MODBUS-RTU Applied to the TempTrac® Control

WATER HEATER ELECTRONIC CONTROLLER

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Table of Contents

1. THIS MANUAL

This is a supplemental manual to cover the communication interface capabilities of the TempTrac® thermostatic module using Modbus RTU. This manual will provide the particulars for the TempTrac®, how the Modbus RTU protocol is implemented on the TempTrac®, and how to interface with the TempTrac®. For details on how to operate or configure the TempTrac®, please refer to the TempTrac® Manual (PV500-41).

This manual is not a complete or definitive guide to Modbus RTU communication. For detailed MODBUS and Modbus RTU information, consult other sources such as (www.modbus.org).

2. MODBUS RTU:

2.1 OVERVIEW:

Modbus RTU This is a communication over twisted pair from a Master device (also called a client) to multiple slave devices (also called servers). The master will send command to a particular slave. The slave will in turn process this command and respond to the Master. All communication is initiated by the Master. The TempTrac® is a slave device and will not “talk” until a Master device talks to it first. Modbus RTU is widely used within Building Management Systems (BMS) and Industrial Automation Systems (IAS). This wide acceptance is due in large part to Modbus RTU’s ease of use. Modbus RTU is a low level communications that contain no unit type, data scaling, or data description. Simply put, it is a list of addresses that can be read and/or written to. The type of data will have to be known by the receiving device in order for the data to be useful. Data types and available registers are usually provided as device documentation register list.

2.1.1 DEFINITIONS:

MODBUS Protocol: A messaging structure used for communication between devices, machines, sensors, and/or computers.

Modbus-RTU: (Remote Terminal Unit) Implementation of the Modbus protocol on top of a serial line with an RS-232, RS-485 or similar physical layer. The TempTrac® uses 2-wire RS-485 Physical Layer and implements Modbus RTU.

Master Device: Also known as Client, this device initiates all communication on the RS-485 network. The Master will send commands to Slave Devices.

Slave Device: Also known as Server, this device will respond only when addressed by the Master device. When the Master sends the slave a command, it will perform the command and respond back to the Master with the data requested, or if no data is required, then it will simply echo the command.

Slave Address: Each slave device in a network is assigned a unique address from 1 to 247. When the Master requests data, the first byte it sends is the Slave address. This way each slave knows after the first byte whether or not to ignore the message.

RS-485 (EIA-485): A 2 wire (twisted pair) multi drop network. Each device can send data by holding positive and negative voltage on the line and reversing polarity on the 2 wires. When no devices are transmitting, the line will be tri-state. The recommended arrangement of the wires is as a connected series of point-to-point (multi-dropped) nodes, i.e. a line or bus, not a star, ring, or multiply connected network. The number of devices that can be connected to a single line is defined in the RS-485 standard by the input impedance of 32 UNIT LOADs. The wire and circuits interfacing on this 2 wire connection is considered the PHYSICAL LAYER. (RS-485 is the same physical layer as used with BACNET MSTP.)

Line Termination: (LT) On RS-485, ideally the two ends of the cable will have a termination resistor connected across the two wires. This helps with reducing noise and interference on high speed and long line lengths. In practice, it is not needed in low speed and short line lengths. When needed, adding a 150ohm resistor across the line at the end devices will reduce electrical noise and reflections.

Biasing Resistors: One device on the RS-485 line should have biasing resistors. This holds the line in a known state when no devices are transmitting (talking). Typically this would be the Master device.

TempTrac® Implementation: Modbus RTU protocol, over RS-485 (EIA-485) physical layer using 2 wires. Each TempTrac® should be considers 1 UNIT LOAD for the network loading. The TempTrac® device do not have biasing resistors. TempTrac® will operate in slave mode and will only transmit when addressed by the Master device.

Registers: (Holding Registers) Each Register is 1 word defined as 2 bytes or 16 bits. See Table 2 for details of each Register. Holding registers are typically READ/WRITE but can be READ ONLY or WRITE ONLY. The TempTrac® uses only this type of register. All Registers are in the range of 40001-4999.

Register Numbers / Register Addresses: Modbus can be confusing when referencing registers and their addresses. Modbus documentation is not consistent and terms are used interchangeably when they have different meanings. Register Addresses always start at 0 and count up, and Register Numbers are the actual number/name of the Register. Example the first Holding Register is 40001. This would be address 0. For each data type, the address would start at 0 again. To avoid confusion, this manual will reference Register Numbers only. Any reference to a Register less than 40000 simply needs the 40000 added to it. Setpoint ST1 is Register 769 or the actual Register Number 40769. For a list of all available registers, see Table 2.

Input Registers, Discrete Inputs and Coils: MODBUS defines several types of data. The only data used by the TempTrac® is the Holding Register (40001 – 49999). The TempTrac® does not use Input Registers, Discrete Inputs or Coils.

CRC ERROR CHECKING: Modbus-RTU includes an error-checking field that is based on a Cyclical Redundancy Checking (CRC) method performed on the message contents. The CRC field checks the contents of the entire message. The CRC field contains a 16-bit value as the last 2 bytes in any message. The low-order byte of the field is appended first, followed by the high-order byte. The CRC value is calculated by the sending device, which appends the CRC to the message. The receiving device recalculated a CRC during receipt of the message, and compares the calculated value to the actual value it received in the CRC field. If the two values are not equal, the message will be ignored. Most Energy Management software packages will automatically calculate the CRC values as a normal part of the protocol.

2.2 COMMUNICATION DETAILS:

The MODBUS application data unit is built by the Master (client) that initiates a MODBUS transaction. The function indicates to the slave (server) what kind of action to perform. The function code field of a MODBUS data unit is coded in one byte. When a message is sent from a Master to a Slave device the function code field tells the Slave what kind of action to perform. The message contains information that the Slave uses to take the action defined by the function code. If no error occurs in receiving the message from the Master, the slave will respond to the Master. The response (Slave to Master) message contains the data requested, if no data was requested, it will echo the Master's command. See Figure 1 for a diagram of a successful communication. If the slave is unable to execute the command (example: invalid command, unreachable address), the message contains an error code and an exception code. See Figure 2 for diagram of an exception response. See Table 1 for a list of exception codes.

