

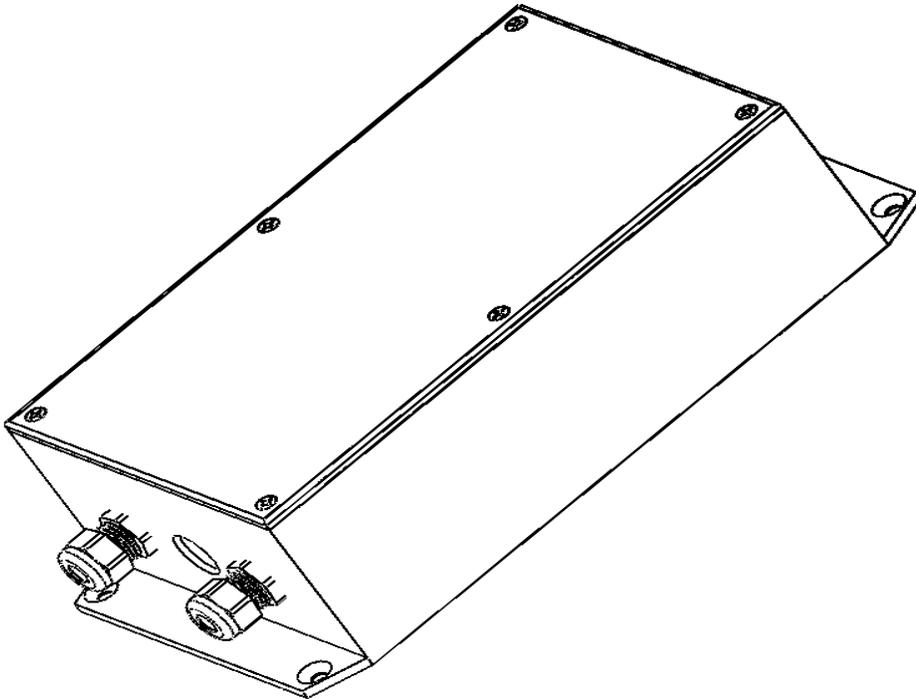


# MODBUS

**INSTALLATION**

**TROUBLESHOOTING**

**MOD BUS Models  
7350P-629**



**FOR USE WITH MODCON, MODCON VWH, PIONEER, VERSA-FLAME**

**MANUFACTURED ON OR AFTER JULY 1, 2011**

**FOR USE WITH ELITE, ELITE VWH**

**MANUFACTURED ON OR AFTER AUGUST 1, 2011**

**NOTICE:** *HTP reserves the right to make product changes or updates without notice and will not be held liable for typographical errors in literature.*

**NOTE TO CONSUMER: PLEASE KEEP ALL INSTRUCTIONS FOR FUTURE REFERENCE.**

## SPECIAL ATTENTION BOXES

The following defined terms are used throughout this manual to bring attention to the presence of hazards of various risk levels or to important information concerning the product.

### **DANGER**

**DANGER** indicates an imminently hazardous situation which, if not avoided, will result in death or serious injury.

### **WARNING**

**WARNING** indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

### **CAUTION**

**CAUTION** indicates a potentially hazardous situation which, if not avoided, may result in minor or moderate injury.

### **CAUTION**

**CAUTION** used without the safety alert symbol indicates a potentially hazardous situation which, if not avoided, may result in property damage.

## FOREWORD

This manual provides guidelines for the use and installation of the Modbus communication system with HTP appliances.

## FOR THE INSTALLER

The installer should be guided by the instructions furnished with the Modbus, local codes and utility company requirements. Preference should be given to codes and requirements where they differ from the furnished instructions.

Additional publications which should guide the installer include:

The latest version of the National Electrical Code, NFPA No. 70.

In Canada, refer to Canadian Electrical Code C 22.1, from Canadian Standards Association, 5060 Spectrum Way, Suite 100, Mississauga, Ontario, Canada L4W 5N6.

## TABLE OF CONTENTS

<b>PART 1 - GENERAL INFORMATION.....</b>	<b>3</b>
A. WHAT'S IN THE BOX.....	4
B. MINIMUM SYSTEM REQUIREMENTS .....	4
C. DEFINITIONS.....	4
<b>PART 2 - INSTALLATION .....</b>	<b>5</b>
A. WIRING REQUIREMENTS .....	5
B. JUMPER SETTING .....	6
<b>PART 3 – COMMUNICATION CONFIGURATION (APPLIANCES WITH A 3 CHARACTER RED LED DISPLAY) .....</b>	<b>7</b>
A. MODBUS ENABLE.....	7
B. MODBUS ADDRESS.....	7
C. BAUD RATE .....	7
D. PARITY AND STOP BITS .....	8
<b>PART 4 – COMMUNICATION CONFIGURATION (APPLIANCES WITH AN LCD TEXT DISPLAY).....</b>	<b>8</b>
A. MODBUS ENABLE.....	8
B. MODBUS ADDRESS.....	8

C. BAUD RATE ..... 9

D. PARITY AND STOP BITS ..... 9

**PART 5 – GENERAL MODBUS INFORMATION ..... 9**

A. DATA TRANSMISSION MODE ..... 9

B. MODBUS BOARD DIAGNOSTICS..... 9

C. MODBUS COMMUNICATION..... 10

D. MODBUS FUNCTION SET ..... 10

E. MODBUS EXCEPTION CODES ..... 11

**PART 6 - REGISTER MAP ..... 11**

A. PRIMARY DATA TABLES ..... 11

B. APPLIANCE MEMORY MAP..... 11

C. BLOCKING CODES ..... 13

D. LOCKOUT CODES ..... 14

E. STATUS CODES..... 14

F. CONFIGURATION BITS..... 14

**PART 7 - APPLIANCE OPERATION..... 15**

A. APPLIANCE OPERATION WITH MODBUS COMMUNICATIONS ..... 15

B. EXAMPLE #1..... 15

C. EXAMPLE #2 ..... 15

**1. SEND FIRING RATE COMMAND FROM MASTER ..... 15**

**2. SEND TEMPERATURE COMMAND FROM MASTER..... 16**

D. EXAMPLE #3 – HOT WATER GENERATION ..... 16

E. CASCADE ..... 16

F. RATE AND TEMPERATURE CONVERSIONS ..... 17

G. APPLIANCE STATUS CODES ..... 19

**PART 8 - TROUBLESHOOTING ..... 19**

A. PHYSICAL LAYER ..... 19

B. COMMUNICATIONS ..... 19

C. LED DIAGNOSTICS..... 19

D. MODBUS ERROR CODES ..... 19

**INSTALLATION AND MAINTENANCE NOTES..... 20**

**HTP CUSTOMER INSTALLATION RECORD FORM..... 21**

**PART 1 - GENERAL INFORMATION**

Modbus communication systems utilize a master-follower format where connected HTP appliances follow commands from a building management system or other Modbus master device linked over an RS-485 serial connection.

**CAUTION**

If any system component(s) is/are exposed to the following, do not operate until the affected component(s) has/have been inspected by a qualified serviceman.

- 1. FIRE
- 2. DAMAGE
- 3. SUBMERSION IN WATER

## CAUTION

Any claims for damage or shortage in shipment must be filed immediately against the transportation company by the consignee.

### **A. WHAT'S IN THE BOX**

1. One MODBUS Adapter
2. One bag of mounting hardware
3. One mounting template

### **B. MINIMUM SYSTEM REQUIREMENTS**

1. A Modbus master device, such as a Building Automation System (BAS) or computer with Modbus master software, and an RS-485 serial port or USB port with a converter to RS-485.
2. HTP Modbus adapter (this kit), and an HTP appliance/water heater equipped with a control with firmware revision MTSA-P110414 or greater. To determine whether your product is compatible with this adapter, refer to Figure 1.
3. Shielded twisted pair communication cable.

