MV electrical network management

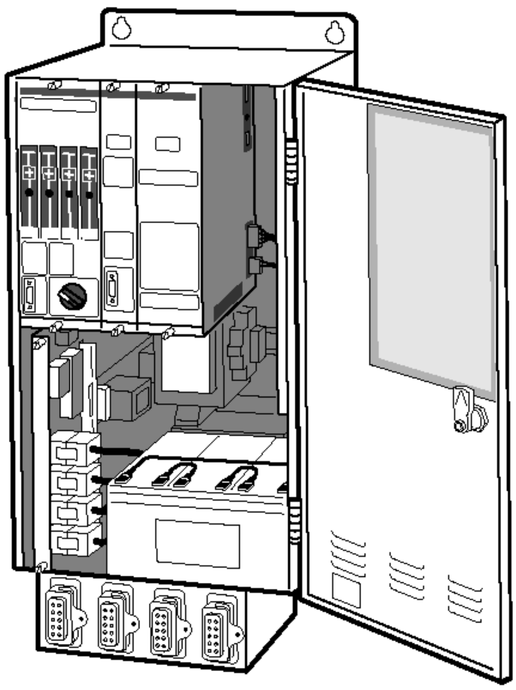
Easergy range

T200 & Flair 200C & R200-ATS100

MV substation control and monitoring units

IEC 60870-5-101 communication

Appendix to the User Manual



Schneider Electric

Content

1. Introduction

This appendix to the User Manual is designed to provide aid with setting up a telecontrol network using the IEC 60870-5-101 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;
- The configuration settings to be made, with
  - general configuration of the protocol;
  - specific configurations relating to the transmission media;
  - specific configurations relating to the objects exchanged;
- Maintenance aid facilities
- A glossary of specific terms (expressions written in italics in the text)
- The descriptive documents specified by the IEC (interoperability)
- Object addressing tables which can serve as a model for establishing databases for the T200 and the Flair 200C.

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 a paying basis, on the IEC website (www.iec.ch).

The international standard used has been specified by the International Electrotechnical Commission in the following documents:

- IEC 60870-5-1:1990, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 1: Transmission frame formats
- IEC 60870-5-2:1992, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 2: Link transmission procedures
- IEC 60870-5-3:1992, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 3: General structure of application data
- IEC 60870-5-4:1993, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 4: Definition and coding of application information elements
- IEC 60870-5-5:1993, Telecontrol equipment and systems – Part 5: Transmission protocols – Section 5: Basic application functions
- IEC 60870-5-101:2003, Telecontrol equipment and systems – Part 5-101: Transmission protocols – Companion standard for basic telecontrol tasks

These documents refer to other normative documents which can also be consulted. They are referenced as follows:

- IEC 60050(371):1984, International Electrotechnical Vocabulary (IEV) – Chapter 371: Telecontrol
- IEC 60870-1-1:1988, Telecontrol equipment and systems – Part 1: General considerations – Section 1: General principles
- IEC 60870-5-103:1997, Telecontrol equipment and systems – Part 5-103: Transmission protocols – Companion standard for the informative interface of protection equipment
- OSI/IEC 8824-1:2000, Information technology – Abstract Syntax Notation One (ASN.1): Specification of basic notation
- ITU-T V.24:2000, List of definitions for interchange circuits between data terminal equipment (DTE) and data circuit-terminating equipment (DCE)s
- ITU-T V.28:1993, Electrical characteristics for unbalanced double-current interchange circuits
- ITU-T X.24:1988, List of definitions for interchange circuits between Data Terminal Equipment (DTE) and Data Circuit-terminating Equipment (DCE) on public data networks
- ITU-T X.27:1996, Electrical characteristics for balanced double-current interchange circuits operating at data signalling rates up to 10 Mbit/s
- IEEE 754:1985, Binary floating-point arithmetic

3. Principles

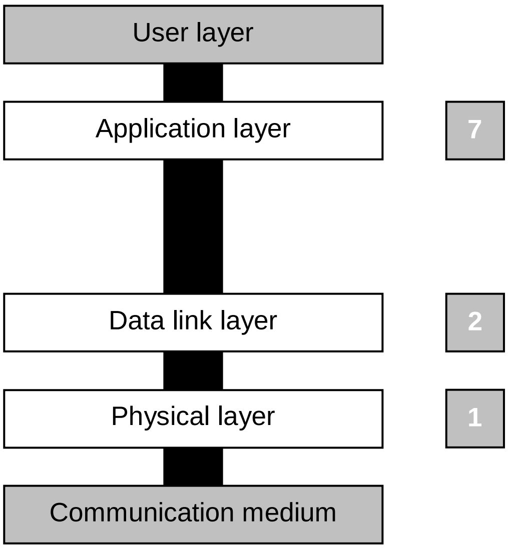
3.1 Definition

The IEC 60870-5-101 protocol specifies data coding and the rules for interchange of such data between two equipments. The T200 is one of these two equipments, while the Supervisor (or another equipment) is the second.

3.2 ISO Model

The IEC 60870-5-101 protocol is based on the 3-layer reference model EPA - *Enhanced Performance Architecture* - which is a simplified version of the 7-layer ISO model.

The three layers used are as follows:
- Physical layer;
- Data link layer;
- Application layer.



3.3 Transmission modes

The IEC 60870-5-101 protocol allows operation in two transmission modes.

Interchange can be of the *unbalanced* type (master - slave mode) or *balanced* type (master - master mode).

In the *unbalanced* mode, the Supervisor is the master and the T200, as slave, merely responds to the master's requests.

In *balanced* mode, each equipment can initiate dialogue.

The operating procedure, in *unbalanced* mode, is generally as follows:
- The Supervisor initializes the link to the first T200.
- It sets the T200 time where necessary.
- It repatriates the T200 states (by a general control, called *interrogation command* in IEC 60870-5-101).
- It goes to the following T200.

Then, the Supervisor works by *polling*:
- It regularly repatriates all the T200 states (by *interrogation command*)

or
- It repatriates only changes of state and thereby maintains its database.

The Supervisor can send a command to the T200s at any time.

In this operating procedure, the SCADA 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. These interchanges are mostly "unproductive" because, in most cases, the T200 interrogated has nothing to report (on this subject, see in section 5.2 Tracing interchange with the Supervisor - Power Up, the Request for class 2 data window (*polling*)).

The operating procedure, in *balanced* mode, is generally as follows:

- When it starts up, the Supervisor initializes the link to the first T200.
- It sets the T200 time where necessary.
- It repatriates the T200 states (by a general control, called *interrogation command* in IEC 60870-5-101).
- It goes to the following T200.

When a T200 starts up:

- It initializes the link.
- It indicates to the SCADA that it has just started up by an *end of initialization*.
- The Supervisor sets the T200 time where necessary.
- It then requests the T200 states (by *interrogation command*).

Then, messages are sent only to provide unknown information. For example, when a change occurs, the T200 will send a message to inform the SCADA of this. 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 (an equipment speaks only when it has something to say). On the other hand, the SCADA no longer controls the data flow and collisions between messages can occur when, at a given point in time, several equipments take control to speak. We shall see further on how it is possible to deal with this problem of collisions.

3.4 Data

The IEC 60870-5-101 protocol specifies the data that can be exchanged and the form in which they are transmitted. Among the numerous items of information to which the protocol gives access, there are:

- signals (single or double);
- measurements (in several formats);
- counters;
- commands (single or double);
- parameters.

These data, called *objects* in the IEC 60870-5-101 protocol, will be described in detail further on.

3.5 Functionalities

- Reading all the states of a T200
  This can be performed in two stages by the SCADA. It first sends an *interrogation command* to the T200. The latter will send back, in reply, the state of all signals and the values of all measurements (on condition that the transmission address has been defined for each of them as we shall see later). Then the Supervisor will send a *counter interrogation command* if the system manages counters. The T200 will then send back the values of its counters.

- Time setting
  This can be performed by the Supervisor:
  - either individually, for each T200, with confirmation by the latter that it has received correctly;
  - or all at once, by *broadcast*, for all the T200s on a given transmission medium. In this case, the T200s in question do not reply.
  On those media that offer a repetitive transmission delay, the SCADA can correct the synchronization of the transmission time with the T200s, by first giving a *delay acquisition command*.

- Transmission of changes, routine transmission
  The T200 can transmit changes on signals, measurement changes (upon a change exceeding the dead band, upon crossing a threshold), and regular measurement reports.
  These changes may be dated or not.

- Counter processing
  It is possible to freeze and reset the counters.

- Commands
  Two command modes are available: *select before execute* and *direct execution*. Commands can be single or double.

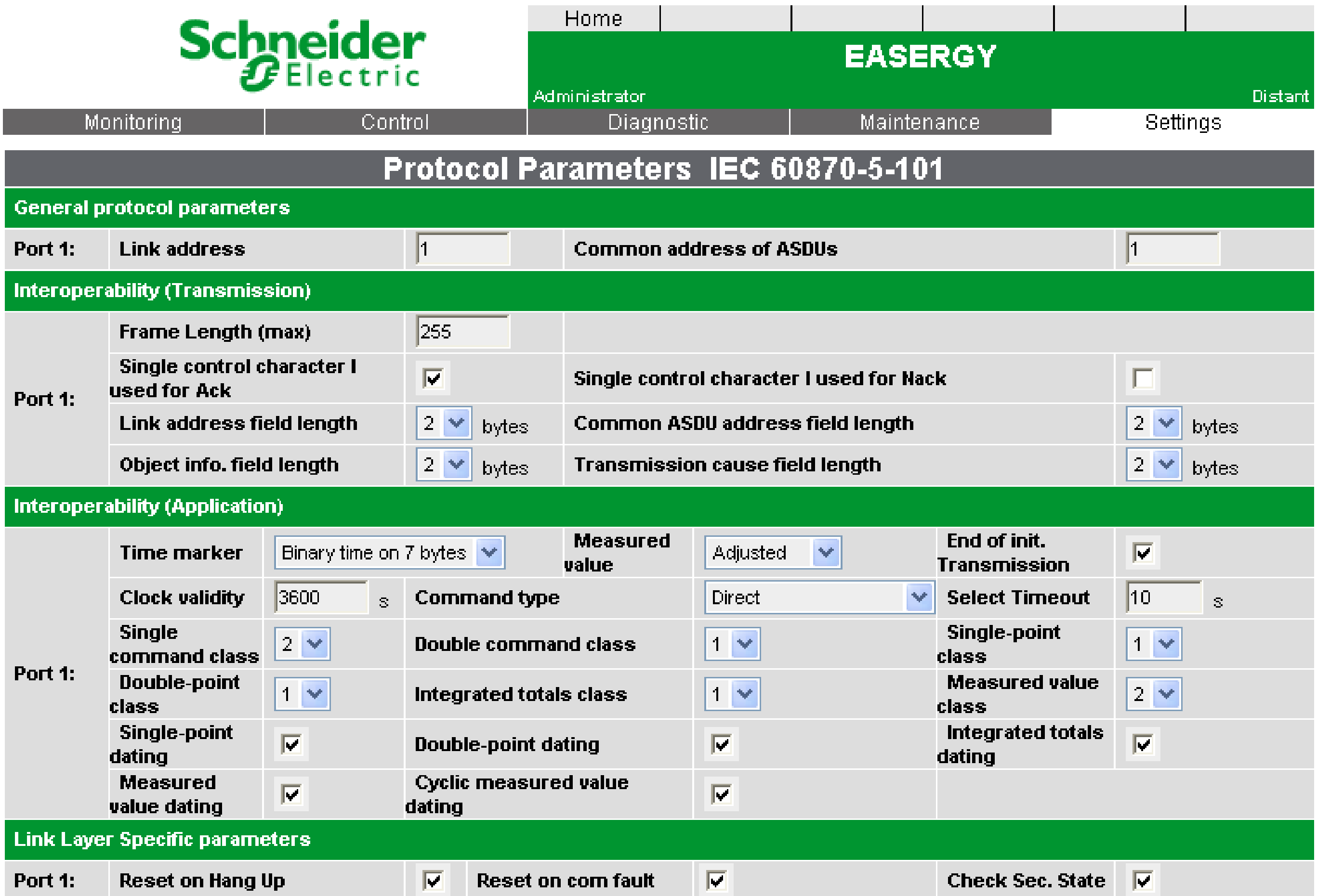
- Modification of parameters
  It is possible to modify certain parameters.

4. Configuration

4.1 General configuration of the protocol

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

When the *unbalanced* mode has been chosen, the screen is as follows:



Protocol Parameters IEC 60870-5-101

General protocol parameters							
Port 1:	Link address	1		Common address of ASDUs		1	
Interoperability (Transmission)							
Port 1:	Frame Length (max)	255					
	Single control character I used for Ack	☑		Single control character I used for Nack		☐	
	Link address field length	2 bytes		Common ASDU address field length		2 bytes	
	Object info. field length	2 bytes		Transmission cause field length		2 bytes	
Interoperability (Application)							
Port 1:	Time marker	Binary time on 7 bytes	Measured value	Adjusted	End of init. Transmission	☑	
	Clock validity	3600 s	Command type	Direct	Select Timeout	10 s	
	Single command class	2	Double command class	1	Single-point class	1	
	Double-point class	1	Integrated totals class	1	Measured value class	2	
	Single-point dating	☑	Double-point dating	☑	Integrated totals dating	☑	
	Measured value dating	☑	Cyclic measured value dating	☑			
Link Layer Specific parameters							
Port 1:	Reset on Hang Up	☑	Reset on com fault	☑	Check Sec. State	☑	

Page Settings / Protocol

General parameters of the protocol:

- Link address
  This identifies the SCADA - T200 pair. On a network, it allows the SCADA to designate (in Control direction) to recognize (in Monitor direction) the T200 among all the far-end equipment.
  Depending on the length of the link address field (1 or 2 octets), it can adopt all values between 0 and 254 or 0 and 65534.
  Address 255 (length 1 octet) or 65535 (length 2 octets), non-configurable, is used by the Control Centre to address all the far-end equipment. It is used only for transmission procedures of the *send/no reply expected* type. In this case, the far-end equipments do not reply to the SCADA. This address then bears the *broadcast* address name.

- Common address of ASDUs
  This address appears in the information frames. It is not used by the T200, but the latter controls it.
  It has the same configuration ranges as the *link address*.
  In general, it is set to 0 (although the standard defines this value as "not used"), to 1 or to the same value as the *link address* (this then requires that it be coded on a length at least equal to that of the *link address*).

Transmission-related parameters:

- Frame length (max.)
  This allows the size of the frames sent by the T200 to be limited. It may be necessary to limit this size in two cases:
  - The size of the SCADA reception buffer is limited or it cannot handle in an acceptable time frames of length greater than that defined. This case is virtually never encountered.
  - The transmission medium is noisy: the frames are in that case easily disturbed during their transmission. This is the case, for example, when analogue radios are used. In this case, it is often advisable to limit the frame length, which limits the risk of their being corrupted. The values then used are generally in a range between 40 and 80.
  The maximum value is 255.

Comments for the following two headings:
- There is not a single box for Ack and Nack handling, because some SCADAs do not handle the *transmission control character I* the same way depending on whether it is used for Ack or Nack.
- Other explanations are given in section 4.2 Specific configurations relating to transmission media - Use of the *transmission control character I*.

- Single control character I used for Ack
  Ack frame reception acknowledgements can be coded either as fixed-length frames or using the *transmission control character I*. This character is coded E5 in hexadecimal.
  In the case of non-noisy point-to-point links (e.g., RS-232 link, PSTN link), the *transmission control character I* can be used in place of the fixed-length frame to reduce transmission times. In that case simply check the corresponding box.
  When working with noisy transmission, one should not use the *transmission control character I*, because it can easily be generated by noise. Moreover, some SCADAs do not handle this character. In that case the box must be deselected.
  Likewise, on multipoint networks, the single control character cannot be used because in this case the receiver cannot know who is the sender.

- Single control character I used for Nack
  Nack frame reception acknowledgements can be coded, like Acks, either as fixed-length frames or using the *transmission control character I*.
  The same reasons as before lead to the same choices.

- Link address field length
  The link address can be coded on 1 or 2 octets.
  As it is always advisable to limit transmission times, the best choice is 1 octet. However, this limits the number of far-end equipments to 255 (addresses 0 to 254). By adopting 2 octets, it is possible to go up to 65535 equipments.

- Common address of ASDUs field length
  The *common address of ASDUs* can be coded on 1 or 2 octets.
  As for the link address, the best choice is 1 octet. However, if you want to put a value greater than 255, choose 2 octets. Likewise, if you want to put, for the *common address of ASDUs*, the same value as for the link address, you will be obliged to use 2 octets if there are values greater than 255.

- Information object address field length
  The *information object address* field can be 1, 2 or 3 octets.
  The T200 uses non-structured *information object addresses*, therefore this address is normally coded on 1 or 2 octets (the 3 octet variant being reserved in the case of structured addresses).
  However, for reasons of compatibility with the SCADA, the value 3 is accepted.
  Moreover, there is nothing to prevent declaring structured type addresses. For example, it is possible to have the third octet give the type of *object*, with 0 for a double signal, 1 for a single signal, etc. The double signals will then have an address between 1 and 65535 (the standard says that address 0 is not applicable), and the single signals an address between 65536 and 131071, etc.
  As before, it is recommended to code this address on a single octet. However, one may have to transmit more than 255 *objects*.
  The SCADA can also force encoding on 2 or 3 octets.

