IEC 60870-5-101
Remote Communication Protocol for REC 501

Technical Description

Contents

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1. Introduction

1.1. This manual

This manual contains technical information about the remote communication protocol IEC 60870-5-101 and about using it with the REC 501 Remote Monitoring and Control Unit (REC 501). This manual is valid for the product REC 501, 1MRS118008, revision B.

1.2. Use of symbols

This publication includes the following icons that point out safety-related conditions or other important information:

The information icon alerts the reader to relevant facts and conditions.

1.3. Abbreviations and terminology

ACD	Access Demand
APCI	Application Protocol Control Information
ASDU	Application Service Data Units
CTS	Clear To Send
DCD	Data Carrier Detected
DCE	Data Circuit terminating Equipment
DFC	Data Flow Control
DTE	Data Terminal Equipment
EPA	Enhanced Performance Architecture
FCB	Frame Count Bit
FCV	Frame Count Bit Valid
IEC	International Electrotechnical Commission
ISO	International Organization for Standardization
LPCI	Link Protocol Control Information
LPDU	Link Protocol Data Unit
LSB	Least Significant Bit (here in the octet)
OSI	Open System Interconnection
MSB	Most Significant Bit (here in the octet)
PRM	Primary Message
RTS	Request To Send
Controlling station	The system receiving data from the controlled outstation.
Controlled outstation	The device providing data, in this case REC 501.

1.4. Related documents

Name of the manual	**MRS number**
REC 501 manuals	
Remote Communication Protocol for REC 501, Technical Reference Manual	1MRS750568-MUM
REC 523 manuals	
Remote Communication Protocol for REC 523, Technical Description	1MRS750956

2. Protocol overview

The companion standard IEC 60870-5-101 is derived from the IEC 60870-5 protocol standard definition. It specifies a functional profile for basic telecontrol tasks.

The IEC 60870-5 protocol stack is based on the reduced reference model called enhanced performance architecture (EPA). This architecture includes three layers of the ISO/OSI model:

- Physical layer
- Link layer
- Application layer

The IEC 60870-5 protocol is described by the following standard documents:

Table 2.-1 Selected standard provision of the defined telecontrol companion standard

Selected application functions of IEC 60870-5-5	User Process
Selected application information elements of IEC 60870-5-4	Application layer (7)
Selected application service data units of IEC 60870-5-3	
Selected link transmission procedures of IEC 60870-5-2	Link layer (2)
Selected transmission frame formats of IEC 60870-5-1	
Selected ITU-T recommendations	Physical layer (1)

Physical layer defines the hardware-dependent specifications of the IEC 60870-5-101 communication interface.

Data link layer defines the frame formats and the transmission procedures of the IEC communication.

Application layer defines the information elements for structuring application data and the communication service functions. The user process describes an assortment of basic application functions.

2.1. Transmission procedures

The companion standard IEC 60870-5-101 allows two alternative transmission procedures, unbalanced and balanced, to be used in the communication between the controlling station (SCADA system) and controlled outstation. REC 501 supports only unbalanced transmission.

2.1.1. Unbalanced transmission

When using unbalanced transmission procedures, the controlling station controls the data traffic by polling the controlled outstations sequentially. In this case, the controlling station initiates all message transfers while the controlled outstations can transmit only in response to the message from the controlling station.

For unbalanced transmission procedure, the supported transmission services initiated by the controlling station are presented below:

Table 2.1.1-1 Supported transmission services

Service	Purpose
SEND/NO REPLY	For global messages and for cyclic set-point commands from the controlling station
SEND/CONFIRM	For control commands and set-point commands from the controlling station
REQUEST/RESPOND	For polling data from the controlled outstations

2.2. Basic application functions

2.2.1. Data acquisition

The data delivered by a controlled outstation can be:

- Process values which are collected cyclically, upon change, or upon request from the controlling station
- Replies to commands

All data is buffered in the controlled outstation, because, in some cases, the data may appear faster than the communication link is able to transfer it to the controlling station.

When unbalanced transmission procedure is used on the link layer, the buffered data must be polled by the controlling station. The controlled outstation must always wait for a request for transmission from the controlling station.

When balanced transmission procedure is used on the link layer, the buffered data is transmitted by the controlled outstation to the controlling station without a delay.

2.2.2. Event acquisition

Events occur spontaneously at the controlled outstation's application level. The events are buffered in the controlled outstation, because, in some cases, the events may appear faster than the communication link is able to transfer them.

When unbalanced transmission procedure is used on the link layer, the buffered events must be polled by the controlling station. The controlled outstation must always wait for a request for transmission from the controlling station.

When balanced transmission procedure is used on the link layer, the buffered events are sequentially, without a delay, transmitted by the controlled outstation to the controlling station.

2.2.3. General interrogation

The controlled outstation's interrogation function is used for updating the controlling station after an internal station initialization procedure, or when the controlling station detects loss of information. When the function is used, the controlling station requests the controlled outstations to transmit the actual values of all their process variables. Normally, the amount of information is known by the application functions in both the controlling stations and controlled outstations.

2.2.4. Clock synchronization

The clock of the controlled outstation has to be synchronized with the clock of the controlling station. This is done to provide a correct chronological sequence of time-tagged events or information objects that are transmitted to the controlling station, or that are logged locally. After system initialization, the clocks are initially synchronized by the controlling station. After this, the clocks are periodically re-synchronized by transmission of a clock synchronization command (C_CS ACT).

The time information must always be corrected either by the controlling station before sending, or by the outstation when an ASDU with time tag is received. A delay acquisition command can be used to define the measured or estimated transmission delay in the outstation. The command corrects the time on the outstation side when sending. Refer to Section 2.2.8. Acquisition of transmission delay.

2.2.5. Command transmission

A command is used in telecontrol systems to change the state of operational equipment, for example, a circuit breaker. Thereby the commands are used to drive a controlled process to an intended direction. The commands may be initiated by an operator or by automatic supervisory procedures in the controlling station. Protection against unauthorized access or against unwanted actions are system- or process-dependent.

The two standard procedures for command transmission are:

- Direct command
- Select and Execute command

Direct commands are used by the controlling station to perform immediate control operations in the controlled outstations. For safety reasons, the controlled outstation's application function checks the permissibility and the validity of the received command message, and executes the operation if the check results are positive.

The two-step command Select and Execute is used by the controlling station in order to:

- Prepare a specified control operation in a controlled outstation
- Check that the correct control operation has been prepared
- Execute the command

The check may be carried out by an operator or by an application procedure. The controlled outstation does not start the control operation until it has received the correct execute indication.

The command transmission is confirmed to the controlled outstation by an activation confirmation response. After the command is executed, an activation termination response can optionally be sent to the controlling station.

2.2.6. Transmission of integrated totals

An integrated total is a value that is integrated over a specified time period. The specific clock times and the periodic time interval of successful acquisitions of the integrated totals are system parameters. The two methods for acquiring counter information are:

- Acquisition of integrated totals
- Acquisition of incremental information

2.2.7. Changes in protocol and link parameters

When the values of the protocol and link parameters are changed, the new values take effect only after they have been stored and the relay has been reset.

2.2.8. Acquisition of transmission delay

The value of time correction is determined by the sum of the transmission delay and the internal equipment delay. The transmission delay is a value which can be acquired either separately by parametrization, or via a dynamic procedure initiated by the controlling station. Refer to `Transmission Delay` parameter.

3. REC 501 profile in IEC 60870-5-101

3.1. Link layer options

The selection of the link layer options is as follows:

- The selected frame format is FT 1.2 (with one exception: single control character is not supported in REC 501).
- The link transmission procedure is unbalanced.
- The link service function 1 (reset of user process) is not supported (the reset operation is supported by the application layer).
- The address field of the link layer can be configured as either one or two octets, unstructured.
- The maximum number of octets in LPDU is 255 including control field, address octet(s) and user data.

