

Reference Manual

BAScontrol Applications

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1 Utilizing Pre-Built Constant Volume AHU Applications

Pre-Built applications make it easy to utilize Contemporary Controls' BACnet/IP Sedona Unitary controllers in constant volume air-handling (AHU) applications.

Although all controller models are freely programmable using Sedona as the control language, it can be made into a configurable controller by installing one of five versions (CvAHU1-CvAHU5) of constant volume AHU applications into the controller from the CvAHU Application Series.

1.1 CvAHU Version Selection Guide

Contemporary Controls has replaced the constant volume CvRTU series of pre-built applications with a new CvAHU series which includes three new macros—Staged Heat/Cool, Wall Setter, and Economizer. The targeted constant volume applications have not changed.

Not all AHU applications are the same, so several application versions exist based upon a modular design where only those sub-systems necessary for specific applications are used. Intended for constant volume (Cv) supply fan applications, the series supports one or two-stages of direct expansion (DX) cooling, one or two-stages of gas or electric heating, and analog heating or cooling. Optional provisions include powered exhaust (PE) with or without variable speed fan motor, air-filter status, local occupancy switch/sensor, fixed or CO2 demand control ventilation (DCV), and dry-bulb or enthalpy control of economizer.

CvAHU Version	Power Exhaust (Rfan)	Cooling	Heating	Economizer	Vent
1	CV or Variable	0-10VDC AO	0-10VDC AO	DBulb or Enthalpy	Fixed% or CO2
2	CV or Variable	2-stage DO	2-stage DO	DBulb or Enthalpy	Fixed% or CO2
3	CV or Variable	2-stage DO	2-stage DO	DBulb or Enthalpy	Fixed%
4	None	2-stage DO	2-stage DO	DBulb or Enthalpy	Fixed%
5	None	2-stage DO or 0-10VDC AO	2-stage DO or 0-10VDC AO	None	None

Occupied/unoccupied modes are supported by commands from a BACnet client, local occupancy sensor or switch, or a temporary occupied push button. Operating modes are standby, ventilation, heating, and cooling. If an analog wall-setter is present, local setpoint control is invoked, otherwise network control from a BACnet client is used. Configurable settings are managed via a common web browser using custom Sedona components called web components (WC). The reading and writing of BACnet points is accomplished with custom Sedona components called virtual components (VT).

1.2 BASC22 Unitary Controller

The BASC22 is BACnet/IP compliant with a B-ASC device profile. Network communication is via dual 10/100 Mbps Ethernet ports using the controller's built-in Ethernet switch thereby supporting daisy-chain cabling. Physical I/O on the BASC22 consists of four universal inputs, eight binary inputs, four analog outputs, and six binary outputs. The control language is Sedona – an open drag-and-drop graphical control language intended for HVAC applications. Contemporary Controls' BAScontrol Toolset is available FREE via download from Contemporary Controls' web site. Within the Toolset, the Sedona Application Editor (SAE) is a user-friendly software for creating tool function block (component) wiresheet applications in the Sedona environment.

1.3 Application Package Contents

Each of the five versions of CvAHU is delivered as a zip file via download. The zip file contains all the documentation, schematics and application files needed to implement the project. Each zip file contains enough information to assist in making a controls submittal and implementing the HVAC sequence. The contents of the package can be customized to handle most constant volume AHU applications. Questions regarding the sequences can be directed to Contemporary Controls' technical support. The following documents are provided in each zip file:

- Application Notes – A Word document that contains useful information on implementing the application and configuring the points.
- System Schematic – A .pdf file that contains the schematic (frequently called the "H" diagram) which documents the air-flow and identifies the location of the sensors and actuators required to implement the sequence.
- Points List - An Excel file that lists the BACnet names, variable types, BACnet object IDs, the Sedona tags and a notes field with relevant information about the point. All real and virtual BACnet points along with web component points are listed. This file can be edited.
- Sequence of Operation (SOO) – A Word document that provides a programmer's SOO making references to some of the BACnet and Sedona tags used in the application. This document can be edited if necessary.
- Wiring Diagram – A .pdf file that contains a sample wiring diagram which includes wiring between sensors, actuators, and a controller to assist in control panel design.

Each CvAHU zip file contains a nested BASbackup zip file that bundles the Sedona application.

- BASbackup file – A zip file that captures the complete project. It includes BACnet configuration data, web component configuration data, controller configuration data, and the actual Sedona application. When using BASbackup, click the "Choose File" button and select the zip file named "BASc22 CvAHUx Backup.zip." Do not unzip this file, BASbackup uses it in zip format.

1.4 Registered Systems Integrator

The Generic CvAHU application packages are free to systems integrators and controls contractors who register with Contemporary Controls attesting that they are skilled in implementing HVAC sequences in programmable

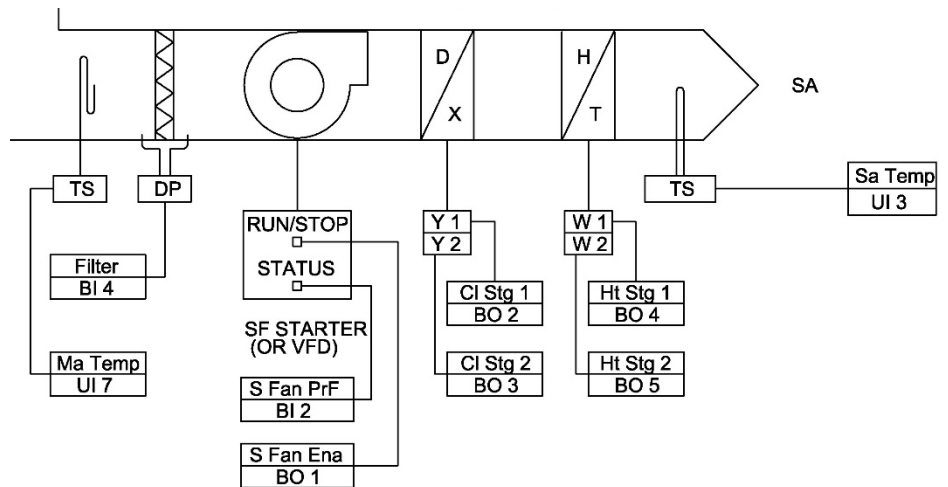
controllers and understand that the sequences are provided as-is and that Contemporary Controls makes no guarantee that the sequences are suitable for any AHU application. The responsibility for suitability rests with the systems integrator and controls contractor.

1.5 System Schematic

Each version in the series comes with its own system schematic or what is sometimes called an “H” diagram. What follows is a short explanation of the various aspects of the “H” diagram that may or may not be included in the version selected.

Constant volume supply fan with staged heating and cooling

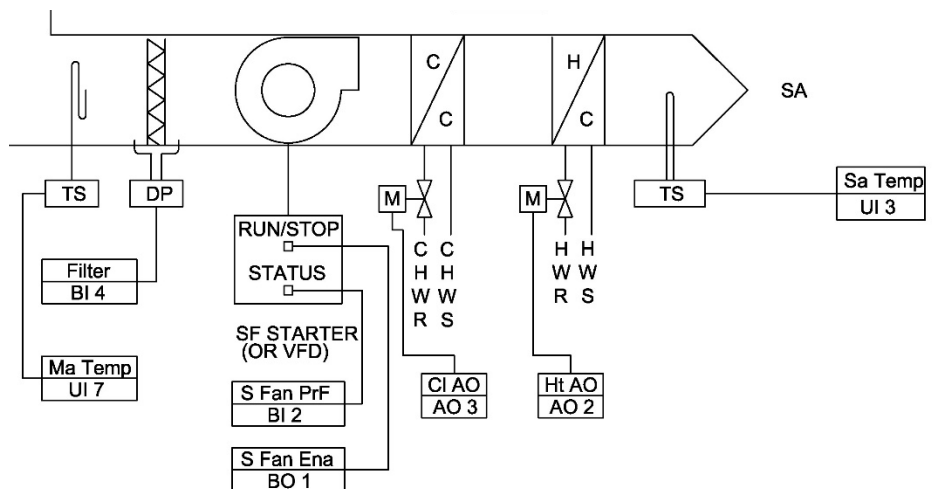
All versions assume constant volume supply air. You have the choice of one or two stages of direct expansion (DX) or analog chilled water (CHW) cooling. For heating you have the choice of one or two stages of gas or electric heating or analog hot water (HW) heating. Temperature sensors exist for supply air and mixed air. A differential pressure switch monitors filter air flow. The constant volume supply air fan has a run-proving signal from a current transformer in addition to start and stop commands.



Constant volume supply fan with analog heating and cooling

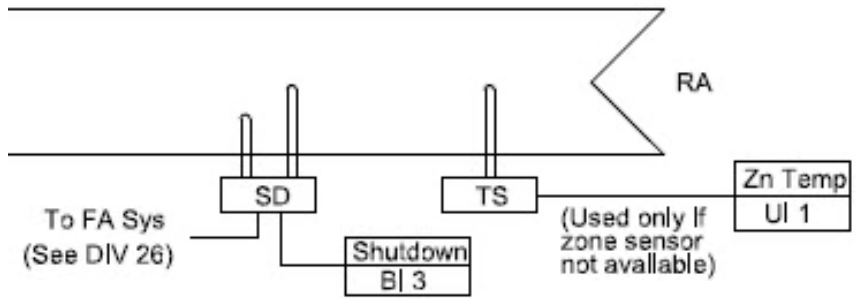
It is also possible to have 0-10 volt analog control for chilled water (CHW) cooling and hot water (HW) heating. All other sensors remain the same as for staged heating and cooling.

Notice that each point has both the Sedona variable name and the I/O channel reference used on the Sedona wiresheet.



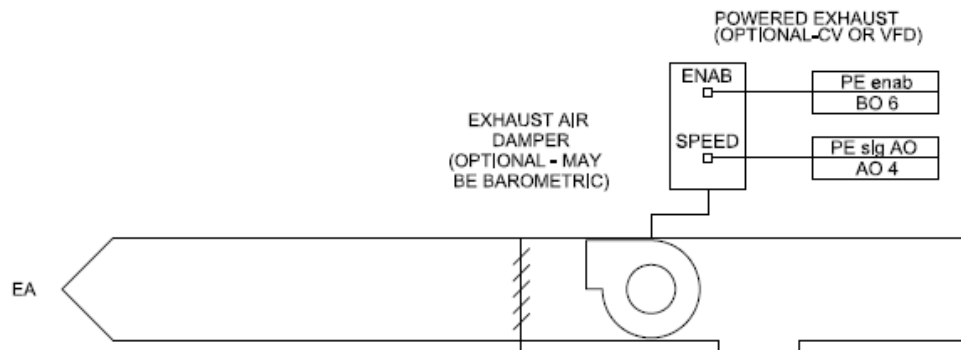
Return air sensor options

For return air, you have a provision for a return air temperature sensor (TS) that can be in the return air duct or you can use a space temperature sensor that is mounted in the wall setter. A shutdown provision such as a smoke detector (SD) is provided to meet local fire code requirements.



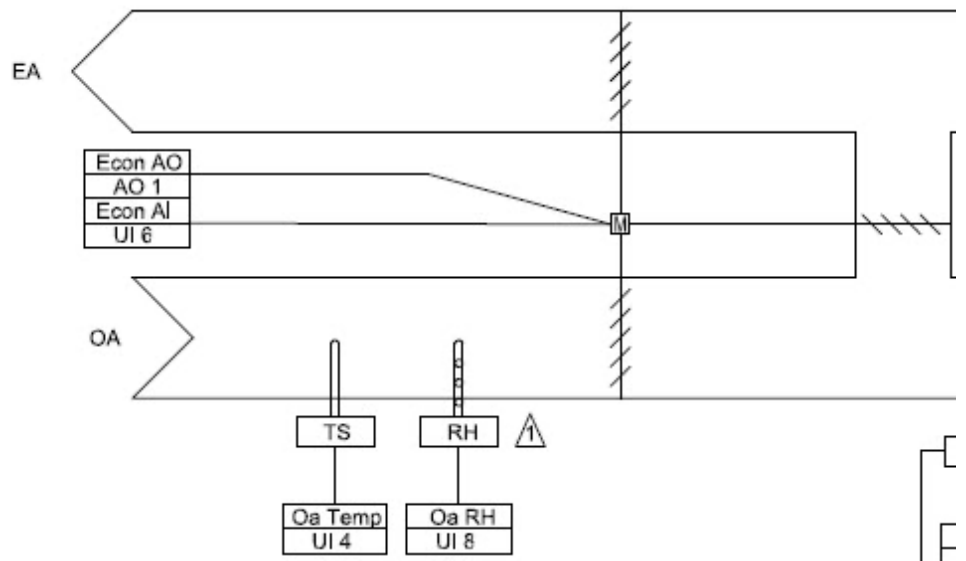
Exhaust air can be constant volume, variable volume or have a simple barometric damper

For the exhaust duct, you can have a constant volume exhaust fan, a variable speed exhaust fan or no fan at all. The exhaust damper could be a simple barometric damper. For variable speed exhaust fan, an analog output signal is provided.



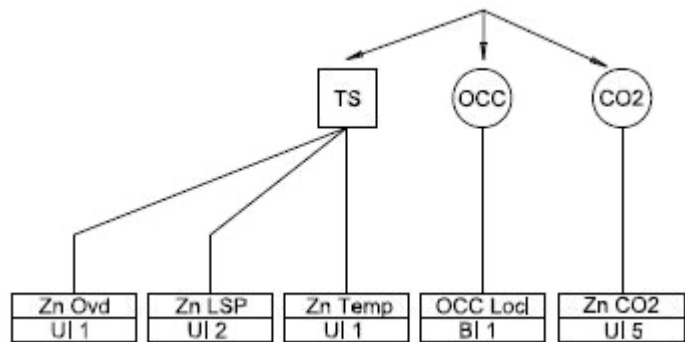
Outside air damper allows for dry-bulb or enthalpy economizing as well as demand control ventilation

You can also have a dry-bulb economizer requiring an outside air temperature sensor, an enthalpy economizer requiring a relative humidity sensor in addition to the dry-bulb sensor or no economizer at all. A proportional damper actuator must be provided which has analog position feedback. For ventilation, you can have a fixed amount of ventilation or have a variable amount of ventilation based upon measured CO2 levels or what is called demand control ventilation (DCV).



For zone control, a wall setter can be used or just a space sensor with BACnet client generated setpoints

The program looks for an analog wall setter slider potentiometer for space temperature setpoint and if one is not found assumes that a setpoint from a BACnet client will be provided. Provisions exist for a local occupancy switch that forces the system into occupy mode. For demand control ventilation, a CO2 sensor that can be part of the wall setter can be used.



1.6 Required Software Tools

Program changes to the Sedona logic can be made with Contemporary Controls' BAScontrol Toolset. Available as a free download, the Toolset includes the Sedona Application Editor (SAE), BASbackup project archiving tool, and a BASemulator which provides BAScontrol emulation on a PC. All three programs are available as a single install. The necessary component bundle for any of the AHU applications versions can be uploaded using SAE.

A helpful tool for simulating a BACnet client is Contemporary Controls' BACnet Discovery Tool (BDT), also available from the company's web site. For making configuration changes to the controller's web pages, a common web browser is required.

1.6.1 Using the BASemulator

The BASemulator mimics the operation of a real controller, such as the BAScontrol22, on a PC. The BASemulator has a built-in backup and restore utility that allows loading one of the AHU applications onto the BASemulator to verify the operation of the program before loading the application onto a real controller. This makes it possible to complete an application configuration and to check on the program's execution before installation on a real controller. BASemulators do not connect to real I/O points but input points can be forced and outputs can be examined to determine effect. It is recommended to use these BASemulators for program evaluation.

The CvAHU application versions come with default IP configurations. Start the BASemulator after selecting one of the BASC22 emulations. Using BASbackup, restore any one of the CvAHU versions to the BASemulator using the 127.0.0.1 address. During this process, you do not need to worry about IP addresses because the BASemulator ignores any IP configuration during the restore process. In this way, you can view the program immediately. When you first access the main web page with your browser, refresh the page twice to eliminate any cached data. To copy the program to a real controller using BASbackup, you will need to enter the proper IP configuration and unique BACnet device instance assignments for the target controller.

1.7 Points Lists

Individual points lists are provided with each version of the application. The points list is handy when studying the SOO or the programmer's SOO. The first group of points are BACnet points used to communicate BACnet commands and requests from a BACnet client to the BAScontrol22 acting as a BACnet server. The BAScontrol22 provides responses to the BACnet client. The second group of points are web components used to configure

the BAScontrol22 or to read status from the BAScontrol22 by way of a common web browser. Keep the following in mind when studying the list.

- The eight UI points are real universal inputs that must be first configured for the type of input. There are some notes as to the type of configuration and use. Depending upon configuration, they can be either a BACnet analog input or a BACnet binary input.
- The four binary inputs (BI) are all contact closures and appear as BACnet binary inputs.
- The four analog outputs (AO) are all 0-10 VDC signals appearing as BACnet analog outputs.
- The six binary outputs (BO) are all relays and they appear as BACnet binary outputs.
- Up to 24 virtual points (VT) can exist as either a BACnet binary variable (BV) or BACnet analog variable (AV). A command from a BACnet client that becomes an input to the Sedona wiresheet is called a wiresheet input (WS input). A response sent to a BACnet client is called a wiresheet output (WS output). Either operation is still considered either a BACnet BV or AV.
- With each BACnet real or virtual point, there is a BACnet tag and Sedona tag. The Sedona tag is helpful when following the wiresheet logic but does not appear with BACnet discovery.
- There are up to 48 web components (WC) available for transferring binary or analog data to and from a web browser with the BAScontrol22. Web components indicated as inputs (I) indicate that the Sedona wiresheet is receiving data from the web browser while components marked as outputs (O) produce data from the wiresheet to the web browser. There are no BACnet names with web components. Web component names just provide clarity. Web components, however, carry Sedona names.

1.8 Device List

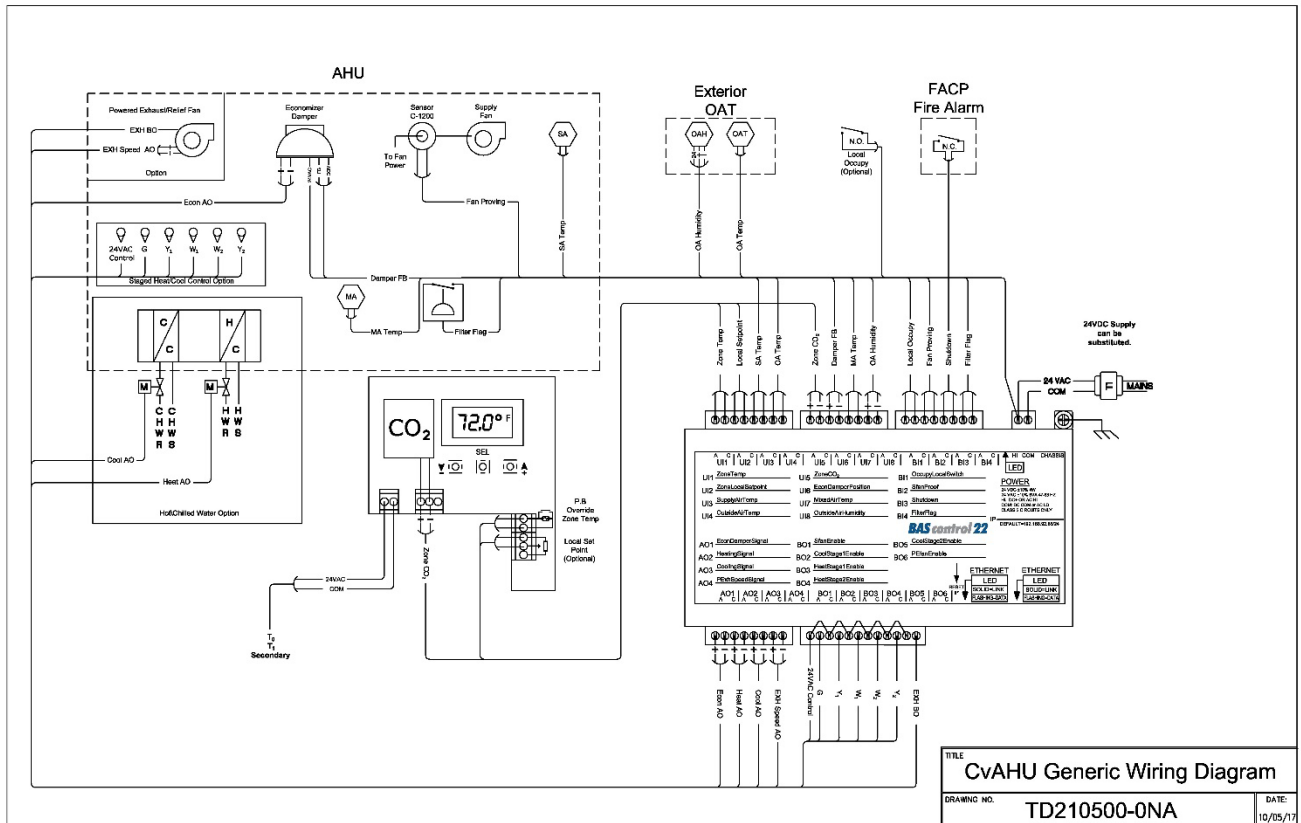
Suggested sensors and actuators used to support these constant volume applications can be found in the device list as shown below. This list provides guidance but is not to be interpreted as the only devices that can be used.

