SIPROTEC

Multifunction Overcurrent and Motor Protection Relay

7SJ602

Communication module

Modbus
Specification and Mapping

Revision 2.0

Edition: September 2004

C53000-L1876-C012-03

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Preface

Purpose of this manual

The manual describes the functions, bus specific parameters, parameterization and the hardware interface of the Modbus slave of the SIPROTEC device 7SJ602 and is divided into the following topics:

- Asynchronous communication modules → Chapter 1;
- Parameters and properties → Chapter 2;
- Data type definitions → Chapter 3;
- Modbus register map → Chapter 4;
- Technical data → Chapter 5.

General details about the function, operation, assembly and commissioning of the SIPROTEC device 7SJ602 you find in the

- 7SJ602 Instruction Manual, order no. C53000-G1176-C125.

Modbus specification

The Modbus specification with a detailed explanation of the Modbus protocol is contained in:

❑ MODICON
Modbus Protocol
Reference Guide
PI-MBUS-300 Rev. J
June 1996, Modicon, Inc.

Validity

This manual is valid for the SIPROTEC devices:

- 7SJ602 (firmware version 3.50 or higher)

with Modbus communication module up to HW revision 3 and

- Modbus firmware from version 03.01.01,

with Modbus communication module from HW revision 4 and

- Modbus firmware from version 04.00.04.

For device parameterization have to be used:

- DIGSI from version 4.30.

Additional Support For questions regarding SIPROTEC4 devices, please contact your Siemens representative.

Training courses Individual course offerings may be found in our Training Catalog and questions can be directed to our Training Centre. Please contact your Siemens representative.

Target audience Protection engineers, commissioning engineers, personnel concerned with adjustment, checking and service of selective protective equipment, automatic and control facilities and personnel of electrical facilities and power plants.

Warning!

Hazardous voltages are present in this electrical equipment during operation. Non-observance of the safety rules can result in severe personal injury or property damage.

Only qualified personnel shall work on and around this equipment after becoming thoroughly familiar with all warnings and safety notices of this and the associated manuals as well as with the applicable safety regulations.

The successful and safe operation of this device is dependent on proper transport and storage, proper handling, installation, operation, and maintenance by qualified personnel under observance of all warnings and hints contained in this and the associated manuals.

In particular the general erection and safety regulations (e.g. IEC, EN, DIN, VDE, or other national and international standards) regarding the correct use of high-voltage installations must observed. Non-observance can result in death, personal injury or substantial property damage.

QUALIFIED PERSONNEL

For the purpose of this manual and product labels, a qualified person is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, he has the following qualifications:

- Is trained and authorized to energize, de-energize, clear, ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

Typographic and graphical conventions

The following text formats are used to identify concepts giving device information described by the text flow:

`Parameter names`, or identifiers for configuration or function parameters that appear in the device display or on the screen of a PC (with DIGSI) are shown in mono-script (same point size) bold text. This also applies to header bars for selection menus.

`Parameter conditions`, or possible settings of parameters that appear in the device display or on the screen of a PC (with DIGSI), are additionally shown in italic style. This also applies to selection items for selection menus.

„`Annunciations`“, or identifiers for information produced by the device or required by other devices or from the switchgear is shown in mono-script (same point size) and placed into quotation marks.

For diagrams in which the identifier type results from the representation itself, text conventions may differ from the above-mentioned.

Revision index

Listing of the changes between the editions of this manual:

Modified chapters / pages	Edition	Reasons of modification
	1.0	First edition, Doc.-No.: C53000-L1876-C012-03 March 23rd, 2004
Chap. 1 Chap. 2.2 general	2.0	• Chap. “Asynchronous communication modules” added (new HW revision 4), *the following numbers moved up* • Diagnostic subfunctions 10, 12, 13, 14 are supported • Page numbering in the manual now continuous, not chapter-related any more Sept. 10th, 2004

Table of contents

Asynchronous communication modules

1

This chapter shows the hardware and software necessary for Modbus communication with SIPROTEC devices.

1.1 Communication module types and hardware revisions

1.1.1 Communication module types

Two communication modules are available for the connection of Modbus to the SIPROTEC devices:

RS485 bus interface

Asynchronous module with isolated RS485 interface.

This module also is called AME module (**a**synchronous communication **m**odule **e**lectrical) subsequently.

Fibre-optical bus interface

Asynchronous module with fibre-optical interface.

This module also is called AMO module (**a**synchronous communication **m**odule fibre-**o**ptical) subsequently.

Technical data

The technical data of the above-mentioned asynchronous communication modules are summarized in chap. 5.

1.1.2 Hardware revisions

There exist two different hardware revisions for asynchronous communication modules:

- up to HW revision 3:
  delivery up to the end of year 2004
- from HW revision 4:
  replacement for modules up to HW revision 3, delivery from beginning of 2005

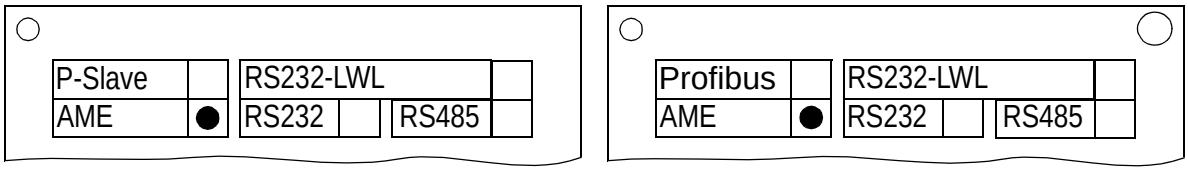
The communication modules from HW revision 4 are function compatible to the modules up to HW revision 3.

Please note the dependency of the Modbus firmware versions with the HW revisions described in chap. 1.1.3.

The hardware revision of the asynchronous communication modules is also recognizable in build-in condition at the rear of the SIPROTEC device at the labelling of the communication module mounting bracket:

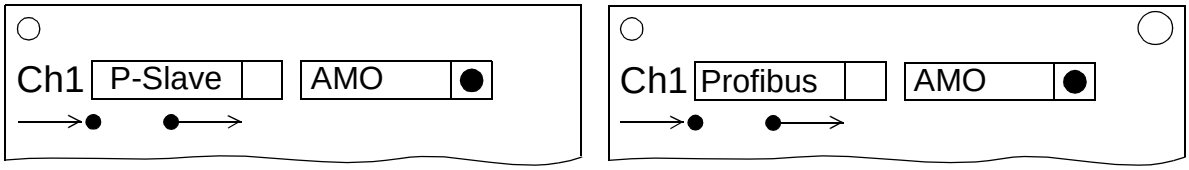
- up to HW revision 3: identification table starts with “P-Slave”
- from HW revision 4: identification table starts with “Profibus”

Asynchronous module RS485 (AME module)



up to HW revision 3 | from HW revision 4

Asynchronous module fibre-optical (AMO module)



up to HW revision 3 | from HW revision 4

Figure 1-1 HW revisions of the communication modules, labelling of the mounting brackets

General details about the assembly of communication modules as well as the setting of the terminating resistors on the AME modules you find in the SIPROTEC4 System Manual (ref. to page 3).