2.2.1 Normal Communication diagram

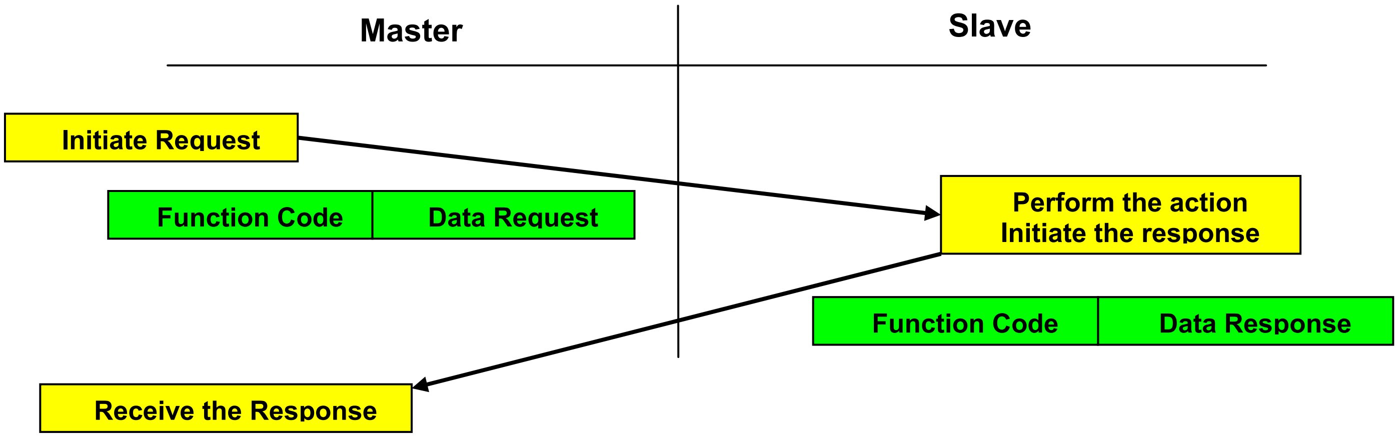

Figure 1
MODBUS Transaction (Error Free)

2.2.2 Communication with exception code

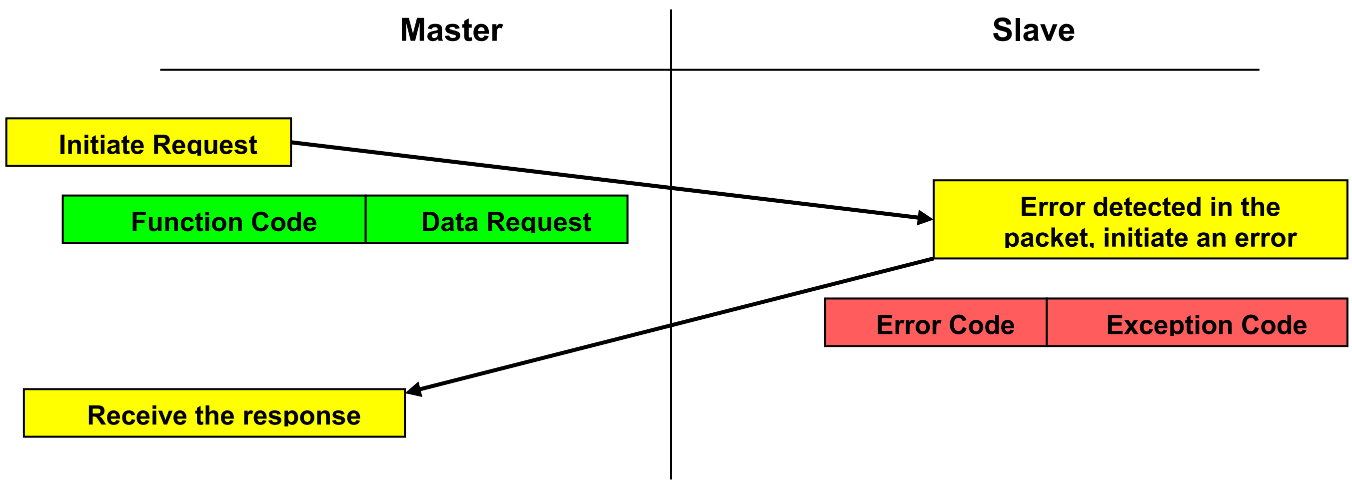

Figure 2
MODBUS Transaction (Error, Exception Code response)

2.3 SEQUENCE OF MODBUS RTU COMMAND AND RESPONSE:

1) Master (Automation System) Sends command to Slave devices (TempTrac®)
2) After transmitting, the Master turns off the line driver and listens
3) All Slave Devices receives command. (They are in listen mode)
   a) If address matches Slave address and the CRC is valid, that Slave will process command.
      i) If command was successfully processed
         (1) Slave responds with its own slave address, and echoes the command it received, and includes any data that may have been requested by the Master.
         (2) After sending, the Slave goes back to listen mode.
      ii) If command was not successfully processed
         (1) Slave will respond with and exception response and exception code indicating why it was not processed.
            (a) Possible caused would be invalid address. See Table 1 Exception Codes
         (2) After sending, The Slave goes back to listen mode.
   b) If the command received fails the CRC validation, no response is given.
   c) If the command received does not match the Slave address, no response is given.
   d) If the command is incomplete, no response is given.
   e) If no command is received, no response is given.

3. COMMANDS (MESSAGES)

Modbus standard has several commands used to access different types of data. The TempTrac® only uses the data type called Holding Registers (40001 – 49999). There are only 3 commands needed to access the Holding Registers. The Modbus specification allow reading and writing to multiple sequential registers, but the maximum number of registers that can be read or written to in one command is 5, this is a limitation of the TempTrac® device. In the following commands, the actual address will be used, the command indicates the type of register it is. For example, the first register 40001 will have address 0.

