MV electrical network management

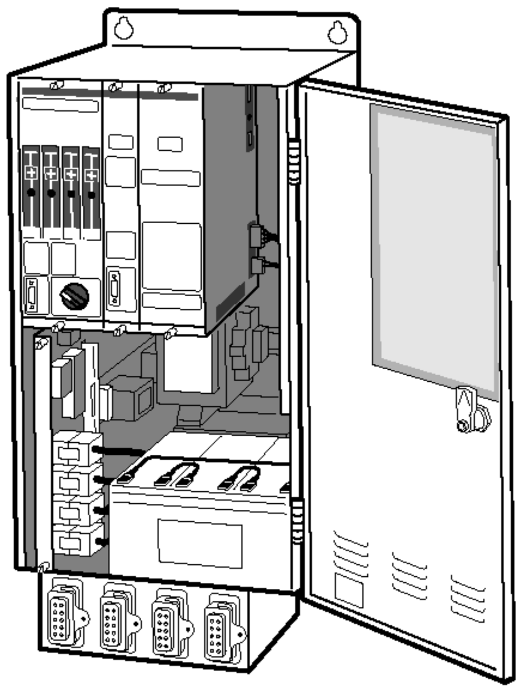
Easergy range

T200 & Flair 200C & R200-ATS100

MV substation control and monitoring units

Modbus communication

Appendix to the User Manual



Schneider Electric

Contents

1 Introduction

This appendix to the User Manual is designed to provide aid with setting up a telecontrol network using the MODBUS protocol. It will therefore provide information to help choose an operating mode, to make the corresponding configuration settings and to analyse any problems faced.

For this purpose, the following will be found:

- References of documents relating to this protocol
- Operating principles, with
  - a brief description of the specification and fundamentals of the protocol;
  - a description of the various operating modes with help in choosing between them;
  - a list of the types of data exchanged;
  - a description of the main functionalities.
  - a description of the MODBUS TCP protocol.
- The configuration settings to be made, with
  - general configuration of the protocol;
  - specific configuration.
- Maintenance aid facilities
- A glossary of specific terms
- Object addressing tables which can serve as a model for establishing databases for the T200 and the Flair 200C
- The descriptive documents specified in the protocol specifications.

All along the documentation, the T200 is taken as an example. The software features of the T200 and Flair 200C are the same. As a result, the same information can be used indifferently with the T200 or with the Flair 200C.

2 References

As mentioned above, the purpose of this appendix is to help the user set up a network. It is not intended to provide a detailed explanation of the protocol specified in the documents referenced below. It is not necessary to read these documents. However, the user faced with a specific problem or wanting to have a more precise knowledge of this protocol will find it useful to read them. They are available on the website of the Modbus-IDA organization (www.modbus.org) which brings together independent users and suppliers.

Their references are as follows:

- Modicon - Modbus Protocol - Reference Guide (June 1996)
- MODBUS Protocol Application Specification - V1.1b (28 December 2006)
- MODBUS over Serial Line - Specification and Implementation Guide - V1.02 (20 December 2006)

3 Principles

3.1 General

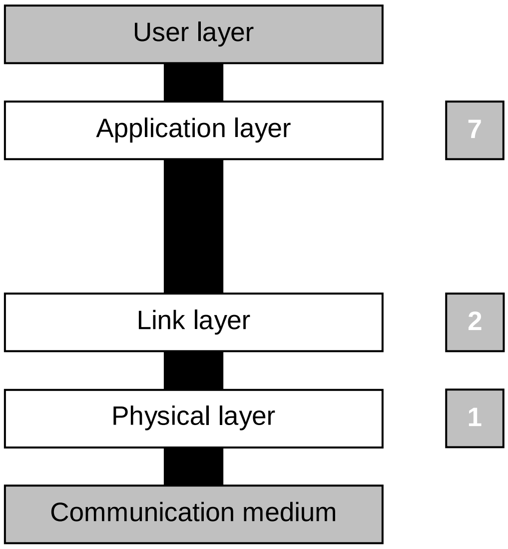
1. MODBUS is a messaging protocol which allows client/server type communications between devices connected to various types of bus or networks.
2. It was originally developed by the company Modicon and, from 1979, became the de facto industrial standard for serial transmission.
3. Nowadays, millions of devices in the automatic control field use it for their communications. The enthusiasm for this simple and elegant structure has enabled it to become established in other fields, and its use is constantly expanding. The Internet community can obtain access to it on port 502 (reserved port) of the TCP/IP stack.
4. This protocol uses a question-and-answer system and offers services specified by function codes.

3.2 ISO Model

MODBUS is positioned on level 7 (application layer) of the ISO model. The document entitled "MODBUS over Serial Line" provides a complement by describing, in the specific case of a serial link, levels 1 (physical layer) and 2 (link layer), thus providing a complete description based on the *EPA (Enhanced Performance Architecture*) 3-layer ISO model which is a simplified version of the 7-layer ISO model.

The three layers described are as follows:

- Physical layer;
- Link layer;
- Application layer.



3.3 Transmission modes

▶**General:**

The MODBUS protocol operates in master/slave mode. The Supervisor is the master and questions the T200 which, as slave, merely replies to the master's requests. The SCADA system therefore operates by *polling* to know the T200 states.

However, to be able to limit communications on non-permanent transmission media, the T200 is capable of generating a call to the SCADA. The latter, in reply, can obtain, by a method that we shall describe in detail later, the address of the calling T200, and thus obtain the changes that the T200 wants to report to it. This operating mode is called *Report by exception*.

Transmission takes place asynchronously at speeds ranging from 200 to 38400 baud depending on the transmission medium. Each MODBUS frame consists of a start bit, 8 data bits and a stop bit.

The MODBUS protocol makes it possible to read or write one or more bits, one or more words and the diagnostic counters at a write/read address specified by the master.
Upon receiving a request from the master, the device sends the desired information in accordance with the MODBUS specification and is capable of replying with an exception message if it does not recognize the request.

• MODBUS functions supported:

- No. 01: Reading of n output or internal bits;
- No. 02: Reading of n input bits;
- No. 03: Reading of n output or internal words;
- No. 04: Reading of n input words;
- No. 05: Writing of 1 bit;
- No. 06: Writing of 1 word;
- No. 08: Reading of diagnostic counters;
- No. 15: Writing of n bits;
- No. 16: Writing of n words.

• Exception codes supported:

- 01: Unknown function code;
- 02: Incorrect address;
- 03: Incorrect data;
- 04: Not ready: impossible to handle the request.

Each message or frame exchanged between the master and slave contains 4 types of information:

- Slave number (1 byte): it specifies the destination slave (0 to 255). If it is equal to 0, the request concerns all the slaves (broadcast) and there is no response from the slaves.

- The function code (1 byte): It makes it possible to select a read or write type command and check whether the response is correct.

- The data field (n bytes): it contains parameters relating to the function: bit address, word address, bit value, word value, number of bits, number of words.

- The control field (2 bytes): it contains a CRC16 used to detect transmission errors.

Slave number *1 byte*	Function code *1 byte*	Data field *n bytes*	Control field *2 bytes*

Comment:
- The length of a frame can range from 4 to 255 bytes depending on the function code.

▶ **Operating procedure:**

In general, when it starts up, the Supervisor makes several requests to address a device:

- It may perform time setting on one or more devices (broadcasting).
- It repatriates events from the T200.
- It repatriates states from the T200.

• Operation in "*No Report By Exception"* mode

The Supervisor operates by polling, regularly repatriating all the states from the T200s or repatriating only the changes (reading the event stack) and thus updating its database.
The Supervisor can send a command to the T200s at any time.
In this operating procedure, the SCADA system controls the communication load. Operation is simple, but results in intense use of communication media, because the more quickly one wants to be informed of a change, the more often the T200s must be interrogated. The polling cycle limit corresponds to the shortest cycle for interrogating all the T200s. The great majority of these exchanges are "unproductive", because in most cases the T200 interrogated has nothing to report.

• Operation in "*Report By Exception"* mode

Messages are sent only to provide unknown information. For example, when a change occurs, the T200 will call the SCADA system via the "*Report By Exception"* function. This will make it possible to initiate dialogue and the SCADA system will then retrieve the change. Likewise, the Supervisor will send messages to the T200 when the operator requests order execution.

This operating mode does not heavily load the communication facilities (a device speaks only when it has something to say). On the other hand, the SCADA system no longer controls the data flow because it can be called at any time. Collisions between messages can occur when, at a given point in time, several devices take control to speak. We shall see further on how this problem of collisions is dealt with.

3.4 Data

The MODBUS protocol can be used to exchange various types of data. The numerous items of information to which the protocol gives access include:

• Signals (single or double);
• Measurements (in several formats);
• Counters;
• Commands;
• Parameters.

3.5 Functions

With the data are associated various functionalities, including, for example:

• State reading
The Supervisor can ask to read the state of all the configured variables.

• Time setting
Can be performed by the Supervisor in two different ways:
- Individually: Frame sent to a single device with confirmation from the latter.
- Universally: Frame broadcast to all the devices without response from them.

• Event reading (time-tagged changes of state).
Since the MODBUS protocol proposes no standard for time tagging of events, a process has been established allowing exchange of events between a master and a slave. The slave provides the master with an event reading table the address of which is configurable.

• Alarm transmission:
A change of state can be configured as an alarm to be sent spontaneously to the telecontrol centre.

• Specific counter functions.
The counters can be reset.

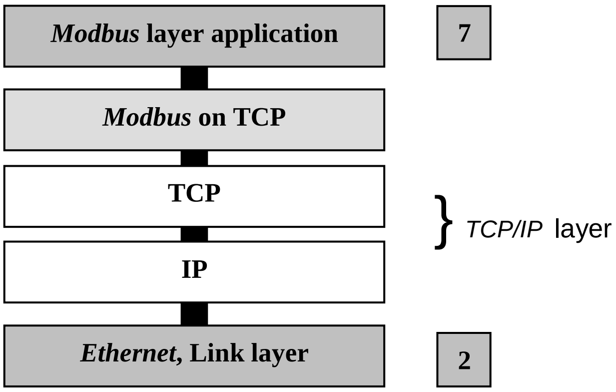
• Command sending:
Two modes are available: *Direct Execution* and *Select before Execute.*

• Parameter writing.
Certain parameters can be changed.

Comment: Time-tagged event management concerns signals only. Counter and measurement type events are not managed.

3.6 Modbus TCP

MODBUS protocol was originally designed for serial point-to-point communication (e.g. RS-232) with limited support for half duplex serial networks (e.g. RS-485). In order for the T200 to exchange MODBUS messages in a local or wide area network, the MODBUS protocol is also implemented over Ethernet via TCP/IP protocols. We will call it MODBUS TCP. Its implementation in the ISO model can be interpreted as followed:



- Protocol characteristics:

As we can see above, a service called Transmission Control Protocol (TCP) is implemented. TCP is one of the core protocols used for internet and other similar networks. In our case, TCP is used because it provides reliable and order delivery of messages for point to point communication.

- Background TCP:

For a TCP connection to take place one side must be the server and one side must be the client. Client-Server architecture is therefore provided. The side of the link that initiates the connection is the client and the side of the link that waits for a connection request is the server. The client requests a connection by specifying the IP address and port number of the server. Once the connection is made, data is transferred without either side having to specify the IP address and port number.
The T200 is usually associated to the server and can hold four different TCP connections with a SCADA. Each connection with a client is managed by a disconnection delay if no data is exchanged.

- Default port used for MODBUS IP:

The T200 support TCP communications on port number 502. All connection requests and all data are sent to this port number. It can be changed for particular reasons.

• Frames structure:

The addressing system and the functions used are the same. The frames have the same structure, except the "slave number" byte which is replaced by an "MBAP header" with the following structure:

Transaction Id (2 bytes)	Protocol Id (2 bytes)	Length (2 bytes)	Unit Id (1 byte)

- *Transaction Identifier (2 bytes):* Used to associate transactions (questions and responses). The Modbus server copies the question "transaction identifier" to the response.

- *Protocol Identifier (2 bytes):* Used for intra-system multiplexing. The Modbus protocol is identified by the value 0.

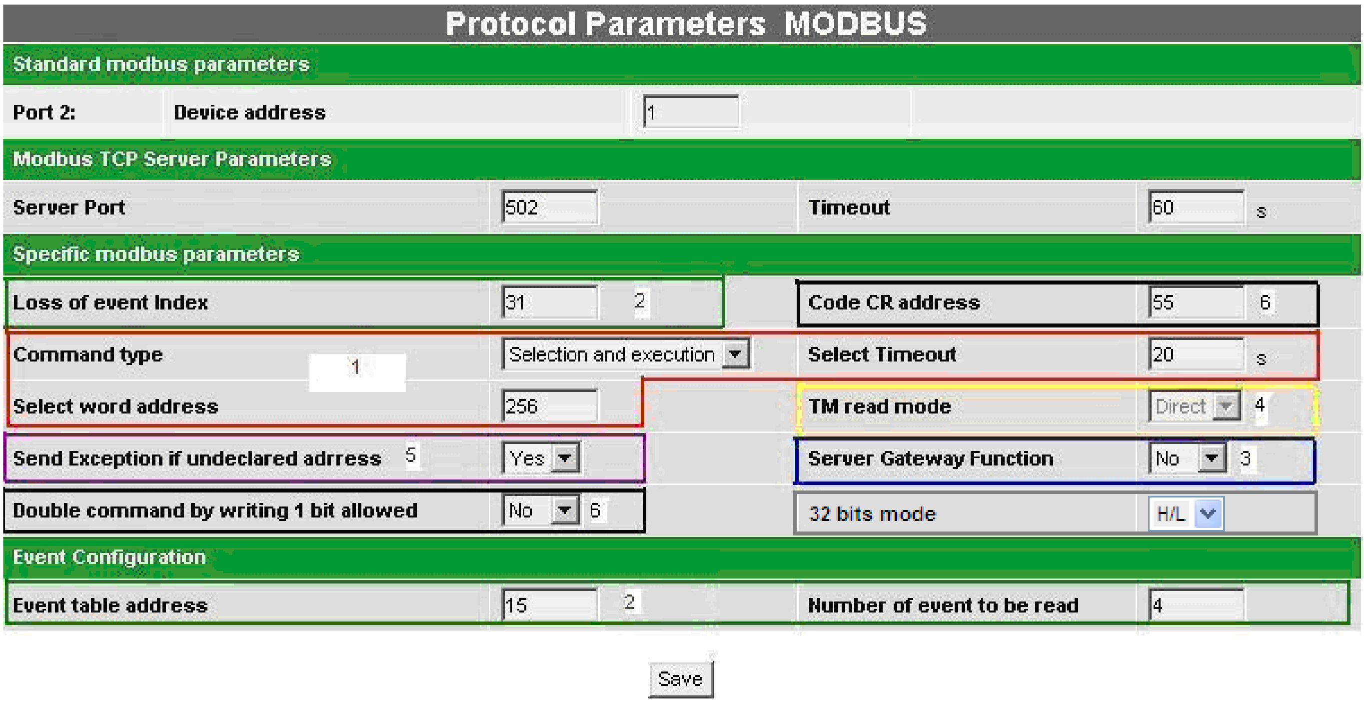
- *Length (2 bytes):* number of bytes following this field, including the "Unit Identifier" and the data.