1.1.3 Compatibility of the communication module hardware with Modbus firmware versions and mapping files

Hardware and firmware

Please note the following listed compatibility between the hardware revisions of the communication modules and the Modbus firmware versions:

Hardware revision	Firmware version to be used
up to HW revision 3	up to Modbus firmware V03
from HW revision 4	from Modbus firmware V04

Table 1-1 Hardware revisions and firmware versions

The Modbus firmware for communication modules from HW revision 4 is function compatible with firmware versions for modules up to HW revision 3 (i.e. contains all there contained functionalities).

Note:

If, during loading of the Modbus firmware on the communication module, a non-compatible hardware revision is recognized, then the firmware update is cancelled.

Please, in case of an abort of loading the Modbus communication firmware, check first the dependencies indicated in Table 1-1.

After attempting to load a Modbus firmware version on a non-compatible hardware revision, then the device has to be switched off and (after at least 3 sec.) switched on again.
The previous firmware configuration is then used furthermore.

Parameters and properties

2

This chapter describes the properties and functions of the Modbus slave and the bus specific parameters which have to be defined during parameterization of the SIPROTEC devices 7SJ602 for Modbus communication.

2.1 Bus specific parameters

The following settings for the serial communication between the Modbus master and the Modbus slave have to be defined during parameterization of the SIPROTEC device.

Names written in `MonoScriptText` are the associated designations of the bus specific parameters in the `Parameter block 72` of the 7SJ602.

Note:

Modbus Plus is not supported by the Modbus slave of the SIPROTEC devices.

2.1.1 Modbus settings

Slave address

`TNR = 7270, “72MbSlAd”`

Permissible slave addresses are in the range between 1 and 247.

Modbus mode

`TNR = 7271, “72MbMode”`

The Modbus slave supports the two serial transmission modes ASCII and RTU:

- In ASCII mode each byte in a Modbus message is sent as two ASCII characters. For error checking a Longitudinal Redundancy Check (LRC) is used.
- If the Modbus slave is configured to communicate on a Modbus network using RTU mode, each byte in a Modbus message contains two hexadecimal digits. In RTU mode a Cyclical Redundancy Check (CRC) is applied for frame checking.

Baud rate

`TNR = 7272, “72MbBaud”`

The following baud rates are available:

- 300, 600, 1200, 2400, 4800, 9600, 19200, 38400 and 57600 Bit/s.

Parity

`TNR = 7273 and 7274, “72MbParR” and ”72MbParA”`

The setting of parity depends on the selected Modbus serial transmission mode:

- RTU mode: `TNR = 7273, “72MbParR”`
  Parity is adjustable to none, even or odd parity bit (NONE, EVEN, ODD).
- ASCII mode: `TNR = 7274, “72MbParA”`
  Parity is adjustable to even or odd parity bit (EVEN, ODD).

Stop bits

Always one Stop bit is used for serial communication (also if parity NONE in RTU mode is used).

This setting is not changeable.

Method of data acceptance for time synchronization

`TNR = 7275, “72MbTset”`

Two methods of data acceptance for time synchronization of the SIPROTEC device via Modbus are possible:

1. `“72MbTset”` = 0: acceptance immediately after writing of date and time using Modbus function “Preset Multiple Regs” as a single (in general broadcast) message to the defined positions in the Holding registers or
2. `“72MbTset”` = 1: the values of date and time which are transferred with a single or with separate messages to the SIPROTEC device are accepted in the moment, a value of $FFFF_{hex}$ is written in the “Set Time and Date” register.

Option 1 is activated per default.

Ref. to chap. 4.5.2 for further information about parameter settings for time synchronization via Modbus.

2.1.2 Bus timing settings

Note:

The bus timings have to meet further requirements:

- RTU mode
  - Following the last transmitted character of the response message from the Modbus slave of the SIPROTEC device, the Modbus master has to ensure a bus silent time interval of at least 2 character times (i.e. 22 bit times).
  - After sending a broadcast message, the bus silent time interval has to be at least 2 character times.
    Because no responses are sent by the Modbus slaves for broadcast messages and the Modbus slaves still need a certain time for processing the query from the master, the time interval up to sending the next message has to be extended (in addition to the 2 character times) by approx. 1 ms up to 10 ms.
  - All bytes of the Modbus messages must be transmitted as a continuous stream. The max. silent interval between two bytes of a message is 2 character times. If the silent interval is greater than 2 character times, the message is assumed as completed and will be evaluated by the Modbus slave.
- ASCII mode
  - The max. silent interval between two bytes of a message is 1 second.

2.2 Supported Modbus functions

Function code	Function name	Description	Broadcast[1] supported?
1	Read Coil Status (0X references)	Reading one or several Coil Status registers of the Modbus slave. A maximum of 1970 registers in RTU mode or 960 registers in ASCII mode can be read with one message. The Coil Status registers reflect the ON/OFF status of discrete outputs of the SIPROTEC device.	no
2	Read Input Status (1X references)	Reading one or several Input Status registers of the Modbus slave. A maximum of 1970 registers in RTU mode or 960 registers in ASCII mode can be read with one message. The Input Status registers reflect the ON/OFF status of discrete inputs and the status of the protection function of the SIPROTEC device.	no
3	Read Holding Registers (4X references)	Reading one or several Holding registers of the Modbus slave. A maximum of 125 registers in RTU mode or 60 registers in ASCII mode can be read with one message. The Holding registers contain device status information, mean values of measured values, metered measurands and others.	no
4	Read Input Registers (3X references)	Reading one or several Input registers of the Modbus slave. A maximum of 125 registers in RTU mode or 60 registers in ASCII mode can be read with one message. The Input registers contain recorded measured values.	no
5	Force Single Coil (0X references)	Writing (force to ON or OFF) one Coil Status register (respectively binary output of the SIPROTEC device assigned with that). Use function code 15 to force multiple Coil Status registers.	yes
6	Preset Single Register (4X references)	Function presets a value into a single Holding register. Use function code 16 to preset multiple Holding registers.	yes
8	Diagnostics	This function provides diagnostic values to the Modbus master. • Subfunction 0: The data passed in the query data field of the message to the slave are returned (looped-back) in the response. • Subfunction 2: The contents of the Diagnostic register is returned in the response to the master. For this, the contents of the Holding register 129 is used. • Subfunction 10 deletes all diagnostic counters; the Diagnostic register is not deleted.[2] • Subfunction 12 “Return Bus Communication Error Count”[2] • Subfunction 13 “Return Bus Exception Error Count”[2] • Subfunction 14 “Return Slave Message Error Count”[2]	no
15	Force Multiple Coils (0X references)	Writing (force to ON or OFF) one or several Coil Status registers (respectively binary outputs of the SIPROTEC device assigned with these). A maximum of 1970 registers in RTU mode or 960 registers in ASCII mode can be written with one message.	yes
16	Preset Multiple Regs (4X references)	Function presets one or several Holding registers. A maximum of 125 registers in RTU mode or 60 registers in ASCII mode can be written with one message.	yes

Table 2-1 Supported Modbus functions

1 Broadcast messages from Modbus master to the Modbus slaves using slave address 0 in the Modbus message.
2 Available from Modbus firmware version 04.00.04.