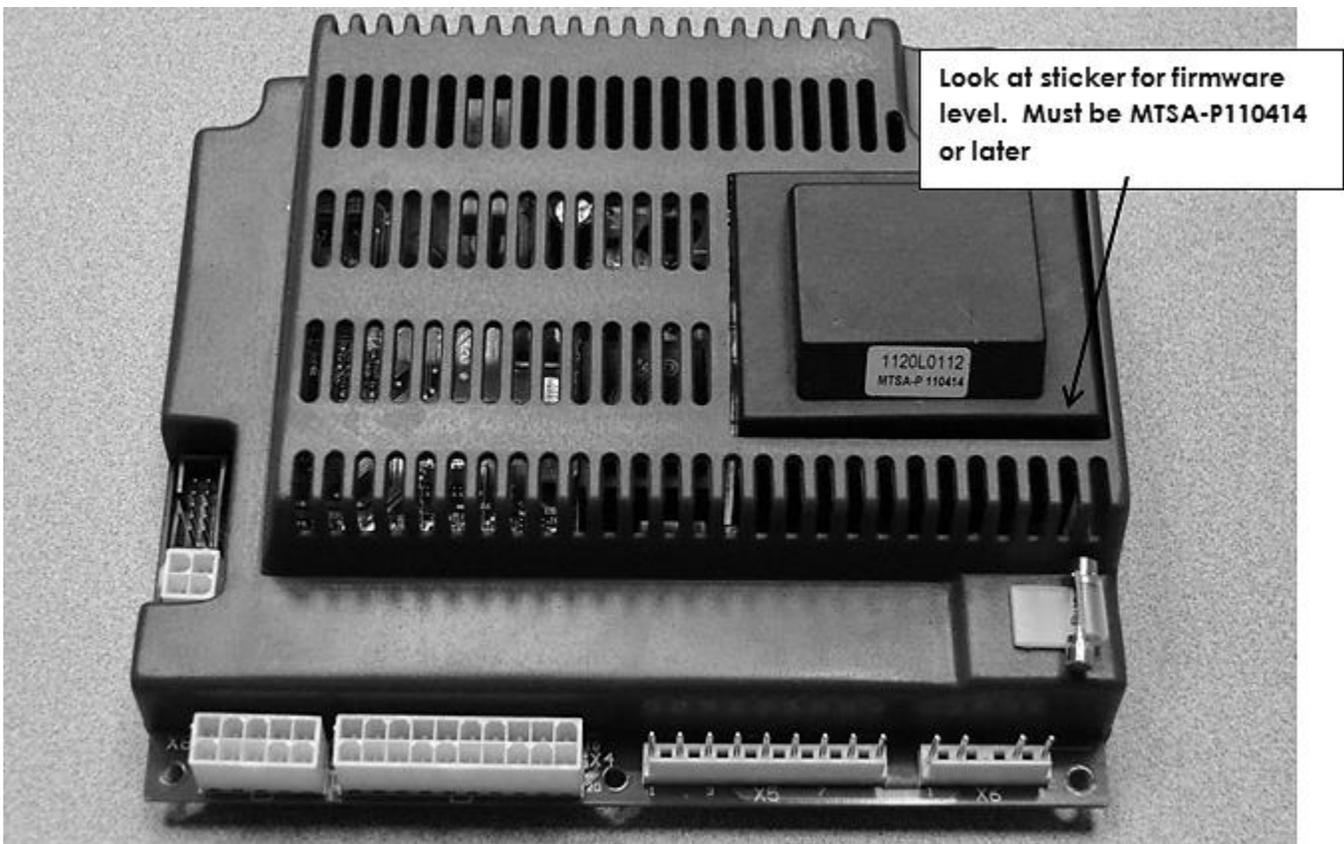


Figure 1 – Controller Revision Label Location

### **C. DEFINITIONS**

Table 1 is a list of definitions used throughout this manual.

ABBREVIATION OR ACRONYM	DEFINITION
ASCII	American Standard Code for Information Interchange
BAS	Building Automation System
Baud (Baud Rate)	Number of data bits transmitted per second (bps)
BMS	Building Management System
EMS	Energy Management System
FDX	Full-Duplex
HDX	Half-Duplex
Hex	Hexadecimal Number (0-9, A-F)
I/O Box	Input/Output
LSB	Least Significant Byte

Modbus	A serial, half-duplex transmission protocol developed by AEG Modicon
MSB	Most Significant Byte
RS232	RS232 serial, full-duplex (FDX) transmission of data standard
RS485	RS-485 serial transmission of data standard
RTU	Remote Terminal Unit
PG	Industry Standard liquid-tight wiring entry connector
MB	MODBUS

**Table 1 – Acronym definitions**

## PART 2 - INSTALLATION

The Modbus adapter should be mounted to a solid surface. The adapter has two tabs with four mounting holes designed specifically for this purpose.

### CAUTION

Use the mounting screws provided with the adapter. Damage to Modbus adapter or appliance due to installation with other mounting screws IS NOT covered by warranty.

When mounting the unit, keep in mind that the top cover must be removed to connect the Modbus communication cable, and that the appliance communication wire must reach the control inside the appliance.

The Modbus adapter can be mounted on the side of the appliance OR the wall next to the appliance, as long as care is taken to avoid components behind the mounting surface. The mounting location must be within 3 feet of the appliance controller in order to be plugged into the controller programming port.

**NOTE:** It is not recommended to install the Modbus adapter inside the appliance housing. Doing so may affect appliance operation or damage the Modbus adapter.

### CAUTION

Damage to Modbus adapter or appliance due to improper installation IS NOT covered by warranty.

### A. WIRING REQUIREMENTS

#### RS-485 Communication Bus

- Maximum length: 1000 feet
- Cable specification: 24 AWG / A,B (twisted pair) and GND shielded, with characteristic impedance: 120 ohm
- Maximum load: 32 units (32 nodes)

Wires will be passed through the PG connector on the side of the adapter, then connected to the three position connector marked "X5" on the circuit board inside the adapter. A label is provided inside the adapter to ensure proper connections of A, B, and GND. Two wires (MB IN and MB OUT) may be attached to each X5 screw.

See Figure 2 for an example wiring diagram.