- *Unit Identifier (1 byte):* This field is used for intra-system routing (see the Gateway function). The default value is 0xFF.

4 Configuration

4.1 General configuration of the protocol

A configuration screen contains all the parameters directly related to the Protocol.



Parameters Setup Page / Protocol

▶ **<u>Standard MODBUS parameters</u>**:

In "standard" communication, the Supervisor can obtain access to a data field called the MODBUS Table. It is thus possible to come and read and write data on the "external address" of a variable. However, it is not possible to export events, since the "standard" MODBUS protocol offers no way of sending time-tagged data.
In such a case, therefore, simply fill in the "Device Address" field on the configuration page:

• *Device address*: Corresponds to the T200 address.

▶ **Specific MODBUS parameters**:

1/ "Select before execute an order" function:

There are two possible modes of execution of writing commands:
- "Direct" mode: Commands are implemented by direct writing to the memory addresses defined for each command (external address). The command is executed upon receiving the command.
- *"Select before Execute"* mode: Writing commands are executed in two transactions for secure writing, the command being finally executed upon receipt of an "Execute" command.

• *Command type*: Choice of mode.
• *Selection timeout*: Maximum waiting time for execution after selection.
• *Selection word address*: This field specifies the command execution address.

2/ "Event management" function:

Since the MODBUS protocol proposes no standard for time tagging of events, a process has been established allowing exchange of events in MODBUS mode between a master and a slave (cf. 4.3). The time tagging function allows a precise date and time to be attributed to changes of state, so as to be able to classify them precisely in time. These events are accessible from a table whose address and size must be entered.

• *Event table address*: Indicates the event table start address.
• Number of events to be read: Indicates the length of the event table
• *Event loss TSS index*: The event table having a defined capacity, a "loss of information" event can be inserted by the T200 when reading the event table. The "Loss of event TSS index" allows the address of this event to be defined. In the event of loss of events, the old events are kept.

3/ "Server Gateway" function:

The Server Gateway function allows the device to be used as a gateway to a MODBUS slave to which it is connected. If this function is enabled, and if the device receives a **Modbus** frame that is not intended for it (MODBUS address different from the device address), the device transfers the frame from its remote communication port (port 1 or port 2) to its local port and then sends the response received to the port of origination of the request.

4/ "Remote measurement reading mode" function:

Each analogue value (measurement) is a signed integer encoded on 16 bits by two's-complement system. The measurements can be sent with scaling.
Two modes are proposed:
- *"Raw" (or "Normalized") mode*: the measure is scaled and converted depending to the Min and Max values defined for the measure.
- *"Direct" (or "Adjusted" or "Scaled") mode*: the variable is sent as it is measured (except if the measure exceeds the Max value defined for the measure).

Note: for details of mode used, see chapter *"8.1 - MODBUS table*", paragraph "*Telemetry and counters zones*".

Comment: This function can be used only by the protocol by changing the value of bit 0 in the Status register.
Bit 0 = 0, Raw mode.
Bit 0 = 1, Direct mode.

5/ "Exception if undeclared element" function:

Case of the "Exception if undeclared element" parameter set to "No": If the Supervisor interrogates a memory address (external address) in which no element is declared, the device will associate the integer 0 with the undeclared bit or word and return this integer (instead of returning a frame indicating an incorrect address).

6/ Telecontrol function:

The TCD function allows certain advanced settings to be made for sending telecontrols:

• *Double command by writing 1 bit enabled*: Enables telecontrols with writing of a single bit.
• *CR code address*: telecontrol fault indication address.

=> The CR code gives information on the processing of the remote control order carried out by the T200:
Bit 0: Remote control in progress.
Bit 1: Fault concerning the initial remote control order
Bit 2: Serious fault detected during internal check.
Bit 3: External fault; the switch has not reached the desired status within the time allotted.
Bit 4: Remote control not executed due to Station in Local mode or other disabling condition
Bit 5: Failure to execute for an unknown reason.

Each change of state of one of this bit will produce a MODBUS event that could be seen on the event log.

The telecontrol center system may reset these codes by writing a 0 to the relevant address.

7/ 32 bits mode:

Measures of F200C and T200 are coded in 16 bits. Nevertheless, energy counters can be coded in 32 bits. So, counters will be sent to the SCADA with using 2 frames of 16 bits.
In case of 32 bits mode, this parameter determines the order of transmission: MSB / LSB (H/L) or LSB/MSB (L/H).

▶ **MODBUS TCP Server parameters**:

We saw on chapter 3.6 that MODBUS protocol can also be used over Ethernet. Consequently, there are some new parameters related to the TCP/IP layer that must be set. Beforehand, the MODBUS IP protocol must be activated. (*Operating mode* menu)

• *Server port:* Server TCP port number (Listen).
Typical Application: It is used when the T200 is waiting for a connection request.

• *Timeout*: link fault detection delay.
It is used to end a session with a client if no data is exchanged.

▶ **Collision avoidance parameters setup**:

When the *Report By Exception* operating mode is selected (and saved), an additional window opens in the Protocol Parameters screen. This window is related to the problem of collisions that can occur when the T200 calls to send an exception. It depends on the transmission medium used.
For point-to-point systems (telephone, GSM), the window is that which conventionally appears when using these types of medium, i.e. the window for configuration of the port used for transmission (it is therefore described in the T200 User Manual in the chapter corresponding to these media).
In this case, no configuration appears in the "Protocol" parameters setup window.
However, for multipoint systems (radio, radio type leased line, etc.), the following window appears in the "Protocol" parameters setup window:

General protocol parameters		
Port 1 : 1200/2400 Bauds FFSK radi...	Collision avoidance:	Off

Collision avoidance:
Collisions may occur:
- between frames sent by the SCADA and frames sent by a remote terminal unit;
- between frames sent by various remote terminal units.

To avoid collisions insofar as possible, one must know the network occupancy state. The more reliable this information, the more efficient the system. The system can be forced to send only if the network is free.
However, this has its limits, since two devices may see the network free and start sending simultaneously. Even apart from this case, there is always a time lag for detection of network occupancy. Let us consider a device going into sending mode. Throughout the time needed for detection of this state, another device will consider the network as free and will therefore be enabled to send.
To overcome this, collision avoidance can be used.
Depending on the transmission medium, there will be several possible options:
- Non-activated or Standard;
- Non-activated, Standard (squelch used for busy state), Standard (CD used for busy state).

The first group of options is proposed when the transmission medium can provide the occupancy state via the CD signal. This is the case when the sent frames are delimited by a signal (generally RTS), said signal being linked to the CD or causing its activation (case in which the RTS signal causes rising of a carrier detected on CD by the other device).
The second group of options is proposed when using a radio medium. There are generally 2 signals: the CD (Carrier Detect) signal and the Squelch signal. When the squelch signal is available, it should be preferred to the CD signal. This is because carrier detection can be caused by noise on the line, whereas the squelch is generally more "secure" and gives more reliable information.
In the second option, when collision avoidance is activated, an additional window appears in the Protocol Parameters screen.

General protocol parameters		
Port 1 : 1200/2400 Bauds FFSK radi...	Collision avoidance:	Standard (squelch used for busy state)
Measures with time-lag :	0 s	

Standard parameters						
Port 1:	Priority:	0	Min. random delay	0 ms	Max. random delay	500 ms
	Squelch Protect:	Yes	Squelch active level:	Low	Tsqu (Squelch protect):	10000 ms
	1st attempt	1 s	2nd attempt	1 mn		

Before describing the various parameters used, we shall explain how collision avoidance operates.

We shall consider two types of frame:
- acknowledgement frames;
- other frames.

When a T200 receives a frame from the Supervisor and this must be acknowledged by it, the acknowledgement frame is sent immediately.

For the other frames, the T200 will allow for a waiting time before sending:
This time is calculated by the following formula:

time = (priority x min. random time) + random time
The random time ranges between the min. random time and the max. random time.

- Priority
  This parameter can be used to hierarchize various T200s.
  The smaller the number, the more priority is assigned to the T200 (it will wait for a shorter time).
  Usually, this priority is left at 0.

- Min. random timeout
  Max. random timeout
  The random timeout, added to the wait related to the priority, is in a range between the minimum and maximum values defined here.
  There are no typical values for these parameters. Setting should be performed taking into account the following comments:
  - The timeouts are to be set according to the sending time for a frame.
  - The smaller the minimum timeout, the smaller the added timeout can be.
  - The greater the difference between the minimum timeout and the maximum timeout, the smaller the risk of sending by two T200s at the same time.
  - The preceding condition is achieved by increasing the maximum timeout. But one should allow for the fact that the greater this timeout, the longer the T200 risks waiting before sending. Generally, therefore, one opts for a value that will not be too high.
  The ideal solution, therefore, is to choose parameters in accordance with the above rules, and then refine them in the field.

The other parameters concern the signal used to obtain the network occupancy state.

- Active squelch level
  Depending on the equipment, the squelch active state will be a low level or a high level. One should therefore choose, here, the appropriate level.

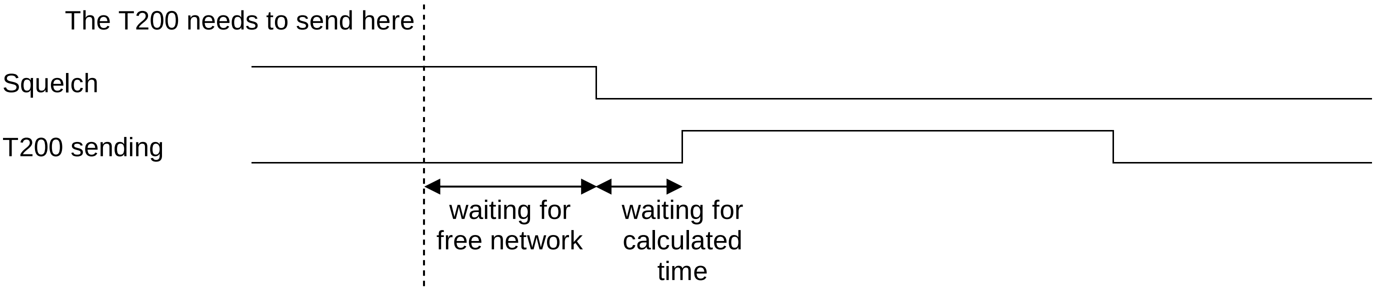
- Squelch protection
  The squelch is an occupancy signal provided by analogue type radio equipment. With this transmission medium, the transmission conditions vary with time. For example, transmission conditions differ depending on whether or not there are leaves on the trees. Therefore, reception levels generally vary throughout the year. Accordingly, the squelch is related to the value to which its detection level has been set. This setting is normally performed in the field and in periods when reception is least satisfactory. However, despite all the precautions taken, squelch detection may become active permanently or over long periods of time. This means that, in this case, the T200 is therefore no longer enabled to send. To avoid this, squelch protection can be activated.
  When it is activated, this protection system will ensure that, when the squelch is active at the time when the T200 wants to send and when it remains active permanently during the time defined below, sending by the T200 will be enabled after this time (this operation is known as squelch setting).

- Tsqu (squelch protection)
  When squelch protection is activated, it will ensure that, when the squelch is active at the time when the T200 wants to send and remains active permanently during the time defined below, sending by the T200 will be enabled after this time (this operation is known as squelch setting).

  This time is the time referred to above.
  The customary value is approximately 10 s.

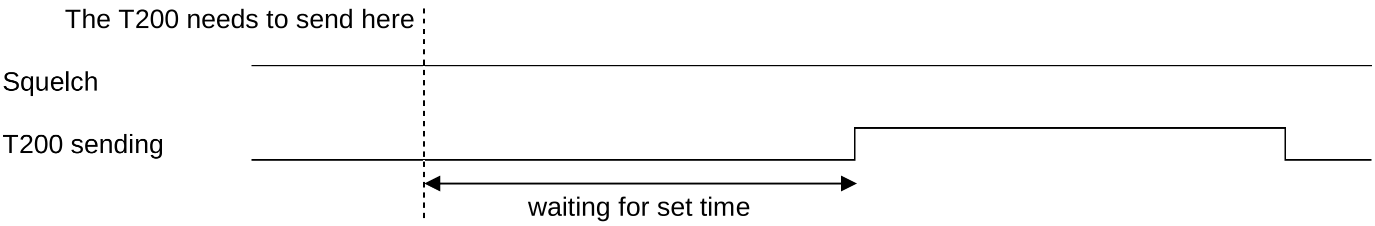
Explanatory diagrams

Normal case

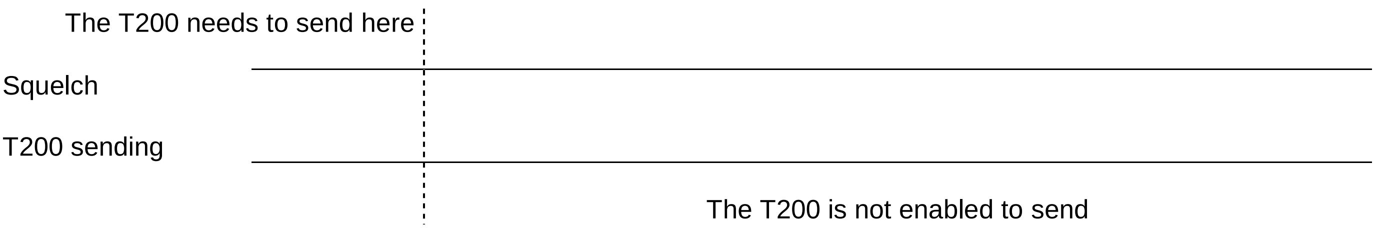


Case of permanent squelch

- with squelch protection



- without squelch protection



4.2 Specific protocol-related operation

▶ **"Report By Exception" mode.**

The slave device sends spontaneously upon condition to a master; for this purpose it initializes an alarm sequence which allows the master to identify the sending slave.

- In the case of a non-permanent link (PSTN, GSM, etc.) requiring the use of a modem to establish the link with a master, connection is managed by the device. When connection is established, the master sends a MODBUS request for identification of the slave: broadcast transmission of a frame with null function code. The device replies to this frame with an exception frame containing its slave address.

- In the case of a permanent link (private line, fibre optic, radio), an exception request allowing it to be identified is sent spontaneously to the master.
The master can thus retrieve the slave address and continue the Master/Slave type MODBUS procedure (reading of fields, events, alarm acknowledgement).

The exception frame sent is: XX 00 00 YY YY
Where: - XX is the slave number of the device;
- YY YY is the frame CRC 16.

Activation of this procedure is available for each physical port from the "operating mode" menu.

▶ **"Report By Exception" mode with Modbus TCP.**

In order to limit the quantity of data transferred via the IP link (to limit GPRS costs for example), the Report by Exception process is adapted to Modbus TCP.
In this case, the connection is still open by the supervisor, but once it is open, the supervisor has not to pull the slave too frequently: alarmed changes of state will be signalled by an Exception.

The exception frame sent is: 00 00 00 00 00 04 FF 00 00 00
- Transaction ID =0
- Function code =0

This Exception can be repeated with a configurable delay if the alarm is not acknowledged.
A thirty second delay has been introduced between two exceptions to prevent network overload.