2.3 Exception responses of the Modbus slave

If the Modbus slave receives a query from the Modbus master which cannot be processed (e.g. a request to read a non-existent register), then the slave answers with an exception response message.

The following exception codes are transferred in a exception response message to the Modbus master by the Modbus slave of the SIPROTEC device:

Exception code 01 ILLEGAL_FUNCTION

The function code used in the query by the Modbus master is not supported by the Modbus slave of the SIPROTEC device.

Ref to chap. 2.2 for a list of supported Modbus functions.

Exception code 02 ILLEGAL_DATA_ADDRESS

The Modbus master addresses a register in the query for which:

- no mapping entry exist (i.e. a non-existent register),
- a single access is not allowed because the addressed register is part of a complex bus object which uses more than one register and can be read only completely.

Exception code is used furthermore, if:

- a write access to the “Set Time and Date” register for time synchronization is detected but the acceptance of time and date is configured without “Set Time and Date” register (ref. to chap. 4.5.2) or
- the acceptance of date and time for time synchronization is configured without “Set Time and Date” register but the date and time structure in the Holding registers is not written completely at ones (ref. to chap. 4.5.2).

Exception code 03 ILLEGAL_DATA_VALUE

- The Modbus master tried to write to a register for which only read access is permitted.
- Writing of an invalid value to the “Set Time and Date” register (ref. to chap. 4.5.2).
- The Modbus master wants to read or write more registers with one query than allowed (ref. to chap. 2.2).

Exception code 06 SLAVE_DEVICE_BUSY

The Modbus slave has no valid mapping data or the Modbus registers still have not been initialized and enabled by the SIPROTEC device (after initial start or restart of the device).

Exception code 07 NEGATIVE_ACKNOWLEDGE

If in a Diagnostic query (Modbus function code 8) a not supported subfunction is requested, then this is rejected with NEGATIVE_ACKNOWLEDGE (ref. to chap. 2.2 for a list of supported subfunctions).

2.4 Annunciations to the Modbus master

Note:

When analyzing the annunciations of the SIPROTEC device in the Modbus master, it should be noted that due to the cycle period of the Modbus system (period between two following queries of the same data of the Modbus slave) temporary changes of an annunciation's value (ON and OFF within one cycle) may eventually not be recognized.

This applies in the first place for protection annunciations.

Protection pickup

Protection annunciations which indicate the status **"Protection pickup"** are active only for the period of time of the protection pickup.

Protection TRIP

The parameter **Minimum Duration of TRIP Command** (parameter address = 1134) allows setting of the minimum duration of the TRIP command.

This time setting applies to all protection functions which may cause a TRIP signal. After a protection TRIP, the corresponding protection annunciations transmit the value ON for the programmed minimum time duration.

Data type definitions

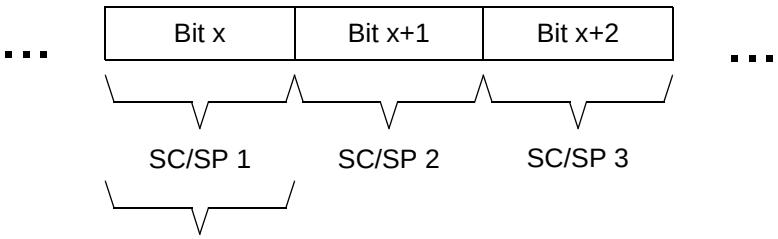
3

This chapter describes the data types which are used for variables in the Modbus registers.

3.1 Single command (SC) / Single-point indication (SP)

Range of values 0 - OFF

1 - ON



Coil / Input Status register or one bit of a Holding register

Figure 3-1 Data type: Single command / Single-point indication

3.2 Measured value (signed integer)

Range of values -32768 to +32767

(-32768 = “Overflow” or “Invalid”)

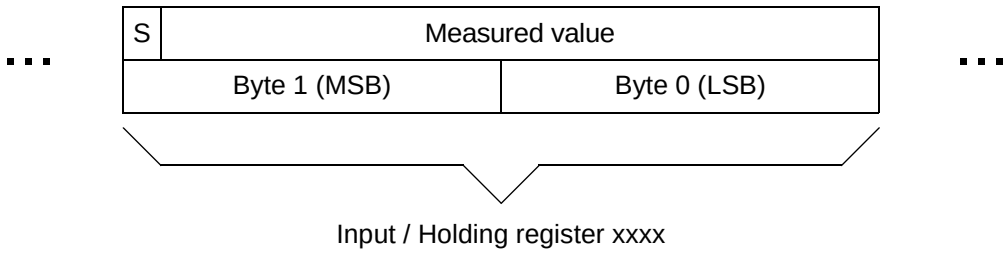


Figure 3-2 Data type: Measured value (signed integer)

Status bit (S)

- Status bit corresponds to the sign bit, active if negative measured value.

  Negative measured values are transmitted in the two's complement, i.e.:
  $-1 = FFFF_{hex}$, $-2 = FFFE_{hex}$, ..., $-32767 = 8001_{hex}$
- Status bit = 1 and measured value = 0
  (i.e. transmission of the value $8000_{hex} = -32768$):
  Measured value overflow or invalid measured value.

3.3 Metered measurand (unsigned long)

Range of values 0 to +4294967295

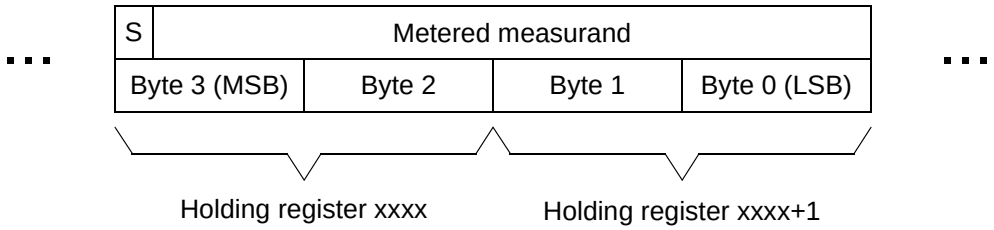


Figure 3-3 Data type: Metered measurand (unsigned long)

Status bit (S) The status bit is set for invalid metered measurands in case of:

- corruption of the metered measurand after device reset/device start-up (the status bit is deleted after two update cycles of the metered measurand after device reset/device start-up).

