



TAVRIDA ELECTRIC



Recloser Control Cubicle

RC/TEL-01E(S)

Modicon Modbus Protocol Implementation

Firmware MPMTEL-03 S02.03.05

(Rev 1.05)

Technical Report

Title:	Recloser Control Cubicle RC/TEL-01E(S). Modicon Modbus Protocol Implementation (Rev 1.02)
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What's new in the latest version:

- [Importantly]** New engine. Protocol was rewritten.
- [Change]** Logic changed for points 10083, 10088-10092, 10094, 10095
- [Change]** Point 10114 Name and Description changed
- [Change]** Ia, Ib, Ic, In Measured range changed
- [Change]** Uab, Ubc, Uca, Urs, Ust, Uta Measured range was changed
- [Change]** Measured range was changed for all energy's
- [Change]** Frequency resolution was changed
- [Change]** Resolution for Phase sequence was changed
- [Change]** Resolution for power flow was changed
- [Change]** MODBUS Exception Code 04 was added (Table 5.1)
- [Change]** Catchwords were changed
- [Change]** Iamax, Ibmax, Icmax, Inmax Trip are added
- [Change]** Reference to MODBUS Application Protocol Specification V1.1 is added (Section Introduction)
- [Change]** Assignment to RS232 port is added (Section Implementation)
- [Change]** UVmin, UFmin Trip are added. IO Modules are added to Function 02 Read Input Status
- [Change]** IO Modules Outputs are added to Function 05 Force Single Coil
- [Change]** New input coils (Local Control, Group X trip) are added.
- [Change]** New input coils (AutoABR) are added.
- [Change]** Five points were deleted from Table 1.1 - 1X references, input coils. They are absent in IEC versions of FW.

Contents

1	INTRODUCTION	5
2	IMPLEMENTATION.....	6
3	TRANSMISSION MODE	7
4	SUPPORTED FUNCTION CODES.....	8
4.1	<i>Function 01 Read Coil Status</i>	<i>8</i>
4.2	<i>Function 02 Read Input Status</i>	<i>9</i>
4.3	<i>Function 03 Read Holding Registers</i>	<i>12</i>
4.4	<i>Function 04 Read Input Registers</i>	<i>13</i>
4.5	<i>Function 05 Force Single Coil.....</i>	<i>17</i>
4.6	<i>Function 06 Preset Single Register</i>	<i>17</i>
4.7	<i>Function 15 (0F Hex) Force Multiple Coils</i>	<i>17</i>
4.8	<i>Function 16 (10 Hex) Preset Multiple Registers</i>	<i>17</i>
5	MODBUS EXCEPTION RESPONSES.....	18

1 INTRODUCTION

MODBUS Protocol is a messaging structure developed by Modicon in 1979, used to establish master-slave/client-server communication between intelligent devices. It is a de facto standard, truly open and the most widely used network protocol in the industrial manufacturing environment.

The purpose of this document is to describe the specific implementation of the Modicon Modbus protocol on the Recloser Control Cubicle RC/TEL-01E(S) (ModbusTEL).

This document, in conjunction with the Modicon Modbus Protocol Reference Guide (PI-MBUS-300) and MODBUS Application Protocol Specification V1.1, published by Modicon, Inc., provides complete information on how to communicate with the RC/TEL-01E(S) via the ModbusTEL.

2 IMPLEMENTATION

The RC/TEL-01E(S) supports ModbusTEL protocol. ModbusTEL can be assigned to RS485 and RS232 ports and supposes transmit/receive data at 300, 600, 1200, 2400, 4800, 9600 and 19200 baud rates. Half-duplex or full-duplex connections on RS-485 port are used. RC/TEL-01E(S) is always slave and supports only RTU (binary) mode.

Valid slave device addresses are in the range of 0 – 247 decimal. The individual slave devices are assigned addresses in the range of 1 – 247. A master addresses a slave by placing the slave address in the address field of the message. When the slave sends its response, it places its own address in this address field of the response to let the master know which slave is responding.

