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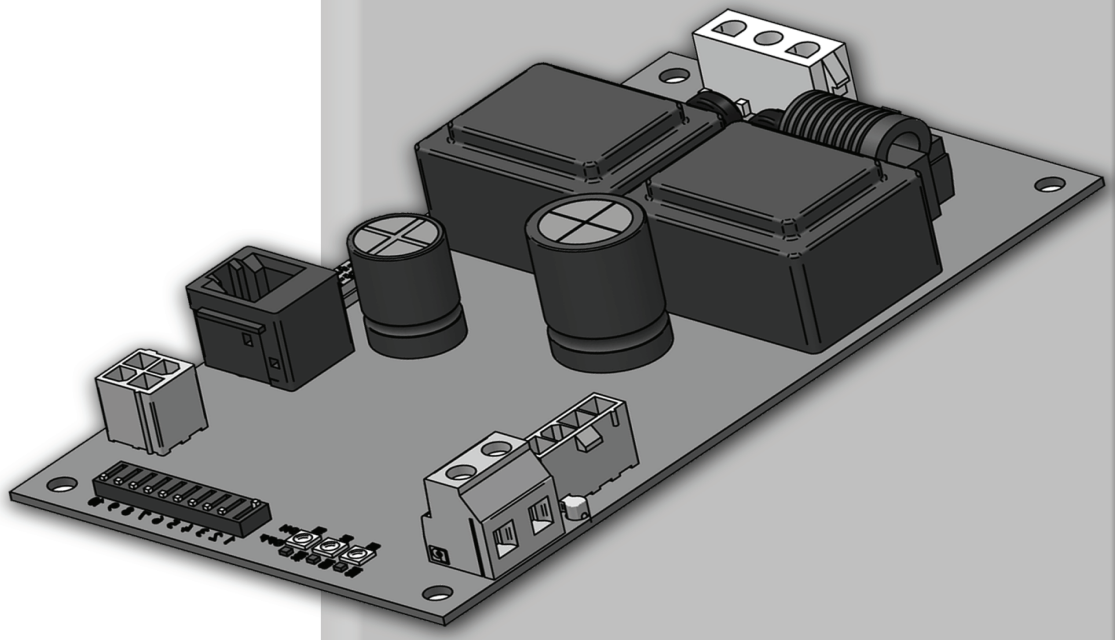
Copper-fin II/IIE Boiler, Water Heater and Pool Heater ModBus and BACnet Communication Instructions

Models: 402 - 2072 (Boiler & Water Heater)

Models: 502 - 2072 (Pool Heater)



⚠ WARNING This manual must only be used by a qualified heating installer / service technician. Read all instructions, including this manual, the Installation and Operation Manual, and the Service Manual, before installing. Perform steps in the order given. Failure to comply could result in severe personal injury, death, or substantial property damage.

Save this manual for future reference.

Lochinvar®
High Efficiency Water Heaters, Boilers and Pool Heaters

Contents

1 Introduction

The information contained in this manual provides general guidelines for the implementation of ModBus communication with the Lochinvar Copper-fin II/IIE.

All ModBus networks are implemented utilizing a master-slave arrangement where all Copper-fins are slaves and the master is a building automation system capable of communicating over a RS-485 serial connection. BACnet networks are implemented using a token passing process where multiple masters and slaves share a common RS-485 bus. The Lochinvar BACnet interface is a master only.

Definitions

Abbreviation or Acronym	Meaning
ASCII	American Standard Code for Information Interchange
BACnet	A data communication protocol for Building Automation and Control Networks
BAS	Building Automation System
Baud (Baud Rate)	Number of data bits transmitted per second (bps)
EMS	Energy Management System
FDX	Full-Duplex
HDX	Half-Duplex
Hex	Hexadecimal Number (0 - 9, A - F)
I/O Box	Input/Output (I/O)
LSB	Least Significant Byte
ModBus®	A serial, half-duplex data transmission protocol developed by AEG Modicon
MSB	Most Significant Byte
RS232	A standard for serial, full-duplex (FDX) transmission of data based on the RS232 Standard
RS485	A standard for serial transmission of data based on the RS-485 Standard
RTU	Remote Terminal Unit

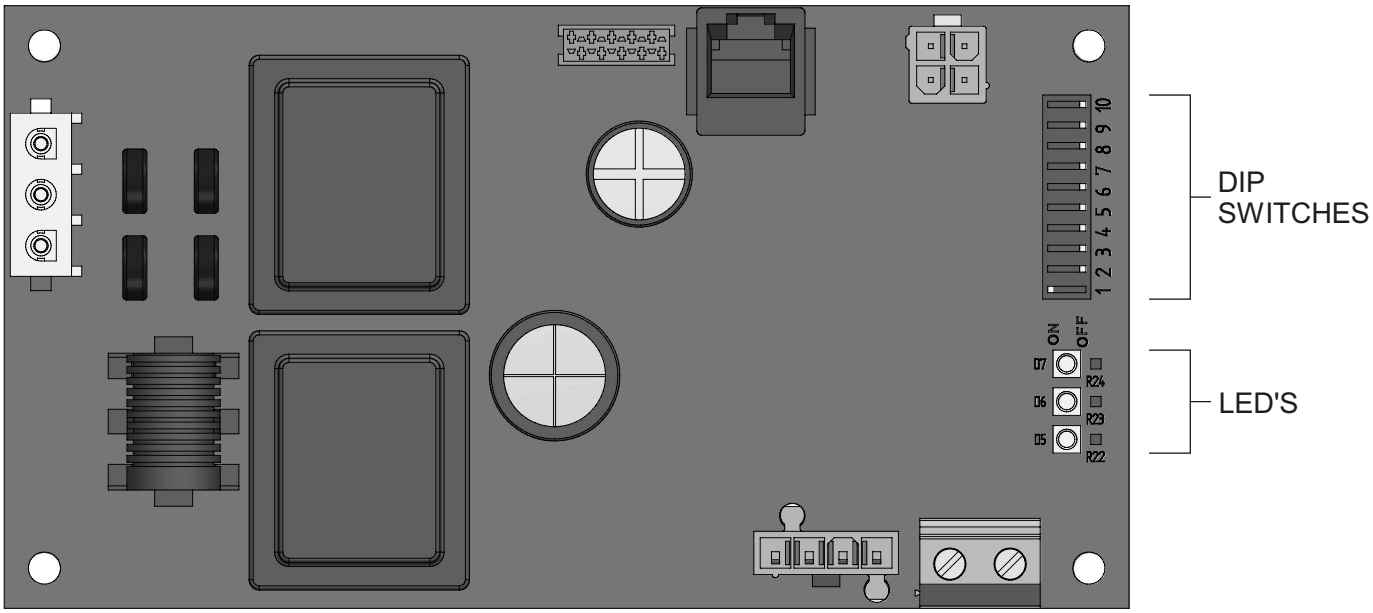
Minimum System Requirements

- BAS system or computer with a serial or USB port with a converter to RS-485.
- Copper-fin II/IIE equipped with ModBus communication board.
- Shielded twisted pair communication cable.

2 ModBus Configuration

The ModBus communication board is equipped with a set of ten dip switches that are used to set the board configuration (address, baud rate, and parity settings). The first eight are used to set the address of each board. The ninth is baud rate. The tenth is parity.

Figure 2-1_ModBus Communication Board



Addressing

The ModBus addressing space is comprised of 256 different addresses.

- 0 is reserved for broadcast messages from the master device
- 1 - 247 are free to use for each unique device
- 248 - 255 are reserved

To set the ModBus address the dip switches can be set in either the 0 position or the 1 position. For switches set to the 1 position their value will be added together to determine the address.

Each switch set to the 1 position has the following value:

Dip switch 1 = 1
Dip switch 2 = 2
Dip switch 3 = 4
Dip switch 4 = 8
Dip switch 5 = 16
Dip switch 6 = 32
Dip switch 7 = 64
Dip switch 8 = 128

Any dip switch set to 0 has a value equal to 0.

Example:

To set the address of the ModBus board to 50, dip switches 2, 5, and 6 have to be set to the 1 position. The address is determined by adding the values of all the dip switches together.

Address = Value of Dip switch 1 + Value of Dip switch 2 + Value of Dip switch 3 + Value of Dip switch 4 + Value of Dip switch 5 + Value of Dip switch 6 + Value of Dip switch 7 + Value of Dip switch 8

In this example:

Address = 0 + 2 + 0 + 0 + 16 + 32 + 0 + 0 = 50

2 ModBus Configuration

Timing Specifications

The baud rate for the ModBus board is selectable with dip switch #9.

1 = 19200 bps
0 = 9600 bps

Each message is started by at least 3.5 character times of silence. The maximum delay between frames is 1.5 character times.

When the system temperature, tank temperature, and/or 0-10V BMS voltage is provided by the BAS to the boiler, it is critical that the values be updated every few seconds. If the boiler does not receive updated values within a timeout period (installer adjustable), the control will revert to using its own readings (if connected). The timeout is programmable by accessing parameter **H7** (see the Copper-fin Service Manual for the procedure on how to set parameters). The timeout is adjustable between 1 and 255 seconds. The default timeout is 10 seconds.

When the BAS is not providing any of these values, but is still controlling the boiler (such as providing an enable command), the BAS must refresh these commands at least every 4 minutes. If the commands are not refreshed, the boiler will revert to operating based on its own inputs.

Parity

Parity is set by the position of Dip switch #10.

0 = No Parity
1 = Even Parity

If No Parity is selected there will be two stop bits, otherwise there will be one.

Data Transmission Mode

Many ModBus bus master devices can be configured to transmit data in either ModBus RTU or ModBus ASCII modes. Since RTU messages can be formatted to use fewer data bits and are therefore more efficient, RTU has been chosen to be used with all Lochinvar ModBus communication. Please ensure that the master device is transmitting ModBus RTU.

ModBus Board Diagnostics

The ModBus board is equipped with three LED's for visual diagnostics: Two yellow LED's and one green. One yellow LED (D5) is used to indicate transmission of data. The other yellow LED (D6) is used to indicate reception of data. The green LED (D7) is used to show internal faults.

Internal Faults:

Normal Operation = 1 second bright, 1 second dim
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

ModBus Communication

The ModBus communication commands and exception codes that are supported by the ModBus communication board can be found on pages 5 and 6 of this manual.

