General Installation Guide

Central Processing Unit 1000
Version 1.38

CPU-1000

HBX Control Systems Inc.

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Comfort Control Innovation

GETTING STARTED

This manual will help with the installation, parameter setting, troubleshooting and general maintenance requirements for the Controller. To guarantee the safe and reliable operation of this Control, you must first read this manual in detail and take particular note to any and all warnings or caution directives prior to connecting to AC power.

Only suitably qualified individuals with formal training in electrical and HVAC controls should attempt the installation of this equipment. Incorrect wiring and installation will affect the warranty provided with this unit. Wiring must be completed in accordance with the codes and practices applicable to the jurisdiction for the actual installation.

The HBX CPU-1000 is a microprocessor based controller and as such is not to be regarded as a safety (limit) control. Please consult and install the heating or cooling appliance in accordance with the manufacturer's recommendations.

SAFETY SYMBOLS:

Extreme Hazard -
This action poses a serious threat that could result in personal injury or death, as well as permanent damage to the equipment. Proceed with caution.

Moderate Hazard -
This action may cause personal injury or have adverse effects on the installation process if handled incorrectly.

Disconnect Power Source -
The presence of low voltage(24VAC) or high voltage(120VAC) could result in personal injury or permanent damage to components or equipment.

Point of Interest -
This point clarifies pertinent information, or brings your attention to an action that may have adverse effects on the installation process.

RECEIVING, UNPACKING, INSPECTION AND STORAGE

This CPU-1000 has gone through rigorous quality control tests at the factory before shipment. After receipt and before installation perform the following checks:

Receipt

After receiving, inspect the unit for any possible physical damage that may have occurred during transportation.

Inspection

After unpacking the unit make sure the box contains:

- CPU-1000 Controller
- 1 Remote Outdoor Temperature Sensor
- 2 Universal Temperature Sensors
- 1 Terminal Screwdriver
- 2 Cable Ties

Make sure the part number on the unit corresponds to the part number on the original box.

Storage

The CPU-1000 should be kept in its original shipping carton prior to installation. In order to retain the warranty coverage it should be stored properly:

- Store in a clean dry place
- Store within an ambient temperature range of +10ºC to +40ºC
- If possible, store in an air-conditioned environment where the relative humidity is less than 95%
- Do not store in places where the unit may come into contact with corrosive gases or liquids
- Do not store in an area or upon an unstable surface where it may become damaged due to falling

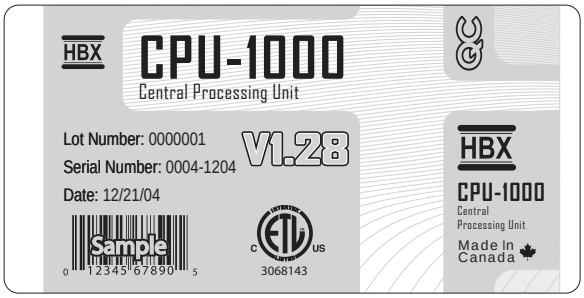
GENERAL TECHNICAL DATA

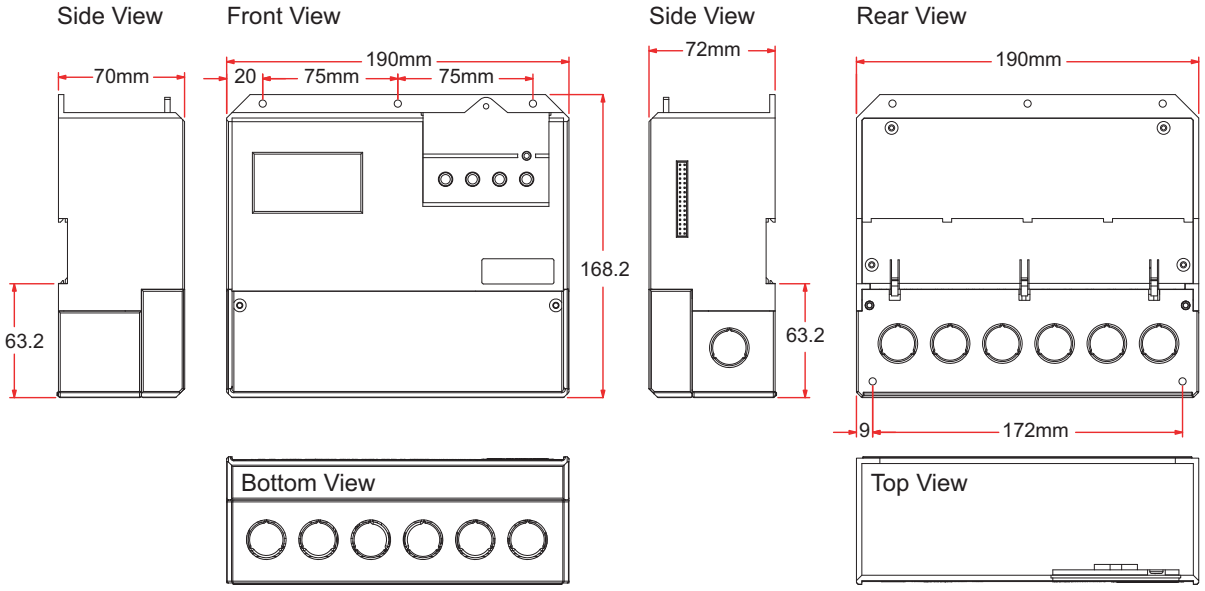
Input Voltage:
120 VAC, ± 10%, 60Hz
3 x Optically Isolated Inputs:
20 - 240 VAC
3 x Thermistor Inputs:
Boiler/System Sensors/Outdoor
3 x Pump Output Relays:
240VAC 10A
2 x Auxiliary Output Relays:
240VAC 10A
Standard Communications:
RS-232
Real Time Clock Battery:
Lithium-Ion
Microprocessor:
16Bit, 20MHz
Languages:
English
Graphic Display:
128 x 64 pixels (55mm x 28mm viewable area)
Weight:
0.95 KG (2.1 lbs)
Dimensions:
190mm W x 170mm H x 70mm D
ETL Listings:
Meets CSA C22.2 No. 24
Meets UL Standard 873
ETL Control No. 3068143
Storage:
+10ºC to +40ºC

All I/O (inputs and outputs) are both colour coded and keyed indexed for non-interchangeability

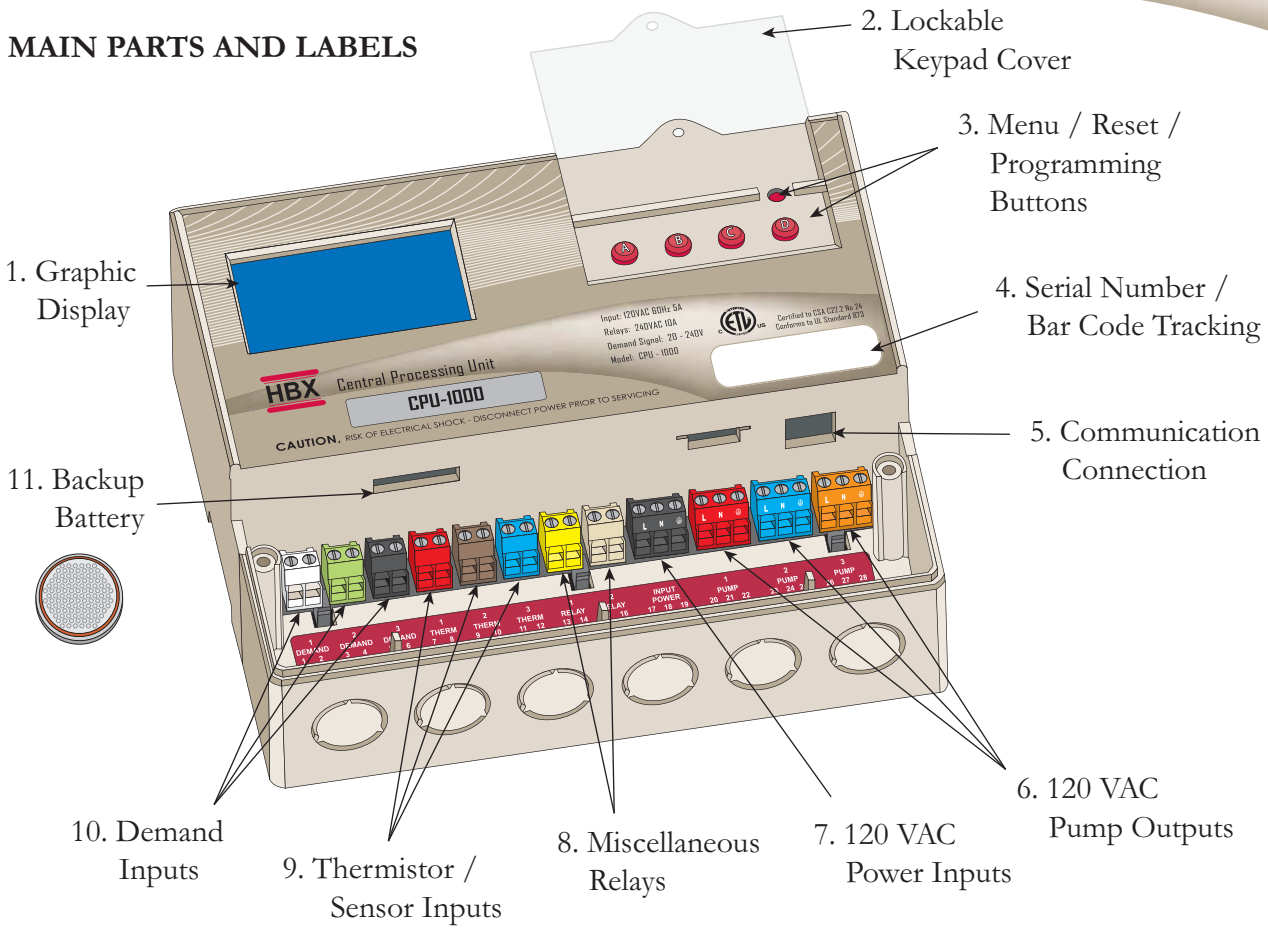
Nameplate Information:

The exterior label contains specific information unique to your HBX HVAC Control and identifies some of the basic features. The label displays the serial number which will match the serial number on your actual Control, the lot number, the bar code and the product's ETL number.





MAIN PARTS AND LABELS



Example:
Viewing from top left and moving right in a clockwise direction:

1. Back-Lit Graphic Display:

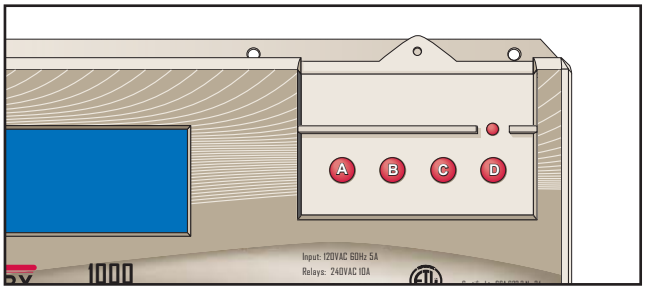
The display is one of the key features of the Controller. Depending upon which mode of operation is selected, you will be able to view most common system values simultaneously. It will also serve as a visual indicator when in the programming mode.

2. Lockable Keypad Cover:

Once your system has been programmed and optimized there should be little or no reason for further changes. The Controller has been designed with the ability to physically "hard-lock" the keypad to prevent tampering with the settings.

3. Menu and Programming Buttons:

These buttons will be used to set up the Controller during commissioning and for toggling between displays or troubleshooting at a later date if necessary.



A. Moves screen or value down
B. Moves screen or value up
C. Enters a value, parameter, or setting, toggles Y/N
D. Return to last screen and access programming mode
• Reset- Protected from being accidentally pushed

4. Serial Number and Bar Code:
This label will identify the entire factory ordered options and the date of manufacture. It can also be used for re-ordering and will be required in the event of factory service assistance or warranty claim.

5. Communication Connection:
The standard communications port (RS-232) is found immediately below the bar code label. Optional communications software needs to be purchased to enable a connection. Please consult factory or dealer.

Only a CAB-0100 can be inserted into this connection without causing damage.

6. 120 VAC Pump Outputs:
There are three separate (3-wire) 120VAC output power terminals designed to run either a pump or fan.

7. 120 VAC Power Input:
There is one (3-wire) terminal block for incoming 120VAC power.

8. Miscellaneous Relays:
There are two (2-wire) miscellaneous/auxiliary relay terminal blocks. These can be used to wire a variety of miscellaneous devices up to 10Amps.

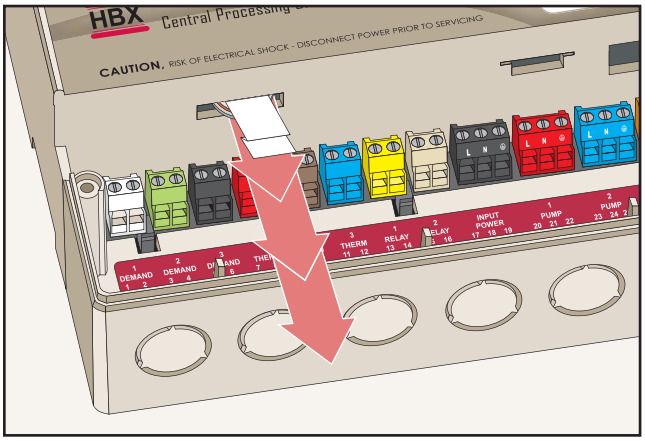
9. Thermistor/Sensor Inputs:
There are three (2-wire) sensor/thermistor inputs.

Under no circumstance should power be applied to these terminals! Permanent damage to the Controller's circuitry may result.

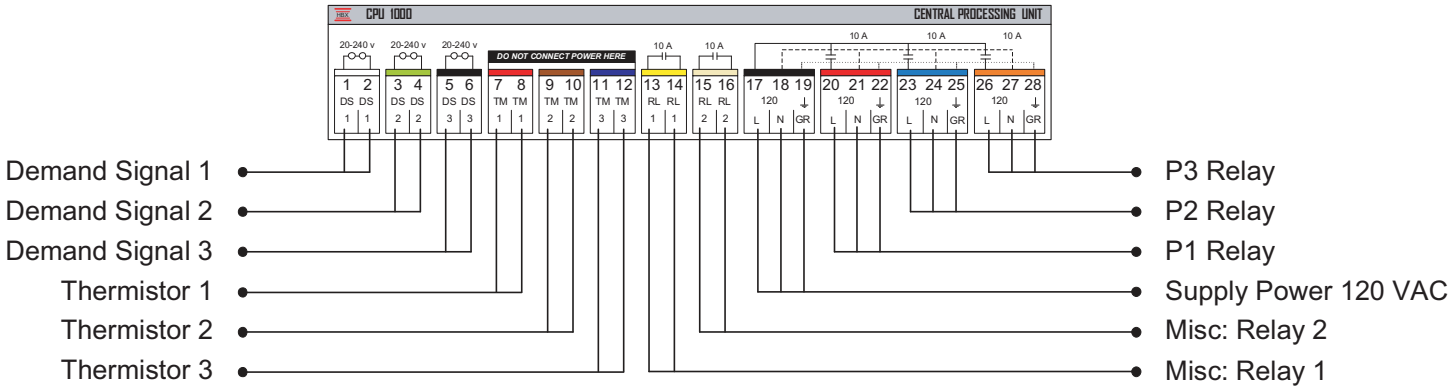
10. Demand Inputs:
There are three (2-wire) "demand" control inputs. Control signals between 20-240VAC are designed to trigger a variety of commands within the Controller, for example run a heat demand, a setpoint demand and/or a DHW demand.

11. Backup Battery:
The lithium-ion battery is purely a back-up supply for the real time clock and will keep the clock refreshed during a power interruption to the Control.

Prior to installation, please remove the protective paper strip to activate the back-up battery as shown below.



Terminal Designations for HBX CPU 1000



Demand Signal 1 - Any heat demand signal powered by 20 - 240VAC. E.g. 24VAC Thermostat. This trigger will follow the Outdoor Reset Curve calculated by the Control.

Demand Signal 2 - Any heat demand signal powered by 20 - 240VAC. E.g. 24VAC Thermostat. This trigger will not follow the Outdoor Reset Curve but stage the boiler to its maximum boiler temp programmed in the Control. Demand 2 has an alternative function and can be programmed to be the default input for a flow proof switch (only available with applications using pump sequencing).

Demand Signal 3 - Any heat demand signal powered by 20 - 240VAC. E.g. 24VAC Thermostat/Aquastat. This trigger is designed to stage the boiler temp to satisfy the DHW settings programmed in the Control.