This procedure can be activated from the "Operating mode" menu.

▶ **"Event management"**:

Event processing requires that the master have access to the T200 event table in write and read mode. An example of an exchange will be described in detail in section 5.1.

• *Event reading:*
The slave provides the master with an event table. The master reads the event table and acknowledges by writing an exchange word. The slave updates the event table.

• *Exchange word:*
The exchange word can be used to manage a specific protocol to be sure not to lose events following a communication problem. For this purpose, the event table is numbered.
The exchange word comprises 2 fields:
- Most significant byte = exchange number (8 bits): 0..255
The exchange number contains a numbering byte which can identify exchanges.
The exchange number is initialized to zero following a power up.
When it reaches its maximum value (0xFF), it automatically returns to 0.
The exchange numbering is established by the slave and acknowledged by the master.
- Least significant byte = number of events (8 bits): 0..X.
The slave indicates the number of significant events in the event table in the least significant byte of the exchange word. This number is limited to the size of the window (e.g. 4 events), even if the number of events available internally is larger.
Each word of the non-significant events is initialized to zero.

• *Acknowledgement of the event table:*
To notify the slave of satisfactory reception of the block it has just read, the master must write, in the "Exchange number" field, the number of the last exchange performed by it, and must reset the "Number of events" field of the exchange word.
Following this acknowledgement, the events in the event table are initialized to zero, and the old acknowledged events are erased in the slave.
So long as the exchange word written by the master is not equal to "X,0" (where X = number of the preceding exchange that the Supervisor wants to acknowledge), the exchange word in the table remains at "X, number of preceding events". The slave increments the exchange number only if new events are present (X+1, number of new events).
If the event table is empty, the slave performs no processing upon reading by the Supervisor of the event table or the exchange word.

• Loss of information:
The slave has an internal storage queue of a defined capacity, which may reach saturation.
In the event of saturation of this queue, a "loss of information" event can be inserted by the slave when reading each event table. The address of this event is configurable. *(cf. Event loss TSS index).*
So long as this event is present in the stack, no other event can be saved, so as to save and not erase the oldest events in the case of a queue overflow.
This event disappears automatically when the Supervisor retrieves all the events and the queue becomes empty.

• Description of event coding:
An event is coded on 8 words with the following structure:

- *Word 1: event type*
  08 00 (signals).
- *Word 2: event address*
  Bit addresses for digital events.
- *Words 3 and 4:*
  00 00 00 00 Falling edge
  00 00 00 01 Rising edge
- *Word 5: year*
  00 0 to 99 (year)
- *Word 6: month-day*
  1 to 12 (months) **(**most significant) 1 to 31 (day) **(**least significant)
- *Word 7: hours-minutes*
  0 to 23 (hours) **(**most significant) 0 to 59 (minutes) **(**least significant)
- *Word 8: milliseconds*
  0 to 59999

▶ **"Select then execute" function**

This function allows a selection message to be sent before a command message:
In this mode, In this mode, sending the command takes place in two phases:
- Writing of "Select" message : writing of word address for the control order to be executed.
- Writing of "Execute" message : confirmation of the control order.

The command is executed by the device only after receiving the 2 messages.
The "Execute" message must be received at least n seconds (configurable timeout) after the "Select" message. In the event of a fault an exception message is returned to the master. (Exception code 3).

4.3 Specific configuration related to transmission media

▶ **Synchronization of communications**

Any character received after a silence exceeding 3 characters is considered as a start of frame. A silence on the line of minimum duration 3 characters (by definition, exceeding 1.5 characters) is considered as an end of frame.
For example: At 9600 baud, this time is equal to approximately 3 milliseconds.

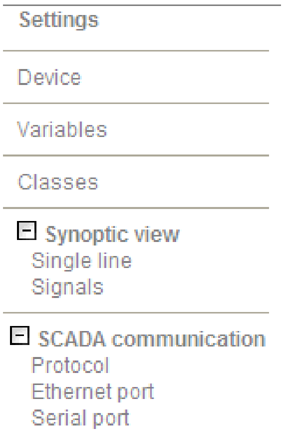
Some modems or transmission modes such as GSM or PSTN sometimes result in longer timeouts in the frames.
For this reason, the end-of-frame timeout is in that case increased to 25 characters.
For example: At 9600 baud, this time will be equal to about 25 milliseconds.

▶ **Time synchronization**

The device can be synchronized by reception of a "time message" frame over the communications network. A general broadcast can be performed with the slave number 0. The "time message" frame is used both for time setting and for slave synchronization.

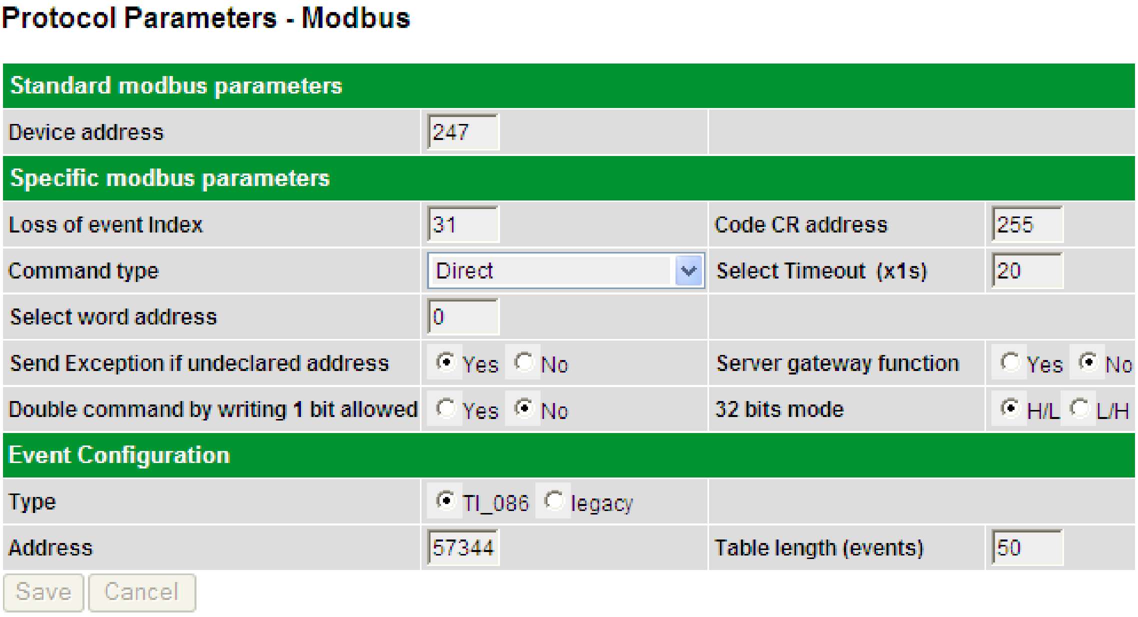
For each new time frame received, the slave's internal clock is reset immediately as of the end of frame reception.
The precision depends on the master, and its control of the time for transmission of the time frame over the communications network. The time for transmission of the frame over the network largely depends on the type of medium used. When slave synchronization is to be performed, the time setting frame should be sent regularly at closely spaced intervals (between 10 and 60 seconds) to obtain a synchronous time.

4.4 R200-ATS100, configuration of the protocol



The protocol configuration can be found under Settings \ SCADA communication \ Protocol.

Most parameters are similar to T200/F200C, and described in chapter 4.1.



Protocol Parameters - Modbus

Standard modbus parameters			
Device address	247		
Specific modbus parameters			
Loss of event Index	31	Code CR address	255
Command type	Direct	Select Timeout (x1s)	20
Select word address	0		
Send Exception if undeclared address	(•) Yes ( ) No	Server gateway function	( ) Yes (•) No
Double command by writing 1 bit allowed	( ) Yes (•) No	32 bits mode	(•) H/L ( ) L/H
Event Configuration			
Type	(•) TI_086 ( ) legacy		
Address	57344	Table length (events)	50

Save Cancel

There are some slight differences:

- Report by exception modes are not available
- TM Read Mode:
  This parameter does not exist. The R200 acts as it is set to "Direct"
- Event configuration:
  The "legacy" type corresponds to the event management described on chapter 4.2
  The "TI_086" type corresponds to another format, described in the technical invariant TI086. This format is not detailed in this document, and should be used only if the scada (or master) is also handling this format.
- Modbus TCP configuration:
  The TCP server port and connection timeout can be modified under Settings \ SCADA communication \ Ethernet Port

TCP Port Parameters - Modbus

Operation mode			
Link	Normal		
Modbus TCP parameters			
Server port	502	Connection Timeout (x1ms)	60000

Save Cancel

- Digital variables address format
  The T200 and F200C are using a “Word,Bit” with Word between 0 and 4095 and Bit between 0 and 15.
  The R200 works with bit address between 0 and 65535 (decimal format), which corresponds to “16 * Word + Bit”

General				
SPS_9	Name	Local/Remote	Access	Display
	Class	Substation	Rank	
	Source	Built in	External address	8000

The hexadecimal value, and the (Word,Bit) format are indicated when the value is changed by the user.

General				
SPS_9	Name	Local/Remote	Access	Display
	Class	Substation	Rank	
	Source	Built in	External address	8001 0x1f41 (500,1)

5 Diagnostic

This chapter provides information which may be necessary when operating problems are encountered. It may help with problem resolution in such cases.

5.1 Tracing exchanges with the Supervisor

In order to clarify the operation of the protocol, we shall give here a few specific examples of exchanges viewed by means of the Trace provided by the T200.

Comment: The following screens were obtained by sending frames step-by-step – so as to show the operation in detail - from a simulator; the time tags are therefore not significant.

● Example 1a:

After starting, the Supervisor performs time setting on the first device. (Device address = 1)

```
11:03:32.251   SlaveAddr = 01   <<<<<   Write N words
                                        Addr = 0x2
                                        01 10 00 02 00 04 08 00 08 08 0B 11 0A 00 00 47 CA
17:10:00.000   SlaveAddr = 01   >>>>>   Write N words
                                        01 10 00 02 00 04 60 0A
```

Observation:
The Supervisor writes the date in IEC format (time tag on 4 words) at address 0x02. The T200 replies with the updated time.

● Example 1b:

After starting, the Supervisor sends a time setting frame to all the devices (in broadcast mode).

```
11:09:08.262   SlaveAddr = 00   <<<<<   Write N words                                         } 1
                                        Addr = 0x2
                                        00 10 00 02 00 04 08 00 08 08 0B 11 0A 00 00 86 CA
17:10:04.142   SlaveAddr = 01   <<<<<   Read N output Words                                   } 2
                                        Addr = 0xf
                                        01 03 00 0F 00 01 B4 09
17:10:04.144   SlaveAddr = 01   >>>>>   Read N output Words
                                        01 03 02 00 03 F8 45
```

Observation:
1 /
- The T200 receives the time setting frame.
- The T200 returns no response.
2 /
- The T200 receives a read request from the master, and one observes that the time has changed.

● Example 1c:

After setting the time on the T200, the Supervisor interrogates the device to find out whether events have been recorded and have not yet been read.

- Device address: 1
- The event field is set to address 0xF with a maximum of 4 events.

```
17:10:18.370   SlaveAddr = 01   <<<<<   Read N output Words
                                        Addr = 0xf
                                        01 03 00 0F 00 01 B4 09
17:10:18.371   SlaveAddr = 01   >>>>>   Read N output Words
                                        01 03 02 01 03 F9 D5
17:10:28.128   SlaveAddr = 01   <<<<<   Read N output Words
                                        Addr = 0xf
                                        01 03 00 0F 00 19 B4 03
17:10:28.130   SlaveAddr = 01   >>>>>   Read N output Words
                                        01 03 32 01 03 08 00 03 96 00 00 00 00 00 08 08 0B 11 0A 15 80 08 00 03 96
                                        00 00 00 01 00 08 08 0B 11 0A 1C 4C 08 00 03 96 00 00 00 00 00 08 08 0B 11
                                        0A 26 CA 46 7D
17:10:56.072   SlaveAddr = 01   <<<<<   Write word
                                        Addr = 0xf
                                        01 06 00 0F 01 00 B8 59
17:10:56.073   SlaveAddr = 01   >>>>>   Write word
                                        01 06 00 0F 01 00 B8 59
17:11:01.284   SlaveAddr = 01   <<<<<   Read N output Words
                                        Addr = 0xf
                                        01 03 00 0F 00 01 B4 09
17:11:01.285   SlaveAddr = 01   >>>>>   Read N output Words
                                        01 03 02 02 00 B9 24
```

Observations:

1/ Exchange word reading:
The Supervisor reads the exchange word to find out whether events have occurred. The T200 replies by specifying that 3 events are available.
2/ Event field reading:
The Supervisor reads the events present in the stack, and the T200 sends them to it.
3/ Event acknowledgement:
The Supervisor acknowledges its request. It writes the exchange word, resetting the number of events to 0.
4/ New reading cycle:
The Supervisor reads the exchange word again to find out whether events are available. The T200 replies by specifying that no event is available. The exchange number has changed (1 -> 2).

Analysis of the 3 events read:

- Event 1: 08 00 03 96 00 00 00 00 00 08 08 0B 11 0A 15 80
Single address signal 918 (word 57, bit 6), value = 0, on 11/08/2008 at 17:10:05
- Event 2: 08 00 03 96 00 00 00 01 00 08 08 0B 11 0A 1C 4C
Single address signal 918 (word 57, bit 6), value = 1, on 11/08/2008 at 17:10:07
- Event 3: 08 00 03 96 00 00 00 00 00 08 08 0B 11 0A 26 CA
Single address signal 918 (word 57, bit 6), value = 0, on 11/08/2008 at 17:10:09

Comment: In our case, the single address signal 918 corresponds to the device's Local/Remote selector switch.

● Example 1d:

After reading the device's event table, the Supervisor performs one or more read operation(s) to find out the current states of the device's variables (signals, measurements, etc.).

```
17:13:44.274   SlaveAddr = 01   <<<<<   Read N input Bit
                                        Addr = 0x300
                                        01 02 03 00 04 00 7A 8E
17:13:44.278   SlaveAddr = 01   >>>>>   Read N input Bit
                                        01 02 80 40 00 00 00 00 00 00 00 40 00 00 00 00 00 00 00 00 00 08 00 00 00
                                        00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                                        00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                                        00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                                        00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00 00
                                        00 00 00 00 00 00 2F 16
```

Observations:

In our example, for sake of simplicity, the Supervisor simply requests the signal state.
It can be observed that the address signal 918 (0x396, word 57 bit 6) is in 0x0 state. This is consistent with the reading for the preceding events in which the last event showed a transition to state 0 (‘Remote’) of the Local/Remote selector switch.

● Example 2:

The Supervisor sends a telecontrol to the device in "Select and Execute" mode. The T200 must be in remote mode. (In direct mode, simply write at the address defined for the command).

