# PENN Precision Superheat Controller/Sensor Software Interface User Manual

**Revision 1.2**

**GUI Version:** *PSHC GUI v1.12.12.3*

**Applicable Firmware Version(s):**
*21.15.12.18.01*
*22.15.12.34.03*
*21.16.12.18.03*
*22.16.12.34.01*

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# 1 Before You Begin

## 1.1 About the PSHC Software

The PSHC software is a graphical user interface (GUI) tool for the PENN Precision SuperHeat Controller (PSHC) product typically used in HVAC and refrigeration applications. The PSHC product utilizes the Modbus RTU communication protocol for user interaction. The following table shows the features this software includes when the PSHC is used as either a controller or a sensor.

| Feature | Controller | Sensor |
|---|---|---|
| *Precise Superheat Control* | ✓ | |
| *Option to Input Desired Target Superheat Setpoint* | ✓ | |
| *Pressure Measuring Capability* | ✓ | ✓ |
| *Evaporator Temperature Measuring Capability* | ✓ | ✓ |
| *Second Temperature Measuring Capability* | ✓ | ✓ |
| *Real-time Superheat Calculation* | ✓ | ✓ |
| *Data Collection Capability* | ✓ | ✓ |
| *Real-time Data Plotting* | ✓ | ✓ |
| *Alarm Detection with Notifications* | ✓ | ✓ |
| *Serial Communication Capability* | ✓ | ✓ |
| *Multiple-unit Communication Capability* | ✓ | ✓ |
| *Automatic Voltage Source Detection* | ✓ | ✓ |

## 1.2 Hardware and System Requirements

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

| Hardware Requirements | System Requirements |
|---|---|
| • *PSHC device*<br>• *PSHC wiring harness*<br>• *Isolated USB to RS485 converter*<br>• *Laptop or desktop PC*<br>• *Small flat tip screwdriver*<br>• *Wire stripper* | • *Operating System: Microsoft Windows XP, Vista, 7, 8/8.1, 10* |

## 1.3 About This Manual

This manual is intended to instruct the user how to install, configure, and operate the PENN Precision SuperHeat Controller/Sensor software – ***PSHC GUI v1.12.12.3***.

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

| Section Title | Description |
|---|---|
| *Before You Begin* | This section provides preliminary information that the user should read before proceeding through the document. |
| *Software Installation and Communications Setup* | This section provides information about uninstalling, installing, and setting up the software. |
| *Software Functions* | This section provides detailed explanations of the functions of the software. |
| *Alarms* | This section provides details about alarms the user may potentially encounter and conditions under which they may appear. |
| *Additional Features* | This section provides details about additional features in the PSHC GUI. |
| *Appendix – Explanation of Control Schemes A through F* | This section provides the user with a technical understanding of each PSHC Control Scheme. |

## 1.4 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. |

## 1.5 Acronyms

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

| Acronym | Description |
|---|---|
| GUI | Graphical User Interface |
| QREV | Quick Response Expansion Valve |
| PSHC | Precision SuperHeat Controller |
| F/W | Firmware |
| PENN | Penn Controls |

# 2 Software Installation and Communications Setup

This section provides instructions for installing, uninstalling, and setting up the PSHC software.

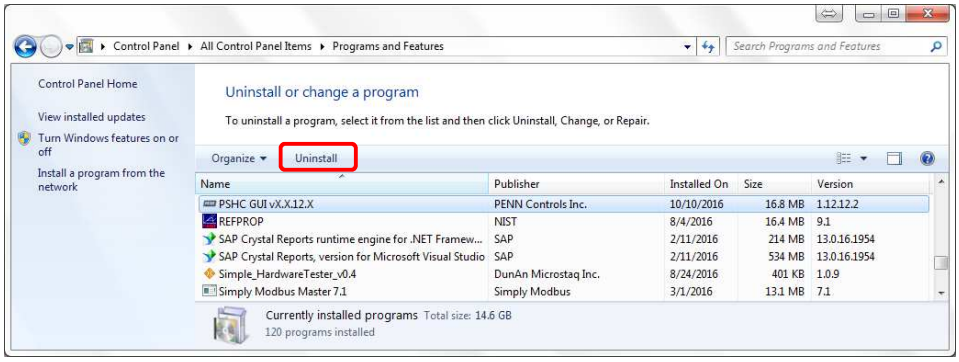
The user must have administrative rights for his or her computer account in order to install or uninstall the PSHC software.

## 2.1 Uninstalling the PSHC Software

Before installing the latest PSHC software, any previous versions of the PSHC software must be uninstalled first. To uninstall previous versions of the PSHC software (if applicable), complete the following steps:

1. Navigate to the **Control Panel**.
2. Click **Uninstall a program** under **Programs**.


3. Select the **PSHC_Modbus_GUI_vX.X.12.X** program and click **Uninstall**. Alternatively, **Right Click > Uninstall** will also uninstall the program on current and older versions of Microsoft Windows.

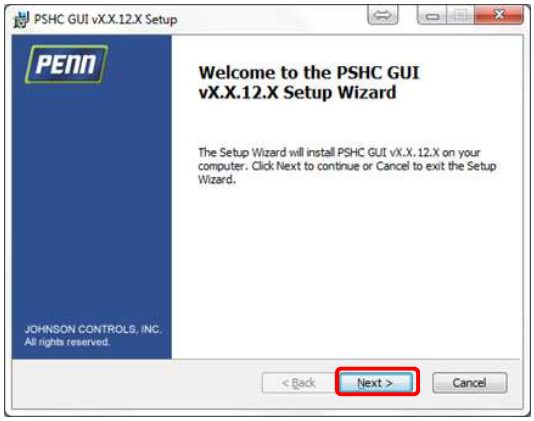



4. The PSHC software Removal Utility will run and later prompt the user to confirm the removal of the PSHC software and all of its components. Click **yes** to continue with the un-installation.
5. The PSHC software un-installation is complete.

## 2.2 Installing the PSHC Software

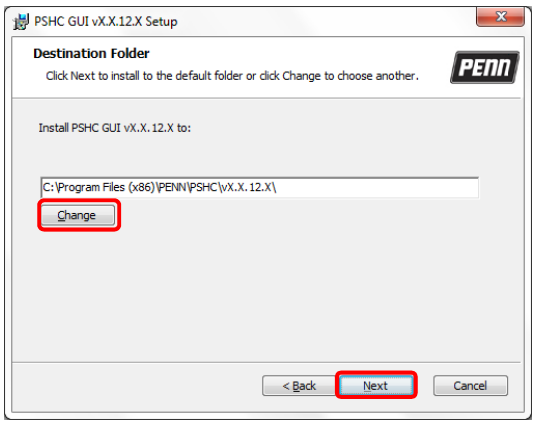
To install the PSHC software, complete the following steps:

1. Double click **PSHC _GUI_vX.X.12.X_Installer.msi**.
2. The **PSHC GUI vX.X.12.X Setup** window appears. Click **Next**.



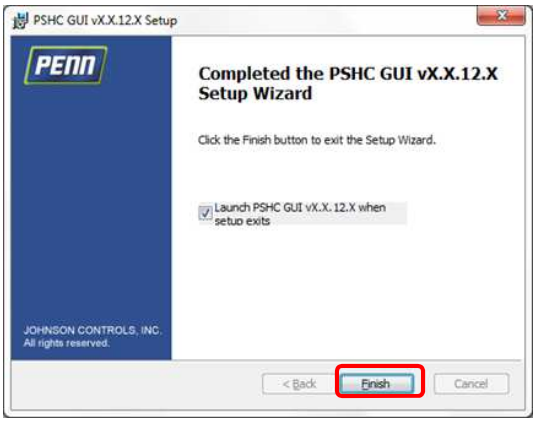

3. Read the end-user license agreement. Click **Next** to continue once the license agreement is accepted (the check box is checked).


4. The default installation directory is the Program Files 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.

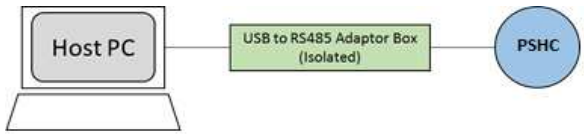
6. Click **Finish** to complete the installation process.




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 > PSHC GUI vX.X.12.X**.

## 2.3 PSHC Communications Setup

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



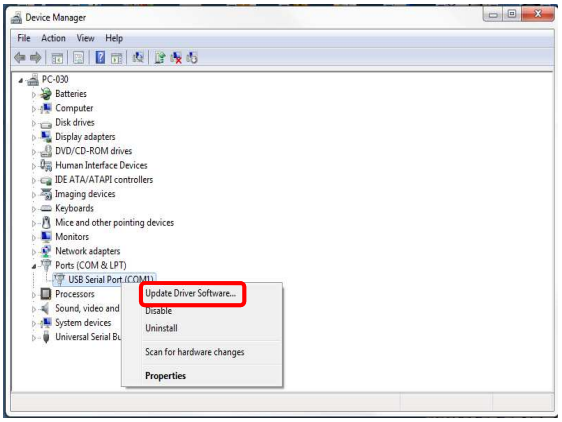

If the USB-to-RS485 converter is being used with the associated computer for the first time, the driver(s) for the device must be downloaded and installed. VirtualSCADA's VSU-485G is one example of a compatible isolated USB-to-RS485 converter. VirtualSCADA, like many manufacturers, hosts its latest drivers on its website. Follow the link below to obtain the driver for this particular device from VirtualSCADA's website. http://www.virtualscada.com/PRODUCTS/Serial_Converters_USB_RS485.htm

To set up communications between the computer and the PSHC 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, navigate to the location of the downloaded driver file(s). If no prompt appears, 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 system will update the driver list and install the USB converter automatically. A new virtual COM Port will now be available on the computer.