3.1 READ HOLDING REGISTERS (0x03):

Read a single register or multiple registers from the TempTrac®. Response will be the values stored in the registers.

3.1.1 MASTER COMMAND TO READ REGISTERS (0x03):

Slave Address	Function Code 0x03	Register Address (MSByte)	Register Address (LSByte)	Number of Registers (MSByte)	Number of Registers (LSByte)	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): Device address that receives the command. Range: 1-247.
Function Code: (1 byte): Code = 0x03 (Read holding register).
Register Address: (2 bytes): The address of the first register to be read, reading multiple registers is sequential.
Number of Registers: (2 bytes): Number of Elements (Registers) that the device has to return (3 = 3 Registers). No more than 5 Elements (registers) allowed. (Each register is 16 bits).
CRC: (2 bytes): CRC calculated for the frame data received and is used to verify the integrity of data received.

3.1.2 SUCCESSFUL RESPONSE, READ HOLDING REGISTERS (0x03):

Slave Address	Success echo: Code 0x03	Number of Bytes	Data 1	Data …	Data n	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): The address of the slave responding. Same as the address in the initiating command.
Function Code: (1 byte): Code = 0x03 Echo from the initiating command.
Number of Bytes: (1 byte): Defines the number of bytes followed minus the CRC.
Data: Byte data buffer, length is "Number of Bytes" long.
CRC: (2 bytes):

3.1.3 EXCEPTION RESPONSE, READ HOLDING REGISTER (0x03):

Slave Address	Exception 0x03 + 0x80 Error: 0x83	Exception Code see list	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): The address of the slave responding. Same as the address in the initiating command.
Exception Response: (1 byte): Code = 0x03 Echo from the initiating command plus high bit 0x80 = 0x83.
Exception Code: (1 byte): Defines the number of bytes followed minus the CRC. See Table 1 for explanation of exceptions.
CRC: (2 bytes):

3.2 WRITE SINGLE REGISTER (0X06):

Command to write a value to a single register. Response will be the data written.

3.2.1 MASTER COMMAND TO WRITE SINGLE REGISTER (0x06):

Slave Address	Function Code 0x06	Register Address (MSByte)	Register Address (LSByte)	Data (MSByte)	Data (LSByte)	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): Device address that receives the command. Range: 1-247.
Function Code: (1 byte): Code = 0x06 (Write single register).
Register Address: (2 bytes): The address of the register to be written to
Data: (2 bytes): The data to write.
CRC: (2 bytes): CRC calculated for the frame data received and has to be used to verify the integrity of data received.

3.2.2 SUCCESSFUL RESPONSE FROM WRITE SINGLE REGISTER (0x06)

Slave Address	Success: Code 0x06	Register Address (MSByte)	Register Address (LSByte)	Data (MSByte)	Data (LSByte)	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): The address of the slave responding. Same as the address in the initiating command.
Function Code: (1 byte): Code = 0x06 Echo from the initiating command.
Register Address: (2 bytes): The address of the register that was written.
Data: (2 bytes): Byte data buffer, will contain the same data that was sent in initiating command.
CRC: (2 bytes):

3.2.3 EXCEPTION RESPONSE FROM WRITE SINGLE REGISTER (0x06):

Slave Address	Exception 0x06 + 0x80 Error: 0x86	Exception Code see list	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): The address of the slave responding. Same as the address in the initiating command.
Exception Response: (1 byte): Code = 0x06 Echo from the initiating command plus high bit 0x80 = 0x86.
Exception Code: (1 byte): Defines the number of bytes followed minus the CRC. See Table 1 for explanation of exceptions.
CRC: (2 bytes):

3.3 WRITE HOLDING REGISTERS (0x10):

Command to write 1-5 registers. Limit is 5 registers. Response will be the number of registers written.

3.3.1 MASTER COMMAND TO WRITE HOLDING REGISTER (0x10):

Slave Address	Function Code 0x10	Register Address (MSByte)	Register Address (LSByte)	Number Registers (MSByte)	Number Registers (LSByte)	Num Byte	Data	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): Device address that receives the command. Range: 1-247.
Function Code: (1 byte): Code = 0x10 (Write holding registers 1-5).
Register Address: The address of the first register to write to.
Number of Registers: (2 bytes): Defines the number of Elements (Registers) to write to. No more than 5 Elements allowed for the TempTrac®.
Num Byte: (1 byte): Defines the number of bytes followed minus the CRC. The number of bytes has to be double the number of addressed Elements (Number of bytes = 2 x number of Registers).
Data: (Num Byte or 2 X Number of Registers): Data to be written in MSByte, LSByte order.
CRC: (2 bytes): CRC calculated for the frame data received and has to be used to verify the integrity of data received.

3.3.2 SUCCESSFUL RESPONSE FROM WRITE HOLDING REGISTERS (0x10):

Slave Address	Function Code 0x10	Register Address (MSByte)	Register Address (LSByte)	Number Registers (MSByte)	Number Registers (LSByte)	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): The address of the slave responding. Same as the address in the initiating command.
Function Code: (1 byte): Code = 0x10 Echo from the initiating command.
Register Address: (2 bytes): The address of the register that was written.
Number Registers: (2 bytes): The number of registers written.
CRC: (2 bytes):

3.3.3 EXCEPTION RESPONSE FROM WRITE HOLDING REGISTERS (0x10):

Slave Address	Error, Code 0x10 + 0x80 Error: 0x90	Exception Code, see list	CRC (LSByte)	CRC (MSByte)

Slave Address: (1 byte): The address of the slave responding. Same as the address in the initiating command.
Exception Response: (1 byte): Code = 0x10 Echo from the initiating command plus high bit 0x80 = 0x90.
Exception Code: (1 byte): Defines the number of bytes followed minus the CRC. See Table 1 for explanation of exceptions.
CRC: (2 bytes):

3.4 EXCEPTION RESPONSE:

Exceptions result from a valid packet being received by the Slave device but the slave is unable to complete the command. This can be the result of an invalid address, or a write command to a read only Register. Table 1 provides an explanation of each Exception Code and the possible cause.

