SMART MANUFACTURING

HANDS-ON ACTIVITIES:

WORKSTATION SETUP

ITEMS NEEDED FOR HANDS-ON ACTIVITIES

Amatrol Supplied
1 990-SM10 Smart Manufacturing Learning System

Customer Supplied
1 Computer with Windows 10 Operating System, with Mozilla Firefox, Microsoft Edge, or Google Chrome Web Browser

Optional Equipment
1 43110 External Current Sensor

FIRST EDITION, MODULE 1, REV. A

Amatrol,Inc., 2400 Centennial Blvd., Jeffersonville, IN 47130 USA, Ph 812-288-8285, FAX 812-283-1584 www.amatrol.com

ACTIVITY 1 — WORKSTATION SETUP

PROCEDURE OVERVIEW

In this procedure, you will identify the components of the 990-SM10 Smart Manufacturing system. You will then power up and perform basic functionality checks.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system as shown in Figure 1-1.

Figure 1-1. 990-SM10 Smart Manufacturing System

2. Perform the following substeps to locate the system components of the 990-SM10 Workstation.

   A. Locate the International Electrotechnical Commission (IEC) IEC connector on the workstation.

      The IEC power cord supplies power to the workstation through this receptacle, as shown in figure 1-2.

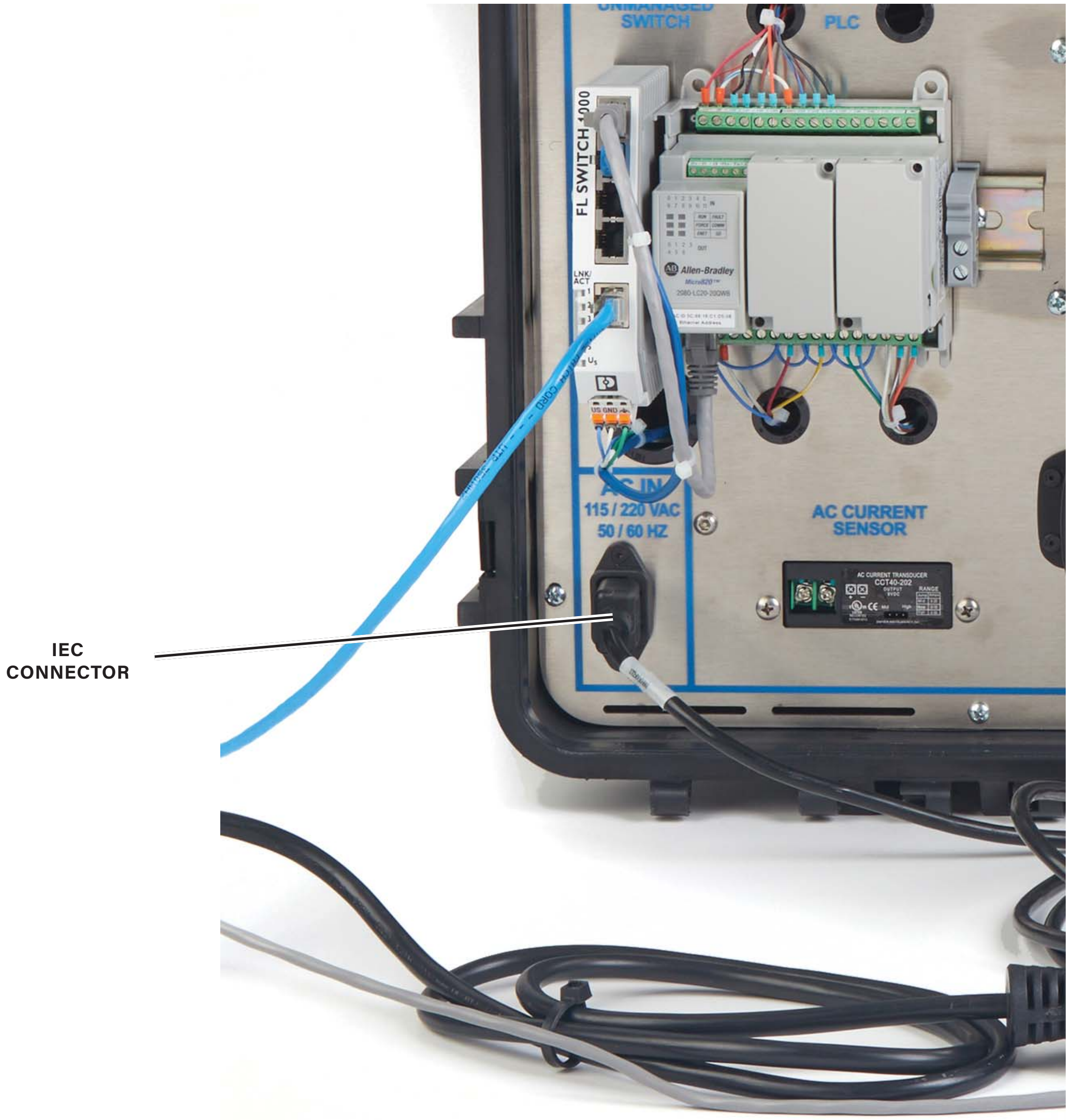

Figure 1-2. Workstation IEC Connector

   B. Locate the workstation's Main Power switch on the panel.

      This main power switch is used to power up and power down the workstation.

C. Locate the unmanaged network switch on the panel.

The unmanaged network switch is used to connect Ethernet ports of multiple devices, such as the PLC and BorgConnect Hub, through one network connection. There should be an Ethernet cable connecting the switch to your local network, shown in figure 1-3. The network is the pathway between two or more computers to share data, files, resources, or communications.

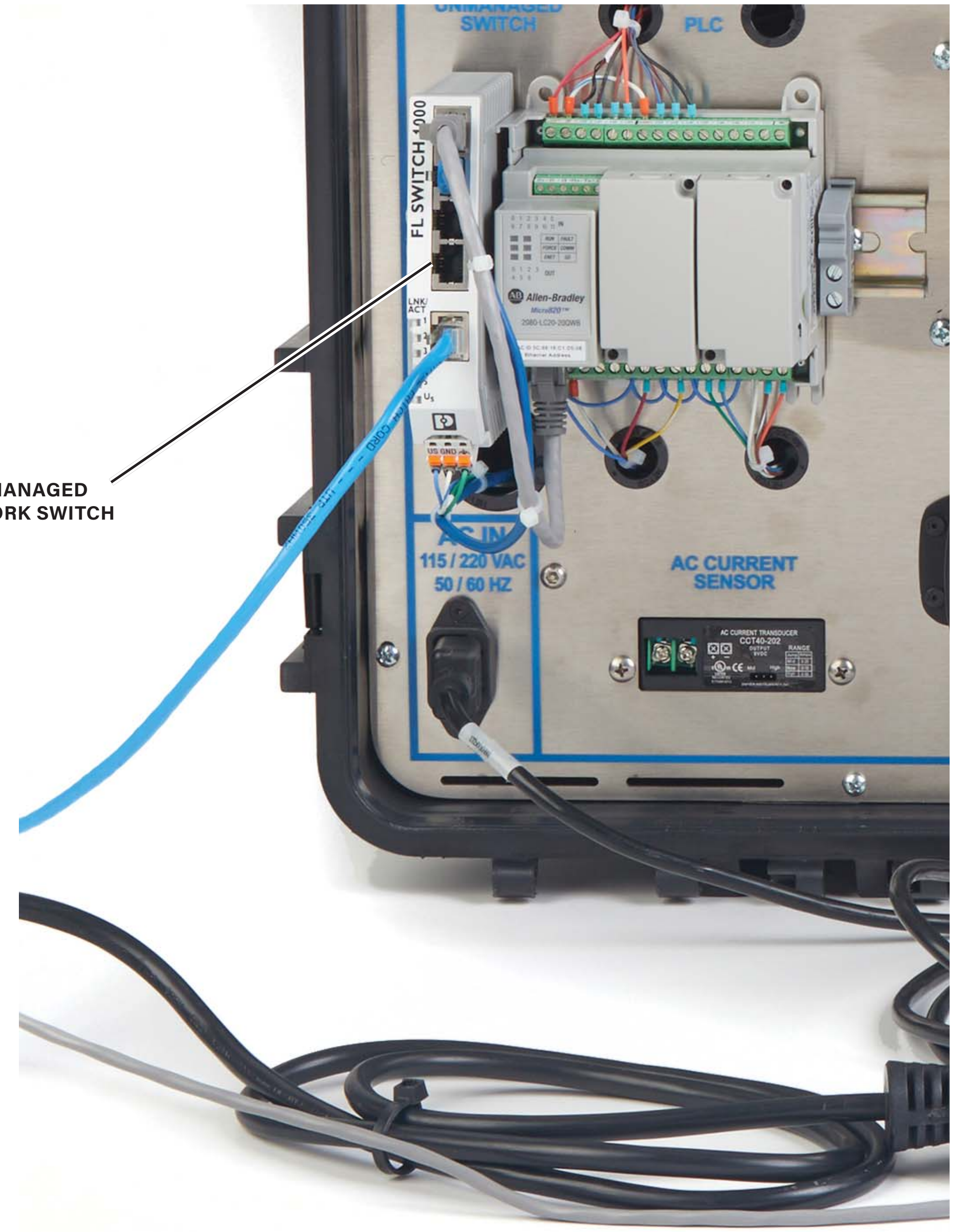

Figure 1-3. Unmanaged Network Switch

D. Locate the programmable logic controller (PLC) on the panel.

A programmable logic controller (PLC) is an industrial computer control system that monitors analog and/or digital input signals and uses a custom program to make decisions to change the state of output devices.

E. Locate the BorgConnect Hub to the right of the PLC.

The BorgConnect Hub is a computer system that communicates through wired Ethernet, Bluetooth, and Wi-Fi connections. On the 990-SM10 workstation, the BorgConnect Hub uses a wired Ethernet connection with the

PLC and PC, a Bluetooth connection with the Bluetooth scanner, and a Wi-Fi connection with the BorgConnect Node, and NCD Wi-Fi temperature sensor. The BorgConnect Hub is being used here to collect data, to store data short term, and to display data on a PC using the BorgConnect Dashboard software.

F. Locate the BorgConnect Node below the BorgConnect Hub.

The BorgConnect Node collects data from wired analog sensors, converts the data to digital signals and transmits the data to and the BorgConnect Hub. The node can connect to up to six analog input sensors, three current inputs and three voltage inputs. The three current inputs operate in a range 0 mA to 50 mA and the three voltage inputs operate in a range of 0 V to 5 V. The BorgConnect Node provides wireless or wired Ethernet communications to the BorgConnect Hub.

On this Workstation, the BorgConnect Node are wired to the load cell, AC current sensor, vibration sensor, and User inputs 1, 2, and 3, as shown in figure 1-4.

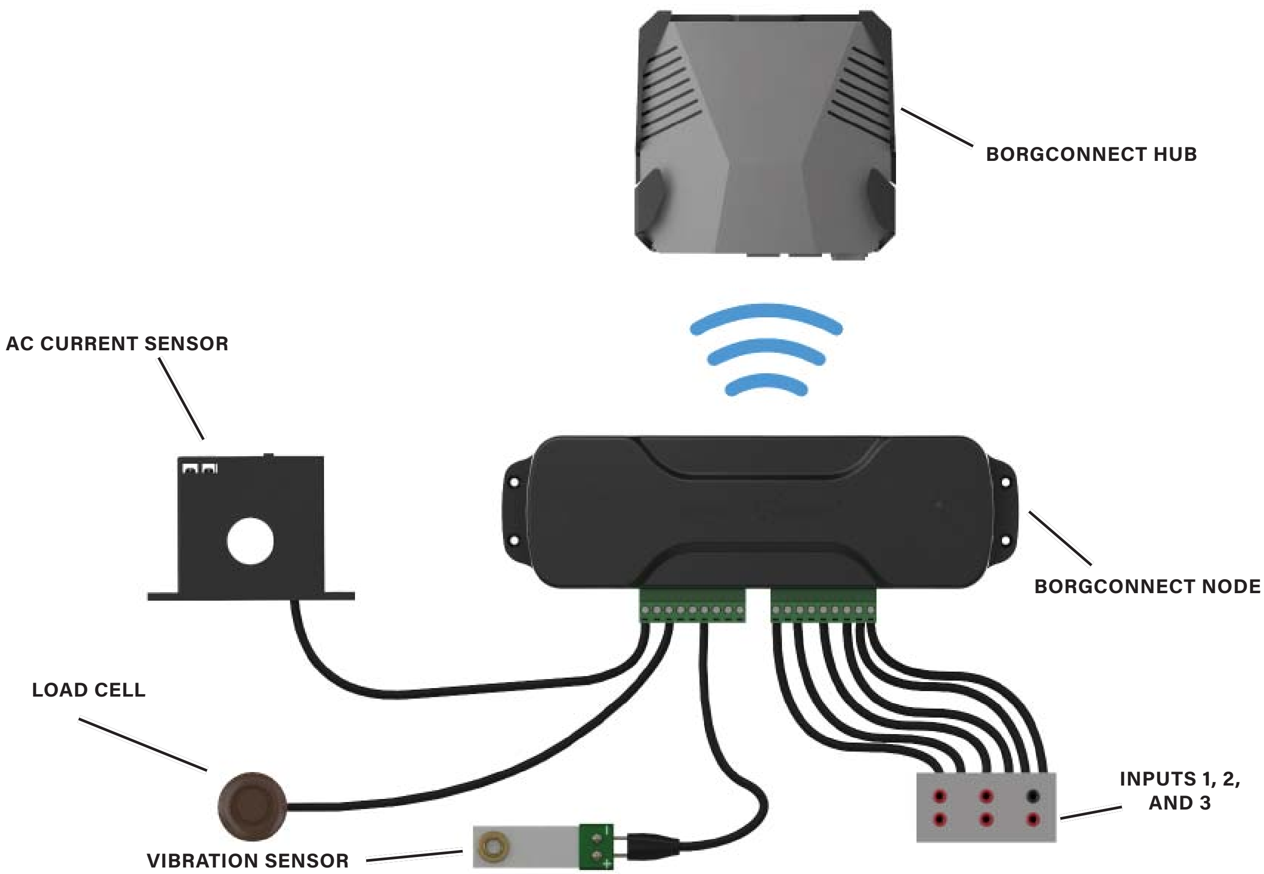

Figure 1-4. BorgConnect Node Connections

G. Locate the Vibration Motor on the panel.

The vibration motor is used to demonstrate vibration sensor data. Vibration monitoring can help to identify mechanical failures before they become mechanical breakdowns. The strength of the vibrations experienced by the vibration sensor is monitored in the BorgConnect Dashboard software using the Motor Vibration Monitoring application.

H. Locate the Interlock Door that covers the Vibration Motor.

The interlock door works as a safety door to protect people around the motor. When the door is opened, the door switch sends a signal to the PLC, causing the motor to stop. While the interlock door is open, the motor cannot be started. Once the interlock door is closed, the door switch will signal the PLC to allow the motor to be started again.

This door uses an inductive sensor, which is wired to a 24 V digital input of the PLC.

I. Locate the NCD Wi-Fi Temperature/Humidity Transmitter on the panel.

The NCD Wi-Fi Temperature/Humidity Transmitter connects through a single cable on the side of the transmitter to wired analog temperature and humidity sensors. This transmitter uses an MQ Telemetry Transport (MQTT) protocol to stream ambient air temperature and humidity sensor data to the BorgConnect Hub through a wireless connection. The MQTT protocol is an efficient and lightweight messaging/data transport between Internet of Things (IoT) devices like the temperature transmitter. The sensor data can be viewed on the BorgConnect Dashboard software.

The Transmitter panel mounting is designed so it can easily be removed and moved to a different location than the Workstation. Its Wi-Fi communications allow it to stream data to the Hub from a remote location.

Figure 1-5. Wi-Fi Temperature/Humidity Transmitter and Sensor Setup

J. Locate the wired Temperature / Humidity Sensors, which measure the ambient air temperature and humidity at the workstation, shown in figure 1-5.

These sensors are combined in a single unit and connected to the NCD Wi-Fi Temperature Transmitter through a cable.

K. Locate the AC Current Sensor mounted on the panel.

The current sensor uses a current transformer to measure the power consumed by the system. This current sensor measures incoming power to the entire 990-SM10 Workstation.

The transformer outputs an analog voltage signal that is measured to determine the current that passes through the system.

Amatrol also offers an optional 43110 remote current sensor that can be used to measure the current of devices outside of the workstation.

L. Locate the Load Cell/Parts Counter on the panel.

The load cell uses strain gauges to measure force. For this workstation, the voltage signal from the load cell is converted into weight in grams. By determining the weight of one fastener, a larger quantity can be weighed, and a quantity can be calculated.

$$Total\ Quantity = \frac{Total\ Weight}{Fastener\ Weight}$$

Figure 1-6. Load Cell Setup for Measurement

M. Locate the Bluetooth Scanner as shown in figure 1-7. This is a loose item, not attached to the workstation.

The Production Quantity App in the BorgConnect Dashboard software uses the Bluetooth Scanner to scan a barcode printed on a sheet of paper that identifies the type of fasteners being counted. The Bluetooth scanner transmits the data of the barcode scanned of a given fastener to the BorgConnect Hub via wireless Bluetooth communication.

To count parts, fasteners are added to the parts counter hopper. The Production Quantity App then uses the scanned data and the unit weight of the given fastener to calculate parts count.

Figure 1-7. Bluetooth Scanner

N. Locate the Indicator Lights on the panel.

There are five indicators, each a different color: red, yellow, green, blue, and white. These indicators are wired to 24 VDC PLC digital outputs and can be controlled by the PLC logic program. They are used for different applications to indicate the status of the application.

O. Locate the Operator Controls on the panel.

These operator controls allow the user to send inputs to the PLC for user designed activities. Switch 1 (SS1), Switch 2 (SS2), Push Button 1 (PB1), and Push Button 2 (PB2) are wired to 24 VDC digital PLC inputs. The Potentiometer 1 (POT 1) is wired to an analog PLC input.

P. Locate the User Inputs on the panel: IN 1, IN 2, and IN 3.

These user inputs are wired to the BorgConnect Node to collect analog data from external analog input devices. External devices are connected to these inputs through pairs of jacks on the front of the panel. IN 1 and IN 2 are current inputs, with a range 0 mA to 50 mA. IN 3 is a voltage input with a range of 0 V to 5 V.

IN 3 is also the designated connection for the optional Amatrol Current Sensor 43110.

Q. Locate the Cooling Fan and Heater on the panel.

The cooling fan motor and heater are all controlled by the PLC 24 V digital outputs. The heater and cooling fan are used to raise and lower the internal temperature of the workstation.

The heater uses a resistor that is built into a metal block mounted behind the panel and is in line with the flow of air from the fan.

A thermistor temperature sensor is also attached to the heater assembly and wired to the PLC analog input. The PLC uses the signal from the thermistor to determine the temperature and when to turn the fan and heater on.

