X-gateway Interface Addendum
Modbus RTU Slave

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Important User Information

This document is intended to provide a good understanding of the functionality offered by the Interface described here.

The reader is expected to be familiar with high level software design, and communication systems in general. The use of advanced interface-specific functionality may require in-depth knowledge of networking internals and/or information from the network specifications. In such cases, the persons responsible for the implementation of this product should either obtain the necessary specifications to gain sufficient knowledge, or alternatively limit the implementation in such a way that this is not necessary.

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!	**WARNING**:	This is a class A product. in a domestic environment this product may cause radio interference in which case the user may be required to take adequate measures.
	ESD Note:	This product contains ESD (Electrostatic Discharge) sensitive parts that may be damaged if ESD control procedures are not followed. Static control precautions are required when handling the product. Failure to observe this may cause damage to the product.

Table of Contents

P. About This Document

P.1. How To Use This Document

This document describes the various features of the Modbus RTU Slave interface, basic network installation procedures and various network specific details. General information and operating instructions for the X-gateway is available in the Anybus X-gateway User Manual.

The reader of this document is expected to be familiar with the Modbus RTU networking system, and communication systems in general.

For further information, documentation etc., please visit www.anybus.com.

P.2. Related Documents

Document name	Author
Anybus X-gateway User Manual	HMS
Anybus-S Modbus RTU Fieldbus Appendix	HMS

P.3. Document History

Revision List

Revision	Date	Author(s)	Chapter(s)	Description
1.00	2004-03-10	PeP	All	First release
1.02	2006-05-31	PeP	1, 2	Minor update
1.03	2007-04-02	PeP	A	Minor update
1.10	2007-12-03	PeP	P, 1, 2, 3	Major rewrite
1.11	2008-05-21	PeP	-	Minor update
2.00	May 2014	SDA	All	New hardware and Anybus Configuration Manager

P.4. Conventions & Terminology

The following conventions are used throughout this document:

- Numbered lists provide sequential steps
- Bulleted lists provide information, not procedural steps
- The term 'X-gateway' is used when referring to the Anybus X-gateway
- The term 'Slave interface' is used when referring to the Modbus RTU Slave interface.
- The term 'user manual' is used when referring to the Anybus X-gateway User Manual.
- Hexadecimal values are written in the format NNNNh, where NNNN is the hexadecimal value.
- 16/32 bit values are generally stored in Motorola (big endian) format unless otherwise stated.

P.5. Support

For general contact information and support, please refer to the contact and support pages at www.anybus.com.

1. About the Modbus RTU Slave Interface

1.1. General Description

The Modbus-RTU Slave Interface for the X-gateway implements a passive Modbus-RTU slave node for the X-gateway platform. As a slave node, it can respond to Query's from a Modbus RTU Master, but will not initiate communication on its own.

The interface exchanges data through two buffers as follows:

- **Input Buffer**

  This buffer holds data forwarded *from* the other network, and can be read by the Modbus Master.

- **Output Buffer**

  This buffer is forwarded *to* the other network, and can be both read and written by the Modbus Master. Note however that the unidirectional nature of the X-gateway means it will still only be forwarded *to* the other network, never the other way around (for that purpose, use registers associated with the Input Buffer instead).
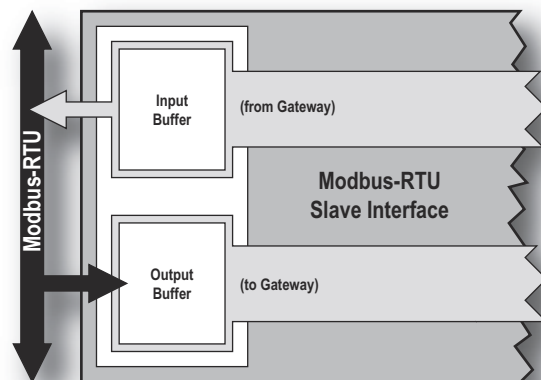
1.2. Features

- Modbus-RTU compliant, passive slave node operation
- Modbus diagnostics
- Up to 256 Modbus registers in each direction
- RS485 or RS232 operation
- Baudrates from 1200bps to 57600bps
- On-board configuration switches
- Galvanically isolated bus electronics

1.3. External View

1.3.1. Modbus RTU Status LEDs

LED	Colour	Indication
Gateway Status	Consult the user manual for further details	
Processing	Green	Processing message
	Off	Not processing
Bus Error	Red	Bus error
	Off	Normal operation
Bus Ready	Green	Normal operation
	Red	Bus timeout error
	off	Bus not running
HW Status	Red	Configuration switch error
	Off	-

Front View

Top-mounted Modbus RTU interface

Gateway status

Processing
Bus error
Bus ready
HW status

Gateway status

Processing
Bus error
Bus ready
HW status

USB Gateway Config Connector

Bottom-mounted Modbus RTU interface

1.3.2. Connectors and Switches

Modbus RTU network connector

See A-13 "Modbus RTU Connector Pinout".