3.2. Application layer options

3.2.1. Selection of application layer options

- The Link Protocol Data Unit (LPDU) contains only one Application Service Data Unit (ASDU).
- ASDU is composed of a Data Unit Identifier and one or more Information Objects.
- The field “Length of ASDU” is not used.
- The size of common address of ASDU can be configured as either one or two octets, unstructured.
- The size of information object address is always two octets, unstructured.
- The size of the cause of transmission is one octet (the originator address not included).

3.2.2. ASDU formats

ASDUs can be of different length. The general format contains two parts: Data unit identifier and Information object.

The data unit identifier consists of:

- type identification (the message type) - 1 octet,
- variable structure qualifier - 1 octet,
- cause of transmission - 1 octet,
- common address of ASDU - 1 or 2 octets (depends on the protocol configuration).

The information object consists of:

- information object address - 2 octets,
- data - length depends on the ASDU type.

3.2.3. Standard ASDU types for REC 501

Table 3.2.3-1 Selected process information elements in monitor direction

Type	Information object	Label
1	Single-point information	M_SP_NA_1
2	Single-point information with time tag	M_SP_TA_1
30	Single-point information with full time tag (CP56Time2a)	M_SP_TB_1
3	Double-point information	M_DP_NA_1
4	Double-point information with time tag	M_DP_TA_1
31	Double-point information with full time tag (CP56Time2a)	M_DP_TB_1
11	Measured value, scaled value	M_ME_NB_1
16	Integrated totals with time tag	M_IT_TA_1
37	Integrated totals with full time tag (CP56Time2a)	M_IT_TB_1

***Table 3.2.3-2 Selected process information elements in* control direction**

Type	Information object	Label
45	Single command	C_SC_NA_1
49	Set point command, scale value	C_SE_NB_1

***Table 3.2.3-3 Selected system information elements in* monitor direction**

Type	Information object	Label
70	End of initialization	M_EI_NA_1

***Table 3.2.3-4 Selected system information elements in* control direction**

Type	Information object	Label
100	Interrogation command	C_IC_NA_1
102	Read command	C_RD_NA_1
103	Clock synchronization command	C_CS_NA_1
105	Reset process command	C_RP_NC_1
106	Delay acquisition command	C_CD_NA_1

3.2.4. Private ASDU types for REC501

Private ASDU types defined in the IEC 60870-5-101 protocol for the REC 501 unit are:

- STRING - type of a character string (used e.g. for modem setup)

Table 3.2.4-1 Type identification 128: M_SR_NA_1 - STRING in monitor direction

1	0	0	0	0	0	0	0	TYPE IDENTIFICATION
1	number j of characters							VARIABLE STRUCTURE QUALIFIER
defined in 7.2.3 in [1]								CAUSE OF TRANSMISSION
defined in 7.2.4 in [1]								COMMON ADDRESS OF ASDU
defined in 7.2.5 in [1]								INFORMATION OBJECT ADDRESS
								CHARACTER [0]

CHARACTER [j-1]

CAUSE OF TRANSMISSION:

< 5 > := requested

Table 3.2.4-2 Type identification 131: C_SR_NA_1 - STRING in control direction

1	0	0	0	0	0	1	1	TYPE IDENTIFICATION
1	number j of characters							VARIABLE STRUCTURE QUALIFIER
defined in 7.2.3 in [1]								CAUSE OF TRANSMISSION
defined in 7.2.4 in [1]								COMMON ADDRESS OF ASDU
defined in 7.2.5 in [1]								INFORMATION OBJECT ADDRESS
								CHARACTER [0]

CHARACTER [j-1]

CAUSE OF TRANSMISSION

in control direction:

< 6 > := activation

in monitor direction:

< 7 > := activation confirmation

- SPABUFFER - type of SPA message buffer used in transparent SPA communication over IEC 60870-5-101.

Table 3.2.4-3 Type identification 130: M_SB_NA_1 - SPABUFFER in monitor direction

1	0	0	0	0	0	1	0	TYPE IDENTIFICATION
1	number j of buffer elements							VARIABLE STRUCTURE QUALIFIER
defined in 7.2.3 in [1]								CAUSE OF TRANSMISSION
defined in 7.2.4 in [1]								COMMON ADDRESS OF ASDU
defined in 7.2.5 in [1]								INFORMATION OBJECT ADDRESS
								BUFFER ELEMENT [0]

BUFFER ELEMENT [j-1]

CAUSE OF TRANSMISSION:

< 5 > := requested

Table 3.2.4-4 Type identification 133: C_SB_NA_1 - SPABUFFER in control direction

1	0	0	0	0	1	0	1	TYPE IDENTIFICATION
1	number j of buffer elements							VARIABLE STRUCTURE QUALIFIER
defined in 7.2.3 in [1]								CAUSE OF TRANSMISSION
defined in 7.2.4 in [1]								COMMON ADDRESS OF ASDU
defined in 7.2.5 in [1]								INFORMATION OBJECT ADDRESS
								BUFFER ELEMENT [0]

	BUFFER ELEMENT [j-1]

CAUSE OF TRANSMISSION

in control direction:

< 6 > := activation

in monitor direction:

< 7 > := activation confirmation

INFORMATION OBJECT ADDRESS for C_SB_NA_1

< 58880 > := E600 hex

3.3. Basic application functions supported in REC 501

Remote initialization

Local initialization

Clock synchronization

Command transmission

Data acquisition by polling

Cyclic data transmission

Acquisition of events

General interrogation

Acquisition of transmission delay

4. Protocol Interface Implementation

4.1. Protocol mapping

The application to protocol mapping defines how various events and parameters of REC 501 application are represented in the IEC 60870-5-101 protocol. The mapping specifies which protocol functions, message formats and addresses shall be used to access the data of REC 501. An essential subset of REC 501 events, status indications, measurements and control parameters is mapped into the IEC 60870-5-101 protocol.

In REC 501, the application to protocol mapping is implemented as a non-configurable cross-reference table. Refer to Chapter 6. Appendix B: Protocol address map.

4.2. Addressing scheme

Table 4.2.-1 The protocol addressing scheme applied to REC 501

Data type (address group)	Direction (access)	IEC information object address range (hex)	Format	IEC type identification
Digital data (incl. binary parameters)	Monitor (read)	0002 - 002A	8 bit	M_SP_NA_1 M_SP_TA_1 - for events[1)]
Digital data (2-bit information)	Monitor (read)	1000 - 1001	8 bit	M_DP_NA_1 M_DP_TA_1 - for events[1)]
Analog data, parameter data	Monitor (read)	4400 - 4436	16 bit	M_ME_NB_1 M_ME_TB_1 for events[1)]
Counters	Monitor (read)	5000 - 5097	32 bit	M_IT_TA_1
STRING data	Monitor (read)	E000 - E005	ASCII	M_SR_NA_1
Time	Monitor (read)	E200	Binary time (7 octets)	C_CS_NA_1 with the cause of transmission SPONTANEOUS
Transparent SPA message (last response)	Monitor (read)	E300	ASCII	M_SB_NA_1
Digital data (incl. binary parameters)	Control (write)	8000 - 8015	8 bit	C_SC_NA_1
Analog data, parameter data	control (write)	B400 - B430	16 bit	C_SE_NB_1
STRING data (ASCII texts)	Control (write)	E400 - E402	ASCII	C_SR_NA_1
Time set	Control (write)	0000	Binary time (7 octets)	C_CS_NA_1
Transparent SPA messages (request – response)	Control (write)	E600	ASCII	C_SB_NA_1

[1)] For frames with time tag representing events, there are three configurable alternative options:

- Standard frames with short time tag (3-byte tag CP24Time2a), e.g. M_SP_TA_1
- ABB standard (time context message C_CS_NA_1 as full time tag is sent before the actual data telegram, e.g. M_SP_TA_1
- Standard frames with full time tags (7-byte tag CP56Time2a), e.g. M_SP_TB_1

4.3. Parametrization of IEC 60870-5-101 interface

This section describes the communication parameters required to configure REC 501 to communicate using the IEC 60870-5-101 protocol over a given link.

