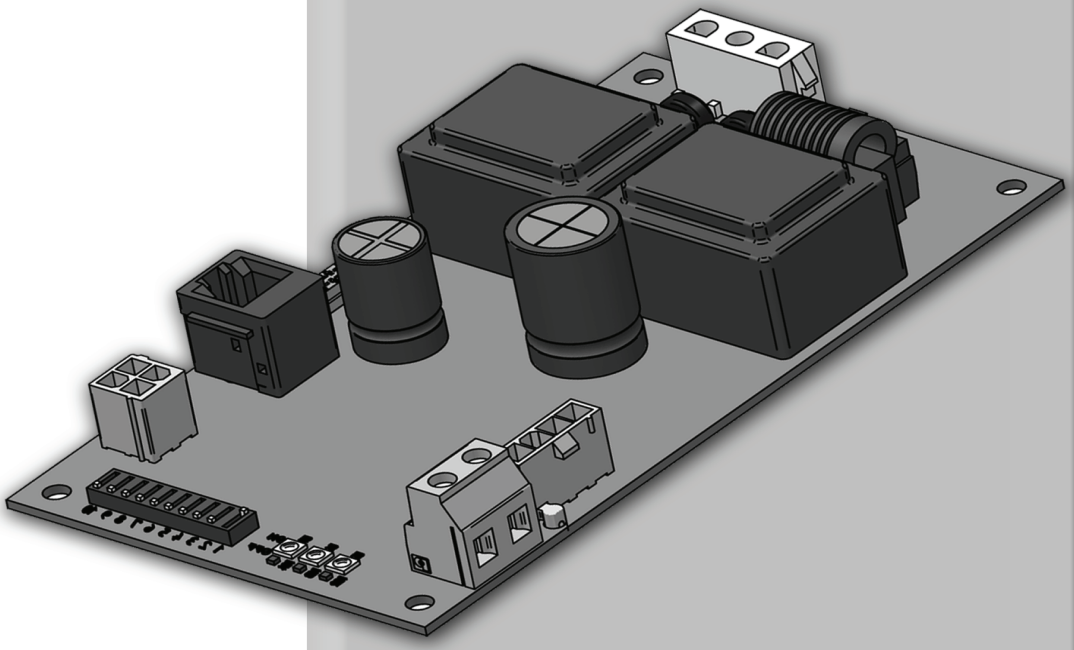
ARMOR™
CONDENSING WATER HEATER

MODBUS AND BACNET COMMUNICATION INSTRUCTIONS

Armor Models: 400 - 4000
Knight Models: 400 - 1000
Series: 100 & 101



⚠ 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 and BACnet communication with the Lochinvar Armor.

All ModBus networks are implemented utilizing a master-slave arrangement where all Armors 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 protocol (MS/TP) 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 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

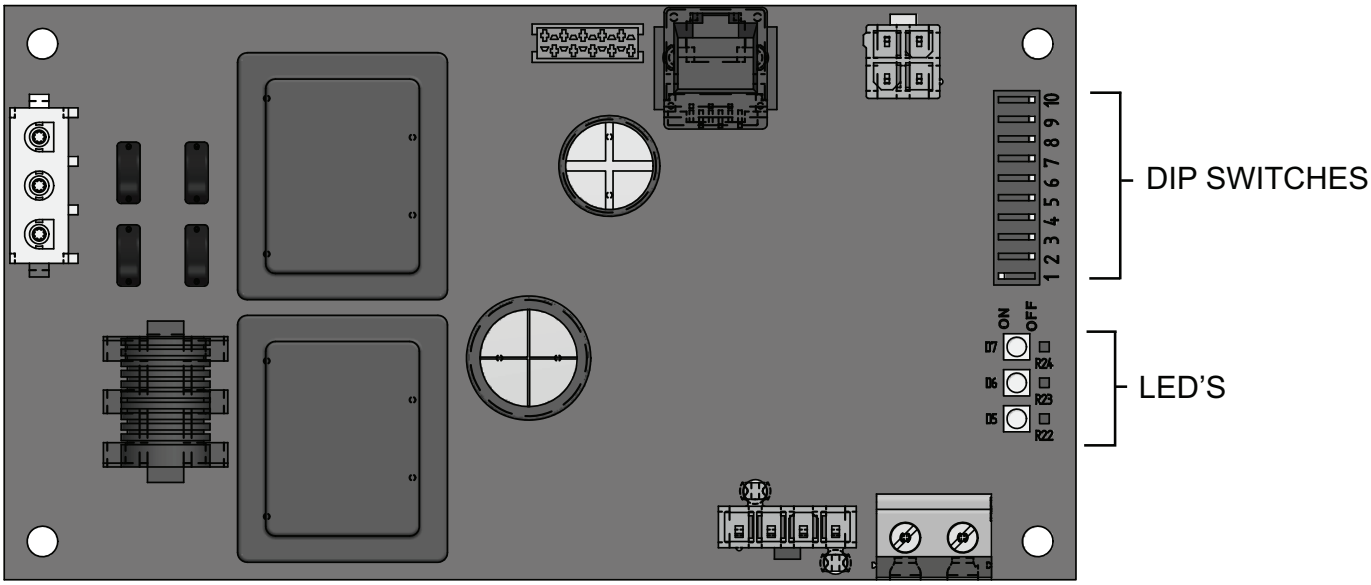
Minimum System Requirements

- BAS system or computer with a serial or USB port with a converter to RS-485.
- 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 used to set the baud rate. The tenth is used to set the parity.

Figure 2-1_ModBus Communication Board



Addressing

The ModBus addressing space is comprised of 256 different addresss.

- 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 tank temperature and/or 0-10V BMS voltage is provided by the BAS to the unit, it is critical that the values be updated every few seconds. If the unit 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 H6 (see the Armor Service Manual for instructions for setting parameters). The timeout is adjustable between 5 and 120 seconds. The default timeout is 10 seconds.