2 ModBus Configuration *(continued)*

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 - Bus Communication Error Count
		13	0D	Diagnostic - Bus Exception Error Count
		14	0E	Diagnostic - Return Slave Message Count
		15	0F	Diagnostic - Return Communication Error Count
		16	10	Diagnostic - Return Slave NAK Count
		17	11	Diagnostic - Return Slave 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 Slave ID
23	17			Read / Write Multiple Registers

2 ModBus Configuration

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 server (or slave). This may be because the function code is only applicable to newer devices, and was not implemented in the unit selected. It could also indicate that the server (or slave) is in the wrong state to process a request of this type, for example because it is unconfigured and is being asked to return register values.
02	ILLEGAL DATA ADDRESS	The data address received in the query is not an allowable address for the server (or slave). More specifically, the combination of reference number and transfer length is invalid. For a controller with 100 registers, the PDU addresses the first register as 0, and the last one as 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 4, then this request will successfully operate (address-wise at least) on registers 96, 97, 98, 99. If a request is submitted with a starting register address of 96 and a quantity of registers of 5, then this request will fail with Exception Code 0x02 “Illegal Data Address” since it attempts to operate on registers 96, 97, 98, 99 and 100, and there is no register with address 100.
03	ILLEGAL DATA VALUE	A value contained in the query data field is not an allowable value for server (or slave). This indicates a fault in the structure of the remainder of a complex request, such as that the implied length is incorrect. It specifically does NOT mean that a data item submitted for storage in a register has a value outside the expectation of the application program, since the ModBus protocol is unaware of the significance of any particular value of any particular register.
04	SLAVE DEVICE FAILURE	An unrecoverable error occurred while the server (or slave) was attempting to perform the requested action.
05	ACKNOWLEDGE	Specialized use in conjunction with programming commands. The server (or slave) has accepted the request and is processing it, but a long duration of time will be required to do so. This response is returned to prevent a timeout error from occurring in the client (or master). The client (or master) can next issue a Poll Program Complete message to determine if processing is completed.
06	SLAVE DEVICE BUSY	Specialized use in conjunction with programming commands. The server (or slave) is engaged in processing a long -- duration program command. The client (or master) should re-transmit the message later when the server (or slave) is free.
08	MEMORY PARITY ERROR	Specialized use in conjunction with function codes 20 and 21 and reference type 6, to indicate that the extended file area failed to pass a consistency check. The server (or slave) attempted to read record file, but detected a parity error in the memory. The client (or master) can retry the request, but service may be required on the server (or slave) device.
0A	GATEWAY PATH UNAVAILABLE	Specialized use in conjunction with gateways, indicates that the gateway was unable to allocate an internal communication path from the input port to the output port for processing as the request. Usually means that the gateway is misconfigured or overloaded.
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.

3 ModBus Memory Map

Primary Data Tables

Table	Data Type	Read / Write
Discrete Inputs	Single Bit	Read Only
Coils	Single Bit	Read / Write
Input Registers	16-Bit Word	Read Only
Holding Registers	16 Bit Word	Read / Write

Copper-fin II/IIE Memory Map

Address	Description	Default	Unit	Min.	Max.	Resolution	Calculation Factor
Coils							
00001	Stage 1 Enable	0	1=ON / 0=OFF	0	1	1	1
00002	Stage 2 Enable	0	1=ON / 0=OFF	0	1	1	1
00003	Stage 3 Enable	0	1=ON / 0=OFF	0	1	1	1
00004	Stage 4 Enable	0	1=ON / 0=OFF	0	1	1	1
00005	Tank Thermostat	0	1=ON / 0=OFF	0	1	1	1
Discrete Inputs							
10001	High Limits	0	1=ON / 0=OFF	0	1	1	1
10002	Flow Switch	0	1=ON / 0=OFF	0	1	1	1
10003	Gas Pressure Switch	0	1=ON / 0=OFF	0	1	1	1
10004	Louver Proving Switch	0	1=ON / 0=OFF	0	1	1	1
10005	Air Pressure Switch	0	1=ON / 0=OFF	0	1	1	1
10008	Flame 1	0	1=ON / 0=OFF	0	1	1	1
10009	Stage 1 On	0	1=ON / 0=OFF	0	1	1	1
10010	Tank Thermostat	0	1=ON / 0=OFF	0	1	1	1
10011	Stage 2 On	0	1=ON / 0=OFF	0	1	1	1
10012	Stage 3 On	0	1=ON / 0=OFF	0	1	1	1
10013	Stage 4 On	0	1=ON / 0=OFF	0	1	1	1
10023	Flame 2	0	1=ON / 0=OFF	0	1	1	1
10024	Enable 2	0	1=ON / 0=OFF	0	1	1	1
10033	Runtime Contacts	0	1=ON / 0=OFF	0	1	1	1
10034	Alarm Contacts	0	1=ON / 0=OFF	0	1	1	1
10035	HTR Pump	0	1=ON / 0=OFF	0	1	1	1
10036	DHW Pump	0	1=ON / 0=OFF	0	1	1	1
10037	Louver Relay	0	1=ON / 0=OFF	0	1	1	1
10038	Gas Valve 1	0	1=ON / 0=OFF	0	1	1	1
10039	System Pump	0	1=ON / 0=OFF	0	1	1	1

3 ModBus Memory Map

Copper-fin II/IIE Memory Map

Address	Description	Default	Unit	Min.	Max.	Resolution	Calculation Factor
10046	Gas Valve 2	0	1=ON / 0=OFF	0	1	1	1
10047	Gas Valve 3	0	1=ON / 0=OFF	0	1	1	1
10048	Gas Valve 4	0	1=ON / 0=OFF	0	1	1	1
Input Registers							
30001	Discrete Inputs 1 - 16	0	N/A	0	65535	1	1
30002	Discrete Inputs 17 - 32	0	N/A	0	65535	1	1
30003	Discrete Inputs 33 - 48	0	N/A	0	65535	1	1
30004	System / Cascade Set point	0	°C	0	130	0,5	0,5
30005	System Pump Speed	0	%	0	100	1	1
30006	Cascade Total Power	0	%	100	800	1	1
30007	Cascade Current Power	0	%	0	800	1	1
30008	Outlet Set point	0	°C	0	130	0,5	0,5
30009	Outlet Temperature	0	°C	0	130	0,1	0,1
30010	Inlet Temperature	0	°C	-20	130	0,1	0,1
30011	Pool Temperature	0	°C	-20	130	0,1	0,1
30012	Firing Rate	0	%	0	100	1	1
30014	Status Code	0	N/A	0	65535	1	1
30015	Blocking Code	0	N/A	0	65535	1	1
30016	Lockout Code	0	N/A	0	65535	1	1
30027	Lockout Code Leader	0	N/A	0	65535	1	1
30028	Lockout Code Member 1	0	N/A	0	65535	1	1
30029	Lockout Code Member 2	0	N/A	0	65535	1	1
30030	Lockout Code Member 3	0	N/A	0	65535	1	1
30031	Lockout Code Member 4	0	N/A	0	65535	1	1
30032	Lockout Code Member 5	0	N/A	0	65535	1	1
30033	Lockout Code Member 6	0	N/A	0	65535	1	1
30034	Lockout Code Member 7	0	N/A	0	65535	1	1
Holding Registers							
40001	Configuration	0	N/A	0	65535	1	1
40002	Coils	0	N/A	0	65535	1	1
40003	0 - 10V Inp. / Rate Cmd / Setp. Cmd	0	%	0	100	1	1
40004	Pool Set point	0	°C	0	87,5	0,5	0,5
40005	Tank Temperature	0	°C	-20	130	0,1	0,1
40006	Outdoor Temperature	0	°C	-40	60	0,1	0,1
40007	System Supply Temperature	0	°C	-20	130	0,1	0,1
40008	System Return Temperature	0	°C	-20	130	0,1	0,1

Configuration Bits

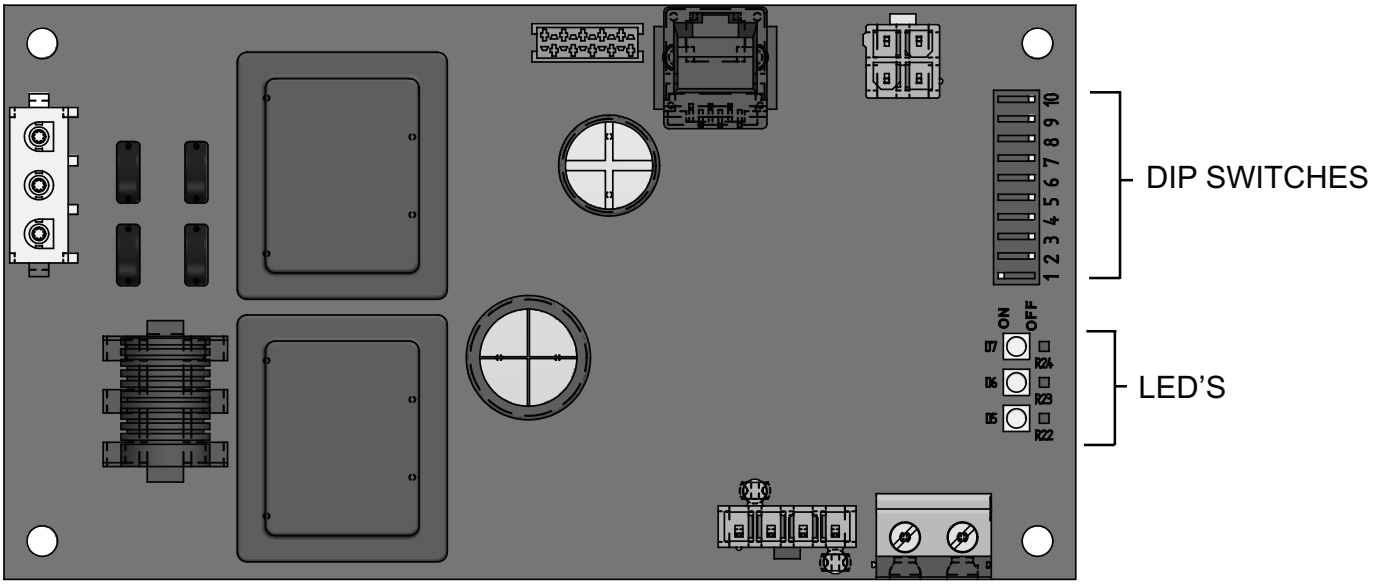
Address 40001 contains configuration bits sent from the BAS to the boiler. These bits tell the boiler to use its own internal inputs, or inputs from the BAS. When a bit is set to 1, the boiler will ignore the corresponding value contained internally, and expect the BAS to write that value into the Holding Registers. The configuration bits are as follows:

Bit 0 (LSB): Boiler Enable
Bit 1: Tank Thermostat
Bit 2: Rate Command / 10 - 10V Input / Set point Command
Bit 3: Tank Set point
Bit 4: System Supply Temperature
Bit 5: Outdoor Temperature
Bit 6: Tank Temperature
Bit 7: System Return Temperature
Bit 8 - 15: Not Used (Default = 0)

4 BACnet Configuration

The BACnet communication board is equipped with a set of ten dip switches that are used to set the board configuration (address and baud rate). The first eight are used to set the address of each board. The ninth and tenth are baud rate.

Figure 4-1_Communication Board



Addressing

The BACnet local addressing space is comprised of 256 different addresses.

- Maximum address of 127.

Since the BACnet communication board is a BACnet master, address 127 is the highest address that can be used.

To set the BACnet local address, the dip switches can be set in either the 0 position or the 1 position. For switches set to the 1 position their value will be added together to determine the address.

Each switch set to the 1 position has the following value:

Dip switch 1 = 1
Dip switch 2 = 2
Dip switch 3 = 4
Dip switch 4 = 8
Dip switch 5 = 16
Dip switch 6 = 32
Dip switch 7 = 64

Any dip switch set to 0 has a value equal to 0.

Accomplish the different selections with Dip switch #8 on the board. The OFF position displays Celsius while the ON position is Fahrenheit.

Example:

To set the address of the BACnet board to 50, dip switches 2, 5, and 6 have to be set to the 1 position. The address is determined by adding the values of all the dip switches together.

