



# **Modbus Communication Module**

## Functional Specification

FS-0053

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# 1. Introduction

## 1.1 Purpose

This document is intended to provide the details of Oztek's Modbus communication protocol support, the Oztek Modbus Module (OMM). It describes the supported communication protocol services as well as connection to the bus or network, signaling, diagnostics, and configuration of communication specific parameters. It does not provide any register information specific to a particular application, as this level of detail is covered in separate, application-specific, communication variables specifications.

## 1.2 Referenced Documents

Ref.	Document	Description
[1]	<a href="http://www.modbus.org/specs.php">http://www.modbus.org/specs.php</a>	Modbus Organization Website

## 1.3 Definitions

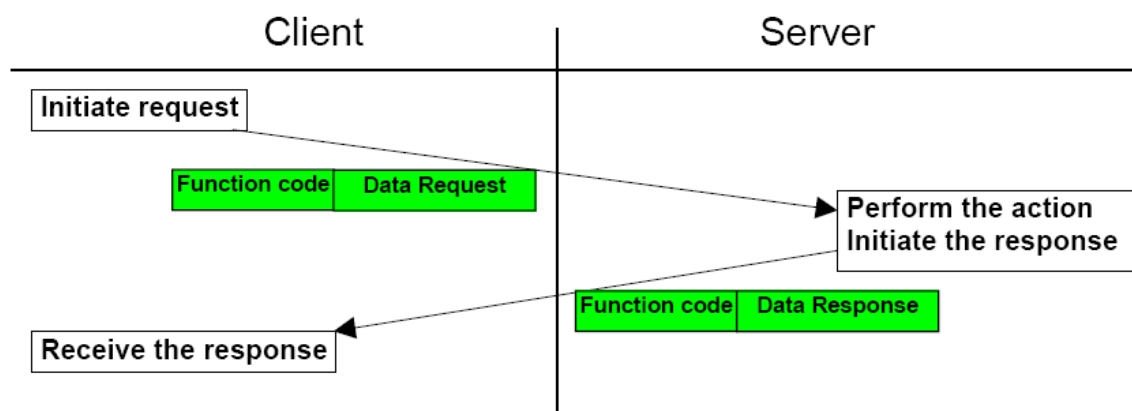
ADU	Application Data Unit
CRC	Cyclic Redundancy Check
DSP	Digital signal processor
EEPROM	Electrically Erasable Programmable Read Only Memory
GUI	Graphical User Interface
OMM	Oztek Modbus Module
PDU	Protocol Data Unit
POR	Power On Reset
RAM	Random Access Memory
RTU	Remote Terminal Unit
USB	Universal Serial Bus

# 2. Overview

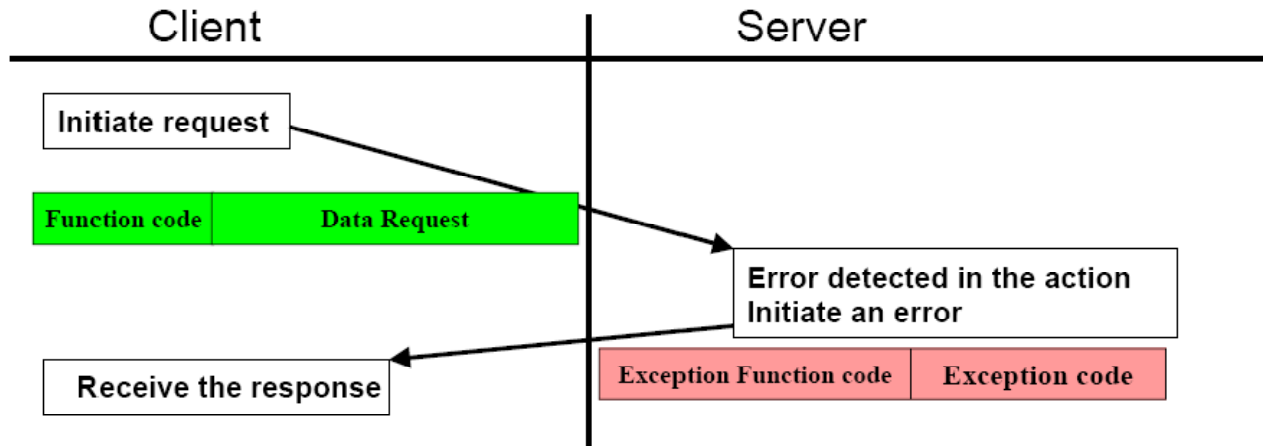
Modbus is an application layer messaging protocol, positioned at level 7 of the OSI model that provides client/server communication between devices connected on different types of buses or networks. Modbus is a request/reply protocol and offers services specified by *function codes*. Modbus function codes are elements of Modbus request/reply protocol data units (PDUs).

