R

Library ModbusRTUlib
Modbus RTU master communication

TXV 003 52.02
3rd Issue
February 2010

History of changes

Date	Issue	Description of changes
April 2009	1	First issue of ModbusRTULib_V10 library
August 2009	2	*StAdr* range corrected (0000..9999) Link to constants for *chanCode* was added Parameter *MBtimeOut* for the settings of waiting time for response was added New version of ModbusRTUlib_V11 library
February 2010	3	Corrected displaying of ErrCode taken over from ComLib Corrected error message description in the table in chapter 2.5 New version of ModbusRTUlib_V12 library

CONTENT

1 INTRODUCTION

Libraries of functions and function blocks are an inseparable part of the installation of the Mosaic programming environment. It is possible to divide them into the following types:

- built-in libraries
- standardly supplied external libraries
- user defined libraries

A library contains declarations of functions, function blocks, data types and global variables for Modbus master communication. Library ModbusRTUlib uses some functions from ComLib and CrcLib library.

The Library is delivered with the Mosaic development environment from 2.0.16.0 version. Function and Function blocks of ModbusRTUlib library are supported by CPU line K (TC700 CP-7004 and all variants of Foxtrot systems) from version 4.4..

1.1 Modbus RTU protocol

The open serial protocol Modbus RTU was released by Modicon company in 1979. Modbus is an application layer messaging protocol for client/server communication between devices connected on different types of buses or networks.

Modbus interchanges data between one master and one or more slave devices over asynchronous serial lines . Master device queries and the other devices response.

Modbus over Ethernet is called Modbus TCP. The Internet community can access MODBUS at a reserved system port 502 on the TCP/IP stack. Principle of data transfer and communication functions is similar Modbus RTU. More clients and servers can communicate all at once in Ethernet networks.

For more details, please see documents at http://www.Modbus-IDA.org :

Modbus_Application_Protocol_V1_1b.pdf
Modbus_over_serial_line_V1_02.pdf
Modbus_Messaging_Implementation_Guide_V1_0b.pdf
Open Mmodbus/TCP Specification.pdf

1.2 Memory data encoding

Modbus uses „Big Endian“ representation to store data in address space (like Motorola standard). This means when a numerical quantity larger than a single byte is put in memory, the most significant byte is stored at the lowest address and the least significant byte at the highest address.. The most significant byte is sent first in the data telegram.

Value 0x1234 is put first 0x12 after 0x34
Value 0x5678 is put first 0x56 after 0x78

address	data
0	0x12
1	0x34
2	0x56
3	0x78

On the other hand PLC Tecomat uses „ Little Endian“ representation for addresses and data items (like Intel standard). This means that when a numerical quantity larger than a single byte is put in memory, the less significant byte is stored at the lowest address. The less significant byte is sent first in the data telegram.

Value 0x1234 is put first 0x34 after 0x12
Value 0x5678 is put first 0x78 after 0x56

address	data
0	0x34
1	0x12
2	0x78
3	0x56

1.3 Modbus protocol public functions

Tab.1 MODBUS protocol promoted functions

Code	Function	Description
01	Read Coil Status	read outputs (memory 0X)
02	Read Input Status	read inputs (memory 1X)
03	Read Holding Registers	read holding registers (memory 4X)
04	Read Input Registers	read input registers (memory 3X)
05	Force Single Coil	set one output (memory 0X)
06	Preset Single Register	set one register (memory 4X)
07	Read Exception Status *)	read exception status
08	Diagnostics *)	read diagnostic status
15	Force Multiple Coils	set multiple outputs (memory 0X)
16	Preset Multiple Registers	set multiple holding registers (memory 4X)
17	Report Slave ID *)	report slave ID

*) for serial line only

1.4 Modbus Data model

Objects	Object type	Access	Data provided by	Memory
Coils	array of single bits	read/write	application program	0xxxx
Discrete inputs	array of single bits	read only	I/O system	1xxxx
Inputs registers	array of 16-bits words	read only	I/O system	3xxxx
Holding registers	array of 16-bits words	read/write	application program	4xxxx

Object numbering in MODICON systems starts from number 1. Objects in the areas 0xxxx and 1xxxx are numbered as single one after another following bits. When number of transmitted objects is entered, it means that this is a number of transmitted bits. Objects in the areas 3xxxx and 4xxxx are numbered as 16bit words and a number of transmitted objects is a number of words following one after another.

2 FUNCTION AND FUNCTION BLOCK FOR MODBUS

Library **ModbusRTULib** contains following function and blocks:

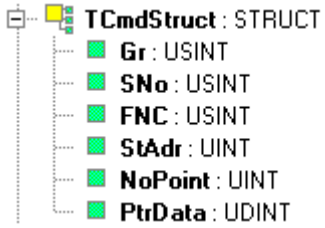
- *ModbusCmd* function to form communication command
- *ModbusRTUmas* FB performing communication commands
- *GetModbusErrTxt* function converting error code to text

The function block uses some functions from **ComLib** and **CrcLib** libraries. These libraries have to be added to the project before the first compilation is performed.