4. Once the converter driver(s) has (have) been successfully installed, connect the converter to the PSHC device to complete the hardware installation process.

# 3 Software Functions

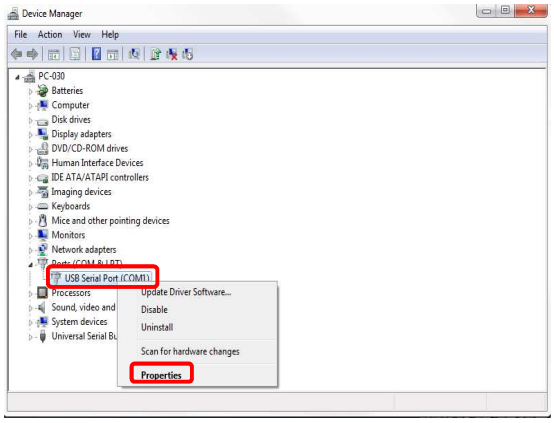
This section provides information on the features of the PSHC software interface and how to use it properly.

## 3.1 COM Port Setup

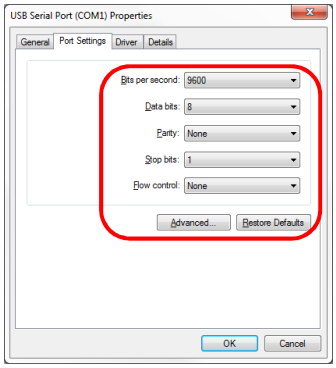
To complete the COM Port setup, follow the steps below:

1. Determine the COM Port number of the converter and check its settings:
    a. Navigate to the **My Computer** screen (or **Computer** depending on the version of Windows).
    b. Right click in the white space on the screen and select **Properties**.
    c. Click the **Device Manager** button. The Device Manager window should appear.
    d. Locate and click **Ports (COM & LPT)**. A sub-list of ports will be displayed.
    e. Disconnect the converter from the computer. If one of the communication ports disappears from the list of ports, the driver has been installed successfully. The COM Port that disappears is the one that corresponds with the converter.

f. Right click on the COM Port associated with the converter and view its **Properties**.

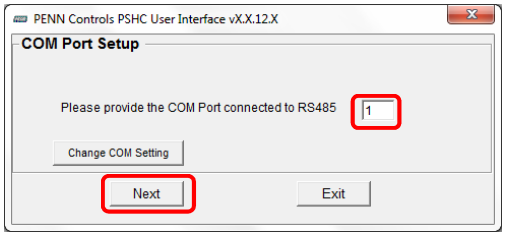



g. Ensure that the COM Port properties are set to the same settings as shown below.




**2.** Enter the COM Port number that is identified in ***Step 1*** and click **Next**. The figure below uses 1 as an example COM Port number. The box is initially blank by default.

The COM Port selection is limited to ports **1 through 16**. If the COM Port number is not within this range, connect the converter to different ports on the computer until it is within the range.




If the COM Port setup is successful, the user will be brought to the Device ID Setup screen.

'Change COM Setting' is a password-restricted menu that allows the user to change the FW/GUI baud rate and parity setting. Please contact the manufacturer for details.

## 3.2 Assigning a New Device ID

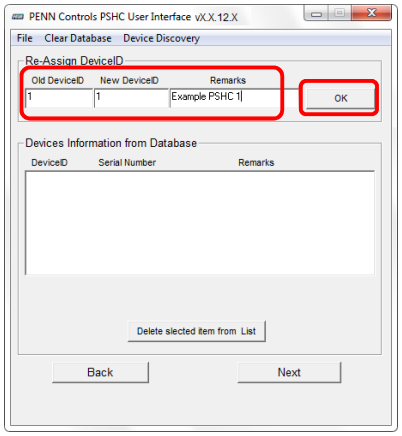
The default Device ID of each PSHC is '1'. To assign a new Device ID to the PSHC, complete the following steps:

At this step, if multiple PSHC have the same Device ID in a network then ensure that power is being supplied to only one PSHC at a time. Only the PSHC device being assigned a new Device ID should be powered via its wiring harness. Disconnect all other PSHC devices from their wiring harnesses before proceeding. Failure to do so will result in errors.

1. Ensure that power is being supplied to the PSHC by checking that the wiring harness is firmly attached to the device.

Review the **Multiple PSHC-QREVs** section in the **QREV and PSHC Hardware Installation Manual** to learn about networking with more than one PSHC device.

2. Enter the current Device ID (default=1) and the desired Device ID in the "Old Device ID" and "New Device ID" fields, respectively. If the current Device ID is not known see **Section 5.2 Device Discovery**. Type any notes about the device in the "Remarks" field then click **OK**.




It is recommended to make a note of the new DeviceID for future use. You can use the export function (see **Section 5.1 File Export/Import**) to save the Device Information Database.

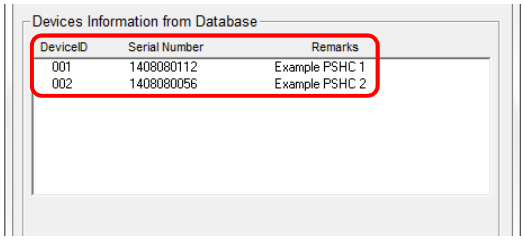
3. If the Device ID is assigned successfully, the connected PSHC device information – Device ID, Serial Number, and Remarks (if applicable) – will be shown in the 'Devices Information from Database' section underneath the Re-Assign Device ID section.

4. For multiple PSHCs, repeat **Steps 2 and 3** to assign Device IDs until all PSHCs have been assigned a new Device ID.

Do not assign the same Device ID to two or more PSHC devices (or possibly other devices). This will create a duplicate Device ID which will cause networking conflicts and result in errors.

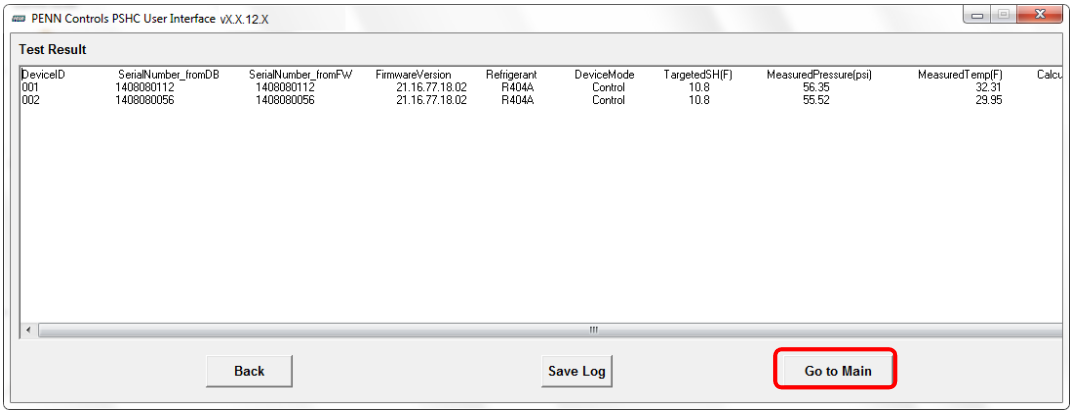
## 3.3 Start-up and Main Window

1. Once all PSHCs have been assigned a Device ID, ensure that all information about the device(s) is correct in the Database section. The figure below shows an example of information accumulated as a result of 5 different PSHCs being assigned Device IDs with example Remarks.



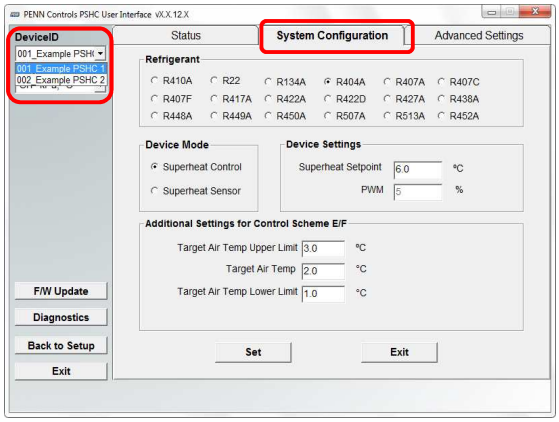

2. Connect and power on all PSHCs (that were assigned Device IDs) via their wiring harnesses.

3. Click **Next** to retrieve firmware information (and additional miscellaneous information) from all connected PSHC devices. The figure below shows an example in which 2 PSHCs are networked and had Device IDs assigned to them.




If a 'mismatch' error message pops up or 'Unknown' appears as data under any of the categories in the above window, contact the manufacturer.

4. Click **Go to Main** on the Test Result window to proceed to the **System Configuration** tab of the main window of the program.



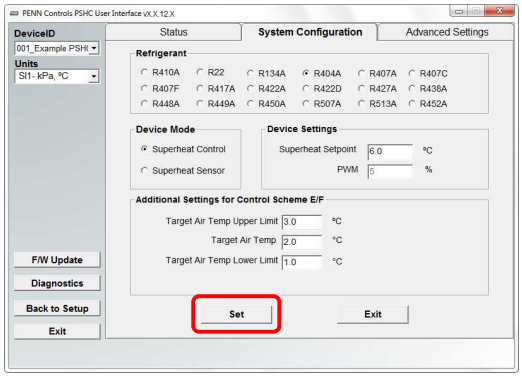

**5.** The PSHC setup is now complete. Select the Device ID of a PSHC device from the drop-down menu to see its settings. Select each PSHC device individually to configure settings.