3. Perform the following substeps to connect the cords and cables to the workstation for operation.

A. Connect the IEC power cord to the IEC connector on the workstation and an AC wall outlet, as shown in figure 1-8.

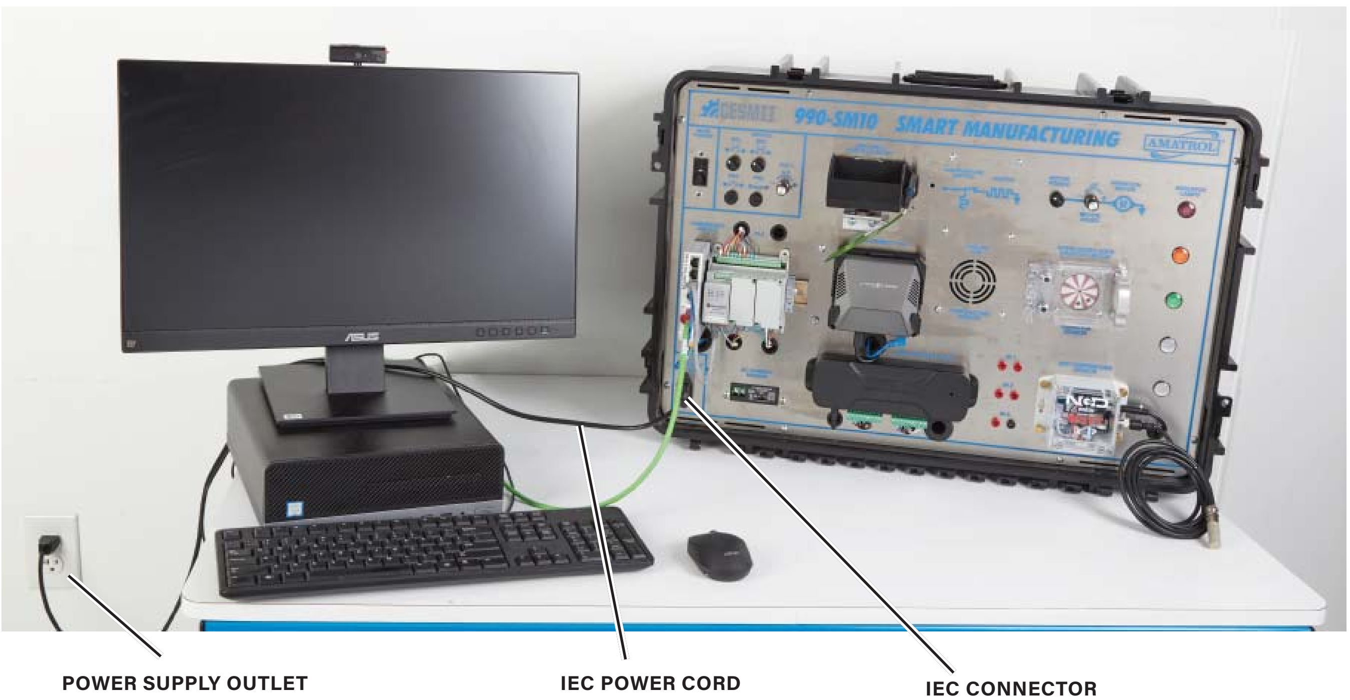

Figure 1-8. IEC Power Cord Plugged into IEC Connector and Power Supply Outlet

B. Connect the Ethernet cables between the unmanaged switch, PLC, and the PC as shown in figure 1-9.

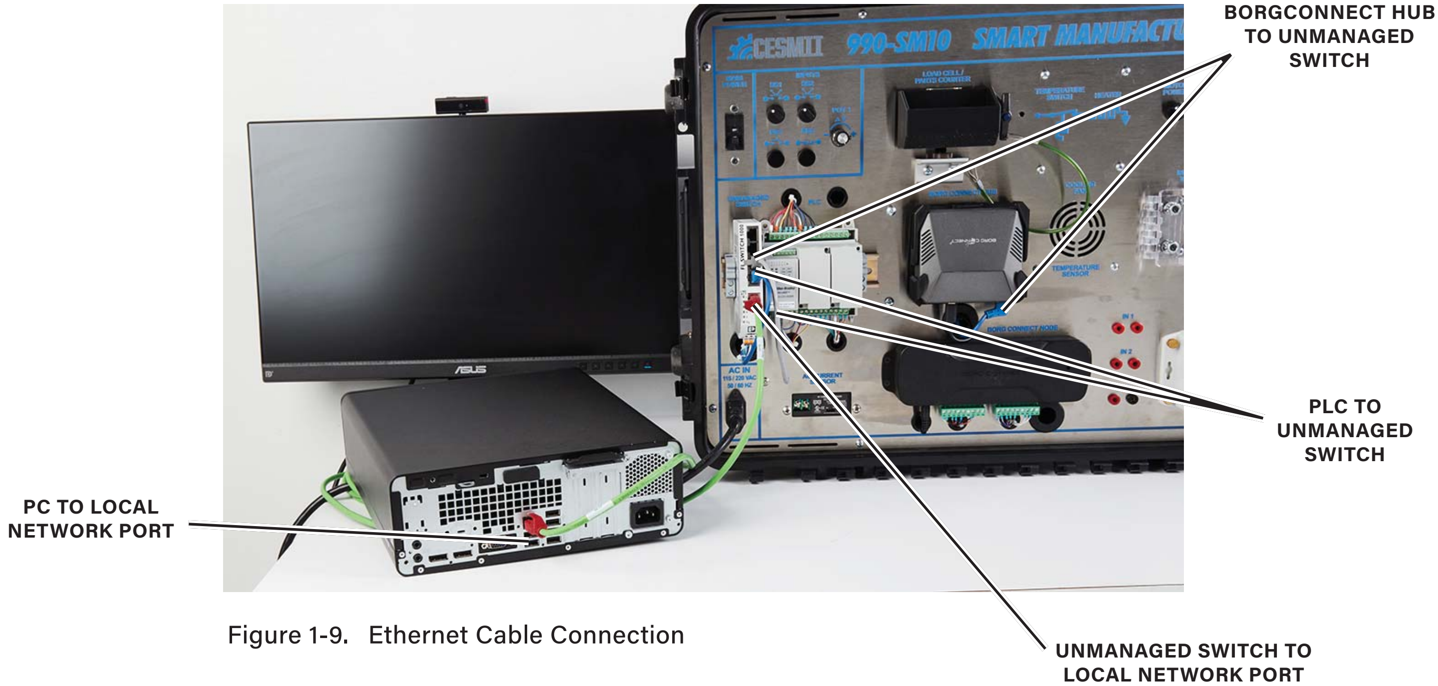

Figure 1-9. Ethernet Cable Connection

4. Turn on the PC and monitor.
5. Flip the main power switch on the 990-SM10 Workstation to **ON** to power up the workstation.

   Once power is on to the workstation, the switch, PLC, BorgConnect Node, and the Wi-Fi temperature/humidity sensor will all turn on an indicator on their enclosures to show they are powered up.
6. Press the power button on the BorgConnect Hub to turn it ON.

   Once the BorgConnect Hub has powered on, a red indicator on the front of the Hub will turn ON.

   The BorgConnect Node will automatically connect to the BorgConnect Hub via a Wi-Fi connection that was made before the workstation shipped from Amatrol.

Figure 1-10. BorgConnect Hub Power Button

7. Perform the following substeps to open the Smart Manufacturing HMI application on your PC.

   A. Click on the FactoryTalk View ME Station 990 SM10 runtime icon in the desktop of the PC, shown in figure 1-11.

      A dialog will appear prompting “Do you want to allow this app to make changes to your device?” as shown in figure 1-12

Figure 1-11. FactoryTalk View ME Station 990 SM10 Runtime Icon

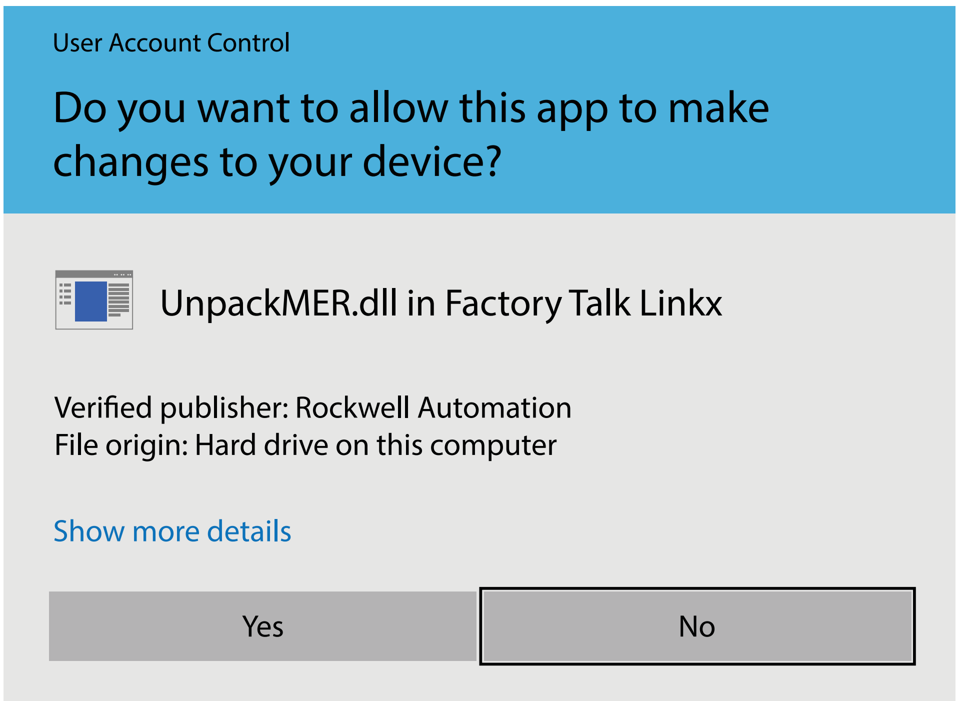

Figure 1-12. Administrative Permission Window

B. Click **Yes.**

After a short load time the Smart Manufacturing System main screen will appear, as shown in figure 1-13.

The Smart Manufacturing HMI application main screen displays three HMI applications and buttons for IO status and Shutdown.

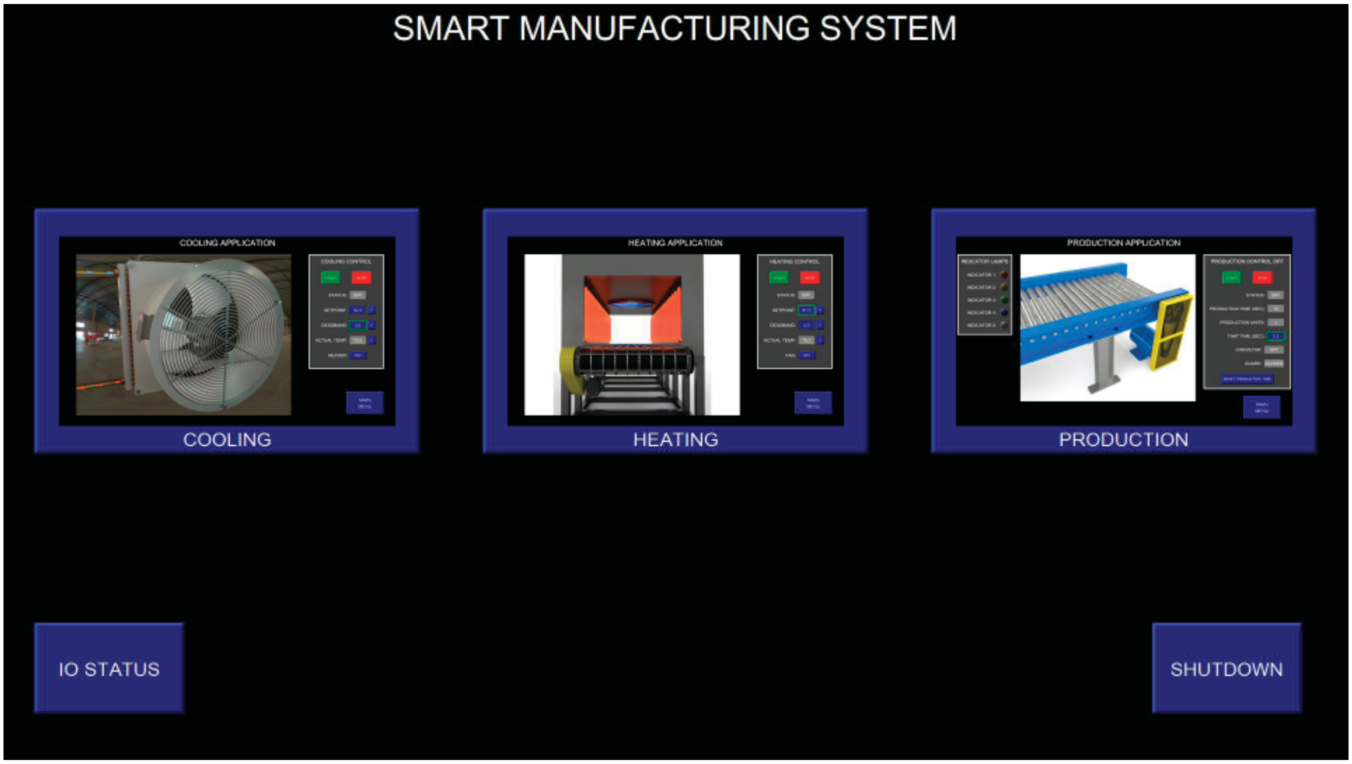

Figure 1-13. HMI Main Screen

The cooling application is designed to simulate a cooling process, with adjustable setpoint and deadband. The workstation contains a fan to lower the system temperature.

The heating application is designed to simulate a heating process, with adjustable setpoint and deadband. The workstation contains a heater to raise temperature.

The temperature sensor is wired to an analog input of the PLC to enable the PLC to measure temperature. The sensor is mounted to the heater block inside the workstation. The PLC turns the heater and fan on and off using 24 V digital outputs.

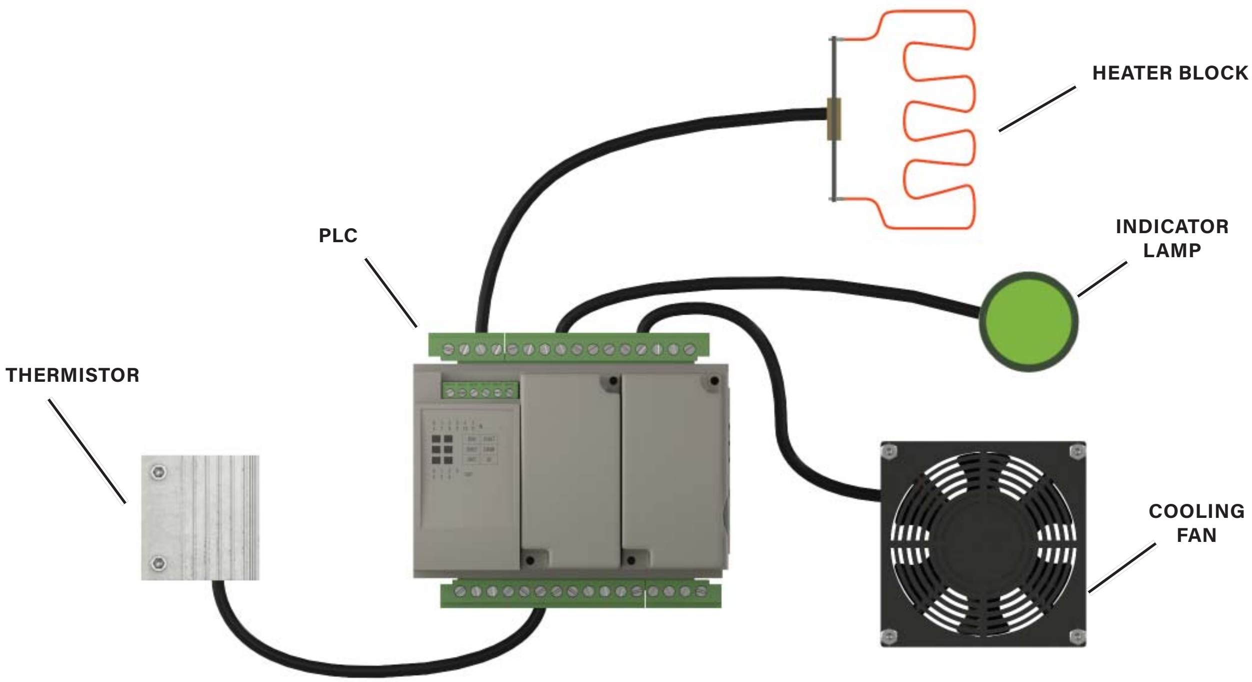

Figure 1-14. LC Inputs / Outputs of the Cooling and Heating Applications

The production application is designed to simulate production control of a motor such as a conveyor system. This application has a motor that can be started and stopped from the HMI. The motor can also be started, stopped, and motor speed controlled from wired controls on the workstation.

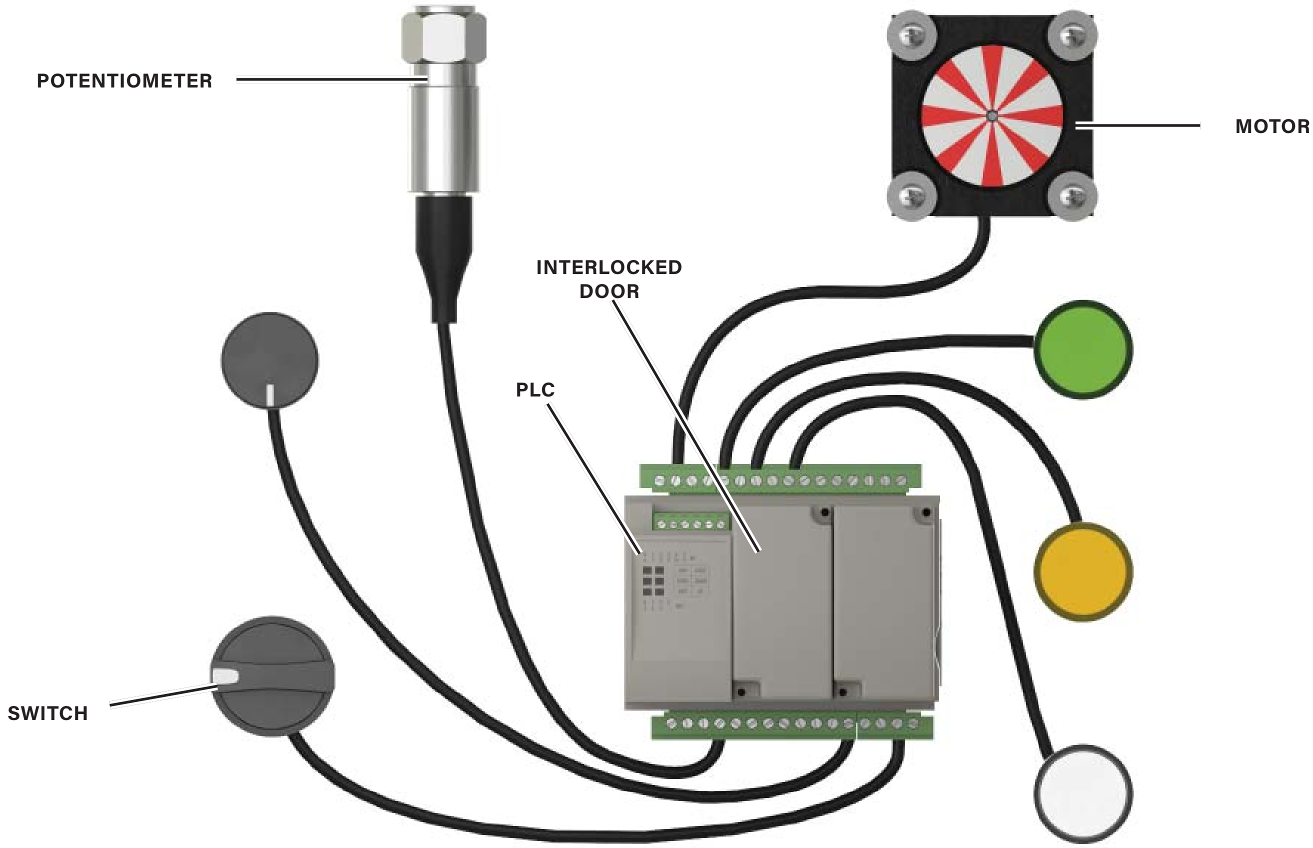

Figure 1-15. Motor Control Diagram

8. Perform the following substeps to connect to the BorgConnect Dashboard software.

   The BorgConnect Dashboard software is a browser-based platform that links to the BorgConnect Hub, either through a wired or Wi-Fi Ethernet connection, to display data stored on the BorgConnect Hub. This data comes from the PLC via a wired Ethernet connection, direct from sensors via Wi-Fi or Bluetooth, and from the BorgConnect Node via wired Ethernet or Wi-Fi.