Protocol configuration:
- "Select and Execute" mode, Timeout 20s, selection word address = 0x100.
- Write command at 1 on TCD of external address 12.0. (Word 0xC0, bit 0)

```
17:17:37.894   SlaveAddr = 01   <<<<<   Write word
                                        Addr = 0x100                    1
                                        01 06 01 00 00 C0 88 66
17:17:37.896   SlaveAddr = 01   >>>>>   Write word
                                        01 06 01 00 00 C0 88 66
17:17:42.868   SlaveAddr = 01   <<<<<   Write bit
                                        Addr = 0xc0                     2
                                        01 05 00 C0 FF 00 8C 06
17:17:42.869   SlaveAddr = 01   >>>>>   Write bit
                                        01 05 00 C0 FF 00 8C 06
```

Observations:

1/ Select:
The Supervisor writes the execution address in the selection word.
2/ Execute:
The device receives the execution request, the command can be tripped.

If the device is in "No Report By Exception" mode, the Supervisor suspends polling to send the command. Once the command is ended and in reply to the next Supervisor polling, the T200 can return a change of state (event) on the signal associated with this telecontrol.

If the device is in "Report By Exception" mode and once the telecontrol is ended, the T200 may take the initiative of indicating to the Supervisor a change of state (event) of the signal associated with this telecontrol.

6 Glossary

B

Binary Input
Single and double signals are treated as objects of the *binary input* type.

Broadcast
The Supervisor can send a message to all the remote terminal units. This is called *broadcasting.* The *destination address* in that case equals 0x00. In this case, the destination units will not reply to the received frame.

D

Device address
MODBUS address of the T200 by which the Supervisor can obtain access to the device.

Direct execution
In this command execution mode, the command, when it is authorized, is executed upon receiving this message. The wanted selection relay is actuated, and, after verification, it is the execution relay's turn. During all the command sequences, checks are performed. Any detected anomaly causes immediate stoppage of the command.

Direct operate
See *Direct Execution*.

E

Event acknowledgement
Process by which the master can notify the device that the events have been read. Resets the number of events contained in the T200's stack. The old events acknowledged are erased from the slave.

Event stack
See time tagged events.

Exchange word
This can be used to manage a specific MODBUS protocol for the T220 to be sure not to lose events following a communication problem. It contains two essential items of information, the exchange number and the number of events present in the stack.

F

Function code
Byte contained in each frame sent by the master and by which the slave can know the nature of the request (read, write, etc.). Upon an error, the slave replies by setting the most significant bit of the function code to 1.

M

Master
Refers, in a MODBUS communication system, to the device that enters into dialogue with one or more slaves.

Measurement
Refers to an analogue input coded on 16 bits which can adopt several formats.

P

Polling
This term designates a method for repatriation of information from the T200.
The Supervisor interrogates each T200 in succession so that it may return its information.

R

Reading
The Supervisor works by *Reading* or *Writing* data to or from the remote terminal units.

Report By Exception
Can be used to manage a specific MODBUS protocol or the T200 which is the slave can take the initiative of dialogue to send an alarm. Mode often used in place of Supervisor polling to avoid overloading the communication media.

S
Select then Execute (Select then Operate)
In this command execution mode, the command, when it is authorized, is executed in two stages. The T200 first receives a selection message. It then receives an execution message. It then checks that the same device is involved. If this check is satisfactory, it executes the command sequence. Throughout the command's duration, checks are performed. Any detected anomaly causes immediate stoppage of the command. Moreover, if, after receiving the selection message, an excessive time elapses without the T200 receiving the execution message, the command is cancelled. This time is configured in the Selection Timeout section.

Slave
Refers, in a MODBUS communication system, to the device that merely replies to the requests of a master.

Squelch
Occupancy signal provided by analogue type radio equipment.

T
TCD
Télécommande (telecontrol) (coded on 2 bits)

Time synchronization field
Contains the internal date and time of the device for time tagging of events. The field can only be read or written to as a whole.

Time tagged events:
Can be used to manage a specific MODBUS protocol or a date can be associated with the change of state of a signal. These events are stored within the T200 in an event stack that can be accessed in read/write mode by the Supervisor.

TM
Télémesure (remote measurement) (coded on 16 bits)

TSD
Télésignalisation double (double telesignal) (coded on 2 bits)

TSS
Télésignalisation simple (single telesignal) (coded on 1 bit)

TCP
Network Protocol used by the T200 to manage MODBUS communications over an IP Link. It is implemented in the Transport layer of the OSI Model.

W
Writing
The Supervisor works by *Writing* or *Reading* data to or from the remote terminal units.

7 Object addressing

In the following tables will be found the default settings for the external addresses of variables.

7.1 Legend

Type – Internal No.	Meaning
TCD	Télécommande double (double telecontrol)
TSS	Télésignalisation simple (single telesignal)
TSD	Télésignalisation double (double telesignal)
TM	Télémesure (remote measurement)
CNT	Counter

Access	Defined as
VISU	Viewing
EXPL	Operator
ADMIN	Administrator

Options	Required commercial option
I	I, IU, IUP, I2UP TR
U	IU, IUP, I2UP TR
P	IUP, I2UP TR
2U	I2UP TR

Object	Meaning
	In this column appears the type of (static) object used in transmission

Index	Meaning
NA	Not Accessible by SCADA: no external address has been configured. For the SCADA to be able to access the Object, simply configure an address (which is not already used)

Reminder: External address syntax

The external address makes the variable accessible in read or write mode from the Supervisor via the MODBUS protocol. The MODBUS addresses of the digital variables are parameterized as follows: "Word, bit".

Calculation of a decimal address from a word bit:
• Decimal address = word address x 16 + bit address
Example: Word 15, bit 10 ➔ 15 x 16 + 10 = 250

Calculation of a word bit from a decimal address:
• Word address = decimal address modulo 16 (integer value)
• *Bit address = decimal part * 16*
Example: address 255 ➔ 255 / 16 = 15.9375 (Word = 15)
0.9375 * 16 = 15 (Bit = 15)

7.2 T200 P

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 1						
Switch position	TSD 1	VISU		Binary input	52.0	340
Switch locked	TSS 49	VISU		Binary input	56.8	388
Switch command	TCD 1	EXPL		Relay output control block	48.0	300
Operation counter	CNT 1	VISU		Analogue input, 16 bits	NA	NA
Operation counter preset command	TCD 25	ADMIN		Relay output control block	NA	NA
Auxiliary DI	TSS 51	VISU		Binary input	NA	NA
MV voltage present	TSS 73	VISU		Binary input	NA	NA
Earth fault	TSS 71	VISU		Binary input	56.1	381
Phase fault	TSS 77	VISU		Binary input	56.0	380
Phase current 1	TM 2	VISU	I	Analogue input, 16 bits	NA	NA
Phase current 2	TM 3	VISU	I	Analogue input, 16 bits	NA	NA
Phase current 3	TM 4	VISU	I	Analogue input, 16 bits	NA	NA
Neutral current	TM 5	VISU	I	Analogue input, 16 bits	NA	NA
Average current	TM 6	VISU	I	Analogue input, 16 bits	64	400
U21 voltage measurement	TM 47	VISU	U	Analogue input, 16 bits	66	420
V1 voltage measurement	TM 50	VISU	U	Analogue input, 16 bits	NA	NA
Frequency	TM 8	VISU	P	Analogue input, 16 bits	NA	NA
Active power	TM 53	VISU	P	Analogue input, 16 bits	NA	NA
Reactive power	TM 54	VISU	P	Analogue input, 16 bits	NA	NA
Apparent power	TM 55	VISU	P	Analogue input, 16 bits	NA	NA
Power factor	TM 7	VISU	P	Analogue input, 16 bits	NA	NA
Active energy	CNT 5	VISU	P	Analogue input, 16 bits	NA	NA
Active energy preset command	TCD 29	ADMIN		Relay output control block	NA	NA
Reactive energy	CNT 13	VISU	P	Analogue input, 16 bits	NA	NA
Reactive energy preset command	TCD 37	ADMIN		Relay output control block	NA	NA

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 2						
Switch position	TSD 2	VISU		Binary input	52.2	342
Switch locked	TSS 81	VISU		Binary input	56.9	389
Switch command	TCD 2	EXPL		Relay output control block	48.2	302
Operation counter	CNT 2	VISU		Analogue input, 16 bits	NA	NA
Operation counter preset command	TCD 26	ADMIN		Relay output control block	NA	NA
Auxiliary DI	TSS 83	VISU		Binary input	NA	NA
MV voltage present	TSS 105	VISU		Binary input	57.3	393
Earth fault	TSS 103	VISU		Binary input	56.3	383
Phase fault	TSS 109	VISU		Binary input	56.2	382
Phase current 1	TM 9	VISU	I	Analogue input, 16 bits	NA	NA
Phase current 2	TM 10	VISU	I	Analogue input, 16 bits	NA	NA
Phase current 3	TM 11	VISU	I	Analogue input, 16 bits	NA	NA
Neutral current	TM 12	VISU	I	Analogue input, 16 bits	NA	NA
Average current	TM 13	VISU	I	Analogue input, 16 bits	65	410
U21 voltage measurement	TM 56	VISU	U	Analogue input, 16 bits	67	430
V1 voltage measurement	TM 59	VISU	U	Analogue input, 16 bits	NA	NA
Frequency	TM 15	VISU	P	Analogue input, 16 bits	NA	NA
Active power	TM 62	VISU	P	Analogue input, 16 bits	NA	NA
Reactive power	TM 63	VISU	P	Analogue input, 16 bits	NA	NA
Apparent power	TM 64	VISU	P	Analogue input, 16 bits	NA	NA
Power factor	TM 14	VISU	P	Analogue input, 16 bits	NA	NA
Active energy	CNT 6	VISU	P	Analogue input, 16 bits	NA	NA
Active energy preset command	TCD 30	ADMIN		Relay output control block	NA	NA
Reactive energy	CNT 14	VISU	P	Analogue input, 16 bits	NA	NA
Reactive energy preset command	TCD 38	ADMIN		Relay output control block	NA	NA
Common objects						
Local/Remote position	TSS 23	VISU		Binary input	57.6	396
Door opening	TSS 24	VISU		Binary input	57.2	392
Fault detection reset command	TCD 17	EXPL		Relay output control block	NA	NA
Immediate AC power supply defect	TSS 17	VISU		Binary input	57.7	397
Time-delayed AC power supply defect	TSS 18	VISU		Binary input	57.12	39C
Power cut imminent	TSS 25	VISU		Binary input	NA	NA

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Automatic controls						
Automatic control ON/OFF position	TSD 9	VISU		Binary input	52.6	346
Automatic control ON/OFF command	TCD 9	EXPL		Relay output control block	48.6	306
Automatic control has operated	TSS 57	VISU		Binary input	57.13	39D
Internal faults						
Motorization power supply failure	TSS 19	VISU		Binary input	57.11	39B
Accessory equipment power supply failure	TSS 20	VISU		Binary input	NA	NA
Charger fault	TSS 21	VISU		Binary input	57.9	399
Battery fault	TSS 22	VISU		Binary input	57.10	39A
Digital Inputs/Outputs						
Digital input 1	TSS 1	VISU		Binary input	57.0	390
Digital input 2	TSS 2	VISU		Binary input	57.1	391
Digital input 3	TSS 3	VISU		Binary input	NA	NA
Digital input 4	TSS 4	VISU		Binary input	NA	NA
Digital input 5	TSS 5	VISU		Binary input	NA	NA
Digital input 6	TSS 6	VISU		Binary input	NA	NA
Digital input 7	TSS 7	VISU		Binary input	NA	NA
Digital input 8	TSS 8	VISU		Binary input	NA	NA
Digital output 1 position	TSD 5	VISU		Binary input	NA	NA
Digital output 1 command	TCD 5	EXPL		Relay output control block	NA	NA
Digital output 2 position	TSD 6	VISU		Binary input	NA	NA
Digital output 2 command	TCD 6	EXPL		Relay output control block	NA	NA
Digital output 3 position	TSD 7	VISU		Binary input	NA	NA
Digital output 3 command	TCD 7	EXPL		Relay output control block	NA	NA

7.3 T200 I

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 1						
Switch position	TSD 1	VISU		Binary input	52.0	341
Switch locked	TSS 49	VISU		Binary input	56.8	388
Switch command	TCD 1	EXPL		Relay output control block	48.0	300
MV voltage present (auxiliary DI)	TSS 54	VISU		Binary input	57.2	392
Earth fault	TSS 71	VISU		Binary input	56.1	381
Phase fault	TSS 77	VISU		Binary input	56.0	380
Phase current	TM 2	VISU		Analogue input, 16 bits	64	400
Channel 2						
Switch position	TSD 2	VISU		Binary input	52.2	342
Switch locked	TSS 81	VISU		Binary input	56.9	389
Switch command	TCD 2	EXPL		Relay output control block	48.2	302
MV voltage present (auxiliary DI)	TSS 86	VISU		Binary input	57.3	393
Earth fault	TSS 103	VISU		Binary input	56.3	383
Phase fault	TSS 109	VISU		Binary input	56.2	382
Phase current	TM 9	VISU		Analogue input, 16 bits	65	410
Channel 3						
Switch position	TSD 3	VISU		Binary input	52.4	344
Switch locked	TSS 113	VISU		Binary input	56.10	38A
Switch command	TCD 3	EXPL		Relay output control block	48.4	304
MV voltage present (auxiliary DI)	TSS 118	VISU		Binary input	57.4	394
Earth fault	TSS 135	VISU		Binary input	56.5	385
Phase fault	TSS 141	VISU		Binary input	56.4	384
Phase current	TM 17	VISU		Analogue input, 16 bits	66	420
Channel 4						
Switch position	TSD 4	VISU		Binary input	52.6	346
Switch locked	TSS 145	VISU		Binary input	56.11	38B
Switch command	TCD 4	EXPL		Relay output control block	48.6	306
MV voltage present (auxiliary DI)	TSS 150	VISU		Binary input	57.5	395
Earth fault	TSS 167	VISU		Binary input	56.7	387
Phase fault	TSS 173	VISU		Binary input	56.6	386
Phase current	TM 24	VISU		Analogue input, 16 bits	67	430

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 5						
Switch position	TSD 41	VISU		Binary input	52.8	348
Switch locked	TSS 321	VISU		Binary input	58.8	3A8
Switch command	TCD 41	EXPL		Relay output control block	48.8	308
MV voltage present (auxiliary DI)	TSS 326	VISU		Binary input	59.2	3B2
Earth fault	TSS 343	VISU		Binary input	58.1	3A1
Phase fault	TSS 349	VISU		Binary input	58.0	3A0
Phase current	TM 84	VISU		Analogue input, 16 bits	68	440
Channel 6						
Switch position	TSD 42	VISU		Binary input	52.10	34A
Switch locked	TSS 353	VISU		Binary input	58.9	3A9
Switch command	TCD 42	EXPL		Relay output control block	48.10	30A
MV voltage present (auxiliary DI)	TSS 358	VISU		Binary input	59.3	3B3
Earth fault	TSS 375	VISU		Binary input	58.3	3A3
Phase fault	TSS 381	VISU		Binary input	58.2	3A2
Phase current	TM 91	VISU		Analogue input, 16 bits	69	450
Channel 7						
Switch position	TSD 43	VISU		Binary input	52.12	34C
Switch locked	TSS 385	VISU		Binary input	58.10	3AA
Switch command	TCD 43	EXPL		Relay output control block	48.12	30C
MV voltage present (auxiliary DI)	TSS 390	VISU		Binary input	59.4	3B4
Earth fault	TSS 407	VISU		Binary input	58.5	3A5
Phase fault	TSS 413	VISU		Binary input	58.4	3A4
Phase current	TM 99	VISU		Analogue input, 16 bits	70	460
Channel 8						
Switch position	TSD 44	VISU		Binary input	52.14	34E
Switch locked	TSS 417	VISU		Binary input	58.11	3AB
Switch command	TCD 44	EXPL		Relay output control block	52.14	30E
MV voltage present (auxiliary DI)	TSS 422	VISU		Binary input	59.5	3B5
Earth fault	TSS 439	VISU		Binary input	58.7	3A7
Phase fault	TSS 445	VISU		Binary input	58.6	3A6
Phase current	TM 106	VISU		Analogue input, 16 bits	71	470