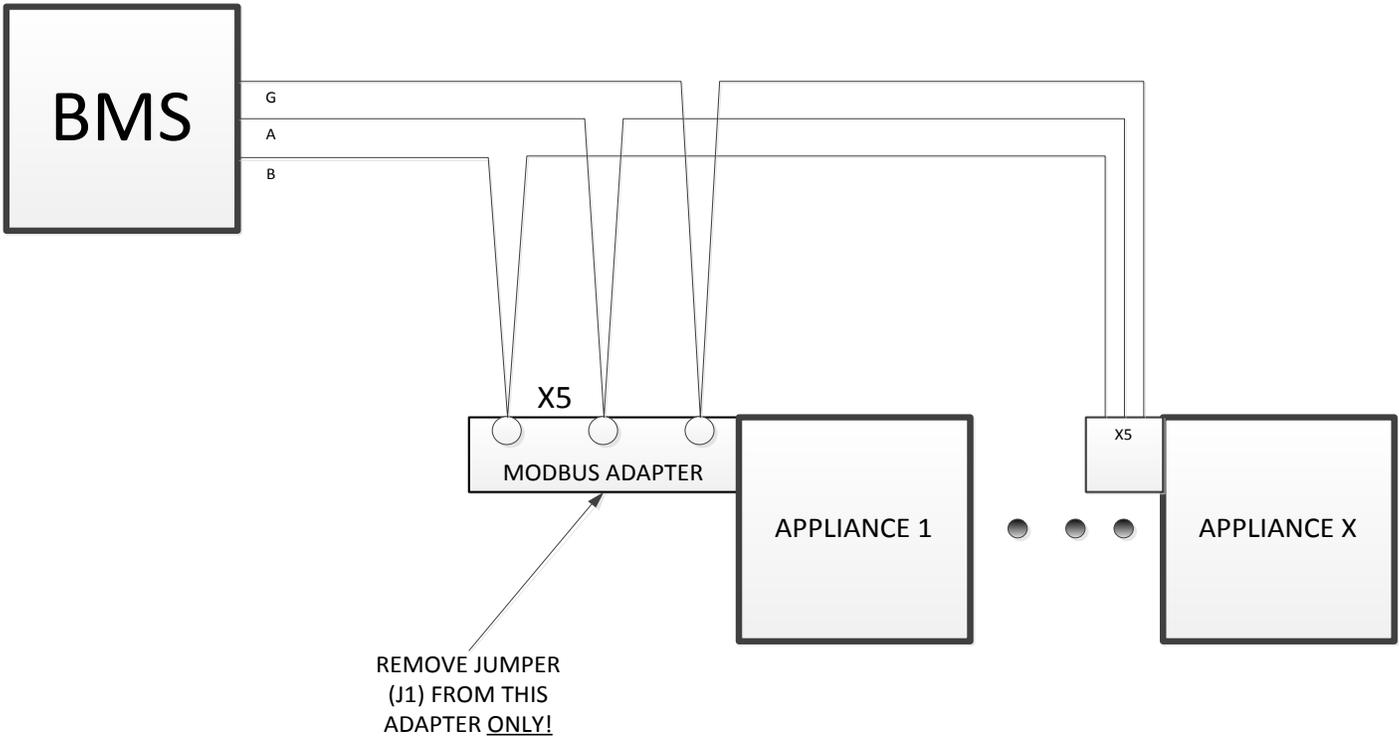


Figure 2 – Jumper Configurations in a Modbus Network

**B. JUMPER SETTING**

The appliance display handles most of the Modbus adapter configuration. There is one jumper on the Modbus adapter. When this jumper is in place (factory default) it connects a termination resistor across the data lines of the RS-485 connection. Leave the jumper in if the Modbus adapter is at the end of the RS-485 bus. Remove the jumper if the Modbus adapter is one of many connections and not at the end of the bus. See Figures 2 and 3.

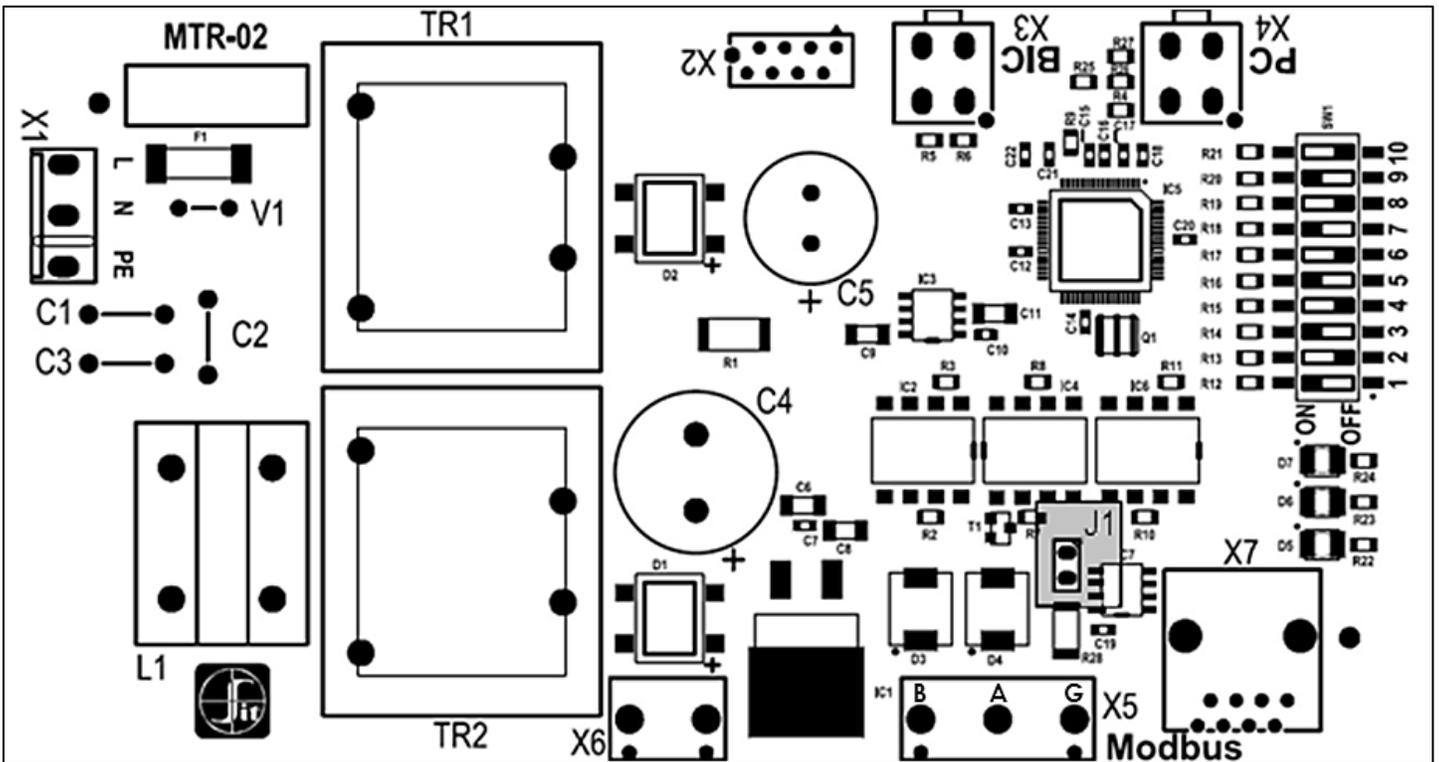


Figure 3 – Modbus Termination Jumper Location (Highlighted in Grey)

## PART 3 – COMMUNICATION CONFIGURATION (APPLIANCES WITH A 3 CHARACTER RED LED DISPLAY)

### A. MODBUS ENABLE

1. Press and hold **ENTER** and **RESET** simultaneously. Use the **UP** and **DOWN** arrows to show 925 on the display, then press and hold **ENTER** to enter the installer menu.

2. Once in the Installer Menu, use the **ENTER** button to navigate to Parameter 37. When at Parameter 37, use **UP** or **DOWN** select the desired setting from the table below:

Parameter	Setting	Description
37	0	MODBUS "DISABLED" (factory default)
37	1	MODBUS "ON"
37	2	MODBUS "AUTO" (enables automatic detection of a PC or Adapter)

**Table 2 – Parameter 37 Settings**

Please do not leave the Installer Menu after making this selection. Configure the Address, Baud Rate, and Parity settings described below.

### B. MODBUS ADDRESS

**NOTE:** Modbus must be enabled on the appliance as outlined above for the following parameters to be viewed and changed.

The Modbus address space is comprised of 256 addresses. These are defined as follows:

- Address 0 is a broadcast address. The master can send data to address 0 and all followers will process the data.
- Addresses 1 – 247 are free to be assigned to Modbus devices on the bus. Each address can be assigned to only one Modbus device on the bus.
- Addresses 248 – 256 are not available for use.

#### **MODBUS ADDRESSING SUGGESTIONS\***

- **Each device must have a unique address.**
- **It is not recommended to use 1 as an address, as this is often the default address for various other Modbus devices that may be on the bus.**
- **In order to keep track of addresses for future maintenance purposes, record all device addresses in the Installation and Maintenance Notes section included in this manual.**

**\*SAVE THIS DOCUMENT IN A SECURE LOCATION FOR FUTURE REFERENCE.**

To set the Modbus adapter address in the appliance installer menu:

From the Installer Menu, press the **ENTER** key to advance to Parameter 38. Use the **UP** and **DOWN** arrows to set the desired address. Press the **RESET** button to store the address.

Press the **DOWN** button to advance to Parameter 39 - Baud Rate.