These parameters can be uploaded, reviewed and modified via the SPA protocol as well as via the IEC 101 protocol.

Before the start-up of the IEC 60870-5-101 communication with REC 501, the link and protocol parameters should be verified. To properly configure the interface of REC 501, it is necessary to know the setup of the controlling station and the characteristics of the utilized communication channel. At the end of the configuration process all updated parameters are stored in the non-volatile memory.

The REC 501 unit must be reset to activate the new parameters.

4.3.1. Port assignment

The IEC 60870-5-101 protocol is assigned to port X2.2.

4.3.2. Link parameters

The link parameters of REC 501 can be accessed using either the SPA or IEC 101 protocol.

Group description	Object name	Description	Notes
Transmission settings	0,V220	Connection mode 0 – fixed line 1 – dial-up	0 - in case of fixed line or leased line connection (with preconfigured modems) 1 – in case of dial-up connection (modem controlled by REC 501)
	0,V211	Communication speed (in bps) Baud rate	The same as configured in the controlling station (fixed line) or in the modem (dial-up).
	0,V230	Parity 0 – no parity 1 – odd parity 2 – even parity (standard)	The same as configured in the controlling station (normally even parity, but with some modems no parity may be used).
	0,V231	Number of data bits	8 is a default value for the IEC protocol as defined by the standard
Timeout settings (frame transmission delays)	0,V215	Next character timeout (in ms): maximum allowed time gap between received characters of the same frame; 0 – not in use.	Not in use in the IEC protocol.
	0,V216	End of frame timeout (in ms): minimum idle time following the frame transmission to REC 501	Must be tuned according to the link characteristics, recommended minimum: longer than the character transmission time. Minimum value 10ms.

Handshaking settings (connection to DCE)	0,V217	CTS usage 0 – not used 1 – in use	In use if required by the DCE (modem in half duplex mode) and supported by the connection cable.
	0,V218	RTS usage 0 – not used 1 – in use	In use if required by the DCE (modem in half duplex mode) and supported by the connection cable.
	0,V213	CTS delay value (in ms)	In REC 501 controlled by hardware, set to 0.
	0,V214	RTS delay value (in ms)	In REC 501 controlled by hardware, set to 0.

Group description	Object name	Description	Notes
Modem settings (only to be used in dial-up connection mode)	0,V221	Modem initialization string (max. 40 characters)	According to the modem type (refer to the modem manual). To achieve better performance of REC 501 – modem communication include E0 (echo off) and V0 (numeric results codes) commands in initialization string.
	0,V222	Modem dialing string (max. 20 characters) Note: This parameter is used only if REC 501 is permitted to activate the dial-up connection with the controlling station.	According to the modem type (refer to the modem manual).
	0,V223	Modem hang-up string (max. 20 characters) Note: This parameter is used in case of enforced interface restart or unknown modem state.	According to the modem type (refer to the modem manual). To achieve better reliability include “~~~+++~~~” sequence at the beginning of modem hangup string.

According to the protocol implementation, the following transmission parameters are required when using fixed line connection:

- 8 data bits
- parity odd, even or none
- 1 stop bits (not configured, determined by REC 501 hardware)
- next character timeout - not active
- end of frame timeout 10 ms
- baud rate in the range supported by the REC 501 link handler

- For communication over leased line, REC 501 should be configured as in the fixed line connection mode. The utilized modem must be set up from the terminal program. For this kind of communication, the end of frame timeout should be adjusted.
- For communication in the dial-up connection mode, the utilized modem is configured by REC 501. The E0 command should be included in the modem initialization string to prevent sending echo of received commands. The modem initialization string must not include any command that establishes connection with the remote modem. Only the dialling string shall be used for this purpose.
- The IEC 60870-5-101 protocol uses even parity for character transmission. In case of specific communication medium requirements, the use of parity bit can be disabled in the REC 501 configuration.

4.3.2.1. Communication in a dial-up environment

When using a modem connection through a public switched network (PSN), string parameters are used. The string parameters include strings for:

- Initialization
- Hang-up
- Dialing

For further information, refer to Section 4.3.2. Link parameters.

A dialing string contains a phone number of the designated controlling station. The REC 501 unit opens the channel only when communication with the designated controlling station is needed, and the channel is closed by the controlling station.

If the phone number REC 501 dials is busy, or if a connection with the controlling station cannot be established, there is a re-dialing algorithm that calls a maximum number of six times.

When dial-up connection is used, the following parameters must be set to configure REC 501 with the IEC protocol:

- `The Connection mode` parameter must be set to dial-up.
- `The Modem init string` parameter must be set to parametrize the modem according to the manual of the used modem.

Each modem operation is started by hanging-up any active connection. This includes also the procedure of establishing the connection between REC 501 and SCADA system. Modem configuration or initialization is done every time the link initialization is performed.

To be able to connect to the primary station, at least Modem dial string must be set to dial the controlling station's number. Note that the string must include an ATD prefix.

The communication channel is opened only after a request from the protocol software. The algorithm of this operation assumes a predefined number of 6 attempts. The attempts are done with random and increasing intervals between consecutive tries (intervals are given in Fig. 4.3.2.1.-1).

After all re-dialing attempts have been made, REC 501 initializes the link, hangs up the connection, and waits for the controlling station to connect. The detailed behavior of the dialing algorithm is shown in the following figure.