The MODBUS application protocol establishes the format of a request initiated by a client. The function code field indicates to the server what kind of action to perform and is coded in one byte. Valid codes are in the range of 1 ... 255 decimal (the range 128 – 255 is reserved and used for exception responses). When a message is sent from a Client to a Server device the function code field tells the server what kind of action to perform. Function code "0" is not valid. Sub-function codes are added to some function codes to define multiple actions. The data field of messages sent from a client to server devices contains additional information that the server uses to take the action defined by the function code. This can include items like discrete and register addresses, the quantity of items to be handled, and the count of actual data bytes in the field. The data field may be nonexistent (of zero length) in certain kinds of requests, in this case the server does not require any additional information. The function code alone specifies the action.

If no error occurs related to the MODBUS function requested in a properly received MODBUS ADU, the data field of a response from a server to a client contains the data requested. If an error related to the MODBUS function requested occurs, the field contains an exception code that the server application can use to determine the next action to be taken. For example a client can read the ON / OFF states of a group of discrete outputs or inputs or it can read/write the data contents of a group of registers. When the server responds to the client, it uses the function code field to indicate either a normal (error-free) response or that some kind of error occurred (called an exception response). For a normal response, the server simply echoes to the request the original function code.



For an exception response, the server returns a code that is equivalent function code from the request PDU with its most significant bit set to logic 1.



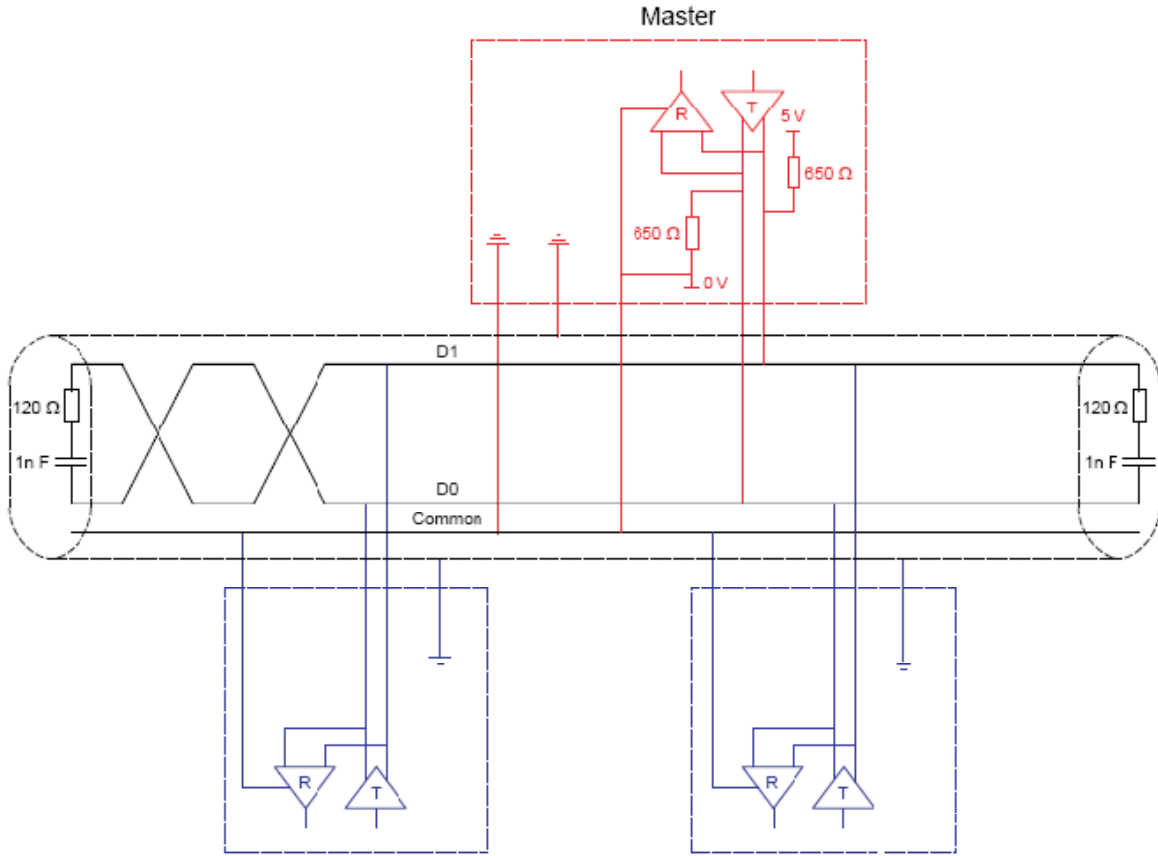
The proposed serial protocol is a simplified version of the industry standard Modbus protocol. Modbus defines a message format common to all devices on a network. This network provides the capability of connecting a single master device to up to 247 slave devices. Each slave must be assigned a unique device address.