   A. Press the Windows key on the keyboard to open the taskbar and start menu on the PC.

   B. Click on your Internet browser to open it (i.e., Firefox, Chrome, or Edge).

   C. Enter http://10.3.141.1/ into the address bar and press the Enter key on the keyboard.

      This will take you to the BorgConnect Login page to connect, as shown in figure 1-16.

Figure 1-16. BorgConnect Login Page

   D. Enter your login credentials in the space provided.

      Username: admin

      Password: Welcome2BC

   E. Click on the **Submit** button.

      The BorgConnect Dashboard main screen that opens, similar to figure 1-17, provides the applications created for the 990-SM10 Smart Manufacturing Learning System. The BorgConnect Dashboard is used for remote viewing of sensors from the workstation for maintenance, operator, and management purposes. Users can observe machine functions, production output, environment, and efficiency close to the machines or from a distance.

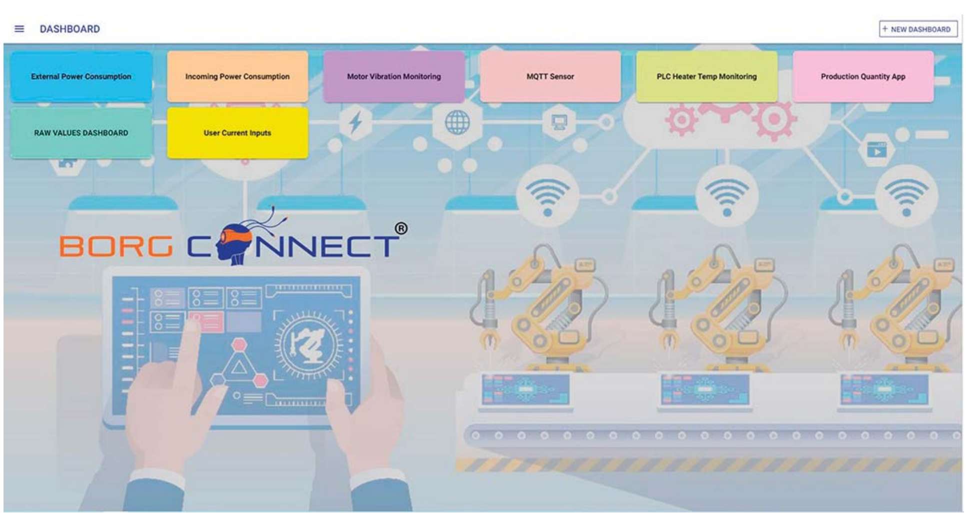

Figure 1-17. BorgConnect Dashboard Home Screen

9. Perform the following substeps to connect the PLC to the Connected Components Workstation (CCW).

   Connected Components Workstation (CCW) is the Rockwell Automation software that is used to program and configure the Rockwell Automation micro800 series PLC on the workstation. In these activities, we will only be using the CCW software to observe PLC program operation.

   A. Click **Start** on the Windows toolbar.

   B. Click on the CCW icon from the Windows Start menu as seen in figure 1-18.

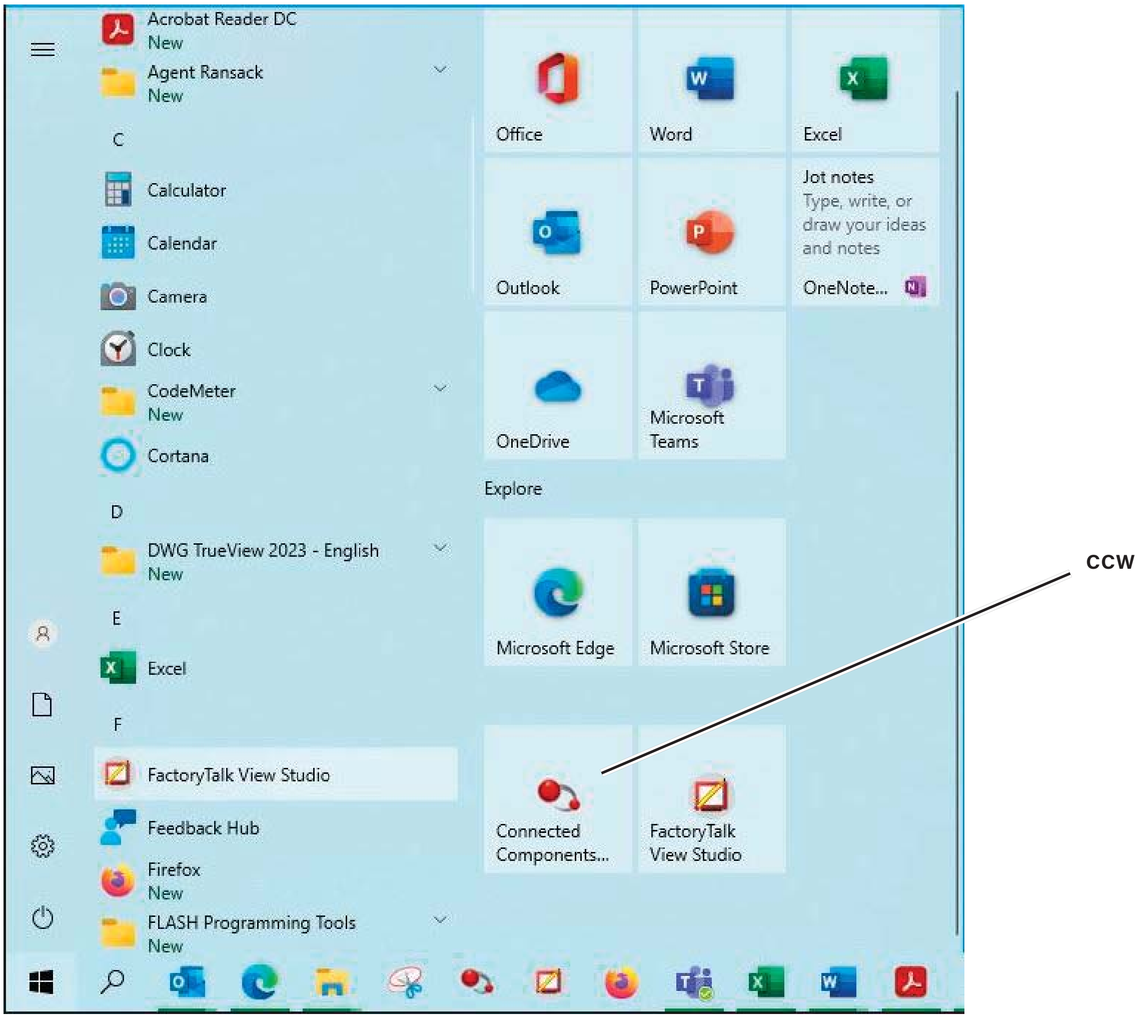

Figure 1-18. Connected Components Workstation (CCW)

C. Select the File tab similar to that in figure 1-19.

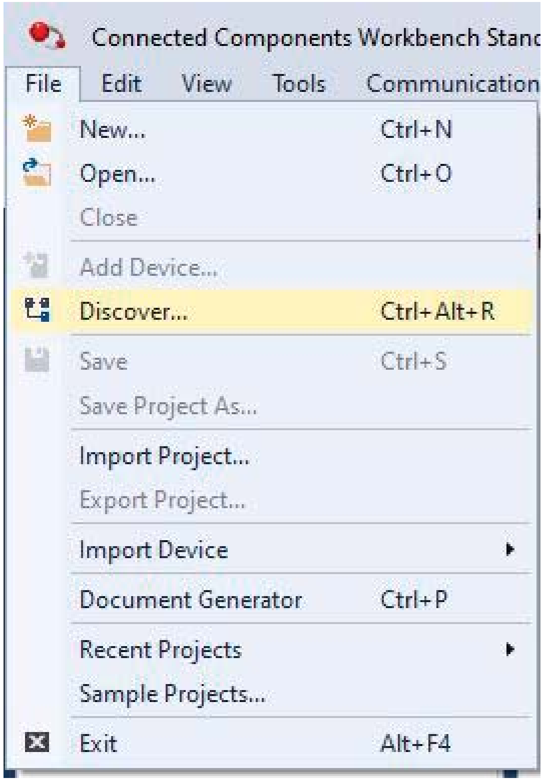

Figure 1-19. CCW File Tab

D. Mouse the pointer over and click on **Discover**.

A Connection Browser window similar to figure 1-20 will open.

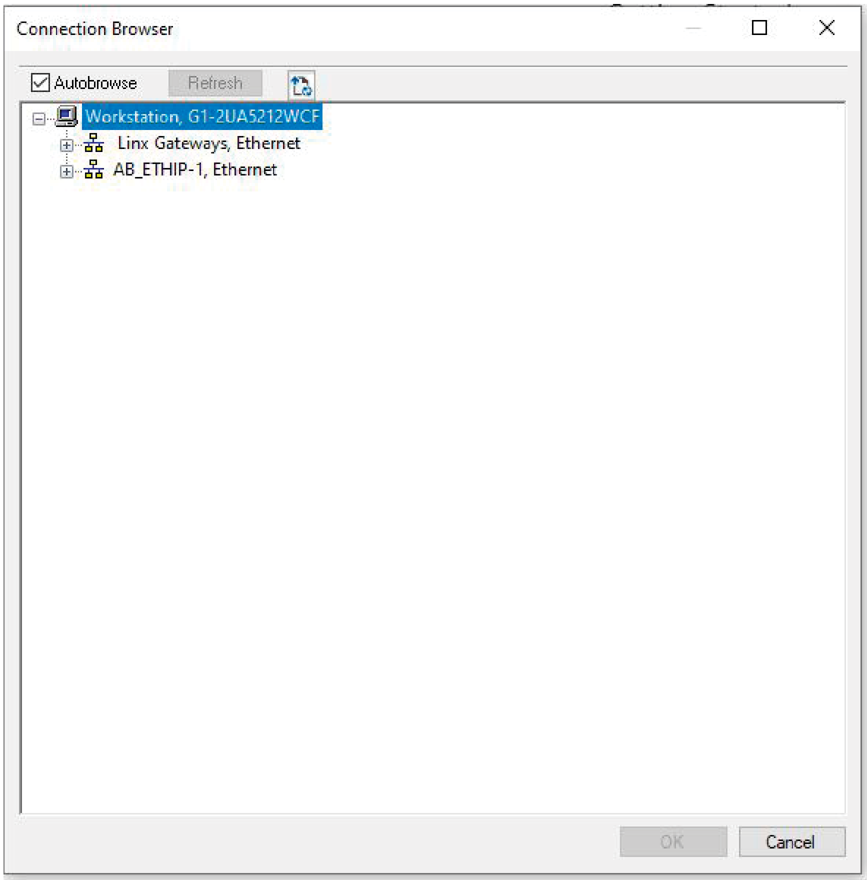

Figure 1-20. Connection Browser Window

E. Click the (**+**) symbol left of AB_ETHIP-1, Ethernet to expand.

F. Locate the Micro820 gateway, similar to that in figure 1-21, and click to highlight.

The IP address may be different than that in figure 1-21.

If unable to locate the Micro820 gateway in AB-ETHIP-1, look in AB-ETHIP-2 if it is an option. Otherwise, contact your IT department for assistance.

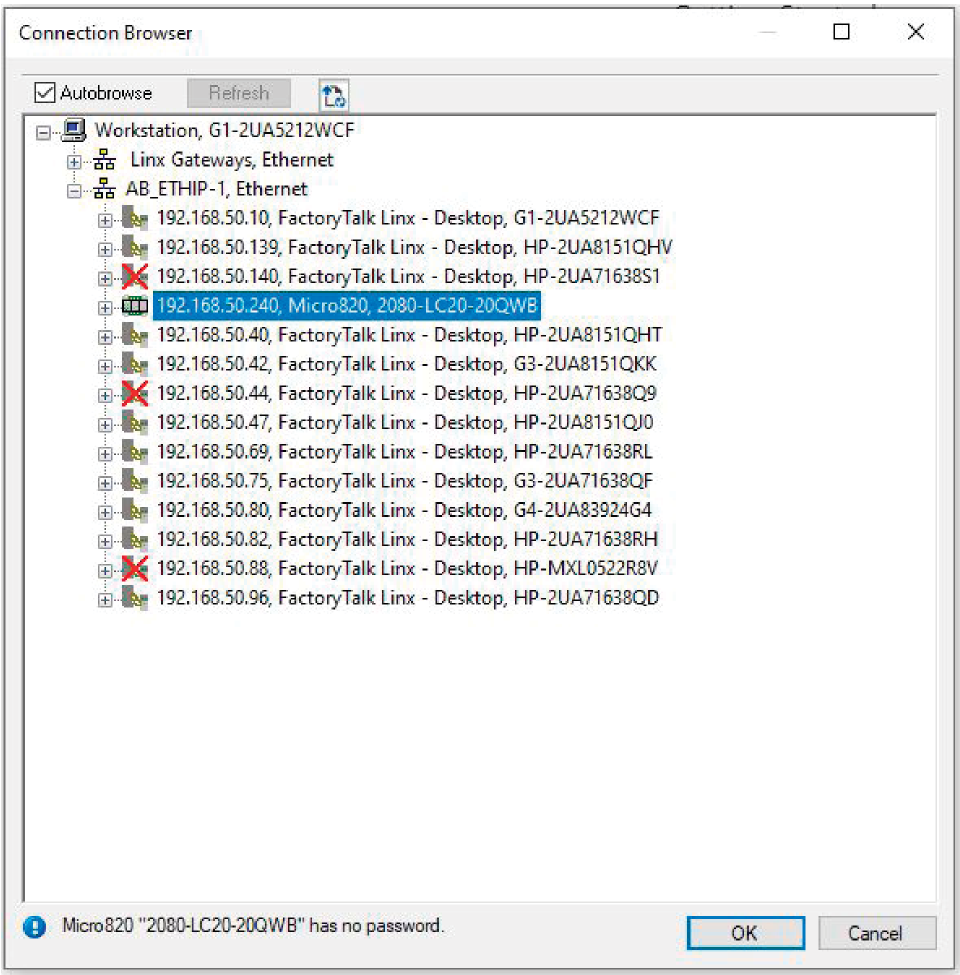

Figure 1-21. Connection Browser Window with Micro820 Selected

G. Click on **OK** on the bottom right of the window, as seen in figure 1-21.

   CCW will connect with the Micro820 PLC which will have the CESMII program, similar to that in figure 1-22.

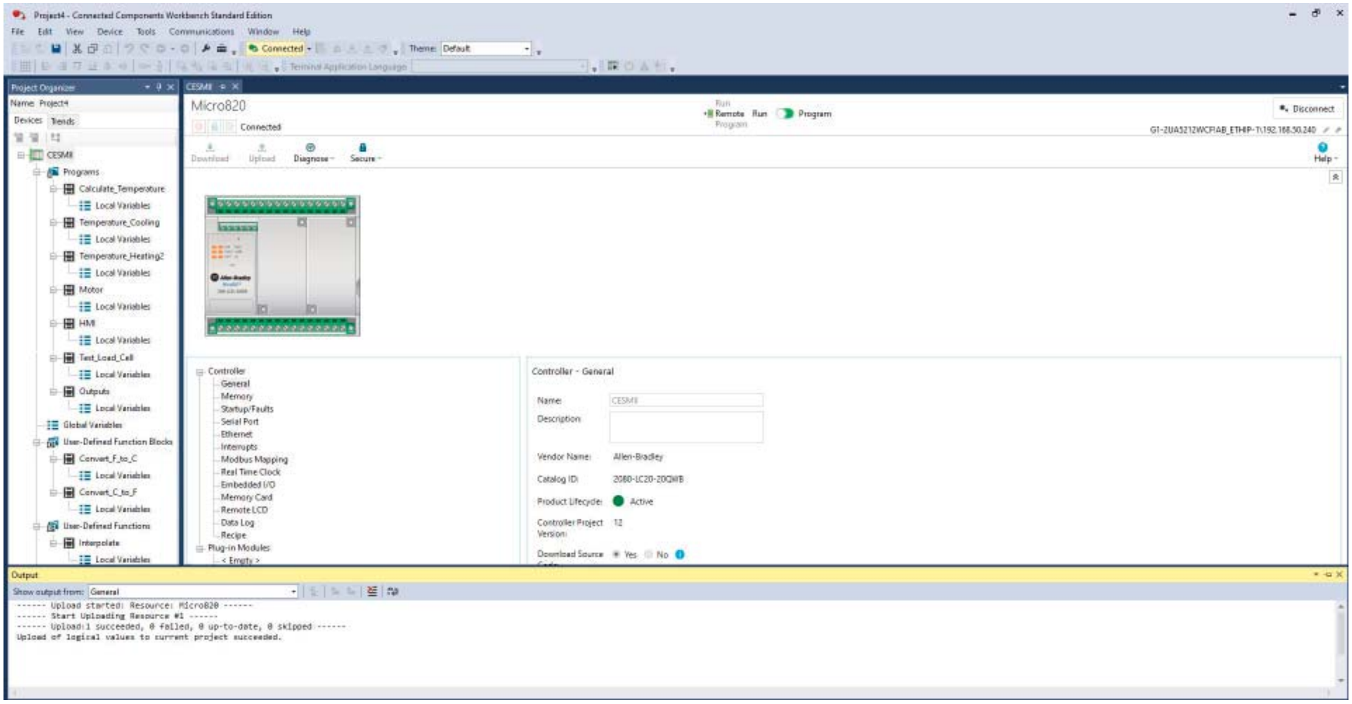

Figure 1-22. CCW with CESMII Program

H. Right click on Calculate_Temperature and select **Open.** This will open the PLC program titled Calculate Temperature, similar to that in figure 1-23.