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 9						
Switch position	TSD 81	VISU		Binary input	53.0	350
Switch locked	TSS 593	VISU		Binary input	60.8	3C8
Switch command	TCD 81	EXPL		Relay output control block	49.0	310
MV voltage present (auxiliary DI)	TSS 598	VISU		Binary input	61.2	3D2
Earth fault	TSS 615	VISU		Binary input	60.1	3C1
Phase fault	TSS 621	VISU		Binary input	60.0	3C0
Phase current	TM 166	VISU		Analogue input, 16 bits	72	480
Channel 10						
Switch position	TSD 82	VISU		Binary input	53.2	352
Switch locked	TSS 625	VISU		Binary input	60.9	3C9
Switch command	TCD 82	EXPL		Relay output control block	53.2	312
MV voltage present (auxiliary DI)	TSS 630	VISU		Binary input	61.3	3D3
Earth fault	TSS 647	VISU		Binary input	60.3	3C3
Phase fault	TSS 653	VISU		Binary input	60.2	3C2
Phase current	TM 173	VISU		Analogue input, 16 bits	73	490
Channel 11						
Switch position	TSD 83	VISU		Binary input	53.4	354
Switch locked	TSS 657	VISU		Binary input	60.10	3CA
Switch command	TCD 83	EXPL		Relay output control block	49.4	314
MV voltage present (auxiliary DI)	TSS 662	VISU		Binary input	61.4	3D4
Earth fault	TSS 679	VISU		Binary input	60.5	3C5
Phase fault	TSS 685	VISU		Binary input	60.4	3C4
Phase current	TM 181	VISU		Analogue input, 16 bits	74	4A0
Channel 12						
Switch position	TSD 84	VISU		Binary input	53.6	356
Switch locked	TSS 689	VISU		Binary input	60.11	3CB
Switch command	TCD 84	EXPL		Relay output control block	49.6	316
MV voltage present (auxiliary DI)	TSS 694	VISU		Binary input	61.5	3D5
Earth fault	TSS 711	VISU		Binary input	60.7	3C7
Phase fault	TSS 717	VISU		Binary input	60.8	3C8
Phase current	TM 188	VISU		Analogue input, 16 bits	75	4B0

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 13						
Switch position	TSD 121	VISU		Binary input	53.8	358
Switch locked	TSS 865	VISU		Binary input	62.8	3E8
Switch command	TCD 121	EXPL		Relay output control block	49.8	318
MV voltage present (auxiliary DI)	TSS 870	VISU		Binary input	63.2	3F2
Earth fault	TSS 887	VISU		Binary input	62.1	3E1
Phase fault	TSS 893	VISU		Binary input	62.0	3E0
Phase current	TM 248	VISU		Analogue input, 16 bits	76	4C0
Channel 14						
Switch position	TSD 122	VISU		Binary input	53.10	35A
Switch locked	TSS 897	VISU		Binary input	62.9	3E9
Switch command	TCD 122	EXPL		Relay output control block	53.10	31A
MV voltage present (auxiliary DI)	TSS 902	VISU		Binary input	63.3	3F3
Earth fault	TSS 919	VISU		Binary input	62.3	3E3
Phase fault	TSS 925	VISU		Binary input	62.2	3E2
Phase current	TM 255	VISU		Analogue input, 16 bits	77	4D0
Channel 15						
Switch position	TSD 123	VISU		Binary input	53.12	35C
Switch locked	TSS 929	VISU		Binary input	62.10	3EA
Switch command	TCD 123	EXPL		Relay output control block	49.12	31C
MV voltage present (auxiliary DI)	TSS 934	VISU		Binary input	63.4	3F4
Earth fault	TSS 951	VISU		Binary input	62.5	3E5
Phase fault	TSS 957	VISU		Binary input	62.4	3E4
Phase current	TM 263	VISU		Analogue input, 16 bits	78	4E0
Channel 16						
Switch position	TSD 124	VISU		Binary input	53.14	35E
Switch locked	TSS 961	VISU		Binary input	62.11	3EB
Switch command	TCD 124	EXPL		Relay output control block	49.14	31E
MV voltage present (auxiliary DI)	TSS 966	VISU		Binary input	63.5	3F5
Earth fault	TSS 983	VISU		Binary input	62.7	3E7
Phase fault	TSS 989	VISU		Binary input	62.6	3E6
Phase current	TM 270	VISU		Analogue input, 16 bits	79	4F0
Common objects						
Local/Remote position	TSS 23	VISU		Binary input	57.6	396
Fault detection reset command channels 1 to 4	TCD 17	EXPL		Relay output control block	NA	NA
Fault detection reset command channels 5 to 8	TCD 57	EXPL		Relay output control block	NA	NA
Fault detection reset command channels 9 to 12	TCD 97	EXPL		Relay output control block	NA	NA
Fault detection reset command channels 13 to 16	TCD 137	EXPL		Relay output control block	NA	NA
Immediate AC power supply defect	TSS 17	VISU		Binary input	57.7	397
Time-delayed AC power supply defect	TSS 18	VISU		Binary input	57.12	39C
Power cut imminent	TSS 25	VISU		Binary input	NA	NA

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Automatic controls						
Automatic control ON/OFF position channels 1 to 4	TSD 9	VISU		Binary input	54.8	368
Automatic control ON/OFF command channels 1 to 4	TCD 9	EXPL		Relay output control block	50.8	328
Automatic control ON/OFF position channels 5 to 8	TSD 49	VISU		Binary input	54.10	36A
Automatic control ON/OFF command channels 5 to 8	TCD 49	EXPL		Relay output control block	50.10	32A
Automatic control ON/OFF position channels 9 to 12	TSD 89	VISU		Binary input	54.12	36C
Automatic control ON/OFF command channels 9 to 12	TCD 89	EXPL		Relay output control block	50.12	32C
Automatic control ON/OFF position channels 13 to 16	TSD 129	VISU		Binary input	54.14	36E
Automatic control ON/OFF command channels 13 to 16	TCD 129	EXPL		Relay output control block	50.14	32E
Internal faults						
Motorization power supply failure	TSS 19	VISU		Binary input	57.11	39B
Accessory equipment power supply failure	TSS 20	VISU		Binary input	NA	NA
Charger fault	TSS 21	VISU		Binary input	57.9	399
Battery fault	TSS 22	VISU		Binary input	57.10	39A
Fault detector link defect	TSS 47	VISU		Binary input	NA	NA
Digital inputs						
Digital input 1	TSS 1	VISU		Binary input	57.0	390
Digital input 2	TSS 2	VISU		Binary input	57.1	391
Digital input 3	TSS 3	VISU		Binary input	57.8	398
Digital input 4	TSS 4	VISU		Binary input	57.13	39D
Digital input 5	TSS 5	VISU		Binary input	57.14	39E
Digital input 6	TSS 6	VISU		Binary input	57.15	39F
Digital input 7	TSS273	VISU		Binary input	59.0	3B0
Digital input 8	TSS274	VISU		Binary input	59.1	3B1
Digital input 9	TSS275	VISU		Binary input	59.8	3B8
Digital input 10	TSS276	VISU		Binary input	59.13	3BD
Digital input 11	TSS277	VISU		Binary input	59.14	3BE
Digital input 12	TSS278	VISU		Binary input	59.15	3BF
Digital input 13	TSS545	VISU		Binary input	61.0	3D0
Digital input 14	TSS546	VISU		Binary input	61.1	3D1
Digital input 15	TSS547	VISU		Binary input	61.8	3D8
Digital input 16	TSS548	VISU		Binary input	61.13	3DD
Digital input 17	TSS549	VISU		Binary input	61.14	3DE
Digital input 18	TSS550	VISU		Binary input	61.15	3DF
Digital input 19	TSS817	VISU		Binary input	63.0	3F0
Digital input 20	TSS818	VISU		Binary input	63.1	3F1
Digital input 21	TSS819	VISU		Binary input	63.8	3F8
Digital input 22	TSS820	VISU		Binary input	63.13	3FD
Digital input 23	TSS821	VISU		Binary input	63.14	3FE
Digital input 24	TSS822	VISU		Binary input	63.15	3FF

7.4 Flair 200C

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Flair 200C state						
Fault current indicator reset	TCD17	EXPL		Relay output control block	48,6	306
Missing voltage	TSS17	VISU		Binary input	52,8	348
Charger fault	TSS21	VISU		Binary input	51,6	336
Battery fault	TSS22	VISU		Binary input	51,7	337
General shutdown	TSS25	VISU		Binary input	NA	NA
Battery disconnected	TSS26	VISU		Binary input	51,8	338
Battery low	TSS27	VISU		Binary input	NA	NA
Equipment start	TSS31	VISU		Binary input	NA	NA
Test communication	TSS32	VISU		Binary input	NA	NA
Measure						
Frequency	TM20	VISU		Analogue input, 16 bits	70	46
Voltage measure	TM42	VISU		Analogue input, 16 bits	80	50
Measure channel 1						
Current P1	TM21	VISU		Analogue input, 16 bits	64	40
Current P2	TM26	VISU		Analogue input, 16 bits	65	41
Current P3	TM31	VISU		Analogue input, 16 bits	66	42
Io Current	TM36	VISU		Analogue input, 16 bits	67	43
Mean phase current	TM41	VISU		Analogue input, 16 bits	68	44
Power factor	TM47	VISU		Analogue input, 16 bits	69	45
Active power	TM48	VISU		Analogue input, 16 bits	81	51
Reactive power	TM52	VISU		Analogue input, 16 bits	82	52
Apparent power	TM56	VISU		Analogue input, 16 bits	83	53
Active energy	CNT101	VISU		Analogue input, 16 bits	160	A0
Reactive energy	CNT103	VISU		Analogue input, 16 bits	NA	NA
Fault channel 1						
Fast earth fault	TSS71	VISU		Binary input	52,7	347
Earth fault	TSS72	VISU		Binary input	52,6	346
Fast phase fault	TSS76	VISU		Binary input	52,13	34D
Phase fault	TSS77	VISU		Binary input	52,12	34C
Counter fast earth fault	CNT7	VISU		Analogue input, 16 bits	NA	NA
Counter earth fault	CNT8	VISU		Analogue input, 16 bits	NA	NA
Counter fast phase fault	CNT10	VISU		Analogue input, 16 bits	NA	NA
Counter phase fault	CNT11	VISU		Analogue input, 16 bits	NA	NA

Measure channel 2						
Current P1	TM71	VISU		Analogue input, 16 bits	71	47
Current P2	TM76	VISU		Analogue input, 16 bits	72	48
Current P3	TM81	VISU		Analogue input, 16 bits	73	49
Io Current	TM86	VISU		Analogue input, 16 bits	74	4A
Mean phase current	TM91	VISU		Analogue input, 16 bits	75	4B
Power factor	TM97	VISU		Analogue input, 16 bits	76	4C
Active power	TM98	VISU		Analogue input, 16 bits	84	54
Reactive power	TM102	VISU		Analogue input, 16 bits	85	55
Apparent power	TM106	VISU		Analogue input, 16 bits	86	56
Active energy	CNT102	VISU		Analogue input, 16 bits	162	A2
Reactive energy	CNT104	VISU		Analogue input, 16 bits	NA	NA
Fault channel 2						
Fast earth fault	TSS103	VISU		Binary input	53,7	357
Earth fault	TSS104	VISU		Binary input	53,6	356
Fast phase fault	TSS108	VISU		Binary input	53,13	35D
Phase fault	TSS109	VISU		Binary input	NA	NA
Counter fast earth fault	CNT12	VISU		Analogue input, 16 bits	NA	NA
Counter earth fault	CNT13	VISU		Analogue input, 16 bits	NA	NA
Counter fast phase fault	CNT15	VISU		Analogue input, 16 bits	NA	NA
Counter phase fault	CNT16	VISU		Analogue input, 16 bits	NA	NA
Temperature measurement						
Internal temperature	TM10	VISU		Analogue input, 16 bits	NA	NA
External temperature estimated	TM11	VISU		Analogue input, 16 bits	79	4F
Digital inputs						
Digital input 1	TSS1	VISU		Binary input	51,0	330
Digital input 2	TSS2	VISU		Binary input	51,1	331
Digital input 3	TSS3	VISU		Binary input	51,2	332
Digital input 4	TSS4	VISU		Binary input	51,3	333
Digital input 5	TSS5	VISU		Binary input	51,4	334
Digital input 6	TSS6	VISU		Binary input	51,5	335

Digital inputs counters						
Counter digital input 1	CNT1	VISU		Analogue input, 16 bits	NA	NA
Counter digital input 2	CNT2	VISU		Analogue input, 16 bits	NA	NA
Counter digital input 3	CNT3	VISU		Analogue input, 16 bits	NA	NA
Counter digital input 4	CNT4	VISU		Analogue input, 16 bits	NA	NA
Counter digital input 5	CNT5	VISU		Analogue input, 16 bits	NA	NA
Counter digital input 6	CNT6	VISU		Analogue input, 16 bits	NA	NA
Digital outputs						
Digital output 1	TCD1	EXPL		Relay output control block	48,0	300
Digital output 2	TCD2	EXPL		Relay output control block	48,2	302
Digital output 3	TCD3	EXPL		Relay output control block	48,4	304
Digital output 1	TSD1	VISU		Binary input	49,0	310
Digital output 2	TSD2	VISU		Binary input	49,2	312
Digital output 3	TSD3	VISU		Binary input	49,4	314
Double digital outputs						
Digital output 1-2	TCD4	EXPL		Relay output control block	NA	NA
Digital input 1-2	TSD4	VISU		Binary input	NA	NA