2.1 Modbus master control commands description

Application requires data exchange among more devices and various points inside memory. This exchange must be described by array of commands.

Command structure is called *TCmdStruct*:



Where:

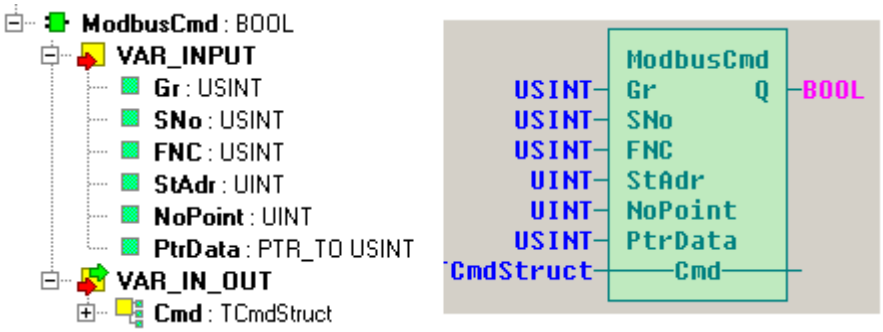
Variable	***Description***
Gr	Command group number for control in an auto mode or a manual mode. (1..255)
SNo	Slave station number from 1 to 247; 0..broadcast; >247 reserved
FNC	Modbus function code (see tab.1)
StAdr	Starting address of objects inside Modbus device (0000..9999)
NoPoint	Number read or written data objects (type BOOL 1 ... 2000 or WORD 1 ... 125)
PtrData	Pointer to array of read/written variables in PLC Tecomat

Each command refer to one communication function. It specifies from where and how many data will transmitted.

Commands can be performed in manual or automatic mode:
If command group number Gr = 1 then command is processed cyclically in automatic mode.
If command group number Gr = 255 then command is processed once after start in automatic mode.
Commands with other group numbers are processed cyclically when parameter *GrSel* is equal to command group number.

2.2 ModbusCmd function

ModbusCmd function forms commands for Modbus communication control. Input parameters are put to variable of *TcmdStruct* type.



Function definition in ST language:

```
FUNCTION ModbusCmd : BOOL;
  VAR_INPUT
    Gr       : USINT;
    SNo      : USINT;
    FNC      : USINT;
    StAdr    : UINT;
    NoPoint  : UINT;
    PtrData  : UDINT;
  END_VAR
  VAR_IN_OUT
    Cmd      : TCmdStruct;
  END_VAR
END_FUNCTION
```

Library : ***ModbusRTUlib***

Variable description:

	Variable	*Type*	*Description*
VAR_INPUT			
	Gr	USINT	Command group number for control in an auto mode or a manual mode. (1..255)
	SNo	USINT	Slave station number from 1 to 247; 0..broadcast; >247 reserved for another use
	FNC	USINT	Modbus function code (see tab.1)
	StAdr	UINT	Starting address of objects inside Modbus device (0000..9999)
	NoPoint	UINT	Number of read/written data objects (type BOOL 1 ... 2000 or WORD 1 ... 125)
	PtrData	PTR_TO USINT	Pointer to array of read/write variables in PLC Tecomat
VAR_IN_OUT			
	Cmd	TCmdStruct	Resultant command for one communication control
ModbusCmd			
	Q	BOOL	Returns 1 when Gr <>0

Example of calling functions in ST language. Two commands are formed for CH2 channel.:

```
VAR_GLOBAL
  Temper   : REAL; // temperatures
  Temper1  : REAL;
  Press    : REAL; // pressures
  Press1   : REAL;
  Press2   : REAL;
  CmdCH2   : ARRAY [1..2] OF TCmdStruct; // Array of Modbus commands for CH2 channel
END_VAR

PROGRAM prgMain
ModbusCmd(Gr:=1,FNC:=03,SNo:=1,StAdr:=1,NoPoint:=4,PtrData:=adr(Temper),Cmd:=CmdCH2[1]);
ModbusCmd(Gr:=1,FNC:=03,SNo:=2,StAdr:=5,NoPoint:=6,PtrData:=adr(Press), Cmd:=CmdCH2[2]);
END_PROGRAM
```

First command will read four words from first object from station number 1 to variable *Temper* in PLC Tecomat by function *03 Read Holding Registers*.