Note:

The overflow of the metered measurands is 2 000 000 000 (77359400_{hex}).

3.4 Time/Date

The Time/Date format is used for:

- Time synchronization of the SIPROTEC device via Modbus (ref to chap. 4.5.2),
- Recording-time of peak or minimum demand values of a measured value.

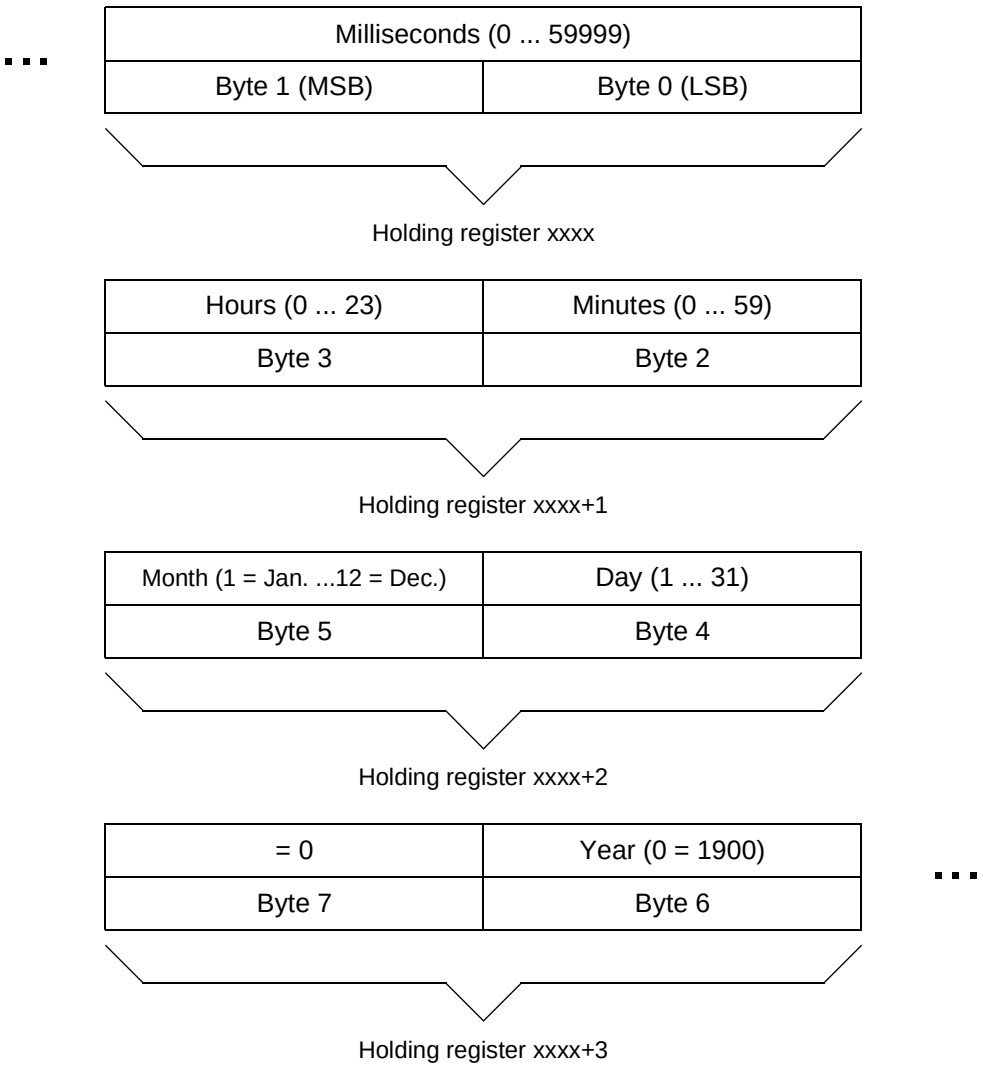


Figure 3-4 Data type: Time/Date

Modbus register map

4

This chapter describes the register map organization of the Modbus slave of the SIPROTEC devices 7SJ602.

4.1 Numbering of Modbus registers

Generally, for numbering of Modbus registers it is to distinguish between:

- the register number and
- the register address.

Register number

The register number is used to identify a Modbus register, normally with a five-digit decimal number in which the highest-order digit defines the register type:

- 0 - Coil Status register
- 1 - Input Status register
- 3 - Input register
- 4 - Holding register

The count of register numbers starts at 1 per register type, e.g.:

- 00127 = Coil Status register 127 (alternative: Coil 127),
- 40108 = Holding register 108.

Register address

The register address is used for address information in Modbus messages and is related to the value 0:

For this reason the following relation between register number and register address exists:

Register address = Register number - 1

For the above example follows:

- Coil 127 is addressed as 126 ($007E_{hex}$) in a Modbus message for reading or writing the Coil Status register,
- 40108 is addressed as 107 ($006B_{hex}$) in a Modbus message for reading or writing the Holding register.

Register assignment

Chapters 4.2 to 4.5 define the mapping of the data objects of the SIPROTEC devices 7SJ602 to the associated Modbus registers.

The listed SIPROTEC data objects are *sorted by register numbers*, e.g.:

Register	Designation	Comments	Scaling (32767 corresponds to...)	FNo.
30004	IL1 =	Current in phase L1	ref. to Table 4-2	651

The measured value "IL1" is assigned to register 30004 (Input register).

Register	Designation	Comments	FNo.
10044	Trip I>	1 = Overcurrent protection I> phase trip	1815

The single-point indication "Trip I>" is assigned to the Input Status register 10044.

4.2 Coil Status registers (0X references)

The Coil Status register block allows the Modbus master:

- command outputs through the output relays of the device,
- manipulation of protective functions (blocking, ..) and taggings in the device,
- reading the status of output relays as well as taggings.

Note:

Depending on the device composition there may be less than indicated Modbus registers available in the SIPROTEC device.

