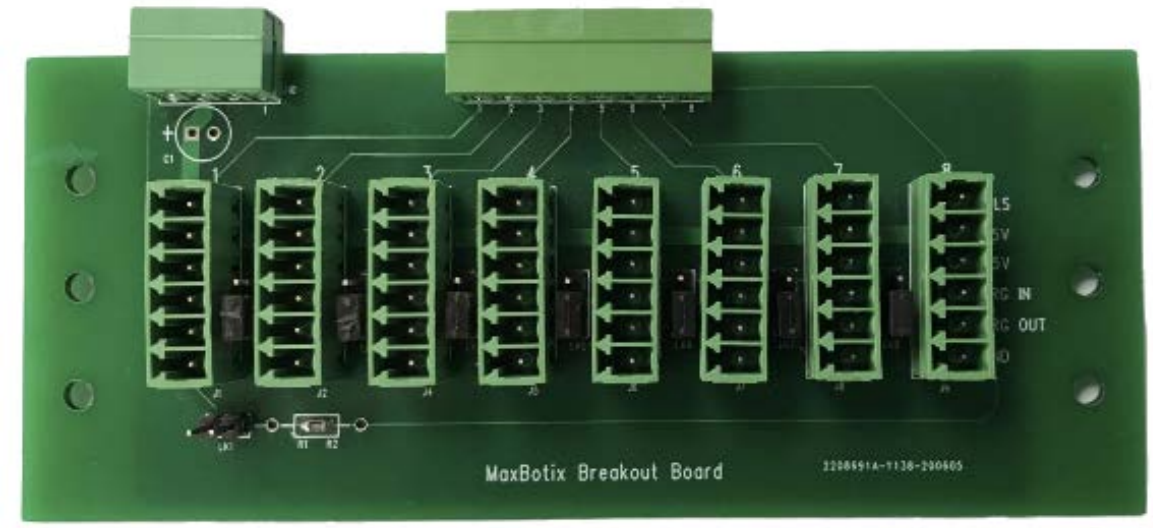
This gives the per-channel rolling average over 6 or 10 readings, here the maximum and minimum readings from each channel are discarded from the data-set and the average is then calculated over the remaining 4 or 8 readings. This method is used to assist with positively eliminating any substantially outlying readings which may have occurred during the period, for example if the signal source is fluctuating or the sensor has produced a glitched/bad read.

PWM Max/Min Peek Reading Indicators

These values are set and tested against at each sensor read, if the current reading exceeds the Max/Min threshold then the Max/Min value is overwritten with the current reading and the new updated value is then used on subsequent reads. This value can also be set via a Modbus write giving allowing the setting to act as a threshold for an alarm level or reset after reading the latest values so as to record the maximum deviation between reads.

Note that all PWM readings/thresholds are volatile and will not be retained over a power on/off/on cycle

Ultrasonic Sensor Accessory Breakout Board



The breakout board is configured such that each sensor triggers sequentially in the sequence 1-8, if using a smaller amount of sensors strictly use the 1-8 ordering for both the sensor plugs and the RTU channel ordering the so that the trigger signal propagates correctly and the matching pulse output is wired to the corresponding RTU digital input channel.

E.g. If 4 ultrasonic sensors are the RTU and breakout board should use channel numbers 1-4 regardless of which digital input channel is used

The sensor trigger pulse will be sent by the RTU module once to start the sequence, the Maxbotix sensors should be wired in daisy chain format to allow this signal to feed through each sensor in the sequence for optimum results.

The breakout board can be mounted on a DIN rail by using the plastic adapter clips provided.

We recommend using low capacitance cabling, such as **Belden 9933/9931**, for interfacing between the breakout card and the ultrasonic sensors to maintain signal integrity over long runs and prevent signal degradation. If the cabling used has a shield make sure to connect this at one end only to an appropriate 0V/Ground reference.