Oztek's Modbus module provides support for a 2-wire, RS-485 physical layer and the RTU transmission mode. In addition, it supports the following functions:

- Configuration
- Settings
- Control
- Monitoring

### 3. Physical Layer

The Oztek supported physical interface corresponds to the Modbus specification published on the [Modbus.org](http://Modbus.org) site in 2002 (Modbus\_over\_serial\_line\_V1.pdf, Nov 2002) and in particular to the schematic of the 2-wire multidrop serial bus duplicated here as Figure 1.

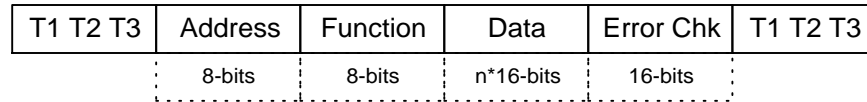


Type of trunk cable	Shielded cable with 1 twisted pair and at least a third conductor
Maximum length of bus	1000 m at 19200 bps with the Telemecanique TSX CSA●●● cable
Maximum number of stations (without repeater)	32 stations, ie. 31 slaves
Maximum length of tap links	20 m for one tap link 40 m divided by the number of tap links on a multiple junction box
Bus polarisation	One 450 to 650 Ω pulldown resistor at 5 V (650 Ω recommended) One 450 to 650 Ω pulldown resistor at the Common (650 Ω recommended) This polarisation is recommended for the master.
Line terminator	One 120 Ω 0.25 W resistor in series with a 1nF 10 V capacitor
Common polarity	Yes (Common), connected to the protective ground at one or more points on the bus

Figure 1 - Two Wire Multi-Drop Serial Bus Configuration

### 4. RTU Transmission Mode

Modbus supports two modes of transmission, ASCII (American Standard Code for Information Interchange), and RTU (Remote Terminal Unit). The OMM implementation uses the RTU transmission mode. Figure 2 shows the general order of an RTU message frame.



**Figure 2 - RTU Message Frame Format**

## 4.1 Synchronization

The Modbus specification for synchronization is as follows: Frame synchronization is established by limiting the elapsed time between receipt of characters. The T1, T2, T3 items at the beginning and end of the frame depict approximately three character times of idle time. If three character times elapse without a new character or completion of a frame, then the pending message will be flushed, and the next byte received will be treated as the address field of the message frame.

## 4.2 Address Field

The 8-bit address field defines the unique address of the slave device that is to receive the message sent by the master. When the slave sends a response, the address field informs the master which slave is communicating.

## 4.3 Function Code

The 8-bit function code tells the addressed slave what function to perform. If the slave is able to perform the requested function, the function code in the response will be that of the request. The slave will set the high order bit of the function code to one in the response to indicate an exception.

## 4.4 Data Field

The data field will vary in length according to which function is specified. This field contains information required by the slave to perform the specific function or it contains data collected by the slave in response to a query.

MODBUS uses a 'big-Endian' representation for addresses and data items. This means that when a numerical quantity larger than a single byte is transmitted, the most significant byte is sent first. For example, a 16-bit register size value of 0x1234 would be transmitted with the first byte sent being 0x12 then 0x34.

## 4.5 Error Check

The two byte error check field allows the master and slave devices to check messages for transmission errors. A Cyclic Redundancy Check (CRC) is performed by the master and the slave



devices. The error checking assures that the master or slave does not react to messages that have changed during transmission.