4.2.1 Registers 00001: Earth fault protection

Register	Designation	Comments	FNo.
00001	>UE bl	1 = >Block displacement voltage stage U_E>	1201

4.2.2 Registers 00002 to 00003: Circuit breaker failure protection

Register	Designation	Comments	FNo.
00002	>BF blo	1 = >Block circuit breaker failure protection	1403
00003	>BF St	1 = >Initiate (start) circuit breaker failure protection from external	1431

4.2.3 Registers 00004: Thermal overload protection

Register	Designation	Comments	FNo.
00004	>O/Lblk	1 = >Block thermal overload protection	1503

4.2.4 Registers 00005 to 00007: Time overcurrent protection

Register	Designation	Comments	FNo.
00005	>O/Cpbk	1 = >Block overcurrent protection	1704
00006	>O/Cebk	1 = >Block overcurrent protection earth	1714
00007	>C/O	1 = >C/O of overcurrent fault detect level	1727

4.2.5 Registers 00008 to 00010: Automatic reclosure

Register	Designation	Comments	FNo.
00008	>AR St.	1 = >AR: Start external	2732
00009	>ARblSt	1 = >AR: External Blocking of Start	2733
00010	>ARblCl	1 = >AR: External Blocking of reclosure	2734

4.2.6 Registers 00011: Circuit breaker

Register	Designation	Comments	FNo.
00011	Q0 Ctr.	Circuit breaker control	4642

4.2.7 Registers 00012 to 00013: Restart lockout for motors

Register	Designation	Comments	FNo.
00012	>MSP bl	1 = >Block motor restart lock-out	4822
00013	>MSP em	1 = >Emergency start information for motor restart lock-out	4823

4.2.8 Registers 00014: Unbalanced load protection

Register	Designation	Comments	FNo.
00014	>I2 blk	1 = >Block unbalanced load protection	5143

4.2.9 Registers 00015: Start-up time monitoring for motors

Register	Designation	Comments	FNo.
00015	>SRT bk	1 = >Block starting time supervision	6801

4.2.10 Registers 00016: Trip circuit supervision

Register	Designation	Comments	FNo.
00016	>SUP bk	1 = >Blocking trip circuit supervision	6851

4.2.11 Registers 00017: Reset Min/Max values of measured values

Register	Designation	Comments	FNo.
00017	>ResMax	1 = Reset minimum/maximum of measured values	415

4.3 Input Status registers (1X references)

The Input Status register block allows the Modbus master to scan the current status of the input channels as well as protection annunciations and status annunciations.

Note:

Depending on the device composition and the existing protection packages not all of the indicated protection annunciations (and corresponding Modbus registers) may be available in the SIPROTEC device.

4.3.1 Registers 10001 to 10004: User-defined annunciations

Register	Designation	Comments	FNo.
10001	>Annu.1	1 = >User defined annunciation 1 = ON	11
10002	>Annu.2	1 = >User defined annunciation 2 = ON	12
10003	>Annu.3	1 = >User defined annunciation 3 = ON	13
10004	>Annu.4	1 = >User defined annunciation 4 = ON	14

4.3.2 Registers 10005 to 10007: Circuit breaker

Register	Designation	Comments	FNo.
10005	>CBclo	1 = >Circuit breaker closed	1157
10006	Q0 Clo.	1 = Control-Close-Command CB-Q0	4640
10007	Q0 Trp.	1 = Control-Trip-Command CB-Q0	4641

4.3.3 Registers 10008 to 10012: Earth fault protection

Register	Designation	Comments	FNo.
10008	FD UE	1 = Pick-up (fault detection) of displacement voltage stage U_E>	1215
10009	Trip UE	1 = Trip by displacement voltage stage U_E>	1217
10010	EFfor	1 = Earth fault (non-earthed system) in forward direction	1276
10011	EFrev	1 = Earth fault (non-earthed system) in reverse direction	1277
10012	EFundef	1 = Earth fault (non-earthed system) direction undefined	1278

4.3.4 Registers 10013 to 10018: Circuit breaker failure protection

Register	Designation	Comments	FNo.
10013	BF off	1 = Circuit breaker failure protection is switched off	1451
10014	BF bloc	1 = Circuit breaker failure protection is blocked	1452
10015	BF act	1 = Circuit breaker failure protection is active	1453
10016	BF fltI	1 = Circuit breaker failure protection internally initiated	1456
10017	BF fltE	1 = Circuit breaker failure protection externally initiated	1457
10018	BF Trip	1 = Trip by circuit breaker failure protection	1471

4.3.5 Registers 10019 to 10024: Thermal overload protection

Register	Designation	Comments	FNo.
10019	O/L off	1 = Thermal overload protection is switched off	1511
10020	O/L blk	1 = Thermal overload protection is blocked	1512
10021	O/L act	1 = Thermal overload protection is active	1513
10022	O/L wrn	1 = Thermal overload protection: Thermal warning	1516
10023	O/L p/u	1 = Thermal overload protection: Pick-up	1518
10024	O/L Trp	1 = Thermal overload protection: Trip	1521

4.3.6 Registers 10025 to 10053: Time overcurrent protection

Register	Designation	Comments	FNo.
10025	>I>>blk	1 = I>> stage of time overcurrent protection is blocked	1721
10026	>I> blk	1 = I> stage of time overcurrent protection is blocked	1722
10027	>Ip blk	1 = Ip stage of time overcurrent protection is blocked	1723
10028	>IE>>bk	1 = IE>> stage of time overcurrent protection is blocked	1724
10029	>IE> bk	1 = IE> stage of time overcurrent protection is blocked	1725
10030	>IEp bk	1 = IEp stage of time overcurrent protection is blocked	1726
10031	O/Cpoff	1 = Time overcurrent protection phase is switched off	1751
10032	O/Cpblk	1 = Time overcurrent protection phase is blocked	1752
10033	O/Cpact	1 = Time overcurrent protection phase is active	1753
10034	O/Ceoff	1 = Time overcurrent protection earth is switched off	1756
10035	O/Ceblk	1 = Time overcurrent protection earth is blocked	1757
10036	O/Ceact	1 = Time overcurrent protection earth is active	1758
10037	O/C L1	1 = Overcurrent fault detection phase L1	1762
10038	O/C L2	1 = Overcurrent fault detection phase L2	1763
10039	O/C L3	1 = Overcurrent fault detection phase L3	1764

Register	Designation	Comments	FNo.
10040	O/C E	1 = Overcurrent fault detection earth	1765
10041	FD I>>	1 = Overcurrentfault detection stage I>> for phase currents	1800
10042	Trp I>>	1 = Overcurrent protection I>> phase trip	1805
10043	FD I>	1 = Overcurrent fault detection stage I> for phase currents	1810
10044	Trip I>	1 = Overcurrent protection I> phase trip	1815
10045	FD Ip	1 = Overcurrent fault detection stage Ip for phase currents	1820
10046	Trip Ip	1 = Overcurrent protection Ip phase trip	1825
10047	FD IE>>	1 = Overcurrent fault detection stage IE>> for earth currents	1831
10048	TrpIE>>	1 = Overcurrent protection IE>> earth trip	1833
10049	FD IE>	1 = Overcurrent fault detection stage IE> for earth currents	1834
10050	Trp IE>	1 = Overcurrent protection IE> earth trip	1836
10051	FD IEp	1 = Overcurrent fault detection stage IEp for earth currents	1837
10052	Trp IEp	1 = Overcurrent protection IEp earth trip	1839
10053	FD dyn	1 = Overcurrent protection: dynamic parameters active	1850