ModbusTEL support broadcast message receiving on address 0.

3 TRANSMISSION MODE

ModbusTEL supports communication on a Modbus network using RTU (Remote Terminal Unit) mode, each 8-bit byte in a message contains two 4-bit hexadecimal characters. The main advantage of this mode is that its greater character density allows better data throughput than ASCII for the same baud rate. Each message must be transmitted in a continuous stream.

Supports format for each byte in RTU mode is:

Coding System:

- 8-bit binary, hexadecimal 0–9, A–F
- Two hexadecimal characters contained in each 8-bit field of the message

Bits per Byte:

- 1 start bit
- 8 data bits, least significant bit sent first
- 1 stop bit

Error Check Field:

- Cyclical Redundancy Check (CRC)

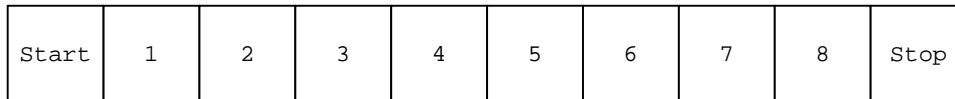


Fig. 3.1 – Transfer in RTU mode

4 SUPPORTED FUNCTION CODES

The listing below shows the function codes supported by ModbusTEL. Codes are listed in decimal. 'Yes' indicates that the function is supported. 'No' indicates that it is not supported.

Table 4.1 – Supported function codes

Code	Name	Supported
01	Read Coil Status	Yes
02	Read Input Status	Yes
03	Read Holding Registers	Yes
04	Read Input Registers	Yes
05	Force Single Coil	Yes
06	Preset Single Register	Yes
07	Read Exception Status	No
08	Diagnostics	No
09	Program 484	No
10	Poll 484	No
11	Fetch Comm. Event Ctr.	No
12	Fetch Comm. Event Log	No
13	Program Controller	No
14	Poll Controller	No
15	Force Multiple Coils	Yes
16	Preset Multiple Registers	Yes
17	Report Slave ID	No
18	Program 884/M84	No
19	Reset Comm. Link	No
20	Read General Reference	No
21	Write General Reference	No
22	Mask Write 4X Register	No
23	Read/Write 4X Registers	No
24	Read FIFO Queue	No

4.1 Function 01 Read Coil Status

4.1.1 Description

Reads the ON/OFF status of discrete outputs (0X references, coils) in the slave. Broadcast is not supported.

The query message specifies the starting coil and quantity of coils to be read. Coils are addressed starting at zero: coils 1–16 are addressed as 0–15.

Table 4.2 - 0X references, output coils

Address	Settings	Description
00001	Trip ¹⁾	Trip
00002	Close	Close
00003	On (Grp1)	Switch Group1 On
00004	On (Grp2)	Switch Group2 On
00005	On (Grp3)	Switch Group3 On
00006	On (Grp4)	Switch Group4 On
00007	On (Prot)	Switch protection On
00008	Off (Prot)	Switch protection Off
00009	On (EF)	Switch earth fault overcurrent element On
00010	Off (EF)	Switch earth fault overcurrent element Off
00011	On (SEF)	Switch sensitive earth fault element On
00012	Off (SEF)	Switch sensitive earth fault element Off
00013	On (AR)	Switch autoreclosing element On
00014	Off (AR)	Switch autoreclosing element Off
00015	On (LL)	Switch live line element On
00016	Off (LL)	Switch live line element Off

¹⁾ Trip operation is also possible when control mode is set Local.