Address = Value of Dip switch 1 + Value of Dip switch 2 + Value of Dip switch 3 + Value of Dip switch 4 + Value of Dip switch 5 + Value of Dip switch 6 + Value of Dip switch 7 + Value of Dip switch 8

In this example:

Address = 0 + 2 + 0 + 0 + 16 + 32 + 0 + 0 = 50

The BACnet Device Instance is calculated by adding the BACnet local address to 620000. Using the above example, the Device Instance will be:

Device Instance = 620000 + 50 = 620050

The base address (620000 in this example) is model dependant and can be changed by the integrator. It can be set to any value between 0 and 4194048. The resulting device instance will be this value + the local address, as before. Once the base address is changed, it can be reset back to the default base address (620000 in this example) using the following procedure:

1. Turn OFF power to the interface board.
2. Set Dip switches 1 - 8 to the 1 position.
3. Turn ON power to the interface board.
4. After a few seconds, turn OFF power to the interface board.
5. Set Dip switches 1 - 7 to the desired local address. Set Dip switch 8 to the 0 position.
6. Turn ON power to the interface board.

Device Name

The default device name is "MTR-01 BACnet." This can be changed by the integrator as desired.

4 BACnet Configuration

Timing Specifications

The baud rate for the BACnet board is selectable with Dip switches #9 and #10.

Switch #9	Switch#10	Baud Rate
OFF	OFF	9600
ON	OFF	19200
OFF	ON	38400
ON	ON	76800

When the system temperature, tank temperature, and/or 0-10V BMS voltage is provided by the BAS to the boiler, it is critical that the values be updated every few seconds. If the boiler does not receive updated values within a timeout period (installer adjustable), the control will revert to using its own readings (if connected). The timeout is programmable by accessing parameter **H7** (see the Copper-fin Service Manual for the procedure on how to set parameters). The timeout is adjustable between 1 and 255 seconds. The default timeout is 10 seconds.

When the BAS is not providing any of these values, but is still controlling the boiler (such as providing an enable command), the BAS must refresh these commands at least every 4 minutes. If the commands are not refreshed, the boiler will revert to operating based on its own inputs.

Communication Board Diagnostics

The Communication board is equipped with three LED's for visual diagnostics: Two yellow LED's and one green. One yellow LED (D5) is used to indicate transmission of data. The other yellow LED (D6) is used to indicate reception of data. The green LED (D7) is used to show internal faults.

Internal Faults:

Normal Operation = 1 second bright, 1 second dim
Controller Fault = Continuously on
No Burner Control Communication = 0.5 seconds on, 1.5 seconds off
No BACnet Communication = 1.5 seconds on, 0.5 seconds off.

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5 BACnet Memory Map

Primary Data Tables

Object Type	Data Type	Read / Write
Binary Input (BI)	Single Bit	Read Only
Binary Value (BV)	Single Bit	Read / Write
Analog Input (AI)	16-Bit Word	Read Only
Analog Value (AV)	16 Bit Word	Read / Write

Memory Map

Object Name	Object Type	Object Instance	Units	Min	Max	Resolution
Binary Values						
Stage 1 Enable	BV	0	none	0	1	1
Stage 2 Enable	BV	1	none	0	1	1
Stage 3 Enable	BV	2	none	0	1	1
Stage 4 Enable	BV	3	none	0	1	1
Tank Thermostat	BV	4	none	0	1	1
Binary Inputs						
High Limits	BI	0	none	0	1	1
Flow Switch	BI	1	none	0	1	1
Gas Pressure Switch	BI	2	none	0	1	1
Louver Proving Switch	BI	3	none	0	1	1
Air Pressure Switch	BI	4	none	0	1	1
Flame 1	BI	7	none	0	1	1
Stage 1 On	BI	8	none	0	1	1
Tank Thermostat	BI	9	none	0	1	1
Stage 2 On	BI	10	none	0	1	1
Stage 3 On	BI	11	none	0	1	1
Stage 4 On	BI	12	none	0	1	1
Flame 2	BI	22	none	0	1	1
Enable 2	BI	23	none	0	1	1
Runtime Contacts	BI	32	none	0	1	1
Alarm Contacts	BI	33	none	0	1	1
HTR Pump	BI	34	none	0	1	1
DHW Pump	BI	35	none	0	1	1
Louver Relay	BI	36	none	0	1	1
Gas Valve 1	BI	37	none	0	1	1
System Pump	BI	38	none	0	1	1
Gas Valve 2	BI	45	none	0	1	1
Gas Valve 3	BI	46	none	0	1	1
Gas Valve 4	BI	47	none	0	1	1

5 BACnet Memory Map

Memory Map *(continued)*

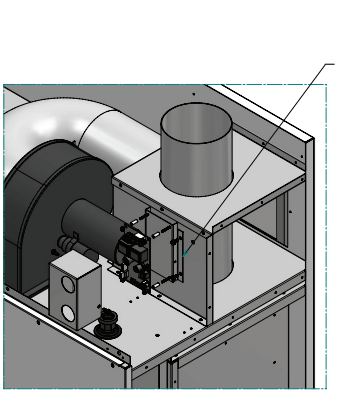
Object Name	Object Type	Object Instance	Units	Min	Max	Resolution
Analog Inputs						
Binary Inputs 0 - 15	AI	0	none	0	65535	1
Binary Inputs 16 - 31	AI	1	none	0	65535	1
Discrete Inputs 32 - 47	AI	2	none	0	65535	1
System / Cascade Set point	AI	3	Deg C	0	130	0.5
System Pump Speed	AI	4	Percent	0	100	1
Cascade Total Power	AI	5	Percent	100	800	1
Cascade Current Power	AI	6	Percent	0	800	1
Outlet Set point	AI	7	Deg C	0	130	0.5
Outlet Temperature	AI	8	Deg C	0	130	0.1
Inlet Temperature	AI	9	Deg C	-20	130	0.1
Pool Temperature	AI	10	Deg C	-20	130	0.1
Firing Rate	AI	11	Percent	0	100	1
Status Code	AI	13	none	0	65535	1
Blocking Code	AI	14	none	0	65535	1
Lockout Code	AI	15	none	0	65535	1
Lockout Error Leader	AI	26	none	0	65535	1
Lockout Error Member 1	AI	27	none	0	65535	1
Lockout Error Member 2	AI	28	none	0	65535	1
Lockout Error Member 3	AI	29	none	0	65535	1
Lockout Error Member 4	AI	30	none	0	65535	1
Lockout Error Member 5	AI	31	none	0	65535	1
Lockout Error Member 6	AI	32	none	0	65535	1
Lockout Error Member 7	AI	33	none	0	65535	1
Analog Values						
Configuration	AV	0	none	0	65535	1
Binary Values 0 - 4	AV	1	none	0	65535	1
0 - 10V Inp. / Rate Cmd / Setp. Cmd	AV	2	Percent	0	100	1
Tank / Pool Set point	AV	3	Deg C	0	87,5	0.5
Tank Temperature	AV	4	Deg C	-20	130	0.1
Outdoor Temperature	AV	5	Deg C	-40	60	0.1
System Supply Temperature	AV	6	Deg C	-20	130	0.1
Pool /System Return Temperature	AV	7	Deg. C	-20	130	0.1

6 Wiring Requirements

Mounting/Wiring Instructions

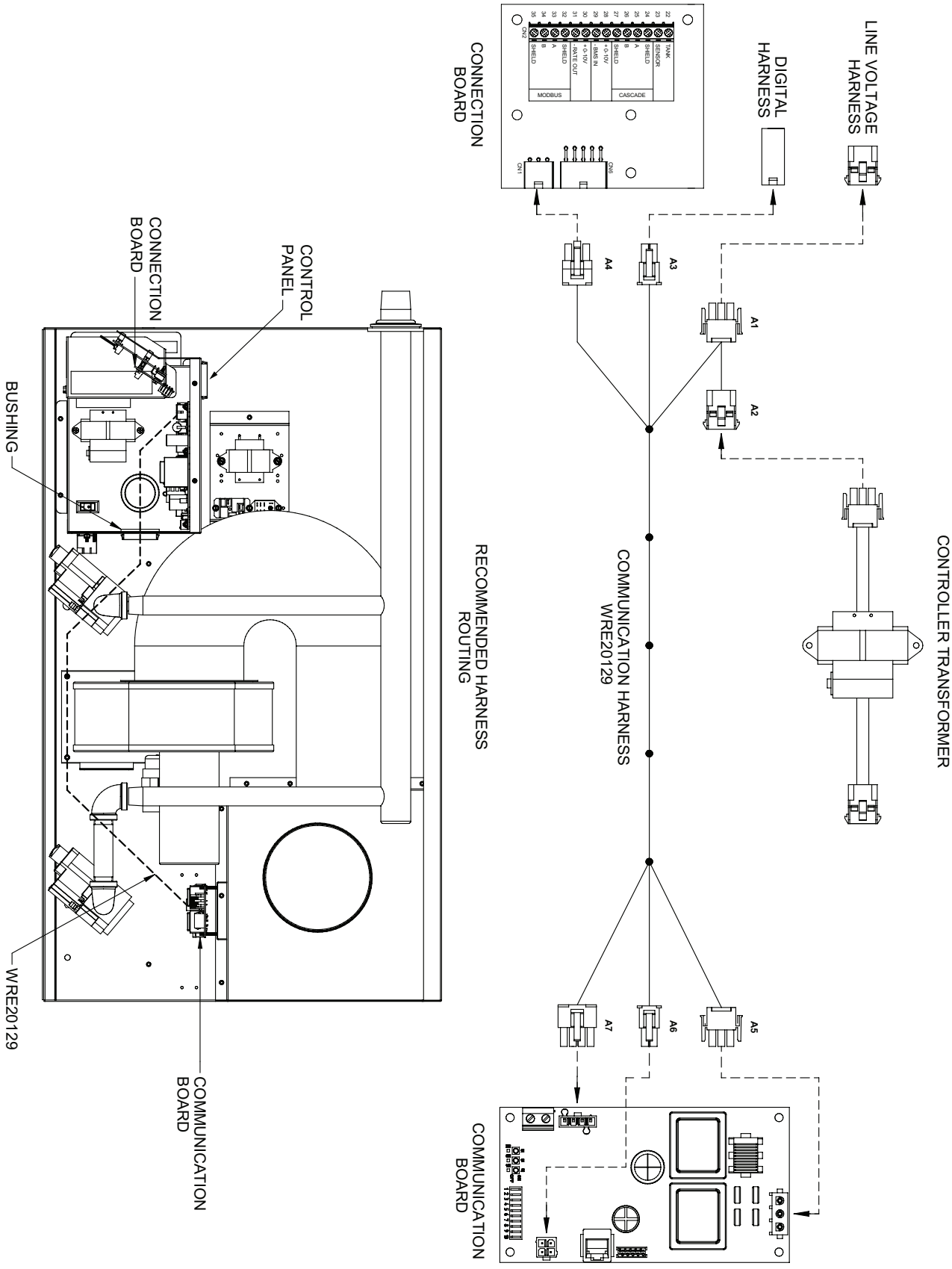
1. Turn OFF power at the source.
2. Remove the left and right access panels to access the inside of the unit.
3. Mount the communication board as shown in FIG. 6-1.
   - Set dip switch settings (reference Section 2 - Configuration) and make the necessary ground connections.
4 Locate the control panel (see FIG. 6-2 on page 10). Locate the bushing on the right-hand side of the control panel (FIG. 6-2).
5. Route the communication board harness (100172877) A1, A2, A3, and A4 housing through the bushing on the right-hand side of the control panel.
6. Locate and disconnect the controller transformer from the line voltage harness (FIG. 6-2).
7. Plug the board harness A1 into the line voltage harness connection (FIG. 6-2).
8. Plug the board harness A1 into the line voltage harness connection (FIG. 6-2).
9. Locate the digital harness connector (FIG. 6-2). Plug the board harness A3 into the digital harness connector.
10. Route 100172877 along the front edge of the unit. Note: Take care not to run the wiring over any sharp edges.
11. Locate the communication board cover. Run power A5 through the top bushing of the communication board cover.
12. Run the board harness A6 and A7 through the lower bushing of the communication board cover.
13. Wire the communication board as follows (FIG. 6-2):
    - Connect A5 to communication board X1
    - Connect A6 to communication board X4
    - Connect A7 to communication board X6
14. If it is desired to ground the communication cable shield at the heater, install a jumper wire between pins 1 and 3 of X5.
15. Replace the cover. Secure the cover using the two (2) screws provided with the communication board.
16. Test the unit before replacing the access panels.
17. Replace the left and right access panels and turn ON power at the source. Resume operation.