CALCULATE_TEMPERATURE

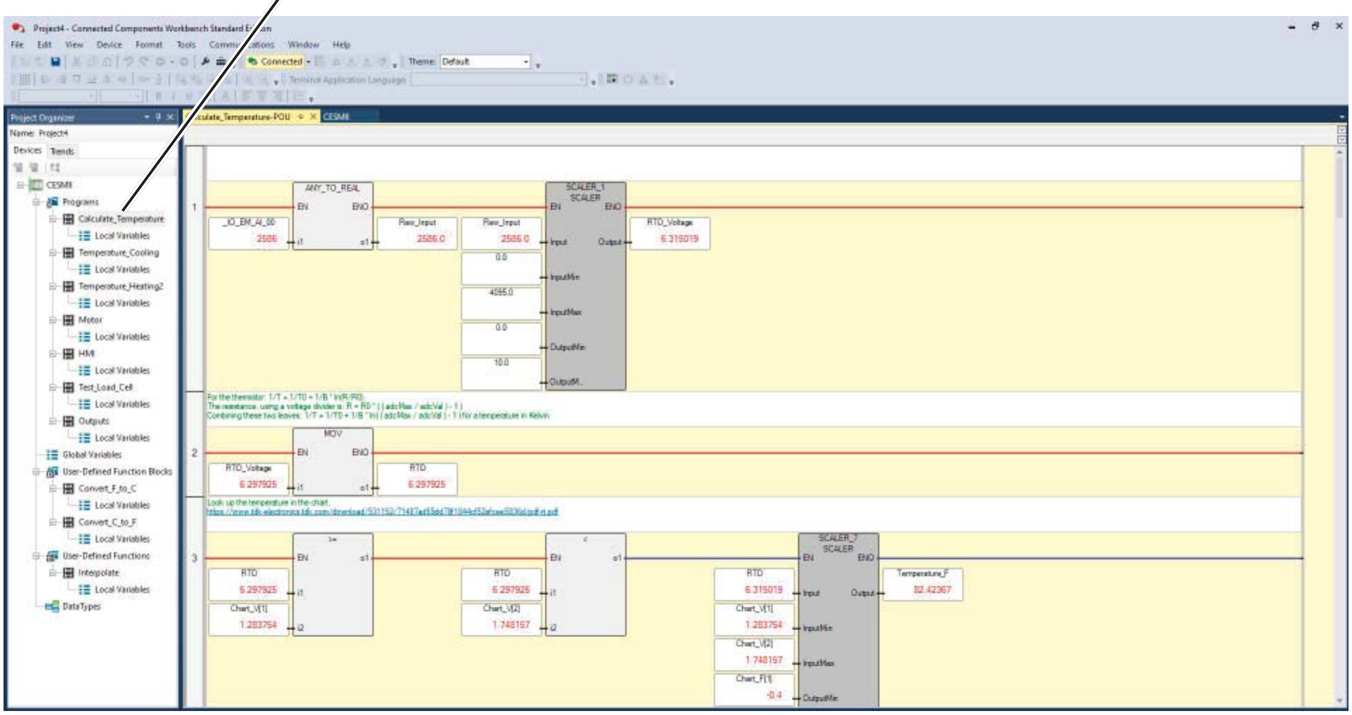

Figure 1-23. CCW Displaying Ladder Logic

I. Repeat substep G to view ladder logic for Temperature_Cooling, Temperature_Heating2, Motor, HMI, Test_Load_Cell, or Outputs.

10. Perform the following substeps to close the HMI window.

    A. Click **STOP** under cooling control to ensure that the application has ended.

    B. Click **MAIN MENU** in the bottom right of the screen.

    C. From the Smart Manufacturing System screen, click **SHUTDOWN** in the bottom right of the screen.

11. Perform the following substeps to power down the 990-SM10 Smart Manufacturing system.

    A. Close the BorgConnect Dashboard by clicking the close button (**X**) in the top right-hand corner of the browser window.

    B. Close the CCW software by clicking the (**X**) in the top right-hand corner of the software.

    C. Press the power button on the BorgConnect Hub to turn OFF.

    The red indicator on the Hub will turn OFF after a short period of time.

    D. Place the workstation's main power switch in the **OFF** position.

    The PLC, switch, BorgConnect Hub, and Wi-Fi temperature sensor should power down.

    E. Turn off the PC and monitor.

ACTIVITY 2 PLC TEMPERATURE CONTROLLED COOLING

PROCEDURE OVERVIEW

In this procedure, you will use the PC HMI application to view and operate the temperature-controlled cooling application. The HMI communicates with the PLC to start and stop the cooling application, to adjust settings, and to observe real-time status.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system shown in figure 2-1.

Figure 2-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the IEC connector on the workstation and an AC wall outlet, as shown in figure 2-2.

Figure 2-2. IEC Power Cord Plugged into IEC Connector and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, PLC, PC, and local network port, as shown in figure 2-3.

Figure 2-3. Ethernet Cable Connections

NOTE

The local network port may be different than the port shown Contact your IT department if assistance is required.

3. Turn on the PC and monitor.
4. Switch the workstation's main power switch to the **ON** position.
5. Perform the following substeps to launch FactoryTalk View Station and the HMI test application window.
   A. Click on the FactoryTalk View ME Studio 990 SM10 icon from the desktop, as shown in figure 2-4.

Figure 2-4. FactoryTalk View ME Studio 990 SM10 Icon

A dialog will appear prompting, "Do you want to allow this app to make changes to your device?", as shown in figure 2-5.

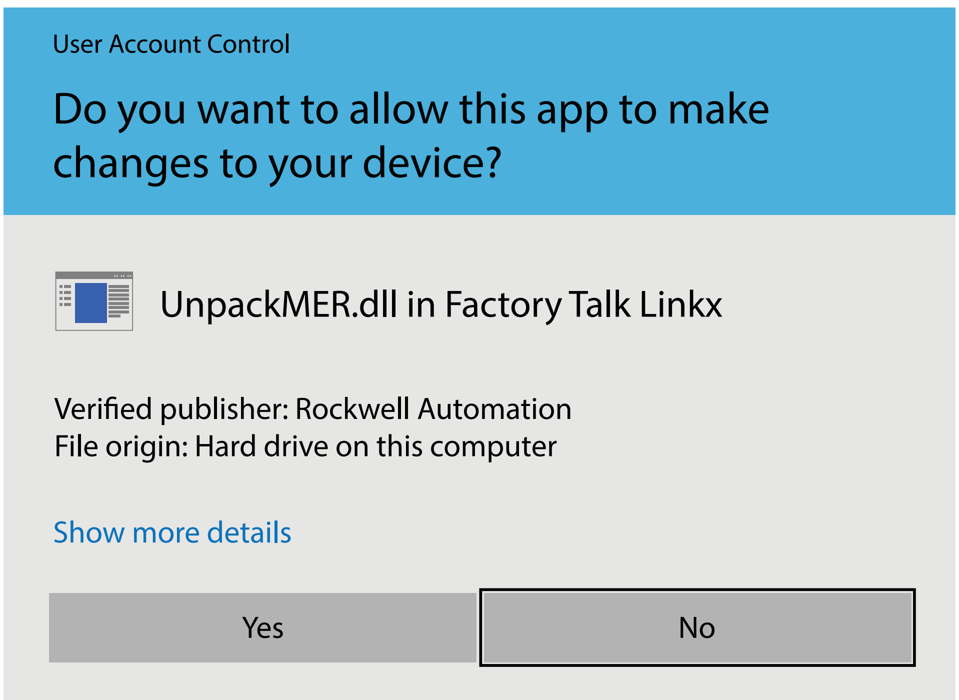

Figure 2-5. Administrative Permission Window

   B. Click **Yes.**

   After a short load time, the Smart Manufacturing System main screen will appear.

6. In the Smart Manufacturing system main screen, press the **Cooling** application tab.

   The cooling application is an HMI program installed on the PC to provide an operator interface. This program uses FactoryTalk View ME Station to communicate with the program installed on the PLC. It is an alternative to using the hardwired manual pushbuttons and switches on the workstation panel.

   The PLC's program uses a thermistor temperature input sensor from inside the workstation to determine when to turn the cooling fan on and off.

   After starting the cooling application using the HMI controls, the PLC compares the internal temperature of the workstation to a programmed setpoint to determine if the fan should turn on to start cooling. If the thermistor reads below the setpoint plus a programmed deadband, the fan will remain off. If the internal temperature of the workstation is above the setpoint plus the deadband, the fan will turn on. Once the fan turns on, it will continue to run until the internal temperature of the workstation falls below the setpoint. Once that point is reached, the fan will stop and wait for the internal temperature to reach the setpoint plus the deadband before starting again.

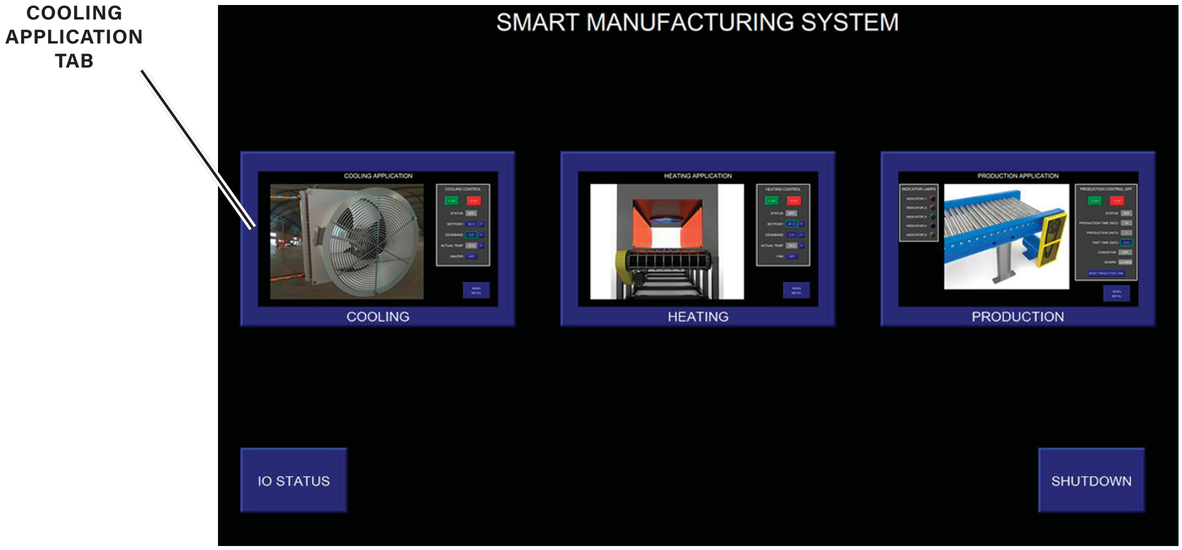

Figure 2-6. Cooling Application Tab

7. Perform the following substeps to explore the operation of the cooling application.

   A. Examine the control diagram of the cooling application shown in figure 2-7.

      The fan is controlled by a digital output (on/off) 24 VDC output from the PLC. The PLC also controls a heater using another 24 VDC digital output. The heater is used to raise the temperature so cooling can be demonstrated.

      The system input is a thermistor temperature sensor, which is connected to an analog input of the PLC. The analog input measures signals in a range of 0 VDC to 10 VDC.

      Also, the PLC uses two output indicators, red and blue, located on the panel to show the status of the application. A blue indicator is turned on when the fan is running. A red indicator is turned on when the heater is running. Both indicators are turned on by 24 VDC digital outputs from the PLC.

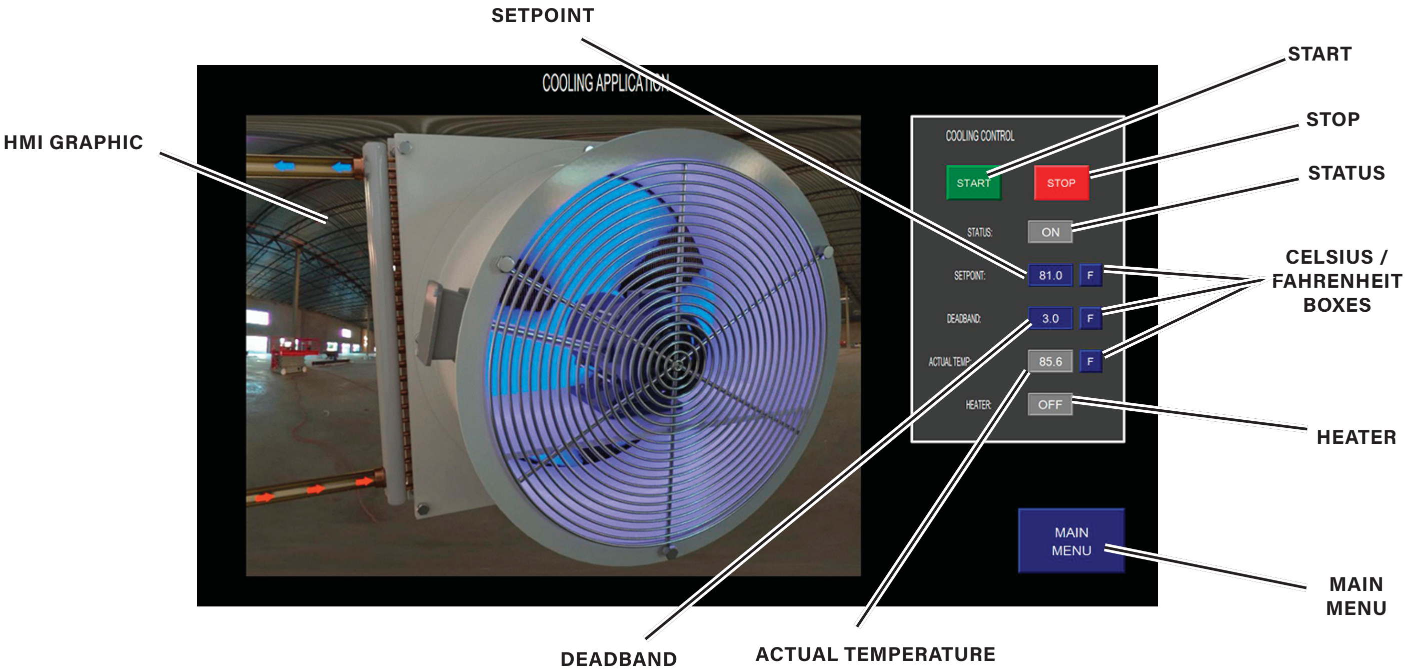

Figure 2-7. Diagram of Cooling Application Inputs and Outputs

B. Examine the image of the temperature sensor used in the cooling application system shown in figure 2-8.

The thermistor is located behind the panel. It senses temperature inside the workstation. Thermistors sense temperature through very small changes in resistance as the temperature changes. The thermistor can measure accurately between -40 °F to 221 °F using 10 kΩ resistance with a 5% tolerance. It produces a voltage change in response to changes in the temperature sensed, which is converted to a digital value by the PLC's analog input module. The PLC program calculates a temperature value using this raw digital value.

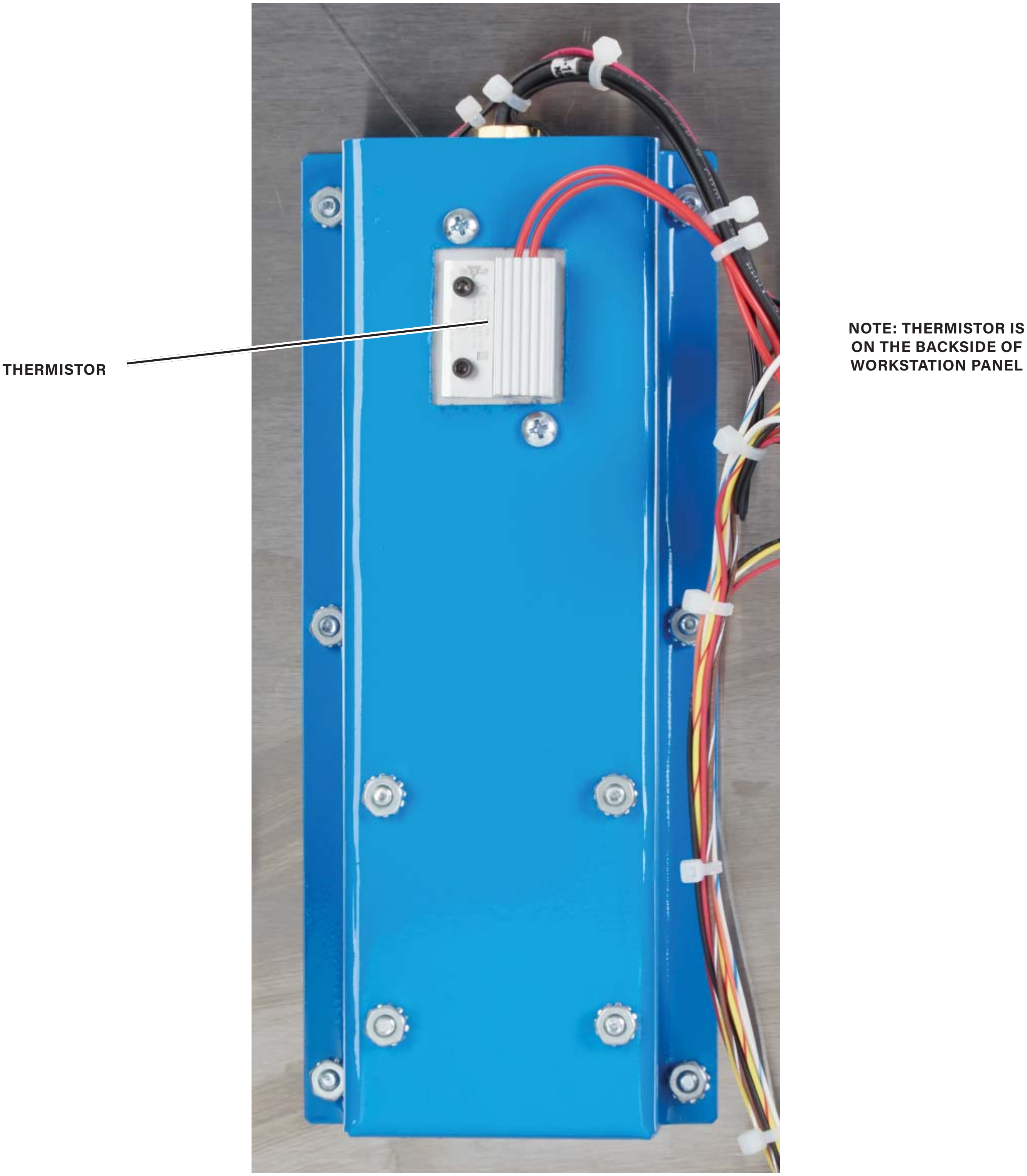

Figure 2-8. Thermistor

C. Examine the HMI screen controls and how they function in the cooling application.

The HMI screen for the cooling application has a start button to start the application and a stop button to stop it. By clicking the start button, the HMI fan graphic will show the fan blades in blue, indicating that the fan is running, and the status will display ON. After the stop button is clicked, the HMI fan graphic will show the blades in a gray color to indicate that the fan is off, and the status will be displayed as OFF.

The setpoint is the temperature low point where the PLC program stops the fan after the cooling process reduces the temperature in the workstation. The setpoint is the ideal temperature you desire for the system.

Each of the three temperature scale boxes display F for Fahrenheit or C for Celsius. You can change the scale from the HMI screen so that each box displays values for °F or °C.

Deadband determines the temperature above the setpoint at which the fan turns on to start the cooling process. Deadband is a range. For example, if the setpoint is 81 °F and the deadband is 10 °F, the temperature at which the fan turns on is 91 °F and the temperature when the fan turns off is 81 °F.