- Cause of transmission field length
  This field can have 1 or 2 octets.
  When it contains 2 octets, the second is used to indicate the *originator address*. This is generally of no interest in our case. However, it can be configured to be compatible with the SCADA's operation.
  In general, 1 is used.

Application-related parameters:

- Time tag
  For time tagged *objects*, the time tag can be expressed on 3 or 7 octets.
  On 3 octets, the time tag is limited to minutes and milliseconds. On 7 octets, this time tag also includes the hour, day of the month, month and year. In both cases, a bit indicates whether the hour is valid.

- Measured value
  The T200 manages measurements in transmission mode according to two of the formats specified by the standard, namely:
  - *Measured value, "N*ormalized" value
  - *Measured value, "Adjusted"* value

  Here the user chooses the form in which he wants the measurements to be transmitted.

  (For more details, see "*Conversion modes for measurement transmission*" and "*Object addressing table*" chapters).

- End of initialization sending
  An *end of initialization* can be sent by the T200. The T200 will send it after power up or after a change of configuration (in certain conditions).
  For the T200 to behave in this way, simply check the box.
  The SCADA will then know that the database representing the state of its T200 is possibly no longer up-to-date. As a consequence, it will then be able to execute the *interrogation command* and the *counter interrogation command* (if necessary) to update its database.

- Clock validity
  Like any clock, the T200's clock deviates over time. Depending on the deviation he considers acceptable, the user will configure the time after which he determines that the deviation is too great to consider the time tag valid.
  The T200 declares the clock invalid after power up or when the set time has elapsed since the last *clock synchronization command* received.
  This time can be as much as 24 h. By setting 0, the T200 considers the time as infinite, i.e. the clock will not be declared invalid.
  The clock deviation is 5 ppm at 25℃, i.e. about 40 0 ms per day (less than 15 s per month). If the user wants a deviation of less than 100 ms, he will have to set the time on the T200 approximately every 6 h. He need then merely program 22,000 ms (leaving a little margin) for the clock to be declared invalid if the T200 has not received a time setting within a period of slightly more than 6 h (6 h 6 min. 40 s).

  Special case of the GPS option: In this case, time setting of the T200 is performed from the GPS. The clock will be declared invalid only after power up or after expiry of the time without the GPS providing valid time setting data. The user will then be notified, when he receives a time tagged event, that the GPS is not working correctly.

- Command type
  A telecontrol can be executed by 2 modes.
  \- *Direct execution*: the command (if it is authorized) is executed as soon as the order is received.
  \- *Select before execute*: in this case, the T200 will first receive a command selection, then, within a maximum authorized time, an execution. It will execute the command (if it is authorized) only after receiving execution (and only if the device indeed corresponds to that previously selected). After receiving a selection, it may receive the abort of this command, in which case it will have to receive a new complete cycle to execute a command.
  The operating mode is selected here.

- Selection timeout
  This is the maximum time authorized between receiving a command selection and receiving its execution. After that time, the command is rejected.
  This time is applicable only in the *select before execute* mode. It can be set to between 1 and 60 s.

In *unbalanced* mode, the *objects* sent by the T200 can belong to 2 different classes. Their class (1 or 2) is selected from the following sections.

- Single commands class
- Double commands class
- Single signals class
- Double signals class
- Integrated totals class
- Measurements class
  Class 1 is generally assigned to commands, signals and *integrated totals*. Measurements are customarily assigned to class 1 when they are sent upon a change or exceeding a threshold, and to class 2 when they are sent cyclically.

  Class data 1 are considered as priority data.
  The SCADA asks the T200 whether it has class 2 data. The latter replies with the data it has in this class, indicating if it also has class 1 data. If this is the case, the SCADA then asks for the data in said class 1.

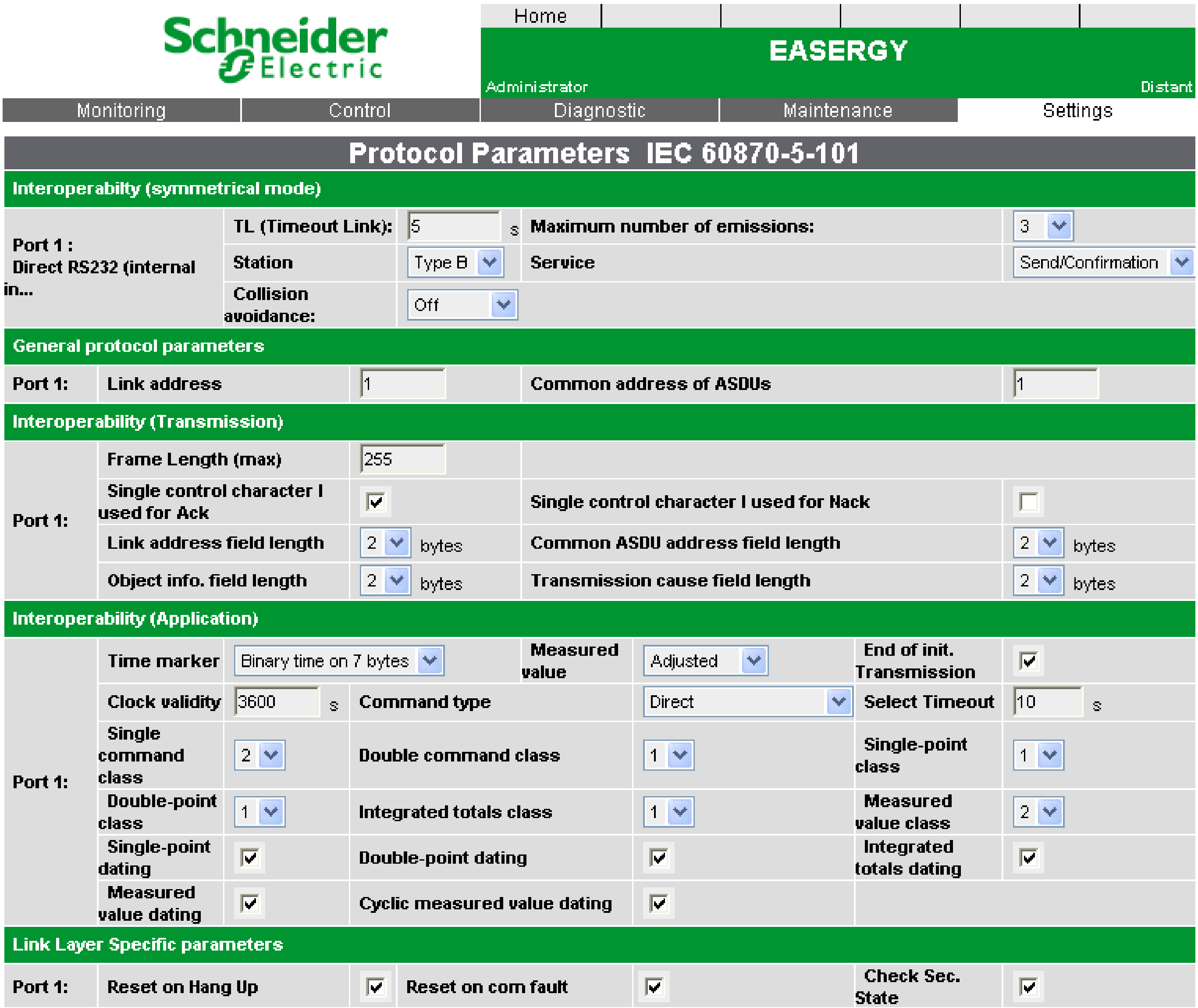
In the T200, the *objects* sent, upon a change or regularly, can be time tagged or not, depending on their type. Simply fill in the following sections as needed.

- Single signals time tag
- Double signals time tag
- Integrated totals time tag
- Measurements time tag
- Cyclic measurements time tag

Link layer specific parameters:

- Reset on hang up:
With non-permanent communication media (GSM, PSTN), enable or disable initialization of primary and secondary after each call
- Reset on com fault :
Not used in unbalanced mode.
- Check Sec. state :
Not used in unbalanced mode.

In *balanced* mode, the protocol parameters screen is as follows:



Page Settings / Protocol

There is an additional section by comparison with *unbalanced* mode, concerning the parameters specific to this mode.

- TL (link timeout interval)
  Since the frames sent can be disturbed, a repetition system is implemented. The time defined here indicates the time that the T200 will wait until the SCADA indicates to it that it has correctly received the frame sent to it by the T200.
  The choice of a value depends on the speed of transmission. The higher the speed, the lower the value that will be inserted.
  In systems in which the frames sent by the T200 can come into collision with the frames sent by the Control Centre, it is important to insert a time-out value greater than that appearing at the SCADA end. For example, if the SCADA and the T200 send at the same time frames which come into collision (half-duplex type operation), repetition of these frames will be performed first at the SCADA end and then at the T200 end. If the values had been identical, they would have been executed simultaneously, thus creating a new collision.

- Maximum number of send operations
  When two equipments on a link are no longer able to understand one another, this may be due to the fact that they are desynchronized. Reinitialization of the link is therefore required. This section will specify the number of frame send operations without acknowledgement (first sending and repetitions) after which the T200 will go into link reinitialization.
  The customary values are in the range between 3 and 5.

- Station
  With each end of the link is associated a station type. There is a station A and a station B.
  This makes it possible to know the direction of a message.
  The SCADA is normally declared as station A. However, for various reasons, it may have been configured as station B. In that case the T200 must be declared as station A.

- Service
  There are two ways of handling sent frames. The *send / no reply* expected service entails no confirmation by the equipment for which it is destined. The *send / confirmation expected* service requires confirmation by the destination.
  The *send / no reply expected* service makes it possible to reduce the number of frames exchanged and hence accelerate the flow of information over a link. However, it should be avoided on noisy transmission media (messages are frequently disturbed and in this case the sender does not know that the frame has not been received correctly). It is therefore in practice usable only on dependable media. Such media are links such as RS232 links, optical fibre links, etc. on which the speeds are generally very high. This explains why it is generally not used. However, it is possible to configure it.

- Collision avoidance
  With certain transmission media, collisions can occur:
  - between frames sent by the SCADA and frames sent by a far-end equipment,
  - between frames sent by various far-end equipments.
  It is often easy to limit its consequences in the former case. A different TL (Timeout Link) - see above - will be set at the SCADA end and at the far-end equipment end, and if two frames come into collision, their repetitions will be staggered and the problem will be solved.
  The second case is more complex. To avoid collisions insofar as possible, one must know the network occupancy state. The more reliable this information, the more efficient the system. It is true that one can forcibly adopt sending only if the network is free.
  However, this has its limits, since two equipments 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 an equipment going into sending mode. Throughout the time needed for detection of this state, another equipment will consider the network as free and will therefore be authorized to send.
  To overcome this, it is possible to use a collision avoidance algorithm proposed by the T200. This algorithm may differ depending on the protocol used; it is called Standard in the IEC 60870-5-101 case and its parameters appear in the protocol parameters screen.
  Depending on the transmission medium, there will be several possible options:
  - Non-activated or Standard
  - Non-activated, Standard (squelch used for busy state), Standard (DCD used for busy state).

The first group of options is proposed when the transmission medium can provide the occupancy state via the DCD signal. This is the case when the sent frames are delimited by a signal (generally RTS), said signal being linked to the DCD or causing its activation (case in which the RTS signal causes rising of a carrier detected on DCD by the other equipment).
The second group of options is proposed when using a radio medium. There are generally 2 signals: the DCD signal (carrier detection) and the squelch signal. When the squelch signal is available, it should be preferred to the DCD 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.

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 allowance should be made 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.

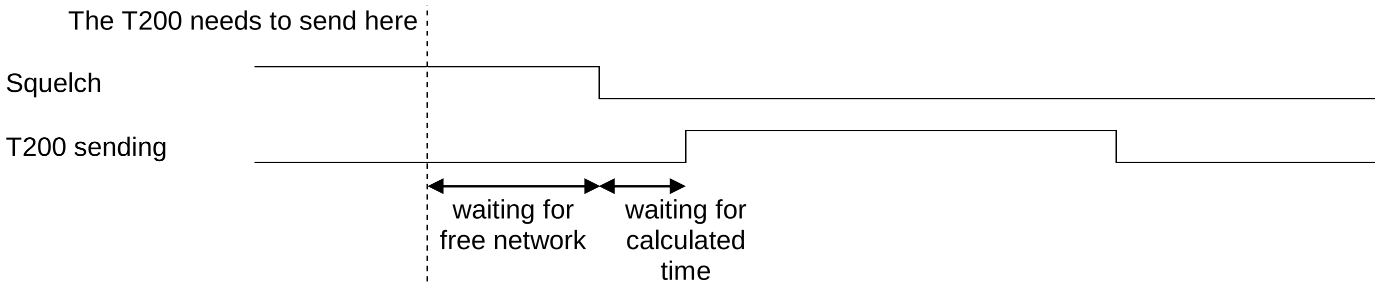
- Active squelch level
  Depending on the equipment, the squelch active state will be a low level or a high level. One should therefore choose, here, the appropriate level.

- 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, the transmission conditions are altered 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 the 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 authorized 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 authorized after this time.

- Tsqu (squelch protection)
  This time is the time referred to above.
  The customary value is approximately 10 s.

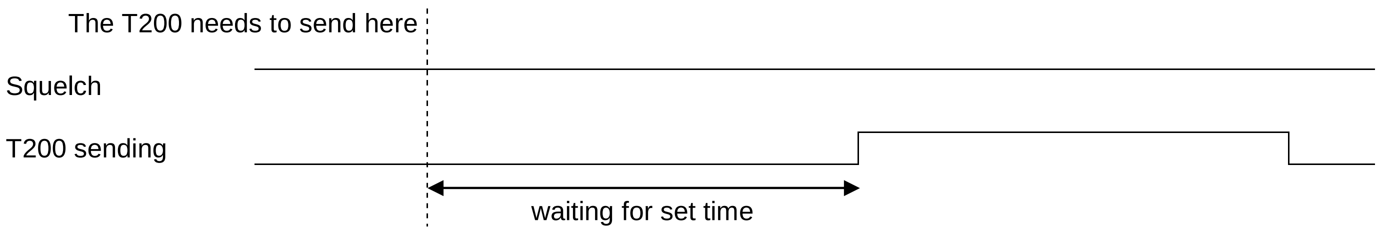
Explanatory diagrams

Normal case

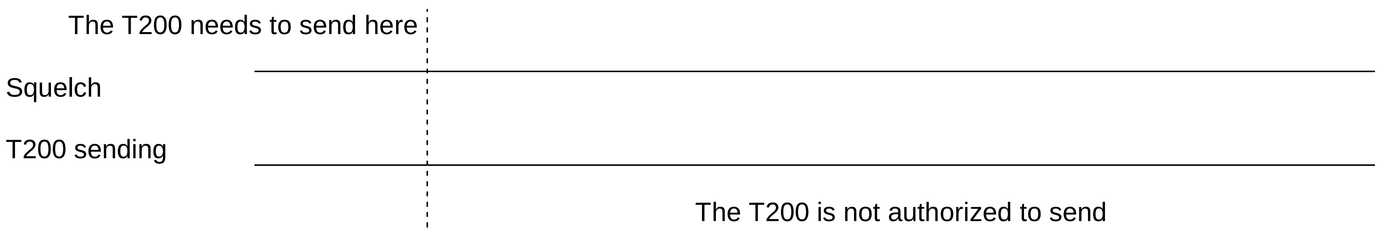


Case of permanent squelch

- with squelch protection



- without squelch protection



Link layer specific parameters:

- Reset on hang up:
  With non-permanent communication media (GSM, PSTN), enable or disable initialization of primary and secondary after each call
- Reset on com fault :
  Balanced mode only. Reset secondary if a spontaneous event as not been confirmed after retransmission.
- Check Sec. state :
  Balanced mode only. Allow to check or ignore the secondary state when data are ready to be sent by primary.

