

Software Installation and User Manual

Universal SuperHeat Controller/Sensor (USHX)

GUI Version: *DMQ USHX APP v2.0.0 beta 12.X*

Document Revision 2.1



Innovations that flow[®]

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1 Before You Begin

1.1 About the USHX Software

The USHX software is a Microsoft Windows compatible graphical user interface (GUI) tool for DunAn Microstaq’s Universal SuperHeat Controller (USHC) and Universal SuperHeat Sensor (USHS) products used typically in HVAC and refrigeration applications. The USHX product utilizes the Modbus RTU communication protocol for user interaction. The following table shows the features this software includes when used as either a USHC or USHS.

Feature	USHC	USHS
<i>Precise Superheat Control</i>	✓	-
<i>Input Desired Target Superheat Setpoint</i>	✓	-
<i>Option to Input Desired Target Air Temperature</i>	✓	-
<i>Pressure Measuring Capability</i>	✓	✓
<i>Evaporator Temperature Measuring Capability</i>	✓	✓
<i>Second Temperature Measuring Capability</i>	✓	✓
<i>Real-time Superheat Calculation</i>	✓	✓
<i>Data Collection Capability</i>	✓	✓
<i>Real-time Data Plotting</i>	✓	✓
<i>Alarm Detection with Notifications</i>	✓	✓
<i>Serial Communication Capability</i>	✓	✓
<i>Multiple-unit Network Communication Capability</i>	✓	✓
<i>Automatic Voltage Source Detection</i>	✓	✓

1.2 Hardware and System Requirements

The following table provides the hardware and software requirements for installing and using the USHX software.

Hardware Requirements	System Requirements
<ul style="list-style-type: none">• <i>USHX device(s)</i>• <i>USHX wiring harness</i>• <i>Isolated USB to RS485 converter</i>• <i>Power Source AC/DC</i>• <i>Laptop or desktop PC</i>• <i>Small flat tip screwdriver</i>• <i>Wire stripper</i>	<ul style="list-style-type: none">• <i>Operating System: Microsoft Windows 7, Windows 8/8.1, or Windows 10</i>• <i>64-bit Version</i> <p><i>*Contact DMQ for 32-bit version</i></p>

1.3 Compatible Firmware

The USHX APP v2.0.0 beta 12.X is compatible with all USHX firmware versions shown below.

21.XX.XX.XX.XX

22.XX.XX.XX.XX

23.XX.XX.XX.XX

‘X’ can be any number starting from 0 through 9.

1.4 About This Manual



This manual is intended to instruct the user how to install, configure, and operate DunAn Microstaq's Universal SuperHeat Controller/Sensor software – **DMQ USHX APP v2.0.0 beta 12.X**.

The following table shows a summary of the sections in this document and their descriptions.

Section Title	Description
<i>Before You Begin</i>	Preliminary information the user should read before proceeding through the document.
<i>Software Installation and Communications Setup</i>	This section provides information about uninstalling, installing, and setting up the software.
<i>Software Functions</i>	This section provides information about the software functions.
<i>Alarms</i>	This section provides information about alarms the user may potentially encounter and conditions under which they may appear.
<i>Appendix</i>	This section provides information about the control algorithm features provided by the USHC.

1.5 Document Conventions

The following table shows a list of symbols found in this document and their descriptions.

Symbol	Description
	WARNINGS indicate that the action you are taking could either cause injury to yourself or could harm your products and systems.
	IMPORTANT NOTES appear in the text to indicate additional information that should be noted.

1.6 Acronyms

The following table shows a list of acronyms used in this document.

Acronym	Description
DMQ	DunAn Microstaq, Inc.
F/W	Firmware
GUI	Graphical User Interface
MSEV	Modular Silicon Expansion Valve
HC-MSEV	High Capacity Modular Silicon Expansion Valve
VHC-MSEV	Very High Capacity Modular Silicon Expansion Valve
USHX	Universal SuperHeat Controller/Sensor
USHC	Universal SuperHeat Controller
USHS	Universal SuperHeat Sensor
SH	Superheat
PWM	Pulse Width Modulation Duty Cycle
OODB	Out Of Deadband

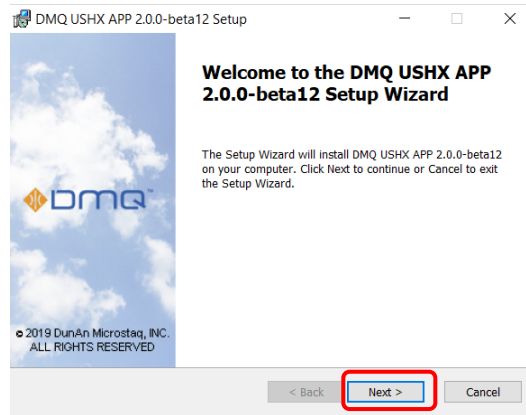
2 Software Installation and Communications Setup

This section provides instructions for installing and setting up the USHX software.

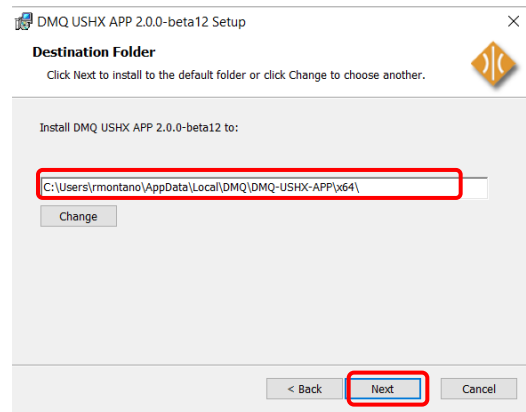
2.1 Installing the USHX Software

To install the USHX software, complete the following steps:

1. Double click **DMQ-USHX-APP_vX.X.X_Installer.msi**
2. The **DMQ-USHX-APP Setup Wizard** window appears. Click **Next**.



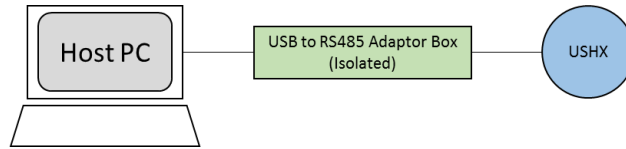
3. Read the end-user license agreement. Click **Next** to continue once the license agreement is accepted (the check box must be checked).
4. The default installation directory is the Users folder. Click **Change** to select a different installation location. Once the desired destination folder is listed, click **Next** to continue with the installation.