7.5 T200 S

	Type Internal No.	Access	Options	Object	Index (Dec)	Index (Hex)
Channel 1						
Switch position	TSD 1	VISU		Binary input	52.0	340
Switch locked	TSS 49	VISU		Binary input	56.8	388
Switch command	TCD 1	EXPL		Relay output control block	48.0	300
Operation counter	CNT 1	VISU		Analogue input, 16 bits	NA	NA
Operation counter preset command	TCD 25	ADMIN		Relay output control block	NA	NA
Auxiliary DI	TSS 51	VISU		Binary input	NA	NA
MV voltage present	TSS 73	VISU		Binary input	57,4	394
Aux DI - MV voltage present	TSS 54	VISU		Binary input	NA	NA
Earth fault	TSS 71	VISU		Binary input	56.1	381
Phase fault	TSS 77	VISU		Binary input	56.0	380
Phase current 1	TM 2	VISU		Analogue input, 16 bits	NA	NA
Phase current 2	TM 3	VISU		Analogue input, 16 bits	NA	NA
Phase current 3	TM 4	VISU		Analogue input, 16 bits	NA	NA
Neutral current	TM 5	VISU		Analogue input, 16 bits	NA	NA
Average current	TM 6	VISU		Analogue input, 16 bits	64	400
Channel 2						
Switch position	TSD 2	VISU		Binary input	52.2	342
Switch locked	TSS 81	VISU		Binary input	56.9	389
Switch command	TCD 2	EXPL		Relay output control block	48.2	302
Operation counter	CNT 2	VISU		Analogue input, 16 bits	NA	NA
Operation counter preset command	TCD 26	ADMIN		Relay output control block	NA	NA
Auxiliary DI	TSS 83	VISU		Binary input	NA	NA
MV voltage present	TSS 105	VISU		Binary input	57.3	393
Earth fault	TSS 103	VISU		Binary input	56.3	383
Phase fault	TSS 109	VISU		Binary input	56.2	382
Phase current 1	TM 9	VISU		Analogue input, 16 bits	NA	NA
Phase current 2	TM 10	VISU		Analogue input, 16 bits	NA	NA
Phase current 3	TM 11	VISU		Analogue input, 16 bits	NA	NA
Neutral current	TM 12	VISU		Analogue input, 16 bits	NA	NA
Average current	TM 13	VISU		Analogue input, 16 bits	65	410

Common objects						
Local/Remote position	TSS 23	VISU		Binary input	57.6	396
Door opening	TSS 24	VISU		Binary input	57.2	392
Fault detection reset command	TCL 26	EXPL		Relay output control block	NA	NA
Immediate AC power supply defect	TSS 17	VISU		Binary input	57.7	397
Time-delayed AC power supply defect	TSS 18	VISU		Binary input	57.12	39C
Power cut imminent	TSS 25	VISU		Binary input	NA	NA
SNTP synchronized	TSL 79	VISU		Binary input	NA	NA
Automatic controls						
Automatic control ON/OFF position	TSD 9	VISU		Binary input	52.6	346
Automatic control ON/OFF command	TCD 9	EXPL		Relay output control block	48.6	306
Automatic control has operated	TSS 57	VISU		Binary input	57.13	39D
Internal faults						
Motorization power supply failure	TSS 19	VISU		Binary input	57.11	39B
Accessory equipment power supply failure	TSS 20	VISU		Binary input	NA	NA
Charger fault	TSS 21	VISU		Binary input	57.9	399
Battery fault	TSS 22	VISU		Binary input	57.10	39A
Equipment fault	TSS 29	VISU		Binary input	NA	NA
Digital Inputs/Outputs						
Digital input 1	TSS 1	VISU		Binary input	57.0	390
Digital input 2	TSS 2	VISU		Binary input	57.1	391
Digital input 3	TSS 3	VISU		Binary input	NA	NA
Digital input 4	TSS 4	VISU		Binary input	NA	NA
Digital input 5	TSS 5	VISU		Binary input	NA	NA
Digital input 6	TSS 6	VISU		Binary input	NA	NA
Digital input 7	TSS 7	VISU		Binary input	NA	NA
Digital input 8	TSS 8	VISU		Binary input	NA	NA
Digital output 2 position	TSD 6	VISU		Binary input	NA	NA
Digital output 2 command	TCD 6	EXPL		Relay output control block	NA	NA
Digital output 3 position	TSD 7	VISU		Binary input	NA	NA
Digital output 3 command	TCD 7	EXPL		Relay output control block	NA	NA

7.6 R200-ATS100

Indexes for digital object type (SPS, DPS, SPC, DPC) are bit addresses (refer to chapter 4.4)

Object type cross-reference table:

Object type	T200/F200C	Designation	Comment
SPS	TSS,DI	Single Point Status	
DPS	TSD, DDI	Double Point Status	
SPC	TCS, DO	Single Point Control	Possibly associated to an SPS
DPC	TCD, DDO	Double Point Control	Possibly associated to a DPS
MV	TM,AI	Measured Value	On 16 and 32 bits
APC	AO	Analogue Point Control	On 16 and 32 bits
INC	CNT	Integer Control	On 16 and 32 bits (used for presettable counters)

Access

A = Administrator (ADMIN), O = Operator (EXPL), M= Monitoring (VISU)

7.6.1 RTU data

	Source	Access	Object	Index (Dec)	Index (Hex)
RTU Specific Data					
Equipment start	R200, ATS100	A	SPS	n/a	n/a
Automatism Data					
Automatism	ATS100	O	DPC	7212	1C2Ch
Go to parallel	ATS100 (ACO/BTA)	O	DPC	7216	1C30h
Go to S1	ATS100	O	DPC	7218	1C32h
Go to Off	ATS100	O	DPC	7220	1C34h
Go to S2	ATS100	O	DPC	7222	1C36h
Go to S1 & S2	ATS100 (BTA)	O	DPC	7224	1C38h
Automatism state	ATS100	D	DPS	9292	244Ch
Automatism has started	ATS100	D	SPS	8015	1F4Fh
Automatism locked	ATS100	D	SPS	8016	1F50h
RTU Digital I/O data					
Digital output 1	R200	O	DPC	7200	1C20h
Digital output 2	R200	O	DPC	7202	1C22h
Digital output 3	R200	O	DPC	7204	1C24h
Digital output 4	R200	O	DPC	7206	1C26h
Double digital output 1-2	R200	O	DPC	7208	1C28h
Double digital output 3-4	R200	O	DPC	7210	1C2Ah
Digital output 1	ATS100 (ACO/BTA)	O	DPC	7200	1C20h
Digital output 2	ATS100 (ACO/BTA)	O	DPC	7202	1C22h
Digital output 1	R200	D	DPS	9280	2440h
Digital output 2	R200	D	DPS	9282	2442h
Digital output 3	R200	D	DPS	9284	2444h
Digital output 4	R200	D	DPS	9286	2448h
Double digital output 1-2	R200	D	DPS	9288	244Ah
Double digital output 3-4	R200	D	DPS	9290	244Ch
Double digital input 1-2	R200	D	DPS	-	
Double digital input 3-4	R200	D	DPS	-	

RTU Digital I/O data					
Digital output 1	ATS100 (ACO/BTA)	D	DPS	9280	2440h
Digital output 2	ATS100 (ACO/BTA)	D	DPS	9282	2442h
Source transfer in progress	ATS100 (ACO/BTA)	D	DPS	9284	2444h
S1 or S2 available	ATS100 (ACO/BTA)	D	DPS	9286	2448h
Digital input 1	R200	D	SPS	8001	1F41h
Digital input 2	R200	D	SPS	8002	1F42h
Digital input 3	R200	D	SPS	8003	1F43h
Digital input 4	R200	D	SPS	8004	1F44h
Digital input 5	R200	D	SPS	8005	1F45h
Digital input 6	R200	D	SPS	8006	1F46h
Digital input 7	R200	D	SPS	8007	1F47h
Digital input 8	R200	D	SPS	8008	1F48h
Digital input 1	ATS100 (ACO/BTA)	D	SPS	8001	1F41h
Digital input 2	ATS100 (ACO/BTA)	D	SPS	8002	1F42h
Digital input 3	ATS100 (ACO/BTA)	D	SPS	8003	1F43h
Digital input 4	ATS100 (ACO/BTA)	D	SPS	8004	1F44h
Voltage presence S1	ATS100 (ACO/BTA)	D	SPS	8005	1F45h
Voltage presence S2	ATS100 (ACO/BTA)	D	SPS	8006	1F46h
Transfer locking	ATS100 (ACO/BTA)	D	SPS	8007	1F47h
Parallel transfer enable	ATS100 (ACO/BTA)	D	SPS	8008	1F48h
RTU Measurement data					
Internal temperature	R200, ATS100	D	MV16	800	320
Substation global data					
Local/Remote	R200, ATS100	D	SPS	8000	1F40h
System minor fault	R200, ATS100	D	SPS	8009	1F49h
System major fault	R200, ATS100	D	SPS	8010	1F4Ah
Maintainance mode	R200, ATS100	D	SPS	8011	1F4Bh
Test SCADA com	R200, ATS100	A	SPS	8012	1F4Ch
System event loss	R200, ATS100	A	SPS	8017	1F51h

7.6.2 Global data

	Source	Access	Object	Index (Dec)	Index (Hex)
Global data					
Restart 24/48V	PS100	O	SPC	n/a	n/a
AC OFF	PS100	D	SPS	8025	1F59h
General Shutdown	PS100	D	SPS	8026	1F5Ah
Battery Low	PS100	D	SPS	8027	1F5Bh
Battery Fault	PS100	D	SPS	8028	1F5Ch
Charger Fault	PS100	D	SPS	8029	1F5Dh
12V failure	PS100	D	SPS	8030	1F5Eh
24/48V failure	PS100	D	SPS	8031	1F5Fh
Battery Charge Indicator	PS100	O	MV16	n/a	n/a

7.6.3 Cubicle 1 data

	Source	Access	Object	Index (Dec)	Index (Hex)
Cubicle 1 data					
Switchgear position	SC110	O	DPC	7232	1C40h
Simulated position	SC110	A	DPC	7234	1C42h
Spring charge locking	SC110	A	DPC	n/a	n/a
Protection setting group	VIP410	O	DPC	7236	1C44h
Switchgear position	SC110	D	DPS	9312	2460h
Earth switch position	SC110	D	DPS	9314	2462h
Simulated position	SC110	A	DPS	9316	2464h
Spring charge locking	SC110	A	DPS	n/a	n/a
Active setting group	VIP410	D	DPS	9318	2466h
Current Maximeters	Flair23DM	O	SPC	n/a	n/a
Fault passage indication	Flair23DM	O	SPC	6416	1910h
Trip indication	VIP410	O	SPC	6417	1911h
Phase peak demand values	VIP410	O	SPC	n/a	n/a
Switchgear control failure	SC110	O	SPS	n/a	n/a
Trip indication	SC110	D	SPS	8048	1F70h
Ready to operate	SC110	A	SPS	n/a	n/a
Ready for remote command	SC110	O	SPS	n/a	n/a
Local/Remote switch state	SC110	D	SPS	n/a	n/a
Phase fault	Flair23DM	D	SPS	8049	1F71h
Earth fault	Flair23DM	D	SPS	8050	1F72h
Transient phase fault	Flair23DM	D	SPS	n/a	n/a
Transient earth fault	Flair23DM	D	SPS	n/a	n/a
Fault by test action	Flair23DM	D	SPS	8051	1F73h
Phase or earth fault	Flair23DM	D	SPS	n/a	n/a
MV voltage presence	Flair23DM	D	SPS	8052	1F74h
MV voltage presence (V1 or U12)	Flair23DM	A	SPS	8053	1F75h
MV voltage presence (V2 or U13)	Flair23DM	A	SPS	8054	1F76h
MV voltage presence (V3 or U23)	Flair23DM	A	SPS	8055	1F77h
Residual voltage presence	Flair23DM	D	SPS	8056	1F78h
MV voltage absence	Flair23DM	D	SPS	8057	1F79h
MV voltage absence (V1 or U12)	Flair23DM	A	SPS	8058	1F7Ah
MV voltage absence (V2 or U13)	Flair23DM	A	SPS	8059	1F7Bh
MV voltage absence (V3 or U23)	Flair23DM	A	SPS	8060	1F7Ch
Max Current Reset Indication	Flair23DM	O	SPS	n/a	n/a
Protection 50-51 I>, delayed	VIP410	O	SPS	n/a	n/a
Protection 50-51 I>>, delayed	VIP410	O	SPS	n/a	n/a
Protection 50-51 I>>>, delayed	VIP410	O	SPS	n/a	n/a
Protection 50-51 I>, pick-up	VIP410	O	SPS	n/a	n/a
Protection 50-51 I>>, pick-up	VIP410	O	SPS	n/a	n/a
Protection 50-51 I>>>, pick-up	VIP410	O	SPS	n/a	n/a
Protection 50N-51N Io>, delayed	VIP410	O	SPS	n/a	n/a
Protection 50N-51N Io>>, delayed	VIP410	O	SPS	n/a	n/a
Protection 50N-51N Io>, pick-up	VIP410	O	SPS	n/a	n/a
Protection 50N-51N Io>>, pick-up	VIP410	O	SPS	n/a	n/a
Protection 49 RMS thermal alarm	VIP410	O	SPS	n/a	n/a

Cubicle 1 data					
Protection 49 RMS thermal tripping	VIP410	O	SPS	n/a	n/a
External trip by external input	VIP410	O	SPS	8061	1F7Dh
Tripping	VIP410	D	SPS	8062	1F7Eh
Trip by test menu	VIP410	O	SPS	8063	1F7Fh
Trip Indication	VIP410	D	SPS	8064	1F80h
Phase peak demand values reset indication	VIP410	A	SPS	n/a	n/a
Operation counter	SC110	O	INC32	n/a	n/a
Trip counter	SC110	D	INC32	n/a	n/a
Phase + earth fault counter	Flair23DM	D	INC32	n/a	n/a
Phase fault counter	Flair23DM	D	INC32	n/a	n/a
Earth fault counter	Flair23DM	D	INC32	n/a	n/a
Number of trip : phase fault	VIP410	D	INC32	n/a	n/a
Number of trip : earth fault	VIP410	D	INC32	n/a	n/a
Number of trip : thermal overload	VIP410	D	INC32	n/a	n/a
Number of trip : external trip	VIP410	D	INC32	n/a	n/a
Energy, active total MSB	PM800	D	INC32	10840	2A58h
Energy, active total LSB	PM800	D	INC32	10842	2A5Ah
Energy, reactive total MSB	PM800	D	INC32	10844	2A5Ch
Energy, reactive total LSB	PM800	D	INC32	10846	2A5Eh
Energy, apparent MSB	PM800	A	INC32	10848	2A60h
Energy, apparent MSB	PM800	A	INC32	10850	2A62h
Phase current I1	Flair23DM	D	MV16	860	035Ch
Phase current I2	Flair23DM	D	MV16	861	035Dh
Phase current I3	Flair23DM	D	MV16	862	035Eh
Residual current I0	Flair23DM	D	MV16	863	035Fh
I1 max	Flair23DM	O	MV16	n/a	n/a
I2 max	Flair23DM	O	MV16	n/a	n/a
I3 max	Flair23DM	O	MV16	n/a	n/a
Phase current I1	VIP410	D	MV16	864	0360h
Phase current I2	VIP410	D	MV16	865	0361h
Phase current I3	VIP410	D	MV16	866	0362h
Measured Earth Fault Current I0	VIP410	D	MV16	867	0363h
Phase peak demand current Im1 (mean current)	VIP410	O	MV16	n/a	n/a
Phase peak demand current Im2 (mean current)	VIP410	O	MV16	n/a	n/a
Phase peak demand current Im3 (mean current)	VIP410	O	MV16	n/a	n/a
Phase current I1	PM800	D	MV16	868	0364h
Phase current I2	PM800	D	MV16	869	0365h
Phase current I3	PM800	D	MV16	870	0366h
Residual current I0	PM800	D	MV16	871	0367h
Voltage U12	PM800	A	MV16	872	0368h
Voltage U23	PM800	A	MV16	873	0369h
Voltage U31	PM800	A	MV16	874	036Ah
Mean voltage between phases	PM800	A	MV16	875	036Bh
Voltage V1	PM800	A	MV16	876	036Ch
Voltage V2	PM800	A	MV16	877	036Dh
Voltage V3	PM800	A	MV16	878	036Eh
Voltage NR	PM800	A	MV16	879	036Fh
Mean voltage phase-N	PM800	A	MV16	880	0370h
Frequency	PM800	A	MV16	881	0371h

Cubicle 1 data					
Real power, total	PM800	A	MV16	882	0372h
Reactive power, total	PM800	A	MV16	883	0373h
Apparent power, total	PM800	A	MV16	884	0374h
True power factor, total	PM800	A	MV16	885	0375h

7.6.4 Cubicle xxx data

Same principles apply for further cubicles, with same default variables and default external address. From the tables of chapter 7.6.3, just add an offset for default external address as follows:

Object type	**Index Decimal Offset per cubicle**	**Index dec depending on cubicle number**
		Base + Dec Offset*(Cub_Nb-1)
DPC	16	Base + 16*(Cub_Nb-1)
DPS	16	Base + 16*(Cub_Nb-1)
SPC	16	Base + 16*(Cub_Nb-1)
SPS	32	Base + 32*(Cub_Nb-1)
INC32	120	Base + 120*(Cub_Nb-1)
Energies	40	Base + 40*(Cub_Nb-1)
MV16	60	Base + 60*(Cub_Nb-1)
MV32	120	Base + 120*(Cub_Nb-1)

Where “base” is the default decimal index of corresponding object in Cubicle1.