When the BAS is not providing any of these values, but is still controlling the unit (such as providing an enable command), the BAS must refresh these commands at least every 4 minutes. If the commands are not refreshed, the unit 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

Memory Map

Coils						
Address	**Description**	**Default**	**Unit**	**Min.**	**Max.**	**Resolution**
00001	Enable	0	1=ON / 0=OFF	0	1	1
00005	Tank Thermostat	0	1=ON / 0=OFF	0	1	1
Discrete Inputs						
10001	Manual Reset High Limit	0	1=ON / 0=OFF	0	1	1
10002	Flow Switch	0	1=ON / 0=OFF	0	1	1
10003	Gas Pressure Switch	0	1=ON / 0=OFF	0	1	1
10004	Louver Proving Switch	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	0	1=ON / 0=OFF	0	1	1
10008	Flame	0	1=ON / 0=OFF	0	1	1
10009	Enable	0	1=ON / 0=OFF	0	1	1
10010	Tank Thermostat	0	1=ON / 0=OFF	0	1	1
10033	Run-time Contacts	0	1=ON / 0=OFF	0	1	1
10034	Alarm Contacts	0	1=ON / 0=OFF	0	1	1
10036	DHW Pump	0	1=ON / 0=OFF	0	1	1
10038	Gas Valve	0	1=ON / 0=OFF	0	1	1
10039	Recirculation Pump	0	1=ON / 0=OFF	0	1	1
10049	Blower Power	0	1=ON / 0=OFF	0	1	1

3 ModBus Memory Map

Memory Map

Input Registers						
Address	**Description**	**Default**	**Unit**	**Min.**	**Max.**	**Resolution**
30001	Discrete Inputs 1 - 16	0	N/A	0	65535	1
30002	Discrete Inputs 17 - 32	0	N/A	0	65535	1
30003	Discrete Inputs 33 - 48	0	N/A	0	65535	1
30004	System / Cascade Setpoint	0	Degrees Celsius	0	130	0,5
30006	Cascade Total Power	0	%	100	800	1
30007	Cascade Current Power	0	%	0	800	1
30009	Outlet Temperature	0	Degrees Celsius	0	130	0,1
30010	Inlet Temperature	0	Degrees Celsius	-20	130	0,1
30011	Flue Temperature	0	Degrees Celsius	-20	130	0,1
30012	Firing Rate	0	%	0	100	1
30014	Status Code	0	N/A	0	65535	1
30015	Blocking Code	0	N/A	0	65535	1
30016	Lockout Code	0	N/A	0	65535	1
30026	Discrete Inputs 49 - 64	0	N/A	0	65535	1
30027	Lockout Code Leader	0	N/A	0	65535	1
30028	Lockout Code Member 1	0	N/A	0	65535	1
30029	Lockout Code Member 2	0	N/A	0	65535	1
30030	Lockout Code Member 3	0	N/A	0	65535	1
30031	Lockout Code Member 4	0	N/A	0	65535	1
30032	Lockout Code Member 5	0	N/A	0	65535	1
30033	Lockout Code Member 6	0	N/A	0	65535	1
30034	Lockout Code Member 7	0	N/A	0	65535	1
Holding Registers						
40001	Configuration	0	N/A	0	65535	1
40002	Coils	0	N/A	0	65535	1
40003	0-10 Volt Input / Rate Command / Setpoint Command	0	%	0	100	1
40004	Tank Setpoint	0	Degrees Celsius	0	87,5	0,5
40005	Tank Temperature	0	Degrees Celsius	-20	130	0,1

Configuration Bits

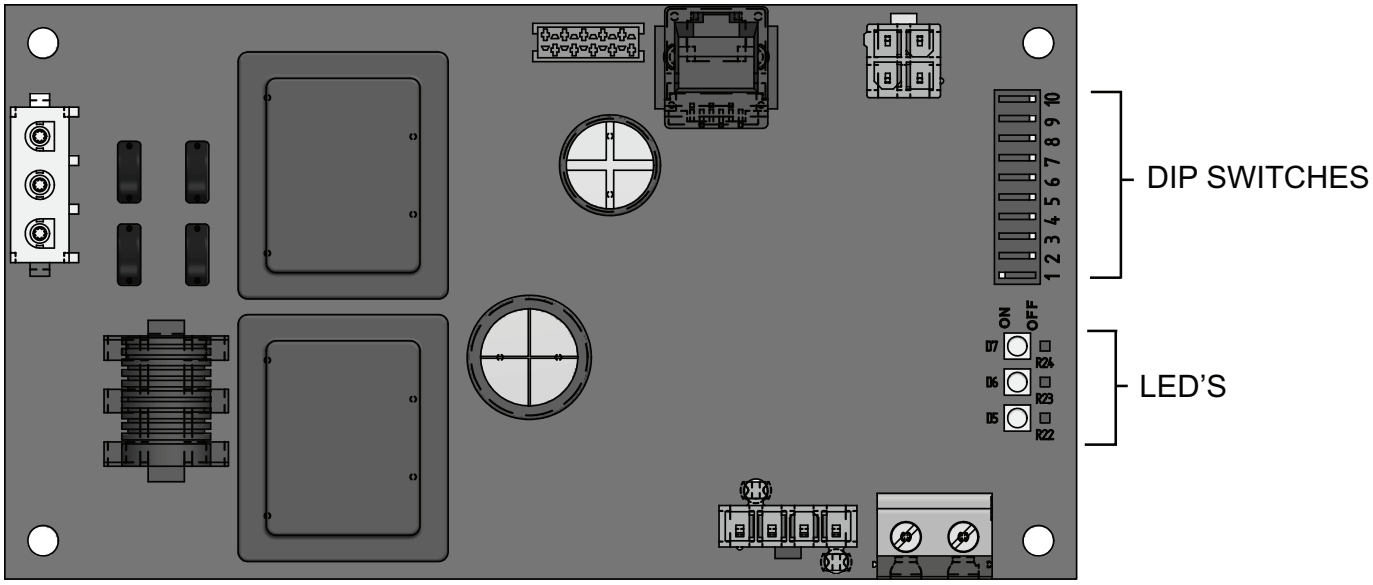
Address 40001 contains configuration bits sent from the BAS to the unit. These bits tell the unit to use its own internal inputs, or inputs from the BAS. When a bit is set to 1, the unit will ignore the corresponding value contained internally, and expect the BAS to write that value into the Holding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

Bit 0 (LSB): Enable
Bit 1: Tank Thermostat
Bit 2: Rate Command / 10 - 10V Input / Setpoint Command
Bit 3: Tank Setpoint
Bit 6: Tank 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.

- 255 is reserved for broadcast messages from a master device.
- 128 - 254 are free to use for slave devices only.
- 0 - 127 are free to use for master or slave devices.

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
Dip switch 8 = 128

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

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 640000. Using the above example, the Device Instance will be:

Device Instance = 640000 + 50 = 640050

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

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 tank temperature and/or 0-10V BMS voltage is provided by the BAS to the appliance, it is critical that the values be updated every few seconds. If the appliance 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 H6 (see the Armor Service Manual for instructions for setting parameters). The timeout is adjustable between 5 and 120 seconds. The default timeout is 10 seconds.

When the BAS is not providing any of these values, but is still controlling the appliance (such as providing an enable command), the BAS must refresh these commands at least every 4 minutes. If the commands are not refreshed, the appliance 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.