5. The **User Account Control** window may appear. Click **Yes** to allow the installation to continue.
6. Click **Finish** to complete the installation process. After the installation is complete, a shortcut to the application will be created on the desktop. The program may also be found through the Start Menu at **Start > All Programs > DMQ USHX APP**

2.2 USHX Communications Setup

The HOST PC and the USHX should be connected through an isolated USB-to-RS485 converter box. See the **MSEV/HC-MSEV and USHX Hardware Installation Manual** for more hardware installation details. The following diagram shows the USHX hardware and software setup.

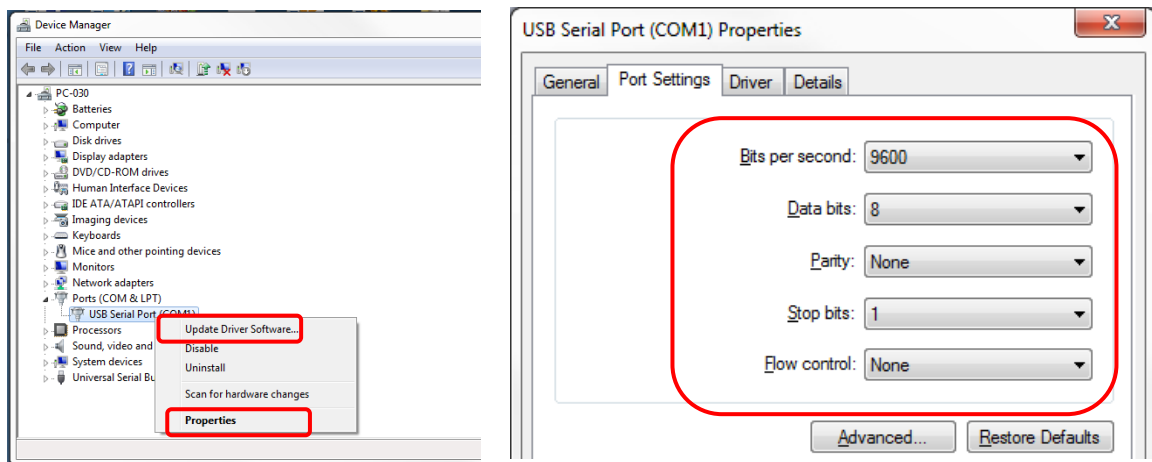


If the USB-to-RS485 converter is being used with the associated computer for the first time, the driver(s) for the device must be downloaded and installed. USconverters U485G is one example of a compatible isolated USB-to-RS485 converter. USconverters, like many manufacturers, hosts its latest drivers on its website. Link down below.

<http://www.usconverters.com/usb-rs485-isolated-converter>

To set up communications between the computer and the USHX through the converter, complete the following steps:

1. Download the converter driver(s) from the Internet or, if applicable, obtain them from a CD/DVD. If the driver(s) is (are) in a compressed file, extract the file(s) to a desired location.
2. Connect the converter to the computer via a USB port.
3. When prompted for the device driver location, go to **My Computer > Right Click > Properties > Device Manager > Ports (COM & LPT)**, right click **USB Serial Port**, and select **Update Driver Software** and navigate to the driver file(s). The computer will update the driver list and install the USB converter automatically. A new virtual COM Port with number will now be available on the computer.

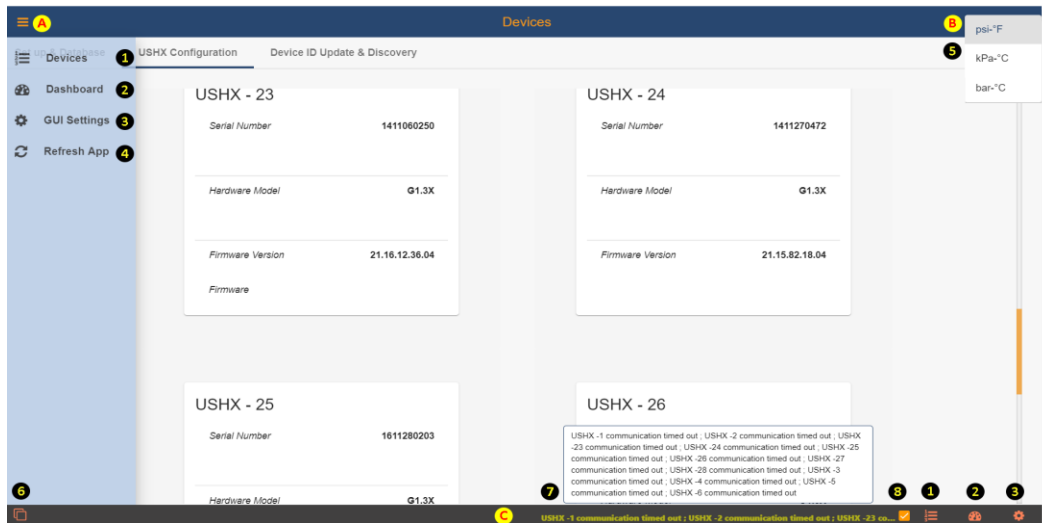


4. Make a note of COM port number and ensure the COM Port Properties are the same as in above picture

3 Software Functions

3.1 APP Basics

This section provides a quick overview of the APP. The features described in this section are present throughout the APP. The features in the window below are labeled as A, B, C and 1 to 8 for quick identification and easy explanation.



“Dashboard” and “USHX Configuration” are disabled until USHX devices are setup

Number/ Section	Description
A	Menu – Helps user to quickly navigate through the app. Clicking the icon will pop-out shortcuts to Devices (1), Dashboard (2), GUI Settings (3), and to Refresh App (4).
B	Units – These units of measurement will be displayed throughout the USHX APP.
C	Footer – Helps user to quickly navigate to Modbus Map Selection (6), Tooltip (8), Devices (1), Dashboard (2) and GUI Settings (3) and Notifications (7)
①	Devices – Shortcut to list of Devices and Settings (Located in both section A & C)
②	Dashboard – Shortcut to Dashboard (view and plot data) (Located in both section A & C)
③	GUI Settings – Shortcut to Application settings (Located in both section A & C)
④	Refresh APP – Will automatically restart the application. “Ctrl” + “R”
⑤	Unit Options – Three options for user to select: psi-°F, kPa-°C, or bar-°C. The selected units here will be used for display purpose only and not for recording
⑥	Modbus Map Selection – The user must add a Modbus map to match the firmware version or default map will be used.
⑦	Notifications – All notifications will appear in this section. In the case that the notification is too long to be displayed, hover over this section and a pop up with all notifications will appear.
⑧	Tooltip – Provides brief descriptions for various features throughout the software when the mouse is hovered over a button.