The CRC-16 polynomial is used to compute the checksum for the message content. The formula for the CRC-16 polynomial is:

$$x^{16} + x^{15} + x^2 + 1$$

The checksum can be computed using the following algorithm:

1. Load a 16-bit register with all 1's.
2. Exclusive OR the first 8-bit byte of the message with the high order byte of the 16-bit register, putting the result in the 16-bit register.
3. Shift the 16-bit register 1 bit to the right.
4. If the bit shifted out to the right is a 1, exclusive OR the generating polynomial (1010 0000 0000 0001) with the 16-bit register. If the bit is a 0, do not modify the register.
5. Repeat steps 3 & 4 until 8 shifts have been performed.
6. Exclusive OR the next 8-bit byte of the message with the 16-bit register.
7. Repeat steps 3 through 6 until all bytes of the message have been exclusive OR'd with the 16-bit register and shifted eight times.
8. The final content of the register is the CRC value

When the 16-bit CRC value is transmitted in the message, the low-order byte must be transmitted first, followed by the high-order byte.

## 4.6 Exception Response

Exception responses are the result of an illegal request by the master device. When a slave device detects an error, it sends a response message to the master consisting of the slave address, function code (with high order bit set to one), error code (8-bits), and the CRC error check. The exception error codes are as follows:

**Table 1 - Modbus Exception Codes**

Code	Name	Meaning
01	Illegal Function	The message function received by the slave is not supported by Oztek.
02	Illegal Data Address	The address (in the write request) or start address (in the read request) referenced in the data field is not valid.
03	Illegal Data Value	The value or count specified in the data field is not allowable.

## 5. Function Code Descriptions

The OMM implementation provides a subset of the available Modbus functions, namely functions 3 (Read Holding Registers), 6 (Preset Single Register), and 8 (Communication Loopback test).

### 5.1 Read Holding Registers (Function Code 03)

This function code allows the master to obtain the binary contents of registers from the addressed slave.

Query Format:

Slave Address	Function Code	Starting Address	# of Registers	Error Chk
8-bits	8-bits	16-bits	16-bits	16-bits

The response includes the slave address, function code, length of response values in bytes, the response values, and error check. The data consists of two bytes for each register, with the binary content right justified within each pair. The first byte includes the high order bits and the second, the low order bits.

Response Format:

Slave Address	Function Code	Data Length	Data ... Data	Error Chk
8-bits	8-bits	8-bits	16-bits 16-bits	16-bits

### 5.2 Preset Single Command Register (Function Code 06)

This function code allows the master to modify the contents of a single command register of the addressed slave. The registers are numbered from zero; (register number 1 = zero, register number 2 = one, etc.).

Query Format:

Slave Address	Function Code	Register Address	Register Value	Error Chk
8-bits	8-bits	16-bits	16-bits	16-bits

The normal response will be identical to the request after the register value has been written.

Response Format:

Slave Address	Function Code	Register Address	Register Value	Error Chk
8-bits	8-bits	16-bits	16-bits	16-bits

### 5.3 Loopback Test (Function Code 08)

This function code allows the master to test the operation of the communication system. The diagnostic code 00 (Return Query Data) will return the entire message to the master from the addressed slave.

Query Format:

Slave Address	Function Code	Diagnostic Code	Data Value	Error Chk
8-bits	8-bits	16-bits	16-bits	16-bits

The normal response will be identical to the request if the loopback test is successful.

Response Format:

Slave Address	Function Code	Diagnostic Code	Data Value	Error Chk
8-bits	8-bits	16-bits	16-bits	16-bits

# Warranty and Product Information

## Limited Warranty

**What does this warranty cover and how long does it last?** This Limited Warranty is provided by Oztek Corp. ("Oztek") and covers defects in workmanship and materials in your product. This Warranty Period lasts for 18 months from the date of purchase at the point of sale to you, the original end user customer, unless otherwise agreed in writing. You will be required to demonstrate proof of purchase to make warranty claims. This Limited Warranty is transferable to subsequent owners but only for the unexpired portion of the Warranty Period. Subsequent owners also require original proof of purchase as described in "What proof of purchase is required?"

**What will Oztek do?** During the Warranty Period Oztek will, at its option, repair the product (if economically feasible) or replace the defective product free of charge, provided that you notify Oztek of the product defect within the Warranty Period, and provided that through inspection Oztek establishes the existence of such a defect and that it is covered by this Limited Warranty.

Oztek will, at its option, use new and/or reconditioned parts in performing warranty repair and building replacement products. Oztek reserves the right to use parts or products of original or improved design in the repair or replacement. If Oztek repairs or replaces a product, its warranty continues for the remaining portion of the original Warranty Period or 90 days from the date of the return shipment to the customer, whichever is greater. All replaced products and all parts removed from repaired products become the property of Oztek.