Table 1

EXCEPTION CODES:

Exception Code	Name	Meaning
01	Illegal Function	The function code received in the query is not an allowable action for the slave. Only function codes 0x03, 0x06, 0x10 are valid commands.
02	Illegal Data Address	The data address received in the query is not an allowable address for the slave. More specifically, the combination of reference number and transfer length is invalid.
03	Illegal Data Value	Requesting a register that does not exist. More than 5 elements requested. Writing a parameter out of range. Writing to read only register.
04	Slave Device Failure	An unrecoverable error occurred while the slave was attempting to perform the requested action. The device didn't succeed in reading or writing requested operation. Operation (Ram, E2, RTC and etc) is not completing operation correctly.
06	Slave Device Busy	The device can't execute requested operation at this time. Busy in another analogue operation. Master has to repeat the same request at another time.

4. TEMPTRAC® REGISTERS

4.1 LIST OF REGISTERS IN THE TEMPTRAC®

Table 2

List of registers for the TempTrac® Label is the descriptive text displayed on the TempTrac® or on the terminal labels. Firm Version refers to Firmware Revision; this can be found on the label on the side of the TempTrac® or in the REL parameter.

Label	Firm Version	Description	Range X÷Y	Rev 0.3 Level	Rev 0.5 Level	Hex Add Modbus base 0	Register
							40000+
St1	0.3 & 0.5	Set point1	LS1÷US1	Pr1	Pr1	0x300	769
St2	0.3 & 0.5	Set point2	LS2÷US2	Pr1	Pr1	0x301	770
St3	0.3 & 0.5	Set point3	LS3÷US3	Pr1	Pr1	0x302	771
St5	0.3 & 0.5	Set point5 Set point 3 alternate	-20÷70°F	Pr1	Pr1	0x303	772
HY1	0.3 & 0.5	Differential for St1	-22÷22°F	Pr2	Pr2	0x304	773
LS1	0.3 & 0.5	Minimum set point1	-40°F÷SET	Pr2	Pr2	0x305	774
US1	0.3 & 0.5	Maximum set point1	SET ÷ 230°F	Pr2	Pr2	0x306	775
AC1	0.3 & 0.5	Anti-short cycle delay for output 1	0÷30 min.	Pr2	Pr2	0x307	776
S2c	0.3 & 0.5	Configuration of St2: dependent on St1 or independent	diP; ind	Pr3	Pr2	0x308	777
HY2	0.3 & 0.5	Differential for St2	-22÷22°F	Pr2	Pr2	0x309	778
LS2	0.3 & 0.5	Minimum set point2	-40°F÷St2	Pr2	Pr2	0x30A	779
uS2	0.3 & 0.5	Maximum set point2	St2 ÷ 230°F	Pr2	Pr2	0x30B	780
AC2	0.3 & 0.5	Anti-short cycle delay for output 2	0÷30 min.	Pr2	Pr2	0x30C	781
S3c	0.3 & 0.5	Configuration of St3: dependent on St1 or independent	diP; ind	Pr2	Pr2	0x30D	782
HY3	0.3 & 0.5	Differential for set point 3 St3	-22÷22°F	Pr2	Pr2	0x30E	783
LS3	0.3 & 0.5	Minimum set point 3 St3	-40°F÷St3	Pr2	Pr2	0x30F	784
uS3	0.3 & 0.5	Maximum set point 3 St3	St3 ÷ 230°F	Pr2	Pr2	0x310	785
AC3	0.3 & 0.5	Anti-short cycle delay for output 3	0÷30 min.	Pr2	Pr2	0x311	786
o3P	0.3 & 0.5	Probe selection for output 3	Pb1 / Pb2	Pr2	Pr2	0x312	787
SSE	0.3 & 0.5	Set point shift for output 3 enable disable	No; Yes	Pr2	Pr2	0x313	788
HY5	0.3 & 0.5	Differential for set point 5	-22÷22°F	Pr2	Pr2	0x314	789
Ac5	0.3 & 0.5	Anti-short cycle delay for output 3 alternate set point	0÷30 min.	Pr2	Pr2	0x315	790
AcA	0.3 & 0.5	Time delay between the St3 to St5 set point shift	0÷15 min.	Pr2	Pr2	0x316	791
	ANALOGUE OUTPUT 4÷20mA (output 4)						
S4c	0.3 & 0.5	Configuration of St4: dependent on St1 or independent	diP; ind	Pr3	Pr2	0x317	792
St4	0.3 & 0.5	Analogue output set point	-100÷100°F	Pr2	Pr2	0x318	793
SR	0.3 & 0.5	Analogue output band width	-100÷100°F	Pr2	Pr2	0x319	794
Th4	0.3 & 0.5	Outlet temperature threshold for forcing to 4ma the analog output	-40°F ÷ 230°F	Pr2	Pr2	0x31A	795
HY4	0.3 & 0.5	Differential for restart working of analog output	-45 ÷ -1 °F	Pr2	Pr2	0x31B	796
Ac4	0.3 & 0.5	Anti-short cycle delay for output 4	0÷30 min.	Pr2	Pr2	0x31C	797
PS4	0.3 & 0.5	Analog output percentage (nu=101)	0÷100, nu	Pr2	Pr2	0x31D	798
PP4	0.3 & 0.5	Analog output percentage with fault probe 1 (nu=101)	0÷100, nu	Pr3	Pr2	0x31E	799