Thermistor 1 - Boiler Sensor

Thermistor 2 - System Sensor (alternative position for DHW Sensor, Staging/DHW Systems only)

Thermistor 3 - Outdoor Sensor

TM1, TM2 & TM3 are designed for 10K Ohm Thermistors and must never be subjected to any external power supply (voltage or current)

P3 Relay - Any pump (or fan) output rated to a max of 10Amps 120VAC. This relay is pre-programmed to be the default DHW pump supplying a DHW in-direct hot water tank. Its alternative function is to be an Injection Pump relay when PMIp is the injection mixing strategy.

P2 Relay - Any pump (or fan) output rated to a max of 10Amps 120VAC. This relay is pre-programmed to be the default (low temp) system pump. When programmed for a mixing system.

P1 Relay - Any pump (or fan) output rated to a max of 10Amps 120VAC. This relay is pre-programmed to be the default boiler or (High Temp) system pump.

P1 & P2 - The (2) dedicated relays when pump sequencing is selected in the Controls program. P1 & P2 become the Hi Temp system pumps in a commercial application requiring pump sequencing.

Supply Power - The 3-wire 120VAC input to the control. Protected by a 30Amp breaker or fuse.

Misc: Relay 2 - This relay is the default relay for bringing on the 2nd Boiler or Boiler stage. It has an alternative function and can be used as an injection valve. This may be PMIv for radiant mixing or a on/off valve for DHW indirect storage tanks.

Misc Relay 1 - This relay is the default relay for bringing on the 1st Boiler or Boiler stage.

Misc Relays 1&2 are Dry Contacts and rated for a max of 10Amps

INSTALLATION & WIRING

The CPU-1000 is designed to be wall mounted, DIN rail mounted, or installed inside a separate electrical enclosure. The unit should be mounted inside and be protected from falling water and high humidity conditions. With all the covers in place it is designed to protect any individual from accidental electrical shock.

The Controller has a built in 5Amp fast acting fuse to protect the circuitry on the Printed Circuit Board (PCB). The unit is designed to power up to 3 pumps and 2 auxiliary relays of 10Amps each. As such, an upstream customer supplied fuse or circuit breaker rated at a maximum of 30 amps must be in circuit. It is the installers responsibility to provide either a 3 pin (3ft max) grounded plug and cable, or the unit must be wired directly to a breaker and terminated inside the control box (terminals 17, 18 & 19).

All power wiring must be with a minimum of 18AWG wire.

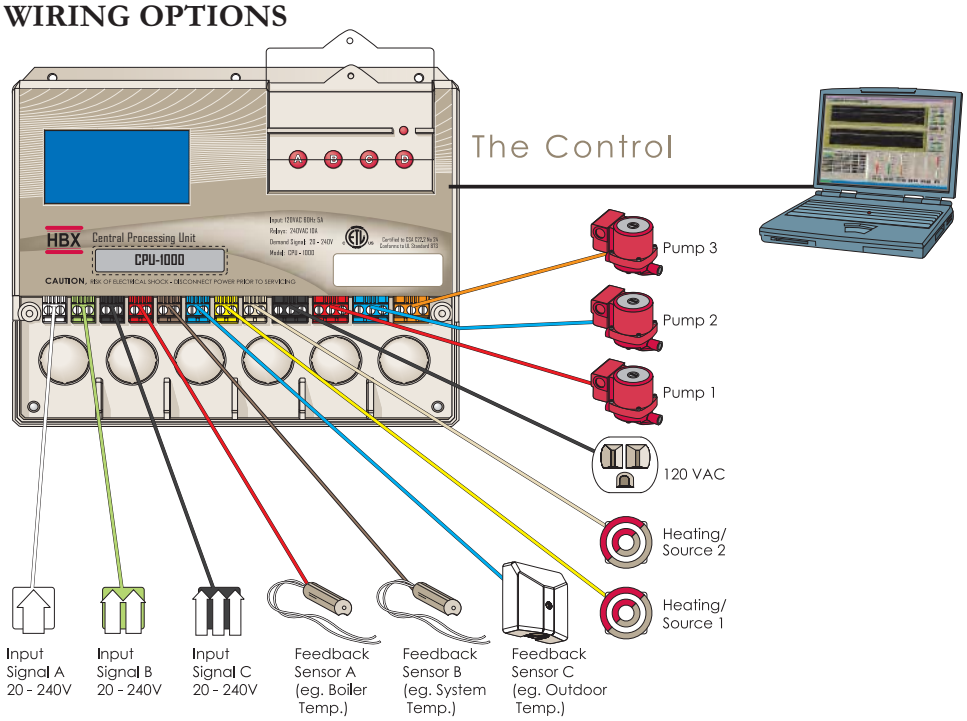
Low power wiring ---------- insulated 18AWG (min.) wire to a max of 500ft.

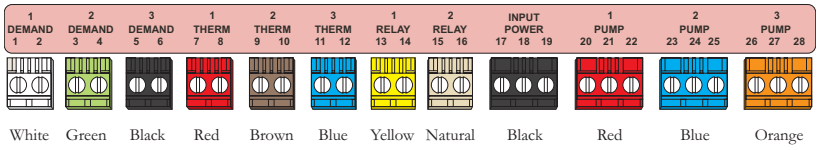
Thermistor wiring ---------- insulated 18AWG (min.) wire to a max of 500ft.

It is recommended to use 18AWG Single Stranded Wire. It is also recommended to run signal and power wiring in separate conduit.

Only suitably qualified individuals with formal training in electrical and HVAC controls should attempt the installation of this equipment. Incorrect wiring and installation will affect the warranty provided with this unit. Wiring must be completed in accordance with the codes and practices applicable to the jurisdiction for the actual installation.

WIRING OPTIONS





White (1-2) Demand 1, 2-wire control input 20-240VAC

Green (3-4) Demand 2, 2-wire control input 20-240VAC

Black (5-6) Demand 3, 2-wire control input 20-240VAC

Red (7-8) Therm 1, 2-wire thermistor Eg. boiler sensor

Brown (9-10) Therm 2, 2-wire thermistor Eg. system sensor

Blue (11-12) Therm 3, 2-wire thermistor Eg. outdoor sensor

Yellow (13-14) Relay 1, misc. auxiliary 10Amps

Natural (15-16) Relay 2, misc. auxiliary 10Amps. Also becomes the default terminals when selecting PMIv (valve injection). Explained further on page 63.

Black (17-19) Input Power, 3-wire. This is the main input power supply connection. 17 is line, 18 is neutral and 19 is earth ground.

Red (20-22) Pump 1, 3-wire 120VAC output power to pump or fan number 1. 20 is line, 21 is neutral and 22 is earth ground.

Blue (23-25) Pump 2, 3-wire 120VAC output power to pump or fan number 2. 23 is line, 24 is neutral and 25 is earth ground.

Orange (26-28) Pump 3, 3-wire 120VAC output power to pump or fan number 3. 26 is line, 27 is neutral and 28 is earth ground. Also becomes the default terminal when using PMIp (pump injection). Explained further in the manual.

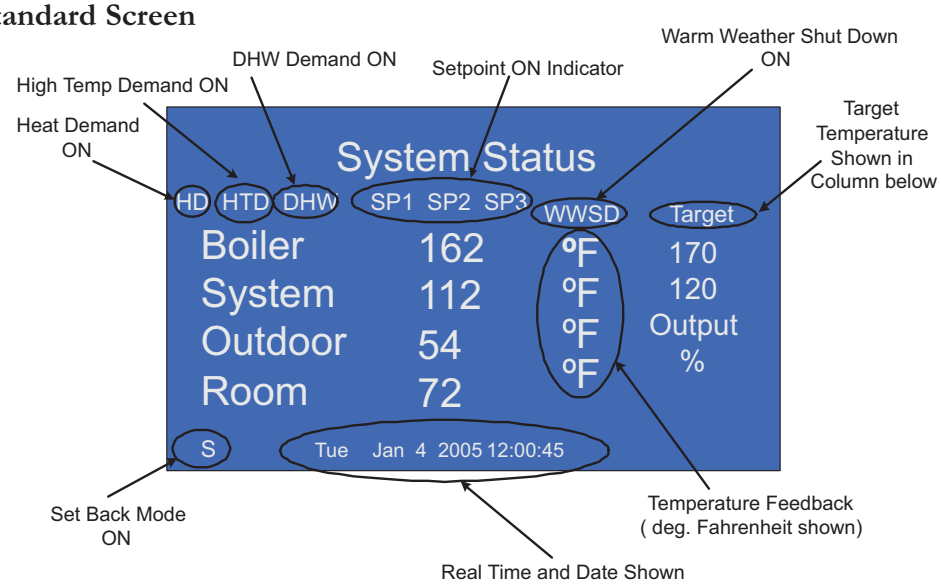
Terminals 7-12 must not be subjected to any external power source