Oztek covers both parts and labor necessary to repair the product, and return shipment to the customer via an Oztek-selected non-expedited surface freight within the contiguous United States and Canada. Alaska, Hawaii and locations outside of the United States and Canada are excluded. Contact Oztek Customer Service for details on freight policy for return shipments from excluded areas.

**How do you get service?** If your product requires troubleshooting or warranty service, contact your merchant. If you are unable to contact your merchant, or the merchant is unable to provide service, contact Oztek directly at:

USA  
Telephone: 603-546-0090  
Fax: 603-386-6366  
Email [techsupport@oztekcorp.com](mailto:techsupport@oztekcorp.com)

Direct returns may be performed according to the Oztek Return Material Authorization Policy described in your product manual.

**What proof of purchase is required?** In any warranty claim, dated proof of purchase must accompany the product and the product must not have been disassembled or modified without prior written authorization by Oztek. Proof of purchase may be in any one of the following forms:

- The dated purchase receipt from the original purchase of the product at point of sale to the end user
- The dated dealer invoice or purchase receipt showing original equipment manufacturer (OEM) status
- The dated invoice or purchase receipt showing the product exchanged under warranty

**What does this warranty not cover?** Claims are limited to repair and replacement, or if in Oztek's discretion that is not possible, reimbursement up to the purchase price paid for the product. Oztek will be liable to you only for direct damages suffered by you and only up to a maximum amount equal to the purchase price of the product. This Limited Warranty does not warrant uninterrupted or error-free operation of the product or cover normal wear and tear of the product or costs related to the removal, installation, or troubleshooting of the customer's electrical systems. This warranty does not apply to and Oztek will not be responsible for any defect in or damage to:

- a) The product if it has been misused, neglected, improperly installed, physically damaged or altered, either internally or externally, or damaged from improper use or use in an unsuitable environment
- b) The product if it has been subjected to fire, water, generalized corrosion, biological infestations, or input voltage that creates operating conditions beyond the maximum or minimum limits listed in the Oztek product specifications including high input voltage from generators and lightning strikes
- c) The product if repairs have been done to it other than by Oztek or its authorized service centers (hereafter "ASCs")
- d) The product if it is used as a component part of a product expressly warranted by another manufacturer
- e) The product if its original identification (trade-mark, serial number) markings have been defaced, altered, or removed
- f) The product if it is located outside of the country where it was purchased
- g) Any consequential losses that are attributable to the product losing power whether by product malfunction, installation error or misuse.

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## Return Material Authorization Policy

Before returning a product directly to Oztek you must obtain a Return Material Authorization (RMA) number and the correct factory "Ship To" address. Products must also be shipped prepaid. Product shipments will be refused and returned at your expense if they are unauthorized, returned without an RMA number clearly marked on the outside of the shipping box, if they are shipped collect, or if they are shipped to the wrong location.

When you contact Oztek to obtain service, please have your instruction manual ready for reference and be prepared to supply:

- The serial number of your product
- Information about the installation and use of the unit
- Information about the failure and/or reason for the return
- A copy of your dated proof of purchase

### Return Procedure

Package the unit safely, preferably using the original box and packing materials. Please ensure that your product is shipped fully insured in the original packaging or equivalent. This warranty will not apply where the product is damaged due to improper packaging. Include the following:

- The RMA number supplied by Oztek clearly marked on the outside of the box.
- A return address where the unit can be shipped. Post office boxes are not acceptable.
- A contact telephone number where you can be reached during work hours.
- A brief description of the problem.

Ship the unit prepaid to the address provided by your Oztek customer service representative.

**If you are returning a product from outside of the USA or Canada** - In addition to the above, you **MUST** include return freight funds and you are fully responsible for all documents, duties, tariffs, and deposits.

### Out of Warranty Service

If the warranty period for your product has expired, if the unit was damaged by misuse or incorrect installation, if other conditions of the warranty have not been met, or if no dated proof of purchase is available, your unit may be serviced or replaced for a flat fee. If a unit cannot be serviced due to damage beyond salvation or because the repair is not economically feasible, a labor fee may still be incurred for the time spent making this determination.

To return your product for out of warranty service, contact Oztek Customer Service for a Return Material Authorization (RMA) number and follow the other steps outlined in "Return Procedure".

Payment options such as credit card or money order will be explained by the Customer Service Representative. In cases where the minimum flat fee does not apply, as with incomplete units or units with excessive damage, an additional fee will be charged. If applicable, you will be contacted by Customer Service once your unit has been received.