Device	Part Number	Manufacturer	Notes
BAS Control 22 - w/relay Outputs	BASC-22R	Contemporary Controls	
Wall Setter 10kT3 w/10kohm setpoint slider & override	AQW-AAACBF1	Senva	Alt: Senva TR (non-display) series See Senva catalog for AQW options
Wall Setter same as above but with built-in CO2 sensor	AQW-ABACBF1	Senva	Alt: separate 0-10v CO2 sensor See Senva catalog for AQW options
Status "Go-No Go" Current Transformer	C1200	Senva	Alt: Veris H300 See Senva catalog for other CT options
24V SPST Relay	VMB1B-F24	Veris	Use if isolation relays are required
RIB Relay	V100	Veris	For PE / Relief fan option if needed

12" 10K T3 probe	TFEHR00	Veris	duct flange mount included
10K T3 OAT sensor	TOHR00	Veris	½" NPT mount
12' 10K T3 averaging sensor	TAHH0	Veris	use with larger RTUs
Small Actuator 90deg 2-10v sig, 2-10v pos	LMB-24SR	Belimo	"SR" type required for 0-10v
Larger Actuator 2-10v with 2-10v feedback	LF24-SR-S-US	Belimo	Larger with spring return
Dry Diff Psi switch - .2 to 2.0" wc	ADPS-03-2-N	Dwyer	For filter status
Occupancy sensor – wall switch type	MSCD1000	Veris	See Veris catalog for other options

1.9 Wiring Diagram

Information about each application version such as system schematic, points list and sequence of operation can be found in the following chapters of this Reference Manual but in low resolution. Higher resolution documents are found in the downloaded application package. For example, a generic wiring diagram is provided in the download which covers all possible versions. It is shown below but a more readable version is included in the download.



Here are some comments regarding wiring and device selection.

- The BAScontrol22 is intended for Class 2 wiring so it is recommended that the complete control panel follow Class 2 wiring practices.
- An input is provided for a fire alarm control panel (FACP) that will shut down the controller if the input is open. If no FACP or smoke detector contact is used, you must jumper this contact.
- If no wall setter is to be used, those inputs can be left open. Network points will be automatically selected if no wall setter slider potentiometer is connected.
- If no demand control ventilation is used, the CO2 sensor input should be left open.
- A supply fan proving circuit is assumed which can be accomplished with a “Go-no Go” current transformer (CT). If none is provided, this input should be jumpered.
- Damper actuators and valves must be sized according to application requirements.

2 Programmer's SOO – CvAHU Application Series

What follows is detailed information on the operation of the various modules available within the CvAHU application series. Called a programmer's sequence of operation, the following information is generic in nature in that it does not discuss each specific application version within the CvAHU series - but discusses individual modules that exist in the series. No one application uses all available modules. You need to refer to the actual Sedona application, the points list, the sequence of operation (SOO) and the system schematic of the version of interest to understand the detail. It is assumed that you are using the SAE when examining the program. To examine the real and virtual points plus the web components, simply use a common web browser. We will examine web pages first to gain a better understanding of the points. All tools require a knowledge of the controller's IP address.

2.1 Main Web Page

Once you restore the controller using BASbackup with one of the CvAHU application versions, you should be able to access the controller's main web page using the IP address you assigned the controller during the restore process. Below is a capture of the main web page showing the 22-points of real input/output. Depending upon the application version, some information may not appear because a module is absent from the selected application version. With BASbackup, the complete Sedona project which includes the universal I/O configuration, the BACnet naming configuration, the web component configuration and the Sedona program itself is restored. If you make any changes – program or configuration – you will need to do a complete backup to a different file location in order to save your changes for archival purposes.

The screenshot displays the BAScontrol22 web interface with four columns of control points:

- Universal Inputs:** UI1 (ZoneTemp: 72.698), UI2 (ZoneLocalSetpoint: 5238.423), UI3 (SupplyAirTemp: 58.839), UI4 (OutsideAirTemp: 61.294), UI5 (ZoneCO2: 2.800), UI6 (EconDamperPosition: 3.231), UI7 (MixedAirTemp: 64.288), UI8 (OutsideAirHumidity: 5.843).
- Binary Inputs:** BI1 (OccupyLocalSwitch: 0), BI2 (StanProof: 1), BI3 (Shutdown: 1), BI4 (FilterFlag: 0).
- Analog Outputs:** AO1 (EconDamperSignal: 3.243), AO2 (HeatAnalogSignal: 0.000), AO3 (CoolAnalogSignal: 3.381), AO4 (PEXhSpeedSignal: 2.500).
- Binary Outputs:** BO1 (SfanEnable: 1), BO2 (CoolStage1Enable: 0), BO3 (HeatStage1Enable: 0), BO4 (HeatStage2Enable: 0), BO5 (CoolStage2Enable: 0), BO6 (PEfanEnable: 0).

At the bottom, there are navigation buttons: System Configuration, System Status, Set Time, Virtual Points, Web Components, and Restart Controller. An 'Auto Refresh OFF' indicator is also present.

The BACnet point name is at the top of each point with the present value of the point immediately below. The physical point designator is at the left side. A green highlight indicates that a Sedona component for this point has been placed on the wiresheet. A checkbox is provided to force points which should be done with care especially when working on live systems. First turn Auto Refresh ON to see data being updated. Next click the box of the point to be forced and then change the value. Click again outside the area. Un-checking the box restores the data to its current value.

2.2 Virtual Points

Click on the Virtual Points button to view its web page.

Virtual Points

VT01	OccupancyViaNetwork 1	VT09	VT09spare 0.000	VT17	EffectCoolSetpoint 72.491
VT02	OccupancyOvrDuration 120.000	VT10	VT10spare 0.000	VT18	HeatingDemand 0.000
VT03	OccCoolingSetpoint 75.000	VT11	VT11spare 0	VT19	CoolingDemand 3.318
VT04	OccHeatingSetpoint 70.000	VT12	VT12spare 0.000	VT20	EconDmprEffPos 15.397
VT05	VT05spare 0.000	VT13	VT13spare 0.000	VT21	VT21spare 0.000
VT06	VT06spare 0.000	VT14	ModeEnumStatus 1.000	VT22	VT22spare 0.000
VT07	EconMinPosSetpoint 10.000	VT15	OA_TrueBlend 73.000	VT23	VT23spare 0.000
VT08	CO2_SP_ViaNetwork 1200.000	VT16	EffectHeatSetpoint 67.491	VT24	HeartbeatFromBAS 0

Virtual points are used for the wiresheet to receive commands from a BACnet head-end and to supply status from the wiresheet to a BACnet head-end. There are 24 available points but not all are used. Like real points, the BACnet name is at the top and the point designator at the left side. A Sedona point designator highlighted in blue means that there is no Sedona component placed on the wiresheet to support the BACnet point. BACnet points are either a binary variable (BV) or an analog variable (AV). To understand if it is an input or output to the wiresheet, you need to study the Sedona logic. Like real points, BACnet points can be forced using the check box method.

2.3 Web Components

Go back to the main web page and click on the Web Components button. This will bring up the first of six possible web component pages. Use the NEXT and PREV buttons to access the 48 possible web components although not all 48 components are used. Web components provide the interface between a Sedona wiresheet and web pages. They can be configured for either inputs or outputs - but they are usually used as wiresheet inputs. They provide a convenient method of configuring the controller for local functionality when BACnet head-end intervention is not needed. On the far-left is the component number. If it is highlighted in Green, it means that the web component is present on the wiresheet. If it is highlighted in Blue, the web component is not present on the wiresheet. If the point is configured as an input, it is possible to set an input range to prevent illegal entries. To change an input value, highlight the value and enter the new value and then click on Submit. After the Working indication disappears click Auto Refresh to ON and view the updated entry.

Web Components

		<PREV				NEXT>
	Description	Value	Wire Sheet	Min	Max	
WC01	ReservedForTesting	0.000000	Input	0.000000	100.000000	
WC02	HeatCoolDeadbandSP	5.000000	Input	0.000000	100.000000	
WC03	FanAutoOnSelect	1.000000	Input	0.000000	100.000000	
WC04	DcvMaxEconDmprLimit	60.000000	Input	0.000000	100.000000	
WC05	SAT_HiLimitSP	160.000000	Input	0.000000	200.000000	
WC06	SAT_LolimitSP	25.000000	Input	0.000000	100.000000	
WC07	OAT_DX_Lockout	55.000000	Input	0.000000	100.000000	
WC08	OAT_Heat_Lockout	68.000000	Input	0.000000	100.000000	

Web Components

		<PREV				NEXT>
	Description	Value	Wire Sheet	Min	Max	
WC09	PEfanStartOrMaxSP	80.000000	Input	0.000000	100.000000	
WC10	PEfanStopOrMinSP	40.000000	Input	0.000000	100.000000	
WC11	PE_EcmMinV_SP	2.500000	Input	0.000000	100.000000	
WC12	WC12spare	0.000000	Input	0.000000	100.000000	
WC13	UnoccupiedHeatSP	55.000000	Input	0.000000	100.000000	
WC14	MaxHeatSP_Limit	72.000000	Input	0.000000	100.000000	
WC15	MinCoolSP_Limit	70.000000	Input	0.000000	100.000000	
WC16	UnoccupiedCoolSP	85.000000	Input	0.000000	100.000000	

Web Components

		<PREV				NEXT>
	Description	Value	Wire Sheet	Min	Max	
WC17	CmprMinRunMinutes	1.000000	Input	0.000000	100.000000	
WC18	CmprMinOffMinutes	3.000000	Input	0.000000	100.000000	
WC19	EconEnthalpySetpoint	30.000000	Input	0.000000	100.000000	
WC20	EconDryWetBulbSel	0.000000	Input	0.000000	100.000000	
WC21	MixedAirLowLimitSP	45.000000	Input	0.000000	100.000000	
WC22	Default Web Component 22	0.000000	Input	0.000000	100.000000	
WC23	Default Web Component 23	0.000000	Input	0.000000	100.000000	
WC24	Default Web Component 24	0.000000	Input	0.000000	100.000000	

		PREV					NEXT
	Description	Value	Wire Sheet	Min	Max		
WC25	CoolPidKpSetpoint	8.000000	Input	2.000000	20.000000		
WC26	CoolPidKiSetpoint	2.000000	Input	0.500000	10.000000		
WC27	HeatPidKpSetpoint	8.000000	Input	2.000000	20.000000		
WC28	HeatPidKiSetpoint	2.000000	Input	0.500000	10.000000		
WC29	EconPidKpSetpoint	6.000000	Input	2.000000	20.000000		
WC30	EconPidKiSetpoint	2.000000	Input	0.500000	10.000000		
WC31	LocalSP_HiResistance	10000.000000	Input	800.000000	10800.000000		
WC32	Default Web Component 32	0.000000	Input	0.000000	100.000000		

When studying the Sedona logic, it will be convenient to refer to web pages showing the real points, virtual points and web components. In the following discussion, points will be referenced by either their point designator or their Sedona name.

2.4 Main Wiresheet

Using a Sedona tool, such as the SAE, enter the controller’s IP address and login into the controller. If the proper kits and manifests are installed in the Sedona tool, you should be greeted by two folders on the main wiresheet – *service* and *Logic*. The service folder provides basic functionality of the controller while the sheet folder contains the unique logic required to execute a specific application. Although a folder is a Sedona component found in the Sys kit, it is unique in that other Sedona components can reside within a folder. By simply double-clicking, you can drill down to the other components residing in the folder. We will start with the *service* folder.

2.4.1 Service Folder (service)

The *service* folder holds the various services required to operate the controller and normally the contents of the folder should not be modified. However, there are two components that could be examined by double-clicking the service folder. The *Platfor* component has a slot called *MemAvailable* showing the amount of memory available for placing of components onto wiresheets. This value should not drop below the 8192 limit where you will be prevented from adding additional components. The second component is the *time* component which has a slot *OsUtcOffset*. This slot should be set true which allows time setting via web pages. You should always set time via the *Set Time* button on the controller’s web page. There is no other need to investigate any other component in the service folder. Do not remove or edit any of the other components. Return to the main wiresheet and double-click on *sheet*.

2.4.2 Logic Folder (Logic)

The *Logic* folder contains three folders—*HqTstat*, *HtCool*, and *Econo*. The *InpOut* folder contains BAScontrol22 hardware-dependent components and therefore are platform-specific components which cannot be shared with other Sedona devices. These components include real BAScontrol22 I/O components, virtual components

and web components. There is no logic in this folder – just hardware-dependent components with *nubs* showing a link to components in other folders.

Universal inputs UI1-UI8 are pre-configured from the BAScontrol22 web page. Binary inputs BI1-BI4, analog outputs AO1-AO4 and binary outputs BO1-BO6 require no configuration. BACnet virtual components VT01-VT24 are pre-configured for inputs or outputs, although not all are used. The same applies to web components WC01-WC48.

The *Logic* folder contains only sub folders, but these folders contain components that are hardware-independent, thus making the sharing of these folders possible. There are three folders within the Logic folder—*HqTstat*, *HtCool*, and *Econo*. Each will be discussed in detail.

2.4.2.1 Headquarters Thermostat Folder (HqTstat)

If WC03 (FanMode) is false, the supply fan is in automatic mode and will come on when heating or cooling. If FanMode is true, the supply fan will run continuously unless the building is unoccupied.

If an analog wallsetter is being used, its 10kΩ slider potentiometer feeds UI2 (ZnLSP) configured for resistance mode with an open-circuit value of 5kΩ. The slider resistance range is set by WC31 (SpHiRes). This value must match the maximum slider resistance employed. The wallsetter macro component (Wallset) scales the slider resistance to a range of 65°-75°F. These values can be adjusted through Wallset slots SP_PotOutMin and SP_PotOutMax. If no slider is present, it will default to mid-range or 70°F. If no wallsetter is to be used, select network setpoints VT09 (UseNetOccSetpoints) to true.

There are two network occupy setpoints – one for heating VT04 (OccHtSP) and one for cooling VT03 (OccClSP). There are also two unoccupied setpoints – one for heating VT06 (UnoHtSP) and one for cooling VT05 (UnoClSP). The network-occupy setpoints are used when there is no wallsetter, or they fixed, or are to come from the BACnet head-end. The unoccupied setpoints are used in both network and wallsetter modes. The minimum deadband between heating and cooling setpoints is determined by VT07 (MnDeadb). The effective setpoints will never be closer than the minimum deadband.

The cooling setpoint can be no lower than WC15 (ClMinSP) and the heating setpoint can be no higher than WC14 (HtMaxSP). These two setpoint limits can be changed in keeping with local codes.

There are three ways to invoke occupied mode. One is local occupy where a presence detector switch attached to BI1 (OccLocl) forces an occupy command for an amount of time the switch is closed. The second method is via the VT01 (OccNet) which is an occupancy command from the head-end. A temporary occupancy indication can occur using a pushbutton switch on the wallsetter (assuming a wallsetter is used). If pushed for more than three seconds, the pushbutton shorts-out the wallsetter thermistor forcing an out-of-range indication as monitored by WallSet. When this occurs, an internal WallSet timer begins counting while creating a temporary occupied condition. A temporary occupancy value in minutes is provided by the BACnet head-end to VT02 (OvdTime) which determines the temporary occupancy time. These signals are used by the Occupy component to establish a single occupy signal that feeds the (OccupyStatus) in the economizer macro component in folder (Econo) and enables the heating and cooling PID components (CIPID1), HtPID1) in the HtCool folder.

During the Unoccupied mode, the WallSet component monitors space temperature to see if it is exceeding the limits set by unoccupied heating and cooling setpoints. When one of these conditions occur, the WallSet will command either Out Unoc Cooling or Out Unoc Heating to temporarily enable either heating or cooling PID loops.

When in the occupied state or if EnabPID is true, heating, and cooling PID components (HtPID1, CIPID1) in the HtCool folder are enabled. In addition, the occupy setpoints versus the unoccupied setpoints and can be monitored via effective heating setpoint VT16 (EffHtSP) and effective cooling setpoint VT17 (EffClSP). Regardless of the FanMode state, the supply fan will be commanded to run if a heating or cooling demand exists.

If zone temperature UI1 (ZnTemp) is out of range or fails, a signal is sent to a 15-second timer (OvrDly). If the timer times out, a fault indication is sent to the fault logic. During this situation, ZnTemp will output its failover temperature of 40°F. The system will remain in a shutdown condition until the fault is repaired.

If any thermistor (UI1, UI3, UI4, UI7) fails, the system will go into an EmergencyShutdown condition after a 30 second delay and VT23 (TsFault) will be set to true until the faulty sensor is repaired.

Successful supply fan operation is monitored. If there is a call for heating or cooling from the HtCool folder, the supply fan will be called upon to start (SfanOr1). An off-delay timer (DlyOff1) is triggered commanding the supply fan to start BO1 (SfanEna) assuming there is no shutdown indication from the shutdown timer (ShtdwnD). To verify that the supply fan successfully started, a feedback signal BI2 (SfanPrf) is used to create the SfVerify signal that feeds the status logic (ModeE) and numerous other components in the HtCool folder that require supply fan running verification. The ModeE component enumerates the highest status indication of several states beginning with Standby (0-default), to Vent (1), Heat (2), Cool (3), Filter (4), to a high of Emergency Shutdown (5).

2.4.2.2 Heating and Cooling Folder (HtCool)

Heating and cooling logic is separate although much of the logic is similar. There are two PID components – one for heating (HtPID1) and one for cooling (CIPID1) – that mostly have identical initial parameters except that the cooling PID is configured for direct action while the heating PID is configured for reverse action. Both PIDs have an output range between 0-100 with zero (Min) indicating no demand and 100 (Max) indicating maximum demand. The maximum setting (Max) can be modified by the logic as we will learn later. The PID execute time is set for 6 seconds meaning that every 6 seconds the PID algorithm is executed - thereby possibly creating a new output. MaxDelta is set for 5 meaning that regardless of the last PID calculation, its output will not change by more than 5 thereby damping the output swing. Even if an output swing from 0 to 100% is to be invoked after a PID calculation, it would still take the PID output 2 minutes to fully reflect this internal calculation.

The tuning parameters for the PID controllers are generally considered to be Kp, Ki and Kd. Kd is set to zero, so we are only working with a PI controller and not a PID controller. The proportional gain (Kp) is initially set for 8 (WC25, WC27) but this can be changed. The integral gain is initially set for 2 (WC26), (WC28) and that can be changed as well. An increase in proportional gain improves responsiveness at the risk of instability. An

increase in integral gain reduces the inherent deviation offset of proportional-only systems at the risk of overshoot and reset wind-up.

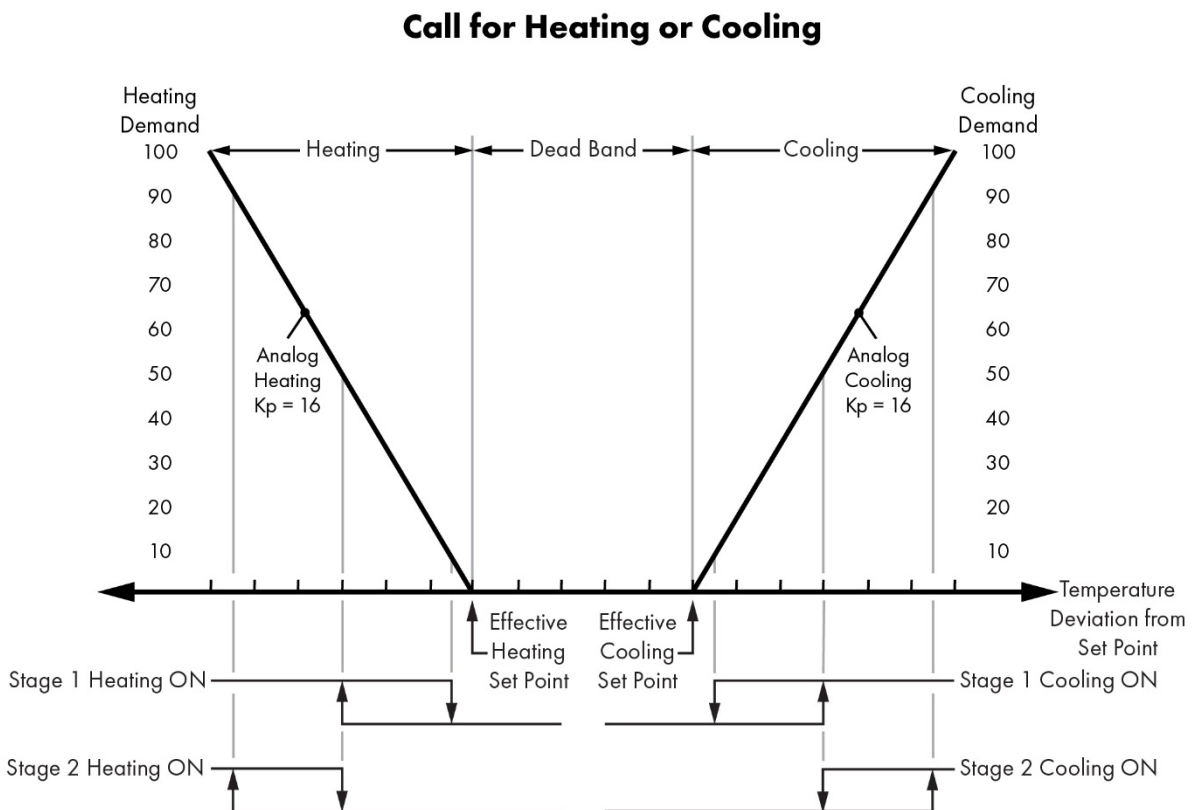
Both PID components are Enhanced PID components from the CControls_HVAC kit and they differ somewhat from the Tridium release LP component. Both enable slots on the two PID components are driven from an Enable signal meaning that the two PID components are disabled when the building is unoccupied, unless the unoccupied setpoint limits are exceeded. In disable mode the PID output drops to the Bias value (zero) in a controlled fashion as determined by MaxDelta. At an output value of zero no heating or cooling will occur.

The controlled variable (Cv) on each PID component comes from zone temperature UI1 (ZnTemp) through a limiter component to ensure that no faulty sensor readings are passed onto the control logic. Individual heating and cooling setpoints feed the (Sp) input on the respective PID component.

Two EnhTstat components (OaHtLok, OaClLok) from the CControls_P_HVAC2 kit are used to disable control action if the outside air temperature is too warm for heating and too cool for cooling. Using analog switches (OaHtSW, OaCLSW), the outputs of the respective PID is ignored when one of these conditions occurs. The cooling lockout setpoint can be set by WC07 (ClLoLoc) and the heating lockout setpoint by WC08 (HtHiLoc).