Figure 6-1_Mounting the Communication Board



6 Wiring Requirements

Figure 6-2_Schematic / Wire Connections



6 Wiring Requirements *(continued)*

Note that when the System Supply Temperature and/or the Tank Temperature are provided by the BAS, they need to be refreshed every few seconds. This is required in order to prevent unwanted fluctuations in these temperatures. If these values are not provided every few seconds (timeout is programmable), the boiler will revert to its own internal control. If neither of these temperatures is provided by the BAS, but any of the other control signals are being provided, the BAS will still need to refresh these inputs at least every 4 minutes.

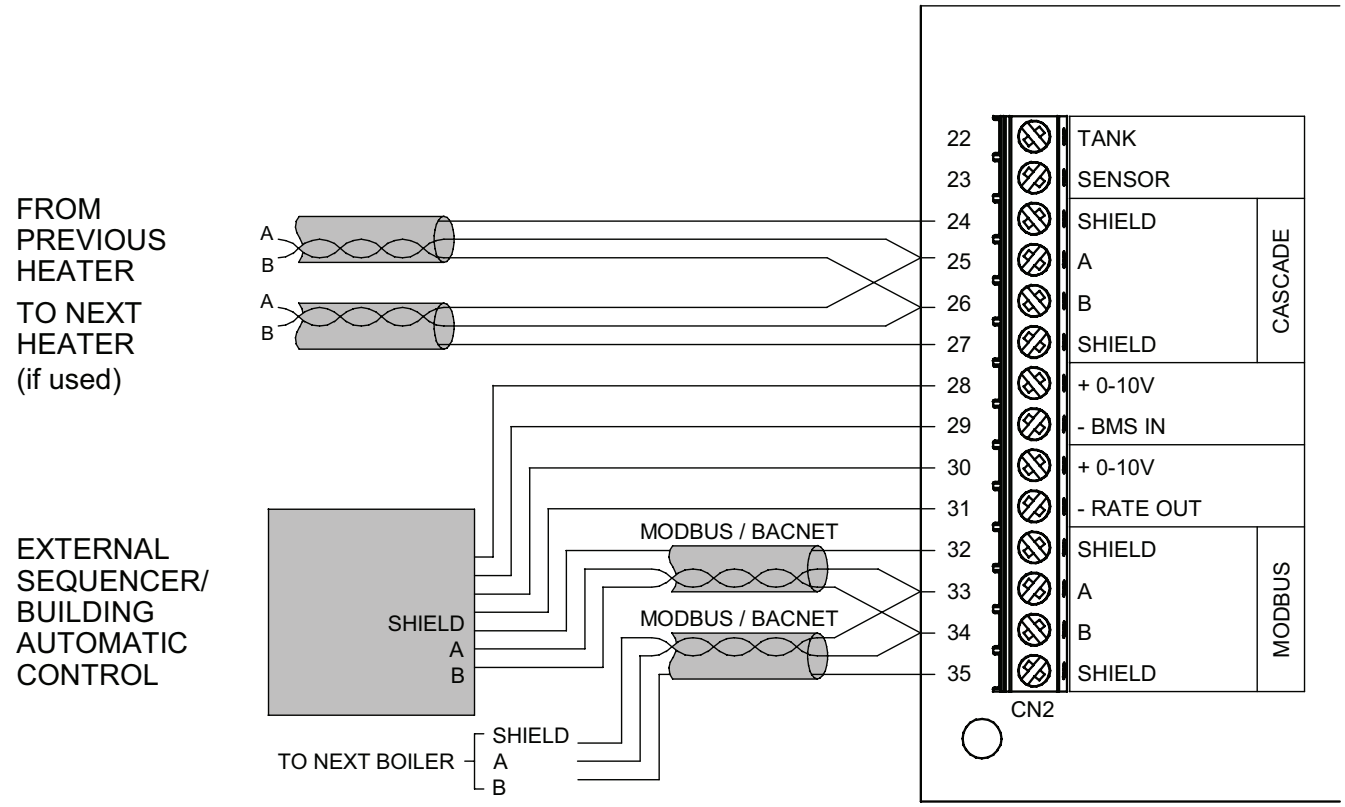
Physical Wiring

RS-485 Communication Bus

- Maximum Length = 4000 feet
- Cable Specification = 24 AWG / A,B (twisted pair) and GND Shielded, with characteristic Impedance = 120 ohm
- Maximum Load = 32 units (32 nodes)

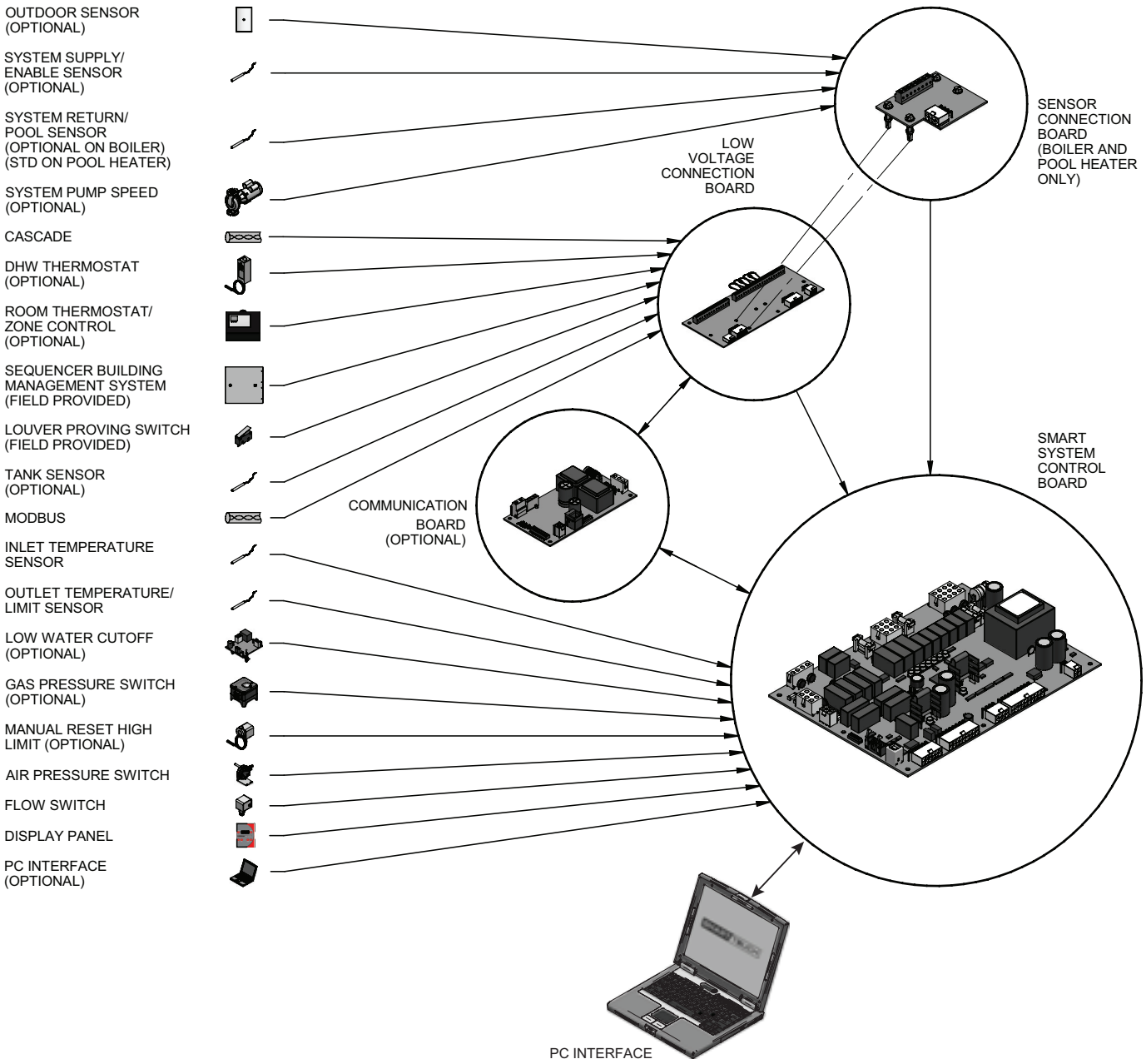
NOTE: Cable must be terminated with 120 ohm impedance matching resistor on each end.
A + (positive)
B - (negative)