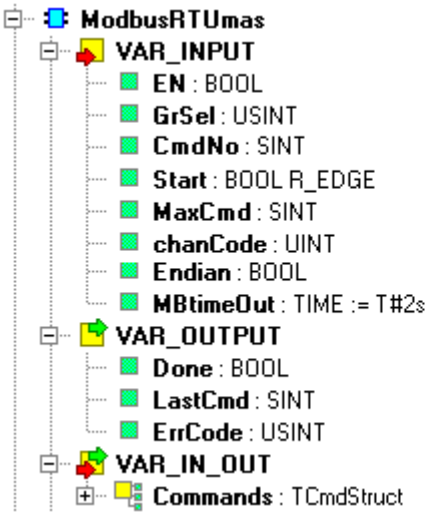
Second command will read six words from fifth object from number station 2 to variable *Press* in PLC Tecomat by function *03 Read Holding Registers*.

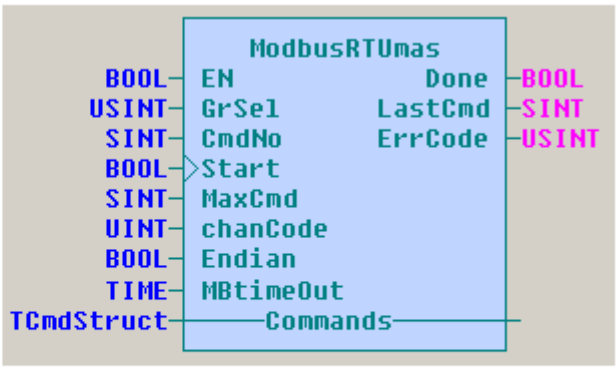
Both commands are written to array commands *CmdCH2*.

Variable are of REAL type. REAL occupies two words therefore parameter *NoPoint* is twice more than number of variables.

2.3 ModbusRTUmas function block

ModbusRTUmas function block arranges communication relations according to the commands prepared before and exchanges data among master PLC and connected to slave device via selected communication channel.





Library : *ModbusRTUlib*

Variable description:

	Variable	*Type*	*Description*
VAR_INPUT			
	En	BOOL	Enable of FB.
	GrSel	USINT	Selects the sequence of sending commands 0 - Manual mode. The command defined by CmdNo is sent. 1 - Auto mode. The commands with Gr=1 are sent cyclically. >1 - Auto mode, The commands with Gr=1 and Gr = GrSel are

	Variable	*Type*	*Description*
			sent cyclically.
	CmdNo	SINT	Command number that will be sent in the manual mode
	Start	BOOL R_EDGE	Command in manual mode will be executed when rising edge appears.
	MaxCmd	SINT	Total number of commands in the control array.
	chanCode	UINT	Code of channel used for communication (see comLib)
	Endian	BOOL	Coding bytes in word ; 0 - BigEndian; 1 - LittleEndian
	MBtimeOut	TIME	Modbus timeout (by default 2 [sec])
VAR_IN_OUT			
	Commands	TCmdStruct	Array of commands for Modbus communication control
VAR_OUTPUT			
	Done	BOOL	Communication done without error
	LastCmd	SINT	Last command number
	ErrCode	USINT	Error code

Manual mode (GrSel = 0) :

FB *ModbusRTUmas* performs one-shot command with *CmdNo* on rising edge of *Start* variable if *En* variable is set to *true*.

Automatic mode (GrSel > 0)

In the first cycle after *En* variable is set to true all commands with Gr = 255 are performed. These commands are used for a slave device initialisation. The commands with Gr=1 and Gr = GrSel are performed in next cycles in the order in which commands are written in the array of Modbus control commands.

Parameter *chanCode*:

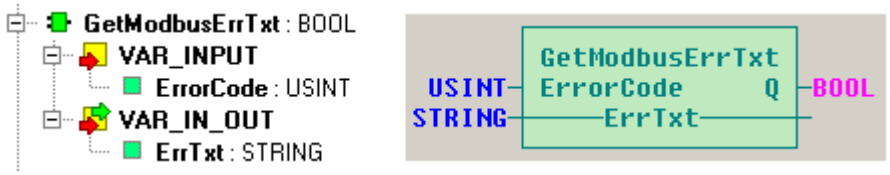
Serial communication channels in PLC Tecomat are called CH1_UNI,... CH10_UNI. They can be fitted by various interface submodules RS-232, RS-485, RS-422 etc.

Ethernet communication channels in PLC Tecomat are called ETH1_UNI0,... ETH1_UNI7. If the Ethernet communication channel is selected, the data telegrams are formed by the function block according to Modbus TCP specification.

Names CH1_UNI,... CH10_UNI and ETH1_UNI0,... ETH1_UNI7 are the names of UINT type constants defined in the ComLib library.

2.4 GetModbusErrTxt function

GetModbusErrTxt function transforms error code from *ModbusRTUmas FB* to error text report and saves it to STRING type variable.