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						
Enable	BV	0	none	0	1	1
Tank Thermostat	BV	4	none	0	1	1
Binary Inputs						
Manual Reset High Limit	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
Blocked Drain Switch	BI	5	none	0	1	1
Auto Reset High Limit	BI	6	none	0	1	1
Flame	BI	7	none	0	1	1
Enable	BI	8	none	0	1	1
Tank Thermostat	BI	9	none	0	1	1
Run Time Contacts	BI	32	none	0	1	1
Alarm Contacts	BI	33	none	0	1	1
DHW Pump	BI	35	none	0	1	1
Gas Valve	BI	37	none	0	1	1
Recirculation Pump	BI	38	none	0	1	1
Power Fan	BI	48	none	0	1	1

5 BACnet Memory Map

Memory Map *(continued)*

Object Name	Object Type	Object Instance	Units	Min	Max	Resolution
Inputs						
Binary Inputs 0-15	AI	0	none	0	65535	1
Binary Inputs 16-31	AI	1	none	0	65535	1
Binary Inputs 32-47	AI	2	none	0	65535	1
System / Cascade Setpoint	AI	3	Deg. C	0	130	0.5
Cascade Total Power	AI	5	Percent	100	800	1
Cascade Current Power	AI	6	Percent	0	800	1
Outlet Temperature	AI	8	Deg C	0	130	0,1
Inlet Temperature	AI	9	Deg C	-20	130	0,1
Flue 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
Binary Inputs 48-63	AI	25	none	0	65535	1
Lock-Out Error Leader	AI	26	none	0	1	1
Lock-Out Error Member 1	AI	27	none	0	1	1
Lock-Out Error Member 2	AI	28	none	0	1	1
Lock-Out Error Member 3	AI	29	none	0	1	1
Lock-Out Error Member 4	AI	30	none	0	1	1
Lock-Out Error Member 5	AI	31	none	0	1	1
Lock-Out Error Member 6	AI	32	none	0	1	1
Lock-Out Error Member 7	AI	33	none	0	1	1
Analog Values						
Configuration	AI	0	none	0	65535	1
Coils	AI	1	none	0	65535	1
0-10 Volt Input / Rate Command / Setpoint Command	AI	2	Percent	0	100	1
Tank Setpoint	AI	3	Deg C	0	87,5	0,5
Tank Temperature	AI	4	Deg C	-20	130	0,1

6 Wiring Requirements

Note that when the Tank Temperature is provided by the BAS, it needs to be refreshed every few seconds. This is required in order to prevent unwanted fluctuations in temperature. If these values are not provided every few seconds (timeout is programmable), the appliance will revert to its own internal control. If this temperature is provided by the BAS, but any of the other control signals are being provided, the BAS will still need to refresh this input 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

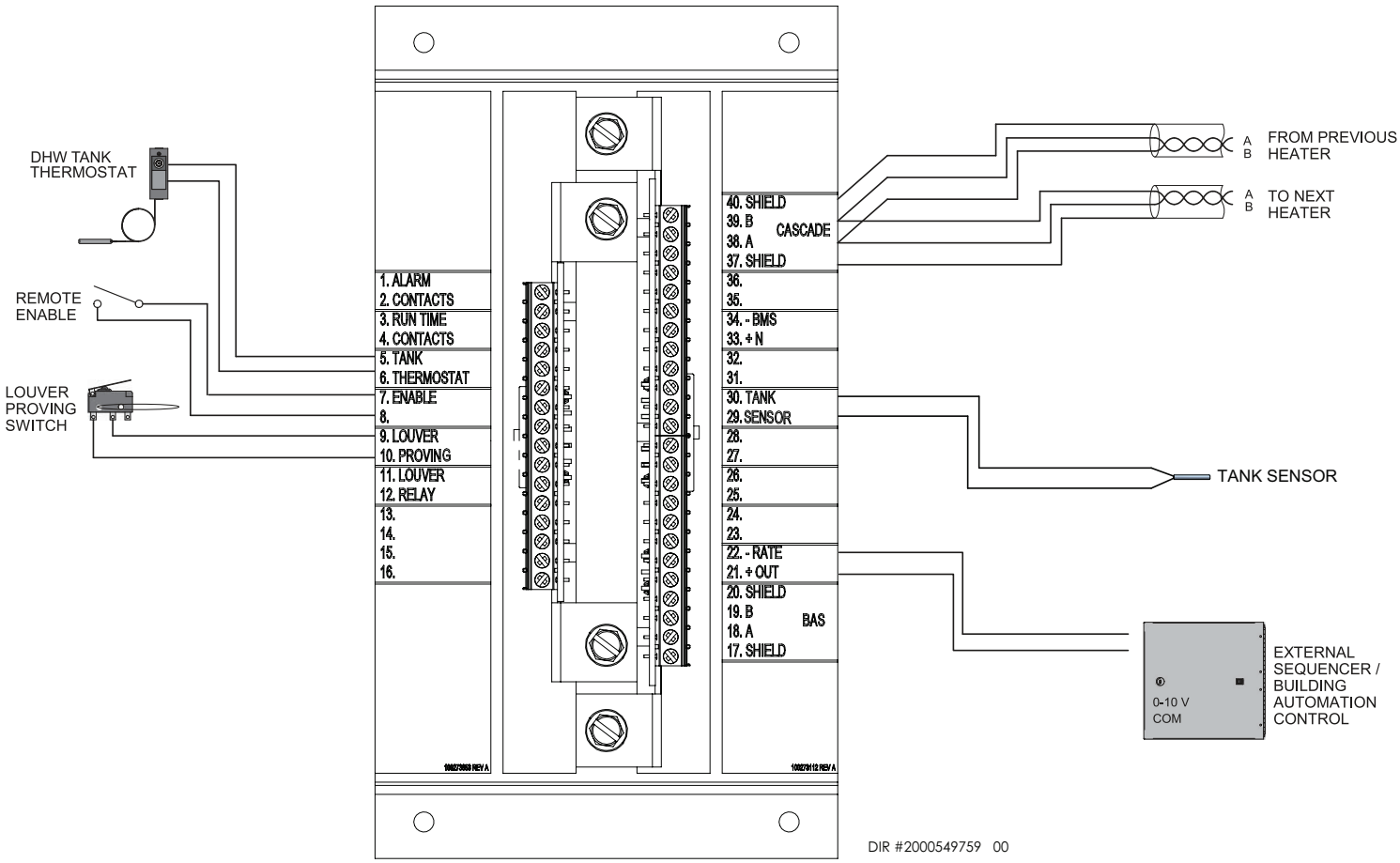
=

120 ohm

- Maximum Load = 32 units (32 nodes)

NOTE: Cable must be terminated with 120 ohm impedance matching resistor on each end.