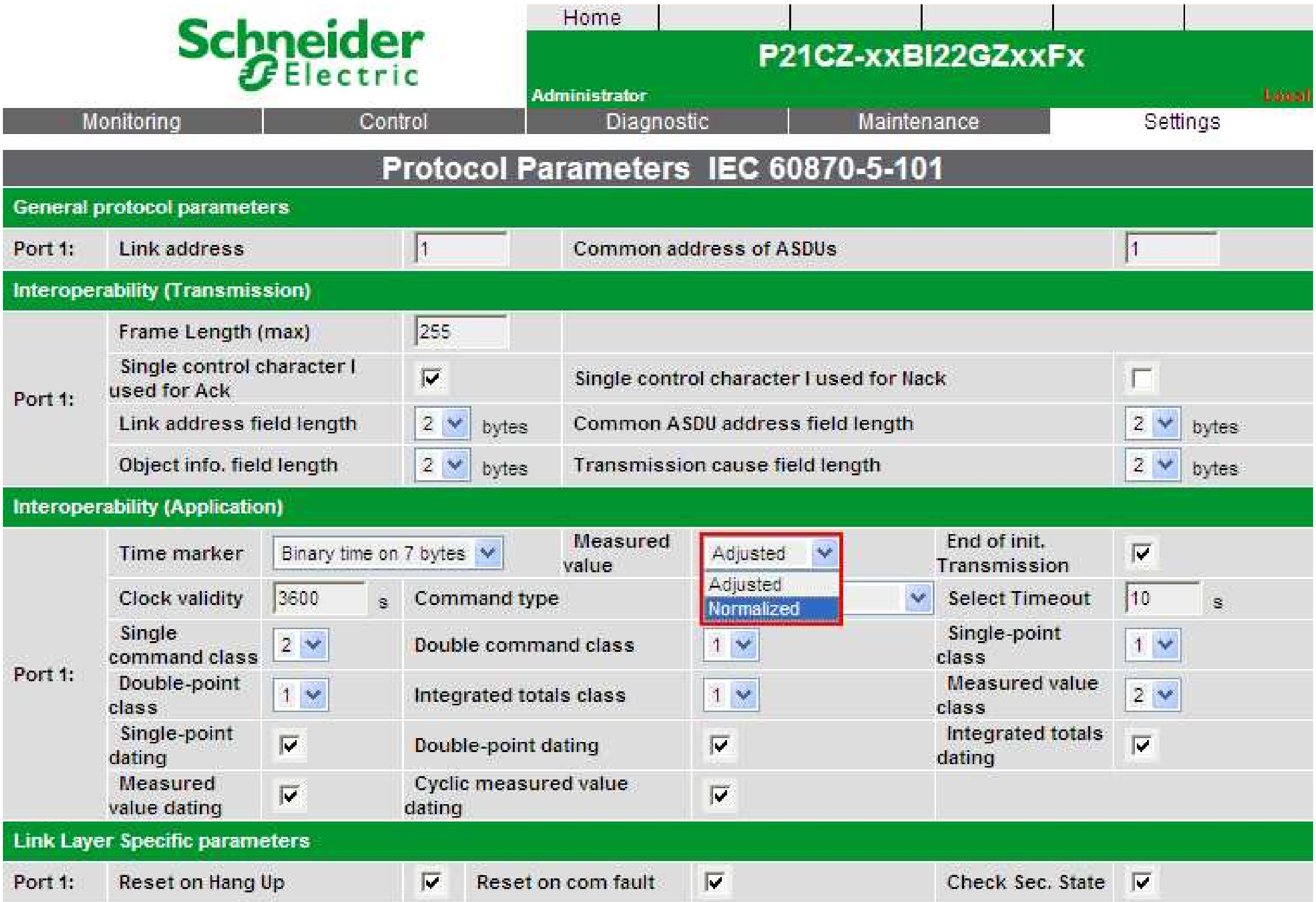
4.2 Conversion modes for measurement transmission

The measurement module provides values expressed in the reference unit. For example, a measured current of 234 A will be delivered in the form 234. To transmit this measure, the value will be converted in a selected format depending on the mode chosen:

The IEC870-5-101 protocol offers three conversion modes:

- Adjusted
- Normalized
- Floating (only present with IEC870-5-104)

The mode can be selected on pages : "*Settings\Protocol*" :

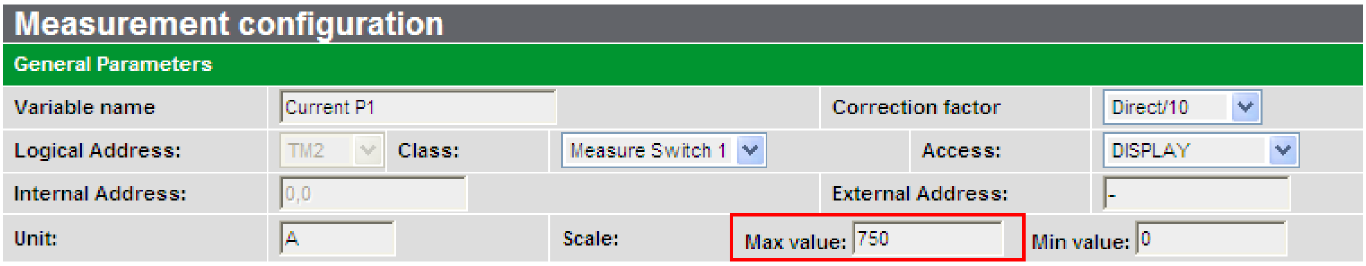


Adjusted mode

This mode is also known as “*Scaled*” mode.
If this mode is selected, all the measurements will be transferred as M_ME_NB_1, M_ME_TB_1 or M_ME_TE_1 objects.
The scaled value is a signed integer 16 bits value (-32768 to 32767)

Following rules are applied to "Adjusted" 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):

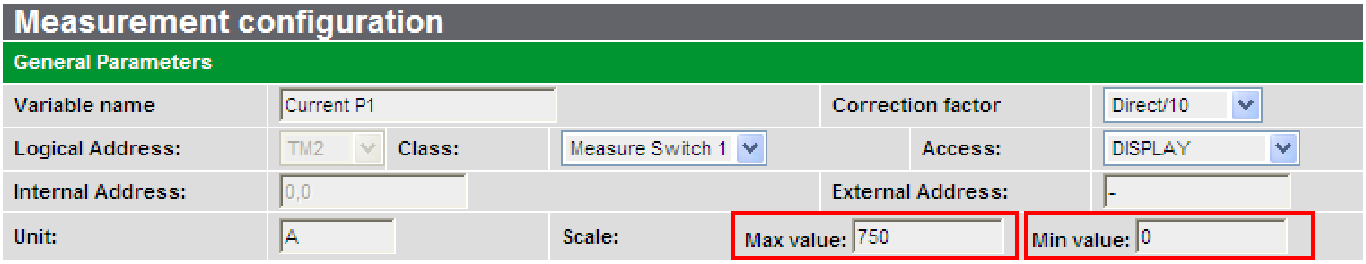
Internal value	**0**	**10000**	**357**	**80000**	**552000**	**-700**	**-5000**	**-75000**	**Invalid**
Max Value (parameter)									
0	0	0	0	0	5	0	0	0	0x8000
4000	0	0x7FFF	357	0x7FFF	0x7FFF		0x8000	0x8000	0x8000
400000	0	100	3	800	0x7FFF	-7	-50	-750	0x8000

Normalized mode

If this mode is selected, all the measurements will be transferred as M_ME_NA_1, M_ME_TA_1 or M_ME_TD_1 objects.
The normalized value is a signed integer 16 bits value (-32768 to 32767)

Following rules are applied to Normalized 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)

4.3 Specific configurations related to transmission media

Here, in summarized form, are the main specifications of these frames:

- The frames are formed of characters consisting of 1 start bit, 8 data bits, 1 even parity bit and 1 stop bit.
- In frames formed of several characters, there should not be any gap between 2 characters exceeding the transmission time for one bit.
- There are three types of frame. They can be of fixed length, variable length or limited, in some cases, to a single character.

Some of the constraints required above cannot be met when using certain transmission media. We shall describe them below.

- <u>Character parity</u>
  Some modems do not permit transmission of characters with parity.
  In this case, the character parity must be set to "No parity" as shown on the screen below.

Page Settings / Port 2 : transmission

Of course, the Control Centre must be able to be also set to "no parity".

In this case one should be aware that this can have major consequences for the system's operating security. In particular, the frame coding, thus modified, no longer ensures transmission security (or at least transmission security is greatly diminished, the likelihood of considering a disturbed frame as correct being greater). To see whether this is acceptable or not, we must take into consideration the transmission scheme. This consists of three portions: the Supervisor - modem link, the modem - modem link (involving the transmission medium), and the modem - T200 link.
It is therefore necessary either to reduce disturbances on these sections or to add a system which will eliminate the disturbed frames.

In what follows, we shall speak, to simplify, of zero risk when the risks are extremely low.
Between the T200 and the modem, if the modem is a modem located on the communication card (Easergy modem), the risks are zero. If the modem is external and located in the enclosure, it is possible to consider the risks as zero if wiring precautions are taken (cable of minimum length, shielded cable, etc.).

Between the Supervisor and the modem, it is also possible to limit the risks insofar as possible by complying with the wiring precautions (shorter Supervisor - modem distance, shielded cable, etc.), especially since, in general, the Control Centre is not located like the T200 in a "hostile" environment.
The most difficult part to protect is therefore the modem-to-modem link. The problem must therefore be examined on a case by case basis:
- Analogue radio or leased line (LL) medium of radio type. These media are highly disturbable and they cannot be protected. It is therefore essential to use the even parity specified by the standard. This can generally be done because the modems used normally have this capability (this is the case for Easergy modems mounted on the communication card).
- Digital radio medium. If this medium itself provides transmission security, it is possible to use no-parity transmission without any risk. Otherwise, it is absolutely essential to use an even parity.
- PSTN medium. This transmission medium is generally undisturbed. But this is not guaranteed and may change over time. It is therefore strongly recommended to use a modem which allows even parity to be configured (this is the case for Easergy modems mounted on the communication card and for practically all "modern" modems). If this is not the case, this medium should be used only if an undetected disturbed frame would have no major impact (the execution of an unwanted order should have no serious consequences).
- GSM medium. Transmission security is provided by the GSM system. The risks are therefore zero.

- <u>Line idle interval between 2 characters of the same frame</u>
  Some transmission systems do transmission by packets. This is the case, for example, of GSM and certain types of digital radios. To use these systems, one should therefore inhibit frame rejection when a gap exceeding the duration of one bit is detected by the receiver. For GSM, the T200 does this systematically. In those cases when it does not do so, it is possible to inhibit it by selecting "No" for "Frame error on idle line".

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As in the previous section, **this has important consequences for transmission security**. The wiring precautions mentioned above should therefore be followed scrupulously. On the other hand, modem-to-modem security, in the case of GSM, is ensured by the GSM system itself, as we said before. The risks are therefore zero. This is also generally the case for digital radios which perform transmission by packets (they operate in a similar way to GSM). If, after obtaining information from the supplier of your digital radio system, you are assured of this transmission security, and you can therefore devalidate frame rejection upon detection of a gap exceeding the duration of one bit between two characters. Otherwise, you must set up another transmission medium.

- <u>Use of the *transmission control character I*</u>
  It is impossible to use the *transmission control character I* (frame consisting of a single character for which the hexadecimal code equals 0xE5) in certain conditions.

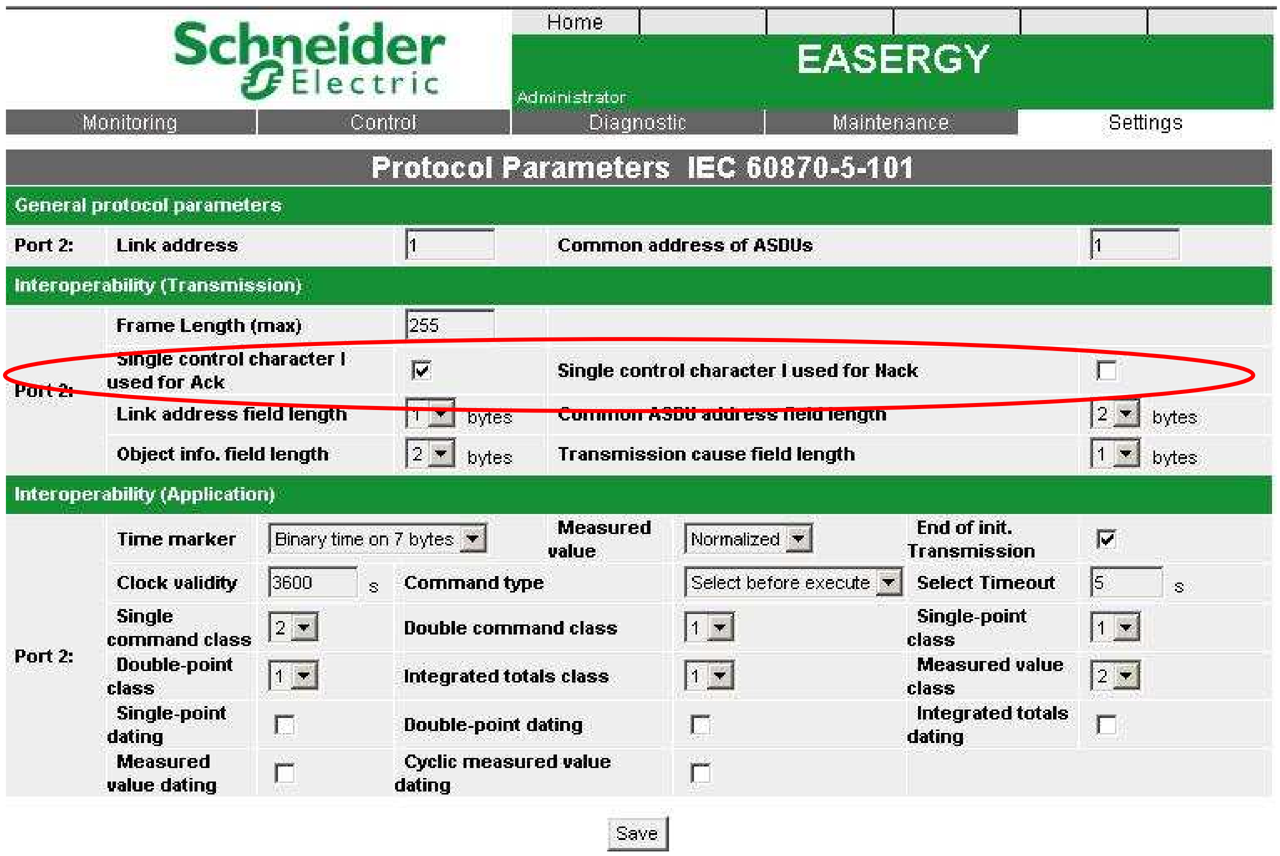
  This is the case when using multipoint transmission media and noisy transmission media.

  The former include radio, radio type leased lines (LL), RS485 links, optical fibre links, and all media providing a link toward the Supervisor, common to several T200s.
  For such media, it is actually impossible to use the *transmission control character I* only in *balanced* mode. In this case, this is due to the fact that the single control character contains no address field and, as a consequence, the receiver cannot know who is its sender.

  The latter include radio (analogue type), and to a lesser extent radio type leased lines (LL). In this case, it can happen that, in the noise generated, the receiver manages to decode this character and interprets it as such, which then leads to incorrect operation.

  It is therefore essential, in such cases, to prohibit the use of frames consisting of this single control character.

  For this purpose, the following boxes will have to be deselected:



Page Settings / Protocol

Other specific configuration settings relating to transmission media, but which are not specific to the protocol, are to be implemented. They are described in the sections of the manual relating to such media.

4.4 Specific configurations related to the objects transmitted

Depending on the nature of the *objects* transmitted (double signals, single signals, measurements, counters), certain parameters may have to be configured. For example, a measurement can be transmitted in several forms.

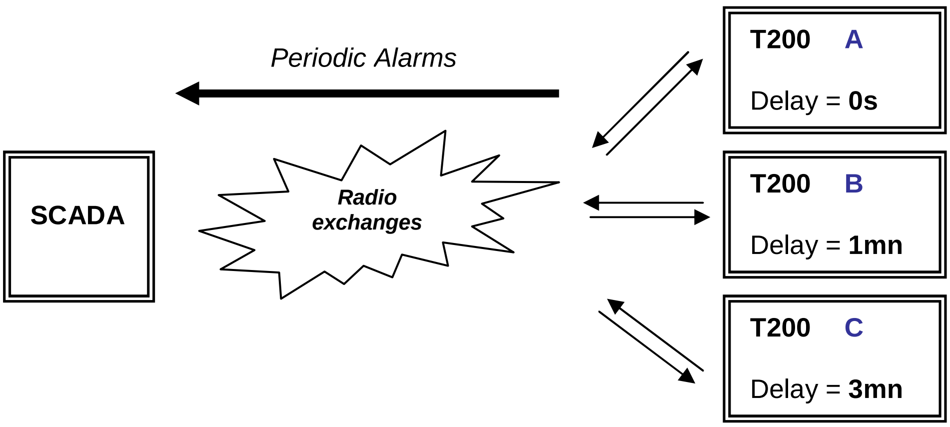
All these settings are described in section 4.1 General configuration of the protocol - Application-related parameters.

- Cyclic Measurements Time lag for radio communications:

- *Background*:
We suppose that several T200 can send periodically and spontaneously their measurements to a SCADA (*Balanced* mode). Therefore, collisions can occurred and the SCADA won't be able to receive all T200 changes of state.