PROGRAMMING

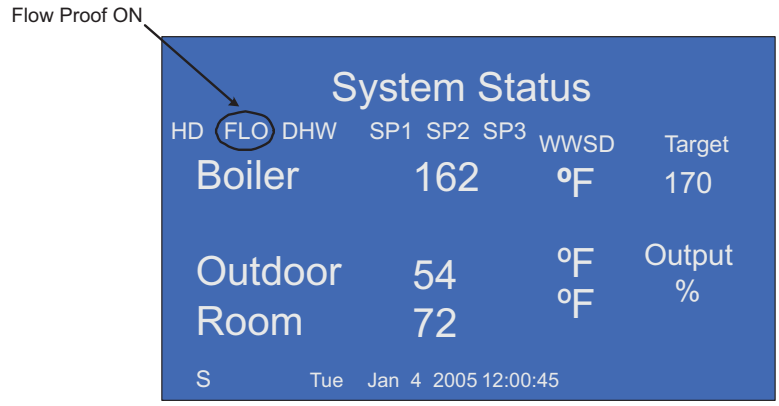
DISPLAY FEATURES

The HBX display is a 128 x 64 pixel, back-lit graphic display on a blue background. In addition to displaying text and icons it has the ability to provide you with visual graphing capabilities. These graphing capabilities will allow you to get representative data and trending information of up to 2 independent feedback values.

Standard Screen

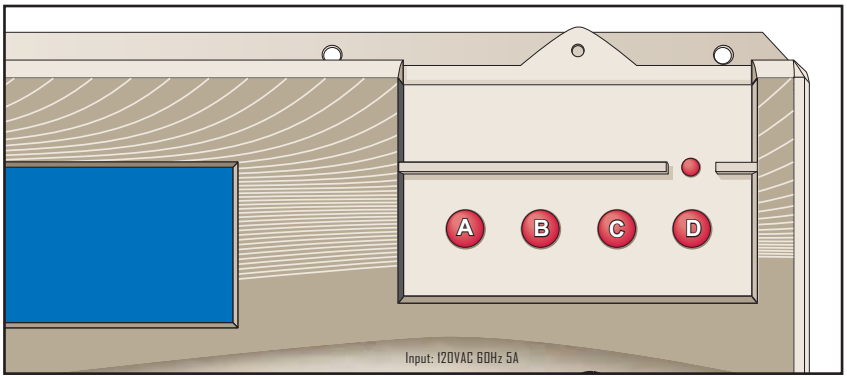


Alternate Screen Showing Flow Proof Feature



Applicable only to a Staging Control with Pump Sequencer turned on.

NAVIGATING THE CONTROL



The four large red buttons labeled "A", "B", "C", and "D" are used to make your way through the programming options within the Control.

Pressing the "A" or "B" button while viewing the initial "System Status" and "System Function" main screens will toggle from screen to screen. Pressing the "D" button will take you to the "Programming Options" screen. Pressing the "D" button again will revert to the main system screens.

Once in the "Programming Options" menu you may move the selection indicator up and down by pressing the "A" and "B" buttons, pressing the "C" button will enter the selected option.

Pressing the "C" button on options with limited choices (ie. on/off, yes/no) will toggle the selection.

Pressing the "A" and "B" buttons on options with variable numerical choices (ie. temperature values, time settings) will increase and decrease the selected amount. Pressing the "C" button upon completion will forward you to the next step.

The "D" button can be used to revert to the previous menu.

Program Lock Feature

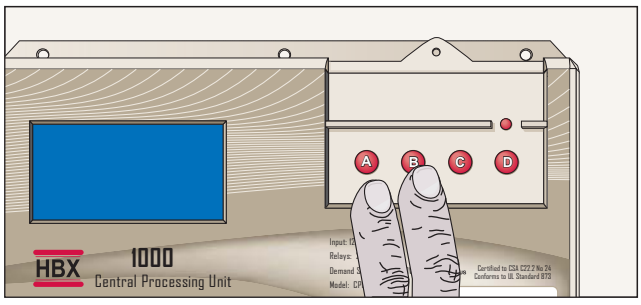
To minimize the potential for unauthorized tampering of your control after commissioning, you have the ability to limit/lock the programming menus.

To lock the Control, use two fingers to press and hold down the A and B buttons simultaneously for approximately 10 secs.

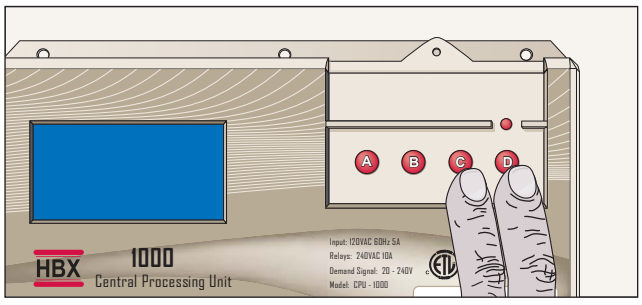
To unlock the Control, use two fingers to press and hold down the C and D buttons simultaneously for approximately 10 secs.

If the display flashes erratically, remove your fingers from the buttons and try again by pressing both buttons at the same time.

Lock Feature



Unlock Feature



SUMMARY OF PARAMETERS

Description	Options	Range	Factory Default
Main View Screen(s)	View: • Boiler Temp	(-40-225) ºC or ºF	ºF
	• System Temp	(-40-225) ºC or ºF	ºF
	• DHW Temp*	(-40-225) ºC or ºF	ºF
	• Outdoor Temp	(Open) ºC or ºF	ºF
	• Indoor Temp (if sensor connected)	(Open) ºC or ºF	ºF
	• Actual vs. Target Temps	ºC or ºF	ºF
	• Min/Maxs values for each sensor	ºC or ºF	ºF
	• Time and Date	24 hr clock	
	• Setpoints	up to 3	Off
	• Setbacks	up to 3	N
	• Separate Heat Demands	up to 3	
	• WWSD	0ºF to 100ºF	75ºF
	• 3 pumps run condition	On/Off	
	• Cycle Count	0-65535 Cycles	
	• Temperature Range	ºC or ºF	ºF
	• Staging Control*		
	• Mixing Control*		
	• DHW Control*		
	• Dual System Control*		
	• Dual Mixing Control*		
	*** Depending on control type selected.**		

Description	Options	Range	Factory Default
Control Options	• Display Options		
	• Always HD?	Y/N	N
	• Use Room Thermistor	Y/N	N
	• Mins and Maxs	Up to 6 sensors c/w reset	
	• Testing	Up to 17 relays (w/ Exp. Modules) Plus 5 x PWM	
	• Stage Run Times	Up to 14	
	• Use Zone Module	Y/N	N
Boiler Options (Staging and DHW Controls)	• Staging Options		
	• Hi/Lo Fire	Y/N	N
	• Fixed First	Y/N	N
	• Fixed Last	Y/N	N
	• Lo/Lo-Hi/Hi	Y/N	N
	• Boiler Differential	Auto/40/30/20/10	Auto
	• Min Boiler Ontime	3 Mins	3-20 Mins
	• # of Stages (14 w/Modules)	1 to 2	Single Stage
	• Pump Options	Y/N	
	• 1 Pump/Boiler	Y/N	N (off)
	• Pump Sequencer	Y/N	N (off)
	• Rotate Boilers	Y/N	Y
	• Pumps Always On?	Y/N	N
	• Post Purge	30 - 240 Sec	30 Sec
	• Rotate Time/Normal		
	• Use Flow Proof?*	Y/N	N
	• Mod out Setpoint	Y/N	N
	• 3- Standard Pumps P1, P2, P3(PMIp)	P1 & P2 can be used for pump sequencing	Boiler, System, DHW
	• 2- Auxiliary Relays		

Description	Options	Range	Factory Default
Mixing Options	• Boiler Options	"Same as last section"	"Same as last section"
	• Injection Type	PMI Valve PMI Pump Floating Action Modulating	PMIv 'Valve'
Change Design	• Design Boiler Temp	0°F to 225°F	190°F
	• Design System Temp	0°F to 225°F	135°F
	• Design System Temp 2*	0°F to 225°F	135°F
	• Design Room Temp	-50°F to 100°F	70°F
	• Design Room Temp 2*	-50°F to 100°F	70°F
	• Design Outside Temp	-50°F to 100°F	-10°F
	• Design Outside Temp 2*	-50°F to 100°F	-10°F
	• Min Boiler Temp	40°F to 200°F	120°F
	• Min System Temp	0°F to 150°F	75°F
	• Min System Temp 2*	0°F to 150°F	75°F
	• WWSD	0°F to 100°F	75°F
	• Default Designs Staging*	o Lo Efficient Building o Mid Efficient Building o Hi Efficient Building	
	• Default Designs Mixing*	o Lo Temp Radiant o Hi Temp Radiant o Fancoil o Baseboard o Lo Temp Radiator o Hi Temp Radiator	