Figure 6-3_Terminal Strip Connections



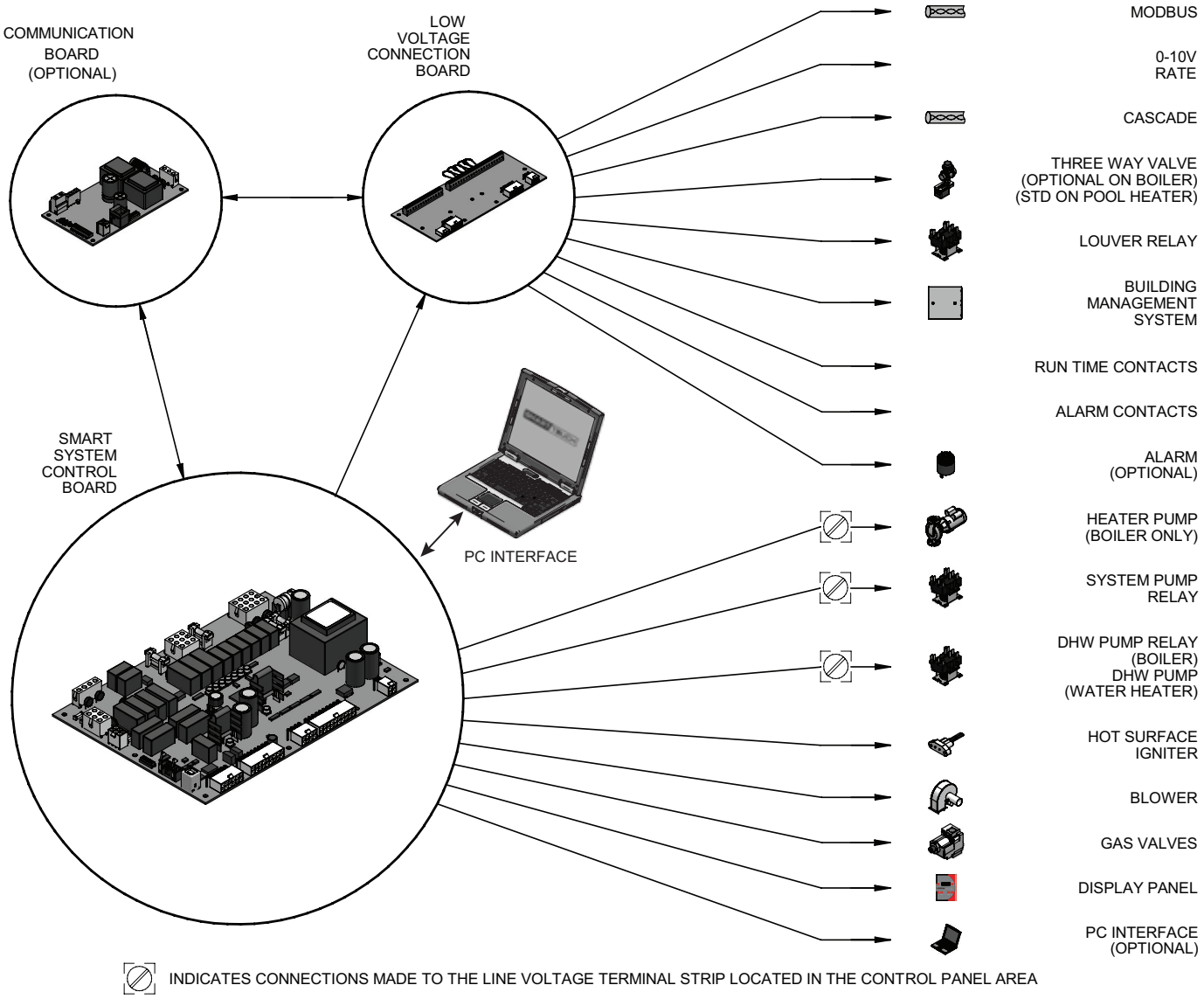
6 Wiring Requirements

Figure 6-4_Control Inputs



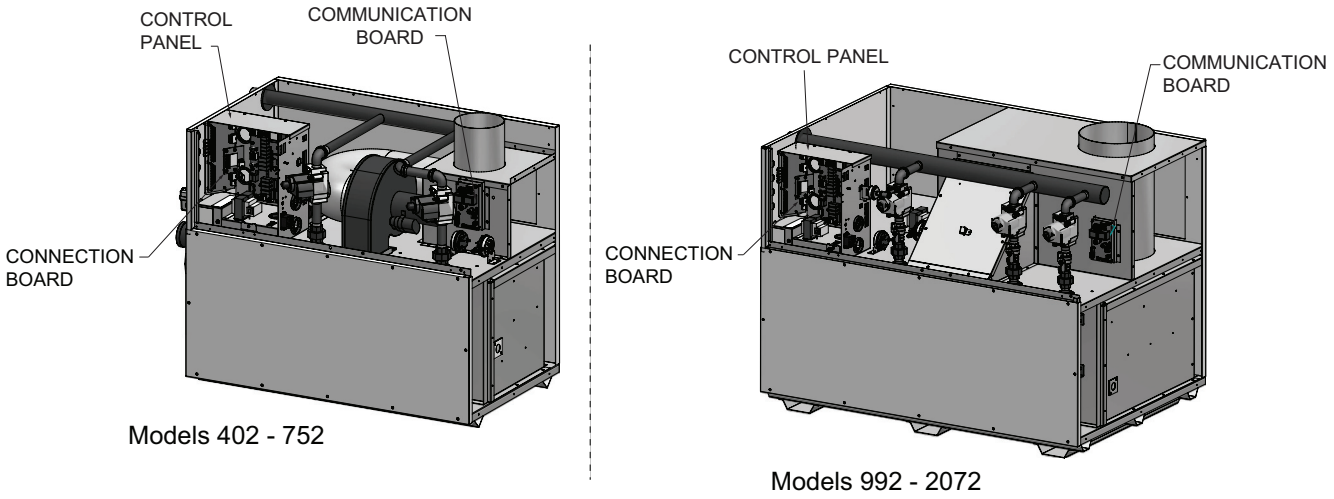
6 Wiring Requirements *(continued)*

Figure 6-5_Control Outputs



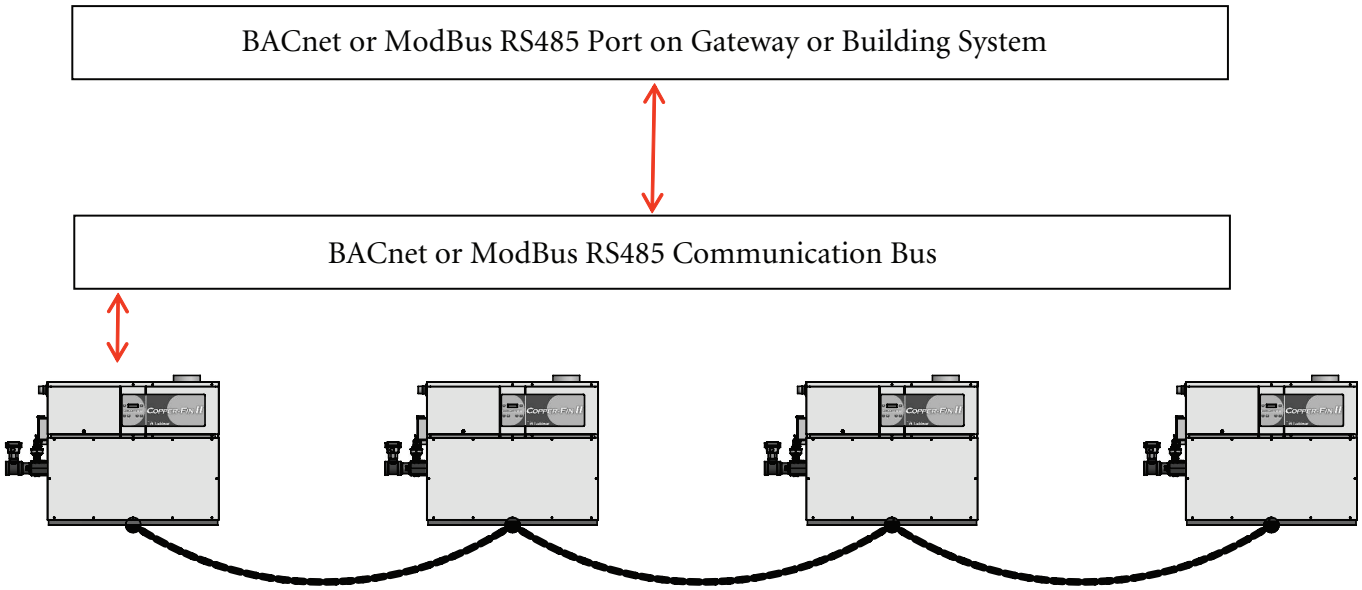
6 Wiring Requirements

Figure 4-6_Control Location



Typical Boiler System Wiring

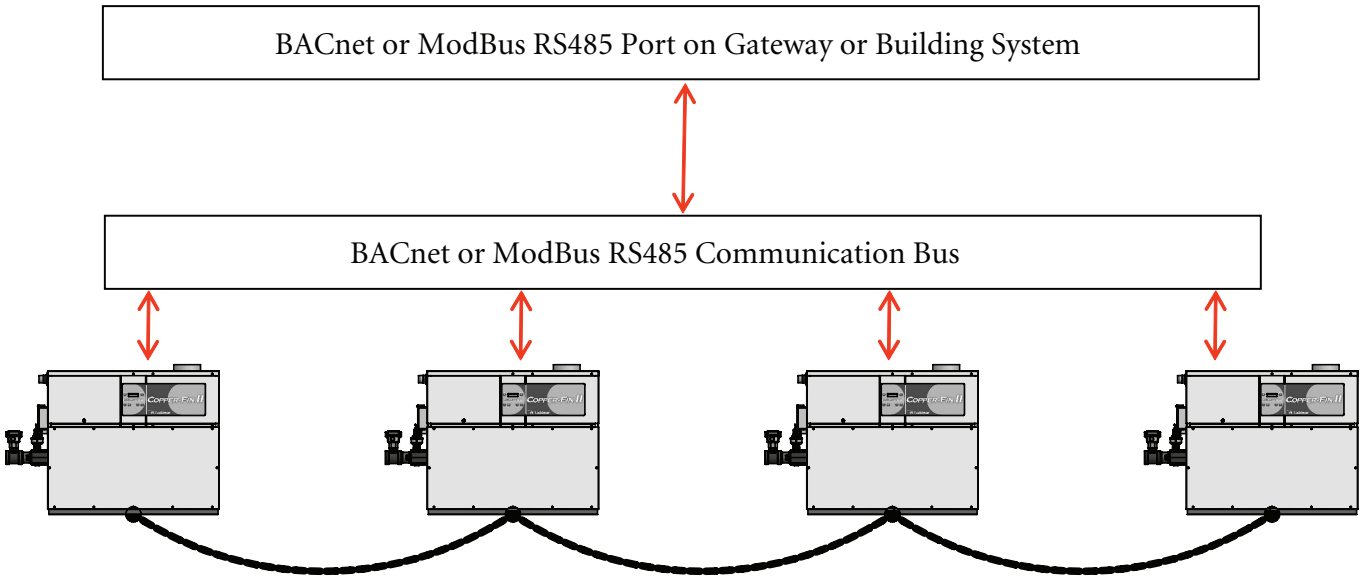
Physical Configuration: Cascade without Individual Monitoring



Cascade Daisy Chain Connection

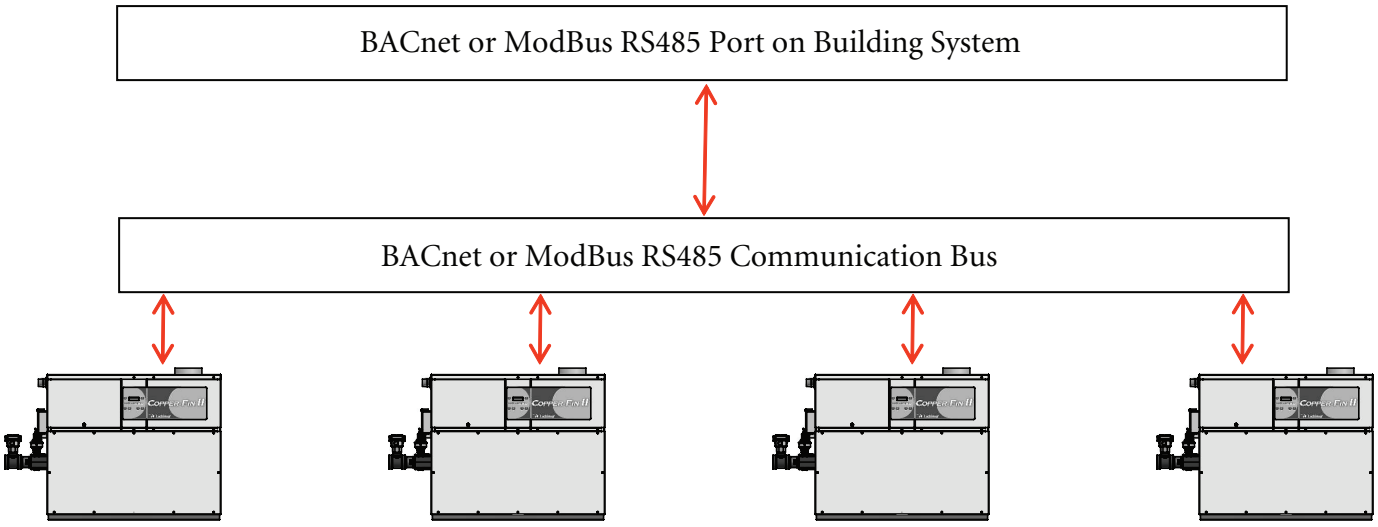
6 Wiring Requirements *(continued)*

Physical Configuration: Cascade with individual Monitoring



Cascade Daisy Chain Connection

Physical Configuration: Direct Control



7 Unit Operation

Unit Operation with ModBus / BACnet Communications

A Building Automation System (BAS) can monitor the Copper-fin II/IIE without the need to change the default configuration of the SMART SYSTEM control. When the BAS is to provide commands or values to the control, parameter **H6 ModBus** must be set to **Active** (reference the Copper-fin II/IIE Service Manual for the procedure on how to set parameters).