### C. BAUD RATE

The baud rate (communication speed) can be set to either 9600 or 19200 baud. All HTP appliances, as well as any other device on the same bus and the Modbus master, must have the same baud rate setting. Select the highest baud rate that offers the most reliable communication performance over the bus.

Some things that can affect communications are:

- Long wire runs
- Wire quality
- A noisy electrical environment
- The number of devices on the bus.

These conditions may require using a lower baud rate.

Use the **UP** and **DOWN** buttons to select the desired setting from the table below:

Parameter	Setting	Description
39	0	BAUD RATE = 9600 (factory default)
39	1	BAUD RATE = 19200

**Table 3 – Parameter 39 Settings**

Press **RESET** to store the baud rate. Press the **DOWN** button to advance to Parameter 40 - Parity and Stop Bits.

### **D. PARITY AND STOP BITS**

The parity/stop bits parameter of the Modbus adapter must be set to match the rest of the devices on the bus. Although it is common to set serial devices to use no parity, setting the parity to even or odd may improve communications reliability on all connected devices on the bus.

This parameter has 4 possible selections which should be sufficient to establish communication with other devices. These selections are outlined in Table 4.

Parameter	Setting	Description
40	0	No parity 1 stop bit (factory default)
40	1	No parity 2 stop bits
40	2	Even parity 1 stop bit
40	3	Odd parity 1 stop bit

**Table 4 – Parameter 40 Settings**

Press and Hold the **RESET** button to store all parameters and exit the Installer Menu.

## **PART 4 – COMMUNICATION CONFIGURATION (APPLIANCES WITH AN LCD TEXT DISPLAY)**

### **A. MODBUS ENABLE**

1. Press and hold the **ENTER** key until you see the screen at right.

ENTER MENU CODE 925
------------------------

Use the **RIGHT** arrow to select a character, then use the **UP** and **DOWN** arrows to select the desired character value. **RIGHT** arrow over to the next character and repeat the selection. Once you have 925 on the screen, press and hold **ENTER** on the display to enter the Installer Menu.

2. Once in the Installer Menu, use the **RIGHT** arrow to navigate to Parameter 37. When at Parameter 37, press **ENTER**. The current setting should be flashing. Press **UP** or **DOWN** to select the desired setting from Table 5:

Parameter	Setting	Description
37	OFF	MODBUS "DISABLED" (factory default)
37	ON	MODBUS "ON"
37	AUTOMATIC	MODBUS "AUTO" (enables automatic detection of a PC or Adapter)

**Table 5 – Parameter 37 Settings**

#### **FUNCTION 37**

MODBUS MODE OFF	37
--------------------	----

Press **ENTER** once the desired setting is flashing on the display. Once accepted, the selection should not flash.

Please do not leave the Installer Menu. Configure the Address, Baud Rate, and Parity settings described below.

### **B. MODBUS ADDRESS**

**NOTE:** Modbus must be enabled on the appliance as outlined above for the following parameter to be viewed and changed.

The Modbus address space is comprised of 256 addresses. These are defined as follows:

- Address 0 is a broadcast address. The master can send data to address 0 and all followers will process the data.
- Addresses 1 – 247 are free to be assigned to Modbus devices on the bus. Each address can be assigned to only one Modbus device on the bus.
- Addresses 248 – 256 are not available for use.

#### **MODBUS ADDRESSING SUGGESTIONS\***

- **Each device must have a unique address.**
- **It is not recommended to use 1 as an address, as this is often the default address for various Modbus devices.**
- **In order to keep track of addresses for future maintenance purposes, record all device addresses in the Installation and Maintenance Notes section, included in this manual.**

**\*SAVE THIS DOCUMENT IN A SECURE LOCATION FOR FUTURE REFERENCE.**

In the Installer Menu, press **RIGHT** to advance to Parameter 38.

#### **FUNCTION 38**

MODBUS ADDRES 0	38
--------------------	----

Press **ENTER**. The address value will blink. Use the UP and DOWN arrows to set the desired address. Press **ENTER** again to accept your selection (and stop the display from

blinking).

Press the **RIGHT** button to advance to Parameter 39 - Baud Rate.

### **C. BAUD RATE**

The baud rate (communication speed) can be set to either 9600 or 19200 baud. All HTP appliances, as well as any other device on the same bus and the Modbus master, must have the same baud rate setting. Select the highest baud rate that offers the most reliable communication performance over the bus.

Some things that can affect communications are:

- Long wire runs
- Wire quality
- A noisy electrical environment
- The number of devices on the bus

These conditions may require using a lower baud rate.

#### **FUNCTION 39**

MODBUS SPEED	
009600	39

Press **ENTER**. The baud rate number will blink. Use the **UP** and **DOWN** arrows to toggle between 009600 and 019200. Press **ENTER** again to select the baud rate and stop the display from blinking.

Press **DOWN** to advance to Parameter 40 - Parity and Stop Bits.

### **D. PARITY AND STOP BITS**

The parity/stop bits parameter of the Modbus adapter must be set to match the rest of the devices on the bus. Although it is common to set serial devices to use no parity, setting the parity to even or odd may improve communications reliability on all connected devices on the bus.

This parameter has 4 possible selections which should be sufficient to establish communication with other devices. These selections are outlined in Table 6.

PARAMETER 40 SETTING TEXT DISPLAY	PARITY / STOP BITS
1 ST	No parity 1 stop bit
2 ST	No parity 2 stop bits
E PA	Even parity 1 stop bit
O PA	Odd parity 1 stop bit

**Table 6 – Parameter 40 Settings**

#### **FUNCTION 40**

MODBUS STOP/PARITY	
1 ST	40

Press **ENTER**. The STOP/PARITY value will blink. Use the **UP** and **DOWN** arrows to toggle between 1 ST, 2 ST, E PA, and O PA. Make your selection based on the table above. Press **ENTER** again to select the STOP/PARITY value and stop the display from

blinking.

Configuration is now complete. Press **RESET** to permanently store ALL the Modbus settings.

## **PART 5 – GENERAL MODBUS INFORMATION**

### **A. DATA TRANSMISSION MODE**

Many Modbus master devices can be configured to transmit data in either RTU or ASCII modes. Since RTU messages use fewer data bits and are more efficient, RTU has been chosen for all communication with the Modbus adapter. Please ensure that the master device is configured for RTU communications.

### **B. MODBUS BOARD DIAGNOSTICS**

The Modbus board is equipped with three LEDs for visual diagnostics: Two yellow and one green. These LEDs are located under the Modbus cover. One yellow LED (D5) is used to indicate reception of data. The other yellow LED (D6) is used to indicate transmission of data. The green LED (D7) shows internal faults. See Figure 4 for LED locations.

Internal Faults (Green LED):

- Normal Operation = 1 second on, 1 second off
- Controller Fault = Continuously on
- No Burner Control Communication = 0.5 seconds on, 1.5 seconds off
- No Modbus Communication = 1.5 seconds on, 0.5 seconds off