## 3.4 System Configuration

In the **System Configuration** tab, the user may switch the **Device Mode**, change the **Refrigerant** type, and alter additional **Device Settings**. Furthermore, a **F/W Update** and **Diagnosistics** may be performed from this tab, but this feature is password protected and only accessible for JCI maintenance purposes.

Two buttons are located at the bottom of the tab and boxed in the figure below:

- **Set** – This button will set all the selections and changes made by the user.
- **Exit** – This button will bring the user to the **Status** tab.



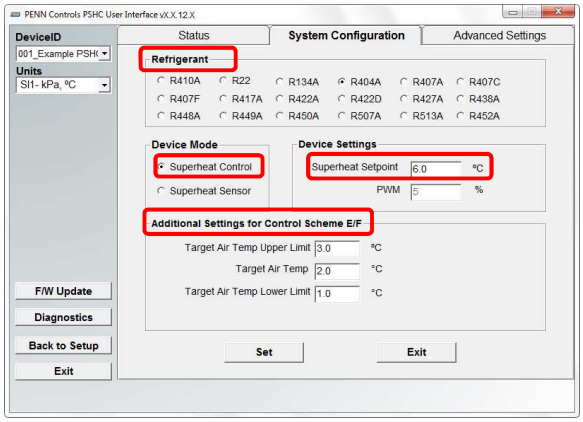

### 3.4.1 PSHC as a Controller

To use the PSHC as a Superheat Controller, complete the following steps:

**1.** Select the respective **Device ID** of the PSHC that the user wants to configure.

**2.** For the **Device Mode**, select Superheat Control.

This mode is used with a QREV to control the superheat temperature of the HVAC/R system. In this mode, the control loop of the software is constantly running, and the PWM will adjust automatically so that the system will maintain its Superheat Setpoint.




3. For the **Refrigerant**, select the appropriate refrigerant for the current system.
4. For the **Device Settings**, input the desired Superheat Setpoint (target) value.

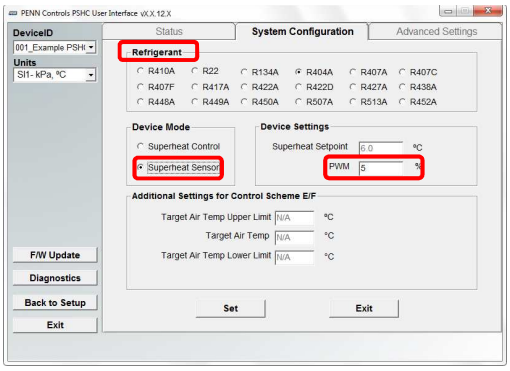
In Superheat Control mode, PWM is not manually adjustable. It continuously adjusts depending on the Control Scheme selected in the Advanced Settings tab.

5. If Control Scheme E or F is in use, select the desired Air-Out temperatures under **Additional Settings for Control Scheme E/F**.
6. Click the **Set** button to save any changes and set the new parameters. Click **OK** when the confirmation window appears.
7. For Advanced Settings setup go to **Section 3.6.**
8. Repeat **Steps 2 through 6** for all Device IDs. When this step is finished, the system configuration for the PSHC(s) will be complete.

### 3.4.2 PSHC as a Sensor

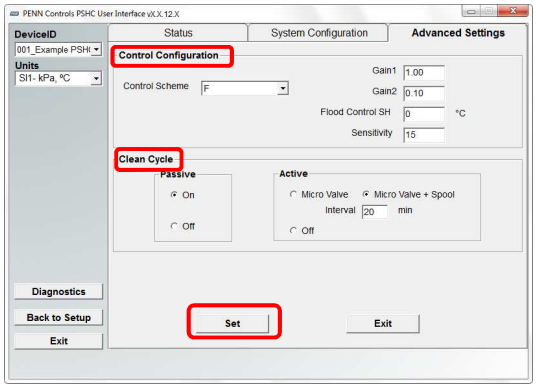
To use the PSHC as a Superheat Sensor, complete the following steps:

1. Select the respective **Device ID** of the PSHC that the user wants to configure.
2. For the **Device Mode**, select Superheat Sensor.
3. For the **Refrigerant**, select the appropriate refrigerant for the current system.
4. For the **Device Settings**, input the appropriate PWM. In Superheat Sensor mode, the Superheat Setpoint setting is disabled and a constant PWM output can be set to the device through the PWM output wires (18 AWG, white).
5. Click the **Set** button to save any changes and set the new parameters. Click **OK** when the confirmation window appears.
6. Advanced Settings will be grayed out for Superheat Sensor.
7. Repeat **Steps 2 through 5** for all Device IDs. When this step is finished, the system configuration for the PSHC(s) will be complete.




## 3.5 Advanced Settings (Only Applicable for Superheat Control Mode)

In the **Advanced Settings** tab, the user may alter the **Control Configuration** of the system, turn the **Passive and Active Clean Cycles** on or off, and access the




### 3.5.1 Control Configuration

The purpose of the **Control Configuration** section is to allow the user to set the control loop parameters. The settings may vary depending on the application. See section 6 for further explanation on the below parameters.

| Parameter | Description | Recommendation |
|---|---|---|
| *Control Scheme* | This provides user to select the control algorithm the firmware will execute. See the Appendix for more detail on each control Scheme. | A (default) |
| *Gain 1* | This determines how quickly the control loop responds to fluctuations in superheat. | 1 |
| *Gain 2* | This determines how quickly the control loop brings the superheat to the superheat setpoint. | 0.1 |
| *Flood Control SH* | This is the superheat value below which the PWM goes to 5% (valve closed) to prevent liquid refrigerant to flood back. This value must be lower than the Superheat Setpoint. | 0°C or 0°F |
| *Sensitivity* | This control parameter is associated with type of application under automatic control. | 15 for Refrigeration Systems; 30 for HVAC Systems |

### 3.5.2 Clean Cycle

The function of the **Clean Cycle** feature is to clean the QREV so that debris that collects within the valve can be removed. See section 6 for further explanation of the parameters.

| Parameter | | Recommendation |
|---|---|---|
| *Passive Clean Cycle* | | On |
| *Active Clean Cycle* | Micro Valve | Off |
| | Micro Valve + Spool | On |
| | Interval | 20 Minutes |

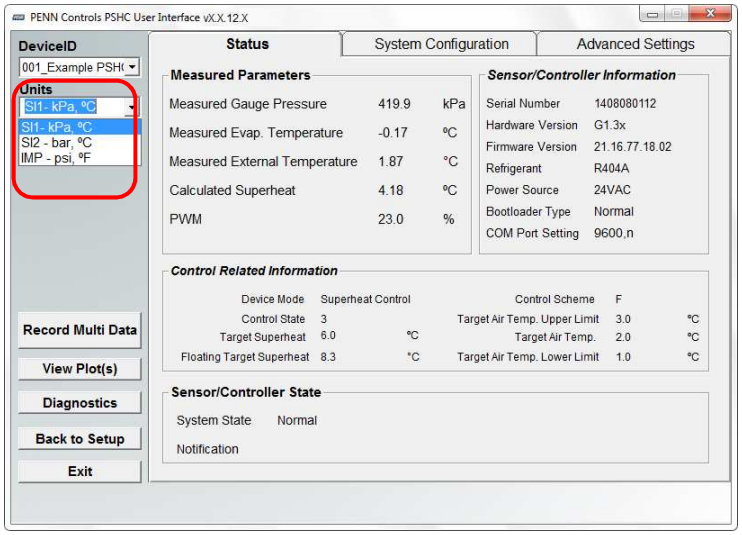
To configure the advanced settings described in **Sections 3.6.1 (Control Configuration) and 3.6.2 (Clean Cycle)**, complete the following steps:

1. Input parameter values or select settings as desired. JCI suggests that the recommended settings are used, although the settings may vary depending on the application.
2. Click the **Set** button to save any changes and set the new parameters. Click **OK** when the confirmation window appears.
3. Repeat **Steps 1 and 2** for all Device IDs. When this step is finished, the advanced settings configuration will be complete.

## 3.6 Status

The **Status** tab displays the current status of the selected PSHC Device ID and relays information about the system to the user.

Select the preferred units of measurement (for pressure and temperature) from the **Units** drop-down menu in the left column of the tab. Values in the tab will automatically be converted and update to reflect changes in units. The default are IMP – psi, °F. This menu is also present in the other tabs.



The table below describes the parameters that are displayed in the **Status** tab.