The SMART SYSTEM control is equipped with two (2) ModBus communication timers. The first is used whenever the control receives the system temperature and/or the tank temperature through ModBus. These values need to be updated on a regular basis to prevent unwanted temperature variations. This timer is programmable from 1 to 255 seconds. It is Lochinvar's recommendation that this timer be set as short as possible. This timeout can be adjusted by accessing parameter **H7 ModBus Time**. The timer is reset with the ModBus Time setting every time the temperatures are updated. The second timer is used for all other commands and values provided through ModBus. It has a fixed timeout of four (4) minutes. If either of these timers expire before the next update, the SMART SYSTEM control will revert to using its local inputs.

When a BAS is to control a Copper-fin II/IIE, the installer must configure the SMART SYSTEM control to receive commands and data through ModBus or BACnet. There are several different control methods available, as described in this section. These methods are determined by the settings in four (4) different parameters.

Control Mode 1

In this configuration the heater is enabled and disabled through ModBus or BACnet. The heater uses its own local set points. All sensors and limiting devices should be connected directly to the terminal strip(s) inside the Copper-fin II/IIE control compartment. The Enable 1 and/or Tank Thermostat signals will be sent to the heater through ModBus or BACnet.

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 01 00 02 00 03	Read Enable 1 status Read Tank Thermostat status Read Enable 1 and Tank Thermostat status
AV1	**40002**	Coils	00 01 00 02 00 03	Enable 1 only active Tank Thermostat only active Enable 1 and Tank Thermostat active

NOTE: To ensure proper operation, re-send the configuration bits to holding register 40001 or Object AV0 prior to issuing commands.

Control Mode 2

In this configuration, each stage is enabled directly (boiler only).

Control Mode 2 - Setup (Configuration Parameters)

To control each stage separately, access parameters **H5 Sequencer**, and set it to **Active** (reference the Copper-fin II/IIE Service Manual for the procedure on how to set the parameters).

Control Mode 2 - Setup (Command Parameters)

The holding register will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	01 01 03 01 07 01	Read Enable 1 and 2 (2-stage heaters) Read Enable 1, 2, and 3 (3-stage heaters) Read Enable 1, 2, 3, and 4 (4-stage heaters)
AV1	**40002**	Coils	00 01 00 03 00 07 00 0F	Enable Stage 1 Enable Stages 1 and 2 Enable Stages 1, 2, and 3 Enable Stages 1, 2, 3, and 4

NOTE: To ensure proper operation, re-send the configuration bits to holding register 40001 or Object AV0 prior to issuing commands.

7 Unit Operation *(continued)*

Control Mode 3

In this configuration, the heater receives its enable signal and a rate command through ModBus or BACnet. All sensors and limiting devices should be connected directly to the terminal strip(s) inside the Copper-fin II/IIE control compartment.

Control Mode 3 - Setup (Configuration Parameters)

To send a rate signal to the SMART SYSTEM control, access parameter **H3 BMS input** and set it to **Active** (reference the Copper-fin II/IIE Service Manual for the procedure on how to set parameters).

Control Mode 3 - Setup (Command Parameters)

The holding register will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 05	Read Enable 1 and 0-10V input
AV1	**40002**	Coils	00 01	Enable 1 Active
AV2	**40003**	0-10V Input	00 ##	Sets % rate

NOTE: To ensure proper operation, re-send the configuration bits to holding register 40001 or Object AV0 prior to issuing commands. See the *Rate and Temperature Conversions Section* on page 19 for instructions on how to send the % rate.

Control Mode 4

In this configuration, the heater receives its enable signal and set points through ModBus or BACnet. All sensors and limiting devices should be connected directly to the terminal strip(s) inside the Copper-fin II/IIE control compartment.

Control Mode 4 - Setup (Configuration Parameters)

To send a Space Heating set point to the SMART SYSTEM control, access parameter **H3 BMS input** and set it to **Active**. Also, access parameter **J1 BMS Type** and set it to **Set point** (reference the Copper-fin II/IIE Service Manual for the procedure on how to set parameters). The space heating set point will be derived from the 0-10V input value, based on the BMS settings in the control. Reference the Copper-fin II/IIE Service Manual for details of these parameters.

Control Mode 4 - Setup (Command Parameters)

The holding register will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 05 00 08 00 09 00 0D	Read Enable 1 and 0-10V input Read Tank/Pool Set point Read Enable 1 and Pool Set point Read Enable 1, 0-10V input, and Tank Set point
AV1	**40002**	Coils	00 01	Enable 1 active
AV2	**40003**	0-10V Input	00 ##	Sets space heating set point
AV3	**40004**	Tank/Pool Set point	00 ##	Sets Tank or Pool set point

NOTE: To ensure proper operation re-send the configuration bits to holding register 40001 or Object AV0 prior to issuing commands. See the *Rate and Temperature Conversions Section* on page 19 for instructions on how to send the Tank/Pool set point.

7 Unit Operation

Control Mode 5

In this configuration, the heater receives its enable and its rate or set point using the 0-10V input through ModBus or BACnet. All sensors and limiting devices should be connected directly to the terminal strip(s) inside the Copper-fin II/IIE control compartment.

Control Mode 5 - Setup (Configuration Parameters)

To use the 0-10V input as an enable, access parameter **H2 Enable input** in the SMART SYSTEM control, and set this parameter to **Inactive**. Also, access parameter **H3 BMS input** and set it to **Active**. If you wish to control the set point, access parameter **J1 BMS Type** and set it to **Set point**. The enable function and the space heating set point will be derived from the 0-10V input value, based on the BMS settings in the control. Reference the Copper-fin II/IIE Service Manual for the details of these parameters.

Control Mode 5 - Setup (Command Parameters)

The holding register will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 04	Read 0-10V input
AV2	**40003**	0-10V Input	00 ##	Sets space heating rate or set point

NOTE: To ensure proper operation, re-send the configuration bits to holding register 40001 or Object AV0 prior to issuing commands. See the *Rate and Temperature Conversions Section* on page 19 for instructions on how to send the rate.

Hot Water Generation

Hot water generation can be accomplished with one of two methods when a Copper-fin II/IIE 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 boiler with the tank thermostat, or tank temperature sensor, wired to the terminal strip of the unit.

DHW with remote control:

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

To ensure that the Copper-fin II/IIE can properly respond to a call for hot water generation the following holding registers must be set in addition to other commands:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 4A	Set Configuration to read 40002, 4 & 5
AV1	**40002**	Coils	00 08	Enables Tank Tstat *(00 00 disables unit)*
AV3	**40004**	Tank Set point	0# ##	Sets Set point
AV4	**40005**	Tank Temperature	0# ##	Passes tank temp from remote sensor

NOTE: To ensure proper operation re-send the configuration bits to holding register 40001 or Object AV0 prior to issuing commands.

For proper hexadecimal conversion of rate percentage, please refer to the *Rate and Temperature Conversion* section on page 19 of this manual.

7 Unit Operation *(continued)*

Cascade

In order to operate the Copper-fin II/IIE in Cascade with ModBus or BACnet communications, configure the leader boiler per the demand configurations in this manual. Connect the remaining boilers in the cascade through the normal cascade communications wiring. Cascade control can then be accomplished automatically through the leader boiler.

Please note that with ModBus or BACnet communication connected to only the leader boiler, total Cascade information can be seen through the communications link. If you wish to see all the individual temperatures of each unit in the Cascade, each unit will have to have a ModBus communication board. However, each unit can be monitored without the need to control each one individually.

Monitoring Only

Any Copper-fin II/IIE can be equipped with the ModBus communication board and then be set up to operate with its own internal controls. If necessary, ModBus or BACnet can be configured as a monitoring device by selecting demand configurations 1 - 3, and polling the communication board for the read only variables.

Rate and Temperature Conversions:

Rate

When issuing a rate command the rate can be communicated as percent modulation or a desired set point, depending on the setting of the BMS Type in the BMS Setup Menu.

The proper data format for the modulation percentage is the 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

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

For Example:

Send a set point of 110°F.

The formula to use for the interpolation is:

Rate Command =

$$\frac{\text{(Desired Set point – BMS Temp at Low Analog Input) (High Voltage-Low Voltage) + Low Voltage}}{\text{(BMS Temp at High Analog Input – BMS Temp at Low Analog Input)}}$$

From the default values:

Desired Set point = 110
BMS Temp at Low Analog Input =68
BMS Temp at High Analog=158
High Voltage =10
Low Voltage = 2

[(110-69.8)(10-2)/(179.6-69.8)] + 2 = 4.92 Volts

(4.92/10) x 100 = 49.2

49 = 31 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.

Temperature

The Copper-fin II/IIE passes temperature data in degrees Celsius. Also, to accommodate decimal places the decimal value must be divided by 10.

Here are the conversions to and from Celsius:

$T_c = (5/9) * (T_f-32)$ $T_f = (9/5) * T_c+32$

Example:
Outdoor temperature from remote sensor on BAS System = 80°F

80°F = 26.7°C
Data that needs to be transmitted is 26.7 * 10 = 267

Decimal	Binary	HEX
267	100001011	10B

Outlet temperature from unit sensor = 155°F

155°F = 68.3°C
Data transmitted from unit in HEX = 2AB = 683

683 ÷ 10 = 68.3 (°C)

Decimal	Binary	HEX
683	1010101011	2AB

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. Unit Status / Blocking / Lockout Codes

Physical Layer

1. Check that all components have power (Boiler, Gateway, BAS Master)
2. Check all wire lengths. Are any drops too long?
3. Check proper shield grounding
4. Check A, B terminal connections
5. Check for Terminating Resistors (120 ohms)
6. Check for broken wires

Communications

1. Check Dip Switch Configuration of MTR-01 Board
2. Check Baud Rate (9600, 19200)
3. Check Parity
4. Check Slave ID
5. Check Port Setting on Master, Gateway, and Computers

ModBus Error Codes

1. Check ModBus communication for error codes (see page 6 for ModBus Exception Codes)
2. Check ModBus PDU
3. Check Slave ID
4. Check ModBus Command
5. Check Configuration bits for Holding Register 40001
6. Check Commands and data for Holding Registers 40002 - 40007

Unit Status Codes

See Codes in this section

Boiler Status

The Copper-fin II/IIE displays a boiler state code on the Building Screen to help aid in troubleshooting. The boiler state indicates what the boiler is actually doing. This state should be compared to the command issued and what is expected. If the boiler state does not agree with the command issued, check communication and configuration.