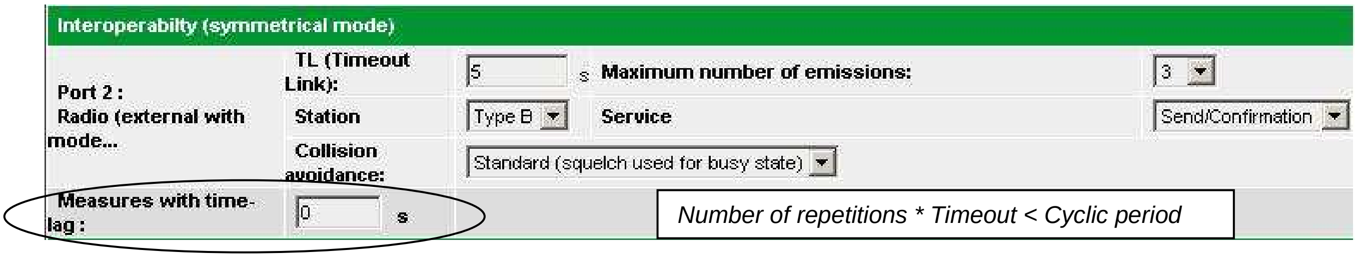
- *Solution*:
We provide a new parameter for each T200 which delays the sending of periodic measurements.

- *Example*:
We have three equipments that send their measurements every 15 minutes. We introduce a delay of 1mn for *T200 B* and a delay of 3mn for *T200 C*.



=> If the next sending is scheduled at 3:15 pm, T200 A will send its alarm at 3:15 pm whereas T200 B will send it at 3:16 pm and T200 C will send it at 3:18 pm.

- *Settings*:
The new parameter appears on the *protocol* page only if a radio modem has been selected and if the selected mode is '*Balanced*'.



- *Remark*:
Make sure that all settings have been defined properly. (Time-lag, cyclic period, number of repetitions in case of failure, Timeout, caller communication delay…). Time-lag should be defined last.

4.5 R200-ATS100, configuration of the protocol

- Settings
- Device
- Variables
- Classes
- ⊟ Synoptic view
  - Single line
  - Signals
- ⊟ SCADA communication
  - Protocol
  - Ethernet port
  - Serial port

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

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

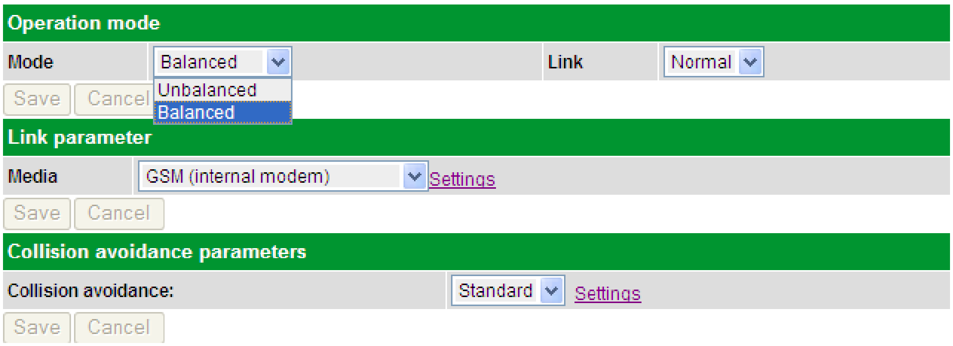
Protocol Parameters IEC 60870-5-101

General protocol parameters			
Link address	1	Common address of ASDUs	1
Interoperability (Transmission)			
Frame Length (max)	255		
Single control character I used for Ack	Yes	Single control character I used for Nack	No
Link address field length	1	Common ASDU address field length	2
Object info. field length	2	Transmission cause field length	1

Interoperability (Application)			
Time marker	Binary time on 3 bytes	Measured value	Normalized
End of init. Transmission	Yes	Clock validity (x1s)	3600
Command type	Select before execute	Select Timeout	5
Single command class	1	Double command class	1
Single-point class	1	Double-point class	1
Integrated totals class	1	Measured value class	2
Single-point dating	No	Double-point dating	No
Integrated totals dating	No	Measured value dating	No
Cyclic measured value dating	No		
Link Layer Specific parameters			
Reset on Hang Up	Yes		

Save Cancel

The Mode (balanced / unbalanced) can be modified under Settings \ SCADA communication \ Serial Port.



In the case of balanced mode, the collision avoidance parameters can also be found there.

5. Diagnostic

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

5.1 Processing protocol-related information

This section provides information on the way in which the T200 handles certain specific aspects relating to the various *objects* defined by the standard.

- Single signal, double signal
  The bits BL (not blocked / blocked), SB (not substituted / substituted), NT (topical / not topical) and IV (valid / invalid) are always transmitted at 0.

- Double signal
  The 2 DPI bits can take all combinations. The values 0 (undetermined or intermediate state) and 3 (undetermined state) are given only in the event of non-complementarity after a filtering timeout.

- Measurement
  The bits BL (not blocked / blocked), SB (not substituted /s ubstituted) and NT (topical / not topical) are always transmitted at 0. The IV bit (valid / invalid) is marked when a dysfunction in the measuring chain is detected. The OV bit (no overflow / overflow) is marked when the measurement reaches a limit value.

- Integrated totals
  The CY bit (no carry / carry) is marked when the counter has reached the maximum since the last read. The CA bit (counter not adjusted / counter adjusted) is always transmitted at 0. The IV bit (valid / invalid) is marked when a counting dysfunction is detected.

- Single command, double command
  When working in *select before execute* mode, if the authorized time between the command with the S/E bit set to 1 (Select) and that with the S/E bit equal to 0 (Execute) is exceeded, the command is rejected.
  See also 4.1 General configuration of the protocol - Command type and select timeout.

- Time tag on 3 octets, time tag on 7 octets
  The IV bit (valid/invalid) is marked at T200 start-up. It will remain at 1 until the time is set on the T200. It will then adopt the value 0. Then, it will be reset to 1 when the timeout between 2 time settings has been exceeded.
  See also 4.1 General configuration of the protocol - Clock validity.

- Time tag on 7 octets
  The SU bit (normalized time / summer time) corresponds to the last SU bit received by the T200 during remote time setting.

5.2 Tracing interchange with the Supervisor

In order to clarify the operation of the protocol, we shall give here a few specific examples of interchange 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.

- Switching on the T200

  In *unbalanced* mode

  The SCADA tries to connect to the T200. It regularly sends *link status requests*. As soon as the T200 replies to it with a link status message, the SCADA reinitializes the link (synchronization of both ends) by sending a *remote link reset*. Upon receiving the positive confirmation (Ack) sent by the T200, the communication initialization phase is completed.

```
10:40:37.657    MODEM - Link available
10:41:09.574    LinkAddr =  123    <<<<<    Request link status
                                            10 49 7B C4 16
10:41:09.604    LinkAddr =  123    >>>>>    Status of link
                                            10 2B 7B A6 16
10:41:12.085    LinkAddr =  123    <<<<<    Reset Link
                                            10 40 7B BB 16
10:41:12.114    LinkAddr =  123    >>>>>    Confirm ACK
                                            10 20 7B 9B 16
```

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  Receipt of positive confirmation indicates by means of bit (ACD) that the T200 has class 1 information to send. The Control Centre then demands this class 1 information. The T200 sends this information back to it. This is an *end of initialization* which thereby indicates to the SCADA that the T200 has just started up.

```
16:34:29.027    LinkAddr =  123    <<<<<    Request user data class 1
                                            10 7A 7B F5 16
16:34:29.127    LinkAddr =  123    >>>>>    User Data
                                            End of initialization
                                            Tid = 70  Qual =  1  Cot =  4  org =  0  Addr ASDU =   1
                                            68 09 09 68 08 7B 46 01 04 01 00 00 00 CF 16
```

  Informed of this start-up, the SCADA will generally perform time setting and repatriate all the static information (T200 database).

The time setting may or may not include a *delay acquisition request*.

```
16:39:14.024   LinkAddr =  123   <<<<<   User Data
                                         Delay acquisition command
                                         Tid = 106  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 0A 0A 68 53 7B 6A 01 06 01 00 00 00 00 40 16
16:39:00.098   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 20 7B 9B 16
16:39:00.115   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 7A 7B F5 16
16:39:00.215   LinkAddr =  123   >>>>>   User Data
                                         Delay acquisition command
                                         Tid = 106  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 0A 0A 68 08 7B 6A 01 07 01 00 00 0A 00 00 16
16:39:05.215   LinkAddr =  123   <<<<<   User Data
                                         Clock synchronization command
                                         Tid = 103  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 0F 0F 68 53 7B 67 01 06 01 00 00 11 5B 27 10 14 03 07 FE 16
16:39:23.157   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 20 7B 9B 16
16:39:23.177   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 7A 7B F5 16
16:39:23.277   LinkAddr =  123   >>>>>   User Data
                                         Clock synchronization command
                                         Tid = 103  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 0F 0F 68 08 7B 67 01 07 01 00 00 5F 14 A7 10 14 03 07 3B 16
```

To retrieve all the T200 states, the SCADA sends it an *interrogation command*. The T200 sends back to it all the *objects* managed by it except for the *integrated totals*.

Below, the *interrogation command* and its application confirmation.

```
16:50:35.668   LinkAddr =  123   <<<<<   User Data
                                         Interrogation command
                                         Tid = 100  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 09 09 68 53 7B 64 01 06 01 00 00 14 4E 16
16:50:35.768   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 20 7B 9B 16
16:50:35.785   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 7A 7B F5 16
16:50:35.886   LinkAddr =  123   >>>>>   User Data
                                         Interrogation command
                                         Tid = 100  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 09 09 68 28 7B 64 01 07 01 00 00 14 24 16
```

Then come double signals,

```
16:50:39.936   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 5A 7B D5 16
16:50:40.036   LinkAddr =  123   >>>>>   User Data
                                         Double-point information
                                         Tid =  3  Qual =  1  Cot = 20  org =  0  Addr ASDU =   1
                                         68 09 09 68 28 7B 03 01 14 01 20 00 00 DC 16
```

single signals,

```
16:50:48.108   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 7A 7B F5 16
16:50:48.208   LinkAddr =  123   >>>>>   User Data
                                         Single-point information
                                         Tid =  1  Qual = 130  Cot = 20  org =  0  Addr ASDU =   1
                                         68 0A 0A 68 28 7B 01 82 14 01 3C 00 00 00 77 16
16:50:49.909   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 5A 7B D5 16
16:50:50.011   LinkAddr =  123   >>>>>   User Data
                                         Single-point information
                                         Tid =  1  Qual = 10  Cot = 20  org =  0  Addr ASDU =   1
                                         68 24 24 68 28 7B 01 0A 14 01 44 00 00 4C 00 00 4D 00 00 4E 00
                                         00 52 00 01 53 00 00 55 00 00 56 00 00 57 00 00 58 00 00 EE 16
```

and measurements.

```
16:51:02.669   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 7A 7B F5 16
16:51:02.769   LinkAddr =  123   >>>>>   User Data
                                         Measured value, normalized value
                                         Tid =  9  Qual = 130  Cot = 20  org =  0  Addr ASDU =   1
                                         68 0E 0E 68 28 7B 09 82 14 01 C0 00 F5 04 00 C9 00 00 C5 16
```

Then the T200 indicates that the *interrogation command* is completed.

```
16:51:07.575   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 5A 7B D5 16
16:51:07.675   LinkAddr =  123   >>>>>   User Data
                                         Interrogation command
                                         Tid = 100  Qual =  1  Cot =  10  org =  0  Addr ASDU =   1
                                         68 09 09 68 08 7B 64 01 0A 01 00 00 14 07 16
```

In this reply, the T200 also indicates that it has no more class 1 data to transmit.

The SCADA will then send class 2 data requests from time to time (*polling*).

```
16:51:14.791   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 7B 7B F6 16
16:51:14.891   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
16:51:15.988   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 5B 7B D6 16
16:51:16.088   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
16:51:17.192   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 7B 7B F6 16
16:51:17.292   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
```

Thus, the T200 will be able to send new data if necessary.

If the SCADA manages the counters, it will send a *counter interrogation command* to the T200 before starting *polling*.

In the following case, the T200 has no *integrated totals* to send (there are none or their *information object addresses* are not configured). This can be seen from the fact that there is no counter message between confirmation of the *counter interrogation command* and the end of *counter interrogation command* sent by the T200.

```
17:11:54.695   LinkAddr =  123   <<<<<   User Data
                                         Counter interrogation command
                                         Tid = 101  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 09 09 68 73 7B 65 01 06 01 00 00 05 60 16
17:11:54.795   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 20 7B 9B 16
17:11:54.812   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 5A 7B D5 16
17:11:54.912   LinkAddr =  123   >>>>>   User Data
                                         Counter interrogation command
                                         Tid = 101  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 09 09 68 28 7B 65 01 07 01 00 00 05 16 16
17:12:16.741   LinkAddr =  123   <<<<<   Request user data class 1
                                         10 7A 7B F5 16
17:12:16.840   LinkAddr =  123   >>>>>   User Data
                                         Counter interrogation command
                                         Tid = 101  Qual =  1  Cot =  10  org =  0  Addr ASDU =   1
                                         68 09 09 68 08 7B 65 01 0A 01 00 00 05 F9 16
```

In *balanced* mode

The T200 having something to say (sending of an *end of initialization* has been configured), it tries to establish the link with the SCADA by sending *link status requests*. Below, the SCADA is not in service, it does not reply, and the T200 therefore regularly repeats this request.

```
10:26:55.689    MODEM - Interface intitialisation start
10:26:55.689    MODEM - Interface initialised
10:26:55.689    MODEM - Link available
10:26:55.719    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:00.850    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:05.983    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:11.116    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:16.248    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:21.381    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:26.513    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:31.645    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:36.777    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:41.911    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
10:27:47.043    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
```

Page Maintenance / Port 2

The SCADA starts up, it then replies to the request of the T200, which then sends a Communication Reset (*remote link reset)* which is acknowledged by the Control Centre.

```
18:00:06.663    LinkAddr =  123    >>>>>   Request link status
                                           10 49 7B C4 16
18:00:06.680    LinkAddr =  123    <<<<<   Status of link
                                           10 8B 7B 06 16
18:00:06.780    LinkAddr =  123    >>>>>   Reset Link
                                           10 40 7B BB 16
18:00:06.797    LinkAddr =  123    <<<<<   Confirm ACK
                                           10 80 7B FB 16
```

The T200 can then send its *end of initialization*.

```
18:00:06.897    LinkAddr =  123    >>>>>   User Data
                                           End of initialization
                                           Tid = 70  Qual =  1  Cot =  4  org =  0  Addr ASDU =   1
                                           68 09 09 68 73 7B 46 01 04 01 00 00 00 3A 16
18:00:06.925    LinkAddr =  123    <<<<<   Confirm ACK
                                           10 80 7B FB 16
```

The SCADA will normally set the T200 time and repatriate its database. But before this, it must initialize the link in the SCADA to T200 direction (the other direction has been initialized by the T200).

```
18:06:56.951    LinkAddr =  123    <<<<<   Reset Link
                                           10 C0 7B 3B 16
18:06:57.051    LinkAddr =  123    >>>>>   Confirm ACK
                                           10 00 7B 7B 16
```

The 2 directions of data interchange are now initialized.

The SCADA performs time setting. Here, it includes a *delay acquisition command* (this is not always done).

```
18:13:24.657   LinkAddr =  123   <<<<<   User Data
                                         Delay acquisition command
                                         Tid = 106  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 0A 0A 68 F3 7B 6A 01 06 01 00 00 00 00 E0 16
18:13:00.099   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 00 7B 7B 16
18:13:00.208   LinkAddr =  123   >>>>>   User Data
                                         Delay acquisition command
                                         Tid = 106  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 0A 0A 68 53 7B 6A 01 07 01 00 00 0A 00 4B 16
18:13:00.235   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
18:13:02.850   LinkAddr =  123   <<<<<   User Data
                                         Clock synchronization command
                                         Tid = 103  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 0F 0F 68 D3 7B 67 01 06 01 00 00 B9 6D 0D 12 14 03 07 20 16
18:13:28.189   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 00 7B 7B 16
18:13:28.297   LinkAddr =  123   >>>>>   User Data
                                         Clock synchronization command
                                         Tid = 103  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 0F 0F 68 73 7B 67 01 07 01 00 00 22 0B 8D 12 14 03 07 48 16
18:13:28.332   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

Then it performs an *interrogation command*.

```
18:20:39.823   LinkAddr =  123   <<<<<   User Data
                                         Interrogation command
                                         Tid = 100  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 09 09 68 F3 7B 64 01 06 01 00 00 14 EE 16
18:20:39.927   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 00 7B 7B 16
18:20:40.035   LinkAddr =  123   >>>>>   User Data
                                         Interrogation command
                                         Tid = 100  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 09 09 68 53 7B 64 01 07 01 00 00 14 4F 16
18:20:40.068   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

Note, here, the 2 types of acknowledgement: link level acknowledgement, application acknowledgement.
The positive confirmation frames are link level acknowledgements (the far end indicates that it has received a correct frame, without prejudging the data it conveys).
The user data frame – *interrogation command* with a *cause of transmission* Cot = 7 (activation confirmation) returned by the T200 is the application acknowledgement.