See below Maxbotix recommendation regarding cabling:

https://www.maxbotix.com/Ultrasonic_Sensors/MB7954.htm

J10 **RTU PWM Interface Plug**

Pin	Function
1	0V
2	+5V
3	0V
4	RTU Trigger Pin

J1/2/4/5/6/7/8/9 **Maxbotix Sensor Plug**

Pin	Function
1	Sensor Pulse Width Output
2	+5V
3	+5V
4	Trigger Signal To Sensor (Input)
5	Trigger Signal From Sensor (Output)
6	0V

J3 **RTU Sensor Plug**

Pin	Function
1	Sensor 1 Output Pulse Positive
2	Sensor 2 Output Pulse Positive
3	Sensor 3 Output Pulse Positive
4	Sensor 4 Output Pulse Positive
5	Sensor 5 Output Pulse Positive
6	Sensor 6 Output Pulse Positive
7	Sensor 7 Output Pulse Positive
8	Sensor 8 Output Pulse Positive

Connect Channel input pair to PWM Output Pulse Positive & PWM Sensor 0V

LK2/3/4/5/6/7/8 **Sensor Trigger Mode**

Pin	Function
1-2 (Factory Default)	Sequential Trigger
2-3	Single Simultaneous Trigger

Pulse Counting Mode

This operating mode puts the system into pulse count mode, where each channel will count the number of pulses received on a given input channel.

The system features a user-definable de-bounce period, which is factory set to 10mS, allowing for pulses <100kHz. This de-bounce period can be reduced if the user can guarantee a solid state signal (as opposed to relay contacts) and a good low electrically noisy environment.

On detection the channel total is incremented and this new value is immediately written to FRAM non-volatile storage so as to reduce venerability to power outages.

The input counts are stored as 32bit unsigned integers giving maximum channel counts of 4,294,967,295.

The system can also be configured with per-channel counter offset values, allowing easy retrofitting into existing environments; these offsets are stored in EEPROM again providing resilience against power outage.

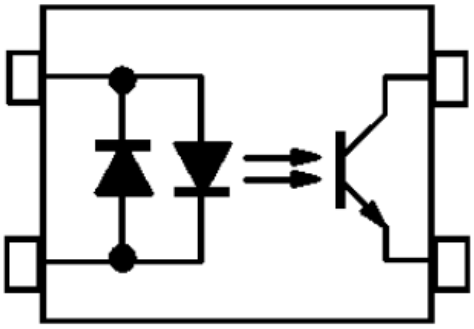
Whilst the values for current pulse count total and offset values are stored separately, these values are added together and stored in the respective Modbus register.

This mode of operation is mutually exclusive to PWM measurement mode, i.e. the system cannot be configured for mixed PWM and pulse count modes at the same time.

Static Level Mode

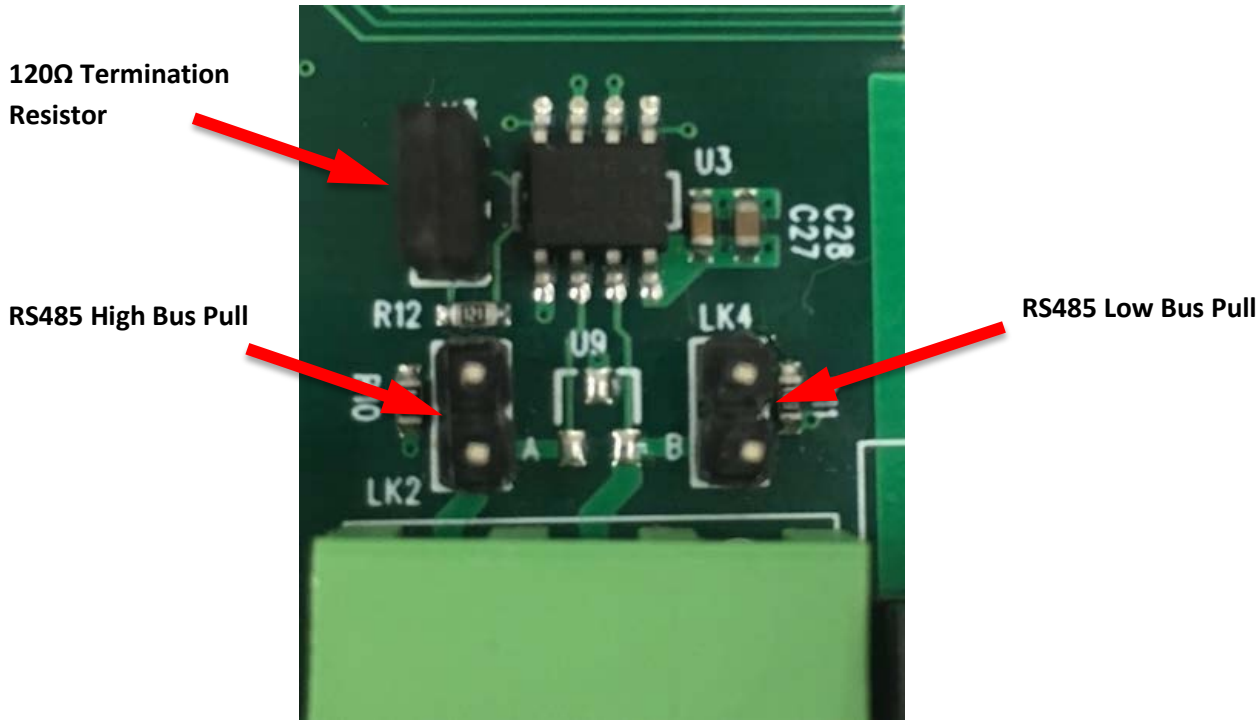
This is the most basic operating mode and puts the system into binary logic level indication. Voltage inputs exceeding the high level threshold will show as logic level 1, and below the low threshold will show as logic level 0, the logic state for voltages in-between are not guaranteed so should not be relied upon.