3.2 Devices

This section of software is used primarily to Select Serial COM port, Setup Database, View, Configure Device Settings, Assign Device ID, Reassign Device ID and Device Discovery.

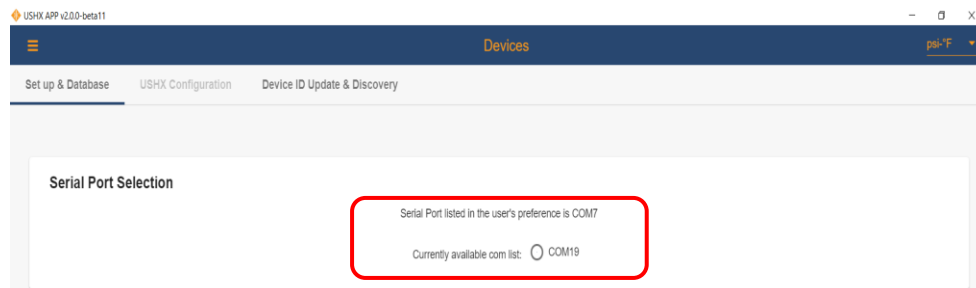
3.2.1 Set up & Database

The two primary functions of this section are to select Serial port and to Setup the database for Single USHX or Multiple USHX network.

3.2.1.1 Serial Port Selection

Follow the steps below to select the Serial Port.

1. Determine the USB COM Port used by the USHX network (Refer to [Section 2.2](#))
2. Start the USHX GUI APP
3. Select the COM port being used by the USHX network (COM 19 used in the example below)
4. Refresh the APP

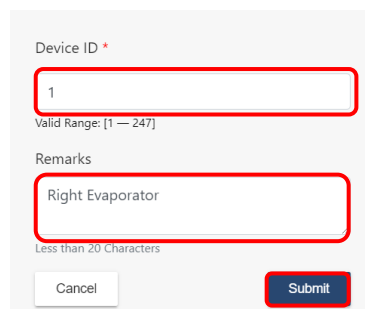


At times the computer will switch the COM port used. The user should change COM port when APP is unable to communicate with any USHX.

3.2.1.2 Database

The database is used to setup communication between the software and each individual USHX. The **factory default Device ID** of each USHX is '1'. To setup the database, complete the following steps:

1. Ensure USHX is powered and connected to the wiring harness. Secure all connections.
2. Enter the Device ID '1' for the USHX.
3. Input any notes about the device in the "Remarks" field and click Submit.

A screenshot of a form for adding a device to the database. The form has two main sections: 'Device ID' and 'Remarks'. The 'Device ID' section has a text input field containing the number '1'. Below the field is the text 'Valid Range: [1 - 247]'. The 'Remarks' section has a text input field containing the text 'Right Evaporator'. Below the field is the text 'Less than 20 Characters'. At the bottom of the form are two buttons: 'Cancel' and 'Submit'.

The following information is populated upon the successful entry of a device.

Device ID	Serial Number	Hardware Model	Firmware Version	Remarks	Status	Monitor
1	1611283374	G1.3X	22.16.82.36.02	Right Evaporator	Online	<input checked="" type="checkbox"/>

Parameter	Description
Device ID	Device ID assigned to the USHX
Serial Number	Unique identification number of each USHX
Hardware Version	USHX hardware type
Firmware Version	USHX firmware version
Status	Online: The USHX device is communicating with the APP Offline: The USHX device is not communicating and is inaccessible with the APP
Monitor	“ON” (blue, toggled right) & “OFF” (grey, toggled left). Toggling ‘Monitor’ to “OFF” stops communication with the USHX.
	Clicking this icon allows the user to update the remarks for that device.
	Clicking this icon removes the device from the database.

3.2.2 Device ID Update & Discovery

This feature is primarily used when **Multiple USHX** are connected in network. The two functions are to ‘Reassign the Device ID’ and ‘Device Discovery’.

3.2.2.1 Reassign Device ID





The database becomes very useful when Multiple USHX are in a network. Each USHX should have a unique Device ID allowable from 1 to 247. ‘Reassign Device ID’ is used to change the default Device ID from 1 to any number up to 247. Follow the steps below to assign a new Device ID.



Multiple USHX should not have the same Device ID in a network. Duplicate Device IDs will cause communication issues.

1. In a Multiple USHX network, ensure only the USHX device being assigned is powered. Disconnect the wiring harness from all other USHX devices if they have the same Device ID.

2. Enter Current ID (Factory default = 1) and Enter New ID (1 to 247) and click Update. A notification will appear which states “Device # has been reassigned to new Device #”.
3. Complete Steps 1-2 for all USHX in the network.
4. Add each device into the database as explained in [Section 3.2.1.2](#). The picture below shows an example of a two USHX network added to the database.

Devices						
Set up & Database		USHX Configuration		Device ID Update & Discovery		
Device ID	Serial Number	Hardware Model	Firmware Version	Remarks	Status	Monitor
1	1611283374	G1.3X	22.16.82.36.02		Online	<input type="checkbox"/>  
2	1611283377	G1.3X	22.16.82.36.02	Right Evaporator	Online	<input checked="" type="checkbox"/>  

3.2.2.2 Device Discovery

This feature allows the user to find unknown Device ID’s of a Single or Multiple USHX network.



Device Discovery does not work for a multi USHX network when two or more USHXs have the same Device ID.

To use the Device Discovery feature, complete the following steps:

1. Confirm all USHX’s are powered by securing the wiring harness to each device.
2. If the number of devices on the network is known select ‘**Yes**’ and enter the value into ‘**Number of Devices**’. If the number is unknown then select ‘**No**’.
3. Select the Device ID search range (default 1 – 247) and then click the ‘**Search**’ button. Once completed, all found device IDs will be listed.