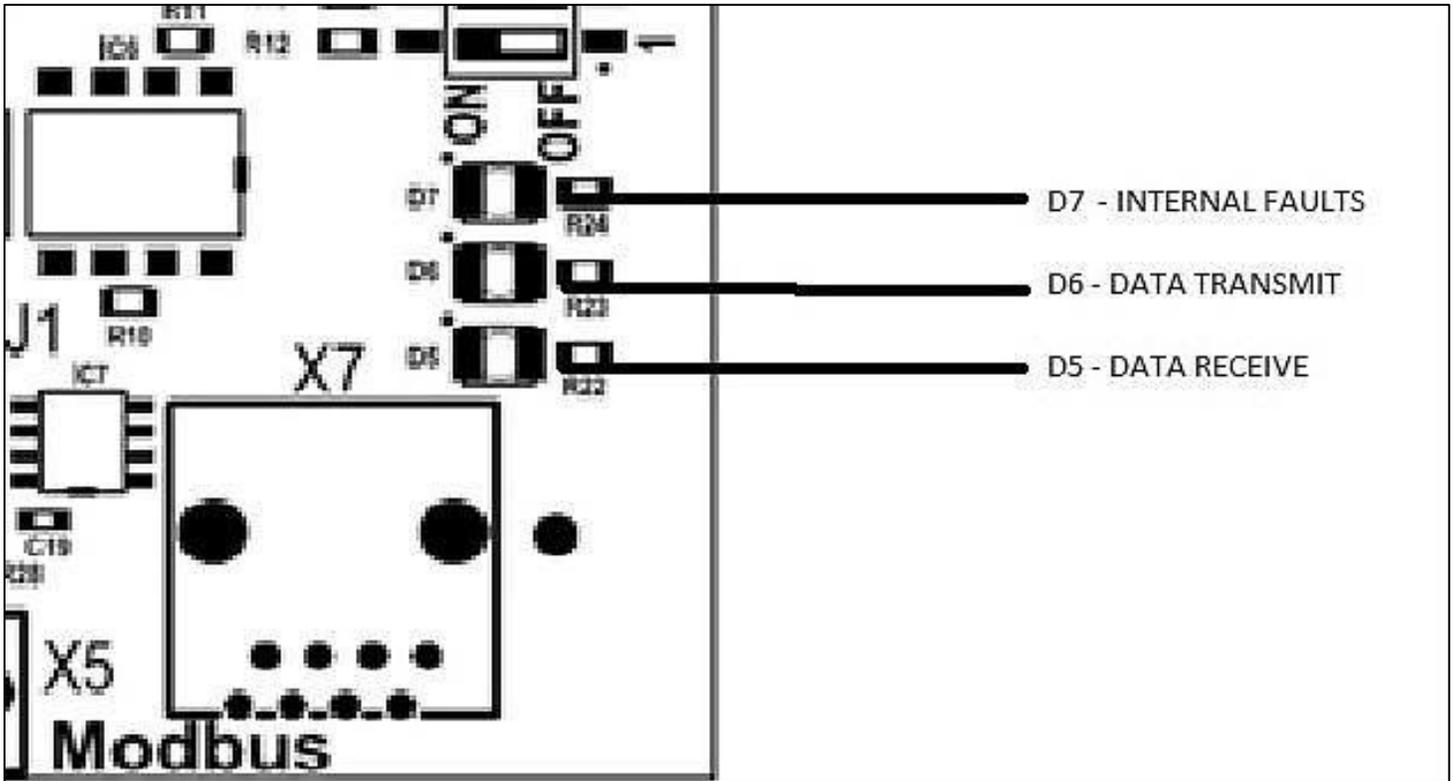


Figure 4 – Modbus Diagnostic LEDs

**C. MODBUS COMMUNICATION**

The Modbus communication commands can be found in Parts 3 and 4 of this manual, and exception codes supported by the communication board can be found in Part 5, Section E.

**D. MODBUS FUNCTION SET**

FUNCTION		SUB FUNCTION	HEX	DESCRIPTION
DEC	HEX	DEC		
1	01			Read coil status
2	02			Read input status
3	03			Read holding registers
4	04			Read input registers
5	05			Force single coil
6	06			Preset single register
7	07			Read exception status
8	08	0	00	Diagnostic – Return query data
		1	01	Diagnostic – Restart communication
		2	02	Diagnostic – Return diagnostic register
		4	04	Diagnostic – Force listen mode
		10	0A	Diagnostic – Clear counters and diagnostic registers
		11	0B	Diagnostic – Return bus message count
		12	0C	Diagnostic – Return bus exception error count
		13	0D	Diagnostic – Bus exception error count
		14	0E	Diagnostic – Return follower message count
		15	0F	Diagnostic – Return communication error count
		16	10	Diagnostic – Return follower NAK count

FUNCTION		SUB FUNCTION	HEX	DESCRIPTION
DEC	HEX	DEC		
		17	11	Diagnostic – Return follower busy count
		18	12	Diagnostic – Return bus character overrun count
		20	14	Diagnostic – Clear overrun counter and flag
11	0B			Get communication event counter
12	0C			Get communication event log
15	0F			Write multiple coils
16	10			Write multiple registers
17	11			Report follower ID
22				Mask write register
23	17			Write multiple registers
24				Read FIFO Queue

Table 7 – Modbus function set

**E. MODBUS EXCEPTION CODES**

CODE	NAME	MEANING
01	ILLEGAL FUNCTION	This code is received when an illegal action is entered into the building management system. This may be because the function code is only applicable to newer devices, or the follower device is in the wrong state to process a request of this type.
02	ILLEGAL DATA ADDRESS	This code is received when an illegal data address is entered into the building management system. More specifically, the combination of reference number and transfer length is invalid.
03	ILLEGAL DATA VALUE	This code indicates that an illegal value has been entered into the building management system.
04	FOLLOWER DEVICE FAILURE	An error occurred while the follower was attempting to perform the requested action.
05	ACKNOWLEDGE	Indicates that the server (or follower) has accepted the request, but will take a significant amount of time to process it. This response prevents a timeout error.
06	FOLLOWER DEVICE BUSY	This is received when a follower device is busy processing a programmed command. User should query this device at a later time.
08	MEMORY PARITY ERROR	The server (or follower) attempted to read a file, but detected a parity error in the memory. The user can retry the request, but service may be necessary to fix this error.
0A	GATEWAY PATH UNAVAILABLE	Indicates that the gateway was unable to allocate an internal communication path from the input port to the output port.
0B	GATEWAY TARGET DEVICE FAILED TO RESPOND	Specialized use in conjunction with gateways - indicates that no response was obtained from the target device. Usually means that the device is not present on the network.

Table 8 – Modbus exception codes

**PART 6 - REGISTER MAP****A. PRIMARY DATA TABLES**

TABLE	DATA TYPE	READ/WRITE	DESCRIPTION
Discrete Inputs	Single bit	Read only	Data can be provided by an I/O system.
Coils	Single bit	Read / Write	Data can be altered by an application program.
Input Registers	16-bit word	Read only	Data can be provided by an I/O system.
Holding Registers	16-bit word	Read / Write	Data can be altered by an application program.

Table 9 – Supplementary information

**B. APPLIANCE MEMORY MAP**

ADDRESS	DESCRIPTION	DEFAULT	UNIT	MIN	MAX	RESOLUTION
COILS						
00001	Appliance enable / Room thermostat / Stage 1	0	1 = on, 0 = off	0	1	1
00005	Tank thermostat	0	1 = on, 0 = off	0	1	1
00006						