Address	Settings	Description
00017	On (CLP)	Switch cold load pickup element On
00018	Off (CLP)	Switch cold load pickup element Off
00019	On (UV)	Switch undervoltage element On
00020	Off (UV)	Switch undervoltage element Off
00021	On (UF)	Switch underfrequency load shed element On
00022	Off (UF)	Switch underfrequency load shed element Off
00023	On (ABR)	Switch ABR element On
00024	Off (ABR)	Switch ABR element Off
00025-00030	On/Off (IO1,Outputs 1-6)	Switch IO1 Module (Outputs 1-6) On/Off
00031-00036	On/Off (IO2,Outputs 1-6)	Switch IO2 Module (Outputs 1-6) On/Off
00037	Reserved	
...
00048	Reserved	

NOTES:

- Reserved – This coil is always 0. The coil status in the response message is packed as one coil per bit of the data field. Status is indicated as: 1 = ON; 0 = OFF.
- The following conditions are necessary to perform control of IO Modules from SCADA:
 - IO mode is enabled in I/O settings;
 - IO Output# has Type equal to Disable in I/O settings;
 - IO faults are absent.

4.2 Function 02 Read Input Status**4.2.1 Description**

Reads the ON/OFF status of discrete inputs (1X references) in the slave.
Broadcast is not supported.

The query message specifies the starting coil and quantity of coils to be read.
Coils are addressed starting at zero: coils 1–16 are addressed as 0–15.

Table 4.3 - 1X references, input coils

Address	Settings	Description
GENERAL		
10001	Lockout	All AR OCEF, AR SEF, AR SEF, ABR elements are set in O1 state
10002	Remote Off	Control mode is set Local
10003	AR initiated	Any of AR OCEF, AR SEF, AR UV or ABR elements set in one of O2, O3 or O4 states
10004	Prot initiated	Logical OR of AR initiated and Pickup signals
PICKUP		
10005	Pickup	Pickup output of any of OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, EFLL, OCLL, UF, UV1, UV2, UV3 elements activated
10006	P(OC1+)	Pickup output of OC1+ activated
10007	P(OC2+)	Pickup output of OC2+ activated
10008	P(OC3+)	Pickup output of OC3+ activated
10009	P(OC1-)	Pickup output of OC1- activated
10010	P(OC2-)	Pickup output of OC2- activated
10011	P(OC3-)	Pickup output of OC3- activated
10012	P(OCLL)	Pickup output of OCLL activated
10013	P(EF1+)	Pickup output of EF1+ activated
10014	P(EF2+)	Pickup output of EF2+ activated
10015	P(EF3+)	Pickup output of EF3+ activated
10016	P(EF1-)	Pickup output of EF1- activated
10017	P(EF2-)	Pickup output of EF2- activated
10018	P(EF3-)	Pickup output of EF3- activated

Address	Settings	Description
10019	P(EFLL)	Pickup output of EFLL activated
10020	P(SEF+)	Pickup output of SEF+ activated
10021	P(SEF-)	Pickup output of SEF- activated
10022	P(UV1)	Pickup output of UV1 activated
10023	P(UV2)	Pickup output of UV2 activated
10024	P(UV3)	Pickup output of UV3 activated
10025	P(UF)	Pickup output of UF activated
10026	P(Uabc>)	Pickup output of Uabc> activated
10027	P(Urst>)	Pickup output of Urst> activated
10028	P(Uabc<)	Pickup output of Uabc< activated
10029	P(Urst<)	Pickup output of Urst< activated
OPEN		
10030	Open	PS=0 irrespective to source
10031	Open (Prot)	Open due to OC1+, OC2+, OC3+, OC1-, OC2-, OC3-, EF1+, EF2+, EF3+, EF1-, EF2-, EF3-, SEF+, SEF-, EFLL, OCLL, UF, UV1, UV2 or UV3 tripping
10032	Open (OC1+)	Open due to OC1+ tripping
10033	Open (OC2+)	Open due to OC2+ tripping
10034	Open (OC3+)	Open due to OC3+ tripping
10035	Open (OC1-)	Open due to OC1- tripping
10036	Open (OC2-)	Open due to OC2- tripping
10037	Open (OC3-)	Open due to OC3- tripping
10038	Open (OCLL)	Open due to OCLL tripping
10039	Open (EF1+)	Open due to EF1+ tripping
10040	Open (EF2+)	Open due to EF2+ tripping
10041	Open (EF3+)	Open due to EF3+ tripping
10042	Open (EF1-)	Open due to EF1- tripping
10043	Open (EF2-)	Open due to EF2- tripping
10044	Open (EF3-)	Open due to EF3- tripping
10045	Open (EFLL)	Open due to EFLL tripping
10046	Open (SEF+)	Open due to SEF+ tripping
10047	Open (SEF-)	Open due to SEF- tripping
10048	Open (UV1)	Open due to UV1 tripping
10049	Open (UV2)	Open due to UV2 tripping
10050	Open (UV3)	Open due to UV3 tripping
10051	Open (UF)	Open due to UF tripping
10052	Open (Remote)	Open due to SCADA or I/O control signal
10053	Open (SCADA)	Open due to SCADA control signal
10054	Open (I/O)	Open due to I/O control signal
10055	Open (Local)	Open due to MMI, PC control signal or manual tripping
10056	Open (MMI)	Open due to MMI control signal
10057	Open (PC)	Open due to PC control signal
10058	Open (Manual)	Open due to manual tripping (no origin discovered)
ALARM		
10059	Alarm	Alarm output of any of OC1+, OC1-, EF1+, EF1-, SEF+, SEF-, UF, UV1, UV2, UV3 elements activated
10060	A(OC1+)	Alarm output of OC1+ activated
10061	A(OC1-)	Alarm output of OC1- activated