Set up & Database USHX Configuration Device ID Update & Discovery

Reassign Device ID v

Device Discovery ^

Search Range
start:1 end:30 247

Do you know how many devices are online?
 Yes No

Number of Devices *

Valid Range: [1 – 247]

Final Result : ID 23,25,26,28 are valid between [1 - 30]

3.2.3 USHX Configuration

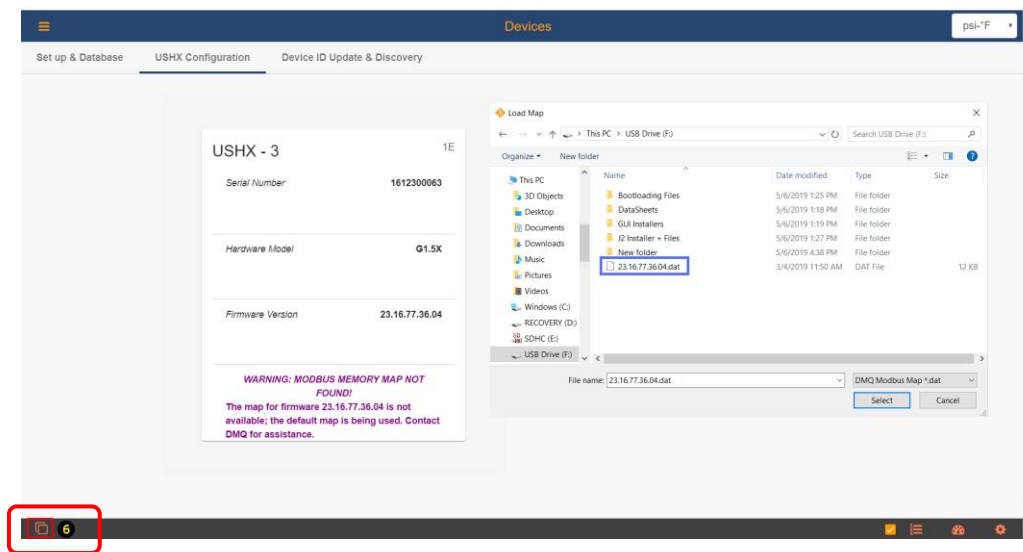
This section of the APP is used to explain ‘Add MODBUS MEMORY MAP’ and ‘Configure USHX Settings’. It displays all the USHX(s) that are ‘Online’ and toggled to ‘Monitor’ in the database.

3.2.3.1 Add Modbus Memory Map

Each firmware requires a specific Modbus Memory Map (.dat file). The software comes with a default map. When the firmware version does not match the default map, it requires users to manually select the corresponding map (.dat file) to match the firmware version of the USHX.



Contact DMQ to obtain the Modbus Memory Map (.dat file) if it is not provided.

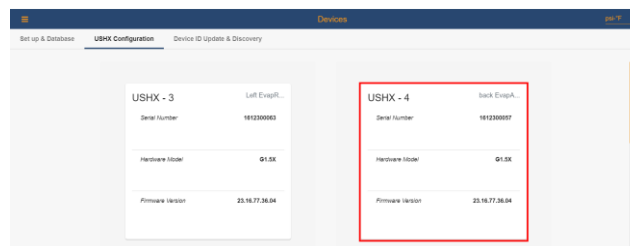


Follow the steps below to add a Modbus Memory Map.

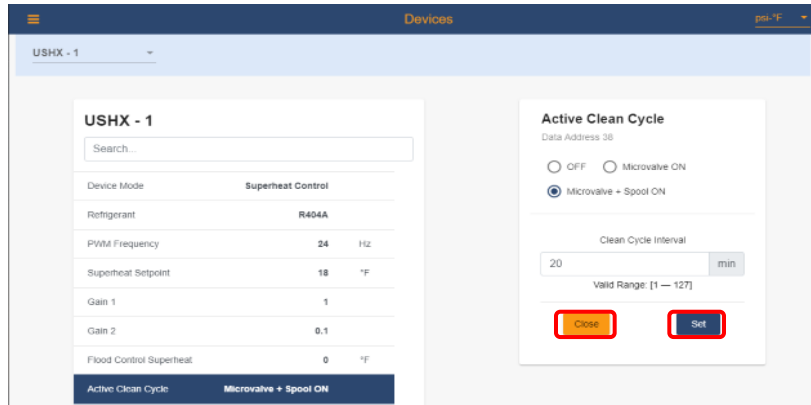
1. Click “Add Maps” button labelled “6” in the picture above.
2. A File Explorer window will appear, navigate to the .dat file on your computer
3. Select .dat file corresponding to the USHX firmware (multiple files can be selected at once)
4. Refresh the APP (shortcut “Ctrl” + “R”), and the new firmware map should be loaded
5. Verify by returning to the USHX Configuration Tab to see that the warning is no longer shown

3.2.3.2 View and Configure USHX Settings

This section of the APP is used to view and configure the USHX settings. Click on the USHX to view the configuration settings.



After selecting the USHX, the APP will redirect the user to configure each setting for that USHX. All USHX settings are set by numerical input or button selection. The example below is for the Active Clean Cycle feature.



For every selected parameter there are two buttons:

- **Close** – This button will close the pop-up window.
- **Set** – This button will set all the selections and changes made by the user.

The following table describes every parameter that can be set, as well as, its recommended value. Also, turn on the **Tooltip** (labelled ⑧ in [Section 3.1](#)) for in APP pop-up explanations.