Each channel is independently isolated and the optocoupler inputs are AC type, as shown below, so signal orientation is not crucial to operation.



RS485 Bus Option Links

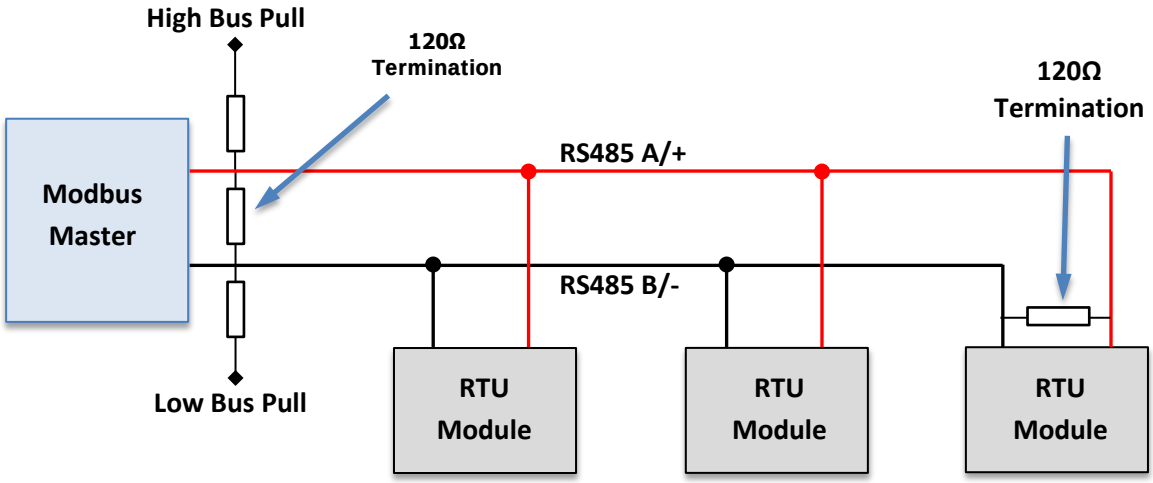
Fit links below to enable the function shown



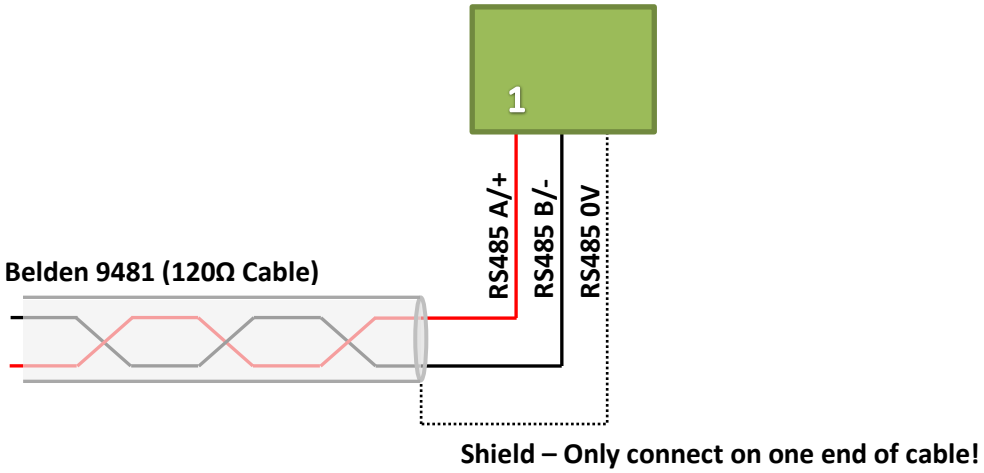
Important: Only one set of bus data line pulls should be active, either at the master side or on a single slave