	DYNAMIC RESET						
tt	0.3 & 0.5	Outdoor temperature threshold for dynamic reset of St1	-40÷230°F	Pr2	Pr2	0x31F	800
rr2	0.3 & 0.5	Outdoor temperature band width	-100÷100°F	Pr2	Pr2	0x320	801
rr1	0.3 & 0.5	Maximum shift of St1	-100÷100°F	Pr2	Pr2	0x321	802
tt2	0.3 & 0.5	Outdoor temperature threshold to open all the loads	-40÷230°F	Pr2	Pr2	0x322	803
Ht2	0.3 & 0.5	Differential for restart working of controller	-45 ÷ -1 °F	Pr2	Pr2	0x323	804
	DIGITAL INPUTS						
i1P	0.3 & 0.5	Digital input 1 polarity	CL÷OP	Pr3	Pr2	0x324	805
i2P	0.3 & 0.5	Digital input 2 polarity	CL÷OP	Pr2	Pr2	0x325	806
i2d	0.3 & 0.5	Digital input 2 alarm delay	0÷255 min.	Pr3	Pr2	0x326	807
i3P	0.3 & 0.5	Digital input 3 polarity	CL÷OP	Pr2	Pr2	0x327	808
i3d	0.3 & 0.5	Digital input 3 alarm delay	0÷255 min.	Pr3	Pr2	0x328	809
	DISPLAY						
cF	0.3 & 0.5	Temperature measurement unit	°C ÷ °F	Pr3	Pr2	0x329	810
rES	0.3 & 0.5	Resolution (integer/decimal point) only for °C	in ÷ de	Pr3	Pr2	0x32A	811
dS2	0.3	Default showing for display #2 Top (red)	Pb2, Pb3	Pr2		0x32B	812
dS2	0.5	Default showing for display #2 Top (red) Pb3 will display yellow EXT, Ani will display yellow Valve/M	Pb1,Pb2,Pb3,AnI		Pr2	0x32B	812
dS1	0.3	Default showing for display #1 Bottom (Yellow)	Pb1; tiM	Pr2		0x32C	813
dS1	0.5	Default showing for display #1 Bottom (Yellow) Pb3 will display yellow EXT, Ani will display yellow Valve/M	Pb1,Pb2,Pb3,AnI, TiM		Pr2	0x32C	813
	ALARMS						
Alc	0.3 & 0.5	Temperature alarms configuration: dependent on St1 or independent	rE÷Ab	Pr3	Pr2	0x32D	814
ALL	0.3	minimum temperature alarm for Pb1 (Alarm LA flash only)	-40÷230°F	Pr2	Pr2	0x32E	815
ALL	0.5	minimum temperature alarm for Pb1 (Alarm LA flash and signal on 3329)	-40÷230°F	Pr2	Pr2	0x32E	815
Alu	0.3	MAXIMUM temperature alarm for Pb1 (Alarm HA flash only)	-40÷230°F	Pr3	Pr2	0x32F	816
Alu	0.5	MAXIMUM temperature alarm for Pb1 (Alarm HA flash and signal on 3329)	-40÷230°F	Pr3	Pr2	0x32F	816
AFH	0.3 & 0.5	Differential for temperature alarm recovery	1÷45°F	Pr2	Pr2	0x330	817
ALd	0.3 & 0.5	Temperature alarm delay	0÷255 min.	Pr2	Pr2	0x331	818
dAo	0.3 & 0.5	Delay of temperature alarm at start up 1 = 10 min disp 0.1	0 ÷ 23h 50 min.	Pr2	Pr2	0x332	819
	ANALOGUE INPUTS						
oF1	0.3 & 0.5	First probe calibration	-21÷21°F	Pr3	Pr2	0x333	820
P2P	0.3 & 0.5	Second probe presence	No; Yes	Pr2	Pr2	0x334	821
oF2	0.3 & 0.5	Second probe calibration	-21÷21°F	Pr3	Pr2	0x335	822
P3P	0.3 & 0.5	Third probe presence	No; Yes	Pr2	Pr2	0x336	823
oF3	0.3 & 0.5	Third probe calibration	-21÷21°F	Pr3	Pr2	0x337	824

	TIME AND DATE						
Hur	0.3 & 0.5	Current hour	0 ÷ 23	Pr2	Pr2	0x338	825
Min	0.3 & 0.5	Current minute	0 ÷ 59	Pr2	Pr2	0x339	826
dAY	0.3 & 0.5	Current day	Sun ÷ SAt	Pr2	Pr2	0x33A	827
	ENERGY SAVING TIMES						
E1	0.3 & 0.5	Energy saving start on Sunday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x33B	828
S1	0.3 & 0.5	Energy saving stop on Sunday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x33C	829
Sb1	0.3 & 0.5	Set back temperature on Sunday	-40÷40°F	Pr2	Pr2	0x33D	830
E2	0.3 & 0.5	Energy saving start on Monday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x33E	831
S2	0.3 & 0.5	Energy saving stop on Monday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x33F	832
Sb2	0.3 & 0.5	Set back temperature on Monday	-40÷40°F	Pr2	Pr2	0x340	833
E3	0.3 & 0.5	Energy saving start on Tuesday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x341	834
S3	0.3 & 0.5	Energy saving stop on Tuesday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x342	835
Sb3	0.3 & 0.5	Set back temperature on Tuesday	-40÷40°F	Pr2	Pr2	0x343	836
E4	0.3 & 0.5	Energy saving start on Wednesday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x344	837
S4	0.3 & 0.5	Energy saving stop on Wednesday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x345	838
Sb4	0.3 & 0.5	Set back temperature on Wednesday	-40÷40°F	Pr2	Pr2	0x346	839
E5	0.3 & 0.5	Energy saving start on Thursday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x347	840
S5	0.3 & 0.5	Energy saving stop on Thursday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x348	841
Sb5	0.3 & 0.5	Set back temperature on Thursday	-40÷40°F	Pr2	Pr2	0x349	842
E6	0.3 & 0.5	Energy saving start on Friday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x34A	843
S6	0.3 & 0.5	Energy saving stop on Friday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x34B	844
Sb6	0.3 & 0.5	Set back temperature on Friday	-40÷40°F	Pr2	Pr2	0x34C	845
E7	0.3 & 0.5	Energy saving start on Saturday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x34D	846
S7	0.3 & 0.5	Energy saving stop on Saturday	0 ÷ 23h 50 min. - nu	Pr2	Pr2	0x34E	847
Sb7	0.3 & 0.5	Set back temperature on Saturday	-40÷40°F	Pr2	Pr2	0x34F	848
	WORKING HOURS						
ou1	0.3 & 0.5	working hours actual of relay 1	0÷9999 Hours	Pr1	Pr2	0x350	849
ou2	0.3 & 0.5	working hours actual of relay 2	0÷9999 Hours	Pr1	Pr2	0x351	850
ou3	0.3 & 0.5	working hours actual of relay 3	0÷9999 Hours	Pr2	Pr2	0x352	851
oP1	0.3 & 0.5	working hours limit of relay 1, Nn1 Alarm when reached	0÷9999, 0=disabled	Pr2	Pr2	0x353	852
oP2	0.3 & 0.5	working hours limit of relay 2, Nn2 Alarm when reached	0÷9999, 0=disabled	Pr2	Pr2	0x354	853
oP3	0.3 & 0.5	working hours limit of relay 3, Nn3 Alarm when reached	0÷9999, 0=disabled	Pr2	Pr2	0x355	854
	OUTPUTS SETTING						
1on	0.3 & 0.5	The output 1 force ON / OFF or Temperature regulation	rEG=2; on=1; oFF=0	Pr2	Pr2	0x356	855
2on	0.3 & 0.5	The output 2 force ON / OFF or Temperature regulation	rEG=2; on=1; oFF=0	Pr2	Pr2	0x357	856
3on	0.3 & 0.5	The output 3 force ON / OFF or Temperature regulation	rEG=2; on=1; oFF=0	Pr2	Pr2	0x358	857