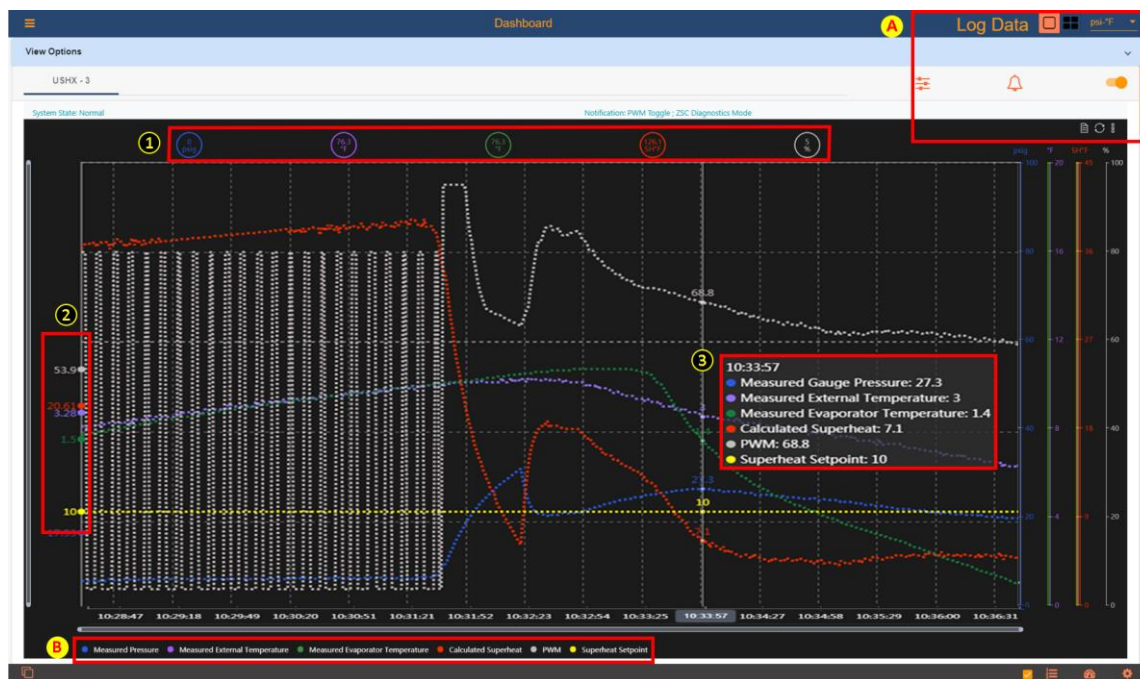
Parameter	Description	Recommendation
Device Mode	Superheat Control: To control the superheat of the HVAC/R system. The control loop of the USHX is continuously running and the PWM will adjust automatically to achieve target superheat. Superheat Sensor: To manually command constant PWM to MSEV.	Superheat Control
Refrigerant	Select the refrigerant of the system where USHX device is installed.	N/A
PWM Frequency	Changes the frequency of the PWM signal to the MSEV.	24 Hz
Superheat Setpoint	Changes the desired superheat setpoint of the USHX measured at the evaporator outlet	10°F
Gain1	Gain 1 acts as a proportional gain. This determines how quickly the control loop responds to fluctuations in superheat.	1
Gain2	Gain 2 acts as an integral gain. This determines how quickly the control loop brings the superheat to the superheat setpoint.	0.1
Flood Control Superheat	A safety feature to prevent compressor floodback from occurring within the system. When the Calculated Superheat falls below this user-defined value, the PWM will instantly go to 5% to close the valve. The control algorithm resumes normal operation when the Calculated Superheat is above the Flood Control Superheat.	0°F (0°C)
Active Clean Cycle	A safety feature to minimize the contaminant build up for either 'Microvalve' or 'Microvalve + Spool', dependent on selection.	Micro Valve + Spool ON (20 minutes)
Control Scheme	Select type of control algorithm. See Appendix.	B
Sensitivity	Used to detect sudden changes in pressure, such as, compressor ON/OFF, etc.	15 for Refrigeration Systems; 30 for HVAC Systems
Valve PWM	Changes the duty cycle of the PWM signal to the MSEV.	N/A

Parameter	Description	Recommendation
Passive Clean Cycle	A safety feature to minimize the stiction for both Microvalve and Spool, which operates at a frequency of every 10 seconds.	ON
PWM Toggle	A feature to conserve power and prevent overheating of the MSEV. It is intended to occur during system OFF and defrost cycles in HVAC-R systems.	ON
Flood Control ROC	Flood Control Rate of Change (ROC) is used in conjunction with the Flood Control Superheat. The PWM duty cycle will be updated after the USHX has exited Flood Control based off the equation: $\text{New PWM\%} = \text{Last Known PWM\%} - \text{Flood Control ROC} * \text{Elapsed Seconds}$	0.3 %/sec
Evap-out Time Constant	Changes the effective time constant of the thermistor used to measure evaporator temperature.	1 sec
Target Air Temp	Changes the desired target air-out temperature of the system.	As per system requirement
Target Air Temp Upper Limit	The maximum desired target air-out temperature of the system.	As per system requirement
Target Air Temp Lower Limit	The minimum desired target air-out temperature of the system.	As per system requirement

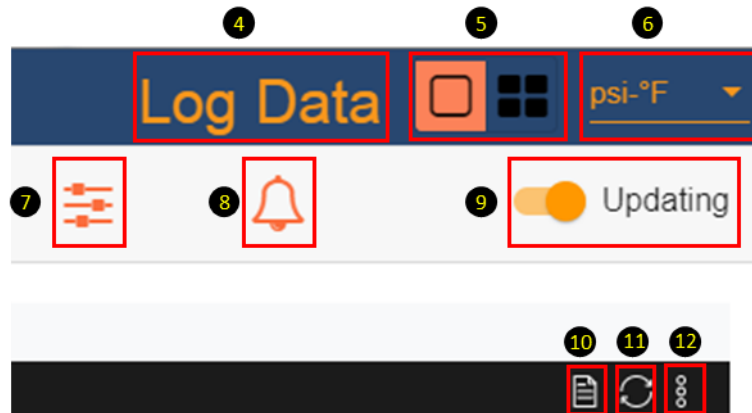
3.3 Dashboard

This section enables user to view the real time plot for every USHX on the network. The data plotted varies depending upon the USHX configuration settings. See table below.

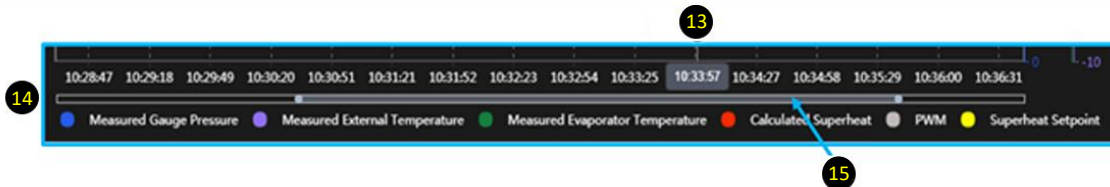
Parameter	Description	Required Configuration Settings
<i>Measured Gauge Pressure</i>	Pressure at the evaporator outlet where the USHX is installed.	Default
<i>Measured Evap. Temperature</i>	Temperature at the evaporator outlet where the thermistor is installed.	Default
<i>Measured External Temperature</i>	Temperature where the second thermistor is installed (contact DMQ for additional thermistor)	Default
<i>Calculated Superheat</i>	Real-time calculated superheat based on pressure and temperature measurements.	Default
<i>PWM</i>	PWM duty cycle applied to the MSEV by USHX.	Default
<i>Target air out temperature, Upper and Lower Limit</i>	Target air temperature features (Available only when second temperature sensor is installed)	Control scheme = E or F
<i>Floating Target Superheat</i>	Target air temperature features	Control scheme = F



Number/Section	Description
①	Current Data values displays the real time value for each parameter.
②	Average Data values of the data on the plot. When a different section of the plot is displayed, these values will adjust accordingly. The location of the values along the Y axis depends on the average data value and the corresponding data's scale.
③	Specific Point Data Hover Pop-Up. When the user places the cursor over the plot, a pop-up shows parameter values at the time corresponding to the cursor location.