Termination Switch

See 2-9 "Network Termination".

Configuration switches

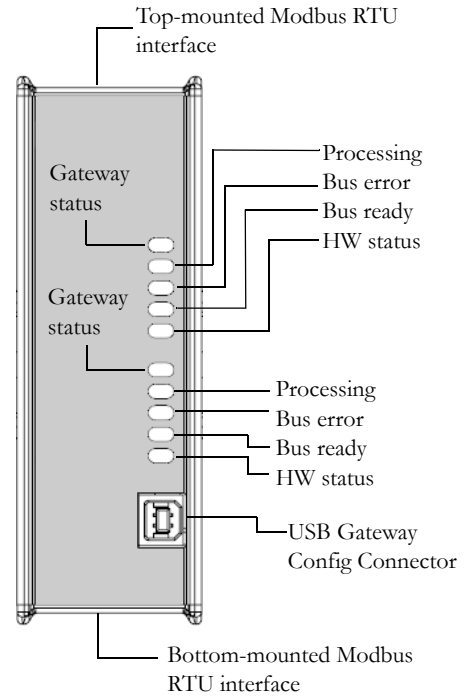See 2-8 "Installation and Configuration".

Gateway Power connector

Se the X-gateway user manual for further details.

USB Gateway Config connector

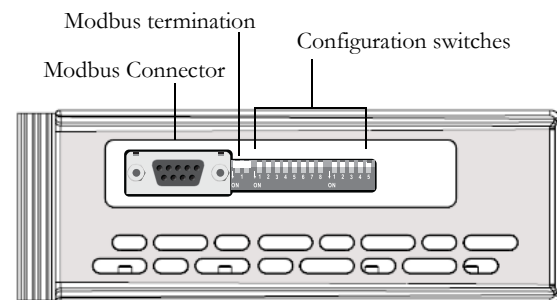See the X-gateway user manual for further details.

Top-mounted Interface

Modbus Termination

Configuration switches

Modbus Connector

Gateway Power Connector
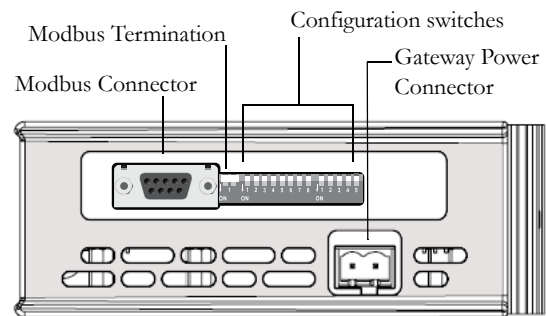
Bottom-mounted Interface

Modbus termination

Configuration switches

Modbus Connector

2. Installation and Configuration

2.1. Node ID Configuration

Each node on a Modbus RTU network must be assigned a unique node ID. Seven switches are used to set the Modbus node ID of the Slave interface in binary form. The switches are read once during startup, i.e. the gateway must be restarted for any changes to have effect.

Switch 1	Switch 2	Switch 3	Switch 4	Switch 5	Switch 6	Switch 7	Switch 8[a]	Node ID
OFF	OFF	OFF	OFF	OFF	OFF	OFF	-	(invalid)
OFF	OFF	OFF	OFF	OFF	OFF	ON		1
OFF	OFF	OFF	OFF	OFF	ON	OFF		2
...	...	...	...	...	...	...		...
ON	ON	ON	ON	ON	ON	ON		127

a. See 2-8 "Baudrate Configuration"

Example:

In this example, the Modbus node ID will be 42.

Note: Depending on if the Slave interface is top or bottom mounted, the orientation of the switches are different.

2.2. Baudrate Configuration

The standard baudrate of Modbus RTU is 19.2kbit/s. The Slave interface does however allow baudrates from 1.2kbit/s to 57.6kbit/s to be selected via the baudrate switches. The switches are read once during startup, i.e. the gateway must be restarted for any changes to have effect.