The purpose of the deadband is to reduce the frequency at which the fan turns on and off. This is called cycling. By reducing cycling, there is less wear on equipment.

By clicking on the MAIN MENU button, the HMI will return to the main menu.

8. Perform the following substeps to set up the cooling application for temperature-controlled cooling.

A. Press the blue temperature box to the right of SETPOINT to open the keypad for changing the setpoint to a desired temperature.

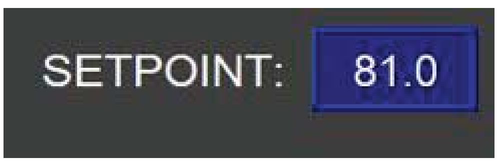

Figure 2-9.   SETPOINT Box

B. Enter **81.0** using the number pad to change the setpoint.

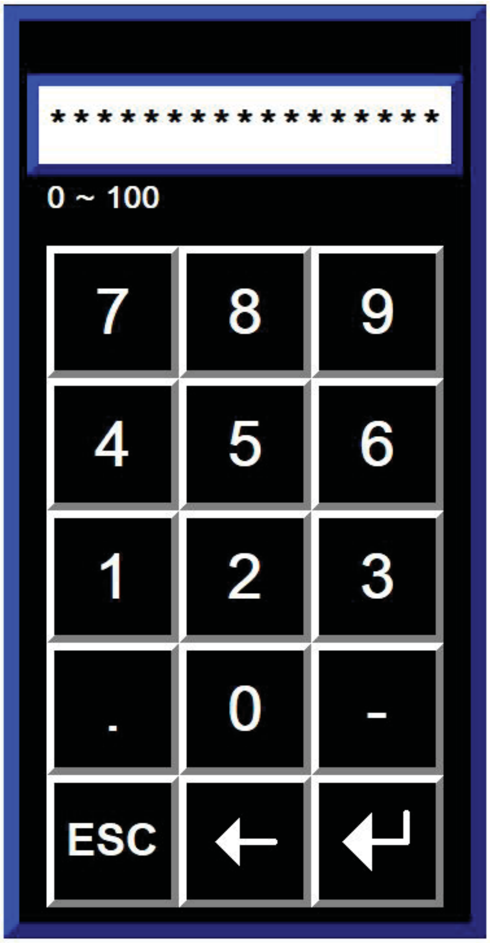

Figure 2-10. Number Pad

C. Press the **Enter** button to accept the change made and return to the cooling application home screen.

D. Press the **F** in the blue box to change from F to C on the right-hand side of the cooling application.

This will change the temperature scale from Fahrenheit (°F) to Celsius (°C). By pressing one box, the other temperature unit boxes will change in unison. Press any of the three boxes to change back to F and the Fahrenheit scale. For this activity, you will use the Fahrenheit scale.

Figure 2-11. Fahrenheit (F) and Celsius (C) Boxes

E. Press the blue box to the right of DEADBAND to open the number pad to change the deadband to a desired range.

Figure 2-12. DEADBAND Box

F. Enter 5.0 in the number pad to change the deadband.

With the setpoint at 81.0 °F and the deadband at 5.0 °F, the fan will start cooling when the internal temperature reaches 86.0 °F or above.

This workstation uses a heater to increase the temperature near the thermistor. This allows the system temperature to rise at a faster rate so that the cooling cycle can be observed repeatedly. If the heater is not used, the system might not cycle if the room temperature is below 86 °F.

G. Press the Enter button to accept changes made and return to the cooling application home screen.

H. Locate the gray ACTUAL TEMP box on the screen.

The actual temperature is the current temperature that the temperature sensor is reading inside the workstation.

Figure 2-13. ACTUAL TEMP Box

9. Perform the following substeps to operate the cooling application.

A. Press the **START** button to initiate the cooling application.

In the cooling application screen, STATUS will change to display ON and the fan blades in the HMI graphic will change to blue.

When the ACTUAL TEMP is below the setpoint, the HEATER will be ON and the red indicator lamp will turn on.

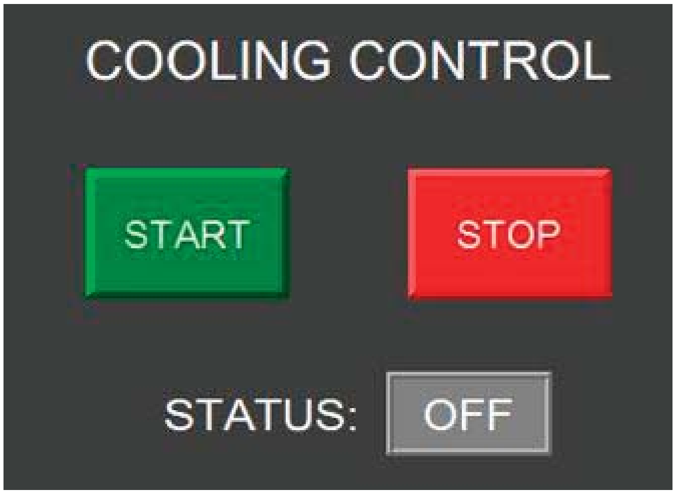

Figure 2-14. START and STOP Tabs

B. Observe that when the temperature rises above 86.0 °F the PLC will turn on the fan and the blue indicator lamp. The HEATER display will change to OFF and the heater will turn off.

   With the setpoint plus deadband equal to 86 °F, the temperature can still rise beyond 86 °F because there is residual energy in the heater.

C. Observe that once the temperature in the workstation drops below 81 °F, the PLC turns OFF the fan and the blue indicator lamp. Once the fan turns OFF, the heater and the red indicator lamp will turn ON.

D. Observe the workstation and the cooling application screen as they go through a few cycles of cooling. Once you are ready to continue, proceed to substep E.

E. Press **STOP** to end the cooling application.

   In the cooling application screen, status will change to OFF and the fan blades will change to silver on the HMI graphic.

10. Perform the following substeps to launch Connected Components Workbench (CCW).

    A. Press the Windows key on the keyboard to open the Start menu.

    B. Click on CCW in the Windows start menu.

    C. Click on the **File** tab to open the file menu.

    D. Click on **Discover** and this will open the connection browser.

    E. Click on the + symbol to expand the AB_ETHIP-1, Ethernet tree.

    F. Click on the Micro820 gateway to highlight it.

    G. Click on **OK** in the bottom right of the window.

11. Perform the following substeps to view the cooling application in ladder logic.

    A. Double-click on **Temperature_Cooling**, located in the devices tree on the lefthand side, as shown in figure 2-15.

TEMPERATURE_COOLING

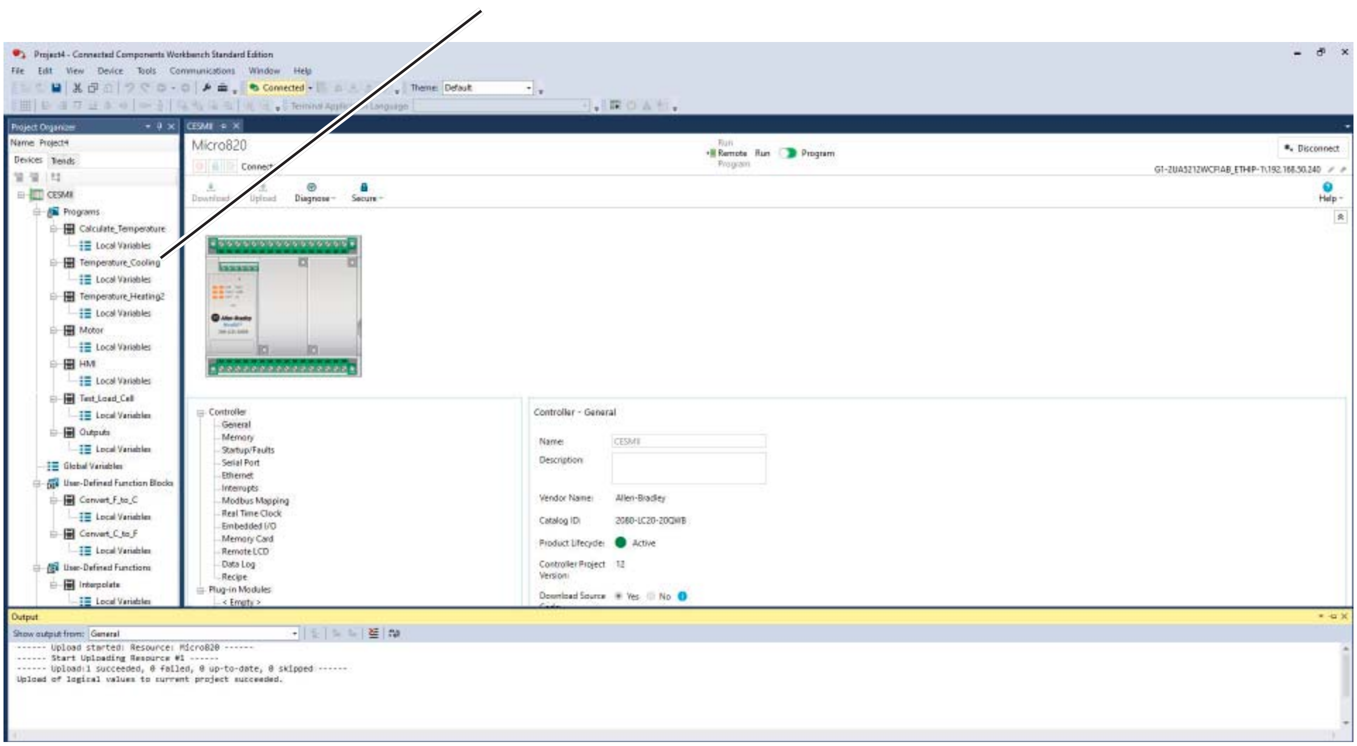

Figure 2-15. CCW with CESMII Program

B. Notice that the Temperature_Cooling program window will open as shown in figure 2-16.

On rung 3, the Temperature_Cooling program compares input temperatures to the setpoint and deadband using Greater Than comparison instructions to determine when to run the cooling fan.

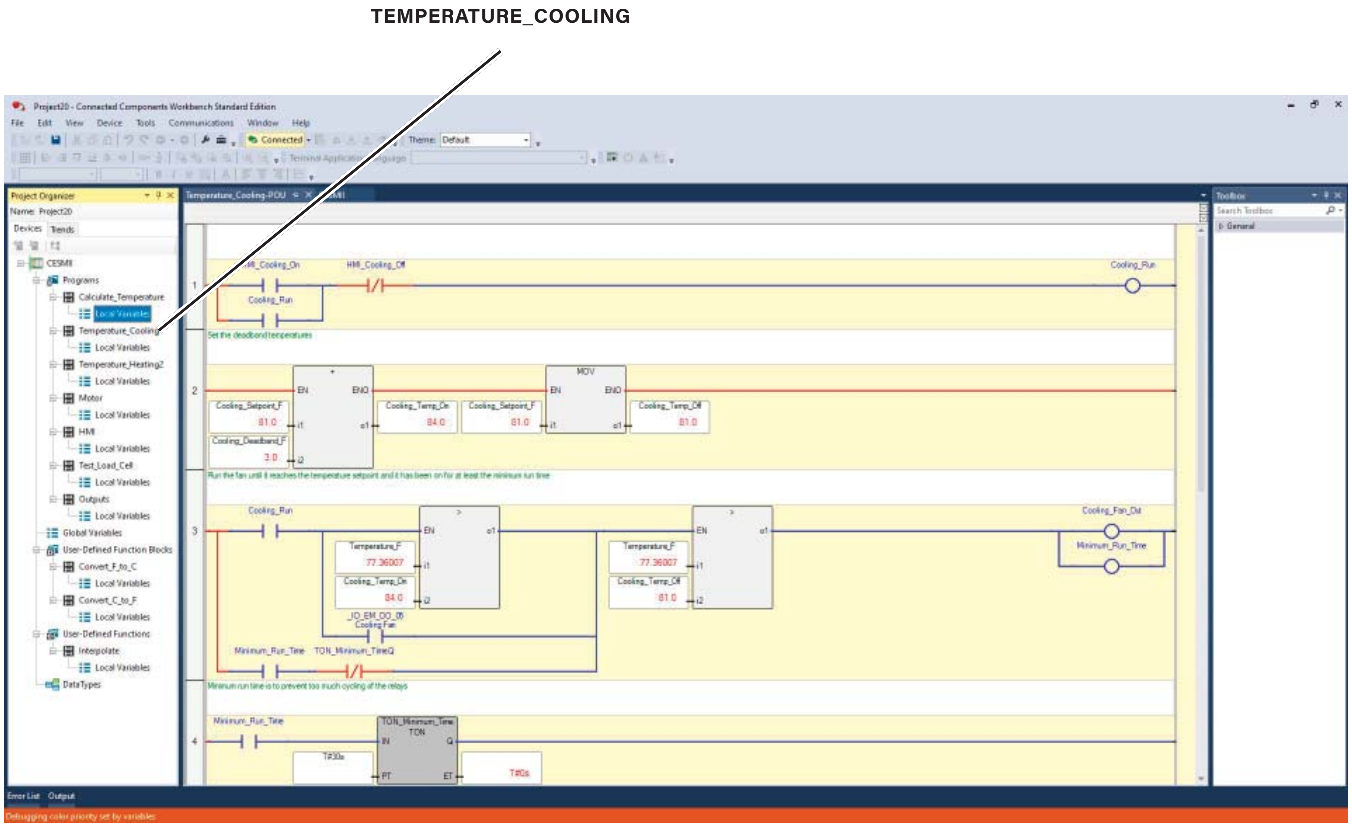

Figure 2-16. CCW Displaying Temperature_Cooling Ladder Logic

C. Scroll down to ladder rung 2 and observe its color status. It should display red from rail to rail, similar to figure 2-17.

The red lines indicate that the rail / instruction block statement to the left of the line is true. When the rung is all red, the output is turned on. Blue lines indicate that the rail / instruction block to the left of the line is false. If any of the rung is blue, the output is turned off.

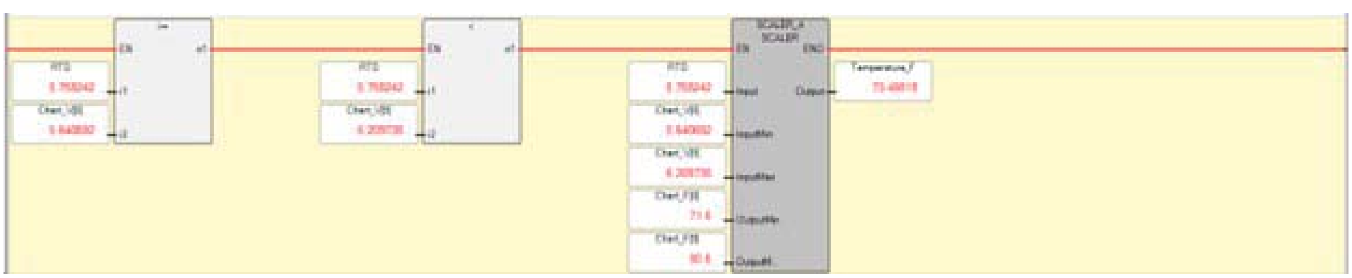

Figure 2-17. CCW Red Line Ladder Rung

D. Click on the FactoryTalk View Studio tab in the taskbar to view the cooling application HMI screen.

E. Press **START** to run the cooling application.

F. Press the Windows key on the PC keyboard to open the taskbar on the PC.

G. Click on the CCW icon in the taskbar to return to CCW.

H. Notice in the Temperature_Cooling program that rung 1 becomes true and turns on output Cooling_Run.

I. Observe the ladder rungs as the temperature changes to see what changes in the program as temperature limits are reached.

J. Notice on rung 3 after the temperature increases beyond the Cooling_Temp_On instruction block, that the output Cooling_Fan_Out will become true and turn the fan ON. As the temperature returns below Cooling_Temperature_Off, the fan will turn OFF as the rung becomes false.

K. Click on the FactoryTalk View Studio icon in the taskbar to return to the cooling application HMI screen.

12. Close CCW by clicking the **(X)** in the top right-hand corner of the software.

13. Perform the following substeps to close the HMI window.

A. Click the FactoryTalk View Station icon in the taskbar to maximize the HMI window, similar to figure 2-18.

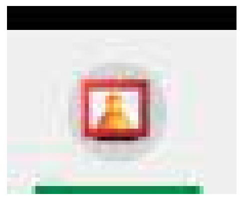

Figure 2-18. FactoryTalk View Station Icon

B. Click **STOP** to end the cooling application.

C. Press MAIN MENU in the bottom right of the screen.

D. From the Smart Manufacturing System screen, press SHUTDOWN in the bottom right of the screen.

14. Perform the following substeps to power down the Smart Manufacturing system.

A. Place the workstation's main power switch in the **OFF** position.

The PLC, switch, BorgConnect Node, and Wi-Fi temperature sensor should power down.

B. Turn off the PC and monitor.

ACTIVITY 3 PLC TEMPERATURE-CONTROLLED HEATING

PROCEDURE OVERVIEW

In this procedure, you will use the PC HMI to view and operate the temperature-controlled heating application. The HMI communicates with the PLC to start and stop the heating application, to adjust settings, and to observe real-time status.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system as shown in figure 3-1.

Figure 3-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the AC in port on the workstation and an AC wall outlet, as shown in figure 3-2.

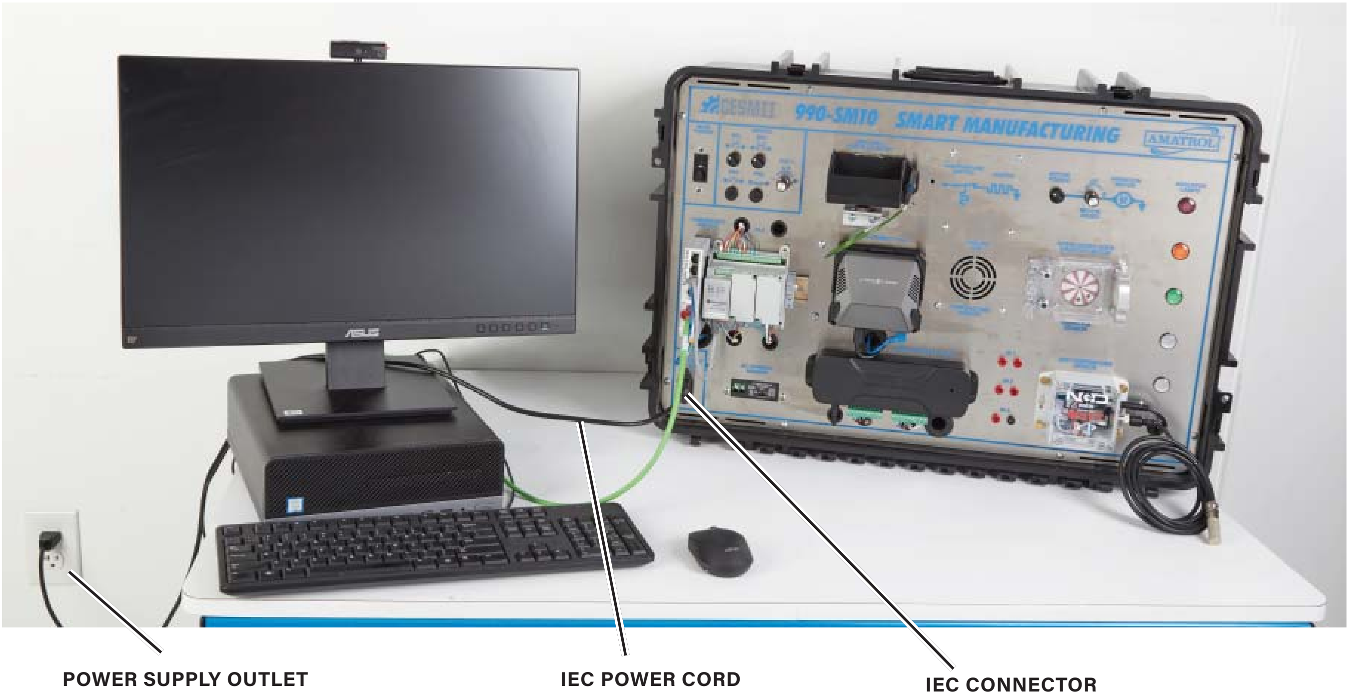

Figure 3-2. IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, PLC, PC, and local network port, as shown in figure 3-3.