Important: Termination resistors should only be enabled at far ends of bus

RS485 Bus Connection



RTU Plug RS485 Wiring



Modbus Registers – Readings

Register	Type	Read/Wite	Description
40001	16bit (Big Endian)	Read Only	Channel 1 Static Level Reading
40002	16bit (Big Endian)	Read Only	Channel 2 Static Level Reading
40003	16bit (Big Endian)	Read Only	Channel 3 Static Level Reading
40004	16bit (Big Endian)	Read Only	Channel 4 Static Level Reading
40005	16bit (Big Endian)	Read Only	Channel 5 Static Level Reading
40006	16bit (Big Endian)	Read Only	Channel 6 Static Level Reading
40007	16bit (Big Endian)	Read Only	Channel 7 Static Level Reading
40008	16bit (Big Endian)	Read Only	Channel 8 Static Level Reading
40009	32Bit (Big Endian)	Read Only	Channel 1 Pulse Count Total
40011	32Bit (Big Endian)	Read Only	Channel 2 Pulse Count Total
40013	32Bit (Big Endian)	Read Only	Channel 3 Pulse Count Total
40015	32Bit (Big Endian)	Read Only	Channel 4 Pulse Count Total
40017	32Bit (Big Endian)	Read Only	Channel 5 Pulse Count Total
40019	32Bit (Big Endian)	Read Only	Channel 6 Pulse Count Total
40021	32Bit (Big Endian)	Read Only	Channel 7 Pulse Count Total
40023	32Bit (Big Endian)	Read Only	Channel 8 Pulse Count Total
40025	32Bit (Big Endian)	Read Only	Channel 1 PWM Live Reading
40027	32Bit (Big Endian)	Read Only	Channel 2 PWM Live Reading
40029	32Bit (Big Endian)	Read Only	Channel 3 PWM Live Reading
40031	32Bit (Big Endian)	Read Only	Channel 4 PWM Live Reading
40033	32Bit (Big Endian)	Read Only	Channel 5 PWM Live Reading
40035	32Bit (Big Endian)	Read Only	Channel 6 PWM Live Reading
40037	32Bit (Big Endian)	Read Only	Channel 7 PWM Live Reading
40039	32Bit (Big Endian)	Read Only	Channel 8 PWM Live Reading
40041	32Bit (Big Endian)	Read Only	Channel 1 PWM Average Reading
40043	32Bit (Big Endian)	Read Only	Channel 2 PWM Average Reading
40045	32Bit (Big Endian)	Read Only	Channel 3 PWM Average Reading
40047	32Bit (Big Endian)	Read Only	Channel 4 PWM Average Reading
40049	32Bit (Big Endian)	Read Only	Channel 5 PWM Average Reading
40051	32Bit (Big Endian)	Read Only	Channel 6 PWM Average Reading
40053	32Bit (Big Endian)	Read Only	Channel 7 PWM Average Reading
40055	32Bit (Big Endian)	Read Only	Channel 8 PWM Average Reading
40057	32Bit (Big Endian)	Read/Write	Channel 1 PWM Max Peek Reading
40059	32Bit (Big Endian)	Read/Write	Channel 2 PWM Max Peek Reading
40061	32Bit (Big Endian)	Read/Write	Channel 3 PWM Max Peek Reading
40063	32Bit (Big Endian)	Read/Write	Channel 4 PWM Max Peek Reading
40065	32Bit (Big Endian)	Read/Write	Channel 5 PWM Max Peek Reading
40067	32Bit (Big Endian)	Read/Write	Channel 6 PWM Max Peek Reading
40069	32Bit (Big Endian)	Read/Write	Channel 7 PWM Max Peek Reading
40071	32Bit (Big Endian)	Read/Write	Channel 8 PWM Max Peek Reading