4.3.7 Registers 10054 to 10058: Automatic reclosure

Register	Designation	Comments	FNo.
10054	AR act.	1 = AR: Auto reclosure is active	2736
10055	AR off	1 = AR: Auto reclose is switched off	2781
10056	AR i pg	1 = AR: Auto reclose cycle in progress	2801
10057	AR ClCm	1 = AR: Close command from auto reclose	2851
10058	AR dTrp	1 = AR: Definitive trip	2863

4.3.8 Registers 10059 to 10062: Restart lockout for motors

Register	Designation	Comments	FNo.
10059	MSP off	1 = Motor restart lock-out is switched off	4824
10060	MSP blk	1 = Motor restart lock-out is blocked	4825
10061	MSP act	1 = Motor restart lock-out is active	4826
10062	MSP tri	1 = Trip by motor restart lock-out	4827

4.3.9 Registers 10063 to 10068: Unbalanced load protection

Register	Designation	Comments	FNo.
10063	I2 off	1 = Unbalanced load protection is switched off	5151
10064	I2 blk	1 = Unbalanced load protection is blocked	5152

Register	Designation	Comments	FNo.
10065	I2 act	1 = Unbalanced load protection is active	5153
10066	FD I2>>	1 = Fault detection of unbalanced load protection stage I2>>	5159
10067	FD I2>	1 = Fault detection of unbalanced load protection stage I2>	5165
10068	Trp I2	1 = Trip by unbalanced load protection	5170

4.3.10 Registers 10069 to 10072: Start-up time monitoring for motors

Register	Designation	Comments	FNo.
10069	SRT off	1 = Starting time supervision is switched off	6811
10070	SRT blk	1 = Starting time supervision is blocked	6812
10071	SRT act	1 = Starting time supervision is active	6813
10072	SRT Trp	1 = Trip by supervision of starting time	6821

4.3.11 Registers 10073 to 10079: Trip circuit supervision

Register	Designation	Comments	FNo.
10073	>TrpRel	1 = Binary input in parallel to trip relay = ON	6852
10074	>CBaux	1 = Binary input in parallel to CB auxiliary contact = ON	6853
10075	SUP off	1 = Trip circuit supervision is switched off	6861
10076	SUP blk	1 = Trip circuit supervision is blocked	6862
10077	SUP act	1 = Trip circuit supervision is active	6863
10078	SUPnoBI	1 = Trip circuit supervision is inactive, binary input is not marshalled	6864
10079	CIR int	1 = Trip circuit is interrupted	6865

4.4 Input registers (3X references)

The Input register block allows the Modbus master to read the values of the analog inputs of the SIPROTEC device.

Scaling

The scaling of the measured values (integer values, ref. to chap. 3.2) which are transferred as primary values depends on the nominal values of the primary equipment:

Adjustment range U_N / kV	**Scaling UL1E, UE (32767 corresponds to ...)**
0.10 ... 2.50	3276.7 V
2.51 ... 25.00	32767 V
25.01 ... 250.00	327.67 kV
250.01 ... 400	3276.7 kV

Table 4-1 Scaling of the voltages

Adjustment range I_N / A	**Scaling IL1...IL3, IE (32767 corresponds to ...)**
10 ... 1365	3276.7 A
1366 ... 13650	32767 A
13651 ... 50000	327.67 kA

Table 4-2 Scaling of the currents

Register	Designation	Comments	Scaling (32767 corresponds to ...)	FNo.
30001	P =	Active power	3276.7 %	641
30002	Q =	Reactive power	3276.7 %	642
30003	S =	Apparent power	3276.7 %	645
30004	IL1 =	Current in phase L1	ref. to Table 4-2	651
30005	IL2 =	Current in phase L2	ref. to Table 4-2	652
30006	IL3 =	Current in phase L3	ref. to Table 4-2	653
30007	IE =	Earth current	ref. to Table 4-2	654
30008	UL1E =	Voltage line to earth	ref. to Table 4-1	671
30009	UE =	Displacement voltage	ref. to Table 4-1	677
30010	CosPhi =	Power factor	32.767	901
30011	I1=	Fault current in phase L1, I / I_N =	3276.7	521
30012	I2 =	Fault current in phase L2, I / I_N =	3276.7	522
30013	I3 =	Fault current in phase L3, I / I_N =	3276.7	523
30014	<reserved>	= 0	-	-

4.5 Holding registers (4X references)

The Holding register block allows the Modbus master to query metered measurands, mean values and min/max values of measured values, system and diagnostic information as well as to execute time synchronization of the SIPROTEC device.

4.5.1 Registers 40001 to 40036: System information

- Registers are write-protected.[1]

Register	Designation	Comments
40001 - 40008	Hardware designation of the communication module (string, max. 16 characters)	"AME-GEN" for AME module, "AMO-GEN" for AMO module
40009 - 40010	Communication module software revision	Example: Register 40009 = 0001H, register 40010 = 0205H → Revision 1.2.5
40011 - 40026	MLFB (order number) of the SIPROTEC device (string, max. 32 characters)	Example: "7SJ60212EB901FA0----0D----------"
40027 - 40034	Date and time of mapping data generation (string, max. 16 characters)	Example: "170204095747330" corresponds to → Date: Feb. 17th, 2004 → Time: 09 hours, 57 min., 47 sec. and 330 milliseconds
40035 - 40036	Number and revision of mapping data	MSB of register 40035: → Number of mapping LSB of register 40035 and value of register 40036: → Revision of mapping data Example: Register 40035 = 3102H, register 40036 = 0304H → Mapping 3-1, Revision 2.3.4

1. A write access is rejected with exception code 03 (ILLEGAL_DATA_VALUE).

4.5.2 Registers 40065 to 40069: Time synchronization

Two methods of data acceptance for time synchronization of the SIPROTEC device via Modbus are possible which can be selected with the parameter **Method of data acceptance for time synchronization** (ref. to chap. 2.1.1):

Direct writing of time and date

Time and date according to the Time/Date format are transferred completely using a “Preset Multiple Registers” broadcast message (slave address = 0) to the devices. Time synchronization is executed immediately after reception and evaluation of the Modbus message.

A separate writing of the Time/Date transfer registers (time and date with separate Modbus messages) is not permitted and rejected with Modbus exception 02 (ILLEGAL_DATA_ADDRESS).

The “Set Time and Date” register does not exist in this time synchronization data acceptance mode.
A read or write access to this register is rejected with Modbus exception 02 (ILLEGAL_DATA_ADDRESS).

Use of “Set Time and Date” Register

A separate writing of date and time to the Time/Date transfer registers using Modbus functions “Preset Single Register” or “Preset Multiple Registers” is possible.
This can be done using broadcast messages preferably or with addressed messages to every device.

The time and date which are transferred are the values for the next time synchronization acceptance.

Time synchronization with the current values in the Time/Date transfer registers is executed when the value $FFFF_{hex}$ is written to the "Set Time and Date" register using a broadcast message and Modbus function "Preset Single Register" or "Preset Multiple Registers".