Figure 6-1_Terminal Strip Connections - 1250-4000 Models



6 Wiring Requirements

Figure 6-2_Terminal Strip Connections - AWH0400-1000 Models

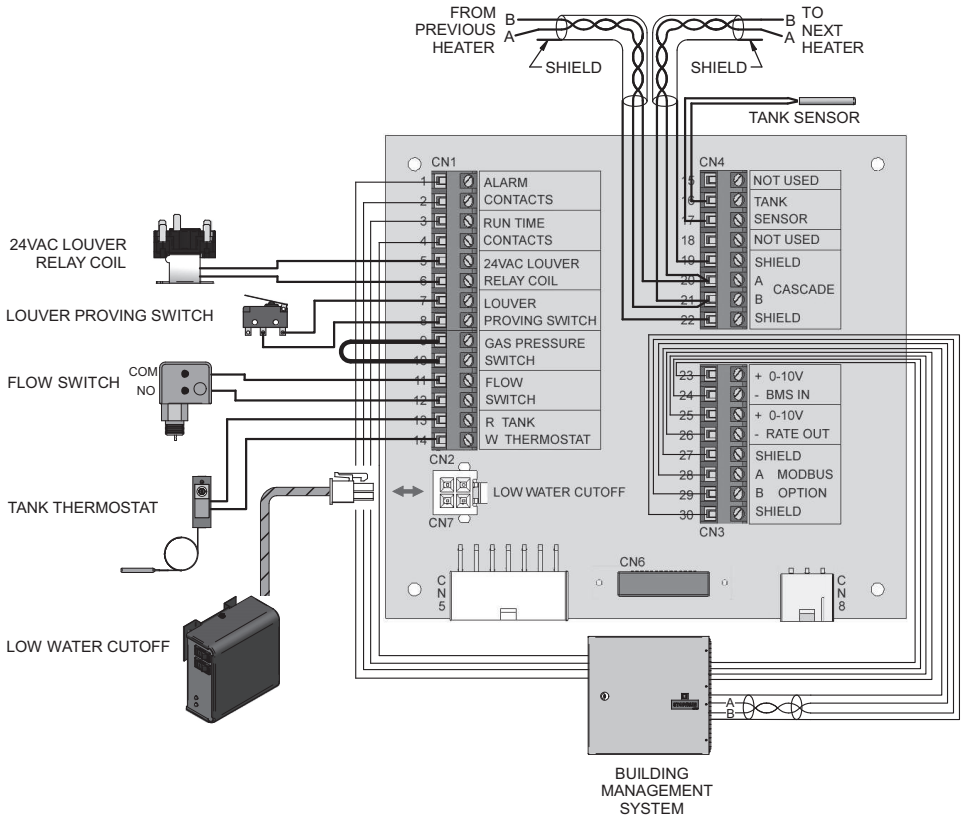
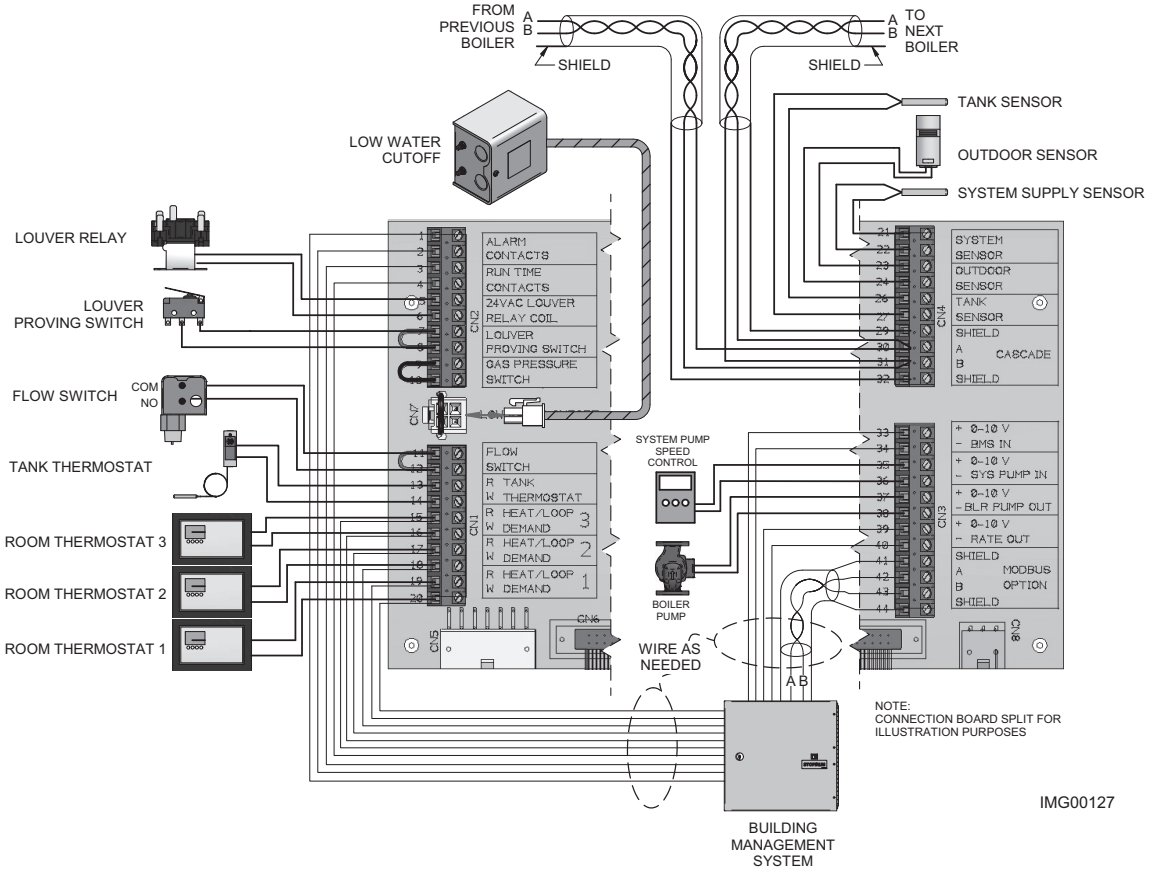
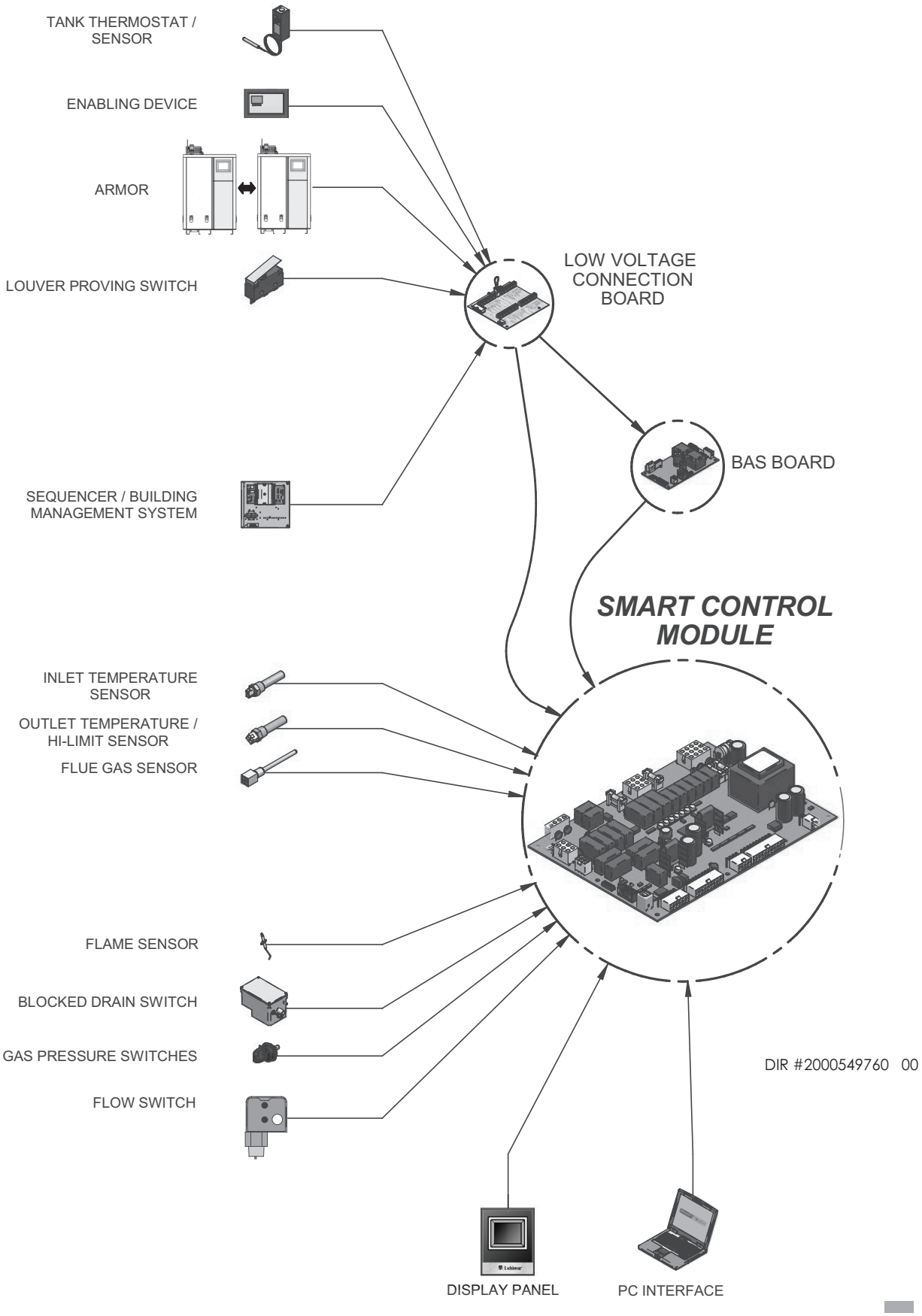