40073	32Bit (Big Endian)	Read/Write	Channel 1 PWM Min Peek Reading
40075	32Bit (Big Endian)	Read/Write	Channel 2 PWM Min Peek Reading
40077	32Bit (Big Endian)	Read/Write	Channel 3 PWM Min Peek Reading
40079	32Bit (Big Endian)	Read/Write	Channel 4 PWM Min Peek Reading
40081	32Bit (Big Endian)	Read/Write	Channel 5 PWM Min Peek Reading
40083	32Bit (Big Endian)	Read/Write	Channel 6 PWM Min Peek Reading
40085	32Bit (Big Endian)	Read/Write	Channel 7 PWM Min Peek Reading
40087	32Bit (Big Endian)	Read/Write	Channel 8 PWM Min Peek Reading
40089	32Bit (Big Endian)	Read/Write	Channel 1 Pulse Count Offset
40091	32Bit (Big Endian)	Read/Write	Channel 2 Pulse Count Offset
40093	32Bit (Big Endian)	Read/Write	Channel 3 Pulse Count Offset
40095	32Bit (Big Endian)	Read/Write	Channel 4 Pulse Count Offset
40097	32Bit (Big Endian)	Read/Write	Channel 5 Pulse Count Offset
40099	32Bit (Big Endian)	Read/Write	Channel 6 Pulse Count Offset
40101	32Bit (Big Endian)	Read/Write	Channel 7 Pulse Count Offset
40103	32Bit (Big Endian)	Read/Write	Channel 8 Pulse Count Offset

Only function codes 0x03 (FC03) and 0x10 (FC16) are accepted by the module

To **read** one or more registers you should use Modbus function code 3 – Read holding registers (4x Range)

To **write** one or more registers you should use Modbus function code 16 – Write multiple registers

Note :

PWM readings are 32bit unsigned integer values recording microsecond values for the pulse width, with a accuracy of ±8uS or better

Channel Maximum/Minimum registers record the peek value, i.e. the highest/lowest values seen by the system, each subsequent live reading is tested against this value with the register value being updated if the live reading exceeds the threshold value stored here.

Writing a value to the Max/Min registers will set a new threshold value for testing against.

Pulse count offset values take immediate effect, but are only saved to EEPROM if 255 is written to the configuration register (see later)

Modbus Registers – Configuration

Register	Type	Read/Wite	Description
40105	16bit (Big Endian)	Read/Write	Channel 1 Operating Mode
40106	16bit (Big Endian)	Read/Write	Channel 2 Operating Mode
40107	16bit (Big Endian)	Read/Write	Channel 3 Operating Mode
40108	16bit (Big Endian)	Read/Write	Channel 4 Operating Mode
40109	16bit (Big Endian)	Read/Write	Channel 5 Operating Mode
40110	16bit (Big Endian)	Read/Write	Channel 6 Operating Mode
40111	16bit (Big Endian)	Read/Write	Channel 7 Operating Mode
40112	16bit (Big Endian)	Read/Write	Channel 8 Operating Mode
40113	16bit (Big Endian)	Read Only	Channel 1 PWM Input Fault
40114	16bit (Big Endian)	Read Only	Channel 2 PWM Input Fault
40115	16bit (Big Endian)	Read Only	Channel 3 PWM Input Fault
40116	16bit (Big Endian)	Read Only	Channel 4 PWM Input Fault
40117	16bit (Big Endian)	Read Only	Channel 5 PWM Input Fault
40118	16bit (Big Endian)	Read Only	Channel 6 PWM Input Fault
40119	16bit (Big Endian)	Read Only	Channel 7 PWM Input Fault
40120	16bit (Big Endian)	Read Only	Channel 8 PWM Input Fault
40121	16bit (Big Endian)	Read/Write	Long/Short PWM Average
40122	16bit (Big Endian)	Read/Write	Pulse Count De-Bounce Setting
40123	16bit (Big Endian)	Read/Write	Modbus RTU Baud Rate
40124	16bit (Big Endian)	Read/Write	PWM Cycle Time
40125	16bit (Big Endian)	Read/Write	Configuration Register

40105-40112 Channel Mode

This is a per channel setting with the following options set as the register value as below, If a system is set such that a PWM/Counter mixed mode is detected the system will not allow counter mode to be initialised.