The value 0 is always read from the "Set Time and Date" register.

Note:

When reading the Time/Date transfer registers then the values of time and date written last via Modbus are given back.

Register	Designation	Comments
40065	Milliseconds	Time/Date transfer registers
40066	Hours / Minutes	
40067	Month / Day	
40068	Year	
40069	“Set Time and Date”	available only, if time synchronization is configured with use of the “Set Time and Date” register

4.5.3 Register 40129: Diagnosis

- Registers are write-protected.[1]
- The contents of this register is also readable using function "Diagnostics" (function code 7), subfunction "Return Diagnostic Register" (subfunction code 2).

Register	Designation	Comments	FNo.
40129/2^0	operat.	1 = Any protection operative	52
40129/2^1	Meas.Bl	1 = Logging and measuring functions blocked	61
40129/2^2	FailΣI	1 = Failure: Current summation supervision	162
40129/2^3	BatFail	1 = Battery failure; low battery	177
40129/2^4	RemBlk	1 = Remote control is blocked	235
40129/2^5	OfClkSy	1 = Operation fault of clock synchronization	239
40129/2^6	IL< al	1 = Undercurrent alarm IL<	284
40129/2^7	Sys.Flt	1 = Fault in the power system	301
40129/2^8	>mCLOSE	1 = Circuit breaker is manually closed (from discrepancy switch)	356
40129/2^9	FT det	1 = General fault detection of device	501
40129/2^{10}	DEV.Trp	1 = General trip of device	511
40129/2^{11}	>LED r.	1 = Reset LED indicators	5
40129/2^{12}	<reserved>	= 0	-
40129/2^{13}	<reserved>	= 0	-
40129/2^{14}	<reserved>	= 0	-
40129/2^{15}	Data invalid	1 = Data in the Modbus message are invalid. (This indication is created by the Modbus slave; not available in the 7SJ602.)	-

1. A write access is rejected with exception code 03 (ILLEGAL_DATA_VALUE).

4.5.4 Registers 40201 to 40208: Metered measurands

- Registers are write-protected.[1]

Register	Designation	Comments	Scaling (1 corresponds to ...)	FNo.
40201 - 40202	Wp pos =	Active energy Wp positive	1 kWh	891
40203 - 40204	Wp neg =	Active energy Wp negative	1 kWh	892
40205 - 40206	Wq pos =	Reactive energy Wq positive	1 kVARh	921
40207 - 40208	Wq neg =	Reactive energy Wq negative	1 kVARh	927

4.5.5 Registers 40251 to 40256: Demand mean values of measured values

- Registers are write-protected.[1]

Register	Designation	Comments	Scaling (32767 corresponds to ...)	FNo.
40251	Pdmd =	Active power demand mean value	ref. to Table 4-3	834
40252	Qdmd =	Reactive power demand mean value	ref. to Table 4-3	835
40253	Sdmd =	Apparent power demand mean value	ref. to Table 4-3	836
40254	IL1dmd =	IL1 demand mean value	ref. to Table 4-2	963
40255	IL2dmd =	IL2 demand mean value	ref. to Table 4-2	964
40256	IL3dmd =	IL3 demand mean value	ref. to Table 4-2	965

1. A write access is rejected with exception code 03 (ILLEGAL_DATA_VALUE).

4.5.6 Registers 40351 to 40500: Min/Max values of measured values

- Registers are write-protected.[1]
- Information regarding the Time/Date data type you find in chap. 3.4.

Scaling

The scaling of the demand mean values and min/max values of measured values which are transferred as primary values depends on the nominal values of the primary equipment and is shown in Tables 4-1 to 4-3:

Adjustment range $U_N * I_N * \sqrt{3}$ / kW (KVAr)	Scaling P, Q, S (32767 corresponds to ...)
0.10 ... 3276	3276.7 kW (KVAr)
3277 ... 32767	32767 kW (KVAr)
32768 ... 327670	327670 kW (KVAr)
327671 ... 3276700	3276700 kW (KVAr)

Table 4-3 Scaling of the demand mean power values and min/max power values

Register	Designation	Comments	Scaling (32767 corresponds to ...)	FNo.
40351	MinI1d=	Minimum IL1 demand mean value	ref. to Table 4-2	837
40352 - 40355	MinI1d - Time/Date	Date and time of MinI1d	-	
40356	MaxI1d=	Maximum IL1 demand mean value	ref. to Table 4-2	838
40357 - 40360	MaxI1d - Time/Date	Date and time of MaxI1d	-	
40361	MinI2d=	Minimum IL2 demand mean value	ref. to Table 4-2	839
40362 - 40365	MinI2d - Time/Date	Date and time of MinI2d	-	
40366	MaxI2d=	Maximum IL2 demand mean value	ref. to Table 4-2	840
40367 - 40370	MaxI2d - Time/Date	Date and time of MaxI2d	-	
40371	MinI3d=	Minimum IL3 demand mean value	ref. to Table 4-2	841
40372 - 40375	MinI3d - Time/Date	Date and time of MinI3d	-	
40376	MaxI3d=	Maximum IL3 demand mean value	ref. to Table 4-2	842
40377 - 40380	MaxI3d - Time/Date	Date and time of MaxI3d	-	

1. A write access is rejected with exception code 03 (ILLEGAL_DATA_VALUE).

Register	Designation	Comments	Scaling (32767 corresponds to ...)	FNo.
40381	MinPd=	Minimum active power demand value	ref. to Table 4-3	845
40382 - 40385	MinPd - Time/Date	Date and time of MinPd	-	
40386	MaxPd=	Maximum active power demand value	ref. to Table 4-3	846
40387 - 40390	MaxPd - Time/Date	Date and time of MaxPd	-	
40391	MinQd=	Minimum reactive power demand value	ref. to Table 4-3	847
40392 - 40395	MinQd - Time/Date	Date and time of MinQd	-	
40396	MaxQd=	Maximum reactive power demand value	ref. to Table 4-3	848
40397 - 40400	MaxQd - Time/Date	Date and time of MaxQd	-	
40401	MinSd=	Minimum apparent power demand value	ref. to Table 4-3	849
40402 - 40405	MinSd - Time/Date	Date and time of MinSd	-	
40406	MaxSd=	Maximum apparent power demand value	ref. to Table 4-3	850
40407 - 40410	MaxSd - Time/Date	Date and time of MaxSd	-	
40411	MinIL1=	Minimum current in phase L1	ref. to Table 4-2	851
40412 - 40415	MinIL1 - Time/Date	Date and time of MinIL1	-	
40416	MaxIL1=	Maximum current in phase L1	ref. to Table 4-2	852
40417 - 40420	MaxIL1 - Time/Date	Date and time of MaxIL1	-	
40421	MinIL2=	Minimum current in phase L2	ref. to Table 4-2	853
40422 - 40425	MinIL2 - Time/Date	Date and time of MinIL2	-	
40426	MaxIL2=	Maximum current in phase L2	ref. to Table 4-2	854
40427 - 40430	MaxIL2 - Time/Date	Date and time of MaxIL2	-	
40431	MinIL3=	Minimum current in phase L3	ref. to Table 4-2	855
40432 - 40435	MinIL3 - Time/Date	Date and time of MinIL32	-	