Analog Heating and Cooling

To better understand how analog heating and cooling works, consult the Call for Heating and Cooling diagram which provides a conceptual look on how the two PID components operate sharing a common measured variable (zone temperature) but with two effective setpoints – one for the cooling PID and one for the heating PID.



The top of the diagram shows the possible analog control action of the two PID components with the heating PID on the left (reverse acting) and the cooling PID on the right (direct acting). Assume an analog wallsetter is being used to establish a desired setpoint based upon a single slider potentiometer in the unit. Two effective setpoints are created – one for heating and one for cooling – separated by a deadband. The horizontal line shows Temperature Deviation from Setpoint with the two effective setpoints identified. Each tick mark indicates one degree of deviation from an effective setpoint. Two vertical scales are shown to indicate heating demand on the left and cooling demand on the right using 0-100% ranges. The slope of the two diagonal lines represents the proportional gain ($K_p=16$).

This diagram is simplistic in that it does not show the effects of integral action ($K_i=2$). However, if the space temperature is equal to the setpoint there would be no integral contribution, so this diagram is valid.

Supply air temperature (SaTemp) from UI3 is brought to two reset components – one for heating (HI_RST) and one for cooling (LO_RST). The purpose of the two reset components is to reset the maximum output setting of the corresponding PID components down as low as 5% (LowLim) when the supply air temperature is too high when heating or too low when cooling.

The supply air high limit (SaHiLim) is set by WC05 with a default of 160°F. There is a fixed range of 20°F where proportional reset action occurs. When the supply air temperature rises to 140°F, the maximum output of the heating PID begins to drop linearly from 100% to 5% as the supply air temperature continues to rise towards the SaHiLim limit. Any higher temperature will continue to keep the maximum heating output at 5%.

The supply air low limit (SaLoLim) is set by WC06 with a default of 35°F. There is a fixed range of 20°F where proportional reset action occurs. When the supply air temperature lowers to 45°F, the maximum output of the heating PID begins to lower linearly from 100% to 5% as the supply air temperature continues to drop towards the SaLoLim limit. Any lower temperature will continue to keep the maximum cooling output at 5%.

With analog control (CvAHU1, CvAHU5 app versions), the output of the cooling PID drives the 0-10VDC output AO3 and the output of the heating PID drives the 0-10VDC output AO2. If a 2-10VDC actuator is used (ie: Belimo) WC13 (ActMinV) may be used to reset the minimum voltage from zero to 2.

Staged Heating and Cooling

The bottom of the diagram shows the two heating and two cooling stages which can be triggered at pre-defined points on the output curve. A macro component (StgHtCl) determines the on and off points on the curve. These engagement points can be changed by re-programming the CutIn and CutOut slot values in the StgHtCl component. The default setting has stage one coming on when the PID output reaches 40% and going off at 5% and stage two coming on at 98% and going off at 50% or 60% but there is a sequence of events before stages are commanded on. We will discuss staged heating first.

Heating Sequence

Once the heating PID output reaches 40%, there is a 3 second on-delay before the supply fan BO1 is commanded on. If either the Fan Flow Proof slot or the Emergency Off slot become disabled, the W1 and W2 outputs will be immediately disabled. If not, there is a call for stage 1 heating via binary output BO4. Unless an emergency or fan failure occurs, stage 1 heating will remain on until the PID output signal drops below 5%.

Stage 2 heating operates much the same way using the same supply fan permissive and emergency permissive, but its trip points are 98% rising and 50% falling. The only difference is that once the 98% trip point is reached, there is a 60-second On delay (H2Dly1) before binary output BO5 is enabled. Stage 2 drives binary output BO5 and will remain on until the heating PID falls to 50%.

Cooling Sequence

The cooling sequence operates from the cooling PID, and its staging logic is almost identical to the heating sequence except in the way the staging commands are executed. With DX cooling it is necessary to protect the stage 1 and stage 2 compressors against short cycling and that is accomplished with two anti-cycle components – AntiS1 for stage 1 and AntiS2 for stage 2. Both components utilize the same minimum runtime as determined by WC17 (RunTim1) in minutes and the minimum off time as determined by WC18 (OffTim1) also in minutes. If there is an emergency shutdown prior to the Minimum Off Time expiring, binary switches EmgSw1 and EmgSw2 ensure that stage one and stage two compressors (BO2 and BO3) are disabled immediately.

2.4.2.3 Economizer Folder (Econo)

Economizers provide a stage of free cooling if outside air conditions are suitable. For economizer operation, outside air temperature (OatTemp), mixed air temperature (MaTemp), and return air temperature (ZnTemp) are needed. All three signals connect to the economizer macro component EconoE from the Ccontrols_P_HVAC2 kit. A true blend of return air, mixed air and outside air is calculated by the econo macro and made available at VT15 (OatBlnd) to display the percentage of outside air that is being introduced. This is more accurate than simply monitoring the position of the economizer damper.

If unit status is Occupied and the supply fan is proven on, and conditions are below Dry bulb (or Wet bulb) limits then economizer cooling is enabled. When econ cooling is enabled the econ damper AO1 (EconAO) is modulated to maintain the Effective Cooling setpoint minus 1F. If Econ damper is 100% open for more than 5 minutes, mechanical cooling is enabled and operates as a second stage of cooling. Any time economizer cooling is disabled mechanical cooling is allowed to become stage one cooling.

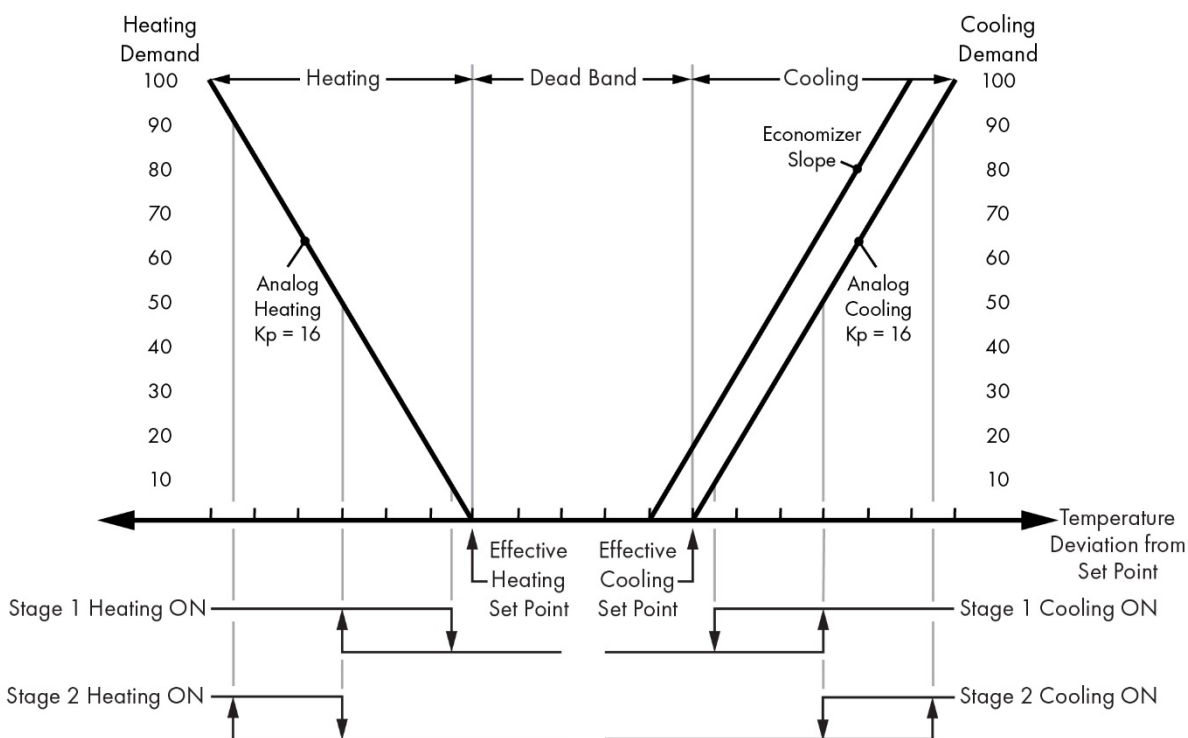
A Psychrometric calculator built into the econo macro provides enthalpy outputs for return air and outside air.

When enthalpy control of the economizer is needed, an outside air relative humidity sensor must be attached at UI8 (OaRH). When differential (dual) enthalpy is needed a return air relative humidity sensor must be attached at UI5 (RaRH). Note that this option is only available on CvAHU3 and CvAHU4.

The economizer may be configured for dry bulb or wet bulb (enthalpy) modes, and either fixed (single) or differential (dual comparison) modes using WC20 (WetSel) and WC22 (DifSel) configuration inputs as appropriate. The default setting is for fixed (single) dry bulb operation. Consult a local Climate Zone Chart for recommended area settings. An 80F Outside Air economizer high limit lockout applies to all dry or wet modes.

The following diagram provides a visual display of the action of the economizer:

Call for Heating or Cooling with Economizer



When there is a call for free cooling, an economizer slope begins 1°F before the curve for normal analog cooling. Instead of providing mechanical cooling, the economizer modulates the outside air damper up to 100% open. Since stage 1 cooling does not begin until the analog demand is at 50%, this effectively provides an early stage of staged cooling. Economizer cooling and mechanical cooling can coexist. If there is no call for free cooling, then this extra stage of cooling is disabled.

When there is a call for free cooling, the economizer PID in the macro is enabled. While the control variable input (Cv) is the zone temperature (ZnTemp), the setpoint (Sp) is from a subtraction component (CSPofst) which reduces the effective cooling setpoint (EffCISP) by 1°F. This PID effectively creates a free cooling slope just to the left of the mechanical cooling slope allowing free cooling to occur just ahead of mechanical cooling. You can see this in the Call for Heating or Cooling with Economizer Chart. Since stage one of mechanical cooling typically begins when the cooling demand exceeds 50%, the intent is to create a free-cooling stage 0 that will operate in the 0-100% free cooling range while providing a proportional 0-100% command to the outside air damper. However, the output range of the outside air damper is limited on the low end by EcoMin (VT07) which forces a minimum (10%) outside damper position for ventilation purposes. The output of EconPID goes to a maximize component (EconMax) as does the output of Co2PID allowing the highest demand signal to pass through.

For demand control ventilation (DCV), you will need a CO2 sensor (ZnCo2) installed at UI5. The output of the sensor is scaled to 0-2000ppm (Co2ppm) and sent to a PID loop in the macro which is enabled when in occupy mode. WC12 (DCVsel) must be set to true (1) to allow DCV control to be utilized.

Note that in DCV mode VT21 (EconMin) should be set to 0*. When not using DCV mode, set VT21 to 10%* (*or according to Balancer or True Blend)

The maximum output swing of the CO2 PID loop is controlled by the web component WC04 (Co2Max). The CO2 setpoint comes from the network VT08 (Co2NSP) with the limiter Co2NSP restricting the range to a minimum of 800ppm and a maximum of 1600ppm. The output of Co2PID is sent to the minimize component (EconMin) which compares this signal strength with that of the economizer. The highest of these signals is passed onto the mixed air temperature logic.

The mixed air temperature logic consists of mixed air temperature UI7 (MaTemp) and WC21 (MatLoSP). When econ cooling is enabled the econ PID loop is enabled, and the mixed air temp is the controlled variable. The damper AO1 (EconAO) is modulated to maintain the Effective Cooling setpoint minus 1F. If the Mixed Air temp (UI7) drops below WC21 (MatLoSP) Low Limit of 45F, damper output is restricted to 10%.

Powered Exhaust option:

If a powered exhaust fan is installed, it is controlled based on the position of the outside air intake damper. The PE fan (BO6) is enabled when the OA damper reaches 80% open (WC09). The PE fan shall be turned off when the OA damper reaches 40% open (WC10).

If a VFD or ECM motor is used the speed shall be modulated between the Max (PE start % setpoint WC09) and Min (PE stop % setpoint WC10). The Minimum voltage output shall be 2.5 vdc (WC11) for a minimum fan speed of 25%. These setpoints and settings should be determined and adjusted by the system balancer or startup technician.

Purge Mode option:

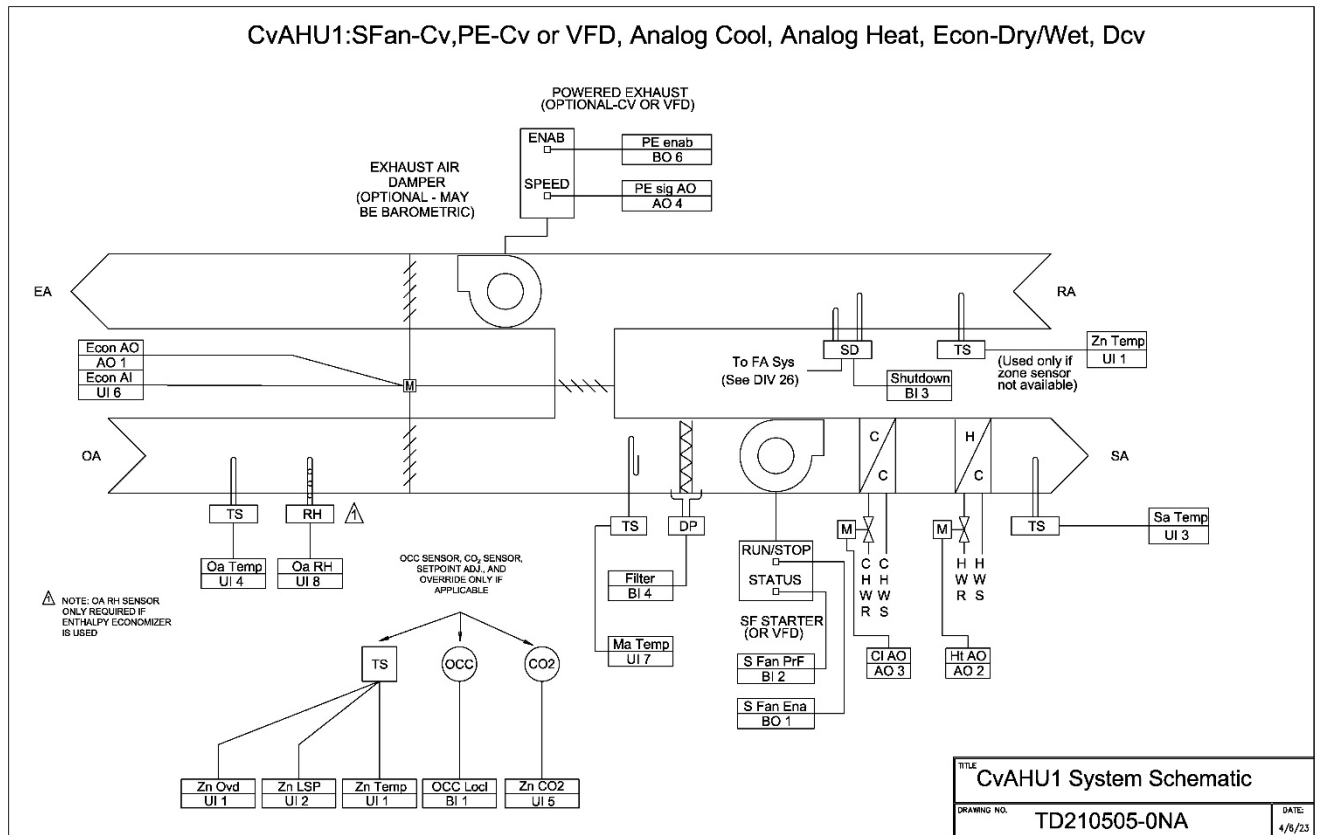
In Purge mode drive econ to 100% and enable Exh fan. Set VT10 (Purge) to true (1) to enable purge mode. Note that MAT Low Limit protection is still in effect during Purge mode.

2.5 Overview

CvAHU1 is a packaged Rooftop Unit with CV supply fan, CHW analog cooling, HW analog heating, wet or dry-bulb economizer & barometric relief. Optional provisions are made for PE (powered exhaust) with or without ECM/VFD motor, air filter status, local occupancy switch/sensor, and CO2 demand control ventilation. The control of the AHU is provided by a BAScontrol22 programmable unitary controller. Although the controller is stand-alone capable, it is assumed that the AHU will be interfaced with a centralized BAS via a BACnet IP connection. Unit configuration and remote monitoring is provided via a web browser interface (WC points) and through the BACnet network interface (VT points).

Equipment Summary	
Fan(s)	Sfan-Cv, PExh-Cv or Variable
Cooling	Analog CHW
Heating	Analog HW
Humidification	None
Dehumidification	None
Economizer	Dual Dry Bulb or Enthalpy

2.6 System Schematic



2.7 Points List

I/O Point	Configured as	Sedona Tag	BACnet Object			
			Instance	Name	Type	Comments
UI1	10k T3	ZnTemp	1	ZoneTemp	AI	Space temperature thermistor
UI2	Resistance	ZnLSP	2	ZoneLocalSetpoint	AI	Two-wire potentiometer
UI3	10k T3	SaTemp	3	SupplyAirTemp	AI	Supply air thermistor
UI4	10k T3	OaTemp	4	OutsideAirTemp	AI	Outside air thermistor
UI5	0-10V	ZnCO2	5	ZoneCO2	AI	0-2000 ppm CO2 transmitter
UI6	0-10V	EconAI	6	EconDamperPosition	AI	OA damper position feedback
UI7	10k T3	MaTemp	7	MixedAirTemp	AI	Mixed air thermistor
UI8	0-10V	OaRH	8	OutsideAirHumidity	AI	Outside air humidity

BI1	contact	OccLocl	9	OccupyLocalSwitch	BI	Temporary occupancy switch
BI2	contact	SfanPrf	10	SfanProof	BI	Supply air fan proving sensor
BI3	contact	Shutdown	11	Shutdown	BI	Shutdown occurs if open
BI4	contact	Filter	12	FilterFlag	BI	Filter requires changing
AO1	0-10V	EconAO	13	EconDamperSignal	AO	OA damper command signal
AO2	0-10V	HtAO	14	HeatAnalogOutput	AO	Heating analog command
AO3	0-10V	CIAO	15	CoolAnalogOutput	AO	Cooling analog command
AO4	0-10V	PEsigAO	16	PExhSpeedSignal	AO	Powered exhaust speed cmd.
BO1	contact	SfanEna	17	SfanEnable	BO	Engage supply fan
BO2	contact		18		BO	
BO3	contact		19		BO	
BO4	contact		20		BO	
BO5	contact		21		BO	
BO6	contact	PEenab	22	PEfanEnable	BO	Engage powered exhaust
VT01	WS input	OccNet	201	OccupyViaNetwork	BV	Network occupy command
VT02	WS input	OvdTime	202	OccupyOvrDuration	AV	Net. Occ. override time (min)
VT03	WS input	OccCISP	203	OccCoolingSetpoint	AV	Occupied cooling setpoint
VT04	WS input	OccHtSP	204	OccHeatingSetpoint	AV	Occupied heating setpoint
VT05	WS input	UnocCISP	205	UnoccCoolingSetpoint	AV	Unoccupied Cooling Setpoint
VT06	WS input	UnocHtSP	206	UnoccHeatingSetpoint	AV	Unoccupied heating setpoint
VT07	WS input	MnDeadB	207	MinDeadbandSP	AV	5F (When local SP DB is fixed)
VT08	WS input	Co2NSP	208	CO2_SP_ViaNetwork	AV	Network supplied CO2 setpoint
VT09	WS input	NetSPsw	209	UseNetOccSetpoints	BV	Network Supplied Occ Setpoints
VT10	WS input	Purge	210	EconPurgeEnable	BV	Enable Purge Econ 100% & Sfan
VT11	WS output	EffCO2	211	EffZoneCO2PPM	AV	Effective Zone CO2 PPM
VT12	WS output	EffOARH	212	EffectOARH	AV	Effective OA Rel. Humidity
VT13	WS output	OAEnth	213	EffOA_Enthalpy	AV	Effective Out Air Enthalpy
VT14	WS output	ModeNet	214	ModeEnumStatus	AV	"0" = Standby "1" = Ventilation "2" = Heating "3" = Cooling "4" = Filter "5" = Emergency Off
VT15	WS output	OatBlnd	215	OA_TrueBlend	AV	Percentage of outside air based upon SA, MA and OA temperatures
VT16	WS output	EffHtSP	216	EffectHeatingSetpoint	AV	Reflects the current heating setpoint
VT17	WS output	EffCISP	217	EffectCoolingSetpoint	AV	Reflects the current cooling setpoint
VT18	WS output	HtNDem	218	HeatingDemand	AV	Heating demand from 0-100%
VT19	WS output	CINDem	219	CoolingDemand	AV	Cooling demand from 0-100%
VT20	WS output	EconPos	220	EconDmprEffPos	AV	Outside damper position
VT21	WS output	EcoMin	221	EconMinPosSetpoint	AV	Economizer Min Open Position
VT22			222			
VT23	WS outout	TsFault	223	Thermistor Fault	AV	Out Range Condition Thermistor
VT24	WS input	Hrtbeat	224	HeartbeatFromBAS	BV	Wink from BAS for fallback