Switch 1-7[a]	Switch 8	Switch 1	Switch 2	Switch 3[b]	Switch 4[b]	Baudrate
-	OFF	OFF	OFF	-	-	(invalid)
	OFF	OFF	ON			1.2kbit/s
	OFF	ON	OFF			2.4kbit/s
	OFF	ON	ON			4.8kbit/s
	ON	OFF	OFF			9.6kbit/s
	ON	OFF	ON			19.2kbit/s (standard)
	ON	ON	OFF			38.4kbit/s
	ON	ON	ON			57.6kbit/s

a. These switches are used for Node ID configuration, see previous section.
b. This switch is used for Parity configuration, see next section.

Example:

In this example, the baudrate will be 1.2kbit/s.

Note: Depending on if the Slave interface is top or bottom mounted, the orientation of the switches are different.

2.3. Parity and Stop Bits Configuration

The Slave interface allows different parity settings to be selected via the parity switches. The switches are read once during startup, i.e. the gateway must be restarted for any changes to have effect.
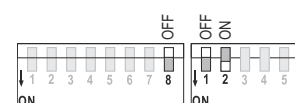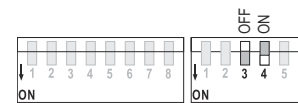
Switch 1[a]	Switch 2[a]	Switch 3	Switch 4	Switch 5[b]	Parity	Stop bits
-	-	OFF	OFF	-	(invalid)	(invalid)
		OFF	ON		None (Standard)	2 (standard)
		ON	OFF		Even	1
		ON	ON		Odd	

a. See 2-8 "Baudrate Configuration"
b. See 2-9 "Physical Interface"

Example:

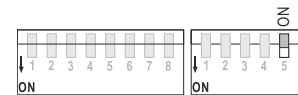2 stop bits, no parity (Modbus RTU standard)

2.4. Physical Interface

The Slave interface supports RS232 and RS485 communication standards.

Switch 1[a]	Switch 2[a]	Switch 3[b]	Switch 4[b]	Switch 5	Physical Interface
-	-	-	-	OFF	RS485
				ON	RS232

a. See 2-8 "Baudrate Configuration"
b. See 2-9 "Parity and Stop Bits Configuration"

Example:

In this example, the physical interface is set to RS232.

2.5. Network Termination

The end nodes of a RS485-based Modbus RTU network must be terminated in order to avoid reflections on the bus line. The Slave interface features a termination switch, which is used to enable internal termination resistors.

Switch Position	Internal Termination
OFF	Disabled
ON	Enabled

The figure below shows the connection and the values of the internal termination and bias resistors. If the values does not match the network termination convention, external termination must be used.
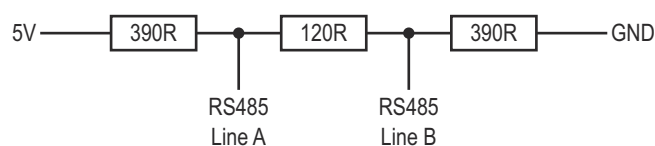
2.6. Gateway Config Interface

The Modbus-specific settings in the X-gateway are configured with the help of Anybus Configuration Manager. See the Anybus X-gateway user manual for further information on using this tool..

When ACM is connected to the gateway via the USB configuration connector, the following settings are available:

Network Type	
Name	Modbus RTU Slave
General	
Input Register data Size (bytes)	20
Output Register data Size (bytes)	20
Offline option	Clear ▼
Control word/Status word	Disable ▼
Fieldbus Specific	
Offline timeout (ms/0=disabled)	0

See also:

- The Anybus X-gateway User Manual, for full details on using ACM.
- The online help in ACM, for further help on the available settings.
- 3-11 "Data Exchange"
- 3-12 "Coil & Register Map"

3. Data Exchange

3.1. General Information

The Slave Interface acts as a passive node and as such it responds to incoming Querys and accepts broadcast messages. It will not initiate communication autonomously.

In the Anybus implementation, several Modbus functions are associated with the very same data. While this may appear confusing at first, it allows data to be manipulated in a very flexible manner (e.g. it is possible to manipulate individual bits of a register by accessing coils associated with the same memory location).

The following functions can be used to access data in the Slave Interface:

Modbus Function	Function Code	Direction	Associated with Buffer
Read Coil	1	Gateway to Modbus	Input- and Output Buffers
Read Input Discretes	2		
Read Holding Registers	3		
Read Input Registers	4		
Write Coil	5	Modbus to Gateway	Output Buffer
Write Single Register	6		
Force Multiple Coils	15		
Force Multiple Registers	16		
Mask Write Register	22		
Read/Write Registers	23	Bidirectional	Input- and Output Buffers

See also...