④	Log Data begins recording data for all monitored controllers.
⑤	Single or Multi View icon changes the number of plots displayed in the window.
⑥	Display units changes all measurement units throughout the APP Note: Does not change the measurement units of the Logged Data.
⑦	USHX Settings icon displays parameters for the USHX being plotted
⑧	Recent Notifications icon displays USHX notifications
⑨	Pause/Update toggle pauses and continues the plot. While paused the user can adjust both x and y axis of the viewing window. While paused the data is still being processed and recorded.
⑩	Table View icon shows plotted data in a table format
⑪	Restore icon is used to reset the plot's viewing window after it has been adjusted. This is used primarily when the plot has been paused.
⑫	Chart Options allows the user to turn ON and OFF grid lines and Chart Tooltip



⑬	Specific Point Data Hover Pop up Hovering the cursor over the plot displays the time corresponding to the cursor's location along the horizontal axis
⑭	Interactive Legend Allows the user to hide and unhide the parameters from plot. Click on "Measured Gauge Pressure" and it will disappear from the plot. All the data is recorded even if it is hidden from the plot.
⑮	Plot's Viewing space (time axis) The user may adjust the bar located below the horizontal axis to view current or historical data. The plot must be paused when using this feature.

3.4 GUI Settings

The GUI Settings tab allows the user to configure data logging settings and customize the plot area to the user's preference. The user has the option to save these preferences.

3.4.1 Display Settings

This section includes the settings which customize the way the dashboard plots are displayed.

Number/Section	Description
①	Display Pressure – Indicates pressure is shown in absolute or gauge pressure
②	Serial Port – Indicates which COM Port is being used
③	Serial Port Refresh Rate – Options to change plot refresh rate and data recording rate
④	Plot Layout – Options to select layout type if multiple USHX devices are being monitored
⑤	Points on Plot – Option to select the number of data points visible in the active plot(s) Note: 1500 points per USHX are always saved on the APP. Adjusting this setting only affects how many of these points are shown in the dashboard
⑥	Time Span on Plot – Indicates the maximum time span on each active plot Time = (Serial Port Refresh rate) x (quantity of USHX being monitored) x (Points on Plot)
⑦	Line Style – Option to select between dotted, dashed, or solid lines
⑧	Y-Axis Ranges – Customizable Y axes scale; Note: Must click the “Update” button for each range change to take effect
⑨	Line Color – Customizable plot lines for each measured parameter by selecting default colors, color palette, Hex value, or RGB/HSL values

3.4.2 Data Log Options

The Data Log Options section only refers to the recording file(s) when logging data. Any changes to these settings will create a new file(s) if user has already logged data.

⑩	File Units – Select the units of measurement the data will be saved as
⑪	Pressure Type – Select absolute or gauge pressure for display and data being saved
⑫	Set Directory – Set the directory to save data; default directory is C:\Users
⑬	Set – This button must be clicked for Data Log Options to take affect
⑭	Click the “ Save User Preferences ” to save all the customized GUI settings, otherwise default settings will be displayed once the APP is reopened. Note: Anytime this button is selected, previous saved preferences will be overwritten.

4 Alarms

The USHX software has the capability to inform the user of hazards, errors, and other information.



Multiple notifications will be displayed if multiple errors are encountered by the USHX at once.

4.1 Notifications

In the **Recent Notifications list** in the Dashboard, the software will display notifications when errors or change of states are encountered. The table below lists the notifications that the user may see and describes the conditions that trigger their appearance.

Notification	Description
PWM Toggle	Is triggered when the PWM is above 90% and superheat is stable for 30secs. During the PWM toggle, the PWM continuously cycles between 5 and 80%. This safety feature prevents the valve from overheating.
High Input Voltage*	The input voltage has exceeded the range of operation.
Low Input Voltage*	The input voltage has fallen below the range of operation.
Primary External Temp. Not within Sensor Range*	The temperature measured by the primary external sensor has exceeded or fallen below the normal operating temperature limits.
Secondary External Temp. Not within Sensor Range*	The temperature measured by the secondary external sensor has exceeded or fallen below the normal operating temperature limits.
Internal Temp. Not within Sensor Range*	The temperature measured by the internal temperature sensor has exceeded or fallen below the normal operating temperature limits.
Pressure Not within Sensor Range*	The input pressure has exceeded the pressure range of the pressure sensor.
Temperature Difference Error	Contact manufacturer if this notification is seen.

* These notifications pertain to errors involving the operating range of the USHX. When any of these notifications are displayed, ensure that the USHX is being operated properly within its design limits as specified in the product datasheet.

4.2 Additional Messages

Additional messages are shown in yellow text at the footer of USHX APP. The table below lists additional messages that the user may see and describes the conditions that trigger their appearance.

Notification	Description
COM [#] is currently unavailable	The Serial Port is no longer available or the converter is plugged into a different serial port.
USHX [#] communication timed out	There is either a partial loss of data or a compatibility issue between the firmware and the USHX software interface.
USHX [#] reading skipped	Occurs when the user is configuring the USHX device or selecting the device to be monitored or not.
Log file for USHX [#] cannot be created or appended to	There is a mismatch of information of the database or the USHX is no longer available to be recorded.

5 Appendix

5.1 Common Features

5.1.1 Gain 1

Gain 1 is a proportional gain and the objective is to adjust the PWM% proportionally with the magnitude of superheat error (Superheat Setpoint – Calculated Superheat). Its effect on PWM is given by:

$$\text{Gain 1} * (\text{Superheat Setpoint} - \text{Calculated Superheat})$$

With *Gain 1*, PWM adjustments will be more drastic with higher magnitude superheat error. The recommended default value is 1.