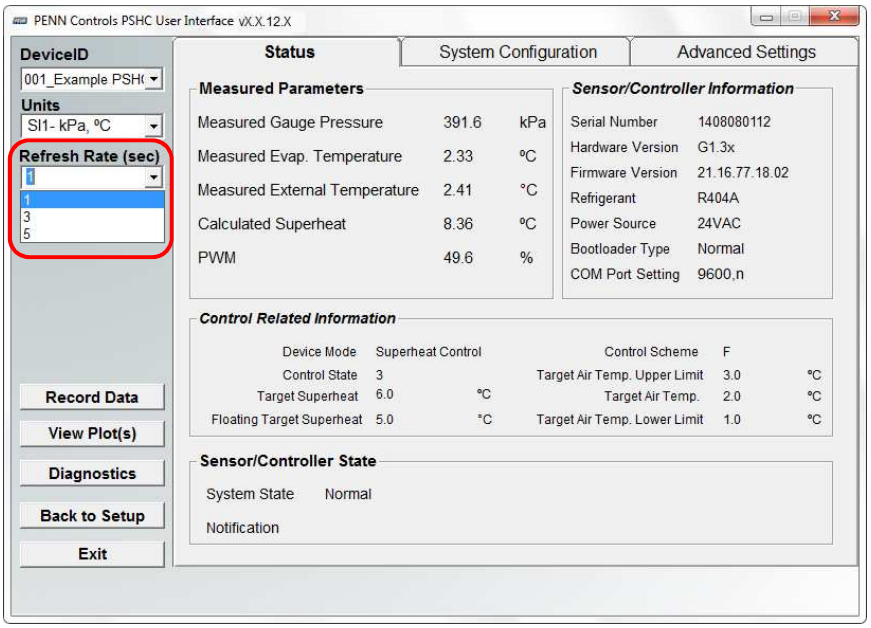
| Parameter | Description |
|---|---|
| *Measured Gauge Pressure* | This is the measured gauge pressure at the evaporator outlet where the PSHC is installed. |
| *Measured Evap. Temperature* | This is the fluid temperature (measured by the temperature of the external wall of the copper tubing) at the evaporator outlet where the thermistor is installed. |
| *Measured External Temperature* | This is the Air-Out temperature as measured by the secondary thermistor (Pin Assignments 5 & 10 on the PSHC harness). |
| *Calculated Superheat* | This is the calculated superheat determined in real-time based on pressure and temperature measurements. |
| *PWM* | This is the PWM duty cycle applied to the QREV by the PSHC. |
| *Sensor/Controller Information* | This section displays the Serial Number, Hardware Version, Firmware Version, Refrigerant, Power Source, Bootloader Type, and COM Port Settings. |
| *Control Related Information* | This section displays the Device Mode, Control State, Target Superheat, Floating Target Superheat, Control Scheme, Target Air Temp. Upper Limit, Target Air Temp., and Target Air Temp. Lower Limit. |
| *Sensor/Controller State: System State* | This is the current system state determined by the PSHC in operation. States that may be displayed include:<br>• Normal – The PSHC is operating normally.<br>• Passive Valve Clean – The QREV is in Passive Clean mode.<br>• Active Valve Clean – The QREV is in Active Clean mode.<br>• Safety Mode – A system or PSHC fault has been detected. In this case, the PWM will be fixed at 40%. Contact Manufacturer |
| *Sensor/Controller State: Notification* | Notifications that are displayed indicate a fault in the system. Conditions under which notifications appear are defined in **Section 4.1 (Notifications)**. |

## 3.7 Recording Data

To record data with the PSHC, complete the steps below. If more than one PSHC is installed, refer directly to **Section 3.8.2 (Multiple PSHCs)** below.

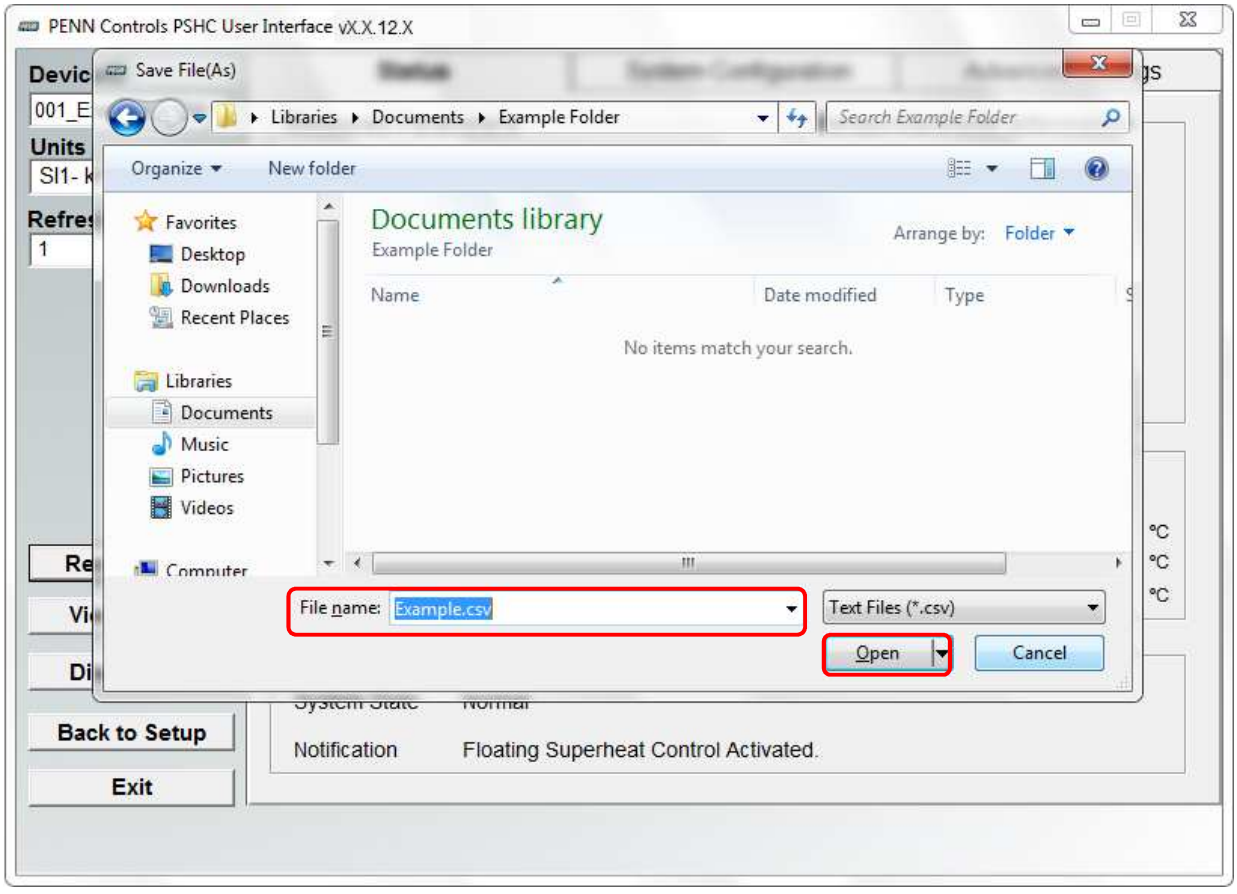
### 3.7.1 Single PSHC

1. Select an appropriate refresh rate for the data collection using the **Refresh Rate (sec)** drop-down menu in the left column of the **Status** tab. The refresh rate selection will impact:
    a. The status screen refresh rate.
    b. The rate at which data is recorded.
    c. The rate at which the run-time plot is updated to show new values.




2. Click the **Record Data** button.

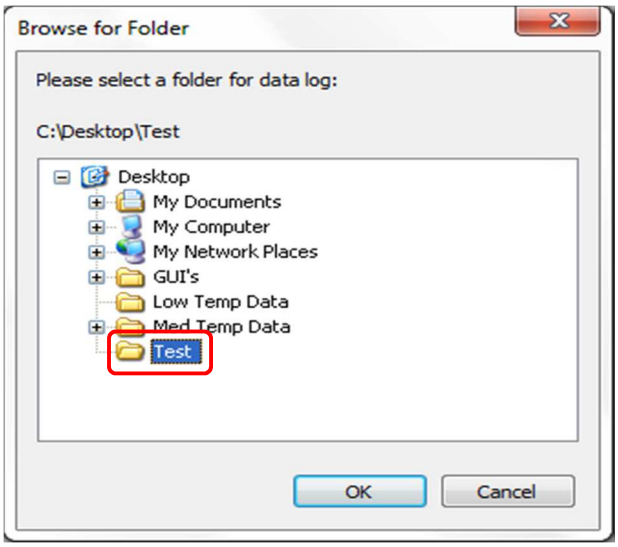
3. In the Save File (As) window that appears, select a suitable location to save the file to, enter an appropriate **File Name**, and then click **Open** to begin recording data. The **Record Data** button will be green and state **Recording Data** while data is being recorded.



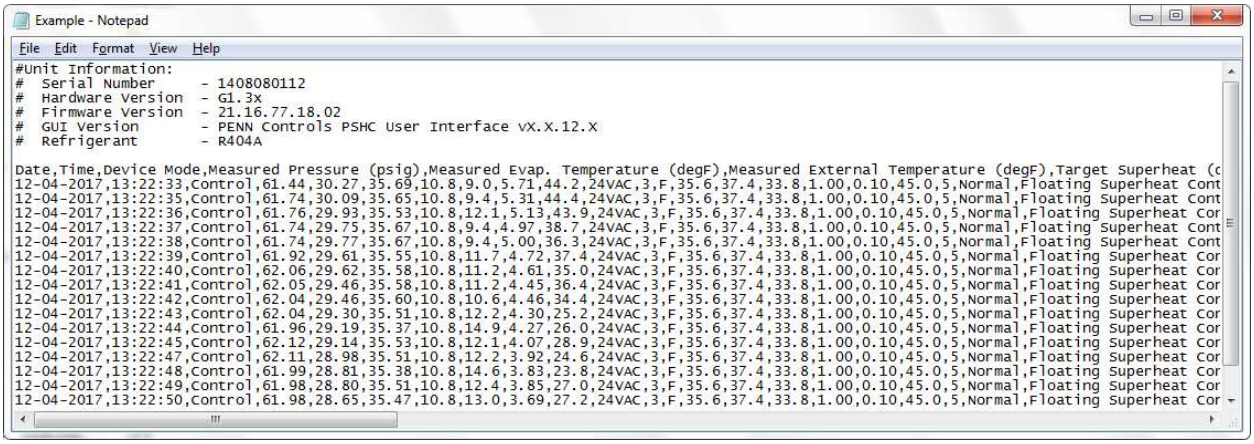
If data will be recorded for more than 4 hours, a 5-second refresh rate is recommended to reduce file size.