Address	Settings	Description
10062	A(EF1+)	Alarm output of EF1+ activated
10063	A(EF1-)	Alarm output of EF1- activated
10064	A(SEF+)	Alarm output of SEF+ activated
10065	A(SEF-)	Alarm output of SEF- activated
10066	A(UV1)	Alarm output of UV1 activated
10067	A(UV2)	Alarm output of UV2 activated
10068	A(UV3)	Alarm output of UV3 activated
10069	A (UF)	Alarm output of UF activated
CLOSED		
10070	Closed	PS=1 irrespective to origin
10071	Closed (AR)	Closed due to AR OCEF, AR SEF, AR UV, ABR control signal
10072	Closed (AR OCEF)	Closed due to AR OCEF reclosing
10073	Closed (AR SEF)	Closed due to AR SEF reclosing
10074	Closed (AR UV)	Closed due to AR UV reclosing
10075	Closed (ABR)	Closed due to ABR closing
10076	Closed (Remote)	Closed due to SCADA or I/O control signal
10077	Closed (SCADA)	Closed due to SCADA control signal
10078	Closed (I/O)	Closed due to I/O control signal
10079	Closed (Local)	Closed due to MMI, PC control signal or undefined closed
10080	Closed (MMI)	Closed due to MMI control signal
10081	Closed (PC)	Close due to PC control signal
10082	Closed (undef)	Closed state recognized after On (Power) or servicing
STATUS		
10083	Prot On	Protection is switched on
10084	Group1 On	Active Group 1
10085	Group2 On	Active Group 2
10086	Group3 On	Active Group 3
10087	Group4 On	Active Group 4
10088	EF On	Earth overcurrent element is switched on
10089	SEF On	Sensitive Earth fault element is switched on
10090	UV On	Undervoltage element is switched on
10091	UF On	Underfrequency element is switched on
10092	CLP On	Cold load pickup element is switched on
10093	LL On	Live line element is switched on
10094	AR On	OC/EF, UV, SEF reclosing and ABR are switched on
10095	ABR On	Automatic backfeed restoration is switched on
MALFUNCTION		
10096	Malfunction	Any malfunction signal activated
10097	Ext load SC	External load short circuit found
10098	Driver SC	Driver short circuit found
10099	T _{bt} sensor fault	T _{Bt} sensor fault found
10100	OSM coil SC	OSM coil short circuit found
10101	Excessive T _o	Opening time (including driver registration time) exceeds 60ms: within 60ms after activation of T(E) control signal PS has been deactivated. "Excessive To" signal is deactivated when PS is deactivated or when C(E) control signal is activated.