DISCRETE INPUTS						
ADDRESS	DESCRIPTION	DEFAULT	UNIT	MIN	MAX	RESOLUTION
10001	Manual reset high limit 1	0	1 = on, 0 = off	0	1	1
10002	Flow switch 1	0	1 = on, 0 = off	0	1	1
10003	Gas pressure switch 1	0	1 = on, 0 = off	0	1	1
10004	Louver switch 1 (NOT USED)	0	1 = on, 0 = off	0	1	1
10005	Air pressure switch / flap valve	0	1 = on, 0 = off	0	1	1
10006	Blocked drain switch	0	1 = on, 0 = off	0	1	1
10007	Auto reset high limit 1	0	1 = on, 0 = off	0	1	1
10008	Flame 1	0	1 = on, 0 = off	0	1	1
10009	Enable / room thermostat / stage 1	0	1 = on, 0 = off	0	1	1
10010	Tank thermostat	0	1 = on, 0 = off	0	1	1
10011	Extra appliance signal	0	1 = on, 0 = off	0	1	1
10033	Run contacts	0	1 = on, 0 = off	0	1	1
10034	Alarm contact 1 (EXCEPT Versa-Hydro)	0	1 = on, 0 = off	0	1	1
10035	CH pump 1	0	1 = on, 0 = off	0	1	1
10036	DHW pump 1	0	1 = on, 0 = off	0	1	1
10038	Gas valve 1	0	1 = on, 0 = off	0	1	1
10039	System pump	0	1 = on, 0 = off	0	1	1
10049	Appliance 0 burning (same as 10008)	0	1 = on, 0 = off	0	1	1
10050	Appliance 1 burning (same as 10023)	0	1 = on, 0 = off	0	1	1
10051	Appliance 2 burning	0	1 = on, 0 = off	0	1	1
10052	Appliance 3 burning	0	1 = on, 0 = off	0	1	1
10053	Appliance 4 burning	0	1 = on, 0 = off	0	1	1
10054	Appliance 5 burning	0	1 = on, 0 = off	0	1	1
10055	Appliance 6 burning	0	1 = on, 0 = off	0	1	1
10056	Appliance 7 burning	0	1 = on, 0 = off	0	1	1
10057	Appliance 0 lockout (same as 10034)	0	1 = on, 0 = off	0	1	1
10058	Appliance 1 lockout (same as 10042)	0	1 = on, 0 = off	0	1	1
10059	Appliance 2 lockout	0	1 = on, 0 = off	0	1	1
10060	Appliance 3 lockout	0	1 = on, 0 = off	0	1	1
10061	Appliance 4 lockout	0	1 = on, 0 = off	0	1	1
10062	Appliance 5 lockout	0	1 = on, 0 = off	0	1	1
10063	Appliance 6 lockout	0	1 = on, 0 = off	0	1	1
10064	Appliance 7 lockout	0	1 = on, 0 = off	0	1	1
10065	Alarm relay (Versa-Hydro ONLY)	0	1 = on, 0 = off	0	1	1
INPUT REGISTERS						
30001	Discrete inputs 1 - 16	0	NA	0	65535	1
30002	Discrete inputs 17 - 32	0	NA	0	65535	1
30003	Discrete inputs 33 - 48	0	NA	0	65535	1
30004	System / cascade set point / system pump speed / PUMP 4	0	Deg F	0	212	0, 1
30005	SPEED	0	%	0	100	1
30006	Cascade total power	0	%	0	800	1
30007	Cascade current power	0	%	0	800	1
30008	Outlet set point 0	0	Deg F	-76	212	0, 1
30009	Outlet temp 0	0	Deg F	-76	266	0, 1
30010	Inlet temp 0	0	Deg F	-76	266	0, 1
30011	Flue temp 0	0	Deg F	0	266	0, 1
30012	Firing rate 0 / Appliance 0 pump speed / Pump 5	0	%	0	100	0, 1
30013	SPEED	0	%	0	100	1
30014	Appliance 0 status code	0	NA	0	65535	
30015	Appliance 0 blocking code	0	NA	0	65535	
30016	Appliance 0 lockout code	0	NA	0	65535	
30017	Outlet set point 1	0	Deg F	-76	212	0, 1

ADDRESS	DESCRIPTION	DEFAULT	UNIT	MIN	MAX	RESOLUTION
30018	Outlet temp 1	0	Deg F	-76	266	0, 1
30019	Inlet temp 1	0	Deg F	-76	266	0, 1
30020	Flue temp 1	0	Deg F	-76	266	0, 1
30021	Firing rate 1 / Appliance 1 pump speed / Pump 4	0	%	0	100	0, 1
30022	OUTPUT	0	%	0	100	1
30023	Appliance 1 status code	0	NA	0	65535	
30024	Appliance 1 blocking code	0	NA	0	65535	
30025	Appliance 1 lockout code	0	NA	0	65535	
30026	Appliance 2 outlet temperature	0	Deg F	-76	266	0, 1
30027	Appliance 2 firing rate	0	%	0	100	1
30028	Appliance 2 status	0	NA	0	65535	
30029	Appliance 2 lockout code	0	NA	0	65535	
30030	Appliance 3 supply temperature	0	Deg F	-76	266	0, 1
30031	Appliance 3 firing rate	0	%	0	100	1
30032	Appliance 3 status	0	NA	0	65535	
30033	Appliance 3 lockout code	0	NA	0	65535	
30034	Appliance 4 supply temperature	0	Deg F	-76	266	0, 1
30035	Appliance 4 firing rate	0	%	0	100	1
30036	Appliance 4 status	0	NA	0	65535	
30037	Appliance 4 lockout code	0	NA	0	65535	
30038	Appliance 5 supply temperature	0	Deg F	-76	266	0, 1
30039	Appliance 5 firing rate	0	%	0	100	1
30040	Appliance 5 status	0	NA	0	65535	
30041	Appliance 5 lockout code	0	NA	0	65535	
30042	Appliance 6 supply temperature	0	Deg F	-76	266	0, 1
30043	Appliance 6 firing rate	0	%	0	100	1
30044	Appliance 6 status	0	NA	0	65535	
30045	Appliance 6 lockout code	0	NA	0	65535	
30046	Appliance 7 supply temperature	0	Deg F	-76	266	0, 1
30047	Appliance 7 firing rate	0	%	0	100	1
30048	Appliance 7 status	0	NA	0	65535	
30049	Appliance 7 lockout code	0	NA	0	65535	
30050	Discrete inputs 49 - 64	0	NA	0	65535	
30051	NTC 6 temperature	0	Deg F	-76	266	0, 1
30052	NTC 7 temperature	0	Deg F	-76	266	0, 1
30053	Solar Panel temperature	0	Deg F	-76	266	0, 1
30054	Solar flow	0	LPM	0	100	0, 1
30055	Solar temp	0	Deg F	14	248	0, 1
<b>HOLDING REGISTERS</b>						
40001	Configuration		See below			
40002	Coils					
40003	0 – 10 volt / rate / set point CMD		V	0	248	0, 1
40004	Tank set point		Deg F	0	10	0, 1
40005	Tank temperature		Deg F	-76	212	0, 1
40006	Outdoor temperature		Deg F	-76	266	0, 1
40007	System supply temperature		Deg F	-76	266	0, 1
40008	System return temperature		Deg F		266	
40009	I4 for direct mode	20	Deg F	0	36	0, 1
40010	CH post purge	0	Seconds	0	255	1
40011	DH post purge	0	Seconds	0	255	1
40012	Solar Pump speed	0	%	0	100	0, 1
40014	Extra 0 – 10 volt output	0	%	0	100	0, 1

**Table 10 – Modbus memory map**

**NOTE:** Use Blocking Codes and Lockout Codes to interpret remote boiler operating conditions.

### **C. BLOCKING CODES**

<b>BLOCKING CODES (INPUT REGISTERS 30015 AND 30024)</b>	
NUMBER	DEFINITION
0	None
11	water pressure low

NUMBER	DEFINITION
12	S1 temperature high
13	S2 temperature high
14	Flue temperature high
16	Regulation temperature high
17	Not enough water flow
21	Anti-cycling CH
23	max flue pressure switch/ max start cycles
25	Max temperature increase limiting CH
26	24 V to low
30	Water level low 1
31	Water level high 1
32	Water level low 2
33	Water level high 2

Table 11

**D. LOCKOUT CODES**

LOCKOUT CODES (INPUT REGISTERS 30016, 30025, 30029, 30033, 30037, 30041, 30045, AND 30049)	
NUMBER	DEFINITION
240	Flue thermostat open
239	Safety thermostat open
237	False Flame
236	APS stuck open
235	APS stuck closed
233	No flame after ignition
232	No flame during running
230	Fan fault
204	Parameters damaged
205	Parameters programmed
206	Error during programming
207	Parameter EEPROM failure
190	S1 maximum temperature
191	S2 maximum temperature
192	S1 shorted
193	S1 interrupted
194	S2 shorted
195	S2 interrupted
196	Low water lockout
197	Flue sensor shorted
198	Flue sensor interrupted
199	Low water lockout 2
185	ECS6 temperature lockout
186	ECS7 temperature lockout

Table 12

**E. STATUS CODES**

STATUS CODES (INPUT REGISTERS 30014, 30023, 30028, 30032, 30036, 30040, 30044, AND 30048)	
NUMBER	DEFINITION
0	Standby
96	Running
100	DHW Mode or Blocking for Cascade
101	Low Water Blocking

Table 13

**F. CONFIGURATION BITS**

Address 40001 contains configuration bits sent from the BAS to the appliance. These bits tell the appliance to use its own internal inputs, or inputs from the BAS. When a bit is set to 1, the appliance will ignore the corresponding value contained internally and expect the BAS to write that value into the holding registers.