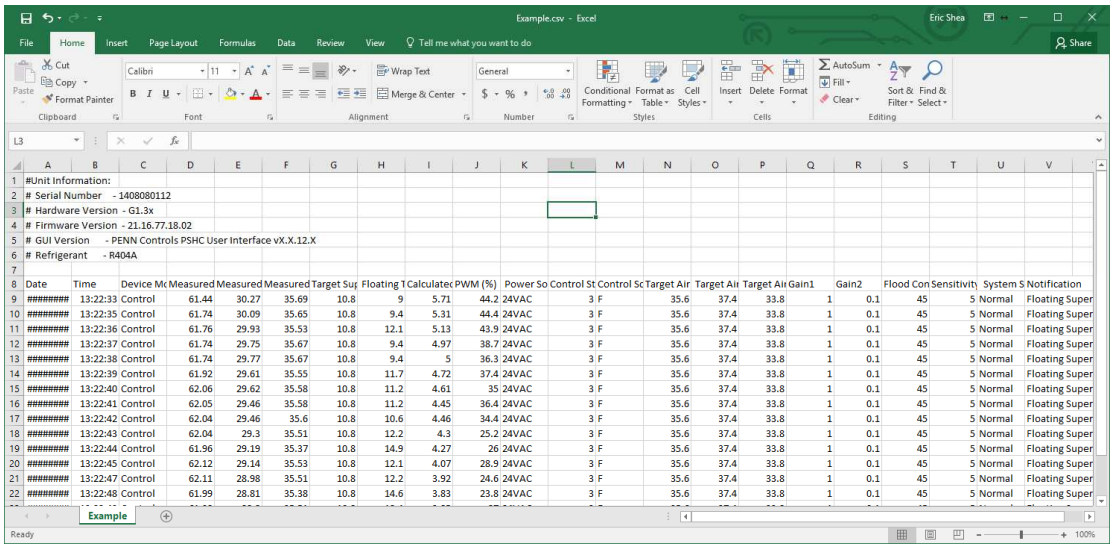
### 3.7.2 Multiple PSHCs

1. Click the **Record Multi Data** button.
2. In the Save File (As) window that appears, select a folder to save the files to and then click **Open** to begin recording data. The **Record Multi Data** button will be green and state **Recording Multi Data** while data is being recorded.




Comma Separated Value (CSV) files containing the data will be generated and named automatically once the user stops the data collection process. Each CSV will correspond to a different Device ID and contain only that Device IDs data.






The units of measurement for pressure and temperature in all data files are psig and °F, respectively, regardless of the units that the user has selected. This is the case with systems containing either a single PSHC or multiple PSHCs.

## 3.8 Plotting Data

The PSHC software is capable of generating a run-time plot of the Targeted Superheat, Calculated Superheat (SH), Measured Evap. Temperature, Measured External Temperature, Measured Gauge Pressure, and PWM. To plot data that is being recorded, complete the following steps:

1. Click the **View Plot(s)** button in the **Status** tab. A plot should appear in a new window with superheat and pressure run-time curves generating in the display.

2. The units of the values graphed in the plot can be changed through the **Units** drop-down menu in the **Status** tab.

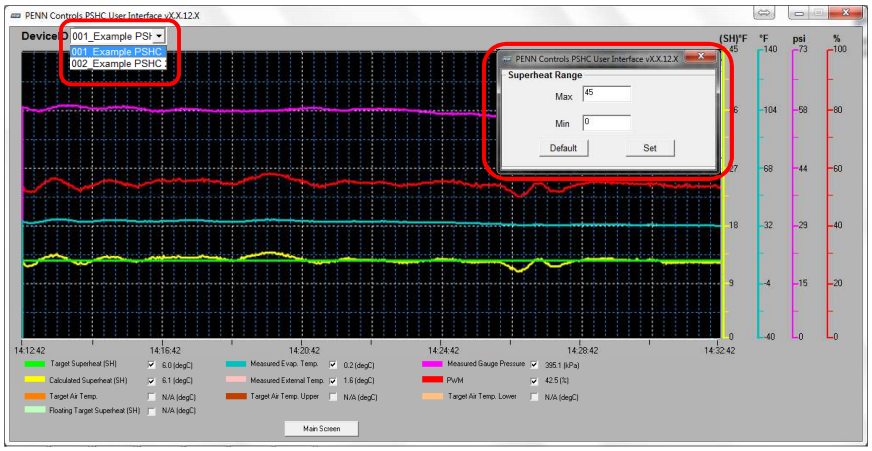
3. The range(s) of the axis (axes) of the parameter(s) displayed can be changed by double clicking the corresponding axis (axes). A new window in which the user can input a desired range for the parameter should pop up.

4. The **Refresh Rate (sec)** setting – which is only available when there is only one PSHC – proportionally affects the time range of data that is displayed in the plot.

   A 1-second refresh rate will plot 10 minutes of data;
   A 3-second refresh rate, 30 minutes of data;
   A 5-second refresh rate, 50 minutes of data.

5. The user may choose for all, some, or none of the parameters to be graphed in the plot by checking or un-checking the check boxes beside the parameter labels below the horizontal axis of the plot.

6. When there are multiple PSHCs, the plot only displays data pertaining to the Device ID currently selected in the **Device ID** drop-down menu at the top-left corner of the window.




To view the plot window, it is mandatory that the **Status** tab is active. Otherwise, the data collection process will pause and the plot will not be updated.

# 4 Alarms

The PSHC 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 PSHC at once.

## 4.1 Notifications

In the **Status** tab, the software will display notifications when errors are encountered. The table below lists the notifications and describes the conditions that trigger their appearance.

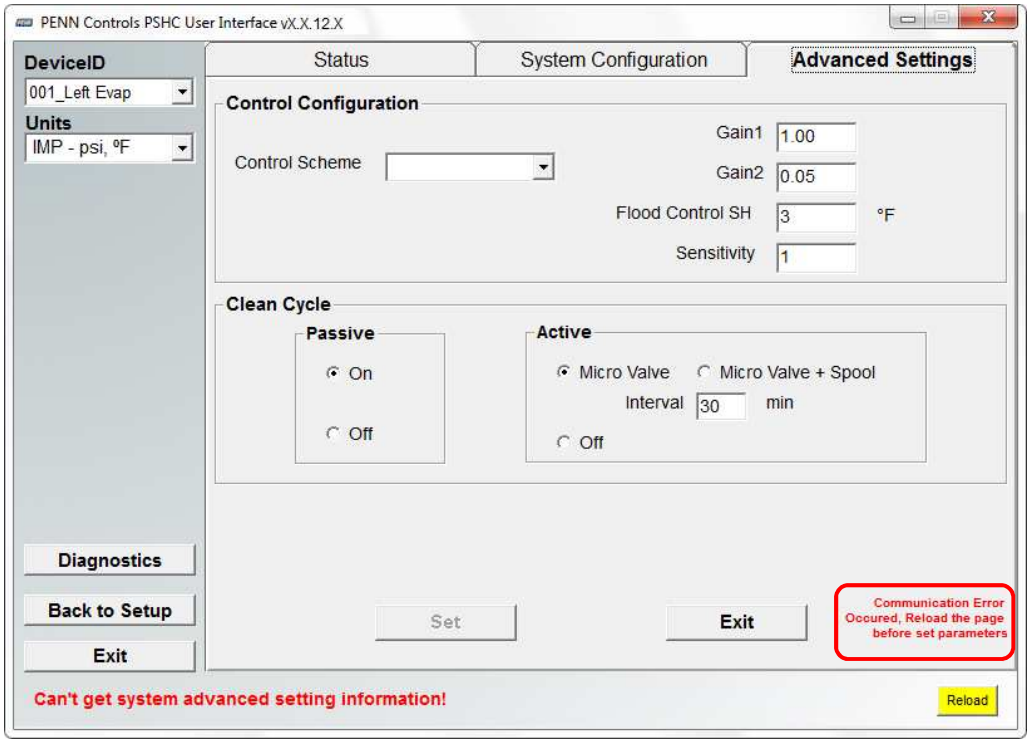
| Notification | Description |
|---|---|
| **PWM Toggle** | Enabled when the PWM is above 90% and steady superheat for 30 seconds. During the PWM toggle, the PWM continuously cycles between 80% and 5%. See section 6.1 for further information. |
| **High Input Voltage*** | The input voltage has exceeded 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. |
| **Temperature Control Activated** | The PSHC is controlling Air-Out Temperature (Control Scheme E) |
| **Floating Superheat Control Activated** | The PSHC is controlling Air-Out Temperature (Control Scheme F) |

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

## 4.2 Additional Messages

Additional messages are shown in red text at the bottom-left corner of the **Status** tab. The table below lists additional messages that the user may see and describes the conditions that trigger their appearance.

| Message | Description |
|---|---|
| **Communication Error Occurred, Reload the page before set parameters** | There was a Modbus communication error when changing tabs on the GUI. Please click the yellow 'Reload' button to refresh the page. |
| **Data recording and plot updating is paused. Return to status screen to continue** | The user is active in a tab other than the **Status** tab while data is being recorded and/or plotted. The user should return to the **Status** tab to continue the data collection process. |