8 MODBUS appendices

8.1 MODBUS table

Identification/configuration field

	Word address 0000h to 0001h	Access mode	Authorized function
Software version	0000h	Read	3,4
Status	0001h	Read/Write	3,4,6

■ **Status bit 0**:

Bit 0 = 0: "Direct" TM mode.

Bit 0 = 1: "Raw" TM mode.

By default, T200 is in "Direct" mode.

■ **Status bit 15**:

Bit 15 = 0: No loss of events

Bit 15 = 1: Loss of events

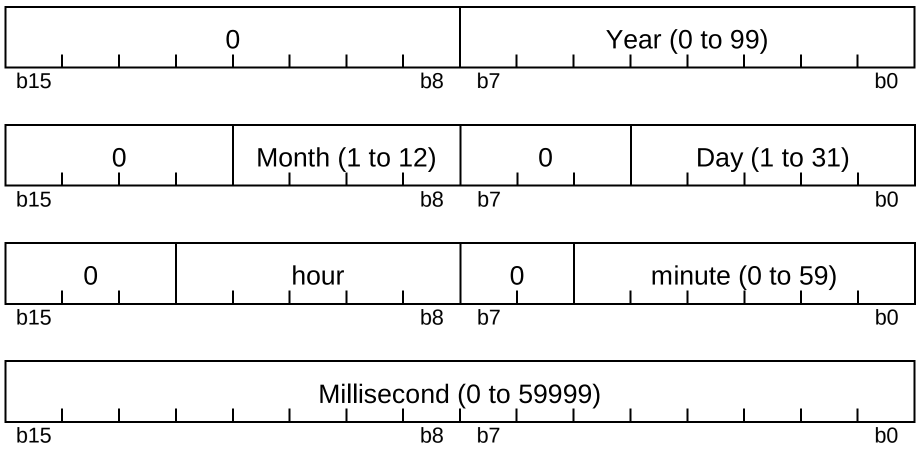
This bit is enabled when the event stack is full. The "event loss" event is then placed in the stack. So long as this event is present in the stack, no other event is placed there. This bit is erased when the stack becomes empty. The disappearance of this bit generates no event.

Time synchronization field

This field contains the internal date and time of the device for time tagging of events.

The field can only be read or written to as a whole.

Date in binary code	Word address 0002h to 0005h	Access mode	Authorized function
Year	0002h	Read/Write	3,4,16
Month+day	0003h	Read/Write	3,4
Hours+minutes	0004h	Read/Write	3,4
Milliseconds	0005h	Read/Write	3,4



Test field

This field contains 9 words accessible in read and write modes. This field, initially in zero state, is available to the user to facilitate debugging tests.

The content of this field has no influence on the functionalities of the T200.

Test field	Word address	Access mode	Authorized function
9 words	0006h to 000Eh	Read/Write	1,2,3,4,5,6,16

Event field

This memory area is configurable. It stores in memory and time tags device changes of state.

Example:

- Base address = 15

- Max. number of events = configurable from 1 to 100.

Event field	Word address	Access mode	Authorized function
Exchange word	000Fh	Read/Write	3,4,6,16
Event 1	0010h to 0017h	Read	3,4
Event 2	0018h to 001Fh	Read	3,4
Event 3	0020h to 0027h	Read	3,4
Event 4	0028h to 002Fh	Read	3,4

Only the exchange word can be written.
It is possible to read the exchange field as a whole or the exchange word alone.

The exchange word can be used to manage a specific protocol so as not to lose events following a MODBUS communication problem.

■The exchange word comprises 2 bytes:

□ Most significant byte = exchange number allowing each event block to be identified. It is initialized to zero after a power up; when it reaches its maximum value (FFh / 255) it automatically returns to 0. The exchange numbering is established by the T200 and acknowledged by the master.

Least significant byte = number of valid events in the event field.

Note: for the details of coding and acknowledgement of events, see paragraph "*4.2 - Specific protocol-related operation - Event Management*"

TC / TSD / TSS zones

T200P :

TCD / TSD / TSS	Word address	Access mode	Function allowed
TCD 1, 2, 9	0300, 302, 306h	Read/Write	1,2,3,4,5,6
TSD 1, 2, 9	0340, 342, 346h	Read	1,2,3,4
TSS 77, 71, 109, 103	0380h to 383h	Read	1,2,3,4
TSS 49, 81	0388h to 389h	Read	1,2,3,4
TSS 1, 2, 24, 105	0390h to 393h	Read	1,2,3,4
TSS 23, 17	0396h to 397h	Read	1,2,3,4
TSS 21	0399h	Read	1,2,3,4
TSS 22, 19, 18, 57	039Ah to 39Dh	Read	1,2,3,4

T200I :

TCD / TSD / TSS	Word address	Access mode	Function allowed
TCD 1-4	0300 to 306h	Read/Write	1,2,3,4,5,6
TCD 41-44	0308 to 30Eh	Read/Write	1,2,3,4,5,6
TCD 81-84	0310 to 316h	Read/Write	1,2,3,4,5,6
TCD 121-124	0318 to 31Eh	Read/Write	1,2,3,4,5,6
TCD 9, 49, 89, 129	0328 to 32Eh	Read/Write	1,2,3,4,5,6
TSD 1-4	0340 to 346h	Read	1,2,3,4
TSD 41-44	0348 to 34Eh	Read	1,2,3,4
TSD 81-84	0350 to 356h	Read	1,2,3,4
TSD 121-124	0358 to 35Eh	Read	1,2,3,4
TSD 9, 49, 89, 129	0368 to 36Eh	Read	1,2,3,4
TSS 77, 71, 109, 103, 141, 135, 173, 167, 49, 81, 113, 145	0380 to 38Bh	Read	1,2,3,4
TSS 1,2,54,86,118,150,23,17,3,21,22, 19,18,4,5,6,349,343,381,375,413,407,4 45,439,321,353,385,417	0390 to 3ABh	Read	1,2,3,4
TSS 273,274,326, 358,390,422	03B0 to 3B5h	Read	1,2,3,4
TSS 275	03B8h	Read	1,2,3,4
TSS 276,277,278,621,615,653,647, 685, 679,717,711,593,625,657,689	03BD to 3CBh	Read	1,2,3,4
TSS 545,546,598, 630,662,694 TSS 547 TSS 548 to 550 TSS 893,887,925,919 ,957,951,989,983,865,897,929,961 TSS 817,818,870, 902,934,966 TSS 819 TSS 820 to 822	03D0 to 3D5h 03D8h 03DD to 3DFh 03E1 to 3EBh 03F0 to 3F5h 03F8h 03FD to 3FFh	Read Read Read Read Read Read Read	1,2,3,4 1,2,3,4 1,2,3,4 1,2,3,4 1,2,3,4 1,2,3,4 1,2,3,4

F200C :

TCD / TSD / TSS	Word address	Access mode	Function allowed
TCD 1, 2, 3, 17	0300 to 306h	Read/Write	1,2,3,4,5,6
TSD 1 to 3	0310 to 314	Read	1,2,3,4
TSS 1 to 6, 21, 22, 26	0330 to 338h	Read	1,2,3,4
TSS 72, 71, 17,	0346 to 348h	Read	1,2,3,4
TSS 77, 76	034D to 34Ch	Read	1,2,3,4
TSS 104, 103	0356 to 357h	Read	1,2,3,4
TSS 108	035Dh	Read	1,2,3,4

T200S :

TCD / TSD / TSS	Word address	Access mode	Function allowed
TCD 1, 2, 9	0300, 302, 306h	Read/Write	1,2,3,4,5,6
TSD 1, 2, 9	0340, 342, 346h	Read	1,2,3,4
TSS 77, 71, 109, 103	0380h to 383h	Read	1,2,3,4
TSS 49, 81	0388h to 389h	Read	1,2,3,4
TSS 1, 2, 24, 105, 73	0390h to 394h	Read	1,2,3,4
TSS 23, 17	0396h to 397h	Read	1,2,3,4
TSS 21	0399h	Read	1,2,3,4
TSS 22, 19, 18, 57	039Ah to 39Dh	Read	1,2,3,4

Each TCD word is encoded as follows:

TCD8	TCD7	TCD6	TCD5	TCD4	TCD3	TCD2	TCD1
C | O	C | O	C | O	C | O	C | O	C | O	C | O	C | O
b15			b8	b7			b0

A TCD is encoded in 2 bits C, O :

■ 01 = open order

■ 10 = close order

The TCDs are assigned as follows:

■ TCD 1 to 4 : O/C control - channels 1 to 4.
■ TCD 41 to 45 : O/C control - channels 5 to 8.
■ TCD 81 to 85 : O/C control - channels 9 to 12.
■ TCD 121 to 125 : O/C control - channels 13 to 16.

■ TCD 17 : Reset of fault detection - channels 1 to 4
■ TCD 57 : Reset of fault detection - channels 5 to 8
■ TCD 97 : Reset of fault detection - channels 9 to 12
■ TCD 137 : Reset of fault detection - channels 13 to 16

■ TCD 9 : Automation ON/OFF control - channels 1 to 4.
■ TCD 49 : Automation ON/OFF control - channels 5 to 8.
■ TCD 89 : Automation ON/OFF control - channels 9 to 12.
■ TCD 129 : Automation ON/OFF control - channels 13 to 16.

■ TCD 25 : Operation counter preset activation - channel 1.
■ TCD 26 : Operation counter preset activation - channel 2.

■ TCD 29 : Active energy preset - channel 1
■ TCD 30 : Active energy preset - channel 2
■ TCD 37 : Reactive energy preset - channel 1
■ TCD 38 : Reactive energy preset - channel 2

■ TCD 5 to 7 : Digital outputs control 1 to 3
■ TCD 4 : O/C switch control via digital outputs 1 and 2

Note: depending on the type of equipment used, the TCDs listed above are not all managed.

Remote control orders are performed by writing a TCD word. Only one remote control order at a time may be requested. The order type is the status complementary to the TSD status (only one bit should be included in the word written). It is only accepted if the T200 is not already processing a remote control order.

The control order zone (TCD) may be read with bit and word read function code. As it contains no information the data is 0.

Each TSD word is encoded as follows:

TSD8	TSD7	TSD6	TSD5	TSD4	TSD3	TSD2	TSD1
C | O	C | O	C | O	C | O	C | O	C | O	C | O	C | O
b15			b8	b7			b0

A TSD is encoded in 2 bits, C,O :

- 01 = switch open.
- 10 = switch closed.
- 00 or 11 = undetermined.

For automation only :

- 11 = automatism locked by internal problem
- 00 = automatism locked by external TSS.

The TSDs are assigned as follows:

- TSD 1 to 4 : O/C position - channel 1 to 4.
- TSD 41 to 45 : O/C position - channel 5 to 8.
- TSD 81 to 85 : O/C position - channel 9 to 12.
- TSD 121 to 125 : O/C position - channel 13 to 16.

- TSD 9 : ON/OFF automation status - channel 1 to 4.
- TSD 49 : ON/OFF automation status - channel 5 to 8.
- TSD 89 : ON/OFF automation status - channel 9 to 12.
- TSD 129 : ON/OFF automation status - channel 13 to 16.

- TSD 5 to 7 : Digital outputs positions 1 to 3

- TSD 4 : O/C switch position via digital outputs 1 and 2

Note: depending on the type of equipment used, the TSDs listed above are not all managed.