Description	Options	Range	Factory Default
Setpoint Options	• Setpoint 1 o Setpoint Temp o Heating o Cool Interlock o Differential o Lag Time o Setpoint Demand	 Off/33ºF to 225ºF Heat/Cool Y/N 2ºF to 100ºF 0S to 600S No/Lo/Hi Temp	 OFF Heating N 2ºF 0S Hi Temp
	• Setpoint 2 and 3	As Above	As Above
Setback Options	• Use Setbacks	Y/N	N
	• Set Setbacks o Start Time 1 o End Time 1 o Start Time 2 o End Time 2 o Start Time 3 o End Time 3	 0:00 – 24:00 0:00 – 24:00 0:00 – 24:00 0:00 – 24:00 0:00 – 24:00 0:00 – 24:00	
Domestic Setup	• Use DHW?	Y/N	N
	• DHW Valve	Valve/Pump	Pump
	• DHW Priority	Y/N	N
	• Domestic Temp	32ºF to 225ºF	100ºF
	• Differential	0ºF to 100ºF	2ºF
	• DHW Interlock	Y/N	N
	• DHW Boiler Temp	100ºF to 225ºF	150ºF
Graphing	• Boiler Graph	Target vs. Actual	
	• System Graph	Target vs. Actual	

ACCESSORIES AND OPTIONS

The CPU-1000 Main Control has been designed to incorporate simple integrated Expansion Modules to provide and accommodate even the most sophisticated control package. Each Expansion Module has a side ported 32-Pin input/output connection.

When connected using the HBX 32-Pin male to male adapter, each module can be joined together (daisy chain style) and will butt together with virtually no side clearance. Due to the 32-pin connector no external cross wiring is necessary.

A maximum of 6 Expansion Modules can be connected in series.

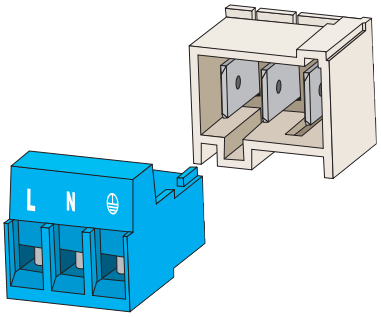
1) Additional Sensors:
   - Universal Sensors part number 029-0022
   - Indoor/Outdoor Sensors part number OUT-0100

2) Connectors
   - 32-Pin Adapter Plug part number 033-0037

KEY/COLOUR CODED CONNECTORS

To simplify the installation, the Control has been designed to utilize dedicated terminal plugs. Each terminal has non-interchangeable male and female mating parts.

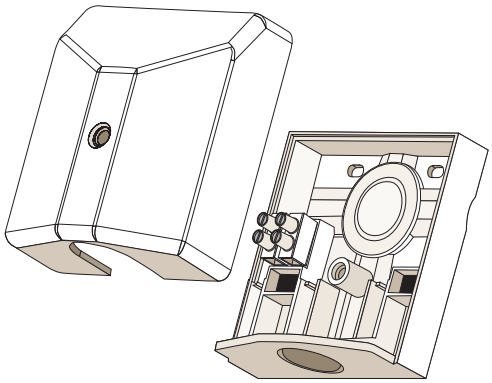
In addition each plug is colour coded as well as being keyed/indexed. There are a combination of two and three wire plugs.



INDOOR/OUTDOOR SENSOR

The HBX remote (Indoor/Outdoor) Temperature Sensor has 2 x 20mm knock out holes, 1 from the underside and 1 from the rear. The HBX housing can accommodate up to four (4) 10K ohm thermistors.

Outside sensors should be placed on the north facing wall of the heated building to avoid any solar heating effect. The sensor should also be located away from other non-ambient heat sources such as exhaust fans, heat generating air conditioners or refrigeration units.



TROUBLESHOOTING & FAULT CODES

Display does not come on	Check power connection at terminals 17,18,19. If no power (120VAC) present then trace power back to source. Cycle power to Control.
No heat demand	Check that you have at least 20VAC being supplied to the heat demand trigger. E.g. power to terminals 1&2 for a heat demand to follow the outdoor reset curve. Power to terminals 3&4 for a Hi temp heat demand and power to terminals 5&6 are for a DHW demand.
Injection not working	Make sure that in the mixing settings you have selected the appropriate device you are using to mix with. If it is PMIp then your connection should be attached to 26 to 28 and if it is PMIv then connect the valve to 15,16.
Buttons do not respond or cannot go into Programming Mode	Hold down buttons C and D to unlock the buttons. Hold until display says BUTTONS UNLOCKED.
Parameters set in control do not seem to be taking effect	Manually Reset Control by using a small blunt tool and gently press the reset button.
Boilers not staging on	Make sure in the boiler options that you have selected the appropriate amount of stages for the system.
Domestic Hot water demand not coming on	Make sure if you are using a Thermistor that it is hooked to terminals 9&10 on a staging control or have your aquastat attached to terminals 5&6 with power.

Lack of Heat or no response to a heat demand	Control may be in Warm Weather Shut Down mode, see "System Status" display. Is the acronym "WWSD" visible? If yes, check in "Change Designs" menu under WWSD, factory default is 75°F. Adjust accordingly to your own design parameters.  **Remember to check and install your Outside temperature sensor away from direct sun or potential heat sources etc.**
Cannot select more than 4 Boilers in Staging Options	If you are using the DHW control type the maximum # of boiler stages is limited to 4.  **Staging and Mixing control types will allow you to program up to a maximum of 14 stages but please note you must have the corresponding number of Expansion Modules to effectively accomplish this**
No Boiler Heat Demand when Zone Module has a call for Heat	Make sure you program 'Use Zone Module' to 'Y' in Control Options. Zone Modules are currently under development.

GLOSSARY OF TERMS

AI (Analog Input) – A control signal that varies in magnitude, example 0-10 volts or 4-20mA. Usually being supplied to the control source.

Aquastat – The name usually supplied to the temperature sensing device immersed in water and sending on/off control signals to its control source.

Closed Loop – This typically describes the control strategy employed in a regulated system. Closed loop controls always have feedback sensors giving signals back to the control source allowing incremental adjustments to be made, thus resulting in more precise control.

Mixing Valve – A special type of valve that is designed to temper water temperature by blending hot water with cooler return water.
Can be 2-way, 3-way and even 4-way mixing.

Modulating Valve – A special type of valve that has the ability to regulate or proportional open or close dependent on the control signal supplied to it.

Open Loop – Normally used to describe a type of control strategy for a regulated system. Open loop systems provide no feedback on temperature changes and thus tend to work blind or unaware of actual temperature conditions.

PID (Proportional, Integral, Derivative) – This is an acronym to describe the control calculations in automatic controls. In essence it decides when to accelerate or decelerate a device and at the same time measures and compensates for the rate of change and how long it has been outside of its target range.

PWM (Pulsed Width Modulation) – It is a control strategy that uses digital technology (1's and 0's or 0 and 5 volts) to emulate an analog signal. The longer the high value (e.g. 5 volts) is pulsed for during a string of pulses, represents a higher analog value.

Relay – Typically a small switching device that aids or assists in the control of turning on/off larger pieces of electrical equipment.

Thermistor – Is an electrical device that varies its resistance in proportion to the temperature it is exposed to. It is commonly used as a feedback signal to a controller.

Thermostat – A temperature sensing device that sends electrical signals back to a central controller to turn on/off the heat/cooling supply.

WWSD (Warm Weather Shut Down) – A control strategy used to turn the boiler off at times when the temperature outside of the building exceeds the design heat loss or heat exchange between the internal and external walls. The strategy is designed to provide energy savings from firing the boiler unnecessarily and to improve the inside comfort of uncontrolled zones.

Zone – An area, room or collection of rooms that have independent heating and cooling control. Each zone will usually have its own thermostat.

Zone Damper – The name usually given to the sliding or rotating vane inside the air supply ducting or plenum. The zone damper will either open or close to meet the heat/cool demand.