Status Codes (Input Registers 30014 and 30023)

2 = Heat Demand blocked due to high absolute outlet temperature
3 = Heat Demand blocked due to high absolute flue temperature
4 = Heat Demand blocked due to high absolute Delta T (Outlet - Inlet)
8 = Heat Demand blocked due to Low 24 VAC
9 = Outdoor shutdown
10 = Block due to switch OFF boiler (ON/OFF of Display)
12 = Block due to no correct communication Cascade
16 = Service function
19 = DHW function Storage Tank
21 = SH function Heat demand from Room Thermostat
22 = SH function Heat demand from Boiler Management System
23 = SH function Heat demand from Cascade
30 = Heat demand activated by Freeze Protection
32 = DHW Pump Delay
33 = SH Pump Delay
34 = No heat function (after pump delay)
40 = Lockout
32764 = Busy with updating status
32765 = DHW blocked due to no present tank sensor
32766 = Burner control(s) manually shut down
32767 = Code not present

Blocking Codes (Input Registers 30015 and 30024)

0 = No blocking _> is divided into sub blockings
1 = SH blocking
2 = Blocking Due to Low 24 VAC Supply
3 = Blocking due to General block
4 = Blocking MRHL is open
5 = Blocking due to Switched OFF boiler (Display ENTER switch)
6 = Blocking due to wrong communication of Cascade
7 = Blocking due to High Delta
8 = Blocking due to High Flue Temperature
9 = Blocking due to High Outlet Temperature
10 = Service blocking
12 = DHW blocking high outlet temperature (DHW configured as storage tank)
13 = Blocking anti-cycling time
14 = Storage Tank demand Blocked due to Fan problems
15 = No system sensor connected and leader control present
16 = Limit fan speed due to high outlet temperature
17 = Fan min decreased due to low flame current
18 = Limit max fan speed due to high Delta T
19 = Limit max fan speed due to high flue temp
32767 = Code not present

8 Troubleshooting *(continued)*

Lockout Codes (Input Register 30016)

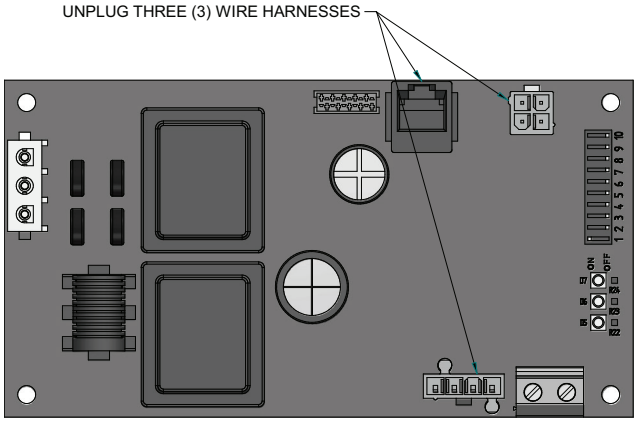
NOTICE

The lockout code (Input Register 30016) is constantly changing during operation and should not be used for lockout notification until the status code (Input Register 30014) indicates a code of 40.

6 = Louver closed
7 = Air SW Fail closed
8 = Air SW Fail open
9 = Gas Pressure SW
10 = Flow Switch/LWCO
11 = Gas Valve Fail 1
12 = Gas Valve Fail 2
13 = Gas Valve Fail 3
14 = Gas Valve Fail 4
15 = Flame Sequence A
16 = Flame Sequence B
17 = Flame Fail IGN A
19 = Flame Fail Run A
29 = Memory Error
51 = Sensor 1 Shorted
52 = Sensor 1 Open
53 = Sensor 2 Shorted
54 = Sensor 2 Open
63 = Outlet Temp MRHL
64 = Outlet Temp ARHL
65 = Outlet Temp ARHL

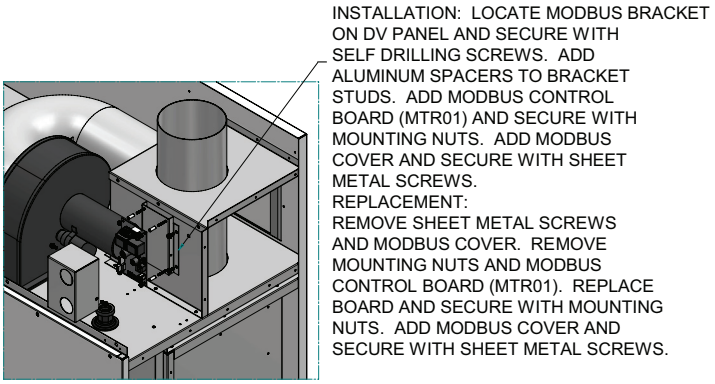
Installation / Replacement Procedure

Figure 8-1_MTR01 Control Board



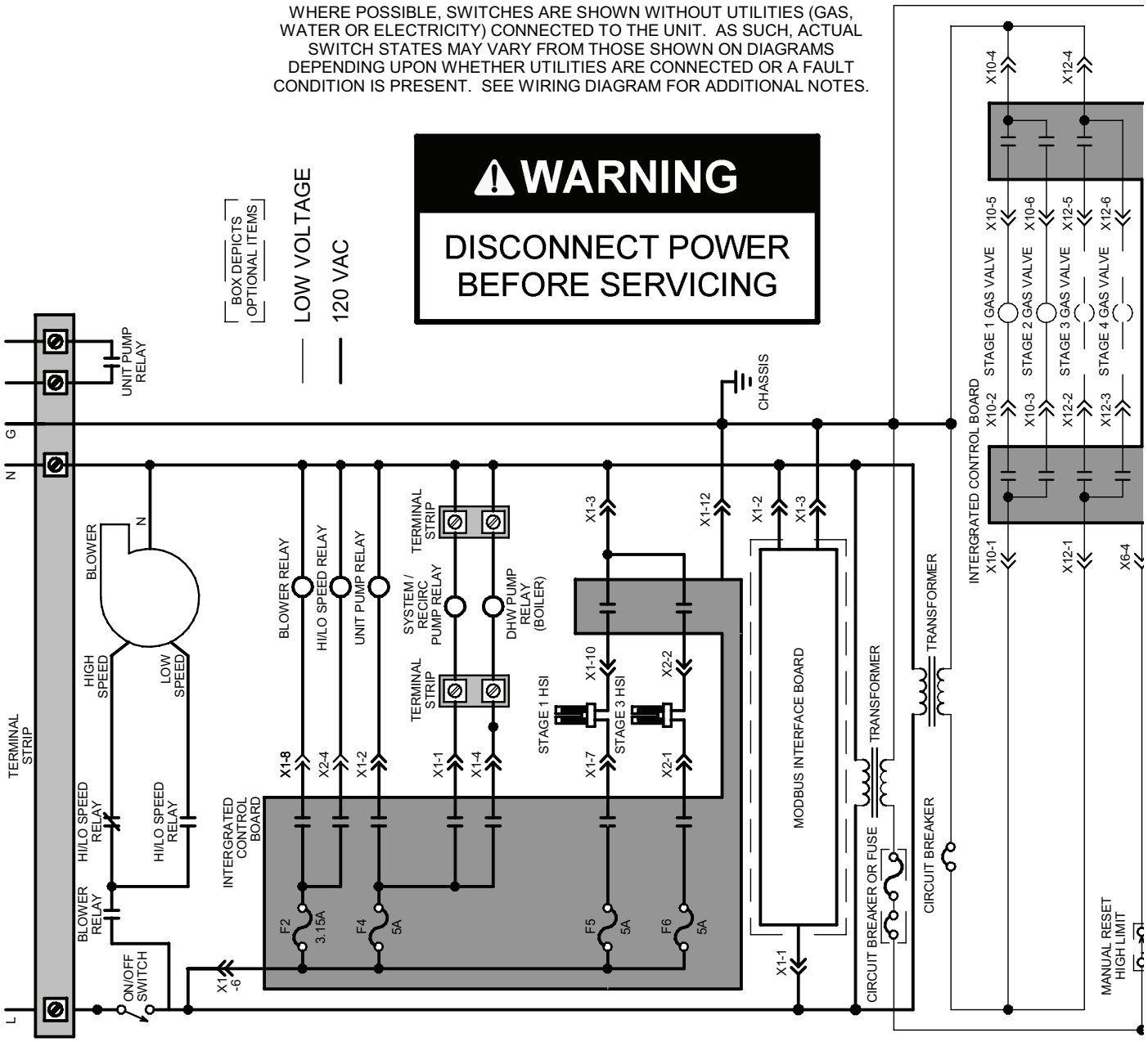
1. Turn OFF the main electrical power to the appliance.
2. Turn OFF the main manual gas shutoff to the appliance.
3. Unplug the three (3) wire harnesses on the MTR01 control board (see FIG. 8-1).
4. Unscrew the four (4) mounting nuts on the MTR01 control board and set aside. Remove the MTR01 control board (see FIG. 8-2).
5. Replace / install the new MTR01 control board.
6. Replace the four (4) mounting nuts removed in Step 4.
7. Reconnect all three (3) wire harnesses unplugged in Step 3.
8. Turn on the main electrical power and the main manual gas shutoff to the appliance.
9. Configure the MTR01 control board and unit controls per this manual and resume operation.