Figure 6-3_Terminal Strip Connections - KBX0400-1000 Models



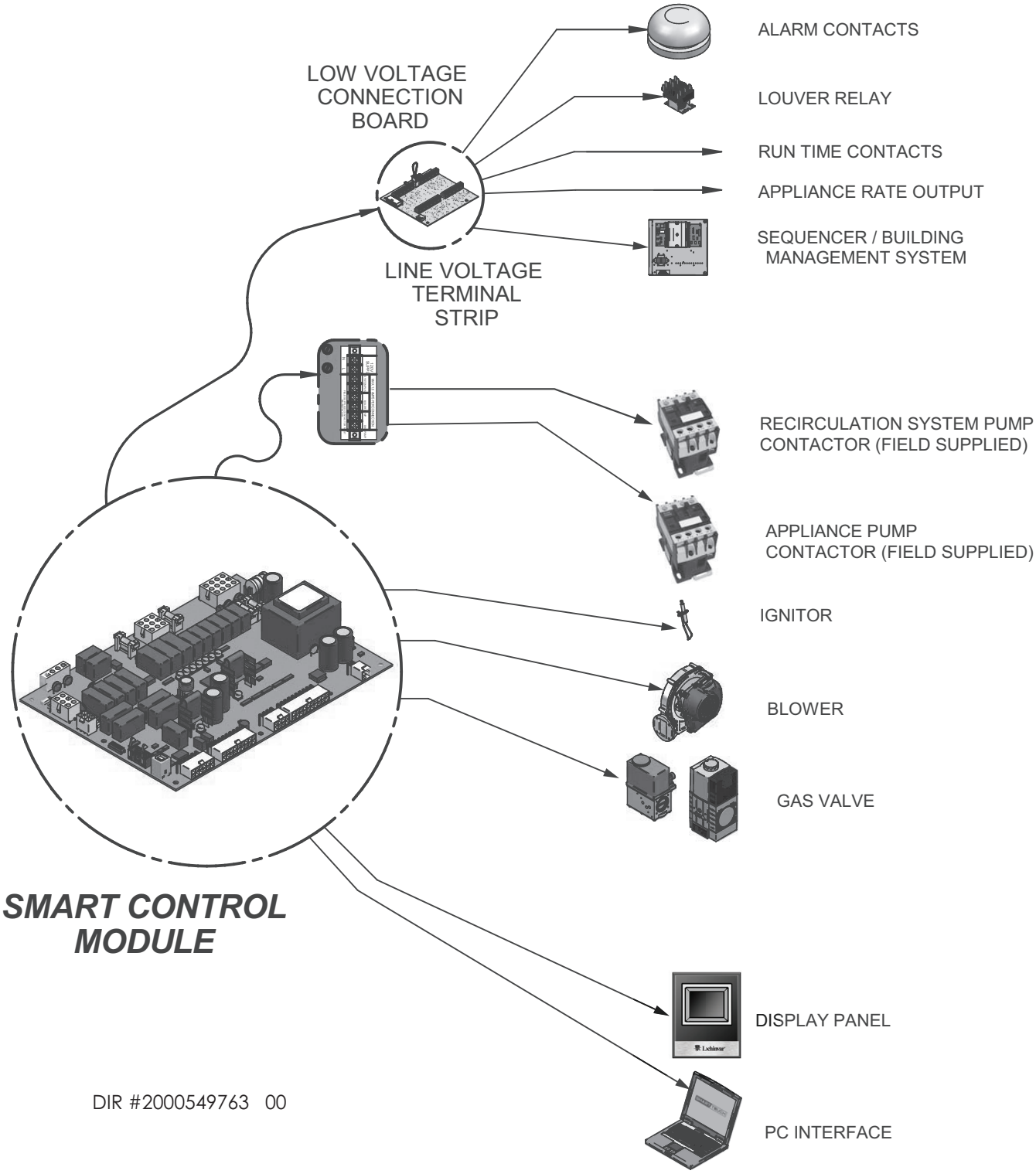
6 Wiring Requirements *(continued)*

Figure 6-4_Control Inputs



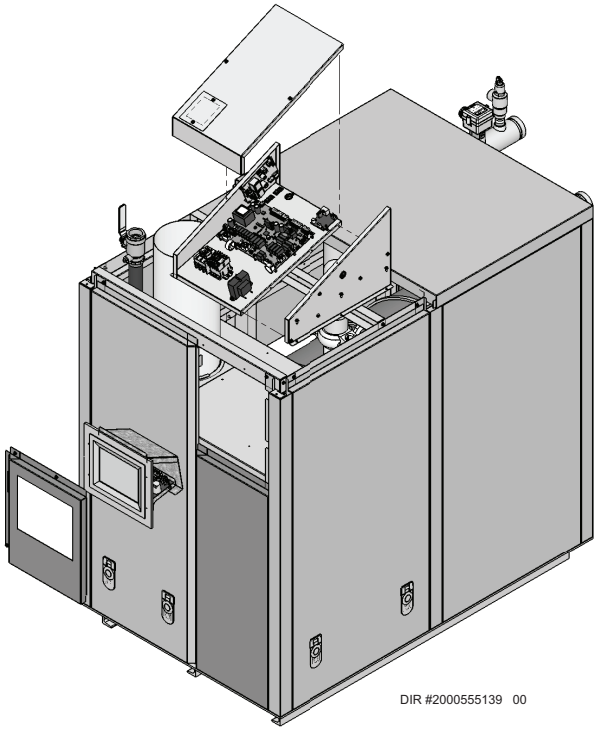
6 Wiring Requirements

Figure 6-5_Control Outputs



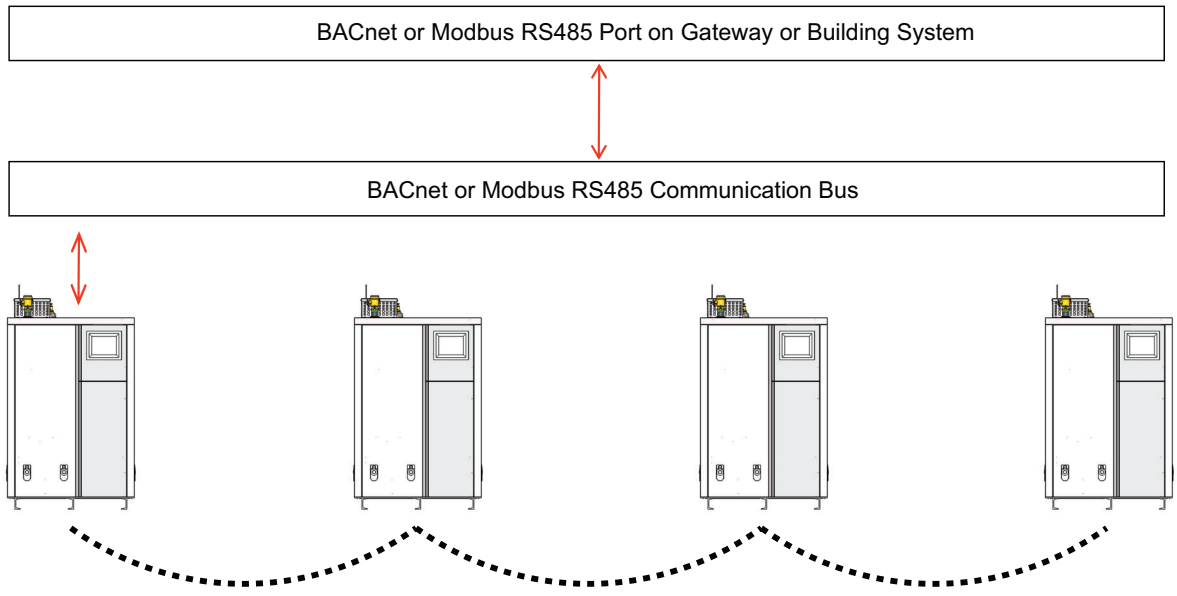
6 Wiring Requirements *(continued)*

Figure 6-6_Control Location



Typical System Wiring

Physical Configuration: Cascade without Individual Monitoring

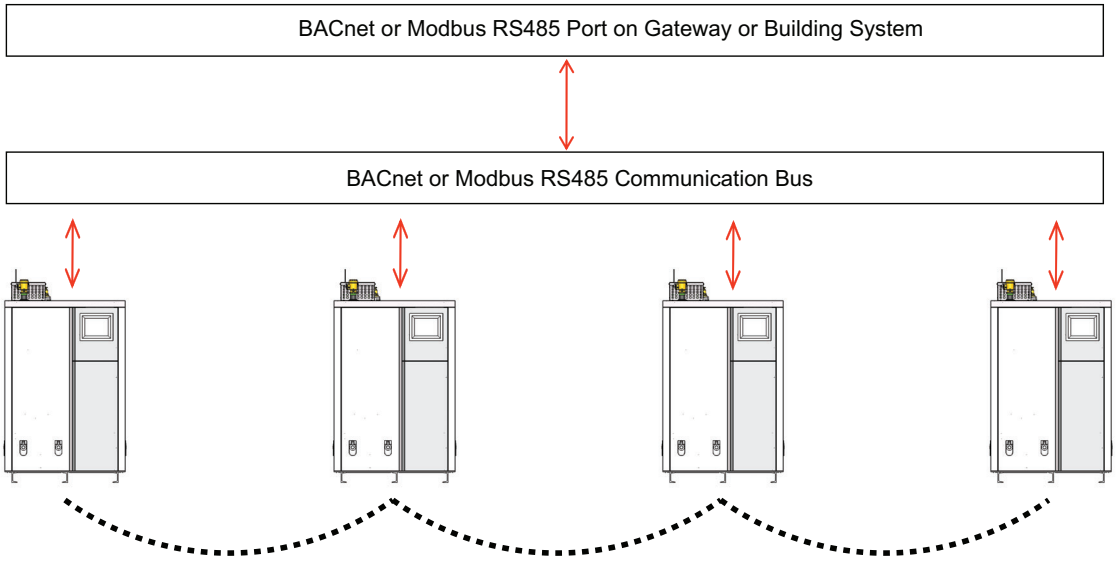


Cascade Daisy Chain Connection

DIR #2000555143 00

6 Wiring Requirements

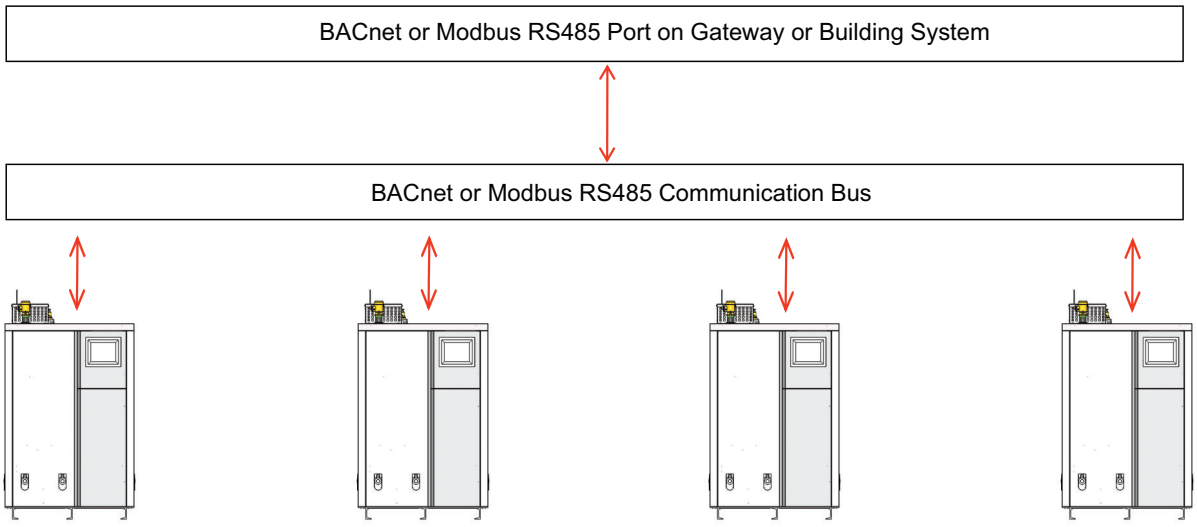
Physical Configuration: Cascade with Individual Monitoring



Cascade Daisy Chain Connection

DIR #2000555143 00

Physical Configuration: Direct Control



DIR #2000555143 00

7 Unit Operation

Unit Operation with ModBus or BACnet Communications

A Building Automation System (BAS) can monitor the Armor 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 **H5 ModBus** must be set to **Active** (reference the Armor Service Manual for the procedure on how to set parameters).

The SMART SYSTEM control is equipped with two (2) communication timers. The first is used whenever the control receives the tank temperature through ModBus or BACnet. 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 **H6 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 or BACnet. 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 Armor, 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.

Demand Configuration: ENABLE = ACTIVE; BMS = INACTIVE

In this configuration the unit is controlled by setting the setpoints locally on the unit and providing an enable signal through ModBus or BACnet communications.

All sensors and limiting devices should be hardwired to the terminal strip on the back of the unit excluding the enable signal. This signal will be sent to the unit via ModBus or BACnet.

The holding objects or registers will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 01	Set Configuration to read 40002
AV1	**40002**	Coils	00 01	Enables unit *(00 00 disables unit)*

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

7 Unit Operation

Demand Configuration: ENABLE = ACTIVE; BMS = ACTIVE

In this configuration the unit is controlled by providing an enable signal. The setpoint command will be determined by the parameters in the control and a rate command through ModBus or BACnet communications.