Zone Valve – The name given to the isolation valve that opens and closes the heat generating/cooling source to the zone requiring temperature adjustment.

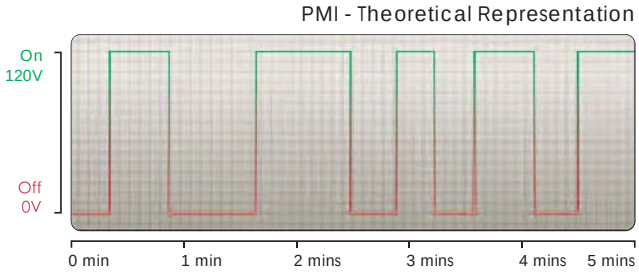
Pulsed Modulated Injection Theory (PMI)

PMI uses all 3 (proportional, integral, derivative) functions of a PID Control algorithm to open and close 1 of 2 relays housed within the CPU-1000. The control can choose to use PMI on either a pump (PMIp) terminals 26, 27 & 28 or a valve (PMIv) terminals 15 & 16.

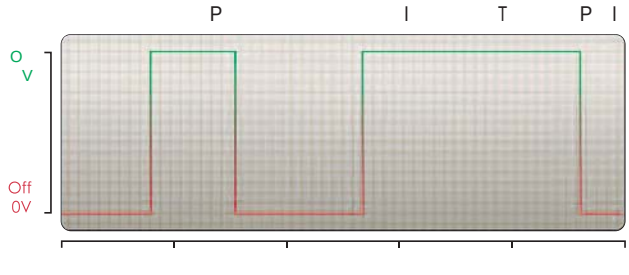
In the example of a pump, the PMI logic will determine how long the pump needs to be ON for and how long to be OFF for to maintain adequate injection rates to stabilize the target temperature in the mixed (radiant) heat emitter. In the case of pump injection, the pump is being held on (pulsed on) e.g. full speed, for a calculated period of time and then held off (pulsed off) e.g. zero speed, for again a calculated period of time. The ON pulse and the OFF pulse, time is continuously being monitored and compensated for by the Controls internal algorithm using PID application theory.

*** It is important to view this as a long on pulse or off pulse as opposed to a rapid series of pulses. The duration of each pulse will likely be several seconds or even minutes before the beginning of a new cycle length. It is also important to recognize that this control principle cycles the device on and off more frequently than is customary. This has been taken into consideration and several safety features are built into the Control to alleviate any potential adverse effects on the Control, the electrical environment, pump motors and valve coils.**

A. Typical Short Cycle Runtime



B. Typical Long Cycle Runtime



*** In both examples, actual cycle time may be longer or shorter then shown**

In the case of PMIv or valve injection the theory is exactly the same. With regard to the slower and varying response time of the valve the control PID will compensate and respond with timing changes accordingly.

HBX has tested this injection principle both in the lab and in extensive customer site locations with a variety of manufacturers' valves and pumps with exceptional control characteristics and no detrimental effects on either valve motors/coils or pump motors etc.

The main advantages to employing this control strategy with mixing are:

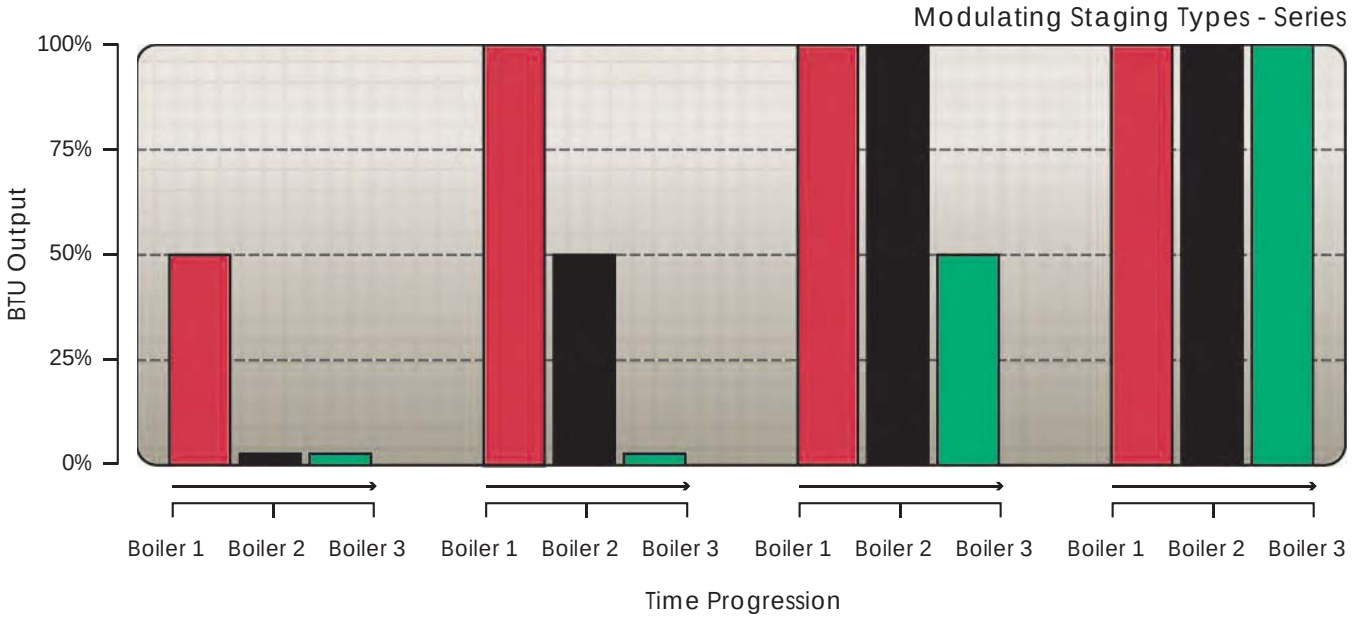
- **i.** Single Phase pumps up to 10 amps (1HP, 120VAC) can be used for injection
- **ii.** Extra Controls do not need to be wired into the main Control
- **iii.** The option exists for future mechanical system upgrades or modifications without changing your primary controller
- **iv.** Greater injection control using valves

PMIp is not recommended with split-phase motors. Premature failure of the start winding and/or centrifugal starting contacts may occur.

MODULATION TYPE: SERIES

The Series method of modulating boilers is based on a simple but effective algorithm. Underlying theory causes boiler 1 to fire when there is a load; modulating from the start percent (designated by the installer within the modulating options of the Control) to 100%. If the heat demand has not been satisfied at this point boiler 2 will then begin to modulate from the start percent to 100% (if required). This process will continue for each installed modulating boiler in the system to a maximum of five.

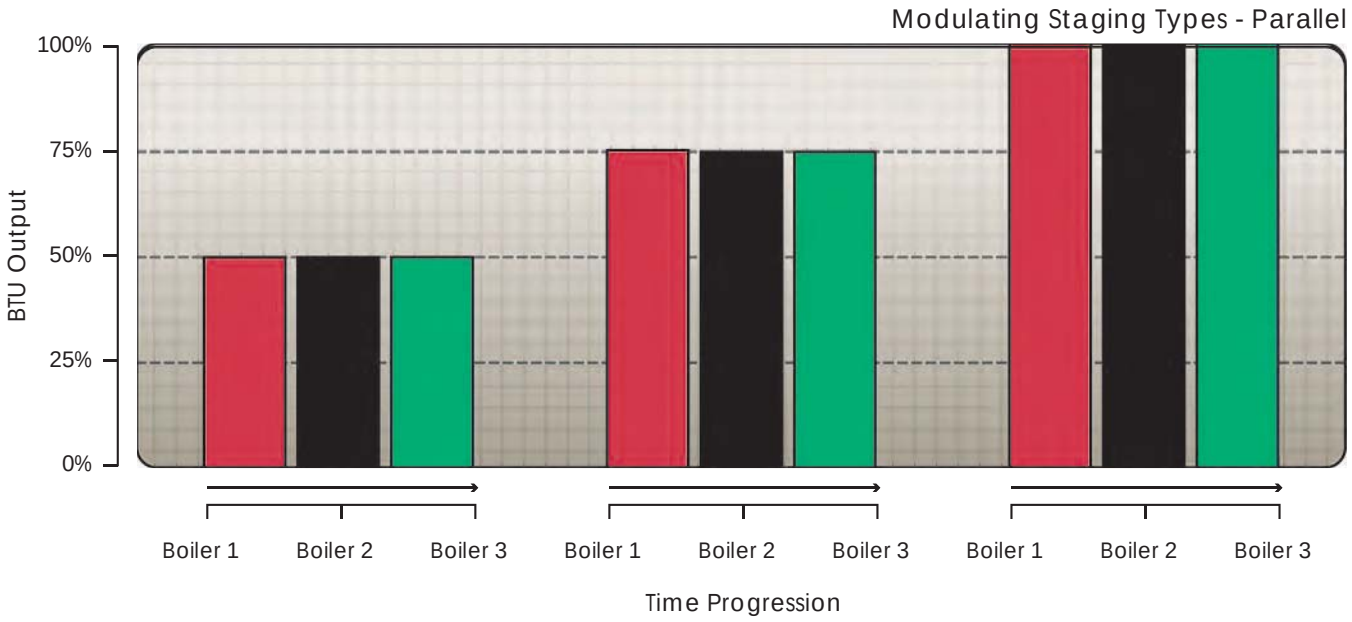
The process of modulating the boilers off works the same. When the last boiler in the system drops to the start percent it will then shut off that boiler. If the load continues to decrease then the Control will modulate down the second last boiler set up in the system. This will continue on until the lead boiler has dropped to the start percent. At this point the Control will allow the PID calculation to increase helping with boiler cycling. This will hold the lead boiler in the minimum fire (or start percent) position for longer, allowing the boiler to cycle less. As a result; system maintenance and system wear due to boiler cycling is decreased.