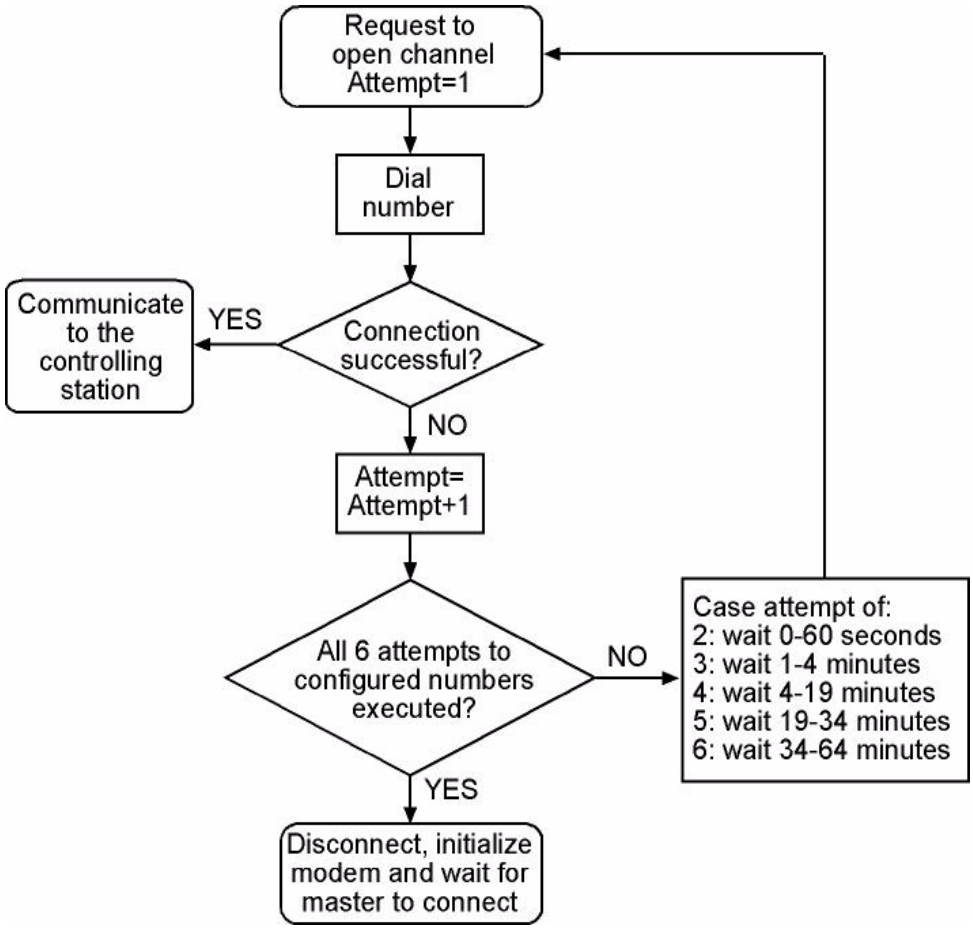

Fig. 4.3.2.1.-1 Behavior of the dialing algorithm

When the controlling station dials the number of the REC 501 unit and successfully connects between the dialing attempts, the situation is treated in the same way as if REC 501 would successfully connect.

REC 501 is responsible for closing the communication channel when there is no communication with the controlling station for a predefined time (no valid frame is received, including also the frames addressed to other units). A watchdog function supervising the incoming valid frames is added to the protocol software. The watchdog time-out is defined by a configurable parameter Watchdog TO in the protocol parameter group.

4.3.3. Broadcast response mode

REC 501 can respond to broadcast messages from the controlling station in the context of dial-up connection established by a call from REC 501.

During a dial-up call from REC 501 to the controlling station, the controlling station may send a broadcast request on which it expects an answer (i.e. a method of detecting which slave unit has called). REC 501 responds to the broadcast request. This is a special function - enabled by the parameter V253, which is accessible via SPA and IEC101. The function is active only in dial-up mode and when the V253 parameter is set to 1.

The broadcast response function in detail:

1. REC 501 starts establishing a dial-up connection to the controlling station.
2. The controlling station accepts the incoming call.
3. The controlling station sends a 'Request for access demand' <8> frame with link layer broadcast address. REC 501 responds with 'Status of link' <11>.

REC 501 does not respond to a broadcast message in the following cases:

- Dial-up connection from the controlling station to REC 501
- Fixed serial connection

4.3.4. Protocol parameters

The IEC 60870-5-101 protocol parameters can be accessed via the SPA and IEC 101 protocol.

For a consistent setup, the protocol parameters can be analysed in five groups:

- address parameters
- timeout and delay parameters
- time stamp option
- temperature and battery voltage threshold parameters
- broadcast response modes

Group description	Object name	Description	Recommendation
Address parameters	0,V244	Size of the link layer address (in bytes): 1 or 2 bytes	The same as configured in the controlling station. Default value is 2.
	0,V245	Link layer address Range: 0 ... 65534 – depends on the size of the link layer address	The same as configured in the controlling station. Default value is 10.
	0,V246	Size of common address of ASDU (in bytes): 1 or 2 bytes	The same as configured in the controlling station. Default value is 2.

	0,V247	Common address of ASDU Range: 0 ... 65534 – depends on the size of the common address of ASDU	The same as configured in the controlling station. Default value is 10.
Timeout and delay parameters	0,V249	Master idle timeout (in s) Used only in dial-up connection mode; in case the primary (controlling) station does not request data and there is pending information buffered for a given time, the secondary (controlled) station establishes the communication with the primary station. Set to 0 if not used. Range: 0 … 65535 s	System specific parameter, depends on data acquisition strategy of the primary (controlling) station. To achieve fast notification of events, this value should be set to 1 (the possible shortest timeout). Default value is 60s.
	0, V248	Internal cycle of checking for analog data changes (in 100 ms units) Set to 0 disable cycling checking of analog values. Range: 0 … 65535 x 100 ms	Default value is 2 (200 ms).
	0,V250	Initial transmission delay (in ms) Initial value used in the clock synchronization procedure for compensation before the actual delay is measured. Range: 0 … 65535 ms	Can be set based on the known channel characteristics. Default value is 200ms.
	0,V252	Intermediate state event suppression delay. The time (in seconds) that the device waits before report change of switch position from open/close to faulty/ middle state. Range: 0 … 60 s	Can be set based on the known circuit breakers hardware characteristics. Default value is 5s.
Time stamp option	0,V251	Time stamp option: 0 – standard frames with short time stamp 1 – ABB standard (time context message C_CS_NA sent before the standard time-tagged message) 2 – standard frames with full time stamp CP56Time2a	As required by the controlling station: - option 0 follows the standard format with time within an hour, - options 1 and 2 provide an unambiguous full time value. Default value is 0.

Temperature and battery voltage threshold parameters	0,V237	Temperature delta (in deg C) Delta for supervision and reporting of enclosure temperature value Set to 0 disable delta supervision – temperature reporting is based only on internal cycle of checking for analog data changes (parameters 0,V248). Range: 0 … 100 deg C	Default value is 1 deg C
	0,V238	Battery voltage delta (in 0,1 V) Delta for supervision and reporting of battery charging voltage Set to 0 disable delta supervision – battery charging voltage reporting is based only on internal cycle of checking for analog data changes (parameters 0,V248). Range: 0 … 100 (0 … 10V)	Default value is 10 (1V)
Broadcast response mode	0,V253	IEC 101 address: 0x810 (Read) / 0x8810 (Write) SPA name: F000V253	Default value is 0.

4.4. Example configuration

This chapter provides an example how to set different communication parameters to configure the REC 501 unit for IEC 60870-5-101 communication over a fixed line.

This configuration requires the following setup (the SPA addresses of parameters are given for the configuration tool using the SPA bus protocol):

V211 = 9.6 Setting of the communication speed to 9600 bps.
V213 = 0 Setting of the CTS delay value to 0.
V214 = 0 Setting of the RTS delay value to 0.
V215 = 0 Setting of the next character timeout to 0 (NOT USED).
V216 = 10 Setting of the end of frame timeout to 10 ms.
V217 = 0 Setting CTS usage to NOT USED.
V218 = 0 Setting RTS usage to NOT USED.
V220 = 0 Setting connection mode to 0 (fixed line).
V230 = 2 Setting of the parity to even.
V231 = 8 Setting of the number of data bits to 8.

V237 = 10 Setting of the temperature delta to 1°C
V238 = 10 Setting of the battery voltage delta to 1V
V244 = 1 Setting of the size of the link address to 1 octet.
V245 = 10 Setting of the link address to 10.
V246 = 2 Setting of the size of the common address of ASDU to 2.
V247 = 10 Setting of the common address of ASDU to 10.

V248 = 2	Setting of the internal checking cycle to 200 ms.
V249 = 60	Setting of the master idle timeout to 60 s.
V250 = 200	Setting of the default transmission delay to 200 ms.
V251 = 0	Setting of the time stamp option to 0 (standard time stamp).
V252 = 5	Intermediate state event suppression delay to 5s.
V253 = 0	No broadcast response in use.

All parameters can be modified as described in REC 501 Technical Description.

5. Appendix A: Profile Checklist

IEC 60870-5-101

Device Profile Document

Vendor Name: ABB Oy, Distribution Automation

Device Name: REC 501, 1MRS110008B

This section presents the sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems.

Certain parameter values, such as the number of octets in the common address of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications.