Address	Settings	Description
10102	Excessive T _c	Closing time (including driver recognition time) exceeds 100ms: within 100ms after activation of C(E) control signal PS has not been deactivated. "Excessive T _c " signal is deactivated when PS is activated or when T(E) control signal is activated.
10103	MPM fault	Internal fault of main processing module found
10104	Driver comms err	No response from driver
10105	PSM comms error	No response from PSM (Power Supply Module)
10106	RTC comms error	No response from real time clock
10107	T _{mpm} comms error	No response from MPM temperature sensor
10108	I/O1 comms error	No response from I/O1
10109	I/O2 comms error	No response from I/O2
10110	Bus comms error	Bus comms error
10111	I/O1 fault	I/O1 internal fault found
10112	I/O2 fault	I/O2 internal fault found
WARNING		
10113	Warning	Any warning signal activated
10114	Standby	UPS controller set into wake up state
10115	Battery supply	UPS is set into Battery supply mode
10116	AC supply	UPS is set into AC supply mode
10117	Driver not ready	Driver is not ready to execute next control signal
10118	Memory error	Corrupted memory cell found
10119	OSM coil isolated	OSM coil open circuit found
IO Modules		
10120-10125	IO1 Inputs 1 - 6	IO1 Inputs1-6 signals activated
10126-10131	IO2 Inputs 1 - 6	IO2 Inputs 1-6 signals activated
10132-10137	IO1 Outputs 1 - 6	IO1 Outputs 1 - 6 signals activated
10138-10143	IO2 Outputs 1 - 6	IO2 Outputs 1 - 6 signals activated
10144	Open (AutoABR)	Open due to AutoABR tripping
10145	Closed (AutoABR)	Closed due to AutoABR reclosing
10146	Reserved	
...
10160	Reserved	

NOTE: Reserved – This coil is always 0.

4.3 Function 03 Read Holding Registers

4.3.1 Description

Read the binary contents of holding registers (4X references) in the slave. Broadcast is not supported.

The query message specifies the starting register and quantity of registers to be read. Registers are addressed starting at zero: registers 1–16 are addressed as 0–15.

4.3.2 Reading/writing of double-word (32-bits) values

Values single and three-phase total and reactive energy related to forward and reverse power flow directions are stored in the 32-bit words.

Double-word (32-bits) values are divided into two parts, a suffix "_Lo" (low-order word) or "_Hi" (high-order word).

Table 4.4 - 4X references, output registers

Address	Settings	Description
Data and time		
40001	Data and time	Data and time Lo
40002	Data and time	Data and time Hi

NOTE: Date and time are established in the seconds beginning from 1970.

4.4 Function 04 Read Input Registers

4.4.1 Description

Read the binary contents of input registers (3X references) in the slave. Broadcast is not supported.

The query message specifies the starting register and quantity of registers to be read. Registers are addressed starting at zero: registers 1–16 are addressed as 0–15.

4.4.2 Reading/writing of double-word (32-bits) values

Values single and three-phase total and reactive energy related to forward and reverse power flow directions are stored in the 32-bit words.

Double-word (32-bits) values are divided into two parts, a suffix "_Lo" (low-order word) or "_Hi" (high-order word).

Table 4.5 - 3X references, input registers

Address	Settings	Description
Phase currents		
30001	Ia	Phase currents Ia
30002	Ib	Phase currents Ib
30003	Ic	Phase currents Ic
Sequence		
30004	In	Zero sequence current
Phase to earth voltages		
30005	Ua	Phase to earth voltages Ua
30006	Ub	Phase to earth voltages Ub
30007	Uc	Phase to earth voltages Uc
30008	Ur	Phase to earth voltages Ur
30009	Us	Phase to earth voltages Us
30010	Ut	Phase to earth voltages Ut
Line to line voltages		
30011	Uab	Line to line voltages Uab
30012	Ubc	Line to line voltages Ubc
30013	Uca	Line to line voltages Uca
30014	Urs	Line to line voltages Urs
30015	Ust	Line to line voltages Ust
30016	Utr	Line to line voltages Utr
Single and three phase total, active and reactive power		
30017	A kVA	A kVA
30018	B kVA	B kVA
30019	C kVA	C kVA
30020	A kW	A kW
30021	B kW	B kW
30022	C kW	C kW
30023	A kVAr	A kVAr