Library : *ModbusRTUlib*

Variable description:

	Variable	*Type*	*Description*
VAR_INPUT			
	ErrorCode	USINT	Error code
VAR_IN_OUT			
	ErrTxt	STRING	Error description
GetModbusErrTxt			
	Q	BOOL	Returns log. 1 if Gr <>0

2.5 Error report code

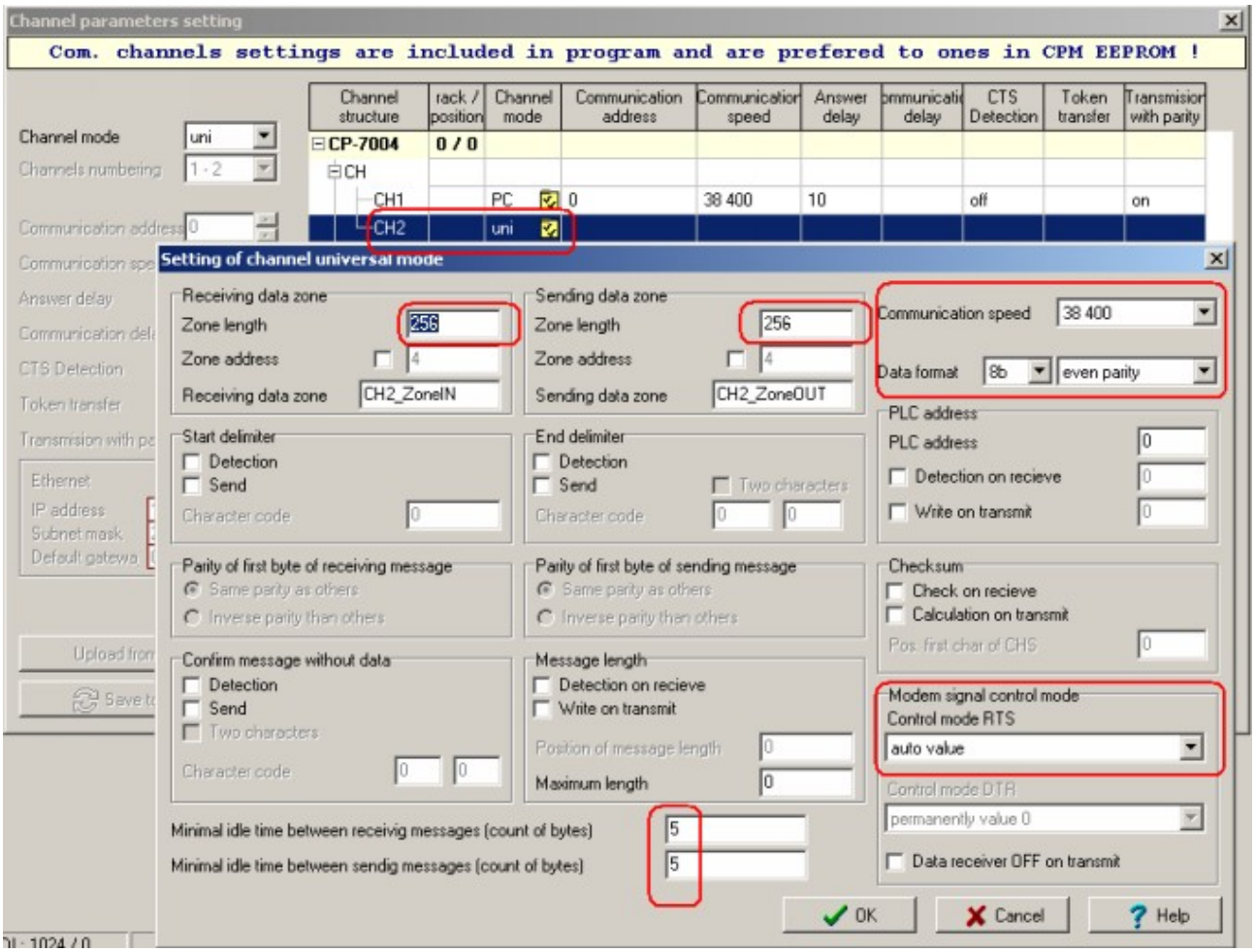
0 ... No error	
1 ... Channel is not in uni mode	
2 ... Sending data are too long	
3 ... Received data are too long	
4 ... Wrong channel code	
5 ... Previous message is not sent yet	
6 … Length of data to sent is zero	
16 ... Invalid start delimiter	
17 ... Parity error	
18 ... Maximum message length exceeded	
19 ... Invalid second byte of acknowledgement	
20 ... Invalid second byte of end delimiter	
24 ... Check sum error	
25 ... Invalid end delimiter	
49 ... Invalid length of sent data	
50 ... Length of data to sent is zero	
64 ... Timeout not held	
129 ... Response with other slave address	
130 ... Response with other FNC	
131 ... Checksum error in reception	
132 ... Unknown FNC in transmit command	
133 ... Response with Unknown FNC	
135 ... Response Timeout Error	
137 ... Exception: ILLEGAL FUNCTION	
138 ... Exception: ILLEGAL DATA ADDRESS	
139 ... Exception: ILLEGAL DATA VALUE	
140 ... Exception: SLAVE DEVICE FAILURE	
141 ... Exception: ACKNOWLEDGE	
142 ... Exception: SLAVE DEVICE BUSY	
144 ... Exception: MEMORY PARITY ERROR	
146 ... Exception: GATEWAY PATH UNAVAILABLE	
147 ... GATEWAY TARGET DEVICE FAILED TO RESPOND	