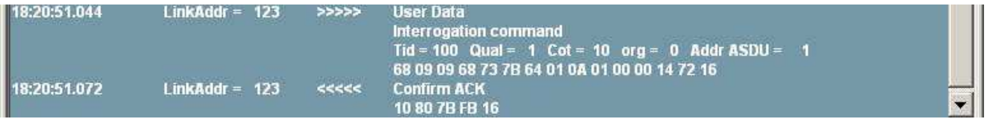
Then come signals (double and then single).

```
18:20:50.490   LinkAddr =  123   >>>>>   User Data
                                         Double-point information
                                         Tid =  3  Qual =  1  Cot = 20  org =  0  Addr ASDU =   1
                                         68 09 09 68 73 7B 03 01 14 01 20 00 00 27 16
18:20:50.522   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
18:20:50.622   LinkAddr =  123   >>>>>   User Data
                                         Single-point information
                                         Tid =  1  Qual = 130  Cot = 20  org =  0  Addr ASDU =   1
                                         68 0A 0A 68 53 7B 01 82 14 01 3C 00 00 00 A2 16
18:20:50.647   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
18:20:50.747   LinkAddr =  123   >>>>>   User Data
                                         Single-point information
                                         Tid =  1  Qual = 10  Cot = 20  org =  0  Addr ASDU =   1
                                         68 24 24 68 73 7B 01 0A 14 01 44 00 00 4C 00 00 4D 00 00 4E 00
                                         00 52 00 01 53 00 00 55 00 00 56 00 00 57 00 00 58 00 00 39 16
18:20:50.806   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

Contrary to *unbalanced* mode, note that, here, the T200 sends the information spontaneously without waiting for the SCADA request.

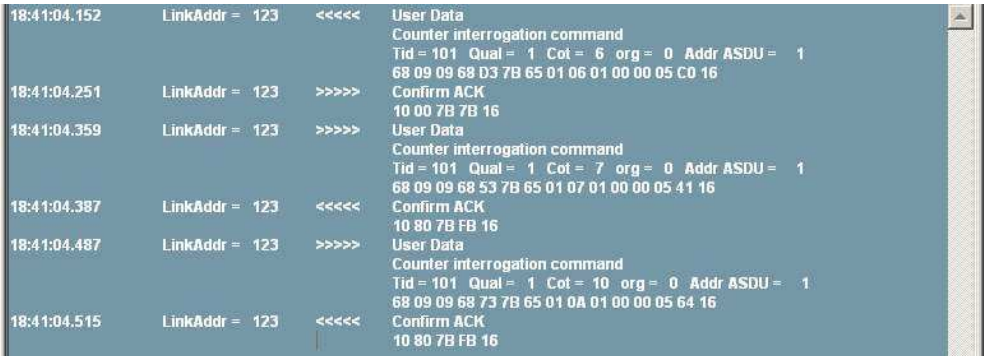
```
18:20:50.906   LinkAddr =  123   >>>>>   User Data
                                         Measured value, normalized value
                                         Tid =  9  Qual = 130  Cot = 20  org =  0  Addr ASDU =   1
                                         68 0E 0E 68 53 7B 09 82 14 01 C0 00 1E 05 00 C8 00 00 19 16
18:20:50.944   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

The reply is terminated by sending an *interrogation command* with a *cause of transmission* Cot = 10 (activation termination).



```
18:20:51.044   LinkAddr = 123   >>>>>   User Data
                                        Interrogation command
                                        Tid = 100  Qual = 1  Cot = 10  org = 0  Addr ASDU = 1
                                        68 09 09 68 73 7B 64 01 0A 01 00 00 14 72 16
18:20:51.072   LinkAddr = 123   <<<<<   Confirm ACK
                                        10 80 7B FB 16
```

If the SCADA manages the counters, it will send a *counter interrogation command* to the T200.



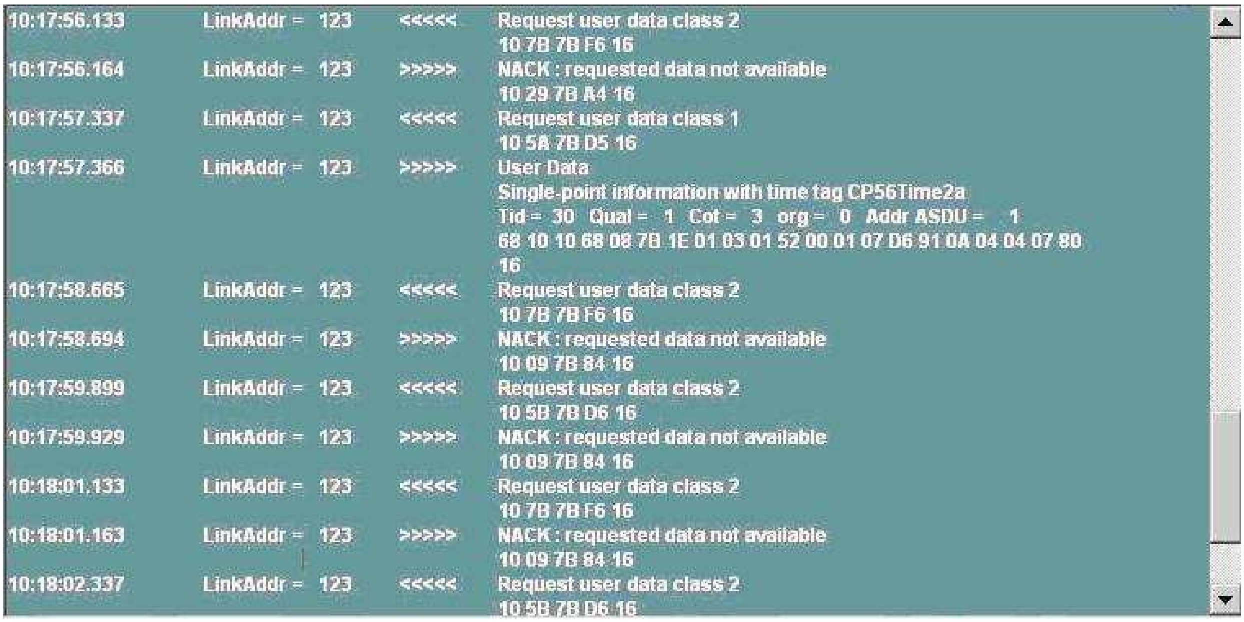
```
18:41:04.152   LinkAddr = 123   <<<<<   User Data
                                        Counter interrogation command
                                        Tid = 101  Qual = 1  Cot = 6  org = 0  Addr ASDU = 1
                                        68 09 09 68 D3 7B 65 01 06 01 00 00 05 C0 16
18:41:04.251   LinkAddr = 123   >>>>>   Confirm ACK
                                        10 00 7B 7B 16
18:41:04.359   LinkAddr = 123   >>>>>   User Data
                                        Counter interrogation command
                                        Tid = 101  Qual = 1  Cot = 7  org = 0  Addr ASDU = 1
                                        68 09 09 68 53 7B 65 01 07 01 00 00 05 41 16
18:41:04.387   LinkAddr = 123   <<<<<   Confirm ACK
                                        10 80 7B FB 16
18:41:04.487   LinkAddr = 123   >>>>>   User Data
                                        Counter interrogation command
                                        Tid = 101  Qual = 1  Cot = 10  org = 0  Addr ASDU = 1
                                        68 09 09 68 73 7B 65 01 0A 01 00 00 05 64 16
18:41:04.515   LinkAddr = 123   <<<<<   Confirm ACK
                                        10 80 7B FB 16
```

Here, the T200 has no *integrated totals* to send (there are none or their *information object addresses* are not configured). This can be seen from the fact that there are no counter data in the T200's reply.

- <u>Change of signal transmission</u>

  In *unbalanced* mode

  Following a class 2 user data request, the T200 indicates that it has a class 1 object to send. The SCADA recovers it by making a class 1 user data request. Once the change(s) has (have) been repatriated, the Control Centre resumes *polling*.



```
10:17:56.133   LinkAddr = 123   <<<<<   Request user data class 2
                                        10 7B 7B F6 16
10:17:56.164   LinkAddr = 123   >>>>>   NACK : requested data not available
                                        10 29 7B A4 16
10:17:57.337   LinkAddr = 123   <<<<<   Request user data class 1
                                        10 5A 7B D5 16
10:17:57.366   LinkAddr = 123   >>>>>   User Data
                                        Single-point information with time tag CP56Time2a
                                        Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                        68 10 10 68 08 7B 1E 01 03 01 52 00 01 07 D6 91 0A 04 04 07 80
                                        16
10:17:58.665   LinkAddr = 123   <<<<<   Request user data class 2
                                        10 7B 7B F6 16
10:17:58.694   LinkAddr = 123   >>>>>   NACK : requested data not available
                                        10 09 7B 84 16
10:17:59.899   LinkAddr = 123   <<<<<   Request user data class 2
                                        10 5B 7B D6 16
10:17:59.929   LinkAddr = 123   >>>>>   NACK : requested data not available
                                        10 09 7B 84 16
10:18:01.133   LinkAddr = 123   <<<<<   Request user data class 2
                                        10 7B 7B F6 16
10:18:01.163   LinkAddr = 123   >>>>>   NACK : requested data not available
                                        10 09 7B 84 16
10:18:02.337   LinkAddr = 123   <<<<<   Request user data class 2
                                        10 5B 7B D6 16
```

In *balanced* mode

10:07:29.887	LinkAddr =	123	>>>>>	User Data Single-point information with time tag CP56Time2a Tid = 30 Qual = 1 Cot = 3 org = 0 Addr ASDU = 1 68 10 10 68 53 7B 1E 01 03 01 52 00 00 80 70 87 0A 04 04 07 D3 16
10:07:30.172	LinkAddr =	123	<<<<<	Confirm ACK 10 80 7B FB 16

The change is sent spontaneously by the T200.

- Telecontrol

In *unbalanced* mode

- *Direct* mode

The Control Centre interrupts T200 *polling* to send the command. For this command, there is first an application acknowledgement by the T200. Here, the necessary conditions for execution of a telecontrol are met (the T200 is in remote mode, there is no command in progress, etc.) and the acknowledgement is therefore an activation confirmation (Cot = 7). The T200 starts order execution.
The SCADA continues *polling* on the T200 until it obtains the change of state following the command (if the command has gone well) and the indication that the command is terminated.

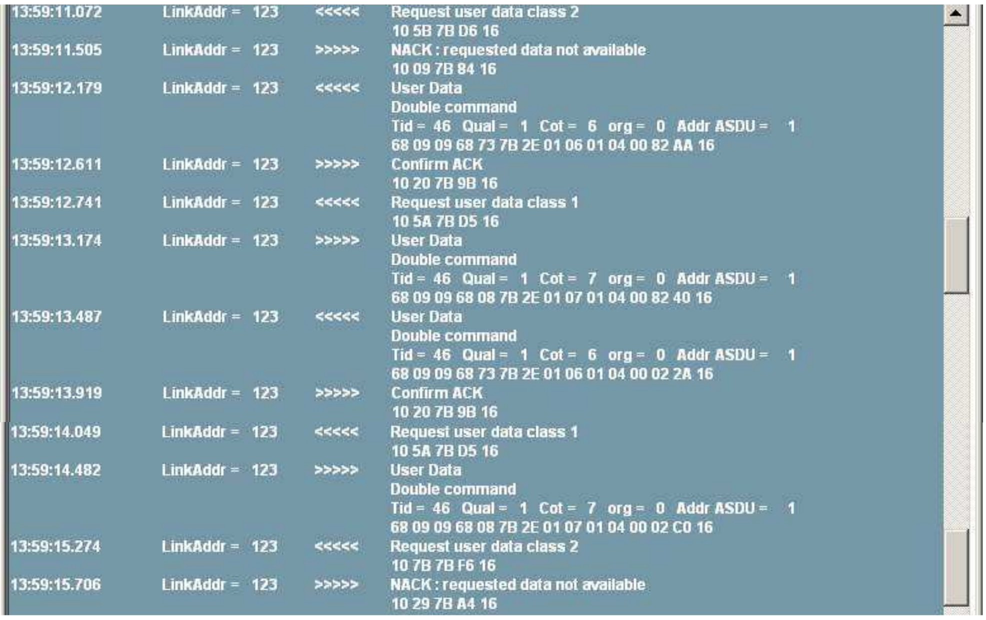
13:39:24.466	LinkAddr =	123	<<<<<	Request user data class 2 10 7B 7B F6 16
13:39:24.899	LinkAddr =	123	>>>>>	NACK : requested data not available 10 09 7B 84 16
13:39:25.119	LinkAddr =	123	<<<<<	User Data Double command Tid = 46 Qual = 1 Cot = 6 org = 0 Addr ASDU = 1 68 09 09 68 53 7B 2E 01 06 01 04 00 01 09 16
13:39:25.552	LinkAddr =	123	>>>>>	Confirm ACK 10 20 7B 9B 16
13:39:25.681	LinkAddr =	123	<<<<<	Request user data class 1 10 7A 7B F5 16
13:39:26.113	LinkAddr =	123	>>>>>	User Data Double command Tid = 46 Qual = 1 Cot = 7 org = 0 Addr ASDU = 1 68 09 09 68 08 7B 2E 01 07 01 04 00 01 BF 16
13:39:27.340	LinkAddr =	123	<<<<<	Request user data class 2 10 5B 7B D6 16
13:39:27.773	LinkAddr =	123	>>>>>	NACK : requested data not available 10 29 7B A4 16

The change of position of the actuated switch and command activation termination are shown below.

13:39:27.773	LinkAddr =	123	>>>>>	NACK : requested data not available 10 29 7B A4 16
13:39:28.887	LinkAddr =	123	<<<<<	Request user data class 1 10 7A 7B F5 16
13:39:29.320	LinkAddr =	123	>>>>>	User Data Double-point information with time tag CP56Time2a Tid = 31 Qual = 1 Cot = 3 org = 0 Addr ASDU = 1 68 10 10 68 08 7B 1F 01 03 01 20 00 01 EE 62 A7 0D 04 04 07 DB 16
13:39:30.652	LinkAddr =	123	<<<<<	Request user data class 2 10 5B 7B D6 16
13:39:31.086	LinkAddr =	123	>>>>>	NACK : requested data not available 10 29 7B A4 16
13:39:32.199	LinkAddr =	123	<<<<<	Request user data class 1 10 7A 7B F5 16
13:39:32.632	LinkAddr =	123	>>>>>	User Data Double command Tid = 46 Qual = 1 Cot = 10 org = 0 Addr ASDU = 1 68 09 09 68 08 7B 2E 01 0A 01 04 00 01 C2 16
13:39:33.855	LinkAddr =	123	<<<<<	Request user data class 2 10 5B 7B D6 16
13:39:34.288	LinkAddr =	123	>>>>>	NACK : requested data not available 10 09 7B 84 16

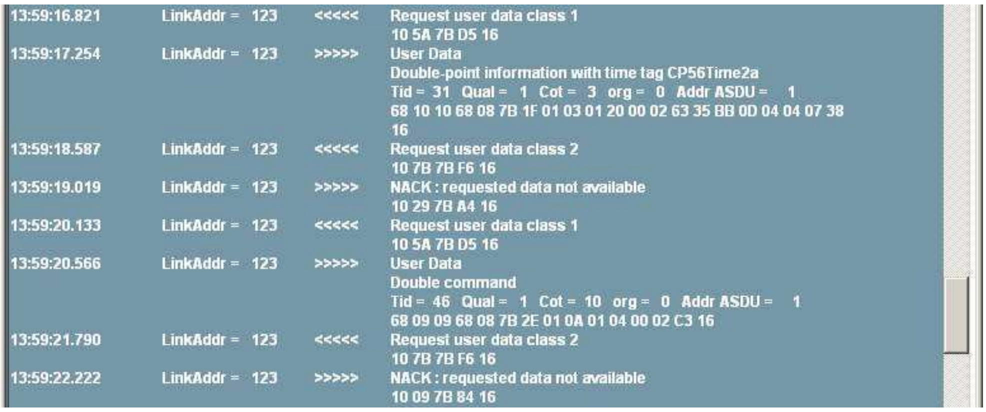
- *Select before execute* mode

  Here again, the SCADA interrupts its *polling* sequence to send the command. This is done in two stages: an initial selection stage, then a confirmation stage. Each time, the T200 checks that the order execution conditions are complied with (T200 in remote mode, no command in progress, execution properly corresponding to the selected device, etc.). It confirms these tests by sending activation confirmations (*select before execute*).



13:59:11.072	LinkAddr = 123	<<<<<	Request user data class 2 10 5B 7B D6 16
13:59:11.505	LinkAddr = 123	>>>>>	NACK : requested data not available 10 09 7B 84 16
13:59:12.179	LinkAddr = 123	<<<<<	User Data Double command Tid = 46 Qual = 1 Cot = 6 org = 0 Addr ASDU = 1 68 09 09 68 73 7B 2E 01 06 01 04 00 82 AA 16
13:59:12.611	LinkAddr = 123	>>>>>	Confirm ACK 10 20 7B 9B 16
13:59:12.741	LinkAddr = 123	<<<<<	Request user data class 1 10 5A 7B D5 16
13:59:13.174	LinkAddr = 123	>>>>>	User Data Double command Tid = 46 Qual = 1 Cot = 7 org = 0 Addr ASDU = 1 68 09 09 68 08 7B 2E 01 07 01 04 00 82 40 16
13:59:13.487	LinkAddr = 123	<<<<<	User Data Double command Tid = 46 Qual = 1 Cot = 6 org = 0 Addr ASDU = 1 68 09 09 68 73 7B 2E 01 06 01 04 00 02 2A 16
13:59:13.919	LinkAddr = 123	>>>>>	Confirm ACK 10 20 7B 9B 16
13:59:14.049	LinkAddr = 123	<<<<<	Request user data class 1 10 5A 7B D5 16
13:59:14.482	LinkAddr = 123	>>>>>	User Data Double command Tid = 46 Qual = 1 Cot = 7 org = 0 Addr ASDU = 1 68 09 09 68 08 7B 2E 01 07 01 04 00 02 C0 16
13:59:15.274	LinkAddr = 123	<<<<<	Request user data class 2 10 7B 7B F6 16
13:59:15.706	LinkAddr = 123	>>>>>	NACK : requested data not available 10 29 7B A4 16

Then the change of state and end of command are sent.