Address	Settings	Description
30024	B kVAr	B kVAr
30025	C kVAr	C kVAr
30026	KVA	KVA
30027	KVAr	KVAr
30028	KW	KW
Single and three phase total and reactive energy related to forward and reverse power flow directions		
30029	A+kVA*h	A+kVA*h_Hi
30030	A+kVA*h	A+kVA*h_Lo
30031	B+kVA*h	B+kVA*h_Hi
30032	B+kVA*h	B+kVA*h_Lo
30033	C+kVA*h	C+kVA*h_Hi
30034	C+kVA*h	C+kVA*h_Lo
30035	A+kVAr*h	A+kVAr*h_Hi
30036	A+kVAr*h	A+kVAr*h_Lo
30037	B+kVAr*h	B+kVAr*h_Hi
30038	B+kVAr*h	B+kVAr*h_Lo
30039	C+kVAr*h	C+kVAr*h_Hi
30040	C+kVAr*h	C+kVAr*h_Lo
30041	+kVA*h	+kVA*h_Hi
30042	+kVA*h	+kVA*h_Lo
30043	+kVAr*h	+kVAr*h_Hi
30044	+kVAr*h	+kVAr*h_Lo
30045	A-kVA*h	A-kVA*h_Hi
30046	A-kVA*h	A-kVA*h_Lo
30047	B-kVA*h	B-kVA*h_Hi
30048	B-kVA*h	B-kVA*h_Lo
30049	C-kVA*h	C-kVA*h_Hi
30050	C-kVA*h	C-kVA*h_Lo
30051	A-kVAr*h	A-kVAr*h_Hi
30052	A-kVAr*h	A-kVAr*h_Lo
30053	B-kVAr*h	B-kVAr*h_Hi
30054	B-kVAr*h	B-kVAr*h_Lo
30055	C-kVAr*h	C-kVAr*h_Hi
30056	C-kVAr*h	C-kVAr*h_Lo
30057	-kVA*h	-kVA*h_Hi
30058	-kVA*h	-kVA*h_Lo
30059	-kVAr*h	-kVAr*h_Hi
30060	-kVAr*h	-kVAr*h_Lo
Frequency from ABC and RST		
30061	Fabc	Fabc
30062	Frst	Frst
Phase sequence from ABC and RST sides		
30063	ABC/ACB/?	ABC/ACB/?
30064	RST/RTS/?	RST/RTS/?
OC, EF, SEF power flow direction		

Address	Settings	Description
30065	OC	OC
30066	EF	EF
30067	SEF	SEF
Single phase and three phase power factor		
30068	3phase	3phase
30069	A phase	A phase
30070	B phase	B phase
30071	C phase	C phase
Lifetime counters		
30072	CO Total	CO Total
30073	Mech.wear,%	Mech.wear,%
30074	Contact wear,%	Contact wear,%
Fault counters		
30075	OC A trips	OC A trips
30076	OC B trips	OC B trips
30077	OC C trips	OC C trips
30078	EF trips	EF trips
30079	SEF trips	SEF trips
30080	UV trips	UV trips
30081	UF trips	UF trips
30082	Inmax Trip	Maximum In current prior to any OCEF elements trip
30083	Iamax Trip	Maximum phase A current prior to any OCEF element trip
30084	Ibmax Trip	Maximum phase B current prior to any OCEF element trip
30085	Icmax Trip	Maximum phase C current prior to any OCEF element trip
30086	UVmin Trip	Minimum voltage prior to any UV elements trip
30087	UFmin Trip	Minimum frequency prior to UF element trip