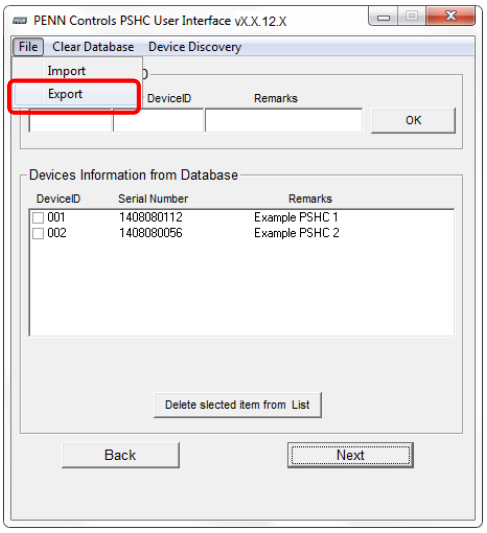


# 5 Additional Features

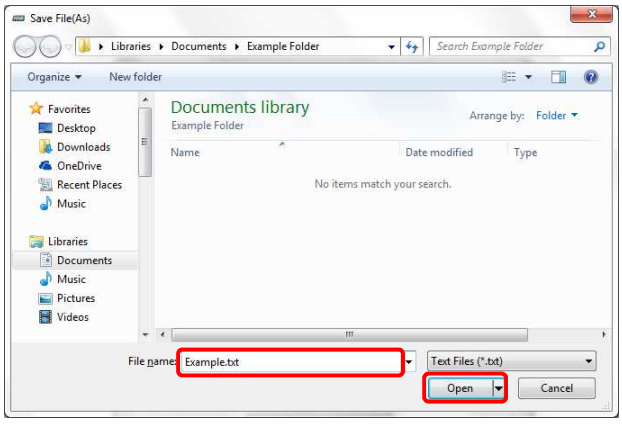
## 5.1 File Export/Import

The **File Export/Import** feature allows the user to save the database of Device IDs (export the database to a text file) and use it later (import the text file to load the database) if the database is needed again. This feature helps protect the user from the loss of the database, which could occur if the user clears the database by clicking **Clear Database** or if the computer used is changed. It eliminates the need to manually recreate a database, which can potentially be time consuming if there are multiple PSHCs networked together. The steps below show how to use the **File Export/Import** feature.

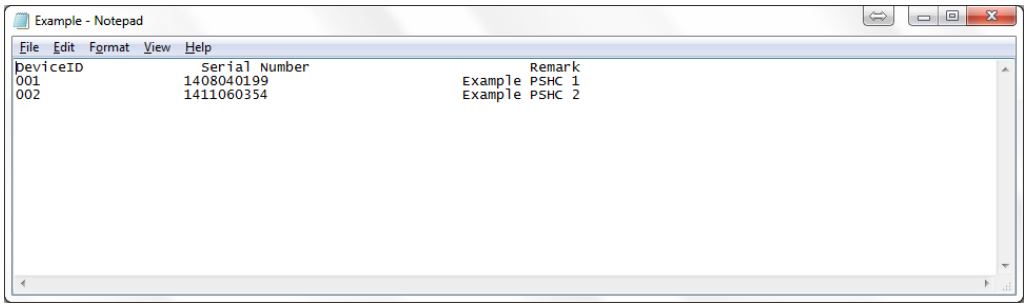
1. Click **File > Export** at the top of the Device ID Setup window seen in **Section 3.2 (Assigning a New Device ID)**.



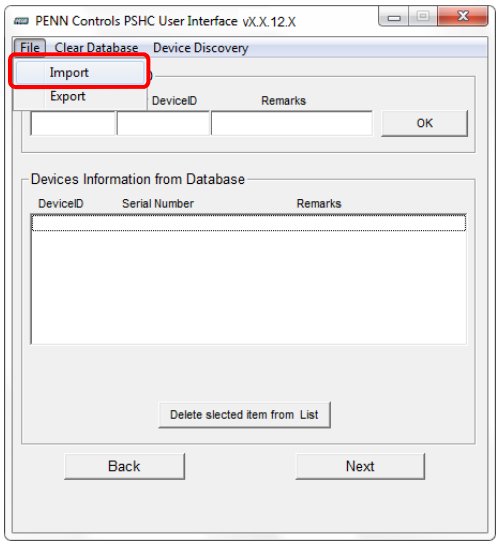

2. In the Save File (As) window that appears, select a suitable location to save the file to, enter an appropriate **File Name**, and then click **Open** to export and save the current database as a text file.



3. The database will be stored in the text file as shown in the figure below.




4. The user can import exported databases by clicking **File > Import** and selecting the appropriate text file.




The **Clear Database** button at the top of the window allows the user to clear all the Device ID information in the database. It is typically used when a new database needs to be created and provides a quick way to delete previous database information all at once. The **Delete selected item from List** button below the Database allows the user to delete the Device ID information of only selected Device IDs within the Database. To select a Device ID, check the box next to it in the Database.

## 5.2 Device Discovery

The Device Discovery feature allows the user to obtain PSHC Device IDs when one or more Device IDs are unknown. To use the Device Discovery feature, complete the following steps:

Device Discovery does not work for multiple PSHC in a network where one or more PSHC have the same Device ID.

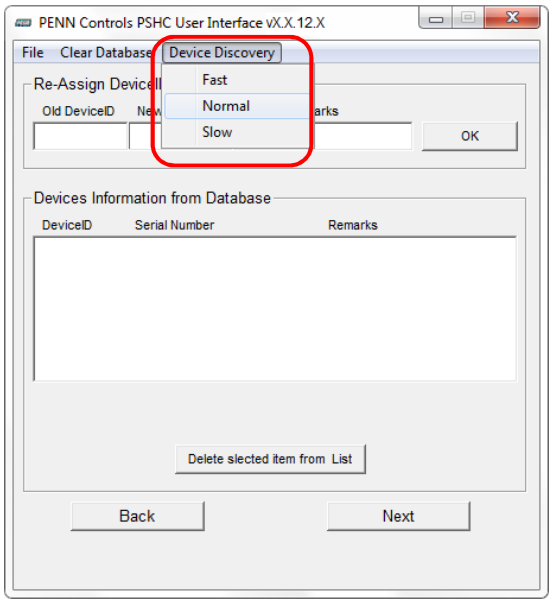
1. Ensure that power is being supplied to all PSHC by checking that the wiring harnesses are firmly attached to each device.

Review the **Multiple PSHC-QREVs** section in the **QREV and PSHC Hardware Installation Manual** to learn about networking with more than one PSHC device.

2. Select the Device Discovery drop-down menu and choose **Fast**, **Normal**, or **Slow** speed.

| Device Discovery Speed | Wait Time (min) | Reliability |
|---|---|---|
| **Fast** | 15 | Good |
| **Normal** | 30 | Better |
| **Slow** | 45 | Best |

Please be patient as Device Discovery will require the full wait time in order to execute properly. Also, note that the check for Device ID #1 may not display during the Device Discovery process.




3. Please wait for Device Discovery to complete. Once completed, load the PSHC Device IDs into the database by clicking **Yes** on the popup window.

# 6 Appendix – *Explanation of Control Schemes A through F*

## 6.1 Control Scheme A

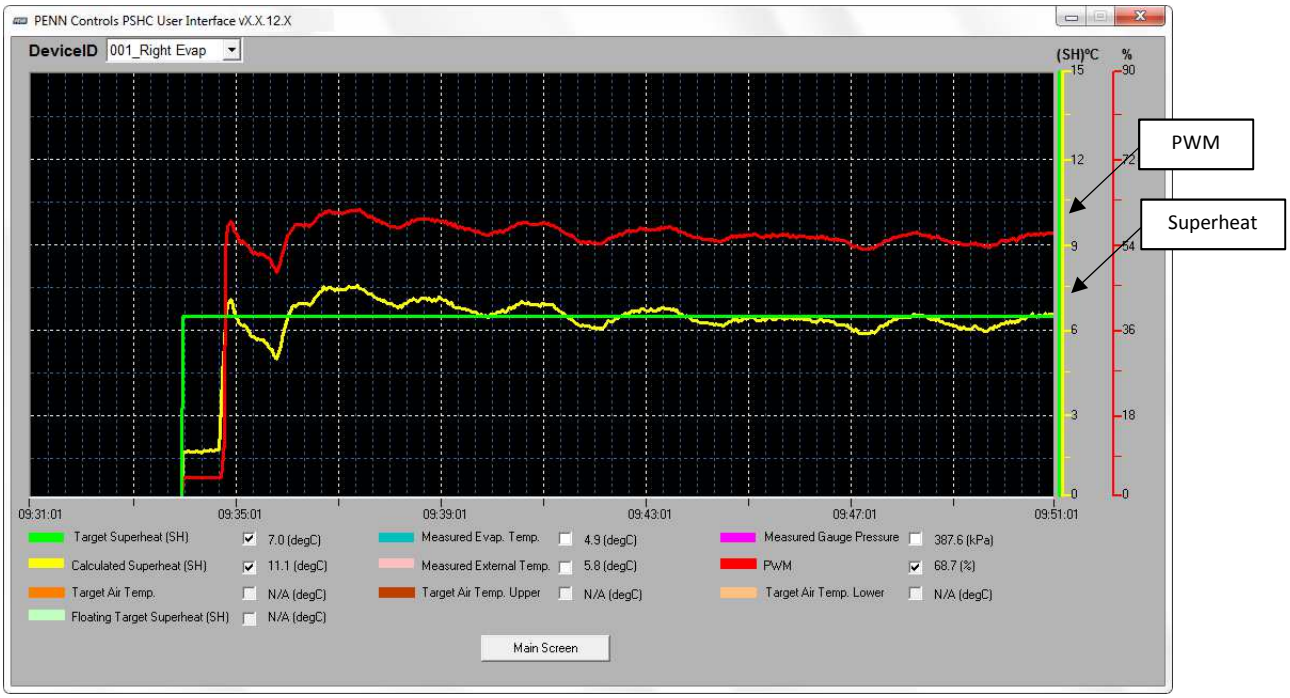
*Control Scheme A* is the default Control Scheme and used to control the superheat towards a user-defined Superheat Setpoint. This control scheme is applicable for both HVAC and Refrigeration Systems. The Calculated Superheat is the feedback parameter used for closed-loop control. The main feature of 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.