This clause summarizes the parameters of the previous clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment from different manufacturers, it is necessary that all partners agree on the selected parameters.

Table 5.-1 Symbol explanations

Symbol	Explanation
■	Supported options
□	Unsupported options

In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

5.1. Interoperability

This companion standard presents sets of parameters and alternatives from which subsets have to be selected to implement particular telecontrol systems. Certain parameter values, such as the number of octets in the COMMON ADDRESS of ASDUs represent mutually exclusive alternatives. This means that only one value of the defined parameters is admitted per system. Other parameters, such as the listed set of different process information in command and in monitor direction allow the specification of the complete set or subsets, as appropriate for given applications. This Clause summarizes the parameters of the previous Clauses to facilitate a suitable selection for a specific application. If a system is composed of equipment from different manufacturers, it is necessary that all partners agree on the selected parameters.

The selected parameters should be marked in the white boxes as follows:

☐ Function or ASDU is not used

☒ Function or ASDU is used as standardized (default)

R Function or ASDU is used in reverse mode

B Function or ASDU is used in standard and reverse mode

The possible selection (blank, X, R, or B) is specified for each specific Clause or parameter.

In addition, the full specification of a system may require individual selection of certain parameters for certain parts of the system, such as the individual selection of scaling factors for individually addressable measured values.

5.2. System or device

☐ System definition

☐ Controlling station definition (Master)

■ Controlled station definition (Slave)

5.3. Network configuration

(network-specific parameter)

■ Point-to-point

☐ Multiple point to point

■ Multi-point-party line

☐ Multi-point-star

5.4. Physical layer

(network-specific parameter)

Transmission speed (control direction)

Unbalanced interchange circuit V.24/V.28 Standard	Unbalanced interchange circuit V.24/V.28 Recommended if > 1200 bit/s	Balanced interchange circuit X.24/X.27
☐ 100 bit/s	☐ 400 bit/s	☐ 2400 bit/s
☐ 200 bit/s	■ 4800 bit/s	☐ 4800 bit/s
■ 300 bit/s	■ 9600 bit/s	☐ 9600 bit/s
■ 600 bit/s	☐ 19200 bit/s	☐ 19200 bit/s
■ 1200 bit/s	■ 14400 bit/s[1)]	☐ 38400 bit/s

☐ 56000 bit/s

☐ 64000 bit/s

Transmission speed (monitor direction)

Unbalanced interchange circuit V.24/V.28 Standard		Unbalanced interchange circuit V.24/V.28 Recommended if > 1200 bit/s		Balanced interchange circuit X.24/X.27	
☐	100 bit/s	☐	2400 bit/s	☐	2400 bit/s
☐	200 bit/s	■	4800 bit/s	☐	4800 bit/s
■	300 bit/s	■	9600 bit/s	☐	9600 bit/s
■	600 bit/s	☐	19200 bit/s	☐	19200 bit/s
■	1200 bit/s	■	14400 bit/s[1)]	☐	38400 bit/s
				☐	56000 bit/s
				☐	64000 bit/s

[1)] Non-standard value supported

5.5. Link layer

Frame format FT 1.2, 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 (number of octets)

255 Maximum length L – control direction

255 Maximum length L – monitor direction

Number of repetitions (configurable from 0 to 100, default 5)

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

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

Type identification	Cause of transmission
Cycling data transmission	<5 >[1)]

[1)] Used for delta supervision of temperature and battery voltage. Assigned to class 2 because of belonging to device condition monitoring, not to process data.

In response to a class 2 poll, REC 501 as a controlled station does not respond with class 1 data when there is no class 2 data available. Class 1 poll must be used to receive class 1 data.

5.6. Application layer

Due to performance reasons, the maximum number of information objects transmitted in one ASDU is limited to 20.

Transmission mode for application data

Mode 1 (Least significant octet first), as defined in clause 4.10 of IEC 60870-5-4, 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)

Selection of standard ASDUs

Process information in monitor direction

(station-specific parameter)

■	<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_TA_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 bit	M_BO_NA_1
☐	<8>	:= Bitstring of 32 bit with time tag	M_BO_TA_1
☐	<9>	:= Measured value, normalised value	M_ME_NA_1
☐	<10>	:= Measured value, normalised 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_TA1
☐	<18>	:= Packed start events of protection equipment with time tag	M_EP_TB1
☐	<19>	:= Packed output circuit information of protection equipment with time tag	M_EP_TC_1
☐	<20>	:= Packed single point information with time tag	M_PS_NA_1
☐	<21>	:= Measured value, normalised 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 bit with time tag CP56Time2a	M_BO_TB_1
☐	<34>	:= Measured value, normalised value with time tag CP56Time2a	M_ME_TD_1

☐	<35>	:= Measured value, scaled value with time tag CP56Time2a	M_ME_TE_1
☐	<35>	:= 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 inform. of protection equip. with time tag CP56Time2a	M_EP_TF_1
■	<128>	:= STRING in monitor direction	M_SR_NA_1

Process information in control direction

(station-specific parameter)

■	<45>	:= Single command	C_SC_NA_1
☐	<46>	:= Double command	C_DC_NA_1
☐	<47>	:= Regulating 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 bit	C_BO_NA_1
■	<131>	:= STRING in control direction	C_SR_NA_1
☐	<133>	:= SPABUFFER in control direction[1)]	C_SB_NA_1

1) REC501 does not support SPA Transaction ID

System information in monitor direction

(station-specific parameter)

■	<70>	:= End of initialization	M_EI_NA_1

System information in control direction

(station-specific parameter)

■	<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_NB_1
■	<105> := Reset process command	C_RP_NC_1
■	<106> := Delay acquisition command	C_CD_NA_1

Parameter in control direction

(station-specific parameter)

☐	<110> := Parameter of measured value, normalised 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)

☐	<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

Type identification and cause of transmission assignments

(station-specific parameters)

Table 5.6.-1 Explanations to type identification and cause of transmission assignments table

Table cell	Explanation
	Not required
(blank)	Function or ASDU is not used
■	Mark type identification/cause of transmission combinations

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					■									■					
<2>	M_SP_TA_1			■																
<3>	M_DP_NA_1					■									■					
<4>	M_DP_TA_1			■																
<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																			
<10>	M_ME_TA_1																			
<11>	M_ME_NB_1			■		■														
<12>	M_ME_TB_1																			
<13>	M_ME_NC_1																			
<14>	M_ME_TC_1																			
<15>	M_IT_NA_1																			
<16>	M_IT_TA_1					■[1)]														
<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			■																
<31>	M_DP_TB_1			■																
<32>	M_ST_TB_1																			
<33>	M_BO_TB_1																			
<34>	M_ME_TD_1																			
<35>	M_ME_TE_1																			
<36>	M_ME_TF_1																			
<37>	M_IT_TB_1			■																
<38>	M_EP_TD_1																			
<39>	M_EP_TE_1																			
<40>	M_EP_TF_1																			
<45>	C_SC_NA_1						■	■	■	■	■									■
<46>	C_DC_NA_1																			
<47>	C_RC_NA_1																			
<48>	C_SE_NA_1																			
<49>	C_SE_NB_1						■	■												■

<50>	C_SE_NC_1																		
<51>	C_BO_NA_1																		
<70>	M_EI_NA_1				■														
<100>	C_IC_NA_1						■	■											
<101>	C_CI_NA_1																		
<102>	C_RD_NA_1					■													■
<103>	C_CS_NA_1			■			■	■											
<104>	C_TS_NA_1																		
<105>	C_RP_NA_1						■												
<106>	C_CD_NA_1						■	■											
<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*																		
<128>	M_SR_NA_1					■													
<131>	C_SR_NA_1						■	■											
<133>	C_SB_NA_1						■	■											

[1] Pulse counters in REC 501 are available only for reading on request. The implementation extends the standard by using cause of transmission <5> (request/requested)

5.7. Basic application functions

Station initialisation

(station-specific parameter)

■ Remote initialisation

Cyclic data transmission

(station-specific parameter)

■ Cyclic data transmission

Read procedure

(station-specific parameter)

■ Read procedure

Spontaneous transmission

(station-specific parameter)

■ Spontaneous transmission

Double transmission of information objects with cause of transmission spontaneous

(station-specific parameter, mark each information type 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 an 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
☐ Bitstring of 32 bit M_BO_NA_1, M_BO_TA_1 and M_BO_TB_1
☐ 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

(system- or station-specific parameter)

■ 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 global interrogation group are marked in the application mapping document.