Table 4.6 – Measured value

Measured value	Register and Designation	Measured range	Resolution	
Phase currents, Iamax, Ibmax, Icmax Trip	Register	Description	0÷7000A	1A
	30001	Ia		
	30002	Ib		
	30003	Ic		
Phase to earth voltages	Register	Description	0÷18kV	1V
	30005	Ua		
	30006	Ub		
	30007	Uc		
	30008	Ur		
	30009	Us		
Line to line voltages	Register	Description	0-30kV	1V
	30011	Uab		
	30012	Ubc		
	30013	Uca		
	30014	Urs		
	30015	Ust		
30016	Uta			

Measured value	Register and Designation	Measured range	Resolution																																		
Zero sequence current, Inmax Trip	<table border="1"> <thead> <tr> <th>Register</th> <th>Description</th> </tr> </thead> <tbody> <tr> <td>30004</td> <td>In</td> </tr> </tbody> </table>	Register	Description	30004	In	0÷7000A	1A																														
Register	Description																																				
30004	In																																				
Single and three phase total, active and reactive power	<table border="1"> <thead> <tr> <th>Register</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>30017</td><td>A kVA</td></tr> <tr><td>30018</td><td>B kVA</td></tr> <tr><td>30019</td><td>C kVA</td></tr> <tr><td>30020</td><td>A kW</td></tr> <tr><td>30021</td><td>B kW</td></tr> <tr><td>30022</td><td>C kW</td></tr> <tr><td>30023</td><td>A kVAr</td></tr> <tr><td>30024</td><td>B kVAr</td></tr> <tr><td>30025</td><td>C kVAr</td></tr> <tr><td>30026</td><td>KVA</td></tr> <tr><td>30027</td><td>KVAr</td></tr> <tr><td>30028</td><td>KW</td></tr> </tbody> </table>	Register	Description	30017	A kVA	30018	B kVA	30019	C kVA	30020	A kW	30021	B kW	30022	C kW	30023	A kVAr	30024	B kVAr	30025	C kVAr	30026	KVA	30027	KVAr	30028	KW	0÷65535	1								
Register	Description																																				
30017	A kVA																																				
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30019	C kVA																																				
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30021	B kW																																				
30022	C kW																																				
30023	A kVAr																																				
30024	B kVAr																																				
30025	C kVAr																																				
30026	KVA																																				
30027	KVAr																																				
30028	KW																																				
Single and three phase total and reactive energy related to forward and reverse power flow directions	<table border="1"> <thead> <tr> <th>Register</th> <th>Description</th> </tr> </thead> <tbody> <tr><td>30029-30030</td><td>A+kVA*h</td></tr> <tr><td>30031-30032</td><td>B+kVA*h</td></tr> <tr><td>30033-30034</td><td>C+kVA*h</td></tr> <tr><td>30035-30036</td><td>A+kVAr*h</td></tr> <tr><td>30037-30038</td><td>B+kVAr*h</td></tr> <tr><td>30039-30040</td><td>C+kVAr*h</td></tr> <tr><td>30041-30042</td><td>+kVA*h</td></tr> <tr><td>30043-30044</td><td>+kVAr*h</td></tr> <tr><td>30045-30046</td><td>A-kVA*h</td></tr> <tr><td>30047-30048</td><td>B-kVA*h</td></tr> <tr><td>30049-30050</td><td>C-kVA*h</td></tr> <tr><td>30051-30052</td><td>A-kVAr*h</td></tr> <tr><td>30053-30054</td><td>B-kVAr*h</td></tr> <tr><td>30055-30056</td><td>C-kVAr*h</td></tr> <tr><td>30057-30058</td><td>-kVA*h</td></tr> <tr><td>30059-30060</td><td>-kVAr*h</td></tr> </tbody> </table>	Register	Description	30029-30030	A+kVA*h	30031-30032	B+kVA*h	30033-30034	C+kVA*h	30035-30036	A+kVAr*h	30037-30038	B+kVAr*h	30039-30040	C+kVAr*h	30041-30042	+kVA*h	30043-30044	+kVAr*h	30045-30046	A-kVA*h	30047-30048	B-kVA*h	30049-30050	C-kVA*h	30051-30052	A-kVAr*h	30053-30054	B-kVAr*h	30055-30056	C-kVAr*h	30057-30058	-kVA*h	30059-30060	-kVAr*h	0÷999999999	1
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Single phase and three phase power factor (see NOTE 2, 3)	Power factor: 3phase, A phase, B phase, C phase	0÷1	0.001																																		

NOTE 1: In order to obtain the value of frequency in Hz the value obtained from ModbusTEL must be multiplied by 0.001.