***Gain 1:***

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

$$Gain\ 1 * (Superheat\ Setpoint - Calculated\ Superheat)$$

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



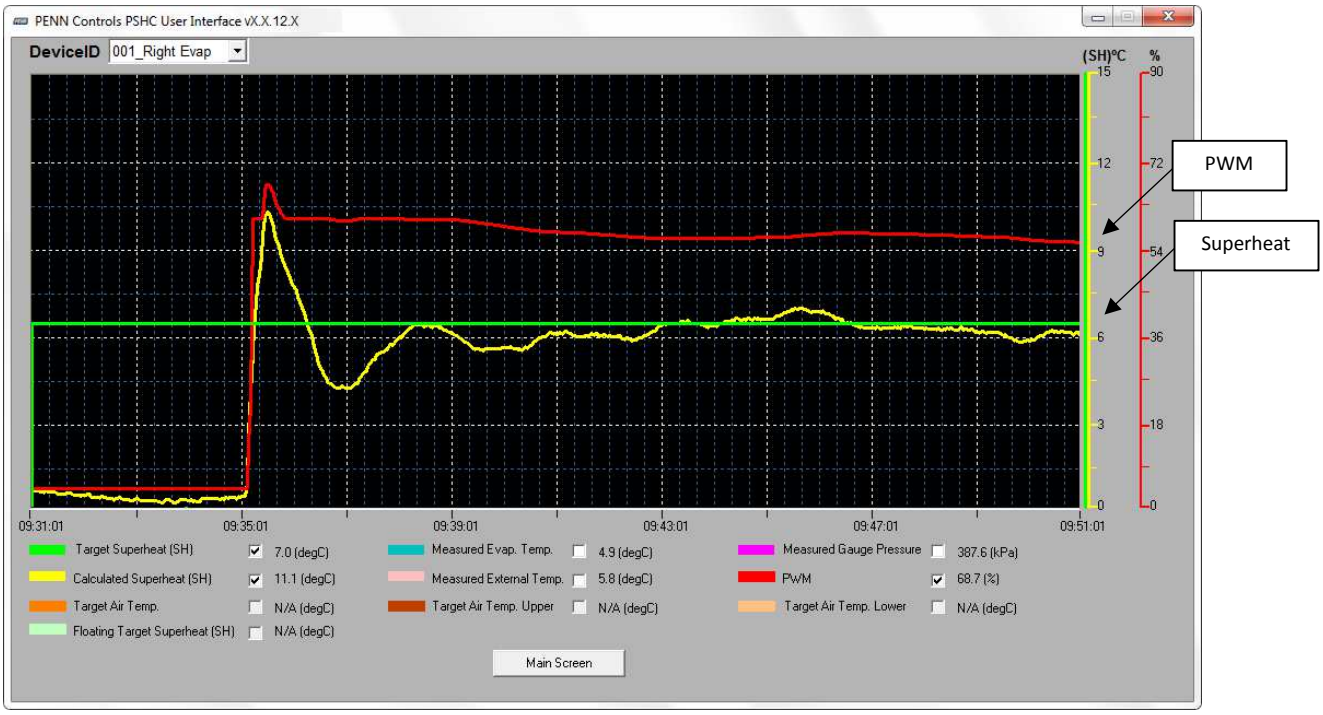

The plot above demonstrates the scenario of $Gain\ 1 \gg Gain\ 2$, in which *Gain 1* dominates. PWM responds to superheat error in a proportional manner.

***Gain 2:***

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

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

The recommended default value is 0.1.




The plot above demonstrates the scenario of $Gain\ 2 \gg Gain\ 1$, in which *Gain 2* dominates. PWM responds to superheat error as a summation over time.

The below combination of *Gain 1* and *Gain 2* settings 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 |

***Sensitivity:***

*Sensitivity* is used to detect sudden changes in pressure such as compressor ON, OFF, etc. When the standard deviation of Evaporator Out 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.

***Flood Control SH:***

*Flood Control Superheat* is used as a safety feature to prevent compressor flood back from occurring in the system. If the system Calculated Superheat falls below the 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).

***Passive Clean Cycle:***

The *Passive Clean Cycle* is another safety feature. The purpose of the *Passive Cleaning Cycle* is to minimize the contaminant build up for the MEMS microvalve. When this feature is ON, the PWM frequency is adjusted to 12 Hz for the first second of every minute. This allows the MEMS microvalve to achieve full stroke and eliminate contaminant buildup. It is recommended to always have this feature ON.

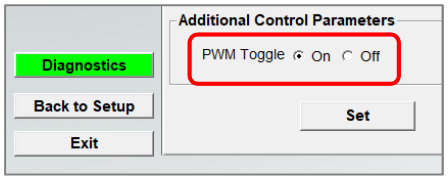
***Active Clean Cycle:***

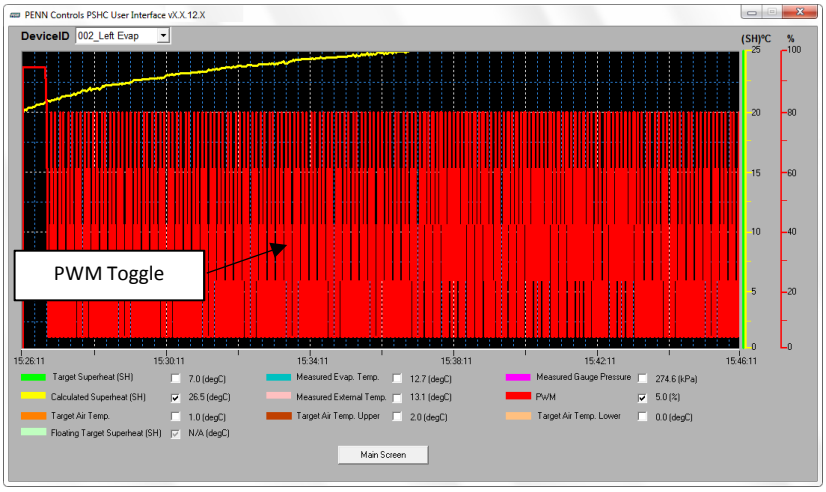
The *Active Clean Cycle* is yet another safety feature to minimize the contaminant build up for either 'MEMS Micro Valve' or 'MEMS Micro Valve + Spool' depending upon user selection. Below describes the difference between these two settings. The recommended option is 'Micro Valve + Spool'.

| 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 first second, pulse the QREV with 80% PWM and 5% PWM in 500 ms durations. | 20 minutes |

***PWM Toggle***

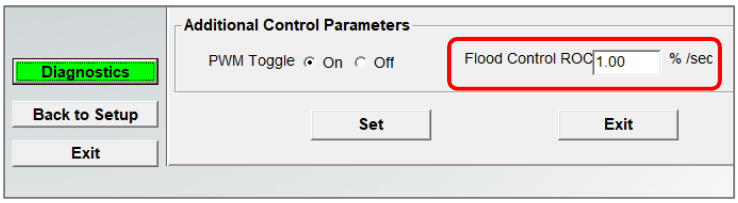
The objective of *PWM Toggle* is to conserve power and prevent overheating of the QREV. It is intended to occur during system OFF and defrost cycles in HVAC-R systems. When the superheat is stable and the PWM value goes above 90% for 30 seconds, *PWM Toggle* is initiated. The PSHC will command the QREV between 80% and 5% PWM indefinitely. When the superheat starts to fluctuate, *PWM Toggle* automatically disables and control algorithm resumes normal operation. The recommended default setting for *PWM Toggle* is ON. It can be turned OFF using the Diagnostics menu. It is password protected, please contact the manufacturer for the password.



***Flood Control ROC (Flood Control Rate of Change):***

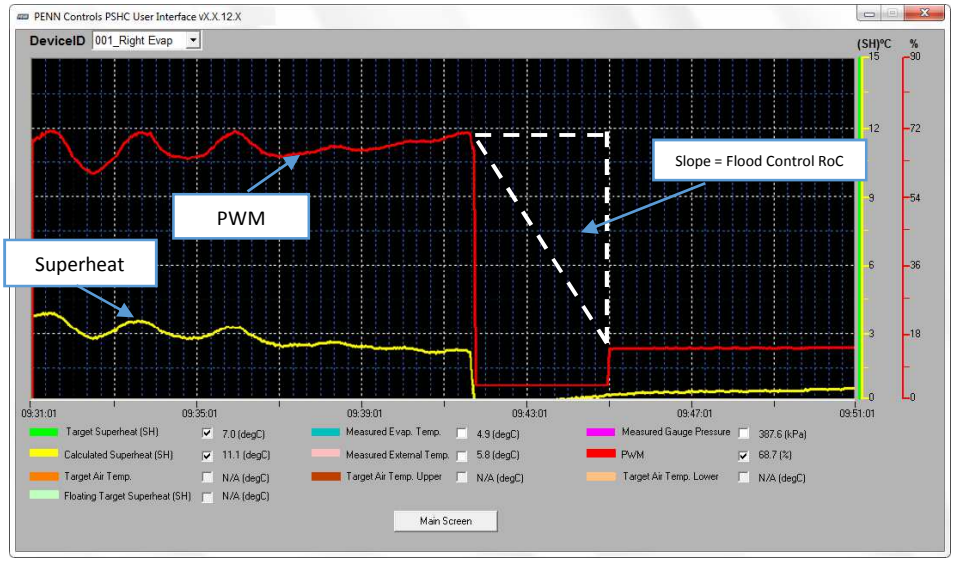
*Flood Control ROC* is a setting used in conjunction with the *Flood Control SH* parameter. It can be found in the Diagnostics menu.