Each TSS word is encoded as follows:

TSS16	TSS15	TSS14	TSS13	TSS12	TSS11	TSS10	TSS9	TSS8	TSS7	TSS6	TSS5	TSS4	TSS3	TSS2	TSS1
b15							b8	b7							b0

Depending on the type of equipment, TSS 1 to TSS 989 and are not all managed.
For the details of TSS used for each type of equipment, see object addressing table (see: paragraph "*7 - objects addressing"*)

Measurement and counter zones

T200P :

TM 32	Word address	Access mode	Function allowed
TM 6 - average current - channel 1	0040h	Read	3,4
TM 13 - average current - channel 2	0041h	Read	3,4
TM 47 - voltage U21 - channel 1	0042h	Read	3,4
TM 56 - voltage U21 - channel 2	0043h	Read	3,4

T200I :

TM 32	Word address	Access mode	Function allowed
TM 2 - phase current channel 1	0040h	Read	3,4
TM 9 - phase current channel 2	0041h	Read	3,4
TM 17 - phase current channel 3	0042h	Read	3,4
TM 24 - phase current channel 4	0043h	Read	3,4
TM 84 - phase current channel 5	0044h	Read	3,4
TM 91 - phase current channel 6	0045h	Read	3,4
TM 99 - phase current channel 7	0046h	Read	3,4
TM 106 - phase current channel 8	0047h	Read	3,4
TM 166 - phase current channel 9	0048h	Read	3,4
TM 173 - phase current channel 10	0049h	Read	3,4
TM 181 - phase current channel 11	004Ah	Read	3,4
TM 188 - phase current channel 12	004Bh	Read	3,4
TM 248 - phase current channel 13	004Ch	Read	3,4
TM 255 - phase current channel 14	004Dh	Read	3,4
TM 263 - phase current channel 15	004Eh	Read	3,4
TM 270 - phase current channel 16	004Fh	Read	3,4

F200C :

TM 32	Word address	Access mode	Function allowed
TM 21 - current I1 - channel 1	0040h	Read	3,4
TM 26 - current I2 - channel 1	0041h	Read	3,4
TM 31 - current I3 - channel 1	0042h	Read	3,4
TM 36 - current I0 - channel 1	0043h	Read	3,4
TM 41 - average current 3I - channel 1	0044h	Read	3,4
TM 47 - power factor - channel 1	0045h	Read	3,4
TM 20 - frequency	0046h	Read	3,4
TM 71 - current I1 - channel 2	0047h	Read	3,4
TM 76 - current I2 - channel 2	0048h	Read	3,4
TM 81 - current I3 - channel 2	0049h	Read	3,4
TM 86 - current I0 - channel 2	004Ah	Read	3,4
TM 91 - average current 3I - channel 2	004Bh	Read	3,4
TM 97 - power factor - channel 2	004Ch	Read	3,4
TM 11 - delta temperature int/ext	004Fh	Read	3,4
TM 42 - voltage measurement	0050h	Read	3,4
TM 48 - active power - channel 1	0051h	Read	3,4
TM 52 - reactive power - channel 1	0052h	Read	3,4
TM 56 - apparent power - channel 1	0053h	Read	3,4
TM 98 - active power - channel 2	0054h	Read	3,4
TM 102 - reactive power - channel 2	0055h	Read	3,4
TM 106 - apparent power - channel 2	0056h	Read	3,4
CNT 101 - active energy - channel 1	00A0h	Read	3,4
CNT 102 - active energy - channel 2	00A2h	Read	3,4

T200S :

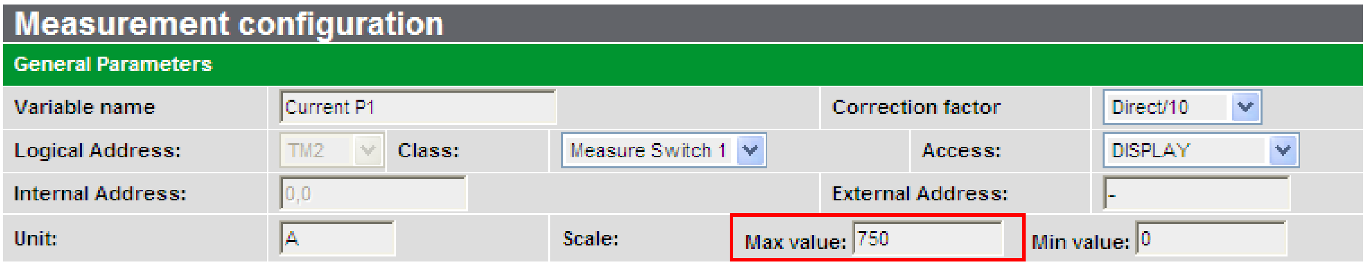
TM 32	Word address	Access mode	Function allowed
TM 6 - average current - channel 1	0040h	Read	3,4
TM 13 - average current - channel 2	0041h	Read	3,4

Each TM value is a signed value encoded in 2's complement 16-bit word.

Depending on the calibration mode configured (in the identification zone), the value should be interpreted as follows:

- **"Direct" mode (or "Adjusted" or "Scaling" mode)** :

Following rules are applied to "Direct" mode:
- Any invalid value (the value can't be read properly by the equipment) will be transmitted with the value 0x8000, and the invalid quality bit set
- Any 16bits measurement will be transferred without conversion
- The 32 bits measurements will be converted depending on their "Max value" parameter.



o If the Max Value has not been set (= 0, default value), the biggest value (=0x7FFFFFFF) is used instead
o If the measurement is bigger than the Max Value, it will be transferred as 0x7FFF with the overflow quality bit set
o If the measurement is lower than the (-Max Value), it will be transferred as 0x8000 with the overflow quality bit set
o The measurement will be divided by ten as many times as the Max value must be divided by ten to fit into the "-32768 to 32767" interval.
The transmitted value is rounded.

Examples: scaled value transmitted, depending on the internal value and the max value:

- For 16 bits types (TM16) :

Internal value	0	10000	357	-5000	Invalid
Max value (parameter)					
0	0	10000	357	-5000	0x8000
4000	0	10000	357	-5000	0x8000
400000	0	10000	357	-5000	0x8000

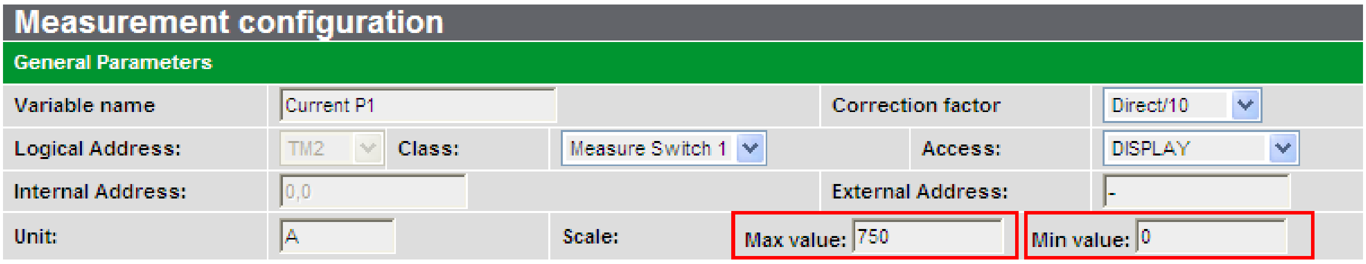
- For 32 bits types (TM32) :

Internal value	0	10000	357	80000	552000	-700	-5000	-75000	Invalid
Max value (parameter)									
0	0	0	0	0	5	0	0	0	0x8000
4000	0	0x7FFF	357	0x7FFF	0x7FFF		0x8000	0x8000	0x8000
400000	0	100	3	800	0x7FFF	-7	-50	-750	0x8000

- **"Raw" mode (or "Normalized" mode)** :

Following rules are applied to "Raw" mode:

- Any invalid value (the value can't be read properly by the equipment) will be transmitted with the value 0x8000, and the invalid quality bit set
- The 16 bits and 32 bits measurements will be converted depending on their "Min value" and "Max value" parameters.



o If the Max value = Min value (= 0, default value), the biggest interval is used instead (-32768 to 32767 for 16 bits, -2147483648 to -2147483647 for 32 bits.

o If the measurement is bigger than the Max Value, it will be transferred as 0x7FFF with the Overflow quality bit set

o If the measurement is lower the Min Value, it will be transferred as 0x8000 with the overflow quality bit set

o The measurement will be converted using a bijection from the min-max interval to the "-32768 to 32767" interval, or "0 to 32767" (depending on the min and max)

The applied formulas are:

- If Min >=0 and Max > 0:
  Transmitted value = (Internal value – Min)*32767 / (Max –Min).
- If Min < 0 and Max <= 0:
  Transmitted value = (Internal value – Max)*32768 / (Max –Min).
- If Min < 0 and Max > 0:
  Transmitted value = (Internal value – Min)*65535 / (Max –Min) – 32768.

The transmitted value is rounded.

Examples: normalized value transmitted, depending on the internal value and the min and max values :

Internal value	0	10000	357	80000	552000	-700	-5000	-75000	Invalid
Min/Max Value (parameters)									
0 / 0 (TM16)	0	10000	357	-	-	-700	-5000	-	0x8000
0 / 0 (TM32)	0	0	0	0	7	0	0	-1	0x8000
0 / 4000	0	0x7FFF	2924	0x7FFF	0x7FFF	0x8000	0x8000	0x8000	0x8000
0 / 400000	0	819	29	6553	0x7FFF	0x8000	0x8000	0x8000	0x8000
-4000 / 4000	0	0x7FFF	2924	0x7FFF	0x7FFF	-5734	0x8000	0x8000	0x8000
-4000 / 400000	-32119	-30496	-32061	-19141	0x7FFF	-32232	0x8000	0x8000	0x8000
-400000 / 400000	0	818	28	6553	0x7FFF	-57	-410	-6144	0x8000
-32768 / 32767	0	10000	357	0x7FFF	0x7FFF	-700	-5000	0x8000	0x8000

Scaling example: for a full scale at 400 amperes (= Max value), an internal TM value of 8192 (0x2000) corresponds to:

8192 * 400 / 32767 + 0 = 100 A (with Max = 400 and Min = 0)

8.2 MODBUS functions

MODBUS is a master - slave protocol.

It is used to read or write one or more words (16 bits), as well as diagnostic counters.

Functions available:

- **1**: read n output bits.
- **2**: read n input bits.
- **3**: read n output words.
- **4**: read n input words.
- **5**: write a bit.
- **6**: write a word.
- **8**: read diagnostic counters.
- **16**: write several words.

Exchanges are carried out at the master's initiative and comprise a request from the master followed by the reply from the slave. The master's requests are addressed to a slave identified by its number in the first byte of the frame or else addressed to all the slaves (broadcast).

Broadcast commands are necessarily write commands. No reply is transmitted by the slaves.

Structure of frames exchanged

All the frames exchanged (request and reply) have the same structure:

Slave number	function code	data zone	check zone CRC16

Each message or frame contains 4 types of information:

- slave number (1 byte): it specifies the receiving equipment (0 to FFh). If it is equal to zero, the request concerns all the slaves (broadcast) and there is no reply message.
- function code (1 byte): it is used to select a command (read, write...) and check that the reply is correct.
- data zone (n bytes): it contains the parameters linked to the function.
- check zone (2 bytes): it is used to detect transmission errors.

Please note that when 32 bits are used (for counters), words (2 bytes = 16 bits) can be transmitted as :
MSB / LSB (H/L) or LSB/MSB weight (L/H).

Checking of messages received by the slave

When the slave receives a frame, it checks the following, in order: CRC16, slave number, function code and function parameters.

- If the CRC16 or the slave number are incorrect, the slave does not reply.
- If the CRC16 and the slave number are correct, but the function code or parameters are not valid, the slave transmits an exception reply.
- If the CRC16, slave number, function code and parameters are correct, the slave replies to the master's request.

Exception reply transmitted by the slave

Slave number	function code received with MSB set to 1	Exception code 01 unknown function code 02 incorrect address 03 incorrect data	CRC16
1 byte	1 byte	1 byte	2 bytes

Reading N bits: functions 1 and 2

Function 1: reading output bits.
Function 2: reading input bits.

Request

Slave number	1 or 2	Address of 1st bit (MSB+LSB)	Number of bits	CRC16
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Response

Slave number	1 or 2	Number of bytes read	First byte read		Last byte read	CRC16
1 byte	1 byte	1 byte		N bytes		2 bytes

Reading N words: functions 3 and 4

Function 3: reading output words.
Function 4: reading input words.

Request

Slave number	3 or 4	Address of 1st word (MSB+LSB)	Number of words (MSB+LSB)	CRC16
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Response

Slave number	3 or 4	Number of bytes read	First word read (MSB+LSB)		Last word read (MSB+LSB)	CRC16
1 byte	1 byte	1 byte	2 bytes		2 bytes	2 bytes

Writing a bit: function 5

Request

Slave number	5	Bit address (MSB+LSB)	Bit value	0	CRC16
1 byte	1 byte	2 bytes	1 byte	1 byte	2 bytes

Bit value: bit forced to 0: write 0

bit forced to 1: write FFh

Response

The response is identical to the request frame.

Slave number	5	Bit address (MSB+LSB)	Bit value	0	CRC16
1 byte	1 byte	2 bytes	1 byte	1 byte	2 bytes

Writing a word: function 6

Request

Slave number	6	Word address (MSB+LSB)	Word value (MSB+LSB)	CRC16
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Response

The response is an echo to the request indicating the slave's acknowledgment of the value contained in the request.

Slave number	6	Word address (MSB+LSB)	Word value (MSB+LSB)	CRC16
1 byte	1 byte	2 bytes	2 bytes	2 bytes

Reading of diagnostic counters: function 8

To each slave are assigned diagnostic counters. In all, there are 5 counters per slave. These counters are 16-bit words. When they reach FFFFh, they loop back to 0000h.
For the request by the master, the most significant bit of the sub-function code is assigned by the sub-address of the T200 device and the data are at 0000h.
For the response by the slave, the data contain the value of the counter concerned.

Request/response

Slave number	8	Sub-function code (MSB+LSB)	Data (MSB+LSB)	CRC16
1 byte	1 byte	2 bytes	2 bytes	2 bytes

	Sub-function code	Data
The slave must send the echo of the request	xx00	XXXX
Resetting of diagnostic counters	xx0A	0000
Reading the total number of:		
frames received without CRC error (CPT1)	xx0B	XXXX
frames received with CRC error (CPT2)	xx0C	XXXX
exception responses (CPT3)	xx0D	XXXX
frames sent to the station (CPT4) (excluding broadcasting)	xx0E	XXXX
broadcasting requests received and executed correctly (CPT5)	xx0F	XXXX

Sub-function 0 can be used to test transmission. The slave returns the echo of the data received.

Writing N consecutive words: function 16

The number of words to be written is in a range between 1 and 123 and the number of bytes is in a range between 2 and 246.
The words are written by increasing order of the addresses.

Request

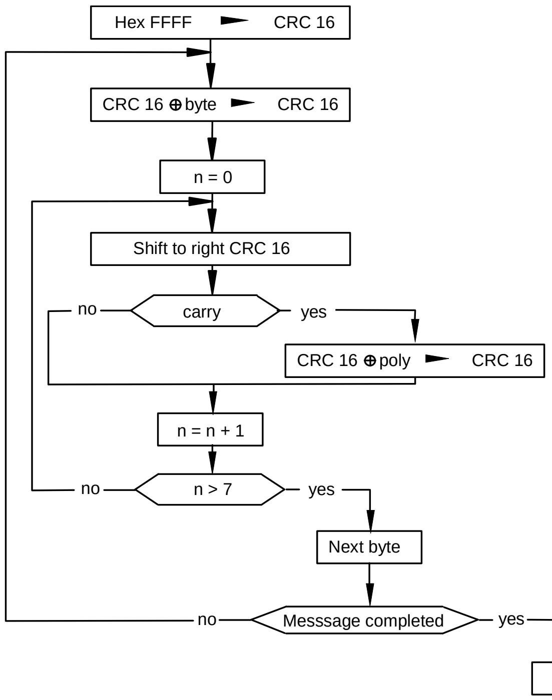
Slave number	10h	Address of 1st word to be written	Number of words to be written	Number of bytes to be written	Values of words to be written	CRC16
1 byte	1 byte	2 bytes	2 bytes	1 byte	N bytes	2 bytes

Response

Slave number	10h	Address of 1st word written (MSB+LSB)	Number of words written (MSB+LSB)	CRC16
1 byte	1 byte	2 bytes	2 bytes	2 bytes

8.3 *MODBUS control field*

Algorithm for calculation of CRC16



n = number of data bits
poly=polynomial for calculation of CRC16=1010 0000 0000 0001

Writing in C language of the CRC16 calculation

Calculates and returns crc16 to the "buf" field of length "len".

- *buf: pointer of the buffer on which calculation is performed.
- len: buffer length.

```
unsigned crc16(char *buf, int len)
  {
  #define POLY  0xA001
  char i;
  unsigned crc;

  for (crc = 0xFFFF; len != 0; len --)
    {
    crc ^= *buf ++;
    for (i = 0; i < 8; i ++)
      {
      if (crc & 0x0001)
        crc = (crc >> 1) ^ POLY;
      else
        crc >>= 1;
      }
    }
  return (crc);
  }
```

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