Register	Designation	Comments	Scaling (32767 corresponds to ...)	FNo.
40436	MaxIL3=	Maximum current in phase L3	ref. to Table 4-2	856
40437 - 40440	MaxIL3 - Time/Date	Date and time of MaxIL3	-	
40441	MinUL1E=	Minimum voltage line to earth	ref. to Table 4-1	859
40442 - 40445	MinUL1E - Time/Date	Date and time of MinUL1E	-	
40446	MaxUL1E=	Maximum voltage line to earth	ref. to Table 4-1	860
40447 - 40450	MaxUL1E - Time/Date	Date and time of MaxUL1E	-	
40451	MinUE=	Minimum displacement voltage	ref. to Table 4-1	872
40452 - 40455	Min1E - Time/Date	Date and time of MinUE	-	
40456	MaxUE=	Maximum displacement voltage	ref. to Table 4-1	873
40457 - 40460	MaxUE - Time/Date	Date and time of MaxUE	-	
40461	MinP=	Minimum active power	ref. to Table 4-3	876
40462 - 40465	MinP - Time/Date	Date and time of MinP	-	
40466	MaxP=	Maximum active power	ref. to Table 4-3	877
40467 - 40470	MaxP - Time/Date	Date and time of MaxP	-	
40471	MinQ=	Minimum reactive power	ref. to Table 4-3	878
40472 - 40475	MinQ - Time/Date	Date and time of MinQ	-	
40476	MaxQ=	Maximum reactive power	ref. to Table 4-3	879
40477 - 40480	MaxQ - Time/Date	Date and time of MaxQ	-	
40481	MinS=	Minimum apparent power	ref. to Table 4-3	880
40482 - 40485	MinS - Time/Date	Date and time of MinS	-	
40486	MaxS=	Maximum apparent power	ref. to Table 4-3	881
40487 - 40490	MaxS - Time/Date	Date and time of MaxS	-	

Register	Designation	Comments	Scaling (32767 corresponds to ...)	FNo.
40491	MinCos =	Minimum power factor	32.767	884
40492 - 40495	MinCos - Time/Date	Date and time of MinCos	-	
40496	MaxCos =	Maximum power factor	32.767	885
40497 - 40500	MaxCos - Time/Date	Date and time of MaxCos	-	

Technical data

5

This chapter gives a summary about the technical data of the Modbus slave of the SIPROTEC devices including the bus interface.

5.1 Functional range

Modbus Slave	Slave addresses	1 - 247
	Modbus modes	RTU, ASCII
	Modbus functions	Read Coil Status Read Input Status Read Holding Registers Read Input Registers Force Single Coil Preset Single Register Diagnostics[1] Subfct. 0 (Return Query Data) Subfct. 2 (Return Diagnostic Reg.) Subfct. 10 (Clear Counters) Subfct. 12 (Return Bus Comm. Error Count) Subfct. 13 (Return Bus Exception Error Count) Subfct. 14 (Return Slave Message Count) Force Multiple Coils Preset Multiple Regs
Data transmission	Baud rates (Bit/s)	300, 600, 1200, 2400, 4800, 9600, 19200, 38400, 57600
	Parity bit	RTU mode: NONE, EVEN, ODD ASCII mode: EVEN, ODD

1. Diagnostic subfunctions 10, 12, 13, 14 are available from Modbus firmware version 04.00.04.

5.2 Hardware interface

Two communication modules are available for the connection of Modbus to the SIPROTEC devices:

AME module Universal asynchronous communication module with isolated RS485 interface.

AMO module Universal asynchronous communication module with fibre-optical interface.

5.2.1 Connection via the AME module

Connection	9-pole D-SUB outlet (ref. to Table 5-1)
Protocol	semi-duplex
Max. line length	1000 m / 3300 ft.
Insulation level	500 V_{AC}
Bus termination	On the communication module: integrated, connectable terminating resistors • 221 Ohm between A and B • 392 Ohm between B and VCC1 as well as A and GND1 Input resistance not terminated ≥ 10 kOhm, then bus termination via bus plug with integrated terminating resistors.
Level	Transmitter: • Low: -5 V ≤ U_{A-B} ≤ -1,5 V • High: +5 V ≥ U_{A-B} ≥ +1,5 V Receiver: • Low: U_{A-B} ≤ -0,2 V • High: U_{A-B} ≥ +0,2 V Transmitter and receiver are surge-proof for voltages between A and GND1 as well as between B and GND1 in the range of -7 V...+12 V.
Max. number of modules at the bus	32 For exclusive utilization of AME modules at the bus. This value could be smaller depending on the used Modbus master and further modules at the bus. If more then 32 devices are needed, RS485 repeaters which support bit retiming have to be used.

Bus connection

Pin	Signal	Meaning
1	Shield	Shield / Operational ground
2	-	-
3	A	RS485 connection pin A
4	RTS	Directions control (TTL level)
5	GND1	Data transmission level (ground towards VCC1)
6	VCC1	Supply voltage for terminating resistors (+5V DC, max. 100 mA)
7	-	-
8	B	RS485 connection pin B
9	-	-

Table 5-1 Assignment of the bus connection at the device (D-SUB outlet)

5.2.2 Connection via the AMO module

Connection	fibre-optical interface, Rx and Tx, 820 nm, BFOC/2.5 (ST plug)
Protocol	semi-duplex
Max. line length	• 2000 m / 1.25 miles for glass fibre 62.5/125 µm • 3.5 m for plastic fibre
Optical receiver sensitivity	-24 dBm for glass fibre 62.5/125 µm
Optical budget	min. 8 dB for glass fibre 62.5/125 µm
Status for “no signal”	light OFF

Glossary

AME	Universal asynchronous communication module with (electrical) isolated RS485 interface for the SIPROTEC devices from Siemens.
AMO	Universal asynchronous communication module with fibre-optical interface for the SIPROTEC devices from Siemens.
CFC	Continuous Function Chart
CRC	Cyclical Redundancy Check
DIGSI	Parameterization system / parameterization software for SIPROTEC devices
GS	General scan
Input data / Input direction	Data from the Modbus slave to the Modbus master.
LRC	Longitudinal Redundancy Check
LSB	Least Significant Byte
Mapping	Allocation of the SIPROTEC data objects to the positions in the Modbus register map.
MSB	Most Significant Byte
Output data / Output direction	Data from the Modbus master to the Modbus slave.
SC	Single command
SP	Single-point indication

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