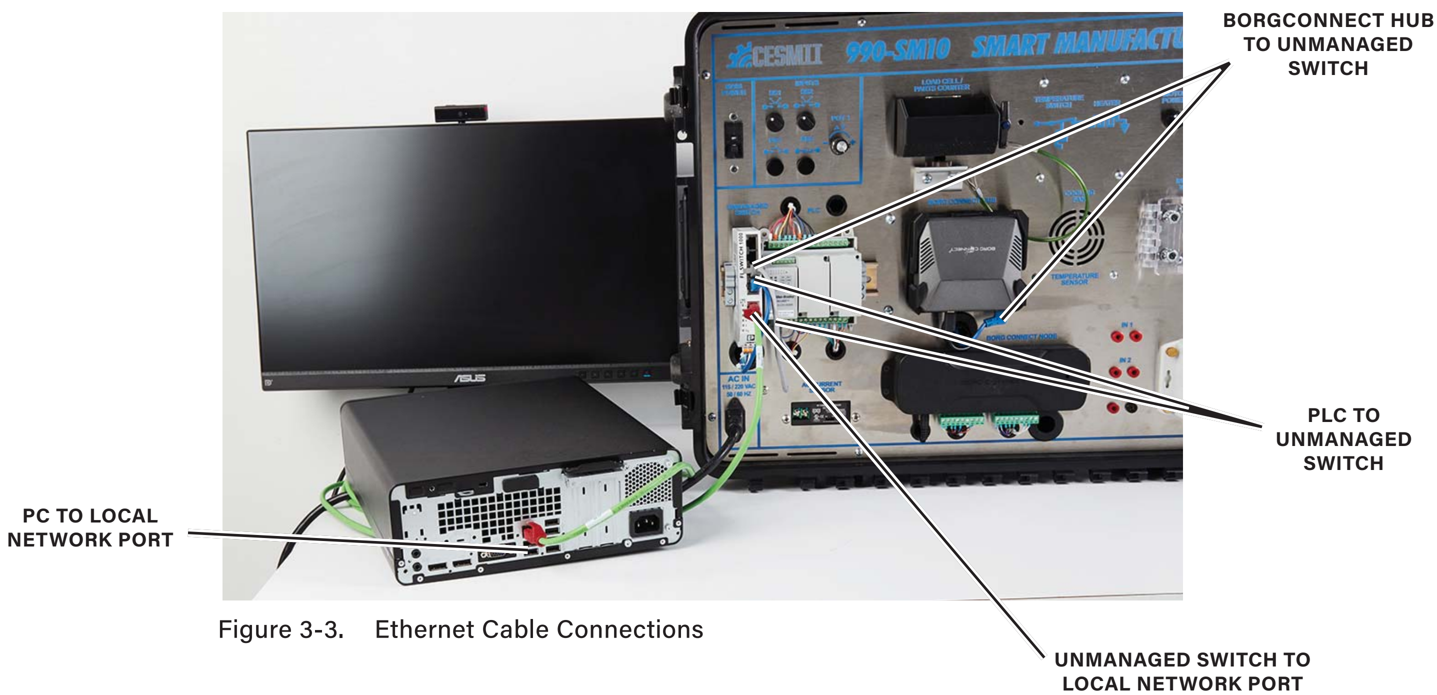

Figure 3-3. Ethernet Cable Connections

NOTE

The local network port may be different than the port shown. Contact your IT department if assistance is required.

3. Turn on the PC and monitor.
4. Switch the workstation's main power to the **ON** position.
5. Perform the following substeps to open the Smart Manufacturing HMI application on your PC.
   A. Click on the FactoryTalk View ME Station 990 SM10 runtime icon in the desktop of the PC, as shown in figure 3-4.

Figure 3-4. FactoryTalk View ME Station 990 SM10 Runtime Icon

A dialog will appear prompting, "Do you want to allow this app to make changes to your device?", as shown in figure 3-5.

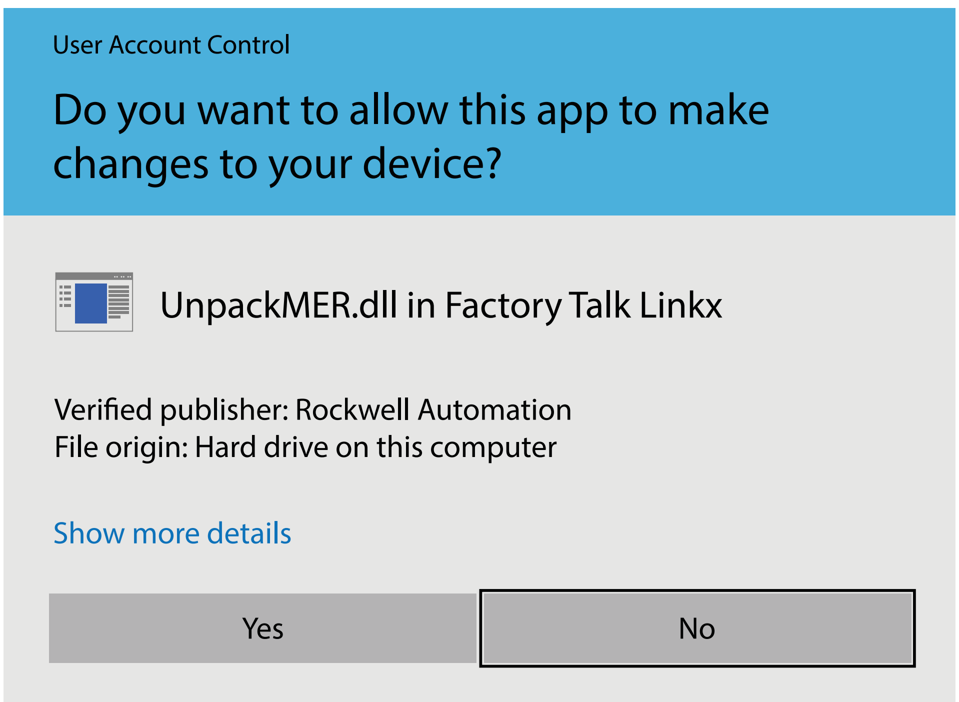

Figure 3-5. Administrative Permission Window

   B. Click **Yes.**

   After a short load time, the Smart Manufacturing System main screen will appear.

6. In the Smart Manufacturing system main screen, click on the **Heating Application** tab.

   The heating application is an HMI program installed on the PC to provide an operator interface. This program uses FactoryTalk View Studio to communicate with the program installed on the PLC. It is an alternative to using the hardwired manual pushbuttons and switches on the workstation panel.

   The PLC's program uses the thermistor temperature input sensor from inside the workstation to determine when to turn the heater on and off.

   After starting the heating application using the HMI controls, the PLC compares the internal temperature of the workstation to a programmed setpoint to determine if the heater should start heating. If the thermistor reads above the setpoint minus the programmed deadband, the heater will remain off. If the internal temperature of the workstation is below the setpoint minus the deadband, the heater will turn on. Once the heater starts, it will run until the internal temperature reaches the setpoint. Once that point is reached, the heater will stop and wait for the internal temperature to reach the setpoint minus the deadband to start again.

   The fan is used in this application to cool down the system faster than would otherwise occur naturally. This allows you to observe the heater turn on and off more frequently.

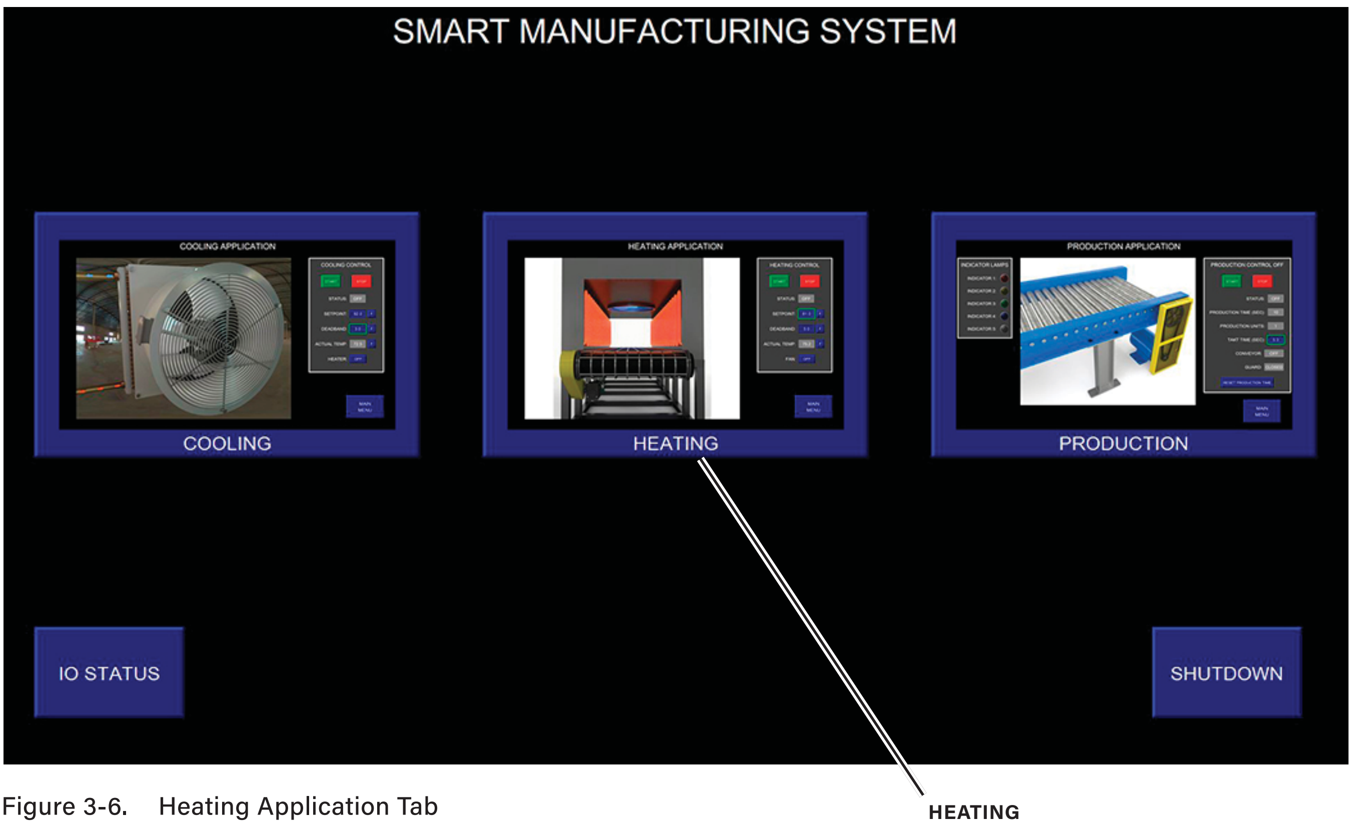

Figure 3-6. Heating Application Tab

7. Perform the following substeps to explore the operation of the heating application.

   A. Examine the control diagram of the heating application shown in figure 3-7.

      The heater is controlled by a digital output (on/off) 24 VDC output from the PLC. The PLC also controls a fan using another 24 VDC digital output. The fan is used to lower the temperature so heating can be demonstrated.

      The system input is a thermistor temperature sensor, which is connected to an analog input of the PLC. The analog input measures signals in a range of 0 VDC to 10 VDC.

      Also, the PLC uses two output indicators, red and blue, located on the panel to show the status of the application. A blue indicator is turned on when the fan is running. A red indicator is turned on when the heater is running. Both indicators are turned on by 24 VDC digital outputs from the PLC.

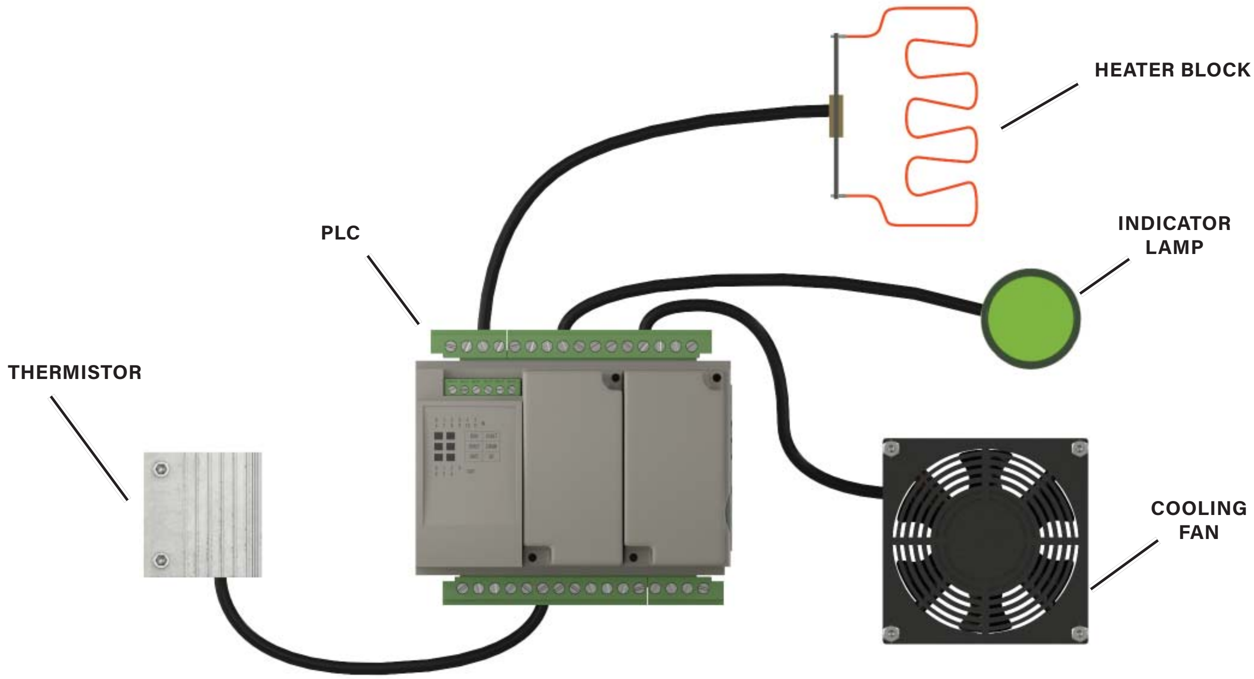

Figure 3-7. Diagram of Heating Application Inputs and Outputs

B. Examine the image of the temperature sensor used in the heating application system shown in figure 3-8.

The thermistor is located behind the panel senses temperature inside the workstation. Thermistors sense temperature through very small changes in resistance as the temperature changes. The thermistor can measure accurately between -40 °F to 221 °F using 10 kΩ resistance with a 5% tolerance. It produces a voltage change in response to changes in the temperature sensed, which is converted to a digital value by the PLC's analog input module. The PLC program calculates a temperature value using this raw digital value.

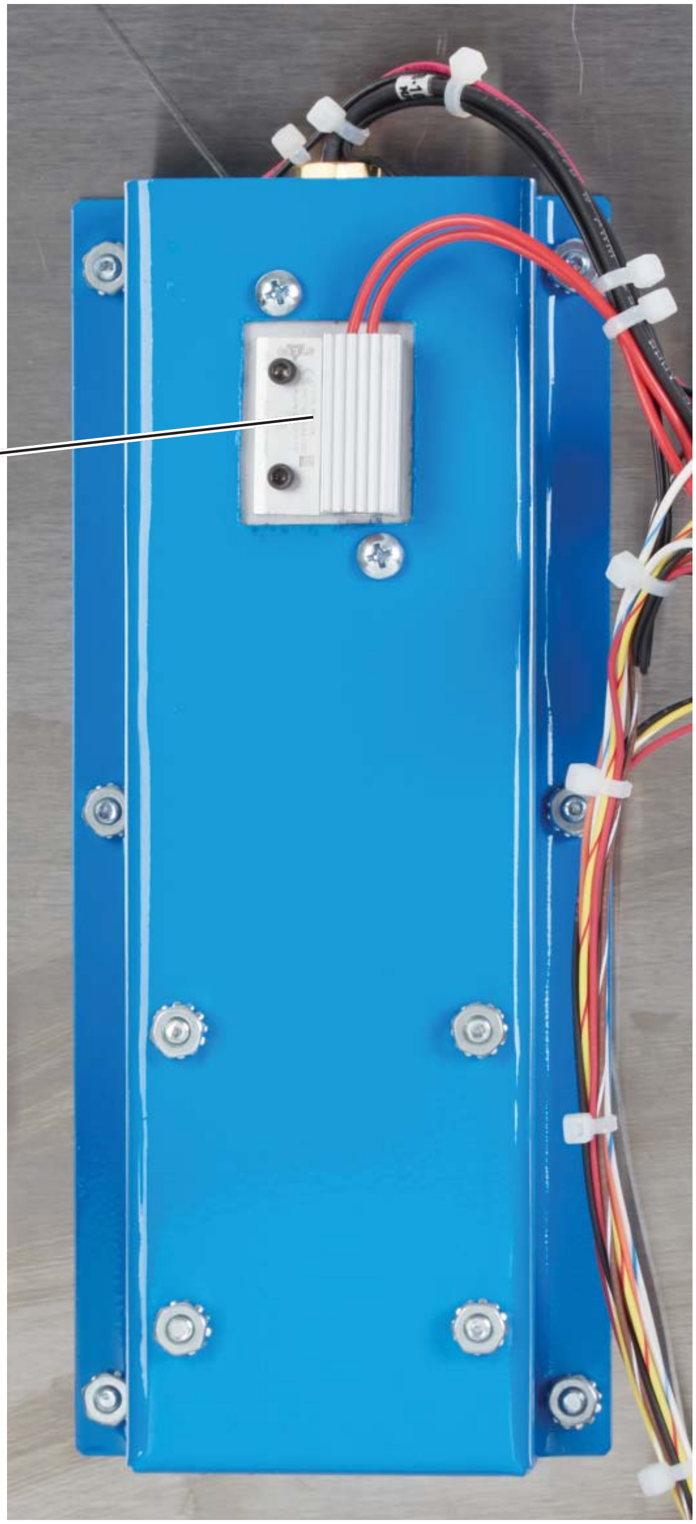

Figure 3-8. Thermistor

C. Examine the HMI screen controls and how they function in the heating application.

The heating application has a start button to start the application and a stop button to stop the application. By clicking the start button, the HMI heater graphic will show the heating coils in red to indicate that the heater is on, and the status will display ON. After the stop button is clicked, the HMI heater graphic will show the coils in a gray color to indicate that the heater is off, and the status will be displayed as OFF.