Web Point	Web Name	Sedona Tag	I/O	Default Value	Comments
WC01	ReservedForTesting	TestVal	I	0	Set to "1" to test the occupy logic. Currently not used as part of the logic.
WC02					
WC03	FanAutoOnModeSelect	FanMode	I	1	When set to "0" the supply fan is in automatic mode. With a "1" the supply fan runs continuously while in occupied mode.
WC04	DcvMaxEconDmprLimit	Co2Max	I	60	The sets the maximum throttling range of the CO@ PID controller. Maximum setting is 100%.
WC05	SAT_HighLimitSP	SaHiLim	I	160	Supply air temperature high limit. Min=0; Max=200
WC06	SAT_LowLimitSP	SaLoLim	I	25	Supply air temperature low limit. Min=0; Max=100
WC07	OAT_DX_Lockout	CILOLoc	I	55	If outside air temperature drops below this setting, cooling will be locked out until the outside air temperature rises 2 degrees F above this setting.
WC08	OAT_HeatLockout	HtHiLoc	I	68	If outside air temperature rises above this setting, heating will be locked out until the outside air temperature drops 2 degrees F below this setting.
WC09	PEfanStartOrMaxSP	PEStart	I	80	If a powered exhaust is being used and the exhaust damper position (percentage open) exceeds this setting, the exhaust fan will turn on. If a variable speed drive is being used, its speed will throttle between the two damper position limits.
WC10	PEfanStopOrMinSP	PEStop	I	40	If a powered exhaust is being used and is running and the exhaust damper position becomes less than this setting, the exhaust fan will turn off.
WC11	PE_EcmMinV_SP	PEminSP	I	2.5	Low-limit of the 0-10V powered exhaust signal
WC12	DCV_ModeSelect	DCVsel	I	False	False=Use minVent True=Use DCV
WC13	UnocHeatingSetpoint	UnoHtSP	I	55	Unoccupied heating setpoint
WC14	MaxHeatSP_Limit	HtMaxSP	I	73	Maximum heating setpoint allowed
WC15	MinCoolSP_Limit	CIminSP	I	69	Minimum cooling setpoint allowed
WC16	UnocCoolingSetpoint	UnoClSP	I	85	Unoccupied cooling setpoint
WC19	EconEnthalpySetpoint	EnthSP	I	30	Above this setpoint economizer operation is disabled.
WC20	EconDryWetBulbSelect	EconSel	I	0	0=Dry Bulb, 1=Enthalpy & Dry Bulb
WC21	MixedAirLowLimitSP	MatLoSP	I	45	MAT low limit setpoint typ. 45°F
WC22	EconFixedDiffModeSel	DiffSel	I	False	false=Fixed limit (Single), true=Differential (Dual)
WC23	EconDryBulbLimitSP	DrySP	I	72	Adjust based on climate zone: 65 to 75 range)

WC24	EconActuatorMinVolts	ActMinV	I	2	2v (usually either 2 or 0 is expected)
WC25	CoolPidKpSetpoint	CoolKP	I	8	
WC26	CoolPidKiSetpoint	CoolKi	I	3	
WC27	HeatPidKpSetpoint	HeatKp	I	8	
WC28	HeatPidKiSetpoint	HeatKi	I	3	
WC29	EconPidKpSetpoint	EconKp	I	6	
WC30	EconPidKiSetpoint	EconKi	I	2	
WC31	LocalSP_HiResistance	SpHiRes	I	10000	(Establishes max resistance of SP slider)
WC32-48					

2.8 Sequence of Operation

- A. OPERATING MODES: CvAHU1 shall have the following modes of operation:
 - 1. BAS OCCUPIED – NORMAL USE: The BAS network shall have an hourly schedule for zone /space occupancy (VT01). The following items shall occur when the system is operating in occupied mode:
 - a. LOCAL SETPOINTS: Zone temperature setpoint slider (UI2) shall have a span of 65°F to 75°F with a 5°F (adj. WC02) deadband. Cooling setpoint shall have a minimum 69°F (adj. WC15) limit. Heating setpoint shall have a maximum 73°F (adj. WC14) limit.
 - b. NETWORK SETPOINTS: If a local setpoint slider is not installed the Network Occupied heating and cooling setpoints shall automatically be utilized. UseOccNetSetpoints (VT09) must be set True. Network setpoints shall be 75°F Cooling (adj. VT03) and 70°F Heating (adj. VT04).
 - c. MODE STATUS: Operating mode status is made available to the BAS via VT14 and shall display Standby (0), Venting (1), Heating (2), Cooling (3), Filter Flag (4) and Emergency Shutdown (5) enumerations.
 - 2. OCCUPIED – LOCAL OVERRIDE OPTIONS
 - a. TIMED OVERRIDE: A push button timed override shall be available at the local wall setter for a maximum of 2 hours (adj. VT02), after which it shall revert to the Normal Use schedule. A button press of 3 seconds that short circuits input UI1 shall be required to initiate override.
 - b. OCCUPANCY SENSOR/WALL TIMER: If required, a local occupancy sensor or local wall timer shall be installed (BI1) and shall work in parallel with the BAS Occupied and Timed Override Occupied inputs.
 - 3. UNOCCUPIED MODES

- a. SETPOINTS: BAS/Network setpoints shall set an unoccupied setpoint of 85°F (adj. VT05) Cooling and 55°F (adj. VT06) Heating. Unoccupied setpoints shall not be available at the local wall setter for adjustment.
- b. HIGH / LOW LIMIT: Space temperature shall be maintained between the high and low unoccupied setpoints during the unoccupied period. CO2 Demand Ventilation control shall be disabled in unoccupied mode.
- c. OPTIMIZED START: If required, Stop/start optimization shall occur exclusively at the BAS network level. The optimized start schedule shall occur up to two hours (adj.) prior to the occupied schedule.

B. NORMAL USE MODE

1. STANDARD OPERATION

- a. SUPPLY FAN: Supply fan shall operate continuously at normal speed (set at air balance to meet design flow). If there is no economizer or provision for ventilation air, the supply fan may operate in the AUTO mode on a call for heating or cooling. AUTO/ON mode is configured from the Web interface WC03 and shall not be locally selectable.
- b. COOLING: Cooling shall be based on a 0 to 100% PID demand output. Cooling shall be sequenced with stage one as economizer and stage two as chilled water cooling. The economizer and CHW coil shall operate together.
 - i. Economizer cooling mode shall be preconfigured as either Dual Dry Bulb or Enthalpy (Wet Bulb) via WC20. In Dual Dry Bulb mode, the economizer shall modulate based on the effective cooling setpoint minus a fixed offset. If the outside air temperature is 2°F lower than the return air temperature (or room air temperature), then the economizer shall be enabled as first stage cooling. In Enthalpy mode, the economizer shall be disabled whenever the outside air enthalpy is above 30 Btu/lb. (adj. WC19). The Mixed air temp shall have a low limit of 45°F (adj. WC21).
 - ii. Chilled water cooling shall be locked out at and below 52°F (adj. WC07) outside air temperature.
 - iii. Cooling Low Limit: If supply air temperature drops below 40°F (adj. WC06) then cooling PID maximum output shall be reset down to 4% output.
 - iv. Analog cooling: The cooling PID shall output a 0 to 10-volt (or 2 to 10) signal to a chilled water valve based on zone temperature.
- c. HEATING: Heating shall be based on a 0 to 100% PID demand output. The heating PID shall output a 0 to 10-volt (or 2 to 10) signal to a hot water valve based on zone temperature.
 - i. Heating is locked out when the OA temperature is higher than 66°F (adj. WC08).
 - ii. Heating High Limit: If supply air temperature rises above 160°F (adj. WC05) then heating PID maximum output shall be reset down to 4% output.

- d. VENTILATION – DEMAND CONTROL: If zone CO2 sensor is installed the economizer minimum position shall be reset down to maintain 1200 ppm (adj. VT08) carbon dioxide. Maximum damper position in CO2 control shall be set at 60% (adj. WC04). Economizer damper shall position based on the maximum signal from the Cooling PID and the DCV PID outputs. When in UNOCCUPIED MODE the outside air damper shall remain closed.
- C. POWERED EXHAUST (RELIEF FAN) OPTION: If a powered exhaust fan is installed, it shall be controlled based on the position of the outside air intake damper. The PE fan shall be started when the OA damper reaches 80% open (adj. WC09) and turned off when the OA damper reaches 40% open (adj. WC10). These setpoints should be determined by the system balancer. If a VFD or ECM motor is used the speed shall be modulated between the Max (PE start % setpoint WC09) and Min (PE stop % setpoint WC10). The Minimum voltage output shall be 2.5 VDC (adj. WC11).
- D. ALTERNATIVE PROVISIONS
 - 1. SUPPLY FAN PROOF: It is highly recommended that a flow switch or a status CT is provided. If it is not installed the input on the controller must be jumpered (BI2) or all heating and cooling functions will be disabled.
 - 2. FILTER STATUS INPUT: A dirty filter indicator can be sent over the network if a DP switch is installed. The filter status input does not affect the unit operation and is provided only for remote alert monitoring.
- E. EMERGENCY/FIRE SHUTDOWN: An interlock shall be provided that will immediately shut down all outside air dampers, fans, and heating/cooling. Upon return to normal, there shall be a 1-minute restart delay. In addition to the fire shutdown interlock, all temperature sensors are monitored. If a temperature sensor is shorted or open circuited, an emergency shutdown will be initiated until the faulty sensor is repaired. Thermistor fault is monitored via VT23.
- F. ALARMS: At a minimum, the following alarms shall be provided:
 - 1. General alarms available at the BAS level
- G. TRENDS (If Applicable):
 - 1. General trends available at the BAS level

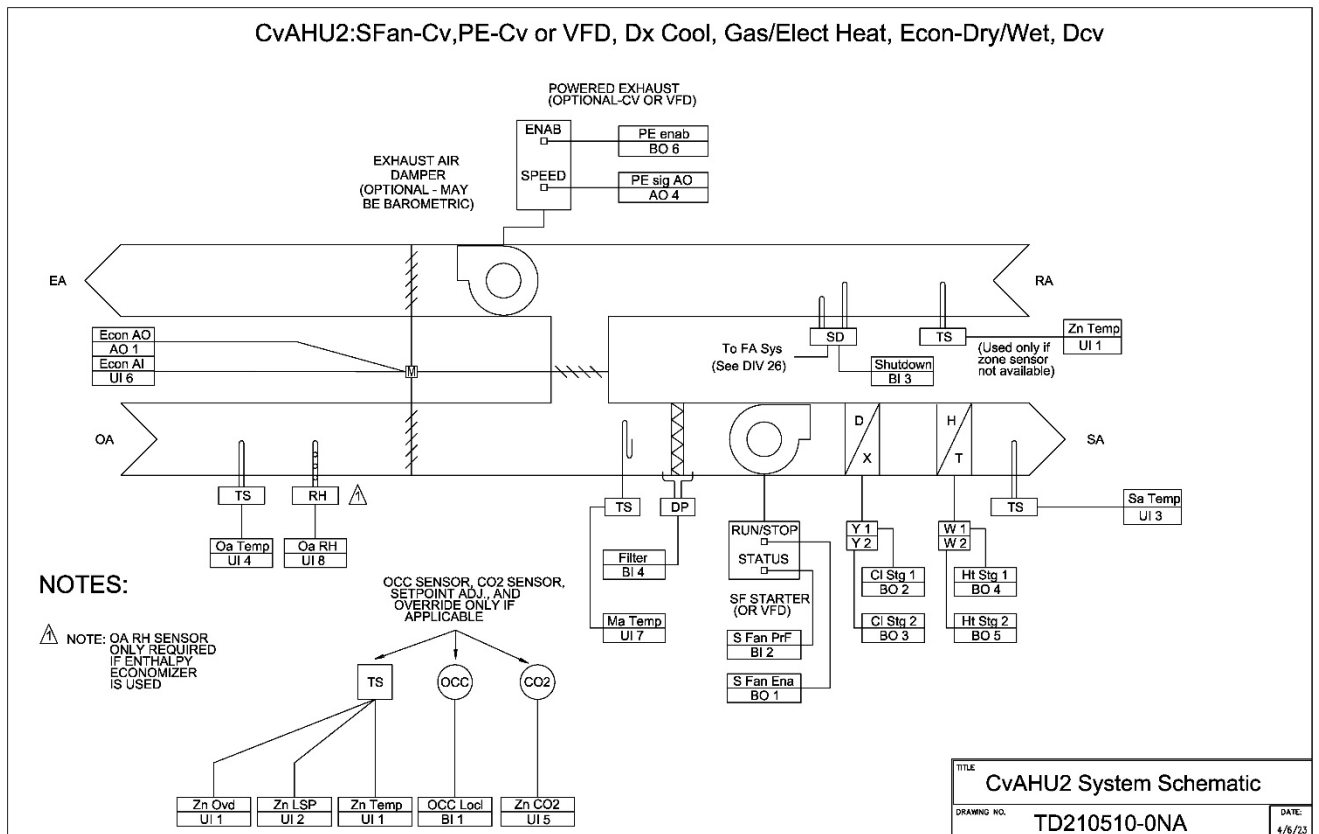
3 Constant Volume AHU Application—CvAHU2

3.1 Overview

CvAHU2 is a packaged Rooftop Unit with CV supply fan, DX cooling (1 or 2 stage), gas or electric heating (1 or 2 stage), wet or dry-bulb economizer & barometric relief. Optional provisions are made for PE (powered exhaust) with or without ECM/VFD motor, air filter status, local occupancy switch/sensor, and CO2 demand control ventilation. The control of the AHU is provided by a BAScontrol22 programmable unitary controller. Although the controller is stand-alone capable, it is assumed that the AHU will be interfaced with a centralized BAS via a BACnet IP connection. Unit configuration and remote monitoring is provided via a web browser interface (WC points) and through the BACnet network interface (VT points).

Equipment Summary	
Fan(s)	Sfan-Cv, PExh-Cv or Variable
Cooling	DX-1 or 2 stage
Heating	Elect/Gas – 1 or 2 stage
Humidification	None
Dehumidification	None
Economizer	Dual Dry Bulb or Enthalpy
Ventilation	Fixed% or DCV – CO2 sensor

3.2 System Schematic



3.3 Points List

I/O Point	Configured as	Sedona Tag	BACnet Object			
			Instance	Name	Type	Comments
UI1	10k T3	ZnTemp	1	ZoneTemp	AI	Space temperature thermistor
UI2	Resistance	ZnLSP	2	ZoneLocalSetpoint	AI	Two-wire potentiometer
UI3	10k T3	SaTemp	3	SupplyAirTemp	AI	Supply air thermistor
UI4	10k T3	OaTemp	4	OutsideAirTemp	AI	Outside air thermistor
UI5	0-10V	ZnCO2	5	ZoneCO2	AI	0-2000 ppm CO2 transmitter
UI6	0-10V	EconAI	6	EconDamperPosition	AI	OA damper position feedback
UI7	10k T3	MaTemp	7	MixedAirTemp	AI	Mixed air thermistor
UI8	0-10V	OaRH	8	OutsideAirHumidity	AI	Outside air humidity
BI1	contact	OccLocl	9	OccupyLocalSwitch	BI	Temporary occupancy switch
BI2	contact	SfanPrf	10	SfanProof	BI	Supply air fan proving sensor
BI3	contact	Shutdwn	11	Shutdown	BI	Shutdown occurs if open
BI4	contact	Filter	12	FilterFlag	BI	Filter requires changing
AO1	0-10V	EconAO	13	EconDamperSignal	AO	OA damper command signal
AO2			14		AO	
AO3			15		AO	
AO4	0-10V	PEsigAO	16	PExhSpeedSignal	AO	Powered exhaust speed cmd.
BO1	contact	SfanEna	17	SfanEnable	BO	Engage supply fan
BO2	contact	ClStg1	18	CoolStage1Enable	BO	Engage stage 1 cooling
BO3	contact	ClStg2	19	CoolStage2Enable	BO	Engage stage 2 cooling
BO4	contact	HtStg1	20	HeatStage1Enable	BO	Engage stage 1 heating
BO5	contact	HtStg2	21	HeatStage2Enable	BO	Engage stage 2 heating
BO6	contact	PEenab	22	PEfanEnable	BO	Engage powered exhaust
VT01	WS input	OccNet	201	OccupyViaNetwork	BV	Network occupy command
VT02	WS input	OvdTime	202	OccupyOvrDuration	AV	Net. Occ. override time (min)
VT03	WS input	OccCISP	203	OccCoolingSetpoint	AV	Occupied cooling setpoint
VT04	WS input	OccHtSP	204	OccHeatingSetpoint	AV	Occupied heating setpoint
VT05	WS input	UnoCLSP	205	UnOccCoolingSetpoint	AV	Unoccupied cooling setpoint
VT06	WS input	UnoHtSP	206	UnOccHeatingSetpoint	AV	Unoccupied heating setpoint
VT07	WS input	MinDeadB	207	MinDeadband_SP	AV	5F (when local SP used DB is fixed)
VT08	WS input	Co2NSP	208	CO2_SP_ViaNetwork	AV	Network supplied CO2 setpoint
VT09	WS input	NetSPsw	209	UseNetOccSetpoints	BV	Off=uselocalUI2 On=USE VT03&4
VT10	WS input	Purge	210	EconPurgeEnable	BV	True=Econ at 100% Sfan&exh on
VT11	WS output	EffCO2	211	EffZoneCO2PPM	AV	Effective Zone CO2 PPM
VT12	WS output	EffOARH	212	EffOARH	AV	Effective Out Air Rel. Humidity
VT13	WS output	OAenthp	213	EffOA_Enthalpy	AV	Effective Out Air Enthalpy
VT14	WS output	ModeNet	214	ModeEnumStatus	AV	"0" = Standby "1" = Ventilation "2" = Heating "3" = Cooling "4" = Filter "5" = Emergency Off
VT15	WS output	OatBlnd	215	OA_TrueBlend	AV	Percentage of outside air based upon SA, MA and OA temperatures
VT16	WS output	EffHtSP	216	EffectHeatingSetpoint	AV	Reflects the current heating setpoint
VT17	WS output	EffCISP	217	EffectCoolingSetpoint	AV	Reflects the current cooling setpoint
VT18	WS output	HtNDem	218	HeatingDemand	AV	Heating demand from 0-100%

VT19	WS output	CINDem	219	CoolingDemand	AV	Cooling demand from 0-100%
VT20	WS output	EconPos	220	EconDmprEffPos	AV	Outside damper position
VT21	WS input	EcoMin	221	EcoMinPosSetpoint	AV	Economizer Minimum open SP
VT22			222			
VT23	WS output	TsFault	223	Thermistor Fault	BV	Out of Range condition thermistor
VT24	WS input	Hrtbeat	224	HeartbeatFromBAS	BV	Wink from BAS for fallback

Web Point	Web Name	Sedona Tag	I/O	Default Value	Comments
WC01	ReservedForTesting	TestVal	I	0	Set to "1" to test the occupy logic. Currently not used as part of the logic.
WC02					
WC03	FanAutoOnModeSelect	FanMode	I	1	When set to "0" the supply fan is in automatic mode. With a "1" the supply fan runs continuously while in occupied mode.
WC04	DcvMaxEconDmprLimit	Co2Max	I	60	The sets the maximum throttling range of the CO@ PID controller. Maximum setting is 100%.
WC05	SAT_HighLimitSP	SaHiLim	I	160	Supply air temperature high limit. Min=0; Max=200
WC06	SAT_LowLimitSP	SaLoLim	I	25	Supply air temperature low limit. Min=0; Max=100
WC07	OAT_DX_Lockout	CIoLoc	I	55	If outside air temperature drops below this setting, cooling will be locked out until the outside air temperature rises 2 degrees F above this setting.
WC08	OAT_HeatLockout	HtHiLoc	I	68	If outside air temperature rises above this setting, heating will be locked out until the outside air temperature drops 2 degrees F below this setting.
WC09	PEfanStartOrMaxSP	PEStart	I	80	If a powered exhaust is being used and the exhaust damper position (percentage open) exceeds this setting, the exhaust fan will turn on. If a variable speed drive is being used, its speed will throttle between the two damper position limits.
WC10	PEfanStopOrMinSP	PEStop	I	40	If a powered exhaust is being used and is running and the exhaust damper position becomes less than this setting, the exhaust fan will turn off.
WC11	PE_EcmMinV_SP	PEminSP	I	2.5	Low-limit of the 0-10V powered exhaust signal
WC12	DCV_ModeSelect	DCVsel	I	False	False=UseMinVent only True=Use DCV mode
WC13					
WC14	MaxHeatSP_Limit	HtMaxSP	I	73	Maximum heating setpoint allowed.
WC15	MinCoolSP_Limit	CIminSP	I	69	Minimum cooling setpoint allowed.
WC16	MechCoolingDelayMinutes	MechDly	I	10	10 min after Econ PID reaches 99% output
WC17	CmprMinRunMinutes	RunTim1	I	1	Minimum running time in minutes when a compressor is engaged.
WC18	CmprMinOffMinutes	OffTim1	I	3	Minimum running time in minutes when a compressor is disengaged.

WC19	EconEnthalpySetpoint	EnthSP	I	30	Above this setpoint economizer operation is disabled.
WC20	EconDryWetBulbSelect	EconSel	I	0	"0"=Dry Bulb, "1"=Enthalpy & Dry Bulb
WC21	MixedAirLowLimitSP	MatLoSP	I	45	MAT low limit setpoint typ. 45°F
WC22	EconFixedDiffModeSel	DiffSel	I	False	false=Fixed limit (Single), true=Differential (Dual)
WC23	EconDryBulbLimitSP	DrySP	I	72	Adjust based on climate zone: 65 to 75 range)
WC24	EconActuatorMinVolts	ActMinV	I	2	2v (usually either 2 or 0 is expected)
WC25	CoolPidKpSetpoint	CoolKP	I	8	
WC26	CoolPidKiSetpoint	CoolKi	I	3	
WC27	HeatPidKpSetpoint	HeatKp	I	8	
WC28	HeatPidKiSetpoint	HeatKi	I	3	
WC29	EconPidKpSetpoint	EconKp	I	6	
WC30	EconPidKiSetpoint	EconKi	I	2	
WC31	LocalSP_HiResistance	SpHiRes	I	10000	(Establishes max resistance of SP slider)
WC32-48					

3.4 Sequence of Operation

H. OPERATING MODES: CvAHU2 shall have the following modes of operation:

1. BAS OCCUPIED – NORMAL USE: The BAS network shall have an hourly schedule for zone /space occupancy (VT01). The following items shall occur when the system is operating in occupied mode:
 - a. LOCAL SETPOINTS: Zone temperature setpoint slider (UI2) shall have a span of 65°F to 75°F with a 5°F (adj. VT07) deadband. Cooling setpoint shall have a minimum 69°F (adj. WC15) limit. Heating setpoint shall have a maximum 73°F (adj. WC14) limit.
 - b. NETWORK SETPOINTS: If a local setpoint slider is not installed the Network Occupied heating and cooling setpoints shall automatically be utilized. Network setpoints shall be 75°F Cooling (adj. VT03) and 70°F Heating (adj. VT04).
 - c. MODE STATUS: Operating mode status is made available to the BAS via VT14 and shall display Standby (0), Venting (1), Heating (2), Cooling (3), Filter Flag (4), and Emergency Shutdown (5) enumerations.
2. OCCUPIED – LOCAL OVERRIDE OPTIONS
 - a. TIMED OVERRIDE: A push button timed override shall be available at the local wall setter for a maximum of 2 hours (adj. VT02), after which it shall revert to the Normal Use schedule. A button press of 3 seconds that short circuits ZoneTemp input UI1 shall be required to initiate override.
 - b. OCCUPANCY SENSOR/WALL TIMER: If required, a local occupancy sensor or local wall timer shall be installed (BI1) and shall work in parallel with the BAS Occupied and Timed Override Occupied inputs.