The rate command will be 0 - 100% of modulation.

All sensors and limiting devices should be hardwired to the terminal strip on the back of the unit excluding the enable and 0-10V BMS signal. These signals will be sent to the unit via ModBus or BACnet.

The holding objects or registers will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 05	Set Configuration to read 40002 & 3
AV1	**40002**	Coils	00 01	Enables unit *(00 00 disables unit)*
AV2	**40003**	Rate Command	00 ##	Sets Modulation % or Setpoint

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

For proper hexadecimal conversion of rate percentage, please refer to the Rate and Temperature Conversion section on page 17 of this manual.

Demand Configuration: ENABLE = INACTIVE; BMS = ACTIVE

In this configuration the unit is controlled by setting the modulation setpoint from 0 - 100%, or the setpoint. The setpoint command will be determined by the parameters in the control.

Rate command will be 0 - 100% of the modulation range.

All sensors and limiting devices should be hardwired to the terminal strip on the back of the unit excluding the 0 - 10Vdc signal. This signal will be sent to the unit via ModBus or BACnet.

The holding registers will need to be set as follows:

Object	Holding Registers	Definition	Bit Value (HEX)	Action
AV0	**40001**	Configuration	00 04	Set Configuration to read 40003
AV2	**40003**	Rate Command	00 00	Sets Modulation % or Setpoint

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

For proper hexadecimal conversion of rate percentage, please refer to the Rate and Temperature Conversion section on page 17 of this manual.

7 Unit Operation *(continued)*

Cascade

In order to operate the Armor in Cascade with ModBus or BACnet communications, configure the leader unit per the demand configurations in this manual. Connect the remaining units in the cascade through the normal cascade communications wiring. Cascade control can then be accomplished automatically through the leader unit.

Please note that with ModBus or BACnet communication connected to only the leader unit, 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 communication board. However, each unit can be monitored without the need to control each one individually.

Monitoring Only