The setpoint is the temperature high point where the PLC program turns off the heater after increasing the temperature in the workstation. The setpoint is the ideal temperature that you desire for the system.

Each of the three temperature scale boxes display F for Fahrenheit or C for Celsius. You can change the scale from the HMI screen so that each box displays values in °F or °C.

Deadband determines the temperature below the setpoint at which the heater turns on to start the heating process. Deadband is a range. For example, if the setpoint is 85 °F and the deadband is 10 °F, the temperature at which the heater turns on is 75 °F and the temperature when the heater turns off is 85 °F.

The purpose of the deadband is to reduce the frequency at which the fan turns on and off. This is called cycling. By reducing cycling, there is less wear on equipment.

By clicking on the MAIN MENU button, the HMI will return to the main menu.

8. Perform the following substeps to set up the heating application for temperature-controlled heating.

A. Click in the blue box to the right of SETPOINT to open the keypad for changing the setpoint to a desired temperature.

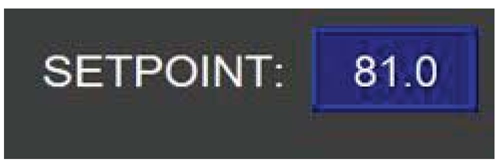

Figure 3-9. SETPOINT Box

B. Enter 85.0 using the keypad to change the setpoint.

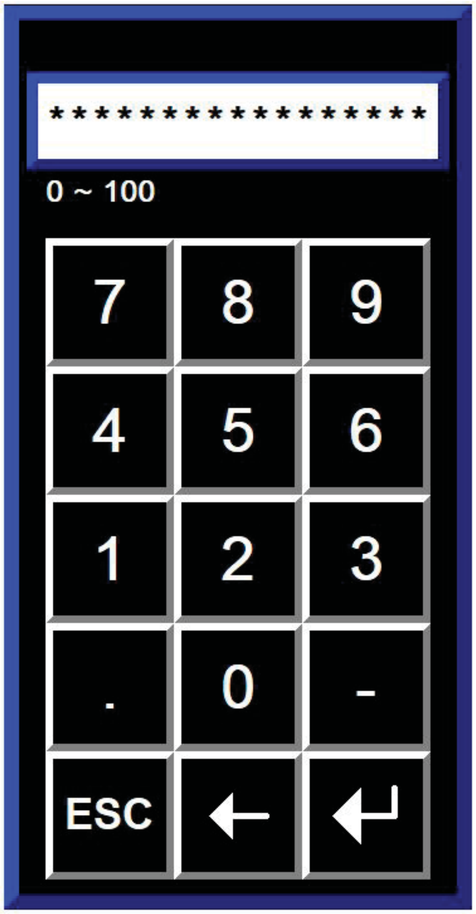

Figure 3-10. Keypad

C. Press the Enter button to accept the change made and to return to the heating application home screen.

D. Click F in the blue box to change from F to C on the right-hand side of the cooling application. This will change the temperature scale from Fahrenheit (°F) to Celsius (°C). By clicking on one box, the other temperature unit boxes will change in unison. Click on any of the three boxes to change back to F and the Fahrenheit scale. For this activity, we will use the Fahrenheit scale.

Figure 3-11. Fahrenheit (F) and Celsius (C) Box

E. Click in the blue box to the right of DEADBAND to open the keypad to change the deadband to a desired range.

Figure 3-12. DEADBAND Box

F. Enter 10.0 in the keypad to change the deadband.

With the setpoint at 85.0 °F and the deadband at 10.0 °F, the heater will start heating when the internal temperature reaches 75.0 °F or below.

This workstation uses a fan to decrease the temperature near the thermistor. This allows the heating cycle to be reset at a faster rate so that the heating cycle can be observed repeatedly.

G. Press the Enter button to accept changes made and to return to the heating application home screen.

H. Locate the gray ACTUAL TEMP box on the screen.

The actual temperature is the current temperature that the temperature sensor is reading from inside the workstation.

Figure 3-13. ACTUAL TEMP Box

9. Perform the following substeps to operate the workstation using the heating application for temperature-controlled heating.

A. Press the START button to initiate the heating application.

In the heating application screen, STATUS will change to display ON and the heater coils in the HMI graphic will change to red.

When the ACTUAL TEMP is above the setpoint, the FAN will be ON and the blue indicator lamp will turn on.

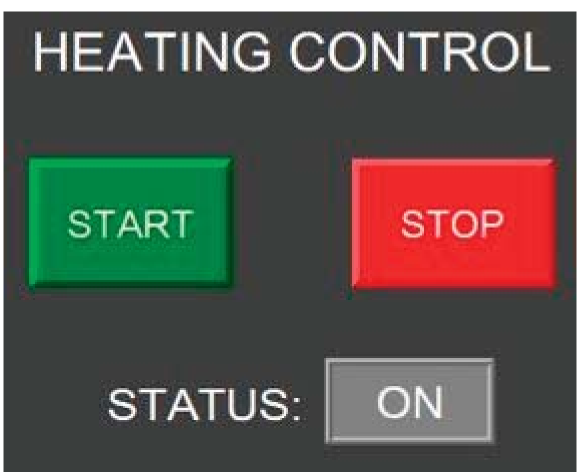

Figure 3-14. START and STOP Tabs

B. Observe that when the temperature rises above 85.0 °F the PLC will turn on the fan and the blue indicator lamp. The HEATER display will change to OFF and the heater will turn off.

With the setpoint being 85 °F, the temperature can still rise beyond 85 °F because there is residual energy in the heater.

C. Observe that once the temperature in the workstation drops below 75 °F, the PLC turns off the fan and the blue indicator lamp off. Once the fan turns off, the heater will turn on and the red indicator lamp will turn on.

D. Observe the workstation and the heating application screen as the cycle repeats. Once you are ready to continue, proceed to substep E.

E. Press STOP to end the heating application.

In the heating application screen, status will change to OFF and the heater coils will change to silver on the HMI graphic.

10. Perform the following substeps to launch Connect Components Workbench (CCW).

A. Press the Windows key on the keyboard to open the Start menu.

B. Click on CCW in the Windows start menu.

C. Click on the **File** tab to open the file menu.

D. Click on **Discover** and this will open the connection browser.

E. Click on the **+** symbol to expand AB_ETHIP-1, Ethernet tree.

F. Click on the Micro820 gateway to highlight it.

G. Click on **OK** in the bottom right of the window.

11. Perform the following substeps to view the heating application in ladder logic.

A. Double-click on **Temperature_Heating2**, located at the top of the devices tree on the lefthand side, as shown in figure 3-15.

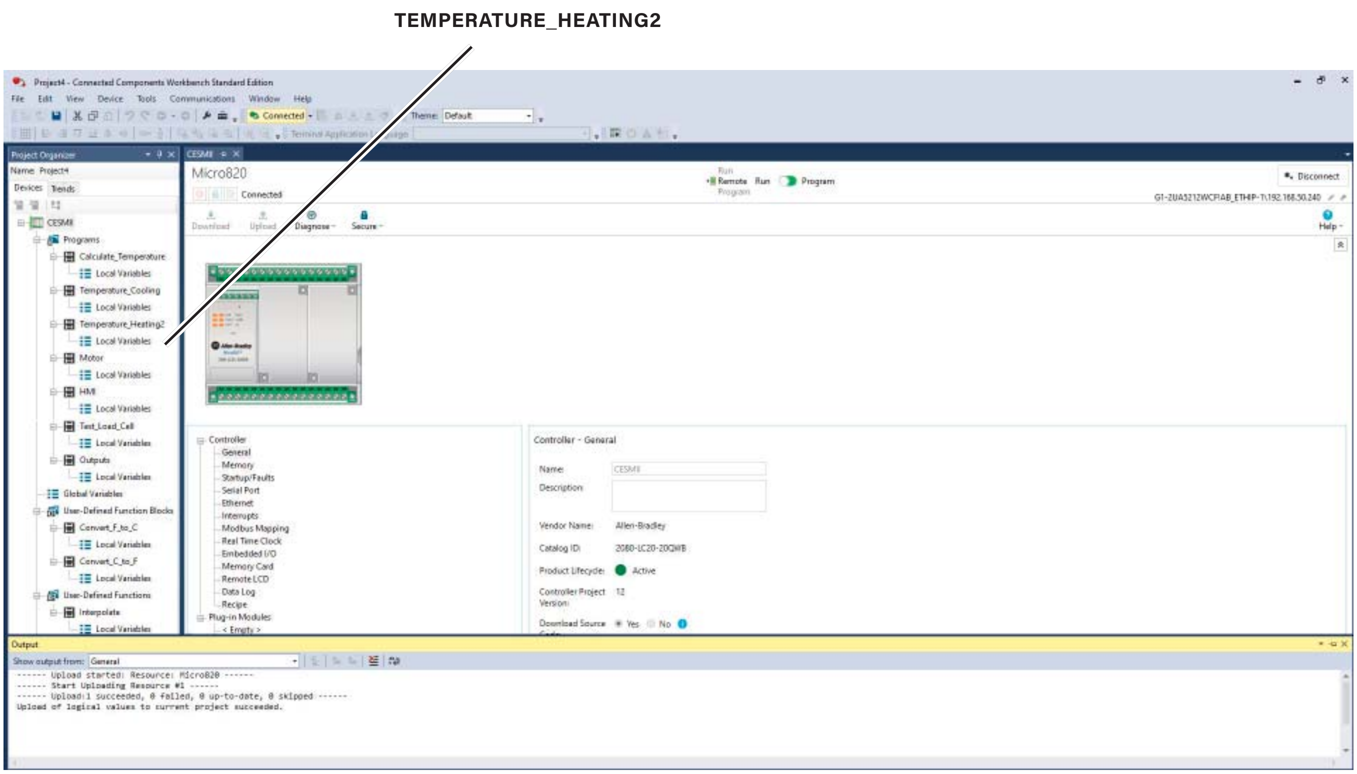

Figure 3-15. CCW with CESMII Program

B. Notice that Temperature_Heating2 program window will open as shown in figure 3-16.

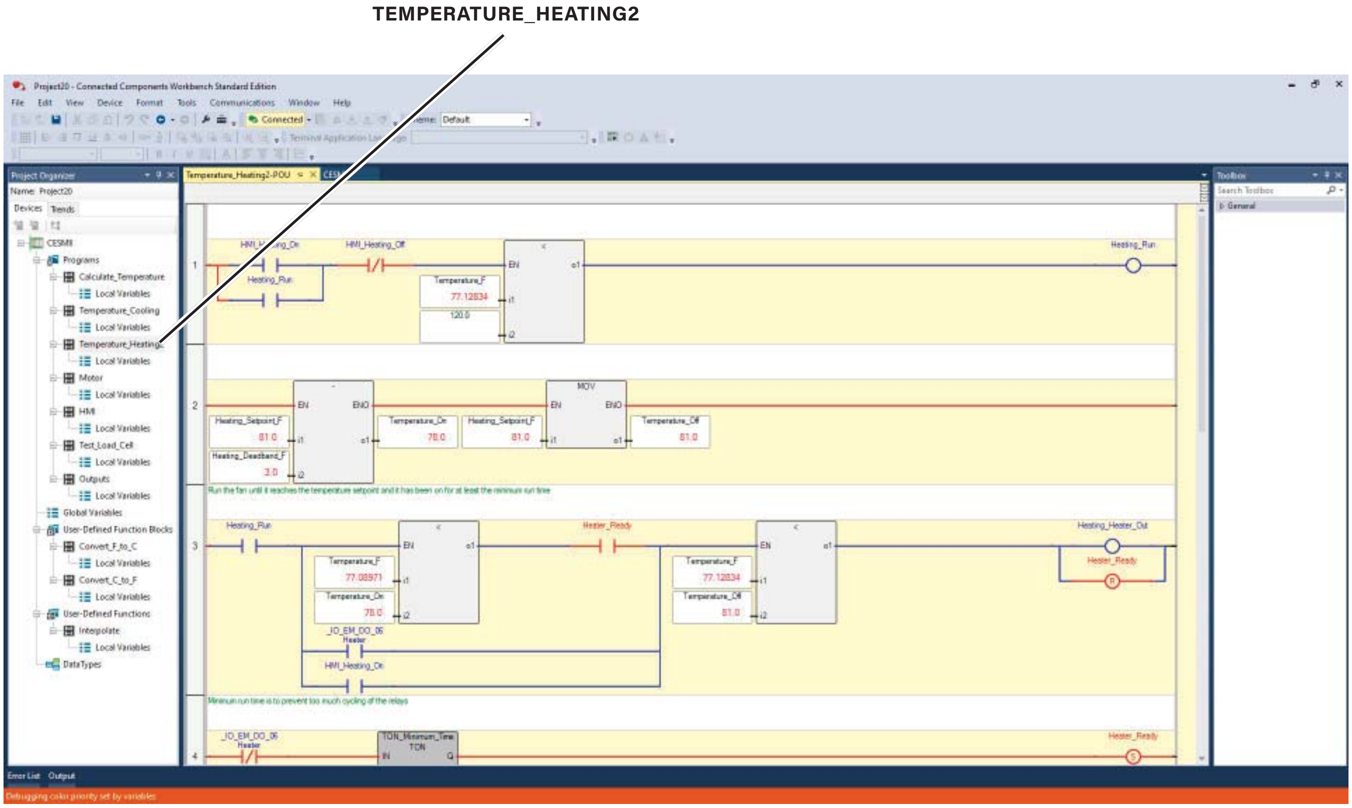

Figure 3-16. CCW Temperature_Heating2 Ladder Logic

On rung 3, the Temperature_Heating2 program compares input temperature against setpoints and deadband points using Less Than comparison instructions to determine when to run the heater.

C. Observe rung 3. When the lines of the rung all display red path, similar to figure 3-17, the output turns on and the heater runs.

The red lines indicate that the rail/instruction block statement to the left of the line is true. When the entire rung is red, the output is turned on. Blue lines indicate that the rail/instruction block to the left of the line is false. This means that the output is remaining off or being turned off.

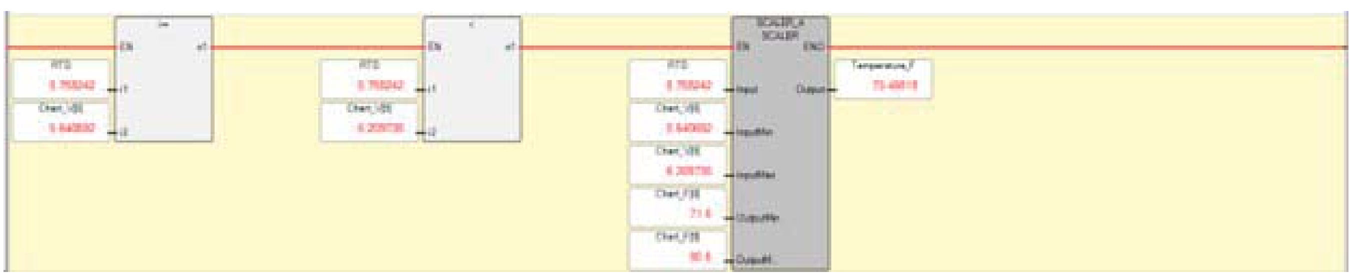

Figure 3-17. CCW Red Line Ladder Rung

D. Using step 9 as reference, click **START** to run the heating application.

E. Notice in the Temperature_Heating2 program, that rung 1 becomes true and outputs Heating_Run.

F. Observe the ladder rungs as the temperature changes to see what changes in the program as temperature limits are reached.

G. Notice on rung 3 after the temperature decreases below the Temperature_On instruction block, that the output Heating_Heater_Out will become true and turn the heater ON. As the temperature increases above Temperature_Off instruction block, the fan will turn OFF as the rung becomes false.

H. Using step 9 as reference, click STOP to end the cooling application.

12. Close CCW by clicking the (**X**) in the top right-hand corner of the software.

13. Perform the following substeps to end the heating application program and to close the HMI window.

A. Click the FactoryTalk View Station icon in the taskbar to maximize the HMI window, similar to figure 3-18.

Figure 3-18. FactoryTalk View Station Icon

B. Click **MAIN MENU** in the bottom right of the screen.

C. From the Smart Manufacturing System screen, click **SHUTDOWN** in the bottom right of the screen.

14. Perform the following substeps to power down the Smart Manufacturing system.

A. Press the power button on the Hub to power down the Hub.

B. Place the workstation's main power switch in the **OFF** position.

The PLC, switch, and Wi-Fi temperature sensor should power down.

C. Turn off the PC and monitor.

PROCEDURE OVERVIEW

In this procedure, you will use the PC HMI application to view and operate the production control application. The HMI communicates with the PLC to start and stop the motor control application. This application simulates the operation of a conveyor and many other motor-driven machines. A guard door is used to demonstrate the concept of a safety interlock. An interlock is a safety interlock device that must be in a certain position or state to allow machine operation.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system as shown in figure 4-1.

Figure 4-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.
   A. Connect the IEC power cord to the IEC connector on the workstation and an AC wall outlet, as shown in figure 4-2.

Figure 4-2. IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, the PLC, and the PC, as shown in figure 4-3.

Figure 4-3. Ethernet Cable Connections

3. Turn on the PC and monitor.
4. Flip the main power switch on the 990-SM10 Workstation to ON to power up the system.
5. Perform the following substeps to open the Smart Manufacturing HMI application on your PC.
   A. Click on the **FactoryTalk View ME Station 990 SM10** runtime icon on the desktop of the PC, shown in figure 4-4.

Figure 4-4. FactoryTalk View ME Station 990 SM10 Runtime Icon

A dialog will appear prompting "Do you want to allow this app to make changes to your device?" as shown in figure 4-5.

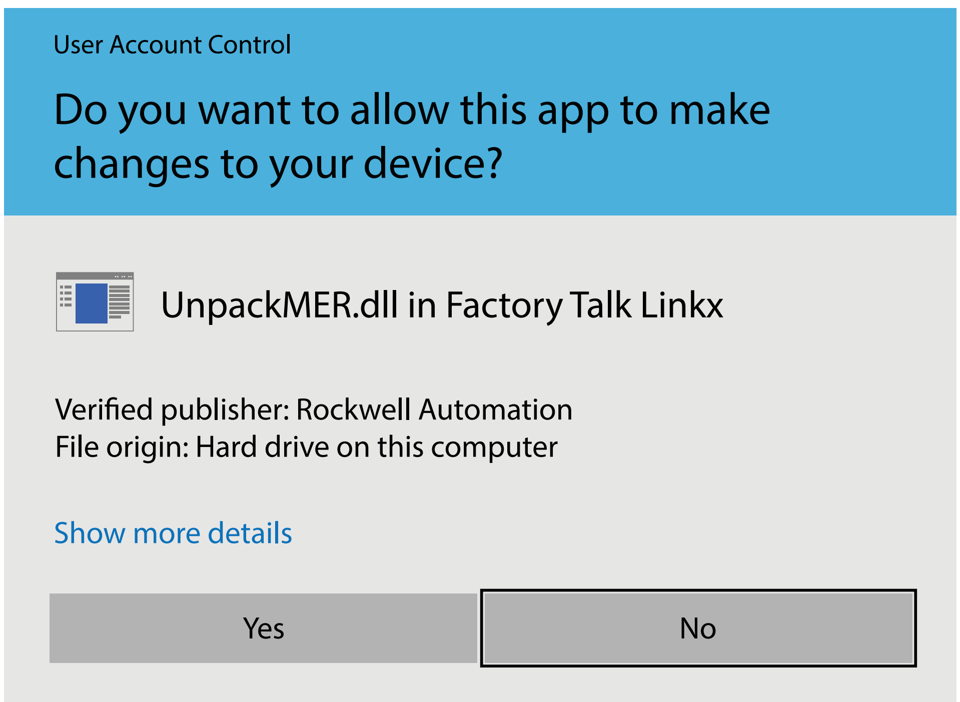

Figure 4-5. Administrative Permission Window

   B. Click **Yes.**

   After a short load time the Smart Manufacturing System main screen will appear.