Clock synchronization

(station-specific parameter)

- [x] Clock synchronization
- [ ] Day of week used
- [ ] RES1, GEN (time tag substituted/ not substituted) used
- [ ] SU-bit (summertime) used

Command transmission

(object-specific parameter)

- [x] Direct command transmission
- [x] Direct set point command transmission
- [x] No additional definition
- [x] Select and execute command
- [ ] Select and execute set point command
- [ ] C_SE ACTTERM used
- [ ] Short pulse duration (duration determined by a system parameter in the outstation)
- [ ] Long pulse duration (duration determined by a system parameter in the outstation)
- [ ] Persistent output

Transmission of integrated totals

(station- or object-specific parameter)

None of the defined modes used: local freeze with counter request

- [ ] Mode D: freeze by counter-interrogation command, frozen values reported spontaneously
- [ ] Mode A: local freeze with spontaneous transmission
- [ ] Mode B: local freeze with counter interrogation
- [ ] Mode C: freeze and transmit by counter interrogation commands

- [ ] Counter request
- [ ] 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

Addresses per group have to be defined

Parameter loading

(object-specific parameter)

- ■ Threshold value[1)]
- ☐ Smoothing factor
- ☐ Low limit for transmission of measured value
- ☐ High limit for transmission of measured value

[1)] Used for battery voltage delta setting and temperature delta setting.

Parameter activation

(object-specific parameter)

- ■ Act/deact of persistent cyclic or periodic transmission of the addressed object[1)]

[1)] Delta supervision of battery voltage and temperature can be deactivated by setting cycle parameter to value 0.

Test procedure

(station-specific parameter)

- ☐ Test procedure

File transfer

(station-specific parameter)

- ☐ File transfer in monitor direction
- ☐ File transfer in control direction

File transfer

File transfer in monitor direction

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

File transfer in control direction

☐ Transparent file

Background scan

☐ Background scan

Acquisition of transmission delay

■ Acquisition of transmission delay

6. Appendix B: Protocol address map

6.1. Addresses of digital data and binary parameters

IEC types:

- in monitor direction (read by controlling station) M_SP_NA_1
- in control direction (written by controlling station) C_SC_NA_1

Table 6.1.-1 Addresses of digital data and binary parameters (single point)

Data item	Corresp. SPA channel, param.	Event code	IEC address (hex) write/read	Data size (octets)	Values
Input I1 X2(1/2) status	0, I4	E1, E2	-/0002	1	0 = not active 1 = active
Input I2 X2(3/2) status	0, I5	E3, E4	-/0003	1	0 = not active 1 = active
Input I3 X2(4/5) status	0, I6	E5, E6	-/0004	1	0 = not active 1 = active
Input I4 X2(6/5) status	0, I7	E7, E8	-/0005	1	0 = not active 1 = active
Input I5 X2(7/8) status	0, I8	E9, E10	-/0006	1	0 = not active 1 = active
Power supply temperature	0, I9	E13, E14	-/0007	1	0 = normal 1 = overheated
Auxiliary supply connection state	0, I10	E15, E16	-/0008	1	0 = connected 1 = disconnected
Battery voltage level	0, I11	E11, E12	-/0009	1	0 = OK 1 = low
Hardware output 1 status	0, O1	E30, E31	-/000A	1	0 = not active 1 = active
Hardware output 2 status	0, O2	E32, E33	-/000B	1	0 = not active 1 = active
Hardware output 3 status	0, O3	E34, E35	-/000C	1	0 = not active 1 = active
Hardware output 4 status	0, O4	E36, E37	-/000D	1	0 = not active 1 = active
Blocking status of object #1			-/000E	1	0 = normal 1 = blocked
Blocking status of object #2			-/000F	1	0 = normal 1 = blocked
Heating	0, I12		-/0010	1	0 = not active 1 = active
Forced output 1	0, O11		8000/0011	1	0 = not active 1 = active
Forced output 2	0, O12		8001/0012	1	0 = not active 1 = active
Forced output 3	0, O13		8002/0013	1	0 = not active 1 = active
Forced output 4	0, O14		8003/0014	1	0 = not active 1 = active

Table 6.1.-1 Addresses of digital data and binary parameters (single point) (Continued)

Enable forced outputs (enable output relay test)	0, O21		8004/0015	1	0 = disabled 1 = enabled
Cumulative or wrap-around pulse counting for counter in channel #1	1, S12		8005/0016	1	0 = wrap-around 1 = cumulative
Cumulative or wrap-around pulse counting for counter in channel #2	2, S12		8006/0017	1	0 = wrap-around 1 = cumulative
IRF blocking	0, V165		8007/0018	1	0 = normal 1 = blocked
Select/Execute/Cancel command for object #1 (two step operation)	1, V1 select open 1, V2 select close 1, V3 execute 1, V4 cancel		800C/-	1	OFF ACTIVATION SELECT = select for open command ON ACTIVATION SELECT = select for close command OFF ACTIVATION EXECUTE = execute of open command ON ACTIVATION EXECUTE = execute of close command DEACTIVATION = CANCEL
Select/Execute/Cancel command for object #2 (two step operation)	2, V1 select open 2, V2 select close 2, V3 execute 2, V4 cancel		800D/-	1	OFF ACTIVATION SELECT = select for open command ON ACTIVATION SELECT = select for close command OFF ACTIVATION EXECUTE = execute of open command ON ACTIVATION EXECUTE = execute of close command DEACTIVATION = CANCEL
Open selected for object #1	1, V1		-/001D	1	0 = not selected 1 = selected
Open selected for object #2	2, V1		-/001E	1	0 = not selected 1 = selected
Close selected for object #1	1, V2		-/001F	1	0 = not selected 1 = selected
Close selected for object #2	2, V2		-/0020	1	0 = not selected 1 = selected
Event E44 (open command executed on object #1)	1, E44		-/0021	1	0 = not active 1 = active
Event E44 (open command executed on object #2)	2, E44		-/0022	1	0 = not active 1 = active

Table 6.1.-1 Addresses of digital data and binary parameters (single point) (Continued)

Event E45 (close command executed on object #1)	1, E45		-/0023	1	0 = not active 1 = active
Event E45 (close command executed on object #2)	2, E45		-/0024	1	0 = not active 1 = active
Event E51 (overflow of event buffer)	0, E51	E51	-/0025	1	0 = not active 1 = active
Event E17 (intermediate counter 1, value received)	0, E17	E17	-/0026	1	0 = not active 1 = active
Event E18 (intermediate counter 2, value received)	0, E18	E18	-/0027	1	0 = not active 1 = active
Event E19 (period counter 1, value received)	0, E19	E19	-/0028	1	0 = not active 1 = active
Event E20 (period counter 2, value received)	0, E20	E20	-/0029	1	0 = not active 1 = active
Event E50 (restart of microcontroller)	0, E50	E50	-/002A	1	0 = not active 1 = active
Reset period counter buffer of channel #1	1, V9		800E/-	1	1 = reset
Reset period counter buffer of channel #2	2, V9		800F/-	1	1 = reset
Activate battery test	0, V8		8010/-	1	1 = activate
Clear event buffer	0, C		8011/-	1	1 = clear
Clear data class 1 buffer			8012/-	1	1 = clear
Clear data class 2 buffer			8013/-	1	1 = clear
Event acquisition enabled			8014/-	1	0 = not active 1 = active (default after initialization)
Acquisition of selected analog data enabled (with dead band control determined by delta parameters) - used for supervision of temperature inside of the enclosure and battery charging voltage			8015/-	1	0 = not active 1 = active (default after initialization)