Armors that are equipped with the ModBus or BACnet communication board can be set up to operate with their own internal controls. If necessary, ModBus or BACnet can be configured as a monitoring device by polling the communication board for the read only variables.

7 Unit Operation

Rate and Temperature Conversions:

Rate

When issuing a rate command the rate can be communicated as percent modulation or a desired setpoint, 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 setpoint, 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 setpoint at low analog input	21	69.8	2
BMS temperature setpoint at high analog input	82	179.6	10

For Example:

Send a setpoint of 110°F.

The formula to use for the interpolation is:

Rate Command =

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

From the default values:

Desired Setpoint = 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 setpoint.

Temperature

The Armor 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:

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

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 (Unit, 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, 38200, 76800)
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

Appliance Status

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

Status Codes (Input Register 30014 / Analog Input AI13)

2 = Heat Demand blocked due to high outlet temperature
3 = Heat Demand blocked due to high flue temperature
4 = Heat Demand blocked due to high Delta T temperature
7 = Heat Demand blocked due to different Personality Plug code
8 = Heat Demand blocked due to Low 24 VAC
10 = Blocked due to switch OFF (ON/OFF of Display)
16 = Service Mode active
18 = Water Heater DHW Demand active
23 = Heat Demand active from Cascade
30 = Freeze Protection Heat Demand active
32 = DHW Pump Delay active
34 = Standby
40 = Lockout

Blocking Codes (Input Register 30015 / Analog Input AI14)

0 = No blocking is present/active
1 = Blocked Due to Flow Switch open
5 = Blocked Due to a Low 24 VAC supply
6 = Blocked Due to Manual Reset High Limit
8 = Blocked Due to Appliance Turned off
10 = Blocked Due to High Delta T Temperature
11 = Blocked Due to High Outlet Temperature
12 = Blocked Due to Anti-Cycling
13 = Blocked Due to different Personality Plug setting
15 = Blocked due to High Flue Temperatures

8 Troubleshooting

Lockout Codes (Input Register 30016 / Analog Input AI14) **Description**

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.