13:59:16.821	LinkAddr = 123	<<<<<	Request user data class 1 10 5A 7B D5 16
13:59:17.254	LinkAddr = 123	>>>>>	User Data Double-point information with time tag CP56Time2a Tid = 31 Qual = 1 Cot = 3 org = 0 Addr ASDU = 1 68 10 10 68 08 7B 1F 01 03 01 20 00 02 63 35 BB 0D 04 04 07 38 16
13:59:18.587	LinkAddr = 123	<<<<<	Request user data class 2 10 7B 7B F6 16
13:59:19.019	LinkAddr = 123	>>>>>	NACK : requested data not available 10 29 7B A4 16
13:59:20.133	LinkAddr = 123	<<<<<	Request user data class 1 10 5A 7B D5 16
13:59:20.566	LinkAddr = 123	>>>>>	User Data Double command Tid = 46 Qual = 1 Cot = 10 org = 0 Addr ASDU = 1 68 09 09 68 08 7B 2E 01 0A 01 04 00 02 C3 16
13:59:21.790	LinkAddr = 123	<<<<<	Request user data class 2 10 7B 7B F6 16
13:59:22.222	LinkAddr = 123	>>>>>	NACK : requested data not available 10 09 7B 84 16

In *balanced* mode

- *Direct* mode

The interchange is far more limited than in *unbalanced* mode, since the T200 polling frames do not exist.

```
14:29:16.103   LinkAddr =  123   <<<<<   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 09 09 68 F3 7B 2E 01 06 01 04 00 02 AA 16
14:29:16.536   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 00 7B 7B 16
14:29:17.053   LinkAddr =  123   >>>>>   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 09 09 68 53 7B 2E 01 07 01 04 00 02 0B 16
14:29:17.274   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
14:29:17.707   LinkAddr =  123   >>>>>   User Data
                                         Double-point information with time tag CP56Time2a
                                         Tid = 31  Qual =  1  Cot =  3  org =  0  Addr ASDU =   1
                                         68 10 10 68 73 7B 1F 01 03 01 20 00 02 2D 40 9D 0E 04 04 07 5B
                                         16
14:29:17.997   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
14:29:20.959   LinkAddr =  123   >>>>>   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot = 10  org =  0  Addr ASDU =   1
                                         68 09 09 68 53 7B 2E 01 0A 01 04 00 02 0E 16
14:29:21.181   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

- *Select before execute* mode

Here again, there are far fewer interchanges than in *unbalanced* mode.

First, the select phase.

```
14:19:48.503   LinkAddr =  123   <<<<<   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 09 09 68 F3 7B 2E 01 06 01 04 00 81 29 16
14:19:48.935   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 00 7B 7B 16
14:19:49.451   LinkAddr =  123   >>>>>   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 09 09 68 53 7B 2E 01 07 01 04 00 81 8A 16
14:19:49.671   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

Then the execute phase.

```
14:19:49.808   LinkAddr =  123   <<<<<   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot =  6  org =  0  Addr ASDU =   1
                                         68 09 09 68 D3 7B 2E 01 06 01 04 00 01 89 16
14:19:50.242   LinkAddr =  123   >>>>>   Confirm ACK
                                         10 00 7B 7B 16
14:19:50.757   LinkAddr =  123   >>>>>   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot =  7  org =  0  Addr ASDU =   1
                                         68 09 09 68 73 7B 2E 01 07 01 04 00 01 2A 16
14:19:50.978   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

Next, the change of device position and end of command.

```
14:19:51.412   LinkAddr =  123   >>>>>   User Data
                                         Double-point information with time tag CP56Time2a
                                         Tid = 31  Qual =  1  Cot =  3  org =  0  Addr ASDU =   1
                                         68 10 10 68 53 7B 1F 01 03 01 20 00 01 27 C3 93 0E 04 04 07 AD
                                         16
14:19:51.698   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
14:19:54.501   LinkAddr =  123   >>>>>   User Data
                                         Double command
                                         Tid = 46  Qual =  1  Cot = 10  org =  0  Addr ASDU =   1
                                         68 09 09 68 73 7B 2E 01 0A 01 04 00 01 2D 16
14:19:54.723   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

- <u>Cyclic measurement transmission</u>

In *unbalanced* mode

The SCADA performs its *polling* normally on the T200. From time to time, the T200 records the measurements declared as cyclic and delivers them to the Control Centre in reply to one of its *polling* operations.

```
15:13:00.298   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 5B 7B D6 16
15:13:00.730   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
15:13:01.860   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 7B 7B F6 16
15:13:02.293   LinkAddr =  123   >>>>>   User Data
                                         Measured value, normalized value with time tag CP56Time2a
                                         Tid = 34  Qual =  1  Cot =  1  org =  0  Addr ASDU =  1
                                         68 12 12 68 08 7B 22 01 01 01 C1 00 C9 00 00 DA 02 8D 0F 04 04
                                         07 B9 16
15:13:03.625   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 5B 7B D6 16
15:13:04.059   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
```

Here, the measurement storage period is 30 s.

```
15:13:30.250   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 7B 7B F6 16
15:13:30.682   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
15:13:31.813   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 5B 7B D6 16
15:13:32.246   LinkAddr =  123   >>>>>   User Data
                                         Measured value, normalized value with time tag CP56Time2a
                                         Tid = 34  Qual =  1  Cot =  1  org =  0  Addr ASDU =  1
                                         68 12 12 68 08 7B 22 01 01 01 C1 00 C9 00 00 FC 78 8D 0F 04 04
                                         07 51 16
15:13:33.578   LinkAddr =  123   <<<<<   Request user data class 2
                                         10 7B 7B F6 16
15:13:34.012   LinkAddr =  123   >>>>>   NACK : requested data not available
                                         10 09 7B 84 16
```

Comment: Despite the fact that the measurements are cyclic, it may be worthwhile time stamping them. This is because they cannot be time stamped using the measurement reception time, because it depends on the time of the class 2 user data request and not on the time at which they were stored in memory. The difference between the two may increase with the time difference between 2 SCADA polling operations.

In *balanced* mode

The cyclic measurements are stored in memory and then sent to the SCADA regularly by the T200.

```
15:21:01.020   LinkAddr =  123   >>>>>   User Data
                                         Measured value, normalized value with time tag CP56Time2a
                                         Tid = 34  Qual =  1  Cot =  1  org =  0  Addr ASDU =  1
                                         68 12 12 68 73 7B 22 01 01 01 C1 00 C9 00 00 49 02 95 0F 04 04
                                         07 9B 16
15:21:01.287   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
15:21:31.263   LinkAddr =  123   >>>>>   User Data
                                         Measured value, normalized value with time tag CP56Time2a
                                         Tid = 34  Qual =  1  Cot =  1  org =  0  Addr ASDU =  1
                                         68 12 12 68 53 7B 22 01 01 01 C1 00 C8 00 00 6B 78 95 0F 04 04
                                         07 12 16
15:21:31.535   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

Here, measurement time stamping is useful to obtain greater precision and in the event that, following a busy network or transmission problems, the frame will be received only a long time after cyclic measurement recording.

- Frame repetition

In *balanced* mode

We give, here, 2 examples showing the mechanism of frame repetition by the T200, when a transmission problem occurs.

The first case corresponds to a temporary transmission problem, the second to a problem lasting a longer time.

Below, the SCADA has not received the change of signal frame sent by the T200 or the T200 has not seen the acknowledgement due to a transmission disturbance. As a consequence, the T200 repeats the frame after expiry of the waiting time (the link timeout interval - TL - is set to 5 s).

```
15:34:32.092   LinkAddr =  123   >>>>>   User Data
                                         Single-point information with time tag CP56Time2a
                                         Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                         68 10 10 68 73 7B 1E 01 03 01 52 00 01 7D 79 A2 0F 04 04 07 1A
                                         16
15:34:37.803   LinkAddr =  123   >>>>>   User Data
                                         Single-point information with time tag CP56Time2a
                                         Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                         68 10 10 68 73 7B 1E 01 03 01 52 00 01 7D 79 A2 0F 04 04 07 1A
                                         16
15:34:38.089   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

If the disturbance lasts longer, the T200 repeats the frame, complying with the link timeout interval (TL - Timeout Link here set to 5 s) and the maximum number of send operations (which includes the first sending and repetitions – here set to 3). Still having no acknowledgement, it waits until the SCADA replies again by sending *link status requests*.

```
15:38:21.729   LinkAddr =  123   >>>>>   User Data
                                         Single-point information with time tag CP56Time2a
                                         Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                         68 10 10 68 53 7B 1E 01 03 01 52 00 00 52 51 A6 0F 04 04 07 AA
                                         16
15:38:27.441   LinkAddr =  123   >>>>>   User Data
                                         Single-point information with time tag CP56Time2a
                                         Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                         68 10 10 68 53 7B 1E 01 03 01 52 00 00 52 51 A6 0F 04 04 07 AA
                                         16
15:38:33.153   LinkAddr =  123   >>>>>   User Data
                                         Single-point information with time tag CP56Time2a
                                         Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                         68 10 10 68 53 7B 1E 01 03 01 52 00 00 52 51 A6 0F 04 04 07 AA
                                         16
15:38:38.864   LinkAddr =  123   >>>>>   Request link status
                                         10 49 7B C4 16
15:38:44.419   LinkAddr =  123   >>>>>   Request link status
                                         10 49 7B C4 16
15:38:49.975   LinkAddr =  123   >>>>>   Request link status
                                         10 49 7B C4 16
```

As soon as the SCADA replies, the T200 reinitializes the link in the T200 to SCADA direction, then sends the change frame.

```
15:39:03.086   LinkAddr =  123   >>>>>   Request link status
                                         10 49 7B C4 16
15:39:03.220   LinkAddr =  123   <<<<<   Status of link
                                         10 8B 7B 06 16
15:39:03.653   LinkAddr =  123   >>>>>   Reset Link
                                         10 40 7B BB 16
15:39:03.782   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
15:39:04.215   LinkAddr =  123   >>>>>   User Data
                                         Single-point information with time tag CP56Time2a
                                         Tid = 30  Qual = 1  Cot = 3  org = 0  Addr ASDU = 1
                                         68 10 10 68 73 7B 1E 01 03 01 52 00 00 52 51 A6 0F 04 04 07 CA
                                         16
15:39:04.500   LinkAddr =  123   <<<<<   Confirm ACK
                                         10 80 7B FB 16
```

6. Glossary

B

Balanced

The *balanced* transmission mode is a master – master transmission mode.

Broadcast

The Supervisor can perform T200 time setting in *broadcast* mode (the *link address* is in that case equal to 255 – if it is on 1 octet – or 65535 – if it is on 2 octets – and the *common address of ASDUs* is likewise equal to 255 – if it is on 1 octet – or 65535 – if it is on 2 octets). In this case, the latter will not reply to the time setting frame (the service used is then, mandatorily, the *send/no reply expected* service).

C

Cause of transmission

The *objects* transmitted are accompanied by a *cause of transmission*. It can be coded on 1 or 2 octets depending on the configuration. When it is on 2 octets, the second octet contains the *originator address*. This equals 0 for the T200, and it is equal to the value received in the reflected frames.
The *cause of transmission* is denoted Cot in the traces.

Clock synchronization command

This command is sent by the SCADA to set the T200 time. It can be sent in *broadcast* mode. In that case, all the T200s allow for it. Depending on the transmission medium, good synchronization between the SCADA and the T200s (when the transmission time is constant) can be achieved, if necessary, by making a correction to the transmission delay (by the *delay acquisition command*), or not (when the transmission delay is variable). In the latter case, the absolute time tag of events in the SCADA and in the T200 will be different, but the relative time tag between different events in the T200 will be correct and precise.

Common address of ASDUs

In the T200, this address has no functionality. It is, however, checked (in the information frames received) relative to the configured value or set to the configured value (in the sent frames). It can be coded on 1 or 2 octets depending on the configuration. In general, it is set to 0, 1 or the same value as the *link address*.
It is denoted Addr ASDU in the traces.

Counter interrogation command

This command, executed by the Supervisor, allows repatriation of all T200 counters (for which an *information object address* has been defined).

D

Delay acquisition command

This command, possibly executed by the Supervisor, is used on transmission media for which transmission delays are repetitive. It permits correction of the transmission delay when setting the T200 time. If this command is not executed, the T200 will perform time setting with a null transmission delay correction.

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 turn of the execution relay. During all the command sequences, checks are performed. Any detected anomaly causes immediate stoppage of the command.

Double command

The protocol supports *single commands* and *double commands*. They are executed in *select before execute* or *direct execution* mode depending on the configuration.

Double point information

Both information types, *double point information* and *single point information* are supported by the protocol.

E

Enhanced Performance Architecture
3-layer transmission model used in the IEC 60870-5-101 standard (simplified version of the 7-layer ISO model).

End of initialization
This *object* can be sent by the T200 or not depending on the configuration. When it is sent, it can indicate to the Supervisor that the T200 has just started up and that, as a consequence, the SCADA does not have a correct image of its status. Generally, the Supervisor then performs time setting on the T200 and repatriates its status by an *interrogation command* and, if necessary, a *counter interrogation command*.

I

Information object address
This is the address characterizing an *object* in the T200. It can be coded on 1, 2 or 3 octets depending on the configuration. It is possible to adopt the same ranges of values for *objects* having different *type identifications*. Accordingly, one can have a *single signal* or a *measurement* having, for example, the address 15 as *information object address. However, many users prefer to have different addresses for each object*.

Integrated totals
The T200 can manage counters which it transmits in the form of *integrated total* type objects.

Interrogation command
This command, executed by the Supervisor, allows repatriation of all single and double signals and all T200 measurements (for which an *information object address* has been defined).

L

Link address
This is the transmission address which must be specific to each Supervisor–T200 link in the network. It can be coded on 1 or 2 octets depending on the configuration.
It is denoted LinkAddr in the traces.

Link status request
This request allows the Supervisor or the T200 (in the case of *balanced* mode) to check the presence of the far-end equipment. It is therefore the first frame acknowledged by the far end when the latter replies again after a loss of link.

M

Measured value
The T200 can transmit the measurements in 2 formats: normalized value or scaled value.
The T200 Control cards provide Com card with the values expressed in the reference unit. The Com card will convert this value into the selected format before transmitting it.
Refer to section 4.1 General configuration of the protocol – Measured value, for more details.

O

Object
Every information item transmitted is called an *object*. They belong to various categories characterized by a *type identification*. For example, there are *single command*, *double signal information*, *measured value* and *interrogation command objects*, etc.

Originator address
This address is coded on the second octet of the *cause of transmission* when the latter is on 2 octets. It equals 0 for the T200, and it is equal to the value received in the reflected frames.
It is denoted org in the trace.

P

Polling
This method, allowing information to be repatriated from the T200s, is the simplest to implement at the Supervisor end. It involves interrogating each T200 in succession so that it may return its information. The operating mode is in that case *unbalanced* mode. It has the disadvantage of entailing numerous interchanges even for a small quantity of useful information. Moreover, the greater the number of T200s, the greater the cycle time on all the T200s. This can mean that status refreshment for a T200 may take place only a long time after the status has changed.

R

Remote link reset

For the Supervisor and a T200 to be able to exchange data, they must be synchronized. Now, data frames are numbered (by the FCB bit) so as to be able to detect a frame loss or repetition. Accordingly, the number of the frame expected by a station must correspond to the number of the frame sent by the remote station. This synchronization of numbering at both ends of the link is performed by the *remote link reset* message.
In *balanced* mode, each end of the link will send this frame before sending data transmitted on its initiative.

S

Select before execute

In this command execution mode, the command, when it is authorized, is executed in two stages. The T200 first receives a select message. It then receives an execute message. It 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 select message, an excessive time elapses without the T200 receiving the execute message, the command is cancelled. The SCADA, after sending the select, can send a command cancellation message.

Send/confirm expected

When the sender uses this transmission service, the receiver must confirm to it that it has received the frame.

Send/no reply expected

When the sender uses this transmission service, it expects no confirmation by the receiver of correct frame reception.

Sequence of information objects

When an equipment has several *objects* of the same type to send (after an *interrogation command*, for example), it can, when the addresses of these *objects* follow one another, code them in sequence, which has the effect of shortening the frame and hence the transmission time. It is therefore advantageous to enter consecutive addresses for all *objects* of the same type.

Single command

The protocol supports *single commands* and *double commands*. They are executed in *select before execute* or *direct execution* mode depending on the configuration.