	OTHER						
Adr	0.3 & 0.5	Serial address	0÷247	Pr2	Pr2	0x359	858
Ptb	0.3 & 0.5	Parameter map code always = 1	readable only	Pr2	Pr2	0x35A	859
rEL	0.3 & 0.5	Software release 5 = V0.5, 3 = V0.3	readable only	Pr2	Pr2	0x35B	860
i1S	0.5	Analog output when Digital Input 1 is activated	4-20mA		Pr2	0x35C	861
i1t	0.5	Analog output at i1S extra time if Digital Input 1 is not activated	0÷30 sec.		Pr2	0x35D	862
i1d	0.5	Digital Input 1 Alarm Delay	0÷255 min.		Pr2	0x35E	863
i1F	0.5	If Yes, Digital Input 1 will function as Alarm. Operating only when trying to call for output 1 and Input 1 is active, subject to i1d timer	No; Yes		Pr2	0x35F	864
i2F	0.5	Digital Input 2 will function only when Output 1 is energized	No; Yes		Pr2	0x360	865
i3F	0.5	Digital Input 3 will function only when Output 1 is energized, When Edi is selected, Output 1 will open when digital input 3 is activated	No; Yes; Edi		Pr2	0x361	866
oS2	0.5	Output 2 function: either temp relay or alarm relay	Std; AL		Pr2	0x362	867
(TP1)	0.3 & 0.5	Probe 1 temperature	Degrees F/C		Pr2	0x100	257
	0.3	Probe 1 Information/Status Normal=512 or 0x0200, Fault=515 or 0x0203. Fault will, drop call for heat, buz, Flash Yellow P1, light yellow valve/M	bit (0,1 on) probe failure		Pr2	0x101	258
(TP2)	0.3 & 0.5	Probe 2 temperature	Degrees F/C		Pr2	0x102	259
	0.3	Probe 2 Information/Status Normal=512 or 0x0200, Fault=515 or 0x0203. Fault will buz, Flash Red P2	bit (0,1 on) probe failure		Pr2	0x103	260
(TP3)	0.3 & 0.5	Probe 3 temperature	Degrees F/C		Pr2	0x104	261
	0.3	Probe 3 Information/Status Normal=512 or 0x0200, Fault=515 or 0x0203. Fault will buz, Flash Red P3	bit (0,1 on) probe failure		Pr2	0x105	262
	0.5	Modulation rate output (4 to 20mA)	0÷100%		Pr2	0x106	263
	0.3 & 0.5	Statas of Relay 1,2&3	bit 0,1,2		Pr2	0x801	2050
	0.3	Input 3 Alarm, buz, ALMMB, Flashes HP= 4096 or 0x0800	bit # 12 or 13th bit		Pr2	0xD00	3329
	0.3	Input 2 Alarm, buz, Flashes LP= 4096 or 0x0800	bit # 12 or 13th bit		Pr2	0xD00	3329
	0.3	Input 2 & 3, buz, Flashed HP & LP= 4096 or 0X0800	bit # 12 or 13th bit		Pr2	0xD00	3329
	0.5	Low Temperature Alarm, beep, Flash Yellow LA= 1 or 0x0001	bit # 0 or 1st bit		Pr2	0xD00	3329
	0.5	High Temperature Alarm, beep, Flash yellow HA= 2 or 0x0002	bit # 1 or 2nd bit		Pr2	0xD00	3329
	0.5	Probe 1 error, open or shorted, Drops call for heat, yel valve/M on, Flash Yellow P1=4 or 0x0004	bit # 2 or 3rd bit		Pr2	0xD00	3329
	0.5	Probe 2 error, open or shorted, Flashing red P2=256 or 0x0100	bit # 8 or 9th bit		Pr2	0xD00	3329
	0.5	Probe 3 error, open or shorted, Flashing red P3=512 or 0x0200	bit # 9 or 10th bit		Pr2	0xD00	3329
	0.5	ALARM 1 (stops heating) Input 1, beep, Flash AL1 = 1024 or 0x0400. Will recover if Input 1 goes away, or need for call for heat goes away	bit # 10 or 11th bit		Pr2	0xD00	3329
	0.5	ALARM 2 (Lockout, stops heating) Input 2, Flash AL2 & Lguage & valve= 2048 or 0x1000	bit # 11 or 12th bit		Pr2	0xD00	3329