The configuration bits are as follows:

HOLDING REGISTER 40001	DEFINITION	0 = TAKEN FROM CONTROL 1 = TAKEN FROM MODBUS
B0	Boiler enable	0/1
B1	Tank enable	0/1
B2	Rate command / 0 – 10V input / set point command (40003)	0/1
B3	DHW set point (40004)	0/1
B4	DHW temperature (40005)	0/1
B5	Outdoor temperature (40006)	0/1
B6	System supply temperature (40007)	0/1
B7	System return temperature (40008)	0/1
B8	I4 offset (40009)	0/1
B9	CH post purge (40010)	0/1
HOLDING REGISTER 40001	DEFINITION	0 = TAKEN FROM CONTROL 1 = TAKEN FROM MODBUS
B10	DHW post purge (40011)	0/1
B11	Pump 4 speed (40012)	0/1
B12	Pump 5 speed (40013)	0/1
B13	Extra 0 – 10 V output (40014)	0/1
HOLDING REGISTER 40002	DEFINITION	
Coil 01 b0	Room thermostat	
Coil 05 b4	Tank thermostat	

Table 14 – Modbus holding registers

## PART 7 - APPLIANCE OPERATION

### A. APPLIANCE OPERATION WITH MODBUS COMMUNICATIONS

The appliance is equipped with a Modbus communication timer. Timeout is set for four minutes. The purpose of the timer is to ensure proper temperature data is communicated to the appliance in a timely manner.

Additionally, the communication timer will provide fail safe operation should Modbus communication be lost. This timer will cause the appliance to revert back to internal appliance controls should the Modbus communication be interrupted longer than the Modbus timer. The timer resets every time a Modbus write command is received with updated temperatures or commands.

The master should update temperature registers at least once per minute, but no more than once per second.

### B. EXAMPLE #1

In this configuration, the appliance is controlled by setting the set points locally on the appliance and providing an enable signal through Modbus communications.

All sensors and limiting devices (excluding the thermostat enable and tank thermostat enable signals, which will be sent to the appliance via Modbus) should be hardwired to the proper terminals in the appliance.

The holding registers need to be set as follows:

HOLDING REGISTERS	DEFINITION	VALUE	ACTION
40001	Configuration	00 01	Set configuration to read 40002
40002	Coils	00 01	Enables CH Demand (00 00 disables demand)
40002	Coils	00 10	Enables DHW demand on appliance (00 00 disables demand)
40002	Coils	00 11	Enables both CH and DHW demand. DHW demand will have priority

Table 15

### C. EXAMPLE #2

#### 1. SEND FIRING RATE COMMAND FROM MASTER

In this configuration, the appliance is controlled by setting the modulation set point from 0 – 100%. Rate command will be 0 – 100% of the modulation range. All sensors and limiting devices (excluding the 0 – 10 Vdc signal, which will be sent to the Modbus) should be hardwired to the terminal strip on the back of the appliance.

For this command to function on Munchkin and Mod Con models, set Installer Parameter 16 at 2 and Installer Parameter 17 at 1. On Elite models, Function 16, Optional Input must be set to 0-10 volt and Function 17 0-10 volt function must be set on Temperature.

The holding registers need to be set as follows:

HOLDING REGISTERS	DEFINITION	VALUE	ACTION
40001	Configuration	00 04	Set configuration to read 40003
40003	Rate Command	00 00	Sets modulation %

Table 16

Register 40003 needs to receive the rate command as follows: Acceptable rang is 0 to 100. Value needs to be greater than 15 for the boiler to fire. When the command is 16, the boiler will run at minimum fan speed (firing rate). When the command is 100 the boiler will run at max fan speed (firing rate). If the command value is anywhere between 16 and 100, the boiler will run at a fan speed proportional to the command sent between minimum and maximum firing rates.

**NOTE:** To ensure proper operation, resend the configuration bits to holding register 40001 prior to issuing a command. For proper hexadecimal conversion of rate percentage, please refer to the rate and temperature conversion section of this manual.

## 2. SEND TEMPERATURE COMMAND FROM MASTER

In this configuration, the appliance is controlled by setting the boiler temperature via the Modbus adapter. The temperature range is the range of the value of Installer Parameter 12 (all except Elite) or Function 12 Min Boiler Temp on the Elite, and the temperature setting of the CH value on the User Menu (all except Elite) or CENTRAL HEAT setting on the Elite. All sensors and limiting devices (excluding the 0-10 Vdc signal, which will be sent to the Modbus) should be hardwired to the terminal strip on the appliance.

For this command to function on Munchkin and Mod Con models, Installer Parameter 16 needs to be set at 2 and Installer Parameter 17 needs to be set at 0. On Elite models, Function 16, Optional Input must be set to 0-10 volt and Function 17 0-10 volt function must be set on Temperature.

**NOTE:** The holding registers are same as above, in Table 15.

Register 40003 needs to receive the rate command as follows: Acceptable rang is 0 to 100. Value needs to be greater than 15 for the boiler to fire. When the command is 16, the boiler will run at minimum temperature (value of Installer Parameter 12 above). When the command is 100 the boiler will run at maximum temperature (CH temperature above). If the command value is anywhere between 16 and 100, the boiler will run at a temperature proportional to the command sent between minimum and maximum temperatures described above.

**NOTE:** To ensure proper operation, resend the configuration bits to holding register 40001 prior to issuing a command. For proper hexadecimal conversion of rate percentage, please refer to the rate and temperature conversion section of this manual.

## **D. EXAMPLE #3 – HOT WATER GENERATION**

Hot water generation can be accomplished using one of two methods when an appliance is connected to a BAS system, DHW with direct control, and DHW with remote control.

### **DHW WITH DIRECT CONTROL**

This is the typical installation with a hot water generator in close proximity to the appliance with the tank thermostat, or tank temperature sensor, wired to the terminal strip of the appliance

### **DHW WITH REMOTE CONTROL**

This installation may or may not have the hot water generator in close proximity to the appliance. Its sensors and thermostat values are only available through the Modbus communication bus.

To ensure that the appliance can properly respond to a call for hot water generation, the following holding registers must be set in addition to other commands:

HOLDING REGISTERS	DEFINITION	VALUE	ACTION
40001	Configuration	00 1A	Set configuration to read 40002, 4 and 5
40002	Coils	00 10	Enables tank Tstat (00 00 disables appliance)
40004	Tank set point	0# ##	Sets set point
40005	Tank Temperature	0# ##	Passes tank temp from remote sensor

Table 17

**NOTE:** To ensure proper operation, resend the configuration bits to holding register 40001 prior to issuing a command. For proper hexadecimal conversion of rate percentage, please refer to the rate and temperature conversion section of this manual.

## **E. CASCADE**

In order to operate the appliance in cascade with Modbus communications, configure the master appliance. Connect the remaining appliances in the cascade through the normal cascade communications wiring. Cascade control can then be accomplished automatically through the master appliance.

Please note that with Modbus communication connected only to the master appliance, only total cascade information can be seen through the communications link. Information from the follower boilers is limited to follower appliance rate command, supply temperature, fault code, and fault status.

If you want to see complete data from each follower, or use the Modbus master to control cascading of multiple appliances, each appliance will need a Modbus communication board.

**Monitoring Only**

Any appliance can be equipped with the Modbus communication accessory and then be set up to operate with its own internal controls. The Modbus master can then poll the Modbus accessory for the read only variables.