MODULATION TYPE: PARALLEL

The Parallel method of modulating boilers is the simplest of modulating algorithms. Underlying theory causes all of the installed boilers to simultaneously modulate from the start percent (designated by the installer within the modulating options of the Control) to 100% depending on the system load requirements. The maximum number of modulating boilers that the Control can handle is five.

The process of modulating the boilers off works in the same manner. When the load decreases, all of the boilers will modulate down until they are at the start percent . At this point, to help with boiler cycling, the Control will allow the PID calculation to increase. This will hold the lead boiler in the minimum fire position(or start percent) for longer allowing the modulating boiler to cycle less. As a result; system maintenance and system wear due to boiler cycling is decreased.

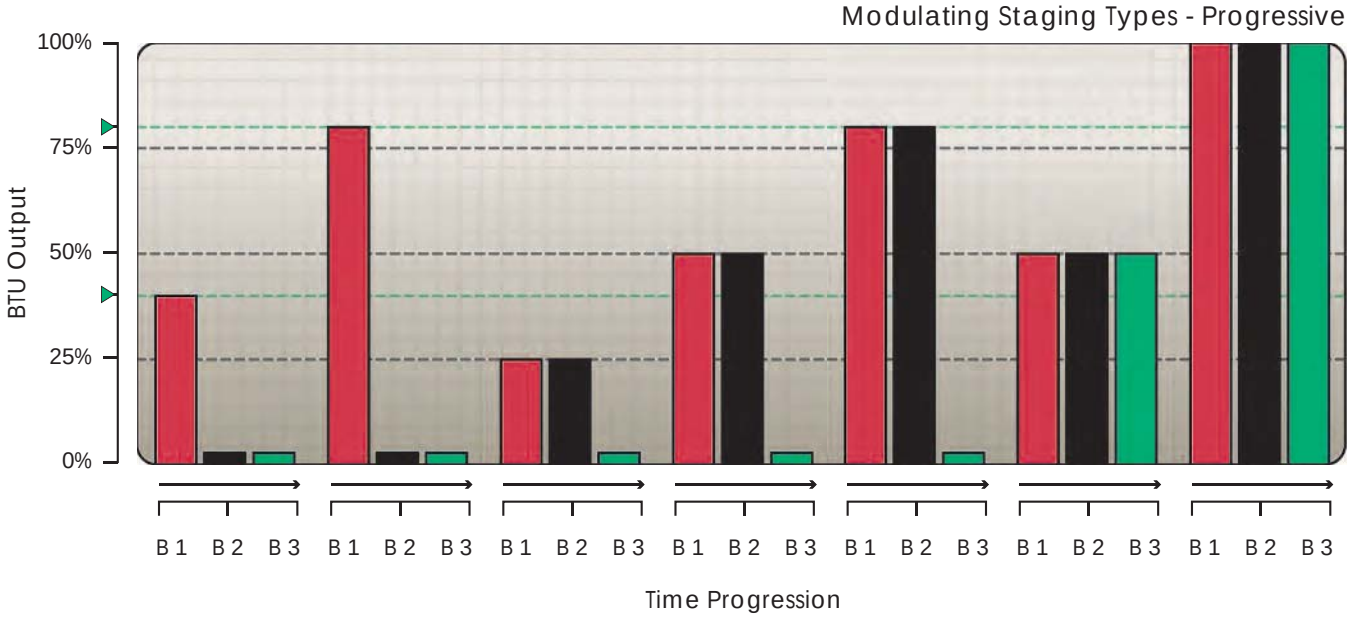


MODULATION TYPE: PROGRESSIVE

Progressive modulation is a complex algorithm for very precise control over modulating devices. HBX Controls has optimized the process to work effectively for multiple modulating boilers. This modulation algorithm is a combination of series and parallel modulation with additional benefits.

Underlying theory causes the first boiler to modulate from the start percent (designated by the installer within the modulating options in of the Control) to 80% modulation. If the load still requires more heat then boiler 1 decreases to 40%, and boiler 2 increases from 0% to 40% (maintaining 80% output with 2 modulating boilers now on). As the load increases both modulating boiler 1 and modulating boiler 2 will increase to 80%. If there is still a higher load requirement, both boiler 1 and boiler 2 will decrease to 55% and modulating boiler 3 will increase from 0% to 55%. All 3 modulating boilers now take on approximately the same load as the 2 modulating boilers at 80%. This process will continue on until all boilers set up in the system are firing. When all the modulating boilers are firing and a load is still required, all 3 boilers will modulate to 100% simultaneously.

As load decreases the modulating boilers will simultaneously modulate down to the start percent. The lag boiler will shut down and remaining modulating boilers will increase their modulating to split the remaining load in percent. At this point to help with boiler cycling the Control will allow the PID calculation to increase. This will hold the lead boiler in the minimum fire position for longer allowing the modulating boiler to cycle less. As a result; system maintenance and system wear due to boiler cycling is decreased.



TYPICAL DESIGN OUTSIDE TEMPERATURES IN NORTH AMERICA

The statistical data presented above is taken as excerpts from the 1989 ASHRAE Handbook Fundamentals, Chapter 24. It is intended as sample design temperatures for winter conditions, in numerous locations. HBX has made every effort to provide accurate data but reserves all rights against misprints or typographical errors.

City	Temp	City	Temp	City	Temp	City	Temp
Canadian Cities	**ºF**	Fort Smith, AR	17	Baltimore, MD	13	Oklahoma City, OK	13
Edmonton, AB	-25	Little Rock, AR	20	Cumberland, MD	10	Tulsa, OK	13
Calgary, AB	-23	Los Angeles, CA	43	Boston, MA	9	Baker, OR	6
Fort Nelson, BC	-40	San Fransisco, CA	38	Greenfield, MA	-2	Portland, OR	23
Vancouver, BC	19	Boulder, CO	8	Detroit, MI	6	Allentown, PA	9
Churchill, MB	-39	Denver, CO	1	Traverse City, MI	1	Philadelphia, PA	14
Winnipeg, MB	-27	Bridgeport, CT	9	Fergus Falls, MN	-17	Newport, RI	9
Fredericton, NB	-11	Hartford, CT	7	Minnesota, MN	-12	Providence, RI	9
Moncton, NB	-8	Dover, DE	15	Clarksdale, MS	19	Charleston, SC	28
Goose Bay, NL	-24	Wilmington, DE	14	Jackson, MS	25	Georgetown, SC	26
St. John's, NL	7	Andrews, DC	14	Hannibal, MO	8	Aberdeen, SD	-15
Inuvik, NT	-53	Washington, DC	17	St. Louis, MO	6	Rapid City, SD	-7
Yellowknife, NT	-46	Miami, FL	48	Billings, MT	-10	Chattanooga, TN	18
Halifax, NS	5	Gainesville, FL	31	Kalispel, MT	-7	Memphis, TN	18
Yarmouth, NS	9	Atlanta, GA	22	Hastings, NE	-3	Amarillo, TX	11
Ottawa, ON	-13	Savannah, GA	27	Omaha, NE	-3	Dallas, TX	22
Toronto, ON	-1	Boise, ID	10	Las Vegas, NV	28	Logan, UT	2
Charlottetown, PE	-4	Coeur D'Alene, ID	-1	Reno, NV	11	Salt Lake City, UT	8
Montreal, PQ	-10	Aurora, IL	-1	Berlin, NH	-9	Barre, VT	-11
Quebec City, PQ	-14	Chicago, IL	-4	Laconia, NH	-5	Rutland, VT	-8
Regina, SK	-29	Bloomington, IN	5	Newark, NJ	14	Charlottesville, VA	18
Saskatoon, SK	-31	Indianapolis, IN	2	Phillipsburg, NJ	6	Norfolk, VA	22
Whitehorse, YT	-43	Cedar Rapids, IA	-5	Alberquerque, NM	16	Seattle, WA	26
		Des Moines, IA	-5	Los Alamos, NM	9	Yakima, WA	5
American Cities	**ºF**	Dodge City, KS	5	Buffalo, NY	6	Beckley, WV	4
Birmingham, AL	21	Wichita, KS	7	New York, NY	15	Huntington, WV	10
Huntsville, AL	16	Lexington, KY	8	Charlotte, NC	22	Ashland, WI	-16
Anchorage, AK	-18	Louisville, KY	10	Jacksonville, NC	24	Milwaukee, WI	-4
Fairbanks, AK	-47	Baton Rouge, LA	29	Bismark, ND	-19	Cheyenne, WY	-1
Phoenix, AZ	34	New Orleans, LA	33	Fargo, ND	-18	Newcastle, WY	-12
Tucson, AZ	32	Augusta, ME	-3	Cincinnati, OH	6		
		Lewiston, ME	-2	Toledo, OH	1		