3. UNOCCUPIED MODES

- a. SETPOINTS – BAS/Network setpoints shall set an unoccupied setpoint of 85°F (adj. VT05) Cooling and 55°F (adj. VT06) Heating. Unoccupied setpoints shall not be available at the local wall setter for adjustment.
- b. HIGH / LOW LIMIT – Space temperature shall be maintained between the high and low unoccupied setpoints during the unoccupied period. CO2 Demand Ventilation control shall be disabled in unoccupied mode.
- c. OPTIMIZED START: If required, Stop/start optimization shall occur exclusively at the BAS network level. The optimized start schedule shall occur up to two hours (adj.) prior to the occupied schedule.

I. NORMAL USE MODE:

1. STANDARD OPERATION:

- a. SUPPLY FAN: Supply fan shall operate continuously at normal speed (set at air balance to meet design flow). If there is no economizer or provision for ventilation air, the supply fan may operate in the AUTO mode on a call for heating or cooling. AUTO/ON mode is configured from the Web interface WC03 and shall not be locally selectable.
- b. COOLING: Cooling shall be based on a 0 to 100% PID demand output. Cooling shall be sequenced with stage one as economizer and stage two and stage 3 as compressor DX cooling. The economizer and compressor shall operate together. When economizer is not available then mechanical cooling shall be stage one and stage two.
 - i. Economizer cooling mode shall be preconfigured as either Dual Dry Bulb or Enthalpy (Wet Bulb) via WC20. In Dual Dry Bulb mode, the economizer PID shall modulate based on the effective cooling setpoint minus a fixed offset of 1°F. If the outside air temperature is 2°F lower than the return air temperature (or room air temperature) then the economizer shall be enabled as first stage cooling. In Enthalpy mode, the economizer shall be disabled whenever the outside air enthalpy is above 26 Btu/lb. (adj. WC19). The Mixed air temp shall have a low limit of 45°F (adj. WC21).
 - ii. Mechanical cooling shall be locked out at and below 55°F (adj. WC07) outside air temperature.
 - iii. Cooling Low Limit: If supply air temperature drops below 40°F (adj. WC06) then cooling PID maximum output shall be reset down to 4% output.
 - iv. Stage 1 mechanical cooling: Compressor #1 activation is based on hysteresis of the cooling PID and is energized after a 30 second time delay.
 - v. Stage 2 mechanical cooling: Compressor #2 is energized after a 6-minute time delay.
 - vi. Compressors shall have anti short-cycle protection using a Minimum runtime delay of 1 minute (adj. WC17) and a Minimum off time delay of 3 minutes (adj. WC18).

- c. HEATING: Heating shall be based on a 0 to 100% PID demand output. Heating shall be accomplished by a staged gas furnace or electric elements. Activation is based on hysteresis of the heating PID. Stage 1 relay is energized after a 30 second time delay and cycled to maintain the heating setpoint. Stage 2 relay is energized after a 6-minute time delay.
 - i. Heating is locked out when the OA temperature is higher than 66°F (adj. WC08).
 - ii. Heating High Limit: If supply air temperature rises above 160°F (adj. WC05) then heating PID maximum output shall be reset down to 4% output.
 - iii. Stage 1 relay is energized after a 30 second time delay and cycled to maintain the heating setpoint.
 - iv. Stage 2 relay is energized after a 6-minute time delay.
- d. VENTILATION – DEMAND CONTROL: If zone CO2 sensor is installed the economizer minimum position shall be reset down to maintain 1200 ppm (adj. VT08) carbon dioxide. Maximum damper position in CO2 control shall be set at 60% (adj. WC04). Economizer damper shall position based on the maximum signal from the Cooling PID and the DCV PID outputs. In DCV mode set MinVentPos (VT21) to 0*. When not using DCV mode, set MinVentPos to 10%* (*or according to Balancer or True Blend). When in UNOCCUPIED MODE the outside air damper shall remain closed.
- J. POWERED EXHAUST (RELIEF FAN) OPTION: If a powered exhaust fan is installed, it shall be controlled based on the position of the outside air intake damper. The PE fan shall be started when the OA damper reaches 80% open (adj. WC09) and turned off when the OA damper reaches 40% open (adj. WC10). These setpoints should be determined by the system balancer. If a VFD or ECM motor is used the speed shall be modulated between the Max (PE start % setpoint WC09) and Min (PE stop % setpoint WC10). The Minimum voltage output shall be 2.5 VDC (adj. WC11).
- K. ALTERNATIVE PROVISIONS:
 - 1. SUPPLY FAN PROOF: It is highly recommended that a flow switch or a status CT is provided. If it is not installed the input on the controller must be jumpered (BI2) or all heating and cooling functions will be disabled.
 - 2. FILTER STATUS INPUT: A dirty filter indicator can be sent over the network if a DP switch is installed. The filter status input does not affect the unit operation and is provided only for remote alert monitoring.
- L. EMERGENCY/FIRE SHUTDOWN: An interlock shall be provided that will immediately shut down all outside air dampers, fans, and heating/cooling. Upon return to normal, there shall be a 1-minute restart delay. If a temperature sensor is shorted or open circuited, an emergency shutdown will be initiated until the faulty sensor is repaired. Thermistor fault is monitored via VT23.
- M. ALARMS: At a minimum, the following alarms shall be provided:
 - 1. General alarms available at the BAS level
- N. TRENDS (If Applicable):
 - 1. General trends available at the BAS level

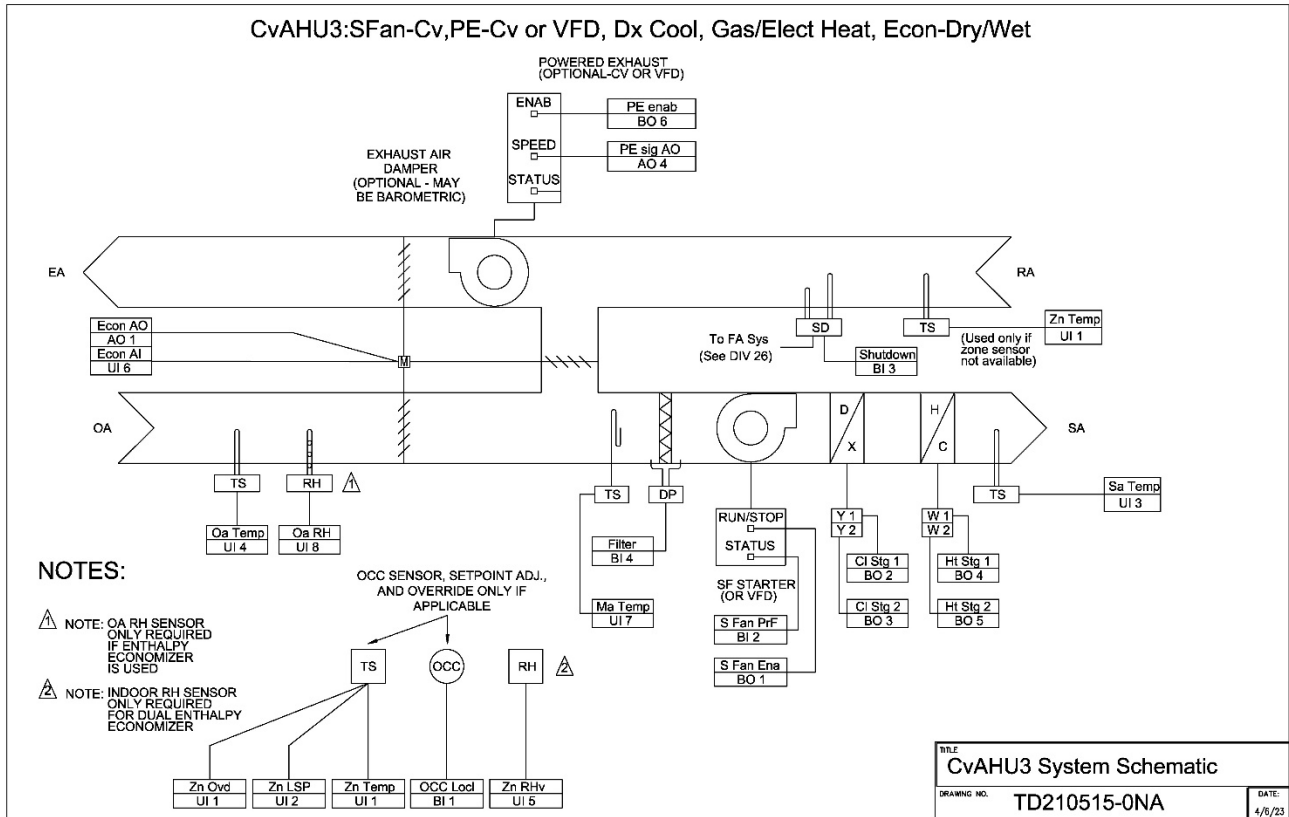
4 Constant Volume AHU Application—CvAHU3

4.1 Overview

CvAHU3 is a packaged Rooftop Unit with CV supply fan, DX cooling (1 or 2 stage), gas or electric heating (1 or 2 stage), wet or dry-bulb economizer & barometric relief. Optional provisions are made for PE (powered exhaust) with or without ECM/VFD motor, air filter status, and provision for local occupancy switch/sensor. The control of the AHU is provided by a BAScontrol22 programmable unitary controller. Although the controller is stand-alone capable, it is assumed that the AHU will be interfaced with a centralized BAS via a BACnet IP connection. Unit configuration and remote monitoring is provided via a web browser interface (WC points) and through the BACnet network interface (VT points).

Equipment Summary	
Fan(s)	Sfan-Cv, PExh-Cv or Variable
Cooling	DX-1 or 2 stage
Heating	Elect/Gas – 1 or 2 stage
Humidification	None
Dehumidification	None
Economizer	Dual Dry Bulb or Dual Enthalpy
Ventilation	Fixed OA Damper %

4.2 System Schematic



4.3 Points List

I/O Point	Configured as	Sedona Tag	BACnet Object			
			Instance	Name	Type	Comments
UI1	10k T3	ZnTemp	1	ZoneTemp	AI	Space temperature thermistor
UI2	Resistance	ZnLSP	2	ZoneLocalSetpoint	AI	Two-wire potentiometer
UI3	10k T3	SaTemp	3	SupplyAirTemp	AI	Supply air thermistor
UI4	10k T3	OaTemp	4	OutsideAirTemp	AI	Outside air thermistor
UI5	0-10V	ZnRHv	5	IndoorHumidity	AI	Required for dual enthalpy
UI6	0-10V	EconAI	6	EconDamperPosition	AI	OA damper position feedback
UI7	10k T3	MaTemp	7	MixedAirTemp	AI	Mixed air thermistor
UI8	0-10V	OaRH	8	OutsideAirHumidity	AI	For outside air enthalpy
BI1	contact	OccLocl	9	OccupyLocalSwitch	BI	Temporary occupancy switch
BI2	contact	SfanPrf	10	SfanProof	BI	Supply air fan proving sensor
BI3	contact	Shutdwn	11	Shutdown	BI	Shutdown occurs if open
BI4	contact	Filter	12	FilterFlag	BI	Filter requires changing
AO1	0-10V	EconAO	13	EconDamperSignal	AO	OA damper command signal
AO2			14		AO	
AO3			15		AO	
AO4	0-10V	PEsigAO	16	PExhSpeedSignal	AO	Powered exhaust speed cmd.
BO1	contact	SfanEna	17	SfanEnable	BO	Engage supply fan
BO2	contact	ClStg1	18	CoolStage1Enable	BO	Engage stage 1 cooling
BO3	contact	ClStg2	19	CoolStage2Enable	BO	Engage stage 2 cooling
BO4	contact	HtStg1	20	HeatStage1Enable	BO	Engage stage 1 heating
BO5	contact	HtStg2	21	HeatStage2Enable	BO	Engage stage 2 heating
BO6	contact	PEenab	22	PEfanEnable	BO	Engage powered exhaust
VT01	WS input	OccNet	201	OccupyViaNetwork	BV	Network occupy command
VT02	WS input	OvdTime	202	OccupyOvrDuration	AV	Net. Occ. override time (min)
VT03	WS input	OccCISP	203	OccCoolingSetpoint	AV	Occupied cooling setpoint
VT04	WS input	OccHtSP	204	OccHeatingSetpoint	AV	Occupied heating setpoint
VT05	WS input	UnoCLSP	205	UnOccCoolingSetpoint	AV	Unoccupied cooling setpoint
VT06	WS input	UnoHtSP	206	UnOccHeatingSetpoint	AV	Unoccupied heating setpoint
VT07	WS input	MinDeadB	207	MinDeadband_SP	AV	5F (when local SP used DB is fixed)
VT08						
VT09	WS input	NetSPsw	209	UseNetOccSetpoints	BV	Off=uselocalUI2 On=USE VT03&4
VT10	WS input	Purge	210	EconPurgeEnable	BV	True=Econ at 100% Sfan&exh on
VT11	WS output	EffZoneRH	211	EffindoorRH	AV	Effective Indoor Rel. Humidity
VT12	WS output	EffOARH	212	EffOARH	AV	Effective Out Air Rel. Humidity
VT13	WS output	OAenthp	213	EffOA_Enthalpy	AV	Effective Out Air Enthalpy
VT14	WS output	ModeNet	214	ModeEnumStatus	AV	"0" = Standby "1" = Ventilation "2" = Heating "3" = Cooling "4" = Filter "5" = Emergency Off
VT15	WS output	OatBlnd	215	OA_TrueBlend	AV	Percentage of outside air based upon SA, MA and OA temperatures
VT16	WS output	EffHtSP	216	EffectHeatingSetpoint	AV	Reflects the current heating setpoint
VT17	WS output	EffCISP	217	EffectCoolingSetpoint	AV	Reflects the current cooling setpoint
VT18	WS output	HtNDem	218	HeatingDemand	AV	Heating demand from 0-100%

VT19	WS output	CINDem	219	CoolingDemand	AV	Cooling demand from 0-100%
VT20	WS output	EconPos	220	EconDmprEffPos	AV	Outside damper position
VT21	WS input	EcoMin	221	EcoMinPosSetpoint	AV	Economizer Minimum open SP
VT22			222			
VT23	WS output	TsFault	223	Thermistor Fault	BV	Out of Range condition thermistor
VT24	WS input	Hrtbeat	224	HeartbeatFromBAS	BV	Wink from BAS for fallback

Web Point	Web Name	Sedona Tag	I/O	Default Value	Comments
WC01	ReservedForTesting	TestVal	I	0	Set to "1" to test the occupy logic. Currently not used as part of the logic.
WC02					
WC03	FanAutoOnModeSelect	FanMode	I	1	When set to "0" the supply fan is in automatic mode. With a "1" the supply fan runs continuously while in occupied mode.
WC04					
WC05	SAT_HighLimitSP	SaHiLim	I	160	Supply air temperature high limit. Min=0; Max=200
WC06	SAT_LowLimitSP	SaLoLim	I	35	Supply air temperature low limit. Min=0; Max=100
WC07	OAT_DX_Lockout	CIoLoc	I	55	If outside air temperature drops below this setting, cooling will be locked out until the outside air temperature rises 2 degrees F above this setting.
WC08	OAT_HeatLockout	HtHiLoc	I	68	If outside air temperature rises above this setting, heating will be locked out until the outside air temperature drops 2 degrees F below this setting.
WC09	PEfanStartOrMaxSP	PEStart	I	80	If a powered exhaust is being used and the exhaust damper position (percentage open) exceeds this setting, the exhaust fan will turn on. If a variable speed drive is being used, its speed will throttle between the two damper position limits.
WC10	PEfanStopOrMinSP	PEStop	I	40	If a powered exhaust is being used and is running and the exhaust damper position becomes less than this setting, the exhaust fan will turn off.
WC11	PE_EcmMinV_SP	PEminSP	I	2.5	Low-limit of the 0-10V powered exhaust signal
WC12					
WC13					
WC14	MaxHeatSP_Limit	HtMaxSP	I	73	Maximum heating setpoint allowed
WC15	MinCoolSP_Limit	CIminSP	I	69	Minimum cooling setpoint allowed
WC17	CmprMinRunMinutes	RunTim1	I	1	Minimum running time when a compressor is engaged.
WC18	CmprMinOffMinutes	OffTim1	I	3	Minimum running time when a compressor is disengaged.
WC19	EconEnthalpySetpoint	EnthSP	I	26	Above this setpoint economizer operation is disabled.
WC20	EconDryWetBulbSelect	EconSel	I	0	"0"=Dry Bulb, "1"=Enthalpy & Dry Bulb

WC21	MixedAirLowLimitSP	MatLoSP	I	45	
WC22	EconFixedDiffModeSel	DiffSel	I	False	false=Fixed limit (Single), true=Differential (Dual)
WC23	EconDryBulbLimitSP	DrySP	I	72	Adjust based on climate zone: 65 to 75 range)
WC24	EconActuatorMinVolts	ActMinV	I	2	2v (usually either 2 or 0 is expected)
WC25	CoolPidKpSetpoint	CoolKP	I	8	
WC26	CoolPidKiSetpoint	CoolKi	I	3	
WC27	HeatPidKpSetpoint	HeatKp	I	8	
WC28	HeatPidKiSetpoint	HeatKi	I	3	
WC29	EconPidKpSetpoint	EconKp	I	6	
WC30	EconPidKiSetpoint	EconKi	I	2	
WC31	LocalSP_HiResistance	SpHiRes	I	10000	(Establishes max resistance of SP slider)
WC32- WC48					

4.4 Sequence of Operation

A. OPERATING MODES: CvAHU3 shall have the following modes of operation:

1. BAS OCCUPIED – NORMAL USE: The BAS network shall have an hourly schedule for zone /space occupancy (VT01). The following items shall occur when the system is operating in occupied mode:
 - a. LOCAL SETPOINTS – Zone temperature setpoint slider (UI2) shall have a span of 65°F to 75°F with a 5°F (adj. VT07) deadband. Cooling setpoint shall have a minimum 69°F (adj. WC15) limit. Heating setpoint shall have a maximum 73°F (adj. WC14) limit.
 - b. NETWORK SETPOINTS – If a local setpoint slider is not installed the Network Occupied heating and cooling setpoints shall automatically be utilized. UseOccNetSetpoints (VT09) must be set True. Network setpoints shall be 75°F Cooling (adj. VT03) and 70°F Heating (adj. VT04).
 - c. MODE STATUS – Operating mode status is made available to the BAS via VT14 and shall display Standby (0), Venting (1), Heating (2), Cooling (3), Filter Flag (4), and Emergency Shutdown (5) enumerations.
2. OCCUPIED – LOCAL OVERRIDE OPTIONS
 - a. TIMED OVERRIDE – A push button timed override shall be available at the local wall setter for a maximum of 2 hours (adj. VT10), after which it shall revert to the Normal Use schedule. A button press of 3 seconds shall be required to initiate override.
 - b. OCCUPANCY SENSOR/WALL TIMER – If required, a local occupancy sensor or local wall timer shall be installed (BI1) and shall work in parallel with the BAS Occupied and Timed Override Occupied inputs.
3. UNOCCUPIED MODES

- a. SETPOINTS – BAS/Network setpoints shall set an unoccupied setpoint of 85°F (adj. VT05) Cooling and 55°F (adj. VT06) Heating. Unoccupied setpoints shall not be available at the local wall setter for adjustment.
- b. HIGH / LOW LIMIT – Space temperature shall be maintained between the high and low unoccupied setpoints during the unoccupied period.
- c. OPTIMIZED START: If required, Stop/start optimization shall occur exclusively at the BAS network level. The optimized start schedule shall occur up to two hours (adj.) prior to the occupied schedule.