Register Value	Channel Setting
0	Static Level
1	Static Level
2	Pulse Counter
3	PWM Measurement

40113-40120 Channel PWM Input Health

If a PWM channel times out during pulse measurement 3 times in a row the system will mark the channel as dead and skip it on subsequent channel reads. A system reset (either invoked via writing 255 to the Modbus configuration register) or a power cycle will clear these registers.

This prevents total Modbus lock out in the situation that multiple sensors lose power or are non-responsive.

Register Value	Setting
0	Channel AOK
1	Channel PWM Input Faulty

40121 Channel PWM Long/Short average Setting

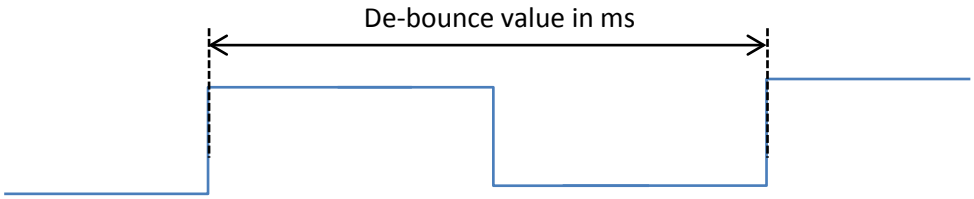
This value defines how many readings the PWM average is taken over. Default is 8

Register Value	Setting
0	8 Readings
1	4 Readings
2	8 Readings

40122 Pulse Count De-bounce Setting

Pulse Counting de-bounce period, this value in milliseconds (ms) gives the minimum gap between pulses before a new pulse is counted.

The default is 10mS, i.e. a new pulse must start *at least* 10mS after the previous pulse was detected, this prevents relay bounce or other spurious signals causing the counter to increment whilst still allowing for pulses upto 100Khz to be counted.



Register Value	Setting
10	10ms de-bounce
20	20ms de-bounce
100	100ms de-bounce
x	x ms de-bounce

40123 - Modbus Baud Rate

This sets the serial baud rate of the unit – Default setting is 19200

Register Value	Setting
0	19200
1	9600
2	14400
3	19200
4	38400
5	57600

40124 PWM Cycle time

This value defines the fastest cycle time for a reading of all sensors, especially important if only 1 sensor is used. Default is 100ms (10Hz), may need increasing to 200mS or greater depending on the sensor in use.

Range from 100ms to 10seconds

Register Value	Setting
0	100ms
100	100ms
1000	1000ms

40125 – Configuration Register

Writing **255** to this register will cause the system to save the current configuration and reboot the unit, this is required if any of the parameters have changed e.g. baud rate or channel resolution.

Values between 880 and 888 will erase and zero out selective channels NVRAM storage for pulse count totals or erase and zero out totals for all channels. Channel Offsets are not affected by this operation.

Register Value	Setting
255	Save Current Configuration Settings to EEPROM
880	Zero Out Channel 1 Pulse Count Total
881	Zero Out Channel 2 Pulse Count Total
882	Zero Out Channel 3 Pulse Count Total
883	Zero Out Channel 4 Pulse Count Total
884	Zero Out Channel 5 Pulse Count Total
885	Zero Out Channel 6 Pulse Count Total
886	Zero Out Channel 7 Pulse Count Total
887	Zero Out Channel 8 Pulse Count Total
888	Zero Out Pulse Count Total For All Channels

Software Support

Open-Source code samples can be downloaded from the GitHub repositories below :

RTU-DI8 Configuration Tool

https://github.com/synapsertu/rtu-di8

Multi RTU module Logger

https://github.com/synapsertu/rtu-log

Modbus Utilities

The following windows and Linux command line utilities are useful for development

Windows/Linux x86 Binary

https://www.modbusdriver.com/modpoll.html

Raspberry Pi/Linux

https://github.com/epsilonrt/mbpoll

*Note that mbpoll does not use FC16 for Modbus writes