Errors 1..16 are general errors taken over from communication library ComLib.
Errors 137..147 are returned from slave device.
The detail description is available in Modbus_Application_Protocol_V1_1b.pdf

3 COMMUNICATION CHANNEL SETTING

Modbus RTU functions require channels set to UNI mode. This setting can be made in the project manager.

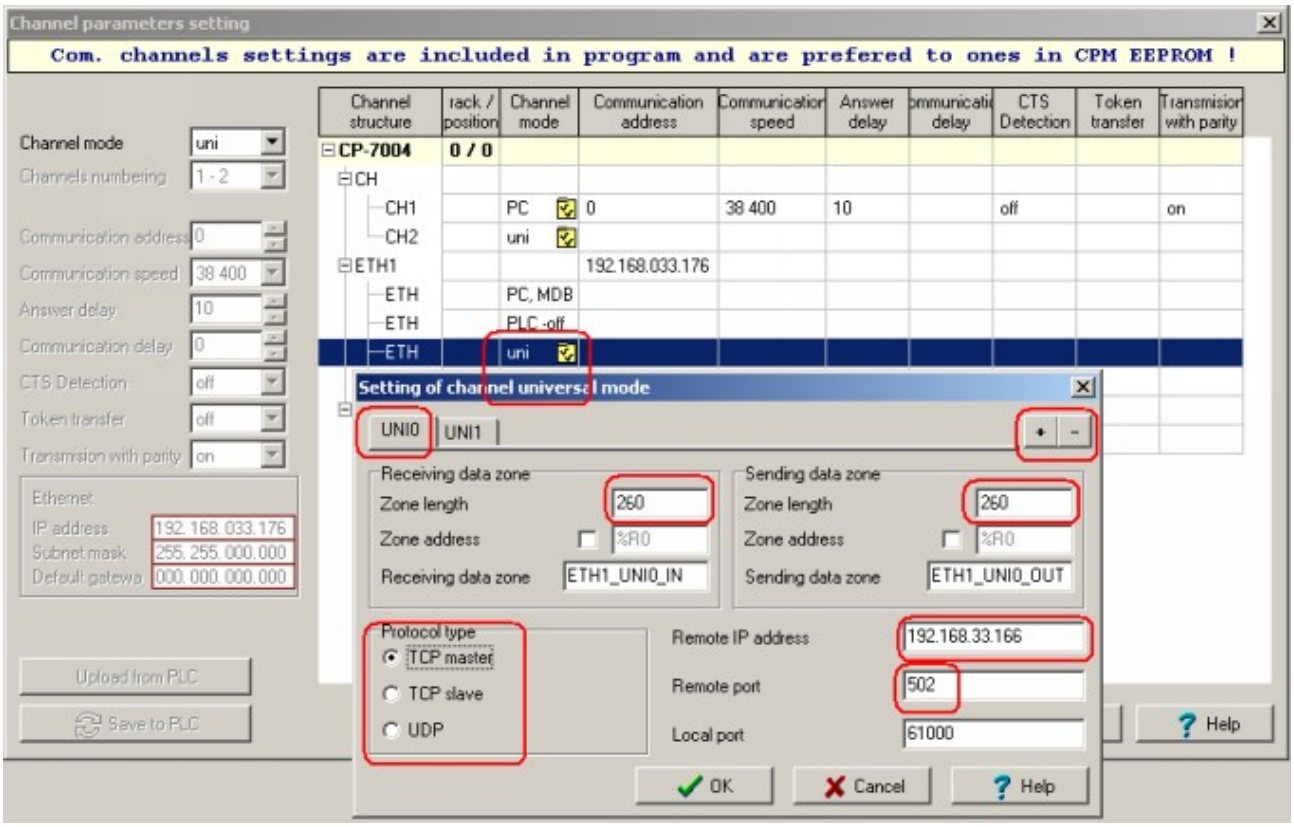
3.1 Serial channel setting for Modbus master



Open channel parameters setting in Project manager | HW configuration (yellow icon near CPU). Set desired channel (for example CH2) to UNI mode. Open setting of channel universal mode (yellow icon at desired channel). Sending and receiving zone length should be **256** byte and minimal idle times **greater than zero** and control mode RTS set to **auto**. Communication speed, data format, parity should be set according slave device (see previous picture). If the slave device has set no parity you have to set parity permanently 1 because Modbus RTU protocol requires two stopbits when no parity is set. Channel has to be equipped with submodule MR-01xx type according to interface type RS-232,485,422.