- 3-12 "Coil & Register Map"

3.2. Modbus Exceptions

With the exception of broadcast messages, the Modbus Master expects it's slaves to respond within a certain defined time period. If no response is received (e.g. due to a transmission error), this eventually triggers a timeout condition in the Master.

If the Slave Interface receives a Query from the Master, but for some reason is unable to process it (e.g. the Master tries to access a non-existent Register), an Exception is returned to inform the Master of the nature of the problem.

The Slave Interface may issue the following Exception responses:

#	Meaning	Description
01h	Illegal Function	The Query contains an illegal or unsupported function call
02h	Illegal Data Address	The Query contains an illegal data address
03h	Illegal Data Value	The Query contains invalid data

3.3. Coil & Register Map

The Input & Output Buffers are mapped to coils and registers as follows:

Register #	Coil #	Buffer	Location in Buffer	Comments
1	1... 16	Input Buffer	000... 001h	Applicable Modbus functions:
2	17... 32		002... 003h	- Read Coil
3	33... 48		004... 005h	- Read Input Discretes
4	49... 64		006... 007h	- Read Holding Registers
5	65... 80		008... 009h	- Read Input Registers
6	81... 96		00A... 00Bh	- Read/Write Registers
7	97... 112		00C... 00Dh	
...	...		...	
255	4065... 4080		1FC... 1FDh	
256	4081... 4096		1FE... 1FFh	
257... 1024	4097... 16384	-	-	(reserved)
1025	16385... 16400	Output Buffer	000... 001h	Applicable Modbus functions:
1026	16401... 16416		002... 003h	- Read Coil
1027	16417... 16432		004... 005h	- Read Input Discretes
1028	16433... 16448		006... 007h	- Read Holding Registers
1029	16449... 16464		008... 009h	- Read Input Registers
1030	16465... 16480		00A... 00Bh	- Write Coil
1031	16481... 16496		00C... 00Dh	- Write Single Register
...	...		...	- Force Multiple Coils
1279	20449... 20464		1FC... 1FDh	- Force Multiple Registers
1280	20465... 20480		1FE... 1FFh	- Mask Write Register
1281...	20481...	-	-	- Read/Write Registers (reserved)

Note: Coils are mapped MSB first, i.e. coil 0 corresponds to bit 15 of register 0.

3.4. Modbus Diagnostics

The Modbus RTU interface features several diagnostic counters which increments each time the interface encounters certain pre-defined events. These counters may provide valuable clues when troubleshooting the Modbus communication, and can be accessed through the standard Modbus Diagnostic function (function code 08h).

The following sub-functions are implemented:

| #	Meaning	Description
00h	Return Query Data	Loopback; instructs the slave to return the data from the Query
0Ah	Clear Counters and Diagnostic Register	Clears all diagnostic counters
0Ch	Return Bus Communication Error Count	Returns the no. of detected CRC-errors
0Dh	Return Bus Exception Error Count	Returns the no. of exception responses previously returned by the slave
0Eh	Return Slave Message Count	Returns the number of messages addressed to the slave interface (broadcast included)

A. Technical Specification

A.1. Modbus RTU Interface Details

- **Media:**   RS485 or RS232 (specified via on-board switches)

- **Cable:**   Shielded copper cable, twisted pair

- **Topology:**   Master-slave communication

- **Isolation:**   Galvanically isolated bus electronics

- **Baudrates:**   1.2kbit/s - 57.6kbit/s (specified via on-board switches)

- **Node ID Range:**   1 - 127 (specified via on-board switches)

- **Data size:**   Up to 256 registers in each direction

- **Implemented Functions:**

  01h - "Read Coil"
  02h - "Read Input Discretes"
  03h - "Read Holding Registers"
  04h - "Read Input Registers"
  05h - "Write Coil"
  06h - "Write Single Register"
  08h - "Diagnostics" (Sub-functions 0,10,12,13 and 14)
  0Fh - "Force Multiple Coils"
  10h - "Force Multiple Registers"
  16h - "Mask Write Register"
  17h - "Read/Write Registers"

A.2. Modbus RTU Connector Pinout

#	Signal
housing	Cable shield
1	-
2	RS232 Tx
3	RS232 Rx
4	-
5	Signal Ground[a]
6	+5V Output (50mA max.)[a]
7	RS485 Line B
8	RS485 Line A
9	-
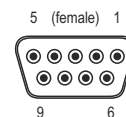
a. These pins can be used to power external bias/termination circuitry, or external equipment such as media converters etc. The maximum current consumption of such equipment must not exceed 50mA.