B. NORMAL USE MODE:

1. STANDARD OPERATION:

- a. SUPPLY FAN: Supply fan shall operate continuously at normal speed (set at air balance to meet design flow). If there is no economizer or provision for ventilation air, the supply fan may operate in the AUTO mode on a call for heating or cooling. AUTO/ON mode is configured from the Web interface WC03 and shall not be locally selectable.
- b. COOLING: Cooling shall be based on a 0 to 100% PID demand output. Cooling shall be sequenced with stage one as economizer and stage two and stage 3 as compressor DX cooling. The economizer and compressor shall operate together.
 - i. Economizer cooling mode shall be preconfigured as either Dual Dry Bulb or Enthalpy (Wet Bulb) via WC20. In Dual Dry Bulb mode, the economizer shall modulate based on the effective cooling setpoint minus a fixed offset. If the outside air temperature is 2°F lower than the return air temperature (or room air temperature) and is above the Low OA temp lockout of 10°F then the economizer shall be enabled as first stage cooling. In Enthalpy mode, the economizer shall be disabled whenever the outside air enthalpy is above 30 Btu/lb. (adj. WC19). The Mixed air temp shall have a low limit of 45°F.
 - ii. Mechanical cooling shall be locked out at and below 55°F (adj. WC07) outside air temperature.
 - iii. Cooling Low Limit: If supply air temperature drops below 40°F (adj. WC06) then cooling PID maximum output shall be reset down to 4% output.
 - iv. Stage 1 mechanical cooling: Compressor #1 activation is based on hysteresis of the cooling PID and is energized after a 30 second time delay.
 - v. Stage 2 mechanical cooling: Compressor #2 is energized after a 6-minute time delay.
 - vi. Compressors shall have anti short-cycle protection using a Minimum runtime delay of 1 minute (adj. WC17) and a Minimum off time delay of 3 minutes (adj. WC18).
- c. HEATING: Heating shall be based on a 0 to 100% PID demand output. Heating shall be accomplished by a staged gas furnace or electric elements. Activation is based on hysteresis of the heating PID. Stage 1 relay is energized after a 30 second time delay and cycled to maintain the heating setpoint. Stage 2 relay is energized after a 6-minute time delay. Heating is locked

out when the OA temperature is higher than 66°F (adj. WC08). If supply air temperature rises above 160F (adj WC05) then heating PID maximum output shall be reset down to 4% output. (10F fixed reset range)

- d. VENTILATION: Economizer damper shall have a minimum open position during OCCUPIED MODE. Minimum economizer damper position shall be 10% (adj. via VT07). When in UNOCCUPIED MODE, the outside air damper shall remain closed.
- C. POWERED EXHAUST (RELIEF FAN) OPTION: If a powered exhaust fan is installed, it shall be controlled based on the position of the outside air intake damper. The PE fan shall be started when the OA damper reaches 80% open (adj. WC09) and turned off when the OA damper reaches 40% open (adj. WC10). These setpoints should be determined by the system balancer. If a VFD or ECM motor is used the speed shall be modulated between the Max (PE start % setpoint WC09) and Min (PE stop % setpoint WC10). The Minimum voltage output shall be 2.5 VDC (adj. WC11).
- D. ALTERNATIVE SENSOR PROVISIONS
- 1. SUPPLY FAN PROOF: It is highly recommended that a flow switch or a status CT is provided. If it is not installed the input on the controller must be jumpered (BI2) or all heating and cooling functions will be disabled.
 - 2. FILTER STATUS INPUT: A dirty filter indicator can be sent over the network if a DP switch is installed. The filter status input does not affect the unit operation and is provided only for remote alert monitoring.
- E. EMERGENCY/FIRE SHUTDOWN: An interlock shall be provided that will immediately shut down all outside air dampers, fans, and heating/cooling. Upon return to normal, there shall be a 1-minute restart delay. In addition to the fire shutdown interlock, all temperature sensors are monitored. If a temperature sensor is shorted or open circuited, an emergency shutdown will be initiated until the faulty sensor is repaired. Thermistor fault is monitored via VT23.
- F. ALARMS: At a minimum, the following alarms shall be provided:
- 1. General alarms available at the BAS level
- G. TRENDS (If Applicable)
- 1. General trends available at the BAS level

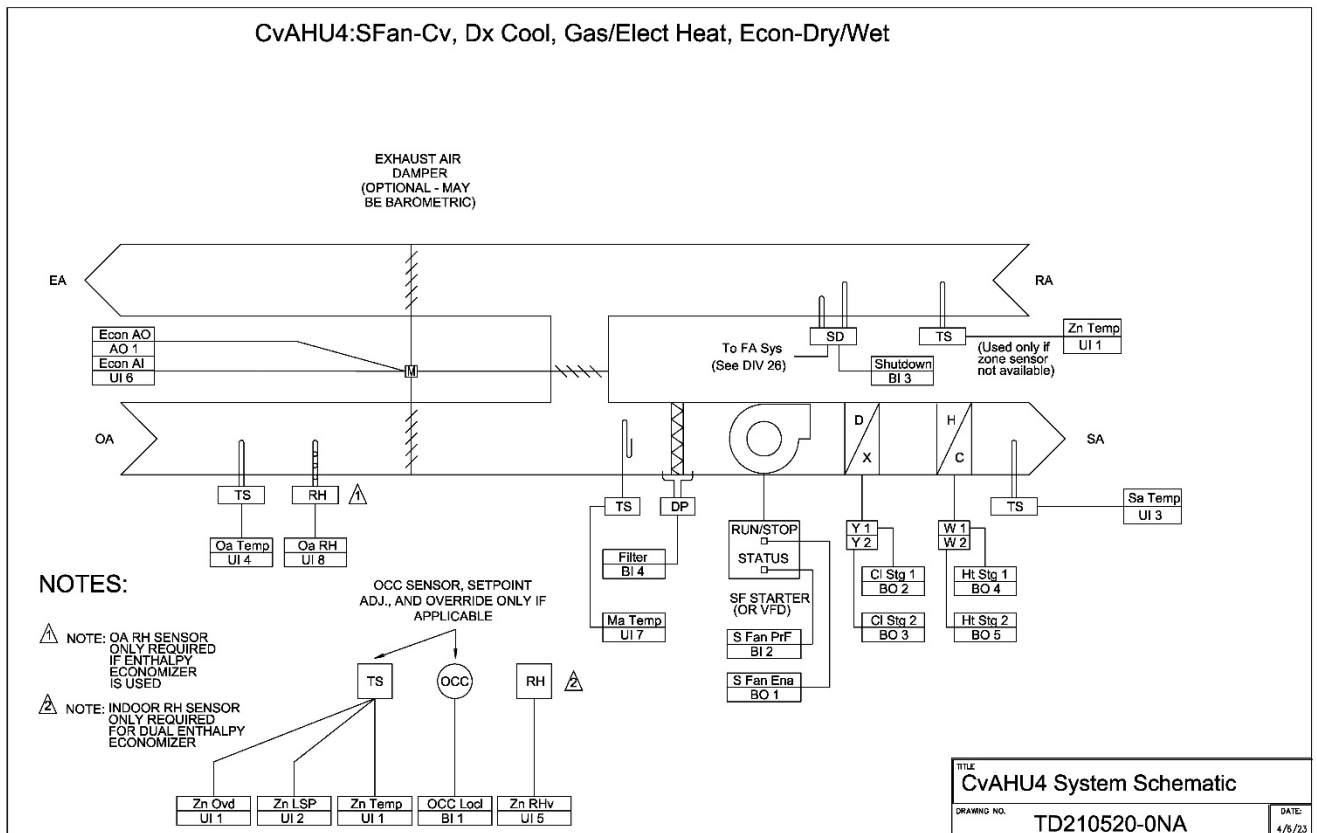
5 Constant Volume AHU Application—CvAHU4

5.1 Overview

CvAHU4 is a packaged Rooftop Unit with CV supply fan, DX cooling (1 or 2 stage), gas or electric heating (1 or 2 stage), wet or dry-bulb economizer & barometric relief, air filter status, and provision for local occupancy switch/sensor. The control of the AHU is provided by a BAScontrol22 programmable unitary controller. Although the controller is stand-alone capable, it is assumed that the AHU will be interfaced with a centralized BAS via a BACnet IP connection. Unit configuration and remote monitoring is provided via a web browser interface (WC points) and through the BACnet network interface (VT points).

Equipment Summary	
Fan(s)	Sfan-Cv, Barometric Relief
Cooling	DX-1 or 2 stage
Heating	Elect/Gas – 1 or 2 stage
Humidification	None
Dehumidification	None
Economizer	Dual Dry Bulb or Dual Enthalpy
Ventilation	Fixed OA Damper %

5.2 System Schematic



5.3 Points List

I/O Point	Configured as	Sedona Tag	BACnet Object			
			Instance	Name	Type	Comments
UI1	10k T3	ZnTemp	1	ZoneTemp	AI	Space temperature thermistor
UI2	Resistance	ZnLSP	2	ZoneLocalSetpoint	AI	Two-wire potentiometer
UI3	10k T3	SaTemp	3	SupplyAirTemp	AI	Supply air thermistor
UI4	10k T3	OaTemp	4	OutsideAirTemp	AI	Outside air thermistor
UI5	0-10V	ZnRHv	5	IndoorHumidity	AI	Required for dual enthalpy
UI6	0-10V	EconAI	6	EconDamperPosition	AI	OA damper position feedback
UI7	10k T3	MaTemp	7	MixedAirTemp	AI	Mixed air thermistor
UI8	0-10V	OaRH	8	OutsideAirHumidity	AI	For outside air enthalpy
BI1	contact	OccLocl	9	OccupyLocalSwitch	BI	Temporary occupancy switch
BI2	contact	SfanPrf	10	SfanProof	BI	Supply air fan proving sensor
BI3	contact	Shutdwn	11	Shutdown	BI	Shutdown occurs if open
BI4	contact	Filter	12	FilterFlag	BI	Filter requires changing
AO1	0-10V	EconAO	13	EconDamperSignal	AO	OA damper command signal
AO2			14		AO	
AO3			15		AO	
AO4			16		AO	
BO1	contact	SfanEna	17	SfanEnable	BO	Engage supply fan
BO2	contact	ClStg1	18	CoolStage1Enable	BO	Engage stage 1 cooling
BO3	contact	ClStg2	19	CoolStage2Enable	BO	Engage stage 2 cooling
BO4	contact	HtStg1	20	HeatStage1Enable	BO	Engage stage 1 heating
BO5	contact	HtStg2	21	HeatStage2Enable	BO	Engage stage 2 heating
BO6			22		BO	
VT01	WS input	OccNet	201	OccupyViaNetwork	BV	Network occupy command
VT02	WS input	OvdTime	202	OccupyOvrDuration	AV	Net. Occ. override time (min)
VT03	WS input	OccCISP	203	OccCoolingSetpoint	AV	Occupied cooling setpoint
VT04	WS input	OccHtSP	204	OccHeatingSetpoint	AV	Occupied heating setpoint
VT05	WS input	UnoCLSP	205	UnOccCoolingSetpoint	AV	Unoccupied cooling setpoint
VT06	WS input	UnoHtSP	206	UnOccHeatingSetpoint	AV	Unoccupied heating setpoint
VT07	WS input	MinDeadB	207	MinDeadband_SP	AV	5F (when local SP used DB is fixed)
VT08	WS input	FanMode	208	FanAutoOnSel	AV	Off=Auto, On(def) continuous when occupied
VT09	WS input	NetSPsw	209	UseNetOccSetpoints	BV	Off=uselocalUI2 On=USE VT03&4
VT10	WS input	Purge	210	EconPurgeEnable	BV	True=Econ at 100% Sfan&exh on
VT11	WS output	EffZnRH	211	EffZoneRH	AV	Effective Indoor Humidity
VT12	WS output	EffOARH	212	EffOARH	AV	Effective Out Air Rel. Humidity
VT13	WS output	OAenthp	213	EffOA_Enthalpy	AV	Effective Out Air Enthalpy
VT14	WS output	ModeNet	214	ModeEnumStatus	AV	"0" = Standby "1" = Ventilation "2" = Heating "3" = Cooling "4" = Filter "5" = Emergency Off
VT15	WS output	OatBlnd	215	OA_TrueBlend	AV	Percentage of outside air based upon SA, MA and OA temperatures
VT16	WS output	EffHtSP	216	EffectHeatingSetpoint	AV	Reflects the current heating setpoint
VT17	WS output	EffCISP	217	EffectCoolingSetpoint	AV	Reflects the current cooling setpoint

VT18	WS output	HtNDem	218	HeatingDemand	AV	Heating demand from 0-100%
VT19	WS output	ClNDem	219	CoolingDemand	AV	Cooling demand from 0-100%
VT20	WS output	EconPos	220	EconDmprEffPos	AV	Outside damper position
VT21	WS input	EcoMin	221	EcoMinPosSetpoint	AV	Economizer Minimum open SP
VT22			222			
VT23	WS output	TsFault	223	Thermistor Fault	BV	Out of Range condition thermistor
VT24	WS input	Hrtbeat	224	HeartbeatFromBAS	BV	Wink from BAS for fallback

Web Point	Web Name	Sedona Tag	I/O	Default Value	Comments
WC01	ReservedForTesting	TestVal	I	0	Set to "1" to test the occupy logic. Currently not used as part of the logic.
WC02					
WC03					
WC04					
WC05	SAT_HighLimitSP	SaHiLim	I	160	Supply air temperature high limit. Min=0; Max=200
WC06	SAT_LowLimitSP	SaLoLim	I	25	Supply air temperature low limit. Min=0; Max=100
WC07	OAT_DX_Lockout	ClLoLoc	I	55	If outside air temperature drops below this setting, cooling will be locked out until the outside air temperature rises 2 degrees F above this setting.
WC08	OAT_HeatLockout	HtHiLoc	I	68	If outside air temperature rises above this setting, heating will be locked out until the outside air temperature drops 2 degrees F below this setting.
WC09					
WC10					
WC11					
WC12					
WC13					
WC14	MaxHeatSP_Limit	HtMaxSP	I	73	Maximum heating setpoint allowed.
WC15	MinCoolSP_Limit	ClMinSP	I	69	Minimum cooling setpoint allowed.
WC16	MechCoolDlyMinutes	MechDly	I	10	After Econ PID Reaches 99%
WC17	CmprMinRunMinutes	RunTim1	I	1	Minimum running time when a compressor is engaged.
WC18	CmprMinOffMinutes	OffTim1	I	3	Minimum running time when a compressor is disengaged.
WC19	EconEnthalpySetpoint	EnthSP	I	26	Above this setpoint economizer operation is disabled.
WC20	EconDryWetBulbSelect	EconSel	I	0	"0"=Dry Bulb, "1"=Enthalpy & Dry Bulb
WC21	MixedAirLowLimitSP	MatLoSP	I	45	MAT low limit setpoint typ. 45°F
WC22	EconFixedDiffModeSel	DiffSel	I	False	false=Fixed limit (Single), true=Differential (Dual)
WC23	EconDryBulbLimitSP	DrySP	I	72	Adjust based on climate zone: 65 to 75 range)
WC24	EconActuatorMinVolts	ActMinV	I	2	2v (usually either 2 or 0 is expected)
WC25	CoolPidKpSetpoint	CoolKP	I	8	
WC26	CoolPidKiSetpoint	CoolKi	I	3	
WC27	HeatPidKpSetpoint	HeatKp	I	8	
WC28	HeatPidKiSetpoint	HeatKi	I	3	

WC29	EconPidKpSetpoint	EconKp	I	6	
WC30	EconPidKiSetpoint	EconKi	I	2	
WC31	LocalSP_HiResistance	SpHiRes	I	10000	(Establishes max resistance of SP slider)
WC22- WC48					

5.4 Sequence of Operation

A. OPERATING MODES: CvAHU4 shall have the following modes of operation:

1. BAS OCCUPIED – NORMAL USE: The BAS network shall have an hourly schedule for zone /space occupancy (VT01). The following items shall occur when the system is operating in occupied mode:
 - a. LOCAL SETPOINTS – Zone temperature setpoint slider (UI2) shall have a span of 65°F to 75°F with a 5°F (adj. VT07) deadband. Cooling setpoint shall have a minimum 69°F (adj. WC15) limit. Heating setpoint shall have a maximum 73°F (adj. WC14) limit.
 - b. NETWORK SETPOINTS – If a local setpoint slider is not installed the Network Occupied heating and cooling setpoints shall automatically be utilized. UseOccNetSetpoints (VT09) must be set True. Network setpoints shall be 75°F Cooling (adj. VT03) and 70°F Heating (adj. VT04).
 - c. MODE STATUS – Operating mode status is made available to the BAS via VT14 and shall display Standby (0), Venting (1), Heating (2), Cooling (3), Filter Flag (4), and Emergency Shutdown (5) enumerations.
2. OCCUPIED – LOCAL OVERRIDE OPTIONS
 - a. TIMED OVERRIDE – A push button timed override shall be available at the local wall setter for a maximum of 2 hours (adj. VT10), after which it shall revert to the Normal Use schedule. A button press of 3 seconds that short circuits ZoneTemp input UI1 shall be required to initiate override.
 - b. OCCUPANCY SENSOR/WALL TIMER – If required, a local occupancy sensor or local wall timer shall be installed (BI1) and shall work in parallel with the BAS Occupied and Timed Override Occupied inputs.
3. UNOCCUPIED MODES
 - a. SETPOINTS: BAS/Network setpoints shall set an unoccupied setpoint of 85°F (adj. VT05) Cooling and 55°F (adj. VT06) Heating. Unoccupied setpoints shall not be available at the local wall setter for adjustment.
 - b. HIGH / LOW LIMIT: Space temperature shall be maintained between the high and low unoccupied setpoints during the unoccupied period.

- c. OPTIMIZED START: If required, Stop/start optimization shall occur exclusively at the BAS network level. The optimized start schedule shall occur up to two hours (adj.) prior to the occupied schedule.

B. NORMAL USE MODE

1. STANDARD OPERATION

- a. SUPPLY FAN: Supply fan shall operate continuously at normal speed (set at air balance to meet design flow). If there is no economizer or provision for ventilation air, the supply fan may operate in the AUTO mode on a call for heating or cooling. AUTO/ON mode is configured from the Web interface VT08 and shall not be locally selectable.
- b. COOLING: Cooling shall be based on a 0 to 100% PID demand output. Cooling shall be sequenced with stage one as economizer and stage two and stage 3 as compressor DX cooling. The economizer and compressor shall operate together.
 - i. Economizer cooling mode shall be preconfigured as either Dual Dry Bulb or Enthalpy (Wet Bulb) via WC20. In Dual Dry Bulb mode, the economizer shall modulate based on the effective cooling setpoint minus a fixed offset. If the outside air temperature is 2°F lower than the return air temperature (or room air temperature) and is above the Low OA temp lockout of 10°F then the economizer shall be enabled as first stage cooling. In Enthalpy mode, the economizer shall be disabled whenever the outside air enthalpy is above 26 Btu/lb. (adj. WC19). The Mixed air temp shall have a low limit of 45°F.
 - ii. Mechanical cooling shall be locked out at and below 55°F (adj. WC07) outside air temperature.
 - iii. Cooling Low Limit: If supply air temperature drops below 40°F (adj. WC06) then cooling PID maximum output shall be reset down to 4% output.
 - iv. Stage 1 mechanical cooling: Compressor #1 activation is based on hysteresis of the cooling PID and is energized after a 30 second time delay.
 - v. Stage 2 mechanical cooling: Compressor #2 is energized after a 6-minute time delay.
 - vi. Compressors shall have anti short-cycle protection using a Minimum runtime delay of 1 minute (adj. WC17) and a Minimum off time delay of 3 minutes (adj. WC18).
- c. HEATING: Heating shall be based on a 0 to 100% PID demand output. Heating shall be accomplished by a staged gas furnace or electric elements. Activation is based on hysteresis of the heating PID.
 - i. Stage 1 relay is energized after a 30 second time delay and cycled to maintain the heating setpoint.
 - ii. Stage 2 relay is energized after a 6-minute time delay. Heating is locked out when the OA temperature is higher than 66°F (adj. WC08).
 - iii. Heating High Limit: If supply air temperature rises above 160°F (adj. WC05) then heating PID maximum output shall be reset down to 4% output.

- d. VENTILATION: Economizer damper shall have a minimum open position during OCCUPIED MODE. Minimum economizer damper position shall be 10% (adj. via VT07). When in UNOCCUPIED MODE, the outside air damper shall remain closed

C. ALTERNATIVE SENSOR PROVISIONS

1. SUPPLY FAN PROOF: It is highly recommended that a flow switch or a status CT is provided. If it is not installed the input on the controller must be jumpered (B12) or all heating and cooling functions will be disabled.
2. FILTER STATUS INPUT: A dirty filter indicator can be sent over the network if a DP switch is installed. The filter status input does not affect the unit operation and is provided only for remote alert monitoring.

- D. EMERGENCY/FIRE SHUTDOWN: An interlock shall be provided that will immediately shut down all outside air dampers, fans, and heating/cooling. Upon return to normal, there shall be a 1-minute restart delay. In addition to the fire shutdown interlock, all temperature sensors are monitored. If a temperature sensor is shorted or open circuited, an emergency shutdown will be initiated until the faulty sensor is repaired. Thermistor fault is monitored via VT23.