5.1.2 Gain 2

Gain 2 is an integral gain and the objective is to gradually trim down the superheat error toward zero. Its effect on PWM is given by:

$$\text{Gain 2} * \sum (\text{Superheat Setpoint} - \text{Calculated Superheat})$$

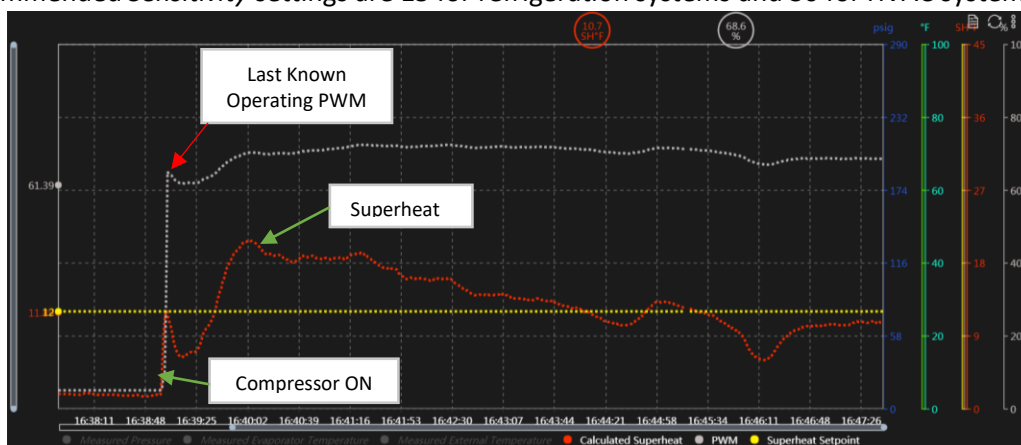
The recommended default value is 0.1.

The combination of *Gain 1* and *Gain 2* settings listed below are recommended when default gains do not provide the best results.

Gain 1	Gain 2	Description
1	0.1	Default
0.5	0.05	To make the PWM% adjust slower
5	0.3	To make the PWM% adjust faster

5.1.3 Sensitivity

Sensitivity is used to detect sudden changes in pressure such as compressor ON, OFF, etc. When the standard deviation of the measured pressure goes above the user-defined *Sensitivity* setting, the PWM will default to the last known operating PWM and the control algorithm will resume normal operation. The recommended *Sensitivity* settings are 15 for refrigeration systems and 30 for HVAC systems.



The plot above demonstrates the scenario of compressor ON in an HVAC system. PWM restores to its previous known good value, enhancing the superheat response time.

5.1.4 Flood Control SH

Flood Control Superheat is a safety feature to prevent compressor floodback from occurring in the system. If the system Calculated Superheat falls below this user-defined setting, the PWM will instantly go to 5% to close the valve. When Calculated Superheat goes back above the *Flood Control SH*, the control algorithm resumes normal operation. The recommended setting is 0 °F (0°C).

5.1.5 Passive Clean Cycle

The *Passive Clean Cycle* is a safety feature and the objective is to minimize stiction for both Microvalve and Spool. When this feature is ON, the PWM frequency is adjusted to 5Hz for 200 milliseconds every 10 seconds. This allows the MEMS microvalve to achieve full stroke and eliminate contaminant buildup for both Microvalve and Spool. It is recommended to always have this feature ON.

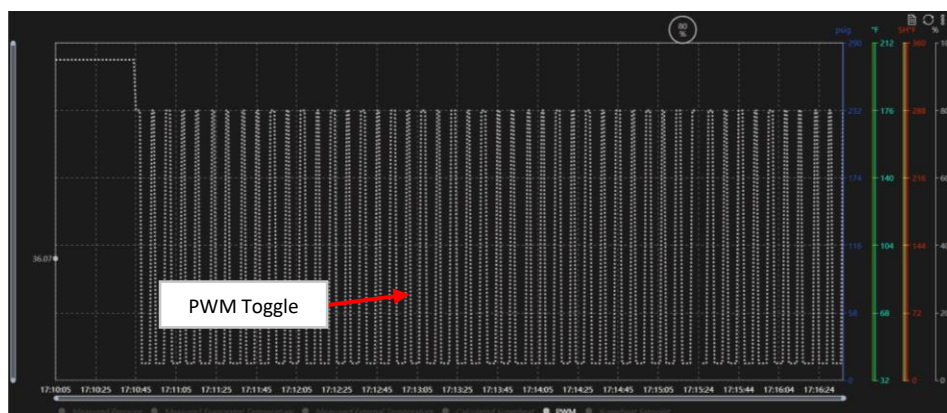
5.1.6 Active Clean Cycle

The *Active Clean Cycle* is a safety feature to minimize the contaminant build up for either ‘MEMS Micro Valve’ or ‘MEMS Micro Valve + Spool’ depending upon user selection. Below describes the difference between these two settings. The recommended option is ‘Micro Valve + Spool’.

Type	Function	Recommended Interval
Micro Valve	Adjust the PWM Frequency to 5 Hz for 5 seconds at a user-defined time interval.	20 minutes
Micro Valve + Spool	Adjust the PWM Frequency to 5 Hz for 5 seconds at a user-defined time interval. For the sixth second, pulse the MSEV with 80% PWM and 5% PWM in 500 ms durations.	20 minutes

5.1.7 PWM Toggle

The objective of *PWM Toggle* is to conserve power and prevent overheating of the MSEV. It is intended to occur when system is OFF or during defrost cycles in HVAC-R systems. It is initiated when the superheat is stable and the PWM goes above 90% for 30 seconds. The USHX will command the MSEV between 80% and 5% PWM indefinitely. PWM Toggle disables when superheat fluctuates and the control algorithm resumes normal operation. It is recommended for the PWM Toggle feature to be ON.