	0.5	ALARM 3 (Lockout, stops heating) Input 3/ALMMB/ALOAF, beep, Flash AL3 & Hguage & valve (This is ALARM ON ANY FAILURE)= 4096 or 0x0800	bit # 12 or 13th bit		Pr2	0xD00	3329
	0.5	Maintenance Relay1, beep, Flash Nn1 & wrench=8192 or 0x2000 You must reset hours ou1 or set oP1=0	bit # 13 or 14th bit		Pr2	0xD00	3329
	0.5	Maintenance Relay2, beep, Flash Nn2 & wrench=16384 or 0x4000 You must reset hours ou2 or set oP2=0	bit # 14 or 15th bit		Pr2	0xD00	3329
	0.5	Maintenance Relay3, beep, Flash Nn3 & wrench=32768 or 0x8000 You must reset hours ou3 or set oP3=0	bit # 15 or 16th bit		Pr2	0xD00	3329
	0.3 & 0.5	On/Off On=257 or 0x0101, Off=1 or 0x0001 Can be used to reset ALMMB alarm by cycling OFF, wait 30 sec , ON	Low byte is mask, Hi byte is command. Bit # 0 & #8		Pr2	0x500	1281
	0.3 & 0.5	Keyboard Lock Lock=2056 or 0x0808, Unlock=8 or 0x0008. If locked PoF is displayed when keypad edit is attempted	Low byte is mask, Hi byte is command. Bit # 3 & #11		Pr2	0x500	1281
	0.3 & 0.5	Reset audible alarm when condition is corrected, 4112 or 0x1010 does not reset alarm, just stops the beeping	Low byte is mask, Hi byte is command. Bit # 3 & #12		Pr2	0x500	1281
		Energy Savings Registers are enumerated 0 to 145 w/145=n/u 10 min each with 145=nu All other enumerations start at 0 and count up					

4.2 TYPICAL PARAMETERS FOR ACCESS OVER MODBUS:

Setpoint: Modbus Register 40769
St1 Set point1,
This is the typical system setpoint. Read/Write.

Working Hours of Burner: Modbus Register 40849
ou1 working hours actual of relay 1 0÷9999 Hours
Number of hours the burner has been on. Rolls over at 9999. Read/Write.

Modbus network ID or Address. Modbus Register 40858
Adr Serial address 0÷247
This is the Modbus address. You should configure this with the keypad.

Temperature of Probes: Modbus Registers 40257, 40259, 40261
(TP1) Probe 1 temperature Degrees F (40257)
Temperature of probe #1. (Terminals 14 & 17) This is the operating probe that ST1 references. Read only.

(TP2) Probe 2 temperature Degrees F (40259)
Temperature of probe #2. (Terminals 15 & 17) Probe use and location varies by job. Reading this will return exception if probe is disabled. Read only.

(TP3) Probe 3 temperature Degrees F (40261)
Temperature of probe #3. (Terminals 16 & 17) Probe use and location varies by job. Reading this will return exception if probe is disabled. Read only.

Modulation output rate: Modbus Register 40263
Modulation rate output (4 to 20mA) 0÷100%
This parameter does not have a Label. It is the modulation rate. Note that Low Fire is 0, and High Fire is 100% on most devices.

Output Relays (Burner ON): Modbus Register 42050
Statas of Relay 1,2&3 bit 0,1,2 42050 Relay 1, (Bit 0) is the signal for burner ON.
Relay 2 & 3 are used in special applications.

Alarms: Modbus Register 43329
Alarms are contained in Register bits
Typically you will want to monitor the Alarm on any Failure:

ALARM ON ANY FAILURE
ALARM 3 (Lockout, stops heating)
Input 3 , beep, Flash AL3
The value in the register = 4096 or 0x0800, or bit # 12

Some heaters use ALARM 2 for ALARM ON ANY FAILURE
ALARM 2 (Lockout, stops heating)
Input 2, Flash AL2
The value in the register = 2048 or 0x1000 bit # 11

Other alarms to monitor:
Probe 1 error, open or shorted,
The value in the register = 4 or 0x0004, or bit # 2
Probe 2 error, open or shorted,
The value in the register = 256 or 0x0100, or bit # 8
Probe 3 error, open or shorted,
The value in the register = 512 or 0x0200, or bit # 9

CONTROL, ON/OFF (Enable/Disable) Modbus Register 41281
It has many functions that are obtained by sending a combination of bits. The only command you need is the ON/OFF.
ON=257 or 0x0101, OFF=1 or 0x0001
In the OFF state, no heating signal will be present, no alarms, all relay outputs are open, and no temperature are displayed. The display will show the word "OFF". It is still possible to read the probe temperatures and other parameters over Modbus.
This is a write only register. Reading this register will provide invalid results.

5. SERIAL CONFIGURATION

5.1 PORT SETUP

Baud Rate: 9600bps (Not adjustable)
Data Length: 8 bit (Not adjustable)
Parity: None (Not adjustable)
Stop Bits: 1 (Not adjustable)
Start/Stop: Silent interval of 3 characters minimum
Minimum Time Between Retry: 500 msec.

6. WIRING

Modbus RTU uses the same wiring practice and wire as BACNET MSTP.