**F. RATE AND TEMPERATURE CONVERSIONS**

**Rate**

When issuing a rate command, the rate can be communicated as percent modulation or a desired set point temperature depending on the setting of parameter 16 in the appliance Installer Menu. Proper data format for the modulation percentage is direct conversion to hexadecimal. This conversion can be accomplished through online number based converters or some scientific calculators.

For example:

RATE %	HEX
0	00
20	14
45	2D
60	3C
80	50
95	5F
100	64

**Table 18**

**Temperature Conversions**

To send a desired set point, the hexadecimal value must be determined through linear interpolation of programmable parameters on the BMS setup menu.

- BMS temperature set point at low analog input
- BMS temperature set point at high analog input

These variables set the temperature values corresponding to the minimum and maximum voltage settings of the 0 – 10 volt signal. The defaults are as follows:

PARAMETER	DEFAULT VALUES		DEFAULT
	Deg C	Deg F	Voltages
BMS temperature set point at low analog input	21	69.8	2
BMS temperature set point at high analog input	82	179.6	10

**Table 19**

For example: Send a set point of 110°F. The formula to use for the interpolation is:

Rate Command =

$$\frac{(\text{Desired set point} - \text{BMS temp at low analog input}) (\text{High voltage} - \text{low voltage}) + \text{Low voltage}}{(\text{BMS temp at high analog input} - \text{BMS temp at low analog input})}$$

From the default values:

- Desired set point = 110
- BMS temp at low analog input = 68
- BMS temp at high analog input = 158
- High voltage = 10
- Low voltage = 2

$$[(110 - 69.8)(10-2)/(179.6 - 69.8)] + 2 = 4.92 \text{ volts}$$

$$(4.92/10) \times 100 = 49.2$$

$$49 = 31 \text{ Hexadecimal}$$

A value of [00] [31] in hexadecimal would be written to holding register 40003 to issue a command for a 110°F set point.

The table below lists temperature to hexadecimal conversions.

Setpoint	Hex	Setpoint	Hex	Setpoint	Hex	Setpoint	Hex
68	12	101	2A	134	42	167	5A
69	13	102	2B	135	43	168	5B
70	14	103	2C	136	44	169	5C
71	14	104	2C	137	44	170	5D
72	15	105	2D	138	45	171	5D
73	16	106	2E	139	46	172	5E
74	17	107	2F	140	47	173	5F
Setpoint	Hex	Setpoint	Hex	Setpoint	Hex	Setpoint	Hex
75	17	108	2F	141	47	174	5F
76	18	109	30	142	48	175	60
77	19	110	31	143	49	176	61
78	19	111	32	144	4A	177	62
79	1A	112	32	145	4A	178	62
80	1B	113	33	146	4B	179	63
81	1C	114	34	147	4C	180	64
82	1C	115	34	148	4C		
83	1D	116	35	149	4D		
84	1E	117	36	150	4E		
85	1F	118	37	151	4F		
86	1F	119	37	152	4F		
87	20	120	38	153	50		
88	21	121	39	154	51		
89	21	122	3A	155	52		
90	22	123	3A	156	52		
91	23	124	3B	157	53		
92	24	125	3C	158	54		
93	24	126	3C	159	54		
94	25	127	3D	160	55		
95	26	128	3E	161	56		
96	27	129	3F	162	57		
97	27	130	3F	163	57		
98	28	131	40	164	58		
99	29	132	41	165	59		
100	2A	133	42	166	5A		

MODBUS Register 40004 Setpoint Conversion Table

### Temperature

The Modbus adapter passes temperature data to the appliance in degrees Fahrenheit. Also, to accommodate decimal places, the decimal value must be divided by 10. The data sent over the Modbus is passed as an unsigned 16 bit integer. This poses no problem unless the data becomes negative, such as temperatures below zero. In this case, the compliment has to be calculated as follows:

Temperature to be sent over Modbus = -22°F. First multiply by 10.  $-22 \times 10 = -220$ . Calculate compliment  $65536 - 220 = 65316$ .

Decimal = 65316. Hex = FF24. Binary = 1111111100100100.

To read the outdoor temperature from the appliance, do the opposite. Read register 40006 and get 65316. Since this value is greater than 32767, the temperature is negative. To calculate the negative value:  $65536 - 65316 = 220$ , then  $220/10 = 22$ .  $22 \times -1 = -22^\circ\text{F}$ .

For example:

Outdoor temperature from remote sensor on BAS system = 80.5°F.

DECIMAL	HEX
805	325

Table 20

Outdoor temperature from remote sensor on BAS system = -25°F. Data that needs to be transmitted is  $-25 \times 10 = -250$ .  $65536 - 250 = 65286$

DECIMAL	HEX
65286	FF06

Table 21

Outlet temperature from appliance sensor = 155°F. 155°F X 10 = 1550.

DECIMAL	HEX
1550	60E

Table 22

### **G. APPLIANCE STATUS CODES**

The appliance displays an appliance state code on the building screen to help aid in troubleshooting. The appliance state indicates what the appliance is actually doing. This state should be compared to the command issued and what is expected. If the appliance state does not agree with the command, check communication and configuration.

STATUS CODES (INPUT REGISTERS 30014 AND 30023)	
NUMBER	DEFINITION
0	standby
96	Running
100	DHW mode or blocking for Cascade
101	Low Water blocking

Table 23

## **PART 8 - TROUBLESHOOTING**

Should you encounter problems communicating over Modbus, the following items should be checked in this order.

1. Physical layer
2. Communications configuration and port settings
3. Modbus error codes
4. Appliance status / blocking / lockout codes

### **A. PHYSICAL LAYER**

1. Verify the correct Modbus communication cable (twisted pair) is being used.
2. Check that all components have power (appliance, Modbus adapter, gateway, BAS master).
3. Check for broken wires.
4. Check A, B terminal connections.
5. Check for terminating resistors (120 ohms) at each end of the RS-485 bus only.
6. Check all wire lengths. Are any drops too long?
7. Check proper shield grounding.

### **B. COMMUNICATIONS**

1. Verify controller is configured for MODBUS (AUTO or ON)
2. Check baud rate (9600, 19200).
3. Check parity.
4. Check Modbus address.
5. Check port setting on master, gateway, and computers.
6. Check the status of the LEDs, referring to the LED Diagnostics section below.

### **C. LED DIAGNOSTICS**

There are two yellow LED's and one green LED on the board that provide diagnostic information.

One of the yellow LED's (D6) is used for indicating reception of data from Modbus and the other LED (D5) indicates transmission of data to Modbus.

The green LED (D7) is used to show the following:

Internal Faults

Modbus Adapter fault: Continuously Bright

General Faults

No MODBUS (RS-485) communication: 1.5 second bright - 0.5 second off

No Burner Control (RS-232) communication: 0.5 second bright - 1.5 seconds off

In case both communication modes fail the LED will not be lit No Faults

Normal running: 1 second Bright and 1 second Dim

### **D. MODBUS ERROR CODES**

1. Check Modbus communication error codes (see in Part 5, Section E in this manual for Modbus exception codes).



### HTP CUSTOMER INSTALLATION RECORD FORM

The following form should be completed by the installer for you to keep as a record of the installation in case of a warranty claim. After reading the important notes at the bottom of the page, please also sign this document.

Customer's Name:	
Installation Address:	
Date of Installation:	
Installer's Code/Name:	
Product Serial Number(s):	
Modbus Adapter Address (As Configured by the Installer)	
Comments:	
Installer's Phone Number:	
Signed by Installer:	
Signed by Customer:	

**IMPORTANT NOTES:**

***Customer: Please only sign after the installer has reviewed the installation, safety, proper operation and maintenance of the system. In the case that the system has any problems, please call the installer. If you are unable to make contact, please contact your HTP Sales Representative.***

*Distributor/Dealer: Please insert contact details.*