Note:
For completeness let's mention Modbus slave is accessible in CPU Tecomat when MBD mode is set on the communication channel.

3.2 Ethernet channel setting for Modbus master



Open channel parameters setting in Project manager | HW configuration (yellow icon on CPU line). Enable ETH-uni channel in channel setting dialogue. Open setting of channel universal mode (yellow icon at ETH-uni). Choose tab UNI0...UNI7 or add tabs by plus/minus buttons. Sending and receiving zone length should be **260** bytes and remote port **502**. Remote IP address and protocol type (TCP master and UDP) should be set according to slave device (see previous picture).

Note:

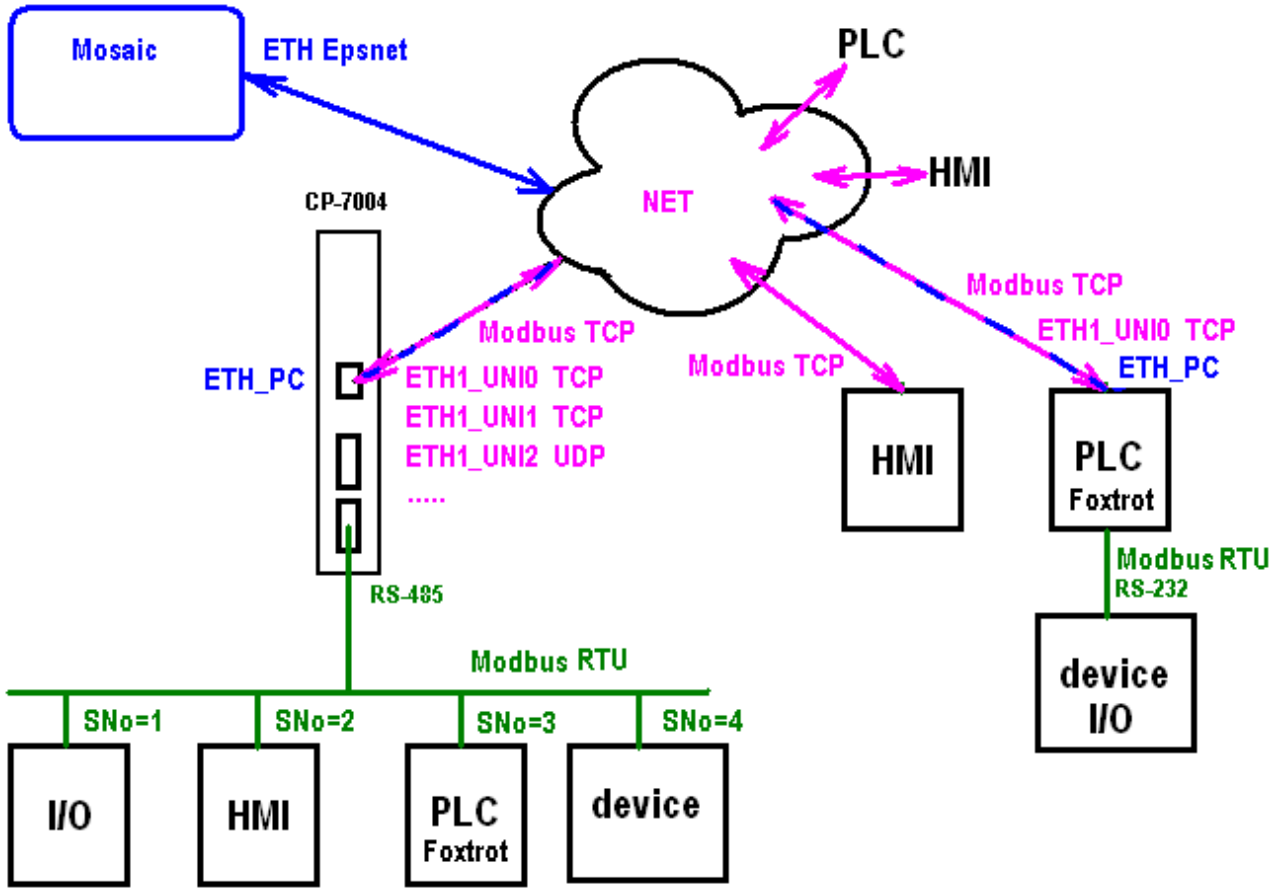
TCP protocol have is characterized by better transfer protection but longer refresh time. TCP protocol is appropriate for wide networks. UDP is more flexible and appropriate for local networks or point to point connection.