TEMPERATURE CONVERSION / RESISTANCE TABLE FOR HBX 029-0022, 029-0032 & OUT-0100 10K TEMPERATURE SENSORS

Celsius	Fahrenheit	Ohms	Celsius	Fahrenheit	Ohms	Celsius	Fahrenheit	Ohms
-30	-22	177,000	15	59	15,714	60	140	2,488
-29	-20.2	166,342	16	60.8	15,000	61	141.8	2,400
-28	-18.4	156,404	17	62.6	14,323	62	143.6	2,315
-27	-16.6	147,134	18	64.4	13,681	63	145.4	2,235
-26	-14.8	138,482	19	66.2	13,071	64	147.2	2,157
-25	-13	130,402	20	68	12,493	65	149	2,083
-24	-11.2	122,807	21	69.8	11,942	66	150.8	2,011
-23	-9.4	115,710	22	71.6	11,418	67	152.6	1,943
-22	-7.6	109,075	23	73.4	10,921	68	154.4	1,876
-21	-5.8	102,868	24	75.2	10,449	69	156.2	1,813
-20	-4	97,060	**25**	**77**	**10,000**	70	158	1,752
-19	-2.2	91,588	26	78.8	9,571	71	159.8	1,693
-18	-0.4	86,463	27	80.6	9,164	72	161.6	1,637
-17	1.4	81,662	28	82.4	8,776	73	163.4	1,582
-16	3.2	77,162	29	84.2	8,407	74	165.2	1,530
-15	5	72,940	30	86	8,056	75	167	1,480
-14	6.8	68,957	31	87.8	7,720	76	168.8	1,431
-13	8.6	65,219	32	89.6	7,401	77	170.6	1,385
-12	10.4	61,711	33	91.4	7,096	78	172.4	1,340
-11	12.2	58,415	34	93.2	6,806	79	174.2	1,297
-10	14	55,319	35	95	6,530	80	176	1,255
-9	15.8	52,392	36	96.8	6,266	81	177.8	1,215
-8	17.6	49,640	37	98.6	6,014	82	179.6	1,177
-7	19.4	47,052	38	100.4	5,774	83	181.4	1,140
-6	21.2	44,617	39	102.2	5,546	84	183.2	1,104
-5	23	42,324	40	104	5,327	85	185	1,070
-4	24.8	40,153	41	105.8	5,117	86	186.8	1,037
-3	26.6	38,109	42	107.6	4,918	87	188.6	1,005
-2	28.4	36,182	43	109.4	4,727	88	190.4	974
-1	30.2	34,367	44	111.2	4,544	89	192.2	944
0	32	32,654	45	113	4,370	90	194	915
1	33.8	31,030	46	114.8	4,203	91	195.8	889
2	35.6	29,498	47	116.6	4,042	92	197.6	861
3	37.4	28,052	48	118.4	3,889	93	199.4	836
4	39.2	26,686	49	120.2	3,743	94	201.2	811
5	41	25,396	50	122	3,603	95	203	787
6	42.8	24,171	51	123.8	3,469	96	204.8	764
7	44.6	23,013	52	125.6	3,340	97	206.6	742
8	46.4	21,913	53	127.4	3,217	98	208.4	721
9	48.2	20,883	54	129.2	3,099	99	210.2	700
10	50	19,903	55	131	2,986	100	212	680
11	51.8	18,972	56	132.8	2,787	101	213.8	661
12	53.6	18,090	57	134.6	2,774	102	215.6	643
13	55.4	17,255	58	136.4	2,675	103	217.4	626
14	57.2	16,464	59	138.2	2,579	104	219.2	609

Limited Warranty
HBX Controls warrants each of its products to be free from defects in workmanship and materials under normal use and service for a period of 24 months from date of manufacture or 12 months from date of purchase from an HBX Authorized Dealer, if within the above documented period after date of manufacture.

If the product proves to be defective within the applicable warranty period, HBX on its sole discretion will repair or replace said product. Replacement product may be new or refurbished of equivalent or better specifications, relative to the defective product. Replacement product need not be of identical design or model. Any repair or replacement product pursuant to this warranty shall be warranted for not less than 90 days from date of such repair, irrespective of any earlier expiration of original warranty period. When HBX provides replacement, the defective product becomes the property of HBX Controls.

Warranty Service, within the applicable warranty period, may be obtained by contacting your nearest HBX Controls office via the original Authorized Agent and requesting a Return Material Authorization Number (RMA #). Proof of purchase in the form a dated invoice/receipt must be provided to expedite the issuance of a Factory RMA.

After an RMA number has been issued, the defective product must be packaged securely in the original or other suitable shipping package to ensure that it will not be damaged in transit. The RMA number must be visible on the outside of the package and a copy included inside the package. The package must be mailed or otherwise shipped back to HBX with all costs of mailing/shipping/insurance prepaid by the warranty claimant.

Any package/s returned to HBX without an approved and visible RMA number will be rejected and shipped back to purchaser at purchaser's expense. HBX reserves the right, if deemed necessary, to charge a reasonable levy for costs incurred, additional to mailing or shipping costs.

Limitation of Warranties.
If the HBX product does not operate as warranted above the purchasers sole remedy shall be, at HBX's option, repair or replacement. The foregoing warranties and remedies are exclusive and in lieu of all other warranties, expressed or implied, either in fact or by operation of law, statutory or otherwise, including warranties of merchantability and fitness for a particular purpose/application. HBX neither assumes nor authorizes any other person to assume for it any other liability in connection with the sale, installation maintenance or use of HBX Controls products.

HBX shall not be liable under this warranty; if its testing and examination discloses that the alleged defect in the product does not exist or was caused by the purchasers or third persons misuse, neglect, improper installation or testing, unauthorized attempts to repair or any other cause beyond the range of intended use, or by accident, fire, lightning or other hazard.

Limitation of Liability.
In no event will HBX be liable for any damages, including loss of data, loss of profits, costs of cover or other incidental, consequential or indirect damages arising out of the installation, maintenance, commissioning, performance, failure or interruption of an HBX product, however caused and on any theory of liability. This limitation will apply even if HBX has been advised of the possibility of such damage.

Local Law.
This limited warranty statement gives the purchaser specific legal rights. The purchaser may also have other rights which vary from state to state in the United States, from Province to Province in Canada and from Country to Country elsewhere in the world.

To the extent this Limited Warranty Statement is inconsistent with local law, this statement shall be deemed modified to be consistent with such local law. Under such local law, certain disclaimers and limitations of this statement may not apply to the purchaser. For example, some states in the United States, as well as some governments outside the United States (including Canadian Provinces), may:

Preclude the disclaimers and limitations in this statement from limiting the statutory rights of a consumer (e.g. United Kingdom);

Otherwise restrict the ability of a manufacturer to enforce such disclaimers or limitations; or

Grant the purchaser additional warranty rights which the manufacturer cannot disclaim, or not allow limitations on the duration of implied warranties.

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