*Flood Control ROC* is best explained by example: Let's say your refrigeration system is operating at 60% PWM and the Calculated Superheat falls below the Flood Control Superheat setting. The PWM will then suddenly fall to 5% to increase the superheat. Let's say after 10 seconds the superheat rises back above the Flood Control Superheat value. The system will then resume normal operation. But at what PWM value? 60%? Not quite. This is where the *Flood Control ROC* value is realized. The PWM value that is initialized after a Flood Control cycle is equal to:

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

In this example, if the *Flood Control ROC* value is 1%/sec, the PWM initialized after a Flood Control cycle would be equal to (60 – 1 * 10) = 50%.




## 6.2 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 will *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.

## 6.3 Control Scheme E

*Control Scheme E* is applicable only for Refrigeration systems. *It* utilizes Air-Out Temperature as an additional input for control. There are two basic requirements to use *Control Scheme E*:

- ✓ *PSHC must have updated Firmware to either v21.16.12.18.03 or v22.16.12.34.01*
- ✓ *PSHC must have an installed secondary external thermistor to measure Evaporator Air-Out Temperature*

*Control Scheme E and F* has newly defined parameters:

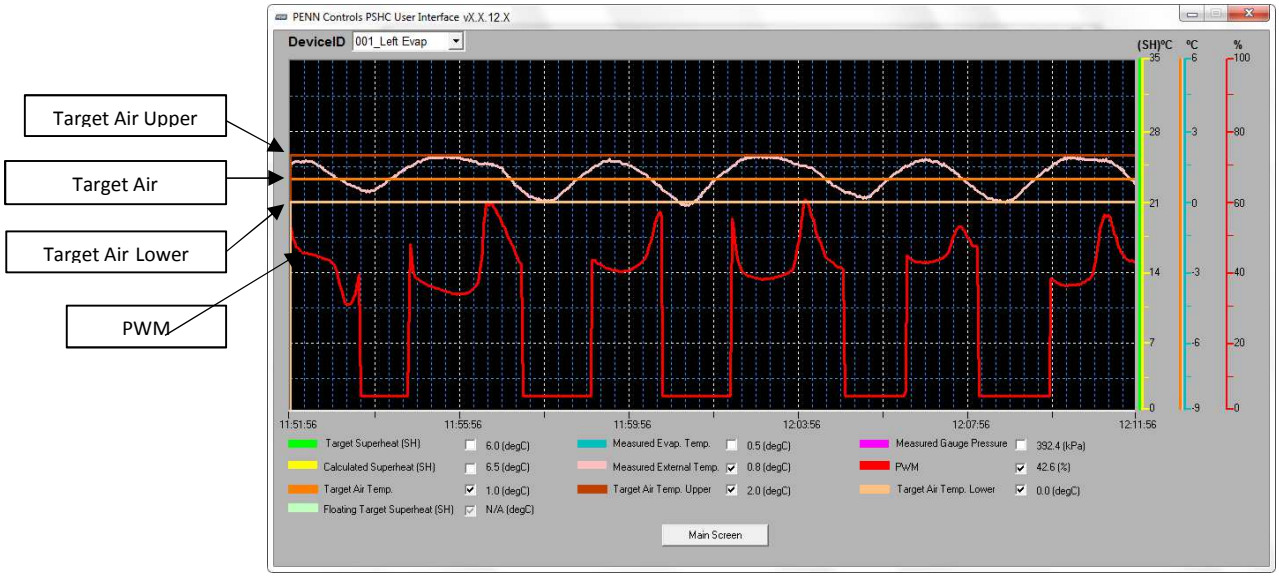
**Target Air Temp Upper Limit -** *The maximum desired Air-Out Temperature*
**Target Air Temp -** *The desired Air-Out Temperature*
**Target Air Temp Lower Limit -** *The minimum desired Air-Out Temperature*

The control logic for *Control Scheme E* cycles between the following conditions:

**Condition 1.** When the case temperature rises above the midpoint of Target Air Temp and Target Air Temp Upper Limit, PSHC to run the standard target superheat control to cool the case temperature. Hold Condition 1 until Condition 2 is met.

**Condition 2.** When the case temperature falls below the midpoint of Target Air Temp and Target Air Temp Lower Limit, PSHC to close the QREV (PWM = 5%) so that the case 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 active example of *Control Scheme E*. Note that as Air-Out Temperature falls below the midpoint of its target and its lower limit, the PWM will fall to zero instantaneously. Similarly, when Air-Out Temperature rises above the midpoint of its target and its upper limit, the PWM will begin controlling superheat as normal. These features are in place to control Air-Out Temperature about its target.

## 6.4 Control Scheme F

*Control Scheme F* is applicable only for Refrigeration systems as well. *It* operates similarly to *Control Scheme E.* It too utilizes Air-Out Temperature as an additional input for control. The requirements for *Control Scheme F* are the same as for *Control Scheme E*:

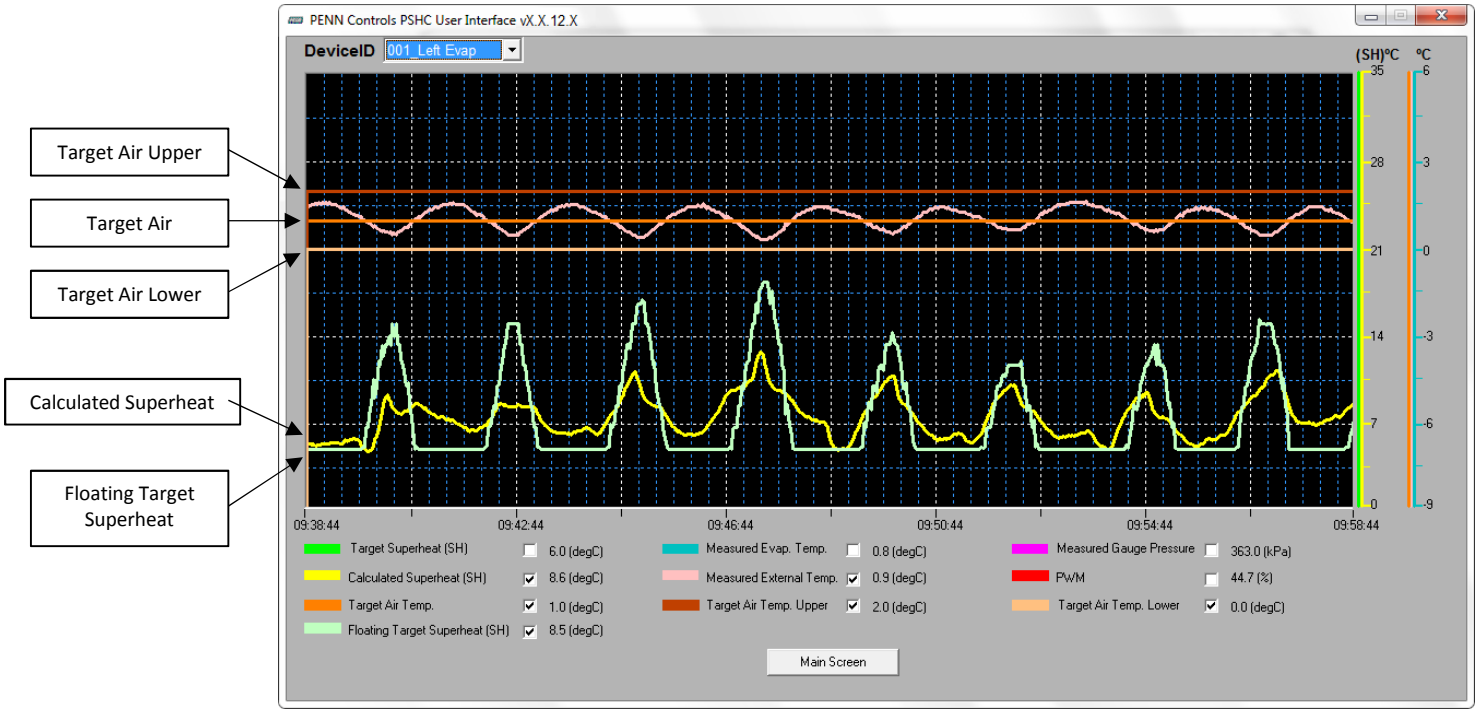
- ✓ *PSHC must have updated Firmware to either v21.16.12.18.03 or v22.16.12.34.01*
- ✓ *PSHC must have an installed secondary external thermistor to measure Evaporator Air-Out Temperature*

The control logic for *Control Scheme F* cycles between the following conditions:

**Condition 1.** When the case temperature rises above the Target Air Temp, PSHC to run the standard target superheat control to cool the case temperature. Hold Condition 1 until Condition 2 is met.

**Condition 2.** When the case temperature falls below the Target Air Temp, dynamically float the superheat target to control the case 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 active 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.