5.1.8 Flood Control ROC (Flood Control Rate of Change)

Flood Control ROC is a setting used in conjunction with the *Flood Control SH* parameter. If the *Flood Control* feature is triggered ([Section 5.1.4](#)), the operating PWM% automatically goes to 5%. Once the Calculated Superheat rises above the Flood Control value, the USHX control algorithm will resume normal operation but not at the last known operating PWM%. This feature avoids putting the system in the same scenario where the Flood Control feature was activated. The new PWM% value that is initialized after a Flood Control cycle is calculated by the following:

$$PWM = \text{Last known PWM} - \text{Flood Control ROC} * \text{Elapsed Seconds}$$

5.2 Control Scheme A

Control Scheme A is the default and used to control the superheat towards a user-defined Superheat Setpoint. This control scheme is applicable for both HVAC and Refrigeration Systems. The Calculated Superheat is the feedback parameter for closed-loop control. The main feature of this scheme is that the parameters *Gain 1* and *Gain 2* dynamically adjust to achieve precise superheat control. The initial values of *Gain 1* and *Gain 2* in the control algorithm are the values entered through the GUI.

5.3 Control Scheme C

Control Scheme C utilizes the same control algorithm with the same control parameters as *Control Scheme A* but *with static gains*. Gain 1 and Gain 2 do not dynamically adjust over time. This can be advantageous if *Control Scheme A* begins to overcompensate for disturbances in the system. This control scheme is applicable for both HVAC and Refrigeration systems.

5.4 Control Scheme B

Control Scheme B utilizes both *Control Scheme A* and *Control Scheme C*. Initially, *Control Scheme A* is used until the Calculated Superheat crosses the Target Superheat value five times and then switches to *Control Scheme C*. The idea for this scheme is to get the superheat closest to target with dynamic gains and then once the Calculated Superheat is settling to target it will use static gains to maintain tight control. This control scheme is applicable for both HVAC and Refrigeration systems.

5.5 Control Scheme E

Control Scheme E is used to control the Air-Out Temperature towards a user-defined Target Air-Out Temperature Setpoint. This control scheme is applicable only for Refrigeration systems. This scheme utilizes Air-Out Temperature as an additional input for control. There is one basic requirement to use *Control Scheme E*:

- ✓ *USHX must have an installed secondary external thermistor to measure Evaporator Air-Out Temperature*

Control Scheme E and F have the following defined parameters:

Target Air Temp Upper Limit - The maximum desired Air-Out Temperature

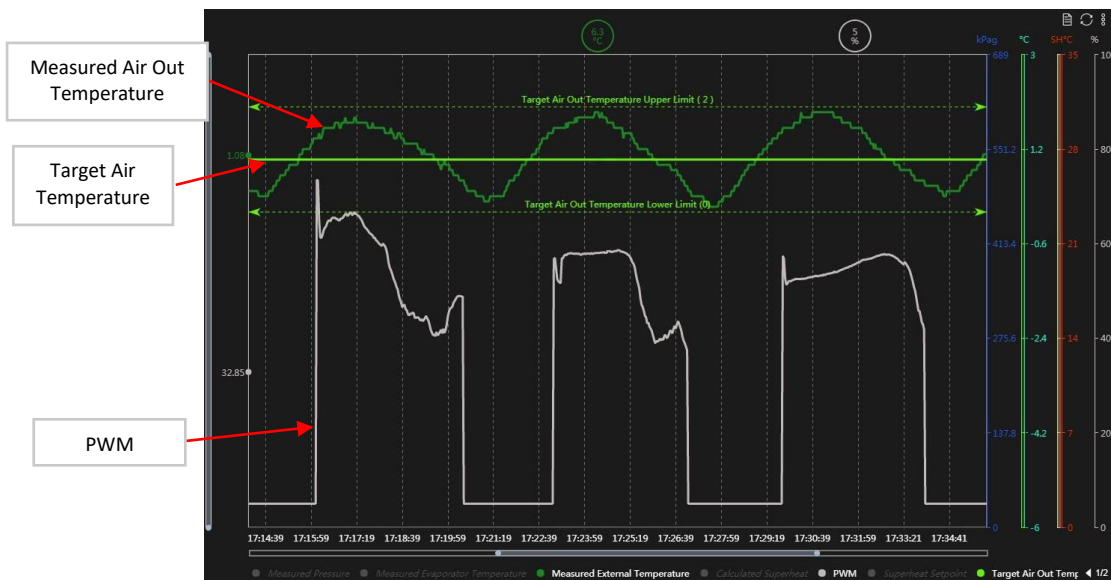
Target Air Temp - The desired Air-Out Temperature

Target Air Temp Lower Limit - The minimum desired Air-Out Temperature

The control logic for *Control Scheme E* cycles between the two conditions described below:

- Condition 1** When the measured air temperature rises above the midpoint of Target Air Temp and Target Air Temp Upper Limit, the USHX will run the standard target superheat control to cool the air temperature. It will hold Condition 1 until Condition 2 is met.
- Condition 2** When the air temperature falls below the midpoint of Target Air Temp and Target Air Temp Lower Limit, the USHX will close the MSEV (PWM = 5%) so that the air temperature rises. Hold Condition 2 until Condition 1 is met.

Control Scheme E will cycle between these two states indefinitely to regulate the Air-Out Temperature between the upper and lower bounds.



The plot above shows an example of *Control Scheme E*. Note as Air-Out Temperature falls below the midpoint of its target and lower limit, the PWM will fall to 5%. Similarly, when Air-Out Temperature rises above the midpoint of its target and upper limit, the PWM will begin controlling superheat as normal. These features are in place to control Air-Out Temperature at target.

5.6 Control Scheme F

Control Scheme F is used to control the Air-Out Temperature towards a user-defined Target Air-Out Temperature Setpoint. This control scheme is applicable only for Refrigeration systems. *Control Scheme F* operates similarly to *Control Scheme E*. The requirements for *Control Scheme F* are the same as for *Control Scheme E*:

- ✓ *USHX* must have an installed secondary external thermistor to measure Evaporator Air-Out Temperature

The control logic for *Control Scheme F* cycles between the two conditions described below:

- Condition 1.** When the air temperature rises above the Target Air Temp, *USHX* to run the standard target superheat control to cool the air temperature. Hold Condition 1 until Condition 2 is met.
- Condition 2.** When the air temperature falls below the Target Air Temp, dynamically float the superheat target to control the air temperature within the target and the lower limit. Hold Condition 2 until Condition 1 is met.

Control Scheme F will cycle between these two states indefinitely to regulate the Air-Out Temperature between the upper and lower bounds. Note that the Floating Target Superheat parameter has a minimum and maximum threshold of *Target Superheat* minus 1 °C and 25 °C, respectively.



The plot above shows an example of *Control Scheme F*. Note that as Air-Out Temperature falls below its target, the Superheat Setpoint will float to proportionally higher values. This brings Air-Out back to target.