240	=	Manual Reset High Limit lockout
237	=	Flame Out of Sequence lockout
233	=	No Flame Ignition lockout
232	=	No Flame Running lockout
231	=	High Fan Speed lockout
230	=	Low Fan Speed lockout
229	=	Watch Dog lockout
207	=	EEprom Error lockout
206	=	EEprom Programming Error lockout
205	=	EEprom Programmed lockout
204	=	EEprom CRC fault lockout
193	=	Outlet Sensor Open lockout
192	=	Outlet Sensor Shorted lockout
180	=	Inlet Sensor Open lockout
179	=	Inlet Sensor Shorted lockout
178	=	Flue Sensor Open lockout
170	=	Flow Switch Open lockout
169	=	Gas Pressure Switch Open lockout
168	=	Louver Proving Switch Open lockout
167	=	Blocked Drain Switch Open lockout
166	=	Auto Reset High Limit lockout
164	=	Flame Current Circuit Test Failed lockout
163	=	Different Personality Plug lockout

8 Troubleshooting *(continued)*

Installation / Replacement Procedure

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 communication board (see FIG. 8-1).
4. Remove the communication board (see FIG. 8-2 & 8-3).
5. Replace / install the new communication board.
6. Reconnect all three (3) wire harnesses unplugged in Step 3.
7. Turn on the main electrical power and the main manual gas shutoff to the appliance.
8. Configure the communication board and unit controls per this manual and resume operation.

Figure 8-1_Communication Board

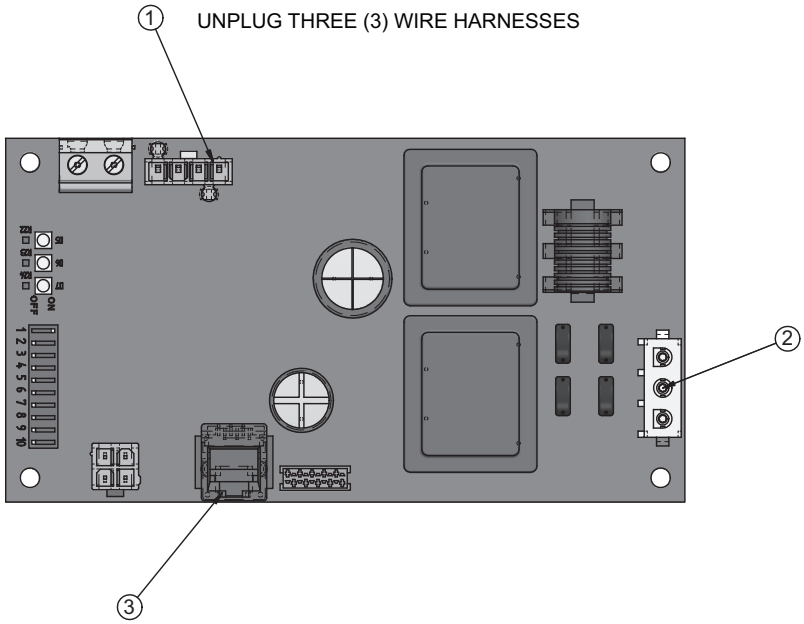


Figure 8-2_Control Panel w/ Communication Board - AWH0400-1000 Models

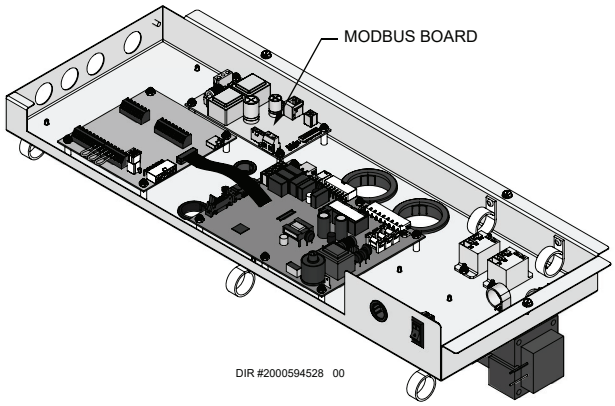


Figure 8-2_Control Panel w/ Communication Board - KBX0400-1000 Models

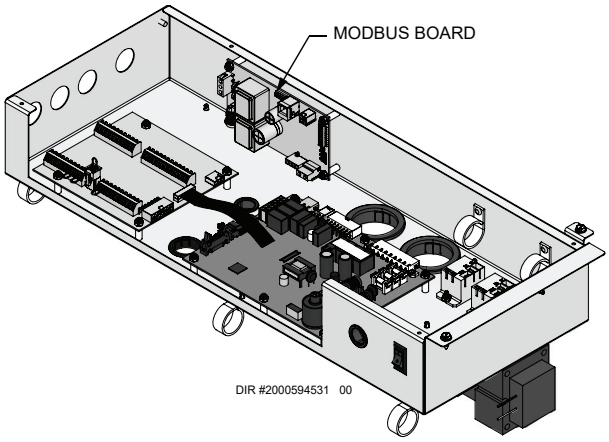
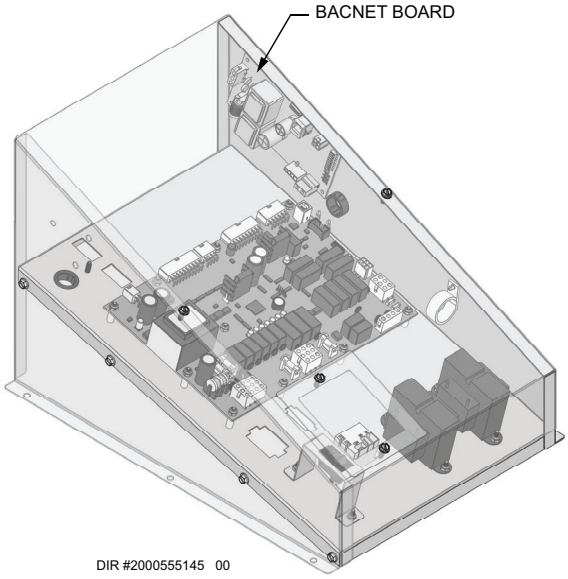


Figure 8-3_Control Panel w/ Communication Board - AWH1250-4000 Models



Notes

Notes

Lochinvar®
High Efficiency Water Heaters, Boilers and Pool Heaters
300 Maddox Simpson Parkway
Lebanon, TN 37090
615-889-8900 / Fax: 615-547-1000
www.Lochinvar.com

Revision Notes: *Revision A (TLA #3000024735 / CN #500014579) initial release.*

Revision B (TLA #3000028201 / CN #500017801) reflects the removal of the wiring and ladder diagrams.

Revision C (TLA #30000 / CN #5000) reflects the addition of the 400-1000 models.

MM# 100305786_DIR# 2000558371_Rev C
09/20