Note:

For completeness let's mention Modbus Ethernet slave is accessible at port 502 in CPU Tecomat from SW version 4.4 (max. two sockets). It means that at maximum two master stations can access to one PLC slave via Modbus protocol.

4 MODBUS MASTER COMMUNICATION EXAMPLES

4.1 Modbus devices network topology



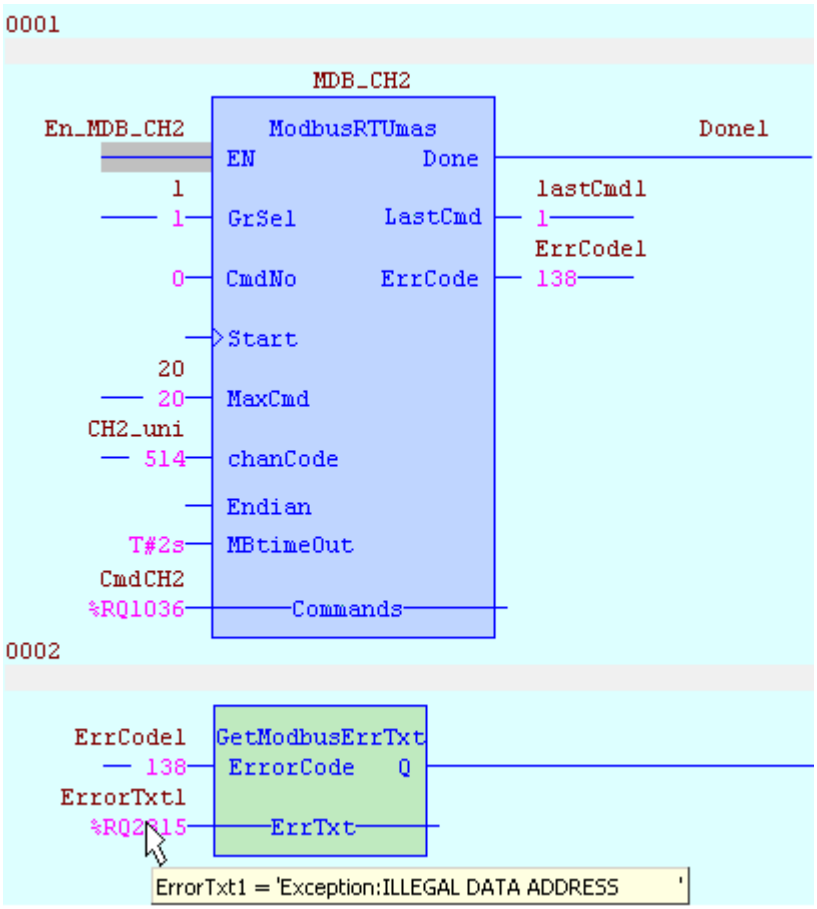
Serial line communication can work as Master-Slave on more channels simultaneously. In Ethernet network it is possible to combine different communications among devices. A master can direct its communications to eight slave devices with various IP addresses at a time. There can run any other communication for example with development environment Mosaic or another PLC at the same time.

4.2 Example 1 - communication by serial channel

Example of a communication among the master and two slave devices. Channel CH2 has to be equipped with MR-0114 submodule with RS-485 interface. **ModbusCmd** function is called to form two commands for channel CH2 in ST language.

```
VAR_GLOBAL
  Temper   : REAL; // temperatures
  Temper 1 : REAL;
  Press    : REAL; // pressures
  Press1   : REAL;
  Press2   : REAL;
  CmdCH2   : ARRAY [1..2] OF TCmdStruct; // Modbus commands array for channel CH2 control
END_VAR
PROGRAM prgMain
 VAR
 END_VAR
ModbusCmd(Gr:=1,FNC:=03,SNo:=1,StAdr:=1,NoPoint:=4,PtrData:=adr(Temper),Cmd:=CmdCH2[1]);
ModbusCmd(Gr:=1,FNC:=03,SNo:=2,StAdr:=5,NoPoint:=6,PtrData:=adr(Press), Cmd:=CmdCH2[2]);
END_PROGRAM
```