6.1 TYPICAL WIRING DETAIL

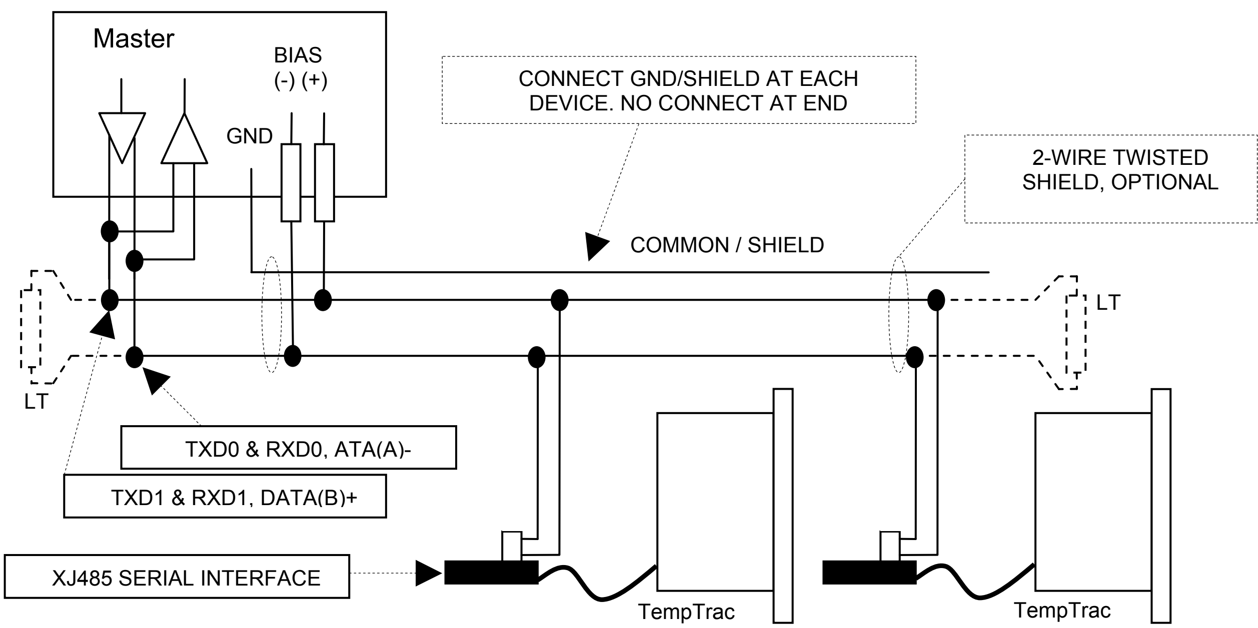

Figure 3 Wiring of a typical Modbus RTU network with TempTrac® devices

6.2 PROPER WIRING EXAMPLE

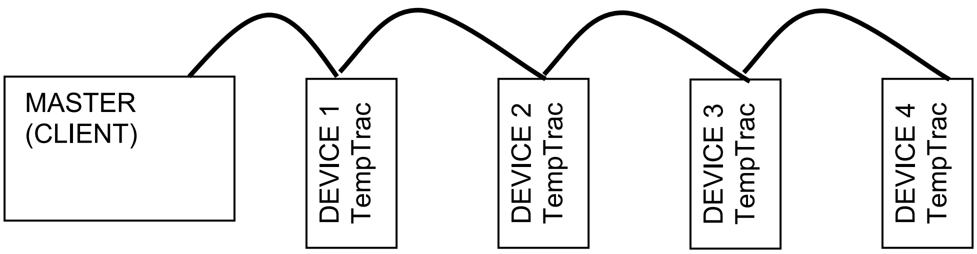

Figure 4 Correctly wired RS-485 Daisy Chain

6.3 IMPROPER WIRING EXAMPLE

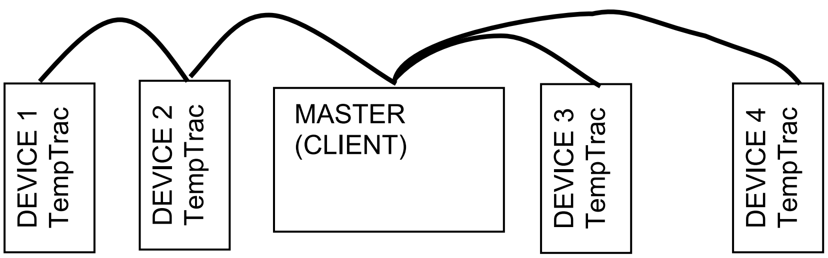

Figure 5 Wiring is not correct. Not a daisy chain and the master is not at an end.

6.4 LINE TERMINATION (LT)

Termination resistors are only required on very long cable runs. A reflection in a transmission line is the result of an impedance discontinuity that a travelling wave sees as it propagates down the line. To minimize the reflections from the end of the RS485-cable, place a Line Termination near each of the 2 ends of the Bus. It is important that the line be terminated at both ends since the propagation is bi-directional, but it is not allowed to place more than 2 LTs on one passive balanced pair.

- Each line termination must be connected between the two conductors of the balanced line: D0 and D1.
- Line termination may be a 150 ohms value (0.5 W) resistor.
- With cable lengths less than 2000', at 9600 baud, reflection is not an issue and does not require LT resistors.

6.5 LINE BIASING

When there is no data activity on an RS-485 balanced pair, the lines are not driven and thus susceptible to external noise or interference. To insure the line is in a known state when the line is not active, one or more devices on the network can provide line biasing by pulling up and down the lines with week resistors. It is common practice for the Master device to provide line biasing. This is generally a jumper setting on the device. The TempTrac® does not have line biasing resistors.

- Data(B)+ will be pulled to positive
- Data(A)- will be pulled to negative

6.6 SERIAL INTERFACE XJ485

The XJ485 serial termination is a factory supplied RS485 to TTL connection device. The TempTrac® control comes standard with a TTL communication port also used as the HOT KEY programming interface. The termination points are labelled as (+ and –) corresponding to (D1 and D0).

7. REFERENCES

7.1.1 MODBUS INFORMATION:

This document is not intended to be a comprehensive guide for application or installation of a MODBUS solution. The following are some additional resources regarding Modbus:

- ANSI/TIA/EIA-232 Interface between data terminal equipment and data circuit-terminating equipment employing serial binary data interchange.
- ANSI/TIA/EIA-485 Electrical characteristics of generators and receivers for use in balanced digital multipoint systems.
- MODBUS.org MODBUS applications protocol specification.

7.1.2 APPLICATION DETAILS AND SENSOR LOCATIONS:

The TempTrac® is used in multiple devices with several configurations. Application and configuration information for the TempTrac® as it is applied to your device can be found in the I & O Manual of the device.

7.1.3 TEMPTRAC® FEATURES:

General features and programing of the TempTrac® can be found in the TempTrac® manual (PV500-40). Advanced features can be found in the Advance TempTrac® manual (PV500-41).

7.1.4 MORE INFORMATION:

For additional information, contact the PVI Industries Customer Service Dept. at 800-784-8326.