Single point information

Both information types, *double point information* and *single point information* are supported by the protocol.

T

Transmission control character I

Ack and Nack frame reception acknowledgements can be coded either as fixed-length frames or using the *transmission control character I*. This character is coded E5 in hexadecimal.
In the case of non-noisy point-to-point links (e.g., RS-232 link, PSTN link), the single control character I can be used in place of the fixed-length frame to reduce transmission times.
When working with noisy transmission, one should not use the single control character I, because it can easily be generated by noise. Moreover, some SCADAs do not handle this character. In that case the box must be deselected.
Likewise, on multipoint networks, the single control character cannot be used because in this case the receiver cannot know who is the sender.

Type identification

This defines the *object* transmitted. One can find, for example, *double command, single point information* with time tag on 7 octets, *delay acquisition command*, etc.
It is denoted Tid in the traces.

U

Unbalanced

The *unbalanced* transmission mode is a master - slave transmission mode in which the Supervisor acts as master and the T200 acts as slave.

7. Interoperability

7.1 System or device

(system-specific parameter)

☐ System definition
☐ Controlling station definition (master)
☒ Controlled station definition (slave)

7.2 Network configuration

(network-specific parameter)

☒ Point-to-point
☒ Multiple point-to-point
☒ Multipoint-partyline
☐ Multipoint-star

7.3 Physical layer

(network-specific parameter)

Transmission speed (control direction)

Unbalanced interchange Circuit V24/V28 Standard	Unbalanced interchange Circuit V24/V28 Recommended if > 1200 bit/s	Balanced interchange Circuit X24/X27
☐ 100 bits/s	☒ 2400 bits/s	☐ 2400 bits/s
☒ 200 bits/s	☒ 4800 bits/s	☐ 4800 bits/s
☒ 300 bits/s	☒ 9600 bits/s	☐ 9600 bits/s
☒ 600 bits/s		☐ 19200 bits/s
☒ 1200 bits/s		☐ 38400 bits/s
		☐ 56000 bits/s
		☐ 64000 bits/s

Transmission speed (monitor direction)

Unbalanced interchange Circuit V24/V28 Standard	Unbalanced interchange Circuit V24/V28 Recommended if > 1200 bit/s	Balanced interchange Circuit X24/X27
☐ 100 bits/s	☒ 2400 bits/s	☐ 2400 bits/s
☒ 200 bits/s	☒ 4800 bits/s	☐ 4800 bits/s
☒ 300 bits/s	☒ 9600 bits/s	☐ 9600 bits/s
☒ 600 bits/s		☐ 19200 bits/s
☒ 1200 bits/s		☐ 38400 bits/s
		☐ 56000 bits/s
		☐ 64000 bits/s

The transmission speed must be the same in the control and monitor directions.

7.4 Link layer

(network-specific parameter)

Frame format FT1.2, single character 1 and the fixed time out interval are used exclusively in this companion standard.

Link transmission procedure

☒ Balanced transmission
☒ Unbalanced transmission

Address field of the link

☐ Not present (balanced transmission only)
☒ One octet
☒ Two octets
☐ Structured
☒ Unstructured

Frame length

255	Maximum length L (control direction)
255	Maximum length L (monitor direction)

9	Number of repetitions

When using an unbalanced link layer, the following ASDU types are returned in class 2 messages (low priority) with the indicated causes of transmission:

☒ The standard assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission
9,11,13,21	<1>

☐ A special assignment of ASDUs to class 2 messages is used as follows:

Type identification	Cause of transmission

Note: In response to a class 2 poll, a controlled station may respond with class 1 data when there is no class 2 data available.

7.5 Application layer

Transmission mode for application data

Mode 1 (least significant octet first), as defined in 4.10 of IEC 870-5-4, is used exclusively in this companion standard.

Common address of ASDU
(system-specific parameter)

☒ One octet ☒ Two octets

Information object address
(system-specific parameter)

☒ One octet ☐ Structured
☒ Two octets ☒ Unstructured
☒ Three octets

Cause of transmission
(system-specific parameter)

☒ One octet ☒ Two octets (with originator address)
Originator address is set to zero if not used

Selection of standard ASDUs

Process information in monitor direction
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒	<1> := Single-point information	M_SP_NA_1
☒	<2> := Single-point information with time tag	M_SP_TA_1
☒	<3> := Double-point information	M_DP_NA_1
☒	<4> := Double-point information with time tag	M_DP_TA_1
☐	<5> := Step position information	M_ST_NA_1
☐	<6> := Step position information with time tag	M_ST_TA_1
☐	<7> := Bitstring of 32 bits	M_BO_NA_1
☐	<8> := Bitstring of 32 bits with time tag	M_BO_TA_1
☒	<9> := Measured value, normalized value	M_ME_NA_1
☒	<10> := Measured value, normalized value with time tag	M_ME_TA_1
☒	<11> := Measured value, scaled value	M_ME_NB_1
☒	<12> := Measured value, scaled value with time tag	M_ME_TB_1
☐	<13> := Measured value, short floating point value	M_ME_NC_1
☐	<14> := Measured value, short floating point value with time tag	M_ME_TC_1
☒	<15> := Integrated totals	M_IT_NA_1
☒	<16> := Integrated totals with time tag	M_IT_TA_1
☐	<17> := Event of protection equipment with time tag	M_EP_TA_1
☐	<18> := Packed start events of protection equipment with time tag	M_EP_TB_1
☐	<19> := Packed output circuit information of protection equipment with time tag	M_EP_TC_1
☐	<20> := Packed single-point information with status change detection	M_PS_NA_1
☐	<21> := Measured value, normalized value without quality descriptor	M_ME_ND_1
☒	<30> := Single-point information with time tag CP56Time2a	M_SP_TB_1
☒	<31> := Double-point information with time tag CP56Time2a	M_DP_TB_1
☐	<32> := Step position information with time tag CP56Time2a	M_ST_TB_1
☐	<33> := Bitstring of 32 bits with time tag CP56Time2a	M_BO_TB_1
☒	<34> := Measured value, normalized value with time tag CP56Time2a	M_ME_TD_1
☒	<35> := Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
☐	<36> := Measured value, short floating point value with time tag CP56Time2a	M_ME_TF_1
☒	<37> := Integrated totals with time tag CP56Time2a	M_IT_TB_1
☐	<38> := Event of protection equipment with time tag CP56Time2a	M_EP_TD_1
☐	<39> := Packed start events of protection equipment with time tag CP56Time2a	M_EP_TE_1
☐	<40> := Packed output circuit information of protection equipment with time tag CP56Time2a	M_EP_TF_1

Process information in control direction
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒	<45> := Single command	C_SC_NA_1
☒	<46> := Double command	C_DC_NA_1
☐	<47> := Regulation step command	C_RC_NA_1
☐	<48> := Set point command, normalized value	C_SE_NA_1
☐	<49> := Set point command, scaled value	C_SE_NB_1
☐	<50> := Set point command, short floating point value	C_SE_NC_1
☐	<51> := Bitstring of 32 bits	C_BO_NA_1

System information in monitor direction
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒	<70> := End of initialisation	M_EI_NA_1

System information in control direction
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒	<100> := Interrogation command	C_IC_NA_1
☒	<101> := Counter interrogation command	C_CI_NA_1
☒	<102> := Read command	C_RD_NA_1
☒	<103> := Clock synchronization command	C_CS_NA_1
☐	<104> := Test command	C_TS_NA_1
☒	<105> := Reset process command	C_RP_NA_1
☒	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☐	<110> := Parameter of measured value, normalized value	P_ME_NA_1
☐	<111> := Parameter of measured value, scaled value	P_ME_NB_1
☐	<112> := Parameter of measured value, short floating point value	P_ME_NC_1
☐	<113> := Parameter activation	P_AC_NA_1

File transfer
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☐	<120> := File ready	F_FR_NA_1
☐	<121> := Section ready	F_SR_NA_1
☐	<122> := Call directory, select file, call file, call section	F_SC_NA_1
☐	<123> := Last section, last segment	F_LS_NA_1
☐	<124> := Ack file, ack section	F_AF_NA_1
☐	<125> := Segment	F_SG_NA_1
☐	<126> := Directory	F_DR_TA_1

Assignment of type identifications and causes of transmission
(station-specific parameter)
The shaded boxes are not required.
Blank = The function or the ASDU is not used.
The type identification/cause of transmission combinations are marked:
"**X**" if used only in the standard direction;
"**R**" if used only in the reverse direction;
"**B**" if used in both directions.

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<1>	M_SP_NA_1			X		X									X					
<2>	M_SP_TA_1			X		X														
<3>	M_DP_NA_1			X		X									X					
<4>	M_DP_TA_1			X		X														
<5>	M_ST_NA_1																			
<6>	M_ST_TA_1																			
<7>	M_BO_NA_1																			
<8>	M_BO_TA_1																			
<9>	M_ME_NA_1	X		X		X									X					
<10>	M_ME_TA_1			X		X														
<11>	M_ME_NB_1	X		X		X									X					
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1																			
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1			X												X				
<16>	M_IT_TA_1			X												X				
<17>	M_EP_TA_1																			
<18>	M_EP_TB_1																			
<19>	M_EP_TC_1																			
<20>	M_PS_NA_1																			
<21>	M_ME_ND_1																			
<30>	M_SP_TB_1			X		X														
<31>	M_DP_TB_1			X		X														
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1			X		X														
<35>	M_ME_TE_1			X		X														
<36>	M_ME_TF_1																			
<37>	M_IT_TB_1			X												X				
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						X	X	X	X	X									
<46>	C_DC_NA_1						X	X	X	X	X									
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1																			

Type identification		Cause of transmission																		
		1	2	3	4	5	6	7	8	9	10	11	12	13	20 to 36	37 to 41	44	45	46	47
<50>	C_SE_NC_1																			
<51>	C_BO_NA_1																			
<70>	M_EI_NA_1				X															
<100>	C_IC_NA_1						X	X	X	X	X									
<101>	C_CI_NA_1						X	X			X									
<102>	C_RD_NA_1					X														
<103>	C_CS_NA_1						X	X												
<104>	C_TS_NA_1																			
<105>	C_RP_NA_1						X	X												
<106>	C_CD_NA_1						X	X												
<110>	P_ME_NA_1																			
<111>	P_ME_NB_1																			
<112>	P_ME_NC_1																			
<113>	P_AC_NA_1																			
<120>	F_FR_NA_1																			
<121>	F_SR_NA_1																			
<122>	F_SC_NA_1																			
<123>	F_LS_NA_1																			
<124>	F_AF_NA_1																			
<125>	F_SG_NA_1																			
<126>	F_DR_TA_1[a)]																			
[a)] Exclusively blank or X																				

7.6 Basic application functions

Station initialisation
(station-specific parameter)

☒ Remote initialisation

Cyclic data transmission
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒ Cyclic data transmission

Read process
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).s

☒ Read process

Spontaneous transmission
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous
(station-specific parameter)
(Mark each information type with an "**X**" where both a type ID without time and corresponding type ID with time are issued in response to a single spontaneous change of a monitored object).

The following type identifications may be transmitted in succession caused by a single status change of information object. The particular information object addresses for which double transmission is enabled are defined in a project-specific list.

- ☐ Single-point information M_SP_NA_1, M_SP_TA_1, M_SP_TB_1 and M_PS_NA_1
- ☐ Double-point information M_DP_NA_1, M_DP_TA_1 and M_DP_TB_1
- ☐ Step position information M_ST_NA_1, M_ST_TA_1 and M_ST_TB_1
- ☐ String of 32 bits M_BO_NA_1, M_BO_TA_1, and M_BO_TB_1 (if defined by a specific project)
- ☐ Measured value, normalized value M_ME_NA_1, M_ME_TA_1, M_ME_ND_1 and M_ME_TD_1
- ☐ Measured value, scaled value M_ME_NB_1, M_ME_TB_1 and M_ME_TE_1
- ☐ Measured value, short floating point number M_ME_NC_1, M_ME_TC_1 and M_ME_TF_1

Station interrogation
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒ Global

☐ Group 1	☐ Group 7	☐ Group 13
☐ Group 2	☐ Group 8	☐ Group 14
☐ Group 3	☐ Group 9	☐ Group 15
☐ Group 4	☐ Group 10	☐ Group 16
☐ Group 5	☐ Group 11	
☐ Group 6	☐ Group 12	

Information object addresses assigned to each group must be shown in a separate table.

Clock synchronisation
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

- ☒ Clock synchronisation
- ☐ Day of week used
- ☐ RES1, GEN (substituted/not substituted timetag) used
- ☒ SU-bit (summertime) used

Command transmission
(object-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒ Direct command transmission
☐ Direct set point command transmission
☒ Select and execute command
☐ Select and execute set point command
☐ C_SE_ACTERM used

☒ No additional definition
☐ Short-pulse duration (duration determined by a system parameter in the controlled station)
☐ Long-pulse duration (duration determined by a system parameter in the controlled station)
☐ Persistent output

Transmission of integrated totals
(station- or object-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒ Mode A: Local freeze with spontaneous transmission
☒ Mode B: Local freeze with counter interrogation
☒ Mode C: Freeze and transmit by counter interrogation commands
☒ Mode D: Freeze by counter interrogation command, frozen values reported spontaneously

☒ Counter read
☒ Counter freeze without reset
☒ Counter freeze with reset
☒ Counter reset

☒ General request counter
☐ Request counter group 1
☐ Request counter group 2
☐ Request counter group 3
☐ Request counter group 4

Parameter loading
(object-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☐ Threshold value
☐ Smoothing factor
☐ Low limit for transmission of measured value
☐ High limit for transmission of measured value

Parameter activation
(object-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☐ Act/deact of persistent cyclic or periodic transmission of the addressed object

Test procedure
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☐ Test procedure

File transfer
(object-specific parameter)

File transfer in monitor direction

☐ Transparent file
☐ Transmission of disturbance data of protection equipment
☐ Transmission of sequences of events
☐ Transmission of sequences of recorded analogue values

File transfer in control direction

☐ Transparent file

Background scan
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☐ Background scan

Acquisition of transmission delay
(station-specific parameter)
(Mark each ID with an "**X**" if it is only used in the standard direction, "**R**" if only used in the reverse direction, "**B**" if used in both directions).

☒ Acquisition of transmission delay

8. Object addressing

In the following tables will be found the default settings for the access classes and information object addresses. The addresses defined here are compatible with the information object addresses of the series 2 T200s.

In these tables do not appear objects which may have been acquired by the T200 (in MODBUS protocol) on the optional link to accessory equipment. This is because their configuration is completely free in relation to the IEC 60870-5-101 protocol (type, information object address), and the only rule to be obeyed is, of course, not to use for one object an address used for another object.