- E. ALARMS: At a minimum, the following alarms shall be provided:

1. General alarms available at the BAS level

- F. TRENDS (If Applicable)

1. General trends available at the BAS level

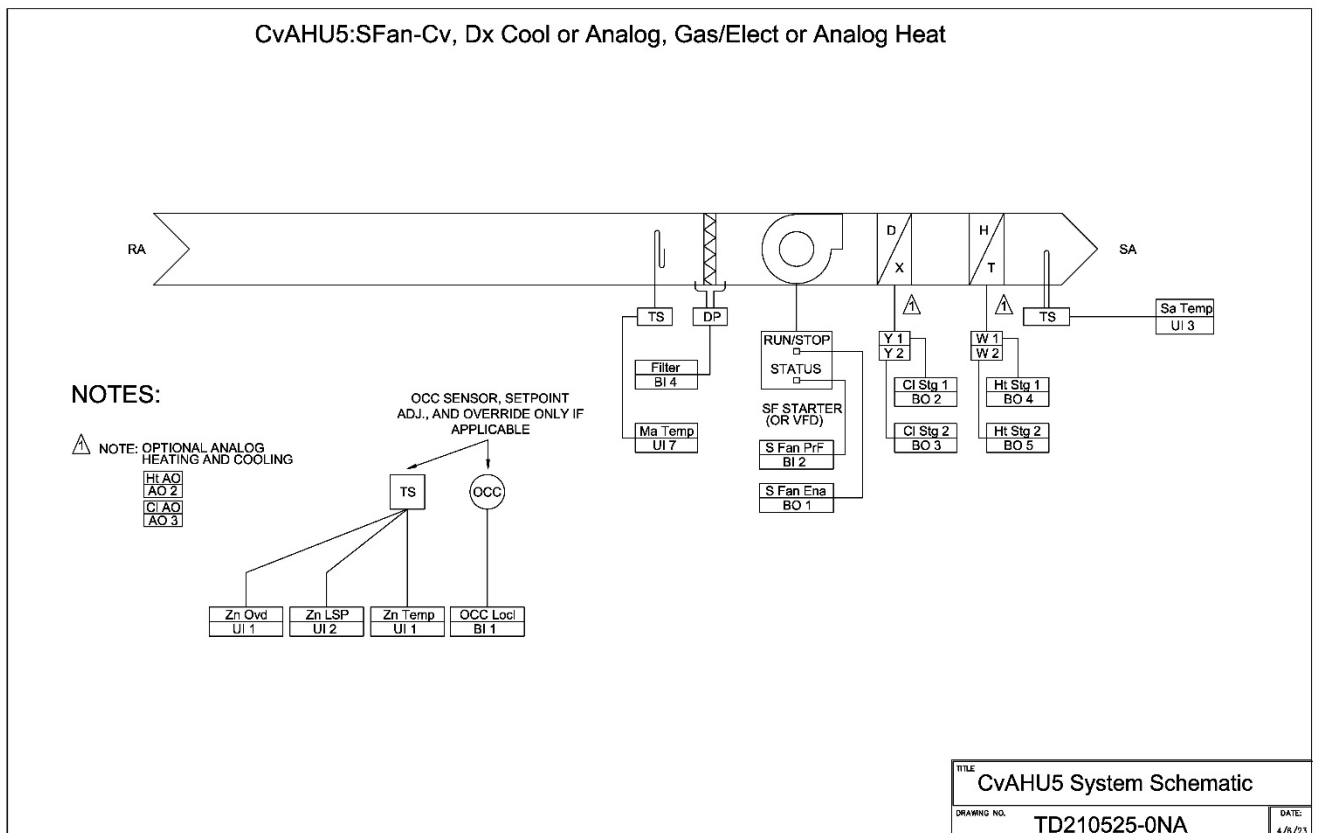
6 Constant Volume AHU Application—CvAHU5

6.1 Overview

CvAHU5 is a “basic” packaged Rooftop Unit with CV supply fan, DX cooling (1 or 2 stage), gas or electric heating (1 or 2 stage). Optional provisions are made for analog heat/cool outputs (0 to 10vdc), air filter status, and local occupancy switch/sensor. The control of the AHU is provided by a BAScontrol22 programmable unitary controller. Although the controller is stand-alone capable, it is assumed that the AHU will be interfaced with a centralized BAS via a BACnet IP connection. Unit configuration and remote monitoring is provided via a web browser interface (WC points) and through the BACnet network interface (VT points).

Equipment Summary	
Fan(s)	Sfan-Cv, Barometric Relief
Cooling	DX-1 or 2 stage or analog
Heating	Elect/Gas – 1 or 2 stg or analog
Humidification	None
Dehumidification	None
Economizer	None
Ventilation	None

6.2 System Schematic



6.3 Points List

I/O Point	Configured as	Sedona Tag	BACnet Object			
			Instance	Name	Type	Comments
UI1	10k T3	ZnTemp	1	ZoneTemp	AI	Space temperature thermistor
UI2	Resistance	ZnLSP	2	ZoneLocalSetpoint	AI	Two-wire potentiometer
UI3	10k T3	SaTemp	3	SupplyAirTemp	AI	Supply air thermistor
UI4						
UI5			5		AI	
UI6			6		AI	
UI7			7		AI	
UI8			8		AI	
BI1	contact	OccLocl	9	OccupyLocalSwitch	BI	Temporary occupancy switch
BI2	contact	SfanPrf	10	SfanProof	BI	Supply air fan proving sensor
BI3	contact	Shutdwn	11	Shutdown	BI	Shutdown occurs if open
BI4	contact	Filter	12	FilterFlag	BI	Filter requires changing
AO1			13		AO	
AO2	0-10V	HtAO	14	HeatAnalogSignal	AO	Heating analog command
AO3	0-10V	CIAO	15	CoolAnalogSignal	AO	Cooling analog command
AO4			16		AO	
BO1	contact	SfanEna	17	SfanEnable	BO	Engage supply fan
BO2	contact	ClStg1	18	CoolStage1Enable	BO	Engage stage 1 cooling
BO3	contact	ClStg2	21	CoolStage2Enable	BO	Engage stage 2 cooling
BO4	contact	HtStg1	20	HeatStage1Enable	BO	Engage stage 1 heating
BO5	contact	HtStg2	20	HeatStage2Enable	BO	Engage stage 2 heating
BO6			22		BO	
VT01	WS input	OccNet	201	OccupyViaNetwork	BV	Network occupy command
VT02	WS input	OvdTime	202	OccupyOvrDuration	AV	Net. Occ. override time (min)
VT03	WS input	OccCISP	203	OccCoolingSetpoint	AV	Occupied cooling setpoint
VT04	WS input	OccHtSP	204	OccHeatingSetpoint	AV	Occupied heating setpoint
VT05	WS input	UnoCLSP	205	UnOccCoolingSetpoint	AV	Unoccupied cooling setpoint
VT06	WS input	UnoHtSP	206	UnOccHeatingSetpoint	AV	Unoccupied heating setpoint
VT07	WS input	MinDeadB	207	MinDeadband_SP	AV	5F (when local SP used DB is fixed)
VT08	WS input	FanMode	208	FanAutoOnSel	AV	Off=Auto,On(def) continuous when occupied
VT09	WS input	NetSPsw	209	UseNetOccSetpoints	BV	Off=uselocalUI2 On=USE VT03&4
VT10			210			
VT11			211			
VT12			212			
VT13			213			
VT14	WS output	ModeNet	214	ModeEnumStatus	AV	"0" = Standby "1" = Ventilation "2" = Heating "3" = Cooling "4" = Filter "5" = Emergency Off
VT15			215			
VT16	WS output	EffHtSP	216	EffectHeatingSetpoint	AV	Reflects the current heating setpoint
VT17	WS output	EffCISP	216	EffectCoolingSetpoint	AV	Reflects the current cooling setpoint
VT19	WS output	CINDem	219	CoolingDemand	AV	Cooling demand from 0-100%
VT18	WS output	HtNDem	218	HeatingDemand	AV	Heating demand from 0-100%

VT20			220			
VT21			221			
VT22			222			
VT23	WS output	TsFault	223	Thermistor Fault	BV	Out of Range condition thermistor
VT24	WS input	Hrtbeat	224	HeartbeatFromBAS	BV	Wink from BAS for fallback

Web Point	Web Name	Sedona Tag	I/O	Default Value	Comments
WC01	ReservedForTesting	TestVal	I	0	Set to "1" to test the occupy logic. Currently not used as part of the logic.
WC02					
WC03					
WC04					
WC05	SAT_HighLimitSP	SaHiLim	I	160	Supply air temperature high limit. Min=0; Max=200
WC06	SAT_LowLimitSP	SaLoLim	I	25	Supply air temperature low limit. Min=0; Max=100
WC07					
WC08					
WC09					
WC10					
WC11	LocalSP_HiResistance	SpHiRes	I	10000	Establishes max resistance of SP slider
WC12					
WC13	HeatCoolActMinV	ActMnV	I	0	(usually either 0v or 2v is expected
WC14	MaxHeatSP_Limit	HtMaxSP	I	73	Maximum heating setpoint allowed.
WC15	MinCoolSP_Limit	ClMinSP	I	69	Minimum cooling setpoint allowed.
WC16					
WC17	CmprMinRunMinutes	RunTim1	I	1	Minimum running time in minutes when a compressor is engaged.
WC18	CmprMinOffMinutes	OffTim1	I	3	Minimum running time in minutes when a compressor is disengaged.
WC19					
WC20					
WC21	UseStandbyMode	StbyEn	I	0	0=No local occ sensor, On=Occ sensor installed
WC22	StandbyOffsetSetpoint	StbySP	I	3F	3F applied to occ Setpoints during standby
WC23	StandbyWaitMinutes	StbyTim	I	15	15 minutes after no motion, shift to standby setpoints
WC24					
WC25	CoolPidKpSetpoint	CoolKP	I	8	
WC26	CoolPidKiSetpoint	CoolKi	I	2	
WC27	HeatPidKpSetpoint	HeatKp	I	8	
WC28	HeatPidKiSetpoint	HeatKi	I	2	
WC29- WC48					

6.4 Sequence of Operation

- A. OPERATING MODES: CvAHU5 shall have the following modes of operation:
1. BAS OCCUPIED – NORMAL USE: The BAS network shall have an hourly schedule for zone /space occupancy (VT01). The following items shall occur when the system is operating in occupied mode:
 - a. LOCAL SETPOINTS – Zone temperature setpoint slider (UI2) shall have a span of 65°F to 75°F with a 5°F (adj. VT07) deadband. Cooling setpoint shall have a minimum 69°F (adj. WC15) limit. Heating setpoint shall have a maximum 73°F (adj. WC14) limit.
 - b. NETWORK SETPOINTS – If a local setpoint slider is not installed the Network Occupied heating and cooling setpoints shall automatically be utilized. UseOccNetSetpoints (VT09) must be set True. Network setpoints shall be 75°F Cooling (adj. VT03) and 70°F Heating (adj. VT04).
 - c. MODE STATUS – Operating mode status is made available to the BAS via VT14 and shall display Standby (0), Venting (1), Heating (2), Cooling (3), Filter Flag (4), and Emergency Shutdown (5) enumerations.
 2. OCCUPIED – LOCAL OVERRIDE OPTIONS
 - a. TIMED OVERRIDE – A push button timed override shall be available at the local wall setter for a maximum of 2 hours (adj. VT10), after which it shall revert to the Normal Use schedule. A button press of 3 seconds that short circuits ZoneTemp input UI1 shall be required to initiate override.
 - b. OCCUPANCY SENSOR/WALL TIMER – If required, a local occupancy sensor or local wall timer shall be installed (BI1) and shall work in parallel with the BAS Occupied and Timed Override Occupied inputs.
 - c. OCCUPANCY SENSOR– If required, a local motion sensor may be installed (BI1). “Use Standby Mode” (WC21) must be ON (1). When local motion is sensed, Occupied mode is enabled for the Occupied Override duration of 120 min (adj. VT02). If no motion is detected for a Standby Wait duration of 15 minutes (adj. WC23) then the effective setpoints change to the Occupied setpoints +/- the Standby Offset of 3°F (adj. WC22) for the remainder of the timed override. Each motion event will reset both the Override duration and the Standby Wait duration.
 3. UNOCCUPIED MODES –
 - a. SETPOINTS – BAS/Network setpoints shall set an unoccupied setpoint of 80°F (adj. VT05) Cooling and 55°F (adj. VT06) Heating. Unoccupied setpoints shall not be available at the local wall setter for adjustment.
 - b. HIGH / LOW LIMIT – Space temperature shall be maintained between the high and low unoccupied setpoints during the unoccupied period.
 - c. OPTIMIZED START: If required, Stop/start optimization shall occur exclusively at the BAS network level. The optimized start schedule shall occur up to two hours (adj.) prior to the occupied schedule.

B. NORMAL USE MODE:

1. STANDARD OPERATION:

- a. SUPPLY FAN: Supply fan shall operate continuously at normal speed (set at air balance to meet design flow). If there is no economizer or provision for ventilation air, the supply fan may operate in the AUTO mode on a call for heating or cooling. AUTO/ON mode is configured from the Web interface VT08 and shall not be locally selectable.
- b. COOLING: Cooling shall be based on a 0 to 100% PID demand output. Cooling shall be sequenced with stage one as DX compressor 1 and stage 2 as DX compressor 2.
 - i. Mechanical cooling shall be locked out at and below 52°F (adj. WC07) outside air temperature.
 - ii. Cooling Low Limit: If supply air temperature drops below 40°F (adj. WC06) then cooling PID maximum output shall be reset down to 4% output.
 - iii. Stage 1 mechanical cooling: Compressor #1 activation is based on hysteresis of the cooling PID and is energized after a 30 second time delay.
 - iv. Stage 2 mechanical cooling: Compressor #2 is energized after a 6-minute time delay.
 - v. Compressors shall have anti short-cycle protection using a Minimum runtime delay of 1 minute (adj. WC17) and a Minimum off time delay of 3 minutes (adj. WC18).
 - vi. Analog cooling option: The cooling PID shall output a 0-to-10-volt (or 2 to 10) signal to a chilled water valve based on zone temperature.
- c. HEATING: Heating shall be based on a 0 to 100% PID demand output. Heating shall be accomplished by a staged gas furnace or electric elements. Activation is based on hysteresis of the heating PID. Stage 1 relay is energized after a 30 second time delay and cycled to maintain the heating setpoint. Stage 2 relay is energized after a 6-minute time delay.
 - i. Heating is locked out when the OA temperature is higher than 66°F (adj. WC08).
 - ii. Heating High Limit: If supply air temperature rises above 160°F (adj. WC05) then heating PID maximum output shall be reset down to 4% output.
 - iii. Analog heating option: The cooling PID shall output a 0-to-10-volt (or 2 to 10) signal to a chilled water valve based on zone temperature.

C. ALTERNATIVE SENSOR PROVISIONS:

1. SUPPLY FAN PROOF: It is highly recommended that a flow switch or a status CT is provided. If it is not installed the input on the controller must be jumpered (BI2) or all heating and cooling functions will be disabled.
2. FILTER STATUS INPUT: A dirty filter indicator can be sent over the network if a DP switch is installed. The filter status input does not affect the unit operation and is provided only for remote alert monitoring.

- D. EMERGENCY/FIRE SHUTDOWN: An interlock shall be provided that will immediately shut down all outside air dampers, fans, and heating/cooling. Upon return to normal, there shall be a 1-minute restart delay. In addition to the fire shutdown interlock, all temperature sensors are monitored. If any temperature sensor is shorted or open circuited, an emergency shutdown will be initiated until the faulty sensor is repaired. Thermistor fault is monitored via VT23.

E. ALARMS: At a minimum, the following alarms shall be provided:

1. General alarms available at the BAS level

F. TRENDS (If Applicable):

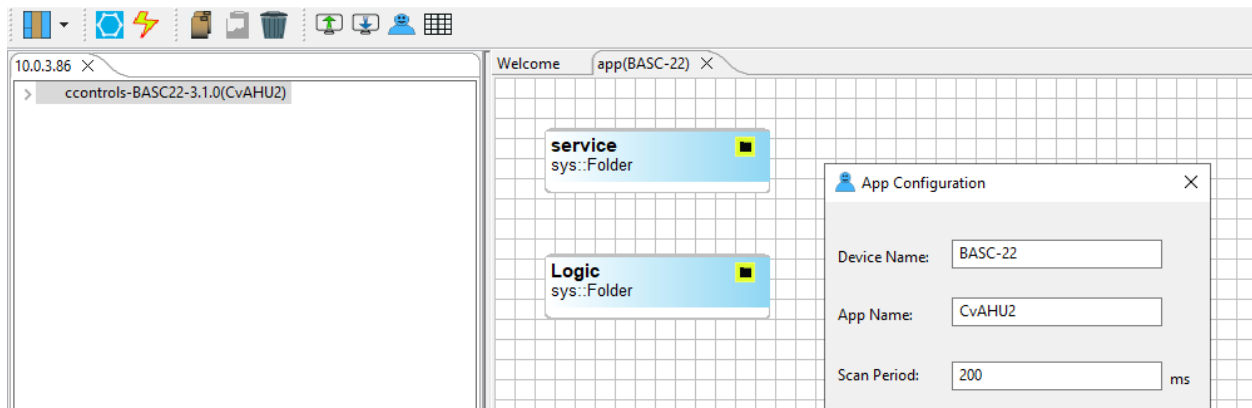
1. General trends available at the BAS level

7 Device and Program Naming Suggestions

With the pre-built applications like the constant volume AHU series, Contemporary Controls took the liberty to name points, provide point descriptions and name programs. All of this can be changed by the system integrator if necessary. What follows are some suggestions when using the same pre-built application on multiple units at the same job site.

7.1 Sedona Device and App Naming

When you access a controller with an installed pre-built application using SAE and you click on Tools>App Configuration you will see what is below. The Device Name and App Name are stored in the pre-built application so this information will be carried to all those controllers you clone with the pre-built application. Therefore, for *Device Name* we suggest you keep it at the default because the pre-built app will only run on this controller due to native functions. If you make absolutely no changes to the pre-built application by way of a Sedona tool, you can keep the *App Name*. However, if you make a modification to the pre-built application, we suggest you append a letter revision to the App Name as shown below. In this way, you know what factory-release version was modified. Contemporary Controls' release versions will only have numbers and no letter revisions.



Assume you make a modification to the pre-built application, and you open the App Configuration window and change the App Name, make sure you click on *Save to Controller*. Then observe the navigation pane at the left and you will notice that the App Name will appear in the top line in parentheses. Preceding the app name is the Platform ID of the controller which comes from the Platform Manifest in the Platforms file of the Component Bundle. It just indicates the controller model and base firmware revision. Just above this line is the IP address of the controller. Note that IP configuration is part of the BACnet configuration which is not related to the Sedona application. When you select *Save to PC* using SAE you are only saving the Sedona application and no configuration data. You can also select *Load from PC* to retrieve your Sedona program.

7.2 Controller Configuration Files

BASbackup creates a more comprehensive backup in that it saves not only the Sedona application but the controller and web components configuration files. XML and SAX files are human readable while the Sedona binary files are not. Regardless if you make no changes to the pre-built application, you should make a backup copy for archiving or for cloning purposes using BASbackup.

app	SAX File
app.sab.target	TARGET File
bas_cfg	XML File
kits.scode	SCODE File
platform	XML File
platformManifest	XML File
webc	XML File

Before making an achieve copy, check the controller configuration page using a web browser.

IP Configuration		BACnet Device Configuration	
IP Mode	<input type="text" value="Static IP"/>	Device Object Name	<input type="text" value="BASC22 AHU2"/>
IP Address	<input type="text" value="10.0.3.86"/>	Device Instance	<input type="text" value="386"/>
Netmask	<input type="text" value="255.255.240.0"/>	UDP Port	<input type="text" value="47808"/>
Gateway	<input type="text" value="10.0.0.1"/>	BBMD IP Address	<input type="text" value="0.0.0.0"/>
Primary DNS	<input type="text" value="10.0.0.8"/>	BBMD Reg Time	<input type="text" value="100"/>
Secondary DNS	<input type="text" value="8.8.4.4"/>		

Enable Protocol	
BACnet/IP	<input checked="" type="checkbox"/>
Sedona	<input checked="" type="checkbox"/>
FTP	<input type="checkbox"/>

Authentication	
User Name	<input type="text" value="admin"/>
Password	<input type="text" value="....."/>

In the above example, we are using a static IP address with a netmask that would give us 4094 host IDs. Make sure not to assign the same static IP address to another controller otherwise the web page information will be confusing and head-end communication will be intermittent or non-existent. The gateway address is usually given to us. Make DNS entries if the network time protocol (NTP) is to be used.

On the BACnet side there are two critical entries to make – *Device Object Name* and *Device Instance*. Both need to be unique within the complete BACnet network. This is where we need to define a policy for naming controllers. Although a naming policy may be dictated to you, here is one possible policy that links the device’s IP address (which must be unique) with the BACnet device instance which must also be unique.

The BACnet device instance range is between 0 and 4,194,302. The IPv4 address has four octets but the first two are always the same in this example – 10.0. If we assume the third octet is in the range of 1 and 15, then we could combine the last two octets into a single decimal number that could be used as the device instance. Therefore, IP address 10.0.3.86 could be assigned to BACnet instance 386 and IP address 10.0.1.73 could be assigned to BACnet instance 1073. With this scheme, we lose 255 addresses but there are plenty of device instances still left to use.

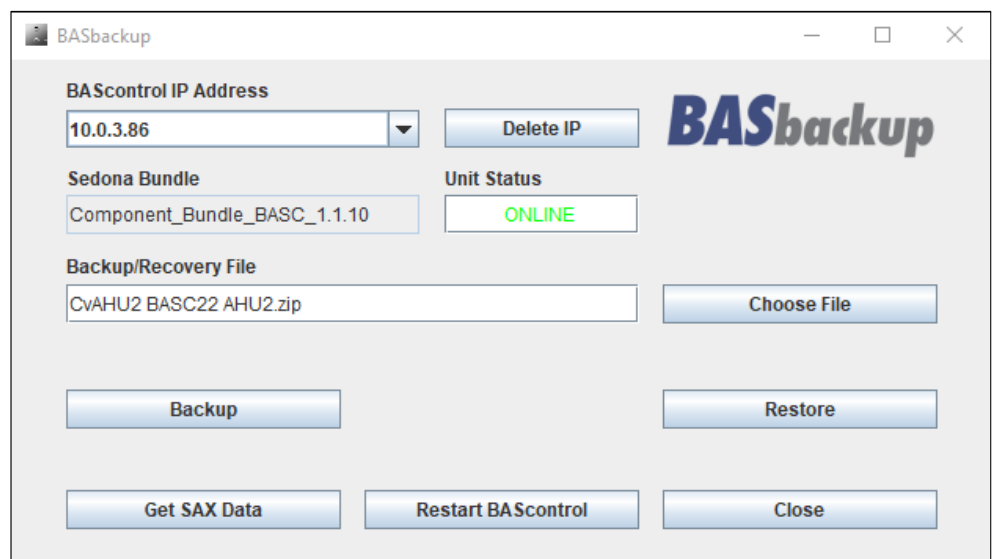
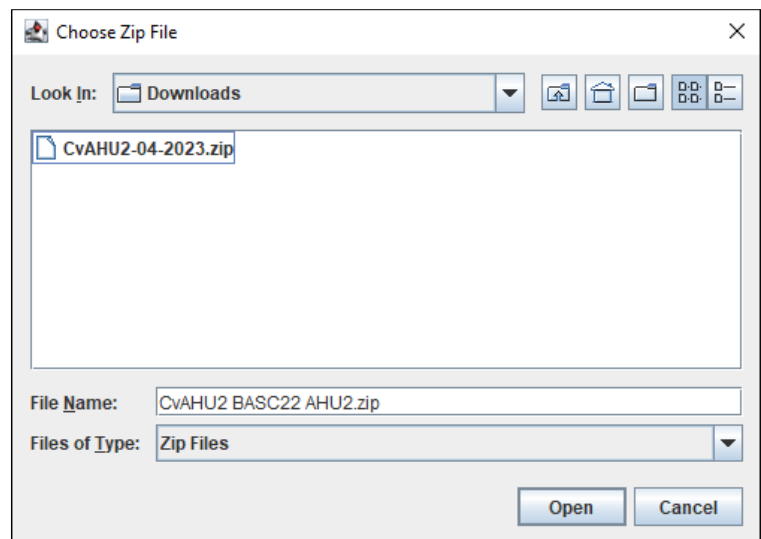
The next assignment is the Device Object Name. We could just repeat the device instance, but we probably want to know something meaningful about the device. So, if the controller is intended for AHU2 then we could simply have a device object name of BASC22 AHU2 as shown above.