Figure 8-2_Control Panel w/MTR01 Control Board



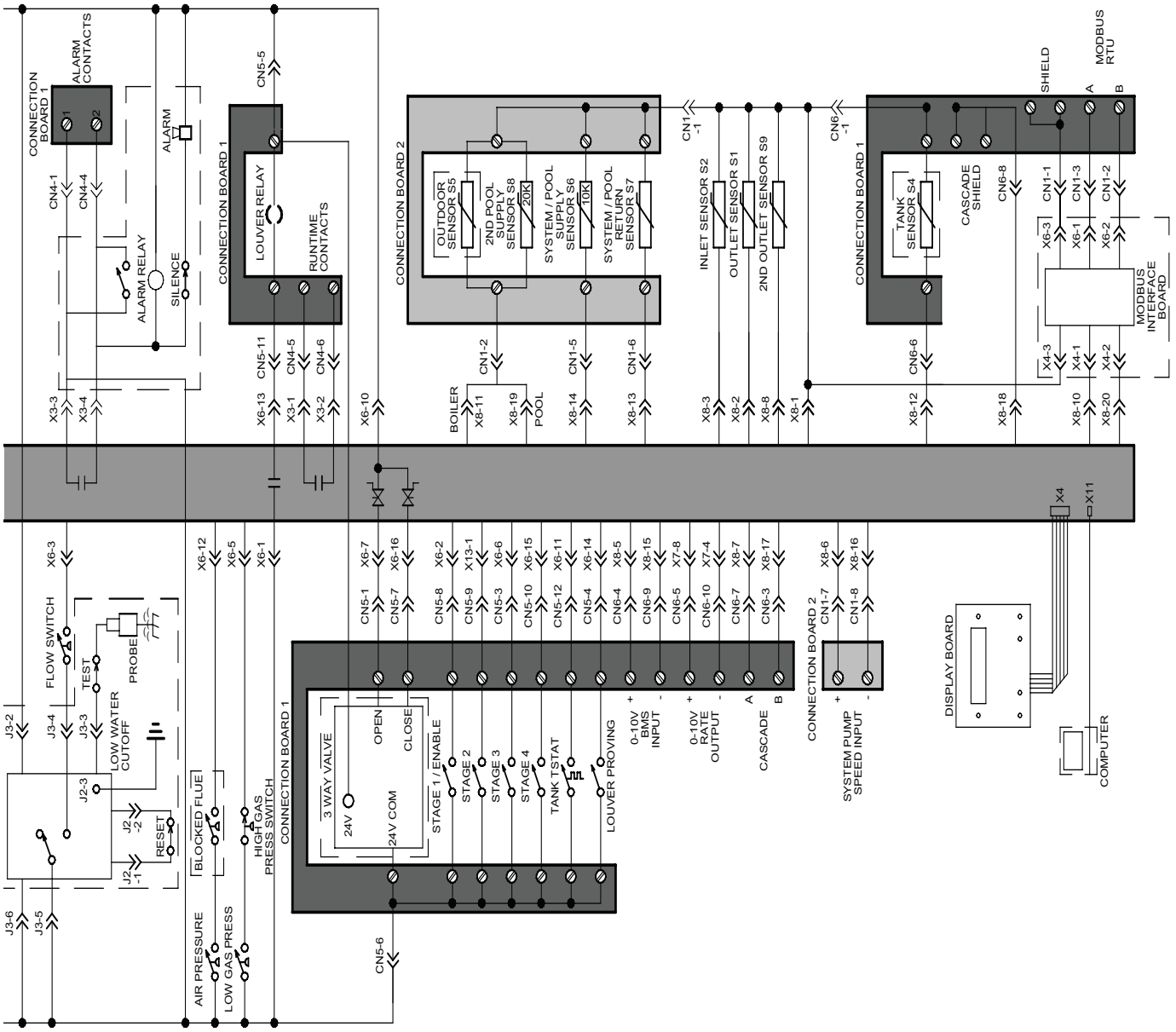
9 Diagrams

Figure 9-1 *Ladder Diagram*



9 Diagrams *(continued)*

Figure 9-1 *Ladder Diagram cont'd*



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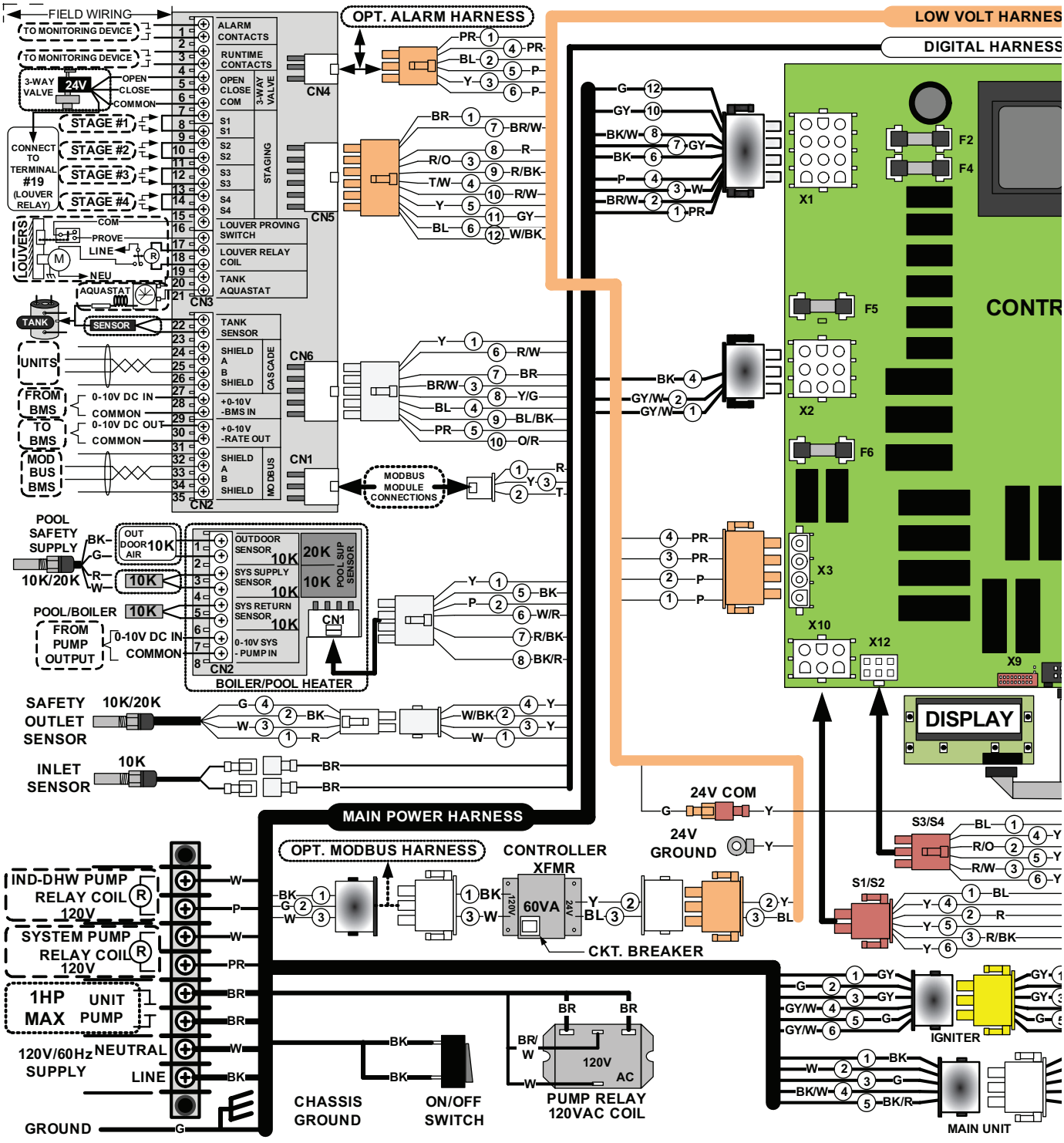
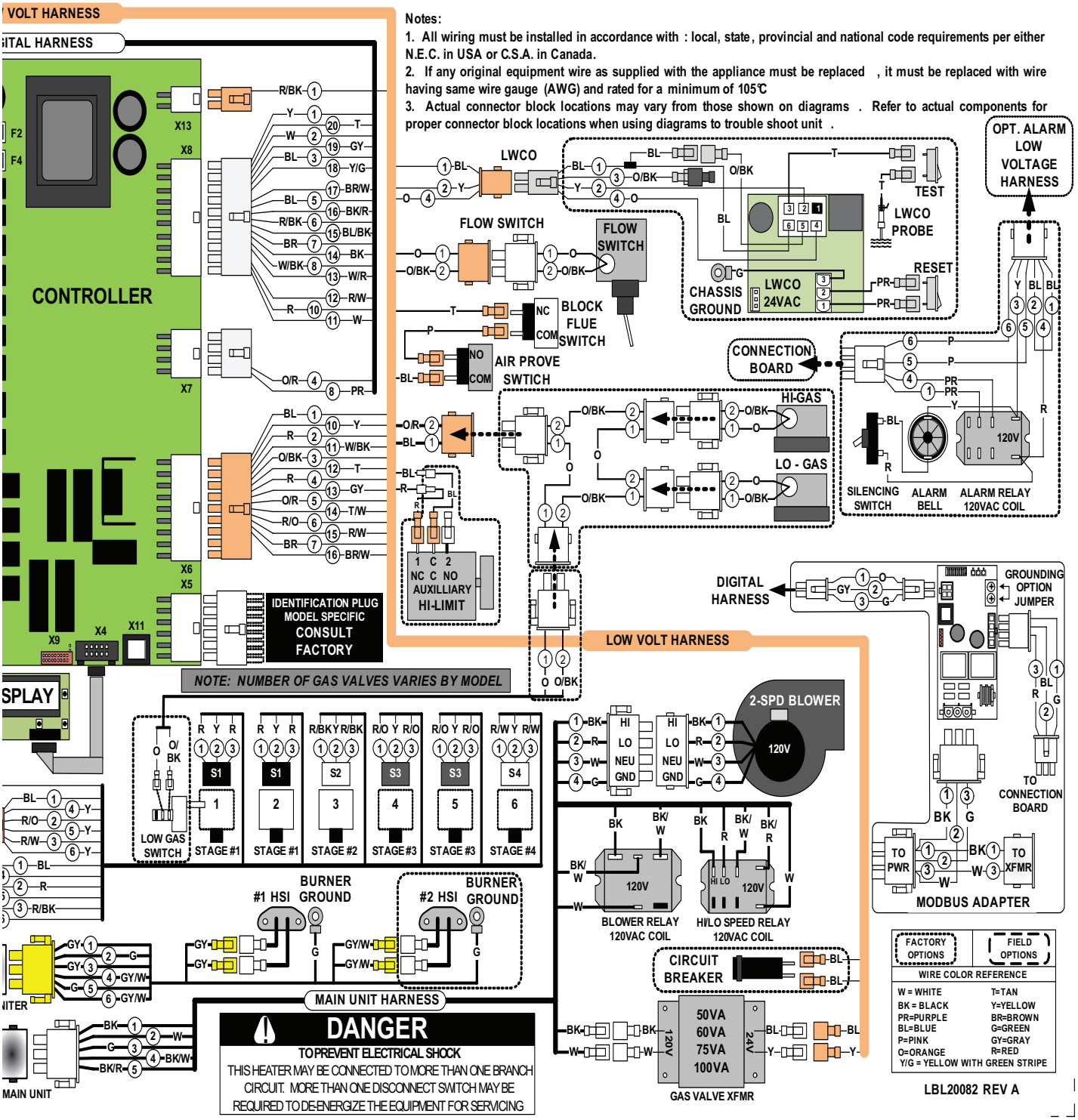
9 Diagrams

Figure 9-2 *Connection Diagram*



9 Diagrams *(continued)*

Figure 9-2 *Connection Diagram cont'd*



Notes

Notes

Revision Notes: *Revision A (ECO #C08638) initial release.*

Revision B (ECO C11616) reflects the addition of the lockout code notice on page 21 (R05772).

Revision C (PCP# 3000002377 / CN# 500002607) reflects the addition of BACnet information and images, edits made to wording of Timing Specifications on pages 4 and 10, and edits made to Memory Map tables on pages 8 and 12.

Revision D (PCP# 3000007541 / CN# 500007580) reflects the addition of references to A+ and B- on page 15.

Revision E (PCP# 3000008406 / CN# 500008361) reflects an update to the addressing information of BACnet configuration on page 9.

Revision F (PCP #3000045243 / CN #500032780) reflects Fahrenheit and Celsius enhancement additions.

Revision G (PCP #3000069837 / CN #500055279) reflects updated lockout codes on page 25.

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300 Maddox Simpson Parkway
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