IEC types:

- in monitor direction (read by controlling station) M_DP_NA_1

Table 6.1.-2 Addresses of digital data and binary parameters (double point)

Data item	Corresp. SPA channel, param.	IEC address (hex)	Data size (octets)	Values
Object #1 status	1, I3	-/1000	1	0 = indeterminate or intermediate state 1 = open 2 = close 3 = indeterminate state
Object #2 status	2, I3	-/1001	1	0 = indeterminate or intermediate state 1 = open 2 = close 3 = indeterminate state

6.2. Addresses of analog data

IEC types:

- in monitor direction (read by controlling station) M_ME_NB_1

Table 6.2.-1 Addresses of analog data

Data item	Corresp. SPA channel, param.	IEC address (hex) write/ read	Data size (octets)	Values
Temperature inside of the enclosure	0, I1	-/4400	2	-40...+70 (-40...+70 °C)
Battery charging voltage	0, I2	-/4401	2	180...330 (18.0...33.0 V DC)

6.3. Addresses of device parameters and packed digital data

IEC types:

- in monitor direction (read by controlling station) M_ME_NB_1
- in control direction (written by controlling station) C_SE_NB_1

Table 6.3.-1 Addresses of device parameters and packed digital data

Data item	Corresp. SPA channel, param.	IEC address (hex) write/ read	Data size (octets)	Values
Fault code	0, V169	-/4402	2	0...255
Module status	0, C	-/4403	2	0...3
Minimum battery voltage	0, V6	-/4404	2	180...330 (18.0...33.0 V)
Input state (combined 5 inputs)		-/4405	2	0...31
Open pulse length for object #1	1, S1	B400/4406	2	5...10000 (0.05...100.0 s)
Open pulse length for object #2	2, S1	B401/4407	2	5...10000 (0.05...100.0 s)
Close pulse length for object #1	1, S2	B402/4408	2	5...10000 (0.05...100.0 s)
Close pulse length for object #2	2, S2	B403/4409	2	5...10000 (0.05...100.0 s)
Heat limit	0, S3	B404/-	2	-25...+15 (-25...+15 °C)
Switchgroup SGF1	0, S4	B405/440B	1	0...255
Switchgroup SGF2	0, S5	B406/440C	1	0...255
Switchgroup SGF3	0, S6	B407/440D	1	0...255
Switchgroup SGF4	0, S7	B408/440E	1	0...255
Switchgroup SGF5	0, S8	B409/440F	1	0...255
Switchgroup SGF6	0, S9	B40A/4410	1	0...255
Intermediate counter cycle for channel #1	1, S10	B40B/4411	2	10...600 (1...60 min)
Intermediate counter cycle for channel #2	2, S10	B40C/4412	2	10...600 (1...60 min)
Period counter cycle for channel #1	1, S11	B40D/4413	2	300...600 (30...60 min)
Period counter cycle for channel #2	2, S11	B40E/4414	2	300...600 (30...60 min)
Event mask for inputs	0, V155	B412/4418	2	0...255 (1 = enable, 0 = disable) bits from lsb: E1 - E8
Event mask for inputs	0, V156	B413/4419	1	0...255 (1 = enable, 0 = disable) bits from lsb: E9 - E16
Event mask for counters	0, V157	B414/441A	1	0...15 (1 = enable, 0 = disable) bits from lsb: E17 - E20
Event mask for outputs	0, V158	B415/441B	1	0...255 (1 = enable, 0 = disable) bits from lsb: E30 - E37

Table 6.3.-1 Addresses of device parameters and packed digital data (Continued)

Event mask for open/close of object #1	1, V159	B416/441C	1	0...63 (1 = enable, 0 = disable) bits from lsb: E40 - E45 (channel #1)
Event mask for open/close of object #2	2, V159	B417/441D	1	0...63 (1 = enable, 0 = disable) bits from lsb: E40 - E45 (channel #2)
Delta for supervision and reporting of enclosure temperature value	0, V237	B418/441E	1	0...100 (0...100 °C) 0 = cyclic reporting
Delta for supervision and reporting of battery charging voltage	0, V238	B419/441F	1	0...100 (0.0...10.0 Vdc) 0 = cyclic reporting
Object #1 control counter	1, V5	B42E/4435	2	0...10000
Object #2 control counter	1, V5	B42F/4436	2	0...10000
Reset minimum battery voltage	0, V7	B430/-	2	1 = reset

6.4. Addresses of counters

IEC types:

- in monitor direction (read by controlling station) M_IT_TA_1 (standard format).

Configurable alternative options:

- C_CS_NA_1 + M_IT_TA_1 (ABB format)
- M_IT_TB_1 (with time tag CP56Time2a)

Table 6.4.-1 Addresses of counters

Data item	Corresp. SPA channel, param.	IEC address (hex) write/ read	Data size (octets)	Values sent always with timestamp
Intermediate counter channel #1	1, V11	-/5000	4	0...999999[1)]
Intermediate counter channel #2	2, V11	-/5001	4	0...999999[1)]
Period counter 1 channel #1	1, V20, V21	-/5002	4	0...999999
Period counter 1 channel #2	2, V20, V21	-/5003	4	0...999999
Period counter 2 channel #1	1, V22, V23	-/5004	4	0...999999
Period counter 2 channel #2	2, V22, V23	-/5005	4	0...999999
Period counter 3 channel #1	1, V24, V25	-/5006	4	0...999999
Period counter 3 channel #2	2, V24, V25	-/5007	4	0...999999
Period counter **n** channel #1	1, V20+2n-2, V20+2n-1	-/5000+ 2**n**	4	0...999999
Period counter **n** channel #2	2, V20+2n-2, V20+2n-1	-/5000+ 2**n**+1	4	0...999999
Period counter 60 channel #1	1, V138, V139	-/5078	4	0...999999
Period counter 60 channel #2	2, V138, V139	-/5079	4	0...999999

[1)] Time stamp contains the time of reading intermediate counter.

6.5. Addresses of STRING data

IEC types:

- in monitor direction (read by controlling station) M_SR_NA_1
- in control direction (write by controlling station) C_SR_NB_1

Table 6.5.-1 Addresses of string data

Parameter	Corresp. SPA channel, param.	IEC **) address (hex) write/read	Data size (octets)
Software version	0, V205	-/E000	30
Modem program version	0, V206	-/E001	7
Device type	0, F	-/E002	8
Comm. link: Initialization string (for dial-up modem)	0, V221	E400/E003	40
Comm. link: Dialing string (for dial-up modem)	0, V222	E401/E004	20
Comm. link: Hang up string (for dial-up modem)	0, V223	E402/E005	20

6.6. Addresses of event data

The following tables show the relation between REC 501 events and IEC information objects. REC 501 events are represented as digital data with time stamp. Input events, output events and open/close events are reported as changed values of corresponding objects. System events are assigned own IEC information object addresses.