8.1 Legend

Abbreviation Type – Internal No.	Meaning	Transmitted as
TCD	Télécommande double (double telecontrol)	Double command
TSS	Télésignalisation simple (single telesignal)	Single-point information
TSD	Télésignalisation double (double telesignal)	Double-point information
TM	Télémesure (remote measurement)	Measured value
CNT	Counter	Integrated totals

Access Class	Defined as
0	Viewing
1	Operator
2	Administrator

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

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

8.2 T200 P

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Channel 1					
Switch position	TSD 1	0		32	20
Switch locked	TSS 49	0		68	44
Switch command	TCD 1	1		4	04
Operation counter	CNT 1	0		NA	NA
Operation counter preset command	TCD 25	2		NA	NA
Auxiliary DI	TSS 51	0		NA	NA
MV voltage present	TSS 73	0		NA	NA
Earth fault	TSS 71	0		61	3D
Phase fault	TSS 77	0		60	3C
Phase current 1	TM 2	0	I	NA	NA
Phase current 2	TM 3	0	I	NA	NA
Phase current 3	TM 4	0	I	NA	NA
Neutral current	TM 5	0	I	NA	NA
Average current	TM 6	0	I	192	C0
U21 voltage measurement	TM 47	0	U	194	C2
V1 voltage measurement	TM 50	0	U	NA	NA
Frequency	TM 8	0	P	NA	NA
Active power	TM 53	0	P	NA	NA
Reactive power	TM 54	0	P	NA	NA
Apparent power	TM 55	0	P	NA	NA
Power factor	TM 7	0	P	NA	NA
Active energy	CNT 5	0	P	NA	NA
Active energy preset command	TCD 29	2		NA	NA
Reactive energy	CNT 13	0	P	NA	NA
Reactive energy preset command	TCD 37	2		NA	NA
Channel 2					
Switch position	TSD 2	0		33	21
Switch locked	TSS 81	0		69	45
Switch command	TCD 2	1		5	05
Operation counter	CNT 2	0		NA	NA
Operation counter preset command	TCD 26	2		NA	NA
Auxiliary DI	TSS 83	0		NA	NA
MV voltage present	TSS 105	0		79	4F
Earth fault	TSS 103	0		62	3E
Phase fault	TSS 109	0		63	3F
Phase current 1	TM 9	0	I	NA	NA
Phase current 2	TM 10	0	I	NA	NA
Phase current 3	TM 11	0	I	NA	NA
Neutral current	TM 12	0	I	NA	NA
Average current	TM 13	0	I	193	C1
U21 voltage measurement	TM 56	0	U	195	C3
V1 voltage measurement	TM 59	0	U	NA	NA
Frequency	TM 15	0	P	NA	NA
Active power	TM 62	0	P	NA	NA
Reactive power	TM 63	0	P	NA	NA
Apparent power	TM 64	0	P	NA	NA
Power factor	TM 14	0	P	NA	NA
Active energy	CNT 6	0	P	NA	NA
Active energy preset command	TCD 30	2		NA	NA
Reactive energy	CNT 14	0	P	NA	NA
Reactive energy preset command	TCD 38	2		NA	NA

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Common objects					
Local/Remote position	TSS 23	0		82	52
Door opening	TSS 24	0		78	4E
Fault detection reset command	TCD 17	1		21	15
Immediate AC power supply defect	TSS 17	0		83	53
Time-delayed AC power supply defect	TSS 18	0		88	58
Power cut imminent	TSS 25	0		NA	NA
Automatic controls					
Automatic control ON/OFF position	TSD 9	0		35	23
Automatic control ON/OFF command	TCD 9	1		7	07
Automatic control has operated	TSS 57	0		89	59
Internal faults					
Motorization power supply failure	TSS 19	0		87	57
Accessory equipment power supply failure	TSS 20	0		NA	NA
Charger fault	TSS 21	0		85	55
Battery fault	TSS 22	0		86	56
Digital Inputs/Outputs					
Digital input 1	TSS 1	0		76	4C
Digital input 2	TSS 2	0		77	4D
Digital input 3	TSS 3	0		NA	NA
Digital input 4	TSS 4	0		NA	NA
Digital input 5	TSS 5	0		NA	NA
Digital input 6	TSS 6	0		NA	NA
Digital input 7	TSS 7	0		NA	NA
Digital input 8	TSS 8	0		NA	NA
Digital output 1 position	TSD 5	0		NA	NA
Digital output 1 command	TCD 5	1		NA	NA
Digital output 2 position	TSD 6	0		NA	NA
Digital output 2 command	TCD 6	1		NA	NA
Digital output 3 position	TSD 7	0		NA	NA
Digital output 3 command	TCD 7	1		NA	NA

8.3 T200 I

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Channel 1					
Switch position	TSD 1	0		32	20
Switch locked	TSS 49	0		68	44
Switch command	TCD 1	1		4	04
MV voltage present (auxiliary DI)	TSS 54	0		78	4E
Earth fault	TSS 71	0		61	3D
Phase fault	TSS 77	0		60	3C
Phase current	TM 2	0		192	C0
Channel 2					
Switch position	TSD 2	0		33	21
Switch locked	TSS 81	0		69	45
Switch command	TCD 2	1		5	05
MV voltage present (auxiliary DI)	TSS 86	0		79	4F
Earth fault	TSS 103	0		63	3F
Phase fault	TSS 109	0		62	3E
Phase current	TM 9	0		193	C1
Channel 3					
Switch position	TSD 3	0		34	22
Switch locked	TSS 113	0		70	46
Switch command	TCD 3	1		6	06
MV voltage present (auxiliary DI)	TSS 118	0		80	50
Earth fault	TSS 135	0		65	41
Phase fault	TSS 141	0		64	40
Phase current	TM 17	0		194	C2
Channel 4					
Switch position	TSD 4	0		35	23
Switch locked	TSS 145	0		71	47
Switch command	TCD 4	1		7	07
MV voltage present (auxiliary DI)	TSS 150	0		81	51
Earth fault	TSS 167	0		67	43
Phase fault	TSS 173	0		66	42
Phase current	TM 24	0		195	C3
Channel 5					
Switch position	TSD 41	0		36	24
Switch locked	TSS 321	0		100	64
Switch command	TCD 41	1		8	08
MV voltage present (auxiliary DI)	TSS 326	0		110	6E
Earth fault	TSS 343	0		93	5D
Phase fault	TSS 349	0		92	5C
Phase current	TM 84	0		196	C4
Channel 6					
Switch position	TSD 42	0		37	25
Switch locked	TSS 353	0		101	65
Switch command	TCD 42	1		9	09
MV voltage present (auxiliary DI)	TSS 358	0		111	6F
Earth fault	TSS 375	0		95	5F
Phase fault	TSS 381	0		94	5E
Phase current	TM 91	0		197	C5

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Channel 7					
Switch position	TSD 43	0		38	26
Switch locked	TSS 385	0		102	66
Switch command	TCD 43	1		10	0A
MV voltage present (auxiliary DI)	TSS 390	0		112	70
Earth fault	TSS 407	0		97	61
Phase fault	TSS 413	0		96	60
Phase current	TM 99	0		198	C6
Channel 8					
Switch position	TSD 44	0		39	27
Switch locked	TSS 417	0		103	67
Switch command	TCD 44	1		11	0B
MV voltage present (auxiliary DI)	TSS 422	0		113	71
Earth fault	TSS 439	0		99	63
Phase fault	TSS 445	0		98	62
Phase current	TM 106	0		199	C7
Channel 9					
Switch position	TSD 81	0		40	28
Switch locked	TSS 593	0		132	84
Switch command	TCD 81	1		12	0C
MV voltage present (auxiliary DI)	TSS 598	0		142	8E
Earth fault	TSS 615	0		125	7D
Phase fault	TSS 621	0		124	7C
Phase current	TM 166	0		200	C8
Channel 10					
Switch position	TSD 82	0		41	29
Switch locked	TSS	0		133	85
Switch command	TCD 82	1		13	0D
MV voltage present (auxiliary DI)	TSS	0		143	8F
Earth fault	TSS	0		127	7F
Phase fault	TSS	0		126	7E
Phase current	TM 173	0		201	C9
Channel 11					
Switch position	TSD 83	0		42	2 A
Switch locked	TSS	0		134	86
Switch command	TCD 83	1		14	0E
MV voltage present (auxiliary DI)	TSS	0		144	90
Earth fault	TSS	0		129	81
Phase fault	TSS	0		128	80
Phase current	TM 181	0		202	CA
Channel 12					
Switch position	TSD 84	0		43	2B
Switch locked	TSS	0		135	87
Switch command	TCD 84	1		15	0F
MV voltage present (auxiliary DI)	TSS	0		145	91
Earth fault	TSS	0		131	83
Phase fault	TSS	0		130	82
Phase current	TM 188	0		203	CB

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Channel 13					
Switch position	TSD 121	0		44	2C
Switch locked	TSS 865	0		164	A4
Switch command	TCD 121	1		16	10
MV voltage present (auxiliary DI)	TSS 870	0		174	AE
Earth fault	TSS 887	0		157	9D
Phase fault	TSS 893	0		156	9C
Phase current	TM 248	0		204	CC
Channel 14					
Switch position	TSD 122	0		45	2D
Switch locked	TSS 897	0		165	A5
Switch command	TCD 122	1		17	11
MV voltage present (auxiliary DI)	TSS 902	0		175	AF
Earth fault	TSS 919	0		159	9F
Phase fault	TSS 925	0		158	9E
Phase current	TM 255	0		205	CD
Channel 15					
Switch position	TSD 123	0		46	2E
Switch locked	TSS 929	0		166	A6
Switch command	TCD 123	1		18	12
MV voltage present (auxiliary DI)	TSS 934	0		176	B0
Earth fault	TSS 951	0		161	A1
Phase fault	TSS 957	0		160	A0
Phase current	TM 263	0		206	CE
Channel 16					
Switch position	TSD 124	0		47	2F
Switch locked	TSS 961	0		167	A7
Switch command	TCD 124	1		19	13
MV voltage present (auxiliary DI)	TSS 966	0		177	B1
Earth fault	TSS 983	0		163	A3
Phase fault	TSS 989	0		162	A2
Phase current	TM 270	0		207	CF
Common objects					
Local/Remote position	TSS 23	0		82	52
Fault detection reset command channels 1 to 4	TCD 17	1		21	15
Fault detection reset command channels 5 to 8	TCD 57	1		NA	NA
Fault detection reset command channels 9 to 12	TCD 97	1		NA	NA
Fault detection reset command channels 13 to 16	TCD 137	1		NA	NA
Immediate AC power supply defect	TSS 17	0		83	53
Time-delayed AC power supply defect	TSS 18	0		88	58
Power cut imminent	TSS 25	0		NA	NA

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Automatic controls					
Automatic control ON/OFF position channels 1 to 4	TSD 9	0		52	34
Automatic control ON/OFF command channels 1 to 4	TCD 9	1		24	18
Automatic control ON/OFF position channels 5 to 8	TSD 49	0		53	35
Automatic control ON/OFF command channels 5 to 8	TCD 49	1		25	19
Automatic control ON/OFF position channels 9 to 12	TSD 89	0		54	36
Automatic control ON/OFF command channels 9 to 12	TCD 89	1		26	1A
Automatic control ON/OFF position channels 13 to 16	TSD 129	0		55	37
Automatic control ON/OFF command channels 13 to 16	TCD 129	1		27	1B
Internal faults					
Motorization power supply failure	TSS 19	0		87	57
Accessory equipment power supply failure	TSS 20	0		NA	NA
Charger fault	TSS 21	0		85	55
Battery fault	TSS 22	0		86	56
Fault detector link defect	TSS 47	0		NA	NA
Digital inputs					
Digital input 1	TSS 1	0		76	4C
Digital input 2	TSS 2	0		77	4D
Digital input 3	TSS 3	0		84	54
Digital input 4	TSS 4	0		89	59
Digital input 5	TSS 5	0		90	5 A
Digital input 6	TSS 6	0		91	5B
Digital input 7	TSS273	0		108	6C
Digital input 8	TSS274	0		109	6D
Digital input 9	TSS275	0		116	74
Digital input 10	TSS276	0		121	79
Digital input 11	TSS277	0		122	7 A
Digital input 12	TSS278	0		123	7B
Digital input 13	TSS545	0		140	8C
Digital input 14	TSS546	0		141	8D
Digital input 15	TSS547	0		148	94
Digital input 16	TSS548	0		153	99
Digital input 17	TSS549	0		154	9A
Digital input 18	TSS550	0		155	9B
Digital input 19	TSS817	0		172	AC
Digital input 20	TSS818	0		173	AD
Digital input 21	TSS819	0		180	B4
Digital input 22	TSS820	0		185	B9
Digital input 23	TSS821	0		186	BA
Digital input 24	TSS822	0		187	Bb

8.4 Flair 200C

	Type N°interne	Access	Option	AOI (Dec)	AOI (Hex)
Flair200C state					
Fault current indicator reset	TCD17	1		4	4
Missing voltage	TSS17	0		28	1C
Charger fault	TSS21	0		16	10
Battery fault	TSS22	0		17	11
General shutdown	TSS25	0		NA	NA
Battery disconnected	TSS26	0		18	12
Battery low	TSS27	0		NA	NA
Equipment start	TSS31	0		NA	NA
Test communication	TSS32	0		NA	NA
Measure					
Frequency	TM20	0		46	2E
Voltage measure	TM42	0		47	2F
Measure channel 1					
Current P1	TM21	0		40	28
Current P2	TM26	0		41	29
Current P3	TM31	0		42	2A
Io Current	TM36	0		43	2B
Mean phase current	TM41	0		44	2C
Power factor	TM47	0		45	2D
Active power	TM48	0		48	30
Reactive power	TM52	0		49	31
Apparent power	TM56	0		50	32
Active energy	CNT101	0		60	3C
Reactive energy	CNT103	0		NA	NA
Fault channel 1					
Fast earth fault	TSS71	0		27	1B
Earth fault	TSS72	0		26	1A
Fast phase fault	TSS76	0		30	1E
Phase fault	TSS77	0		29	1D
Counter fast earth fault	CNT7	0		NA	NA
Counter earth fault	CNT8	0		NA	NA
Counter fast phase fault	CNT10	0		NA	NA
Counter phase fault	CNT11	0		NA	NA
Measure channel 2					
Current P1	TM71	0		51	33
Current P2	TM76	0		52	34
Current P3	TM81	0		53	35
Io Current	TM86	0		54	36
Mean phase current	TM91	0		55	37
Power factor	TM97	0		56	38
Active power	TM98	0		57	39
Reactive power	TM102	0		58	3A
Apparent power	TM106	0		59	3B
Active energy	CNT102	0		61	3D
Reactive energy	CNT104	0		NA	NA

Fault channel 2					
Fast earth fault	TSS103	0		35	23
Earth fault	TSS104	0		34	22
Fast phase fault	TSS108	0		38	26
Phase fault	TSS109	0		37	25
Counter fast earth fault	CNT12	0		NA	NA
Counter earth fault	CNT13	0		NA	NA
Counter fast phase fault	CNT15	0		NA	NA
Counter phase fault	CNT16	0		NA	NA
Temperature measurement					
Internal temperature	TM10	0		NA	NA
External temperature estimated	TM11	0		39	27
Digital inputs					
Digital input 1	TSS1	0		10	A
Digital input 2	TSS2	0		11	B
Digital input 3	TSS3	0		12	C
Digital input 4	TSS4	0		13	D
Digital input 5	TSS5	0		14	E
Digital input 6	TSS6	0		15	F
Digital inputs counters					
Counter digital input 1	CNT1	0		NA	NA
Counter digital input 2	CNT2	0		NA	NA
Counter digital input 3	CNT3	0		NA	NA
Counter digital input 4	CNT4	0		NA	NA
Counter digital input 5	CNT5	0		NA	NA
Counter digital input 6	CNT6	0		NA	NA
Digital outputs		0			
Digital output 1	TCD1	1		1	1
Digital output 2	TCD2	1		2	2
Digital output 3	TCD3	1		3	3
Digital output 1	TSD1	0		31	1F
Digital output 2	TSD2	0		32	20
Digital output 3	TSD3	0		33	21
Double digital outputs					
Digital output 1-2	TCD4	1		NA	NA
Digital input 1-2	TSD4	0		NA	NA

8.5 T200 S

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Channel 1					
Switch position	TSD 1	0		32	20
Switch locked	TSS 49	0		68	44
Switch command	TCD 1	1		4	04
Operation counter	CNT 1	0		NA	NA
Operation counter preset command	TCD 25	2		NA	NA
Auxiliary DI	TSS 51	0		NA	NA
MV voltage present	TSS 73	0		80	50
Aux. MV voltage present	TSS 54	0		NA	NA
Earth fault	TSS 71	0		61	3D
Phase fault	TSS 77	0		60	3C
Phase current 1	TM 2	0		NA	NA
Phase current 2	TM 3	0		NA	NA
Phase current 3	TM 4	0		NA	NA
Neutral current	TM 5	0		NA	NA
Average current	TM 6	0		192	C0
Channel 2					
Switch position	TSD 2	0		33	21
Switch locked	TSS 81	0		69	45
Switch command	TCD 2	1		5	05
Operation counter	CNT 2	0		NA	NA
Operation counter preset command	TCD 26	2		NA	NA
Auxiliary DI	TSS 83	0		NA	NA
MV voltage present	TSS 105	0		79	4F
Aux. MV voltage present	TSS 86	0		NA	NA
Earth fault	TSS 103	0		62	3E
Phase fault	TSS 109	0		63	3F
Phase current 1	TM 9	0		NA	NA
Phase current 2	TM 10	0		NA	NA
Phase current 3	TM 11	0		NA	NA
Neutral current	TM 12	0		NA	NA
Average current	TM 13	0		193	C1

	Type - Internal No.	Access	Options	AOI (Dec)	AOI (Hex)
Common objects					
Local/Remote position	TSS 23	0		82	52
Door opening	TSS 24	0		78	4E
Fault detection reset command	TCD 17	1		21	15
Immediate AC power supply defect	TSS 17	0		83	53
Time-delayed AC power supply defect	TSS 18	0		88	58
Power cut imminent	TSS 25	0		NA	NA
SNTP synchronized	TSL 79	0		NA	NA
Automatic controls					
Automatic control ON/OFF position	TSD 9	0		35	23
Automatic control ON/OFF command	TCD 9	1		7	07
Automatic control has operated	TSS 57	0		89	59
Internal faults					
Motorization power supply failure	TSS 19	0		87	57
Accessory equipment power supply failure	TSS 20	0		NA	NA
Charger fault	TSS 21	0		85	55
Battery fault	TSS 22	0		86	56
Equipment fault	TSS 29	0		NA	NA
Digital Inputs/Outputs					
Digital input 1	TSS 1	0		76	4C
Digital input 2	TSS 2	0		77	4D
Digital input 3	TSS 3	0		NA	NA
Digital input 4	TSS 4	0		NA	NA
Digital input 5	TSS 5	0		NA	NA
Digital input 6	TSS 6	0		NA	NA
Digital input 7	TSS 7	0		NA	NA
Digital input 8	TSS 8	0		NA	NA
Digital output 2 position	TSD 6	0		NA	NA
Digital output 2 command	TCD 6	1		NA	NA
Digital output 3 position	TSD 7	0		NA	NA
Digital output 3 command	TCD 7	1		NA	NA

8.6 R200-ATS100

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)

8.6.1 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

8.6.2 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

8.6.3 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

8.6.4 Cubicle xxx data

Same principles apply for further cubicles, with same default variables and default external address. From the tables of previous paragraph, 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.

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As standards, specifications and designs change from time to time, please ask for confirmation of the information given in this publication.

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