Using a BACnet discovery tool like Contemporary Controls BACnet Discovery Tool (BDT), you can find all the BACnet controller device instances along with the device object names. Drilling down, you can learn the properties of the controller so BACnet references are the best way to identify controllers.

7.3 Making a Backup Copy with BASbackup

Once the pre-built application is running on a controller with an assigned IP address, a copy should be made of the controller. Using BASbackup, connect to the controller with the installed pre-built application. You will need to click on Choose File which opens the Backup folder. Create a file name that will uniquely identify the controller with its application because the BASbackup copy captures all aspects of the programmed controller. One suggestion is to begin with the Sedona application name and to combine it with the BACnet object name.

For our example, this is CvAHU2 BASC22 AHU2.zip. Click Open and then Backup, and a backup file will be created that can serve as a master for other files.



7.4 Cloning a Controller with a BASbackup file

Once you have a complete backup of a working controller you can replicate the saved program onto another controller using BASbackup. Bring up BASbackup again and enter the IP address of the controller to be programmed.

Assume for this example that we want to use AHU2 to clone AHU3 which has an IP address of 10.0.3.86. Enter in 10.0.3.86. Next click on Choose File that gives you the Backups folder. Select the name of the file that will serve as the master file for cloning which in our example is CvAHU2 BASC22 AHU2.zip.

Next click on Restore that will open up the Restore Setup window. You will notice the settings of the AHU2 program which you do not want. Change the IP address to that of the AHU3 controller. It should be the same address as on the BASbackup screen. Enter the remainder of the IP settings in case they are different. For BACnet Device Instance and BACnet Device Name, our example would require 386 for the instance and BASC22 CvAHU3 for the BACnet Device Name.

Next you need to create a restore file name for this controller you are adding. On the Restore Setup window click on Choose File that brings you again to the Backups folder. Create a file name. In our example, it would be CvAHU2 BASC22 AHU3. Click Open, and your new recovery file will be created. Click Restore.

The image shows two overlapping windows from the BASbackup software. The background window is titled "Restore Setup" and contains the following fields and options:

- IP Address:** 10.0.3.86
- Netmask:** 255.255.240.0
- Gateway:** 10.0.0.1
- DNS1:** 10.0.0.8
- DNS2:** 8.8.4.4
- BACnet Device Instance:** 386
- BACnet Port:** 47808
- BACnet Device Name:** BASC22 CvAHU3
- Recovery File Name:** (empty field)
- Restore Options:**
 - Wire Sheet
 - Main Configuration
 - Web Component Configuration
- Buttons:** Restore, Close

A tooltip message is visible: "Configuration values in the text boxes will replace values in the Main Configuration file when a recovery operation is performed. The recovery process generates new files to be..."

The foreground window is titled "Choose Zip File" and shows a file selection process:

- Look In:** Downloads
- Files:** CvAHU2 BASC22 AHU2.zip (selected), CvAHU2-04-2023.zip
- File Name:** CvAHU2 BASC22 AHU3.zip
- Files of Type:** Zip Files
- Buttons:** Open, Cancel

If you receive a warning that there is a miss-match between the two entered IP addresses, check your work. If there is no message the restore process will begin and you will have a backup file created for the new controller.

Restore Setup

IP Address
10.0.3.86

Netmask
255.255.240.0

Gateway
10.0.0.1

DNS1
10.0.0.8

DNS2
8.8.4.4

BACnet Device Instance
386

BACnet Port
47808

BACnet Device Name
BASC22 CvAHU3

Recovery File Name
CvAHU2 BASC22 AHU3.zip

Choose File

Restore Options

Configuration values in the text boxes will replace values in the Main Configuration file when a recovery operation is performed.

The recovery process generates new files to be uploaded to the controller. If you want to save a backup of the recovery data, choose a file; when the recovery process is complete, a new zip file will be created.

8 Installation Example – Dual-stage Heating/Cooling RTUS

What follows is an example installation of a CvAHU application onto existing rooftop units (RTUs). In this example, we are retrofitting controls on four Carrier 7.5-ton two-stage natural gas heating/DX cooling with analog economizer RTUs. The purpose of the project is to reduce energy usage, increase occupant comfort and to better monitor the performance of multiple RTUs serving a 14,000 sq.-ft. facility. With analog economizers, it is difficult to know if the economizers are operating as intended so they are being replaced with freely-programmed DDC controllers – BASC-22R BACnet/IP Sedona Unitary controllers. The CvAHU2 application was the basis for the retrofit.

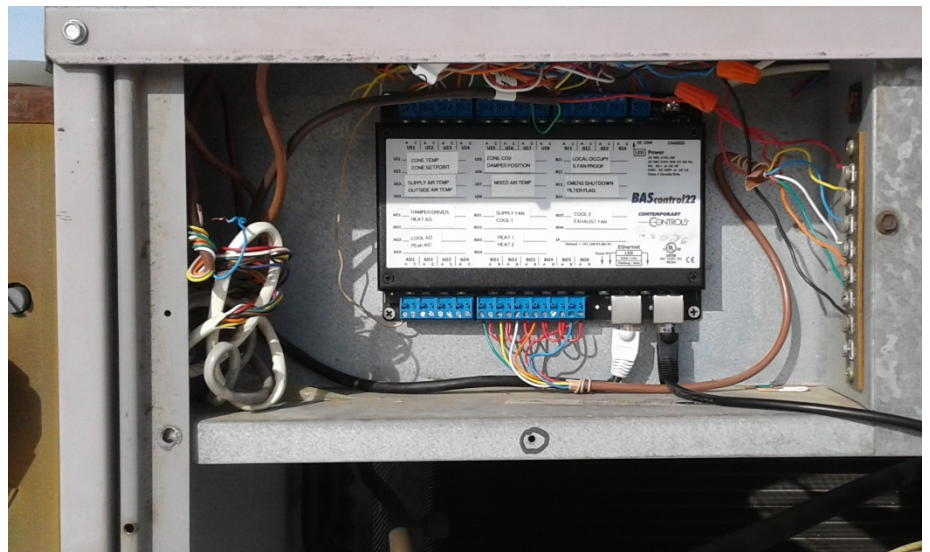


A BACnet head-end schedules equipment and provides a dashboard of all HVAC equipment assigned to a suite within this single-story building. Included in the project was the scheduling of two 4-ton single-stage RTUs without economizers and four-unit heaters used mostly for backup heating or pre-heating.

Before attempting any work on any RTU, lock-out and tag the power source.

8.1 Mounting the BASC-22 DDC Controllers

The existing RTUs were being controlled with simple wall-mounted thermostats which were being replaced with wall-setters with built-in CO₂ displays. Space was needed to mount the DDC controllers within the RTU. The advantage of mounting the BASC-22 DDC controllers within the RTU was to limit the wiring distances to the mixed-air sensor, outside-air damper, outside-air temperature sensor and outside-air humidity sensor.



The BASC-22 is rated for outside temperatures (-40°C to +75°C) but it needs physical protection from the elements. Mounting space was found in an area devoted to customer terminal board connections as shown in the picture. The BASC-22 is rated for N.E.C. Class 2 wiring so this low-voltage location is ideal for mounting the BASC-22.

As a low-voltage device, the BASC-22 is powered by from a 24 VAC supply so the RTU control transformer was used for power. In this way, if the RTU loses power the BASC-22 will lose power as well. Once power is returned, the BASC-22 does not engage outputs immediately but waits for a pre-determined time to prevent short cycling of compressors. The BASC-22 requires 6VA so it is necessary to check the RTU control transformer to verify it has adequate power to service the controller. The low-side of the control transformer secondary must be connected to the low-side of the BASC-22. Verify that the low-side of the transformer secondary is grounded to RTU frame as is the BASC-22. A convenient earth connection is provided on the BASC-22 for this connection.

The BASC-22 has two Ethernet switch ports allowing for daisy-chain Ethernet cabling to the other RTUs. However, in this project an Ethernet switch was installed inside the building providing a star topology to all the RTUs and the BACnet head-end. The spare Ethernet port was reserved for a temporary laptop connection for troubleshooting or commissioning.

In addition to Ethernet cabling, a 9-wire thermostat cable was run between wall setter and RTU. However, only seven wires of the cable were used leaving spares for a dedicated temporary occupancy switch (BI1) which was not incorporated into the design.

8.2 Outside Air Damper

In this project, two RTUs were fitted with outside air dampers and two were not. However, it was possible to obtain outside air damper kits for Carrier equipment for installation on a retrofit basis and that was what was done in this case. In this view, the outside air damper can be seen closed. Normally, a grill blocks this view. You can see the internal nylon gears that are used to drive the damper to the open position bringing in outside air for ventilation and free-cooling during moderately cool weather. A damper actuator is used to modulate the amount of opening needed for ventilation.



In this example, two damper actuators were from Honeywell and two from Carrier. The size and shape of the actuators vary depending upon the torque required. However, proportional dampers usually require either a 0-10VDC or 2-10VDC signal to move the damper from fully-closed to fully-open. It is possible to use a less expensive floating actuator but this application called of a high degree of control and position feedback so a proportional actuator was specified.



The two Honeywell dampers had their analog economizers mounted on top of the field connections. Once the analog economizers were discarded the 2-10VDC specifications could be seen. These economizers had feedback position, which is required in the CvAHU2 application, if 0-10VDC actuators must be used instead, they can be accommodated in the logic. The Sedona Reset component is used to convert a 0-10VDC signal to a 2-10VDC signal and vice-versa. Command is provided by AO1 and feedback is received by UI6.

In the picture above, a nylon gear attaches to right side of the actuator engaging the nylon gears of the damper to allow for movement.



8.3 Outside-Air and Outside-Humidity (OSA/OSH)

A BAPI OSA/OSH sensor in a weatherproof enclosure was mounted on the outside of the RTU. For temperature, a 10kΩ Type 3 sensor is used but for humidity, a 2-10VDC transmitter is used. For a one percent change of humidity, a 0.08VDC change is indicated in the output. It is possible to have a 0-10VDC BAPI humidity transmitter in which case a one percent change equates to a 0.1VDC change in output. Temperature is received by UI4 and humidity by UI8.



8.4 Mixed-Air Temperature Sensor

Economizers require a mixed-air temperature sensor but the existing mixed-air sensor for the analog economizer was discarded for a Honeywell 20kΩ model (C7250). Not knowing the details of the existing sensor prompted the change. The mixed-air sensor is mounted on the supply fan housing. Because the pre-built application assumes 10kΩ Type 3 thermistors for all temperature sensors, it was necessary to reconfigure UI7 for 20kΩ. This can be done from the main web page.

8.5 Supply Fan Proving

Verifying that the supply fan is running is critical to the CvAHU applications. The supply fan may be commanded to run but may have a blown fuse. To verify that current is flowing in the supply fan motor winding, a Senva Go/No (C-2300) sensor is used. The sensor receives no power other than that which is generated by the fan motor



running. Only a two-wire connection is needed to the controller and polarity is unimportant. A current of at least 0.15A flowing in the fan motor winding is enough to trigger the BASC-22 contact closure input. Follow safety instructions when installing the sensor. Split-core models can be attractive on retrofit jobs. Supply fan proving is received by BI2.

8.6 Dirty or Clogged Filter Detection

BI4 is used to detect a dirty air filter in the RTU. The sensor used is a Dwyer ADPS series differential pressure switch (DPS) with the high-pressure port (P1) attached to a probe mounted on the mixed-air side of the filter and the low-pressure port (P2) attached to a probe on the opposite side of the filter towards the supply fan. With the supply fan off there is no air flow so there is no pressure drop across the filter. Once the supply fan comes on there is air flow and if the flow is restricted due to a clogged or dirty filter a pressure drop occurs that trips a normally-open contact that forces BI4 to the *true* state. BI4 in turn will force the virtual point VT14 to indicate a “4” to signify a filter fault by way of the Enumeration component MAXE. This assumes no other higher priority signal besides “filter fault.”



The trick to using the DPS is setting the trip point which can be accomplished on the unit. Some experimenting is necessary. Also consult DPS application documentation for the proper location and installation of the DPS.

8.7 Safety Shutdown

BI3 is used for the Shutdown command which can come from a smoke detector or other safety shutdown command. Local ordinance prevails. This contact must be closed otherwise a Shutdown condition exists with the controller where all control ceases and all binary outputs revert to *false* state and all analog outputs revert to either 0VDC or 2.0VDC.

8.8 Supply-Air Temperature Probe

For supply-air temperature measurement, a 10kΩ Type 3 duct temperature probe is used and connected to UI3. Consult probe installation documentation to determine the distance from the supply fan where the probe can be mounted.



8.9 Wall-setter Selection

The wall-setter used in this example is a Senva AQW Series combo device with a CO2 transmitter, space temperature sensor (10k Type 3), temperature/CO2 display, setpoint slider and push button override (AQW-ABACBF1). Senva provides guidance in their documentation regarding the proper location of the wall-setter. The display alternates between CO2 and space temperature.

For this project, space temperature is used instead of return-air temperature. The temperature display in the wall-setter is driven by an internal temperature transmitter while a 10kΩ Type 3 thermistor is used by the BASC-22 for zone temperature (UI1). Therefore, it was best to verify that the wall-setter temperature display is accurate with a temperature standard and then to set the zone temperature input point on the BASC-22 to read the same temperature by using the temperature offset for that channel.

The wall-setter has a protruding button that when pressed shorts out the thermistor. A short or an open thermistor creates a fault condition called Out of Bounds. In this state, the UI binary value will equal a *true* and the UI float value will equal the Out of Bounds Value set for that channel. With the UI binary state being set to a *true*, a temporary occupied state is invoked which will remain until the Override Timer VT02 times out. The push button is to be pushed no more than three seconds. If the temperature point remains in a fault condition for over 30 seconds VT23 will indicate Temperature Sensor fault. This is true for any of the four temperature sensors. Under a thermistor fault, the heating and cooling PIDs are disabled providing no control.



The CO2 transmitter is connected to UI5 and is scaled to read 0-2000ppm for a 0-10VDC output swing. This input is used for demand control ventilation (DCV) which will impact the outside air damper once CO2 reaches 1200ppm. This threshold is set by VT08 and its control range is limited by CO2Max (WC04).

The wall-setter has a 10kΩ slider potentiometer which is used for increasing or decreasing the zone setpoint during the occupied state. If you want it warmer push up the slider and if you want it cooler push down the slider. On the main web page, you can examine the resistance value at UI5 but there is a Reset component that limits its impact to a range of 65-75°F. However, that is still not the setpoint. Deadband is determined by VT07. This value is divided by two with the slider value increased by half the deadband to become the cooling setpoint and decreased by half the deadband to become the heating setpoint. These two local setpoints govern heating and cooling when in occupied mode. When in unoccupied mode, VT06 and VT05 determine heating and cooling setpoints respectively. If at any time it is desired to know the effective heating and cooling setpoints they can be viewed at VT16 and VT17 respectively.

It is possible not to have any wall-setter at all. If the program does not detect the presence of a slider, it will assume that the head-end occupied heating (VT03) and occupied cooling (VT03) setpoints should be used instead. In this case, the wall-setter needs to be replaced with a simple wall-mounted zone temperature sensor.

8.10 Powered Exhaust

On the AHUs being retrofitted, there were no exhaust fans or motorized exhaust dampers. The exhaust dampers were simple barometric dampers that would relieve any built-up pressure. Although exhaust logic can be found in the Exhaust folder, it was ignored as well as the Powered Exhaust Enable signal BO6 and the Powered Exhaust Speed signal AO4.

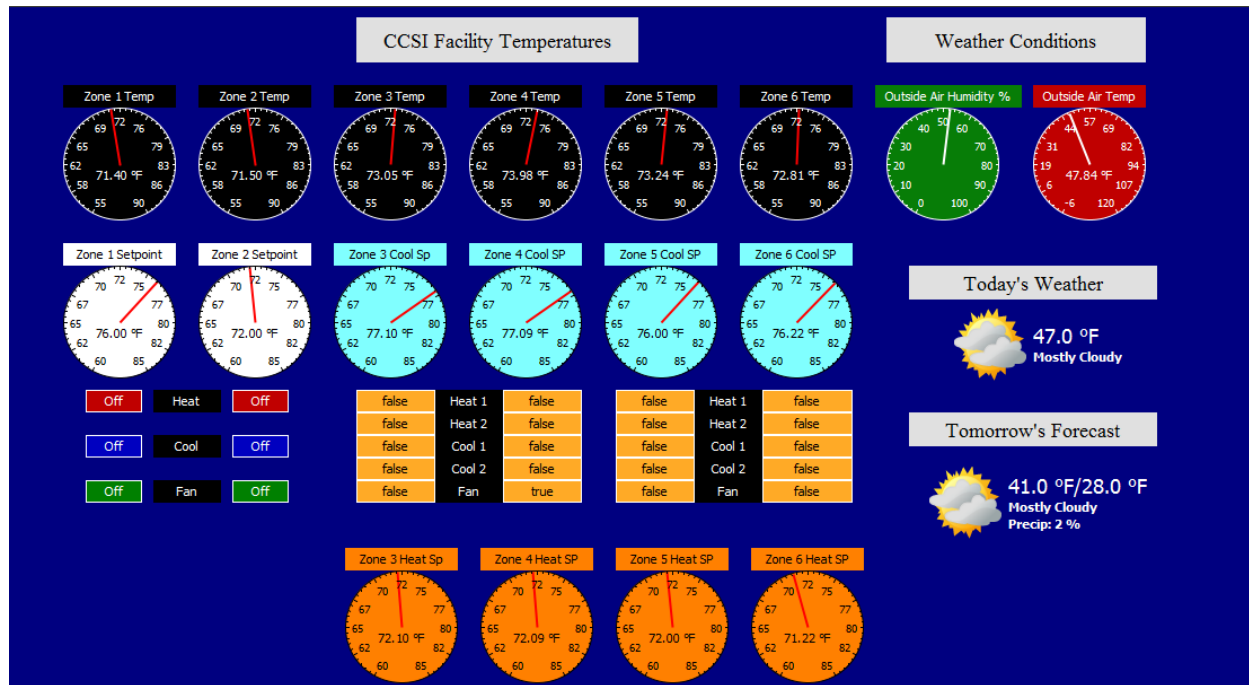
8.11 Staged Heating and Cooling Outputs

The remaining real outputs relate to the staging of heating and cooling and they interface directly to the terminal board connections reserved for thermostat wiring. These connections follow the NEMA convention for wall-mount thermostats with 24VAC (R), 24VAC common (C), stage 1 heat (W1), stage 2 heat (W2), stage 1 cool (Y1), stage 2 cool (Y2) and fan (G). Wiring of the five relay contacts is from R to the related function. For stage 1 heating (BO4) it is W1, for stage 2 heating (BO5) it is W2, for stage 1 cooling (BO2) it is Y1, for stage 2

cooling (BO3) it is Y2 and for supply fan (BO1) it is G. The 24VAC common (C) connects to the BASC-22 power Com while the 24VAC (R) connects to BASC-22 HI.

8.12 Head-end Dashboard

For this project, a Tridium JACE-600 running Niagara 3.8 was used to create a head-end dashboard consisting mostly of gauges to provide on a single screen an overview of all air-handling devices. Because BACnet points are discoverable, discovery was the method used with the JACE to populate its points database. On this dashboard, you see six zones. Zones 1 and 2 are controlled by wall-mounted BACnet MS/TP thermostats. They are brought up to BACnet/IP using BACnet MS/TP to BACnet/IP routers. Zones 3 through 6 are the retrofitted AHUs addressed in this document. A weather service gadget is used for outside air temperature and humidity



measurement and weather forecasting. The weather condition is a good check on the local outside air and humidity sensors. At the very top are the six zone temperatures and right below them are the six setpoints. Zones 1 and 2 are showing a single setpoint being either in heating or cooling mode while zones 3 through 6 are showing both heating (at the bottom) and cooling (at the top) setpoints. The difference in the two setpoints is the preset deadband. These effective setpoints are best viewed by accessing VT16 and VT17 because they will reflect any changes in local settings and the impact on occupancy.

Between the two rows of setpoint gauges are status indicators for staged heating and cooling and fan status. Zones 1 and 2 are single-stage units so there is less reporting. The other zones are all dual-stage and their five points of status are shown.

With a BACnet head-end, there are many other possible screens for alarms, trend history and system schematic graphics. However, this overall dashboard demonstrates some of the reporting possibilities with a BACnet head-end.

8.13 RTU Tuning

The CvAHU2 application comes with four PID control loops (heating, cooling, economizer, CO2) with preset PID tuning parameters (Kp, Ki, Kd). Kd can usually be kept at zero but the other two may need adjustment for comfort or to minimize mechanical movement that would cause wear and tear. It is best to view trend data of the RTU binary and analog points to understand deviation from setpoint and frequency of correction before adjusting any tuning parameters. You also have staging timers and staging trip points that can be adjusted. Of course, you always have access to setpoints and deadband to suit occupancy comfort. If any changes are made it is best to save your changes by making an archive copy of your project with BASbackup.

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