NOTE 2: If appears situation when it is not possible to conduct the calculation of power factor or frequency the ModbusTEL returns value equal 0x7FFF.

NOTE 3: In order to obtain the value of power factor the value obtained from ModbusTEL must be multiplied by 0.001.

4.5 Function 05 Force Single Coil

4.5.1 Description

Forces a single coil (0X reference) to either ON or OFF. When broadcast, the function forces the same coil reference in all attached slaves.

If error in the processing of broadcast request, the exception response is not formed.

The setting of coils does not occur with the appearance of exception.

The list of coils is given in Table 4.2.

NOTE 1: The setting of coil in 0 brings not any changes in the RC/TEL-01E(S).

NOTE 2: The setting of "Reserved" coil in 0 or 1 brings not any changes in the RC/TEL-01E(S).

4.6 Function 06 Preset Single Register

4.6.1 Description

Presets a value into a single holding register (4X reference). When broadcast, the function presets the same register reference in all attached slaves.

If error in the processing of broadcast request, the exception response is not formed.

The list of coils is given Table 4.4.

4.7 Function 15 (0F Hex) Force Multiple Coils

4.7.1 Description

Forces each coil (0X reference) in a sequence of coils to either ON or OFF. When broadcast, the function forces the same coil references in all attached slaves.

If error in the processing of broadcast request, the exception response is not formed.

The setting of coils does not occur with the appearance of exception.

The list of coils is given in Table 4.2.

NOTE 1: The setting of coil in 0 doesn't affect on protection algorithms in the RC/TEL-01E(S).

NOTE 2: The setting of "Reserved" coil in 0 or 1 brings not any changes in the RC/TEL-01E(S).

4.8 Function 16 (10 Hex) Preset Multiple Registers

4.8.1 Description

Presets values into a sequence of holding registers (4X references). When broadcast, the function presets the same register references in all attached slaves.

If error in the processing of broadcast request, the exception response is not formed.

The list of coils is given in Table 4.4.

5 MODBUS EXCEPTION RESPONSES

The exception response message has two fields that differentiate it from a normal response:

Function Code Field: In a normal response, the server echoes the function code of the original request in the function code field of the response. All function codes have a most-significant bit (MSB) of 0 (their values are all below 80 hexadecimal). In an exception response, the server sets the MSB of the function code to 1. This makes the function code value in an exception response exactly 80 hexadecimal higher than the value would be for a normal response.

With the function code's MSB set, the client's application program can recognize the exception response and can examine the data field for the exception code.

Data Field: In a normal response, the server may return data or statistics in the data field (any information that was requested in the request). In an exception response, the server returns an exception code in the data field, defining the server condition that caused the exception.

ModbusTEL returns three types of errors; they are given in table 5.1. With the complete list of errors possible it will become acquainted from the document of PI-MBUS-300.

Table 5.1 - MODBUS Exception Codes

MODBUS Exception Codes		
Code	Name	Meaning
01	ILLEGAL FUNCTION	The function code received in the query is not an allowable action for the slave. If a Poll Program Complete command was issued, this code indicates that no program function preceded it. This error can arise with the demand of the not supported function
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the slave. This error can arise in such a case when nonexistent data object address is used in request.
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for the slave. This error can arise during the attempt to set values at the moment when RC/TEL-01E(S) set in the Remote Off (Local) mode.
04	SLAVE DEVICE FAILURE	An unrecoverable error occurred while the slave was attempting to perform the requested action.