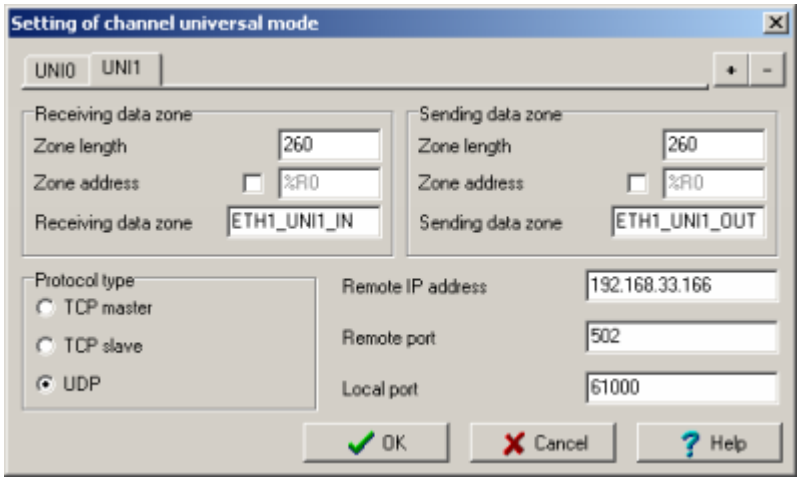
Network 0001 contains **ModbusRTUmas** function block. It is called in FBD language. There is used communication channel CH2. Picture shows debug mode. FB just returns error code from first command now. Network 0002 contains **GetModbusErrTxt** function which transforms error code from variable *ErrCode1* to text and writes it to variable *ErrorTxt1*.



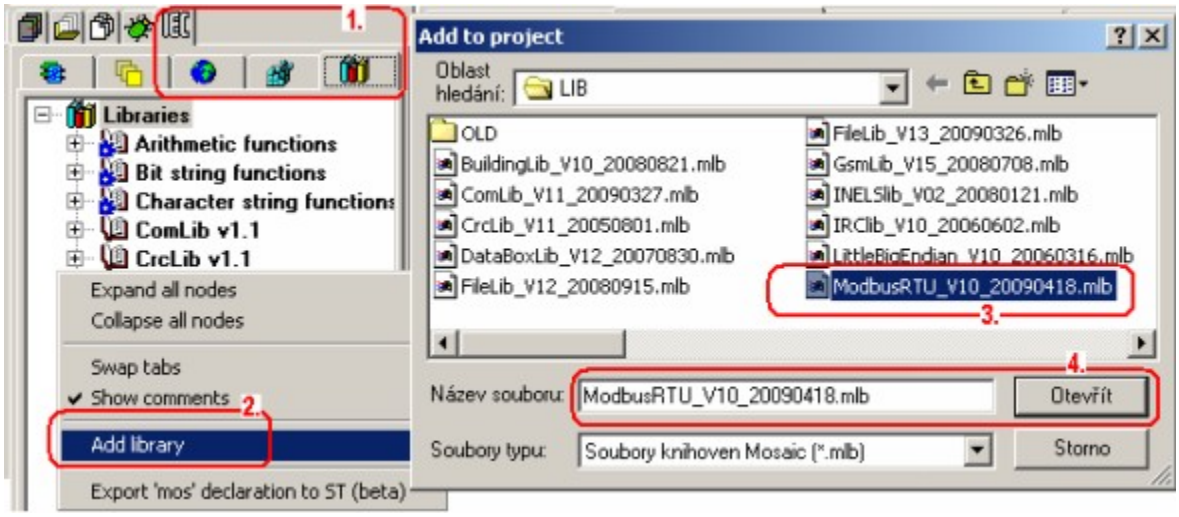
Note:
Moving mouse cursor over text variable shows a hint about the error description in a moment.

4.3 Example 2 - *simple Modbus TCP communication*

Simple example for Modbus TCP communication in ST language.
First we have to set Ethernet channel (see chapter 3.2). Remote IP address, remote port 502 - Modbus, protocol type and zone lengths have been set on ETH1_UNI1 channel.



In IEC manager | libraries we choose an option „Add library“ by right mouse button. Step by step add libraries **ComLib**, **CRClib** a **ModbusRTULib.** Order of libraries is significant for compiler. Order can be changed in window „**Files in project**“ on the left pane of Mosaic environment.



Program is reading six words from end device via Ethernet. Unused input/output parameters of called FB needn't to be written. Its values stay implicit (false or 0 according to its type). Control command array has one item only. Communication period may be conditioned by connecting suitable periodic signal to input *En*.

```
VAR_GLOBAL
  Tempr1    : REAL;                      // temperatures
  Tempr2    : REAL;
  Tempr3    : REAL;
  CmdTCP1 : ARRAY [1..2] OF TCmdStruct;// Array of Modbus commands for ETH1_UNI1
END_VAR

PROGRAM prgMain
VAR
  MDB_TCP : ModbusRTUmas; // definition of ModbusRTUmas FB instance
  Done2    : BOOL;
  LastCmd2: SINT;
  ErrCode2: USINT;
END_VAR

ModbusCmd(Gr:=1,FNC:=03,SNo:=0,StAdr:=1,NoPoint:=6,PtrData:=adr(Tempr1),Cmd:=CmdTCP1[1]);
MDB_TCP(EN := true, GrSel := 1, MaxCmd := 2, chanCode := ETH1_UNI1,
          LastCmd => LastCmd2, ErrCode => ErrCode2, Commands := CmdTCP1[1]);
END_PROGRAM
```

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