IEC types (single point):

- in monitor direction (reported by controlled station) M_SP_TA_1 (standard format)

Configurable alternative options:

- C_CS_NA_1 + M_SP_TA_1 (ABB format)
- M_SP_TB_1 (with time tag CP56Time2a)

IEC types (double point):

- in monitor direction (reported by controlled station) M_DP_TA_1 (standard format)

Configurable alternative options:

- C_CS_NA_1 + M_DP_TA_1 (ABB format)
- M_DP_TB_1 (with time tag CP56Time2a)

6.6.1. Input events

Table 6.6.1-1 Input events

Event	IEC object address associated with event (hex)
Input I1 activated	0002
Input I1 deactivated	0002
Input I2 activated	0003
Input I2 deactivated	0003
Input I3 activated	0004
Input I3 deactivated	0004
Input I4 activated	0005
Input I4 deactivated	0005
Input I5 activated	0006
Input I5 deactivated	0006
Battery voltage low	0009
Battery voltage normal	0009
Power supply overheated	0007
Power supply temperature normal	0007
Auxiliary supply disconnected	0008
Auxiliary supply reconnected	0008
Intermediate counter 1, value received	0026
Intermediate counter 2, value received	0027
Period counter 1, value received	0028
Period counter 2, value received	0029

6.6.2. Output events

Table 6.6.2-1 Output events

Event	IEC object address associated with event (hex)
Output O1 activated	000A (value 1)
Output O1 deactivated	000A (value 0)
Output O2 activated	000B (value 1)
Output O2 deactivated	000B (value 0)
Output O3 activated	000C (value 1)
Output O3 deactivated	000C (value 0)
Output O4 activated	000D (value 1)
Output O4 deactivated	000D (value 0)

6.6.3. Open/close events

Table 6.6.3-1 Output events

Event	Corresp. SPA channel, event code	IEC object address associated with event (hex)

Table 6.6.3-1 Output events

Change in status: xx → 10 (open)[1)]	1..2, E40	1000, 1001
Change in status: xx → 01 (close)[1)]	1..2, E41	1000, 1001
Change in status: xx → 11 (undefined)[1)]	1..2, E42	1000, 1001
Change in status: xx → 00 (undefined)[1)]	1..2, E43	1000, 1001
Open command executed		0021, 0022
Close command executed		0023, 0024

1) Double point information

6.6.4. General events

Table 6.6.4-1 General events

Event	Corresp. SPA channel, event code	IEC object address associated with event (hex)
Restart of microcontroller	0, E50	(end of initialisation)
Overflow of event buffer	0, E51	0025

6.7. Addresses of monitored analog data with delta supervision

The following data items are cyclically supervised by the protocol interface software, compared against configured delta parameters (IEC addresses: B418/441E and B419/441F) and transmitted when changed as data class 2 using M_ME_NB ASDU with cause of transmission spontaneous. Remember that setting delta parameter to 0 value enables cyclic reporting of the supervised analog data.

Table 6.7.-1 Addresses of cyclically monitored analog data

Data item	Corresp. SPA channel, param.	IEC address (hex)	Data size (octets)	Values
Temperature inside of the enclosure	0, I1	-/4400	2	-40...+70 (-40...+70 °C)
Battery charging voltage	0, I2	-/4401	2	180...330 (18.0...33.0 Vdc)

6.8. Addresses of time

Table 6.8.-1 Addresses of time

Data item	Corresp. SPA channel, param.	IEC address (hex) write/read	Data size (octets)	Values [1)]
Date and time	0, D	0000/ E200	7	YY-MM-DD HH.MM;SS.ms

1) Format of the value: octet 1, 2 = milliseconds (0...59999)
octet 3 = minutes (0...59)
octet 4 = hours (0...23)
octet 5 = day of month (10...31)
octet 6 = months (1...12)
octet 7 = year (0...99)

6.9. Addresses of transparent SPA messages

Table 6.9.-1 Addresses of SPA messages

Data item	Corresp. SPA channel, param.	IEC address (hex)	Max. length of entry
Transparent SPA buffer in (for request)		E600 (write)	80 characters
Transparent SPA buffer out (for response)		E300 (read)	127 characters

The SPA command should be encoded by the controlling station using the shortened format:

<Slave address><Command>[<Channel>[/<Channel>]]<Data category>[<Data number>[/<Data number>]]:[<Data value>:]<CR> e.g.

1RF:<*CR*>

1R1S1:<*CR*>

1WV167:2:<*CR*>

1R1O2:<*CR*>

The data value is used for write messages (W). The data value is not used for read messages (R).

The SPA response is returned by the slave station in full format. In the returned response a complete SPA response message is included (i.e. with start character **<**, checksum and line feed character):

<*LF*>**<901:REC 501:00**<*CR*><*LF*>

<*LF*>**<901:D50:45**<*CR*><*LF*>

<*LF*>**<901A:7F**<*CR*><*LF*>

The start character and the checksum are omitted.

6.10. Addresses of communication parameters

IEC types:

- in monitor direction (read by controlling station) M_SP_NA_1
- in control direction (write by controlling station) C_SC_NA_1

Table 6.10.-1 Addresses of binary communication parameters

Data item	Corresp. SPA channel, param.	IEC address (hex) write/ read	Data size (octets)	Values
Comm. link: RTS usage	0, V218	8008/0019	1	0 = not active 1 = active
Comm. link: Connection mode	0, V220	8009/001A	1	0 = fixed line 1 = modem
Comm. link: CTS usage	0, V217	800A/001B	1	0 = not active 1 = active
Broadcast response mode	0, V253	0x810 (Read) / 0x8810 (Write) SPA name: F000V253		0 = not active 1 = active Default value is 0.

IEC types:

- in monitor direction (read by controlling station) M_ME_NB_1
- in control direction (written by controlling station) C_SE_NB_1

Table 6.10.-2 Addresses of non binary communication parameters

Data item	Corresp. SPA channel, param.	IEC address (hex) write/ read	Data size (octets)	Values
Comm. link: RTS delay (in ms)	0, V214	B41F/4425	2	0...32767
Comm. link: Baud rate	0, V211	B420/4426	2	300...14400
Comm. link: Parity	0, V230	B421/4427	1	0...2
Comm. link: Data bits	0, V231	B422/4428	1	7...8
Comm. link: Next char timeout (in ms)	0, V215	B424/442A	2	0...FFFF
Comm. link: End of frame timeout (in ms)	0, V216	B425/442B	2	0...FFFF
Comm. link: CTS delay (in ms)	0, V213	B426/442C	2	0...32767
IEC: Size of link address	0, V244	B427/442D	1	1...2
IEC: Link address	0, V245	B428/442E	2	0...65534
IEC: Size of common address of ASDU	0, V246	B429/442F	1	1...2
IEC: Common address of ASDU	0, V247	B42A/4430	2	0...65534
IEC: Internal cycle of checking for analog data changes (in 10 ms units)	0, V248	B42B/4431	2	0...65535
IEC: Master idle timeout (in 1 s units)	0, V249	B42C/4432	2	

6.11. General interrogation group

The following process data are assigned to the general interrogation group.

Table 6.11.-1 General interrogation group

Data item	Corresp. SPA channel, param	IEC address (hex)	Data size (octets)
Object #1 status	1, I3	1000	1
Object #2 status	2, I3	1001	1
Input I1 X2(1/2) status	0, I4	0002	1
Input I2 X2(3/2) status	0, I5	0003	1
Input I3 X2(4/5) status	0, I6	0004	1
Input I4 X2(6/5) status	0, I7	0005	1
Input I5 X2(7/8) status	0, I8	0006	1
Hardware output 1 status	0, O1	000A	1
Hardware output 2 status	0, O2	000B	1
Hardware output 3 status	0, O3	000C	1
Hardware output 4 status	0, O4	000D	1

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