6. In the Smart Manufacturing system main screen, press the **Production Application** tab.

   The production application is an HMI program installed on the PC to provide an operator interface to control a motor via the PLC.

   The PLC program is designed to start and stop an electric motor using an on/off type digital output. The motor speed is controlled by a manual potentiometer located on the workstation panel.

   The motor is equipped with a guard door for safety. An inductive input sensor senses whether the door is open or closed to determine if the motor is safe to be turned on. This sensor is wired to a PLC digital input. The PLC program prevents the motor from starting if the door is open, indicated when the inductive sensor is off.

   If the sensor is on, indicating that the door is closed, the operator can start and stop the motor using the buttons on the HMI screen.

   The workstation panel also has a selector switch to manually start and stop the motor and a potentiometer to adjust motor speed. The selector switch and PLC output must both be on to operate the motor.

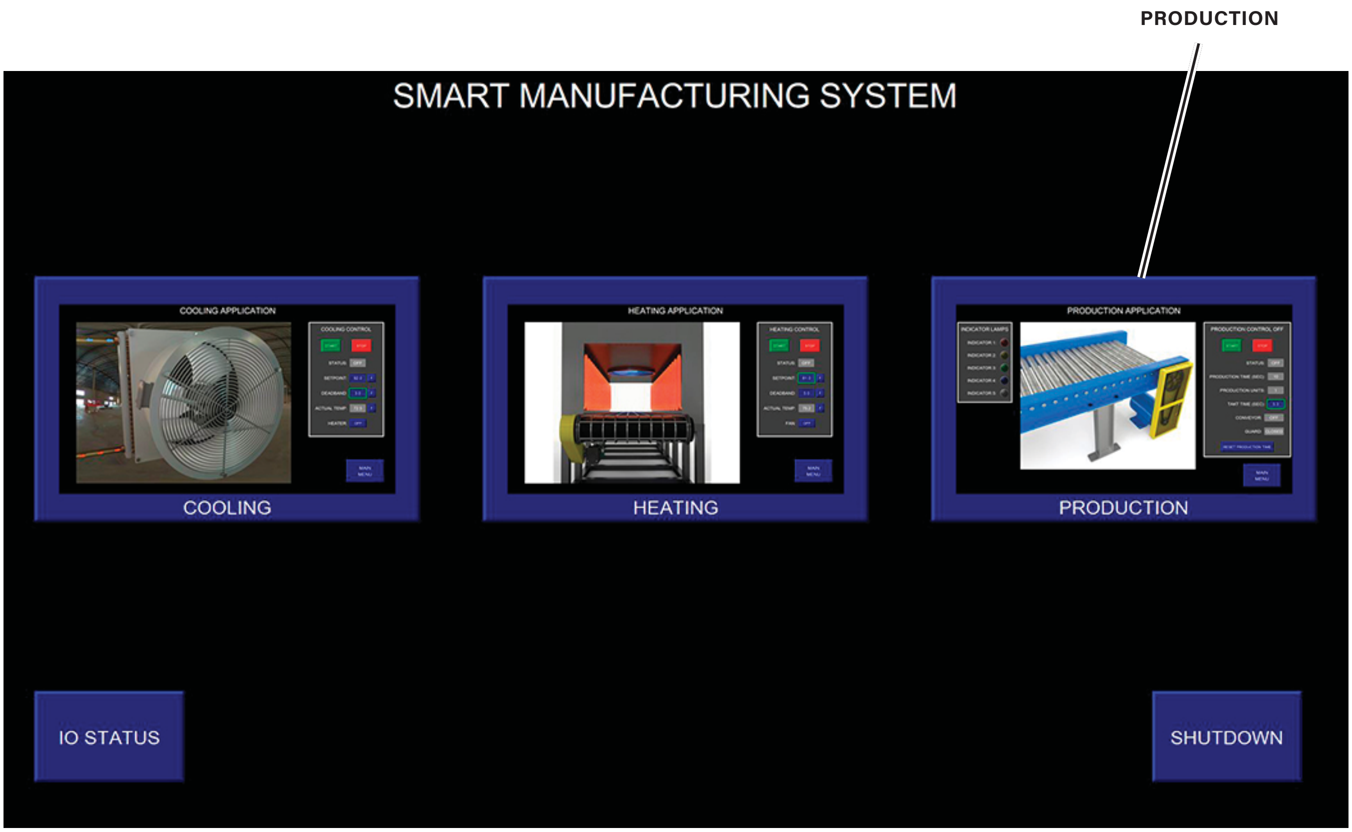

Figure 4-6. Production Application Tab

7. Examine the control diagram of the production application in figure 4-7.

   The motor is controlled by a 24 VDC digital output (on/off) from the PLC. The white indicator is connected to the motor circuit, after the motor switch. The PLC controls the green and yellow indicator lights using individual 24 VDC digital outputs for each indicator.

   The only input to the PLC is an induction sensor, which is connected to a digital (on/off) input of the PLC.

   The three indicators indicate system status. If the induction sensor is off, indicating an open door, the PLC turns on the yellow indicator. If the door is closed and the production control start button has been pressed, the PLC turns on the green indicator. When start button is pressed and the motor switch is on, the PLC turns on the white indicator.

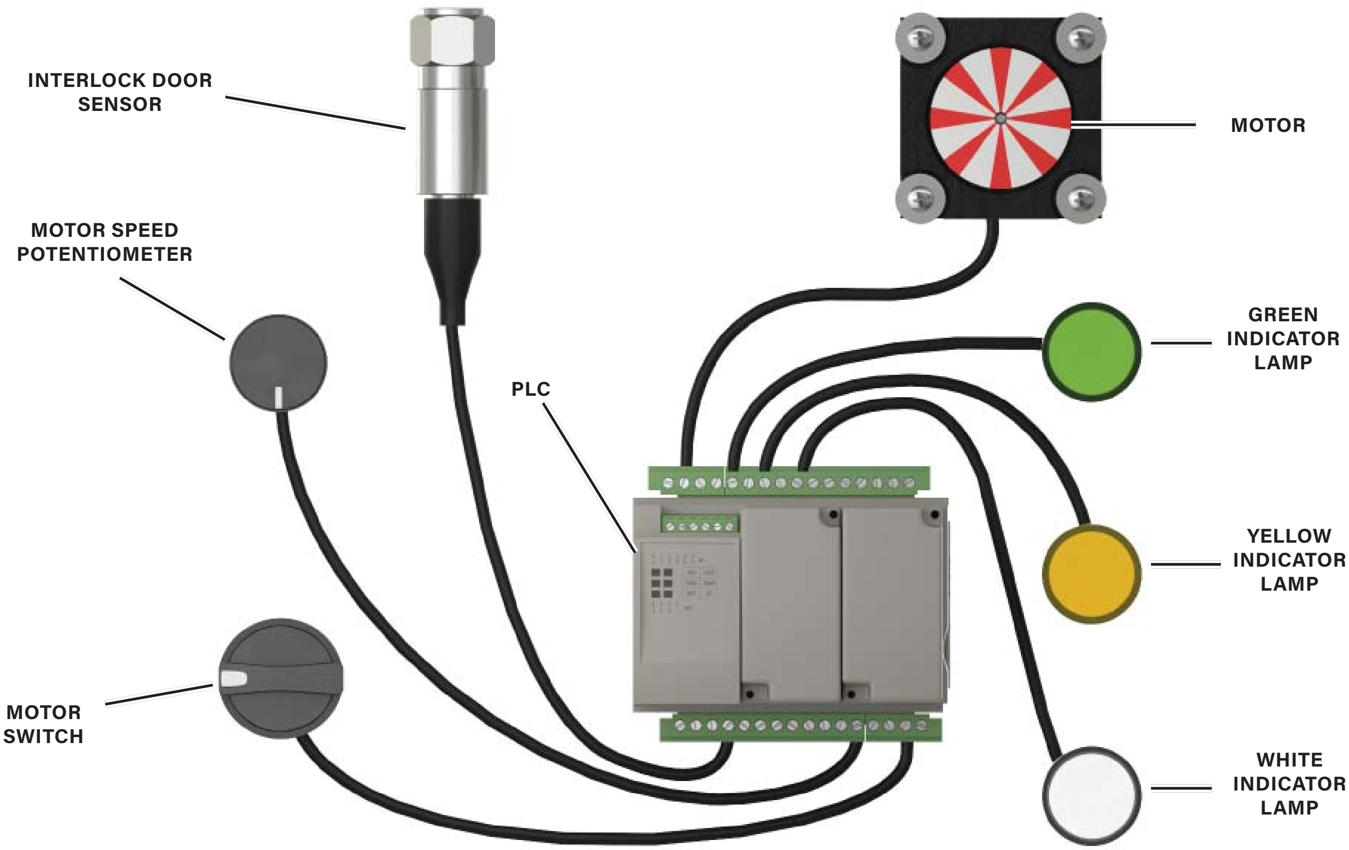

Figure 4-7. Diagram of Production Application Inputs and Outputs

8. Perform the following substeps to test the interlocked guard door.

   A. Pull open the INTERLOCKED GUARD DOOR on the workstation and observe the motor and indicator lights.

      The guard door performs as a safety switch to protect people from the turning motor, like a safety guard for a conveyor. When the door is opened, the sensor sends a signal to the PLC to stop the motor. In the HMI production application screen, the status will change to OFF, the conveyor will change to OFF, and the rollers and pulley will stop rotating. While the door is opened, the yellow indicator will turn on.

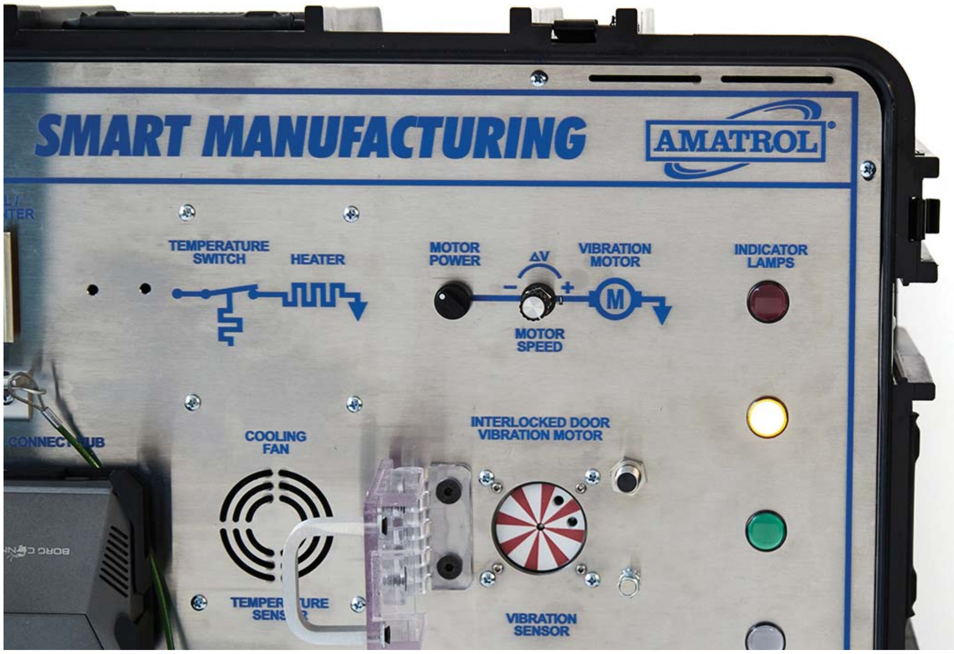

Figure 4-8. INTERLOCKED GUARD DOOR Open

   B. Close the guard door so the door switch can signal the PLC that the door has been closed. Observe the motor and indicator lights.

      Once the PLC receives the input from the door switch that the door is closed, the motor can be manually started. If the door has been opened while the motor is running, the motor must be restarted to function again.

9. Perform the following substeps to familiarize yourself with the controls on the workstation and how they function with the HMI Production Application.

   A. Rotate the MOTOR POWER switch (on the workstation panel) clockwise to the ON position to enable the motor, as shown in figure 4-9.

      The white indicator will turn on to show that the manual motor switch is active so that the motor can function. This switch can also be used to manually turn off the motor.

ON

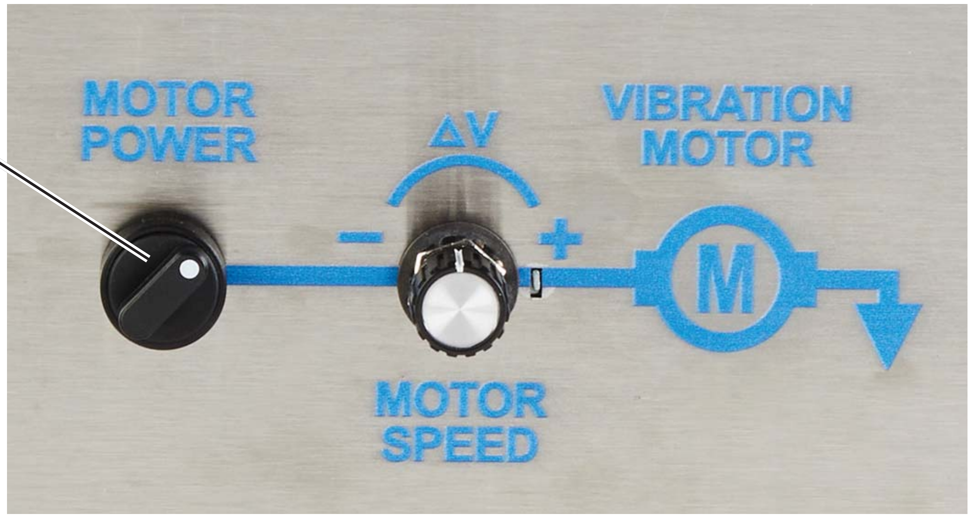

Figure 4-9. MOTOR POWER Switch in On Position

   B. Press **START** on the HMI to activate the production application.

      The motor will start. Initially, the motor may not turn if the potentiometer is turned fully counterclockwise. In the Production Application Screen, STATUS will change to ON, CONVEYOR will change to ON, and the rollers and pulley will rotate. The green indicator lamp will turn on to show that the motor is on and the production application is running.

Figure 4-10. START and STOP Objects

C. Rotate the MOTOR SPEED potentiometer clockwise to the midpoint to increase the rotation speed of the motor on the workstation.

As the potentiometer is rotated clockwise, you will notice that the speed of the motor increases. Stopping the motor by turning the potentiometer fully counterclockwise to zero does not stop the production application. The PLC output to the motor is still on.

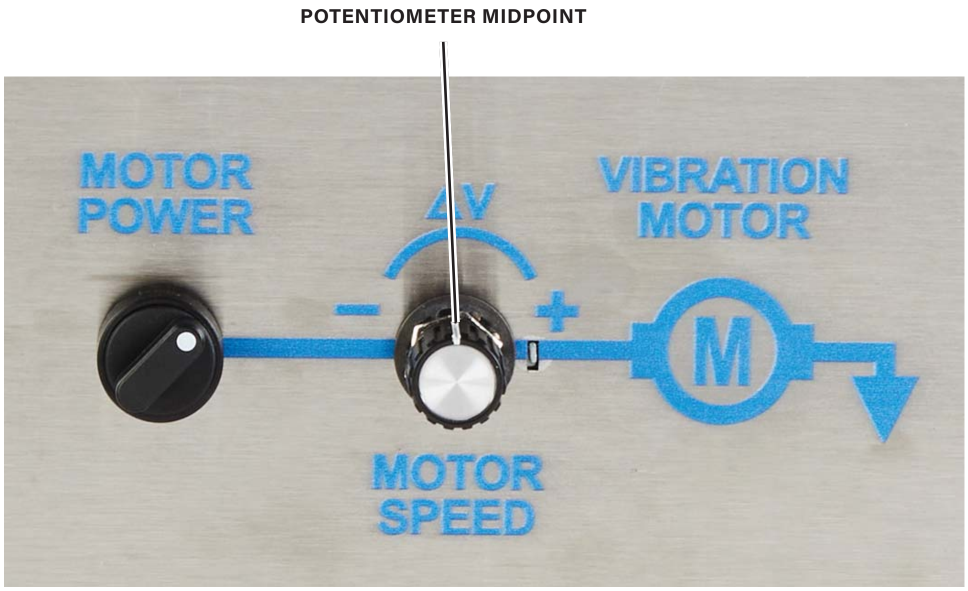

Figure 4-11. MOTOR SPEED Potentiometer

D. Press **STOP** on the HMI application.

The green indicator will turn off and the motor will stop.

E. Rotate the MOTOR SPEED potentiometer fully clockwise.

F. Press **START**.

The green indicator will turn on and the motor will start. Observe the change in motor rotation. It will now be rotating at a higher rate.

G. Turn the potentiometer counterclockwise to the midpoint.

Observe that the motor is now rotating at a slower rate than in the last substep.

H. Press **STOP**.

The green indicator will turn off and the motor will stop.

I. Repeat substeps B through H to become more familiar with the operation of the application, then continue to substep J.

J. Press **START**.

The green indicator will turn on and the motor will start.

K. Rotate the MOTOR SPEED potentiometer fully counterclockwise to reduce the rotational speed of the motor until it stops rotating.

L. Press **STOP**.

The green indicator will turn OFF and the motor will stop.

M. Rotate the MOTOR POWER switch counterclockwise to disable the motor.

The white indicator will turn off to show that the manual motor switch is off.

10. Perform the following substeps to familiarize yourself with operation of the production application on the HMI.
    A. Locate the production time (gray) box on the screen.

       This box displays the time, in seconds, that the production control application is running. This value is being tracked in the PLC program.

       When the start button is pressed, the production time will begin incrementing. The production time will continue to increase until the stop button is pressed or the guard door is opened.
    B. Locate the production units (gray) box on the screen.

       This box displays a count of the number of simulated units produced by the simulated application. This value is tracked by the PLC.

       Like the production time, the production units will increment while the production control application is running. The rate at which it increments is based on TAKT time.
    C. Locate the TAKT time (blue) box on the screen.

       Takt time is the rate at which a quantity of product must be produced to meet customer demand.

$$Takt\ Time\ (units\ of\ time) = \frac{Workable\ Production\ Time\ Per\ Day}{Customer\ Demand\ Units\ Per\ Day}$$

       As the customer demand changes, the production conveyor speed may need to be increased for more output or decreased for less output. Workable production time can also increase or decrease and affect the equation.
    D. Press the TAKT time blue box to open the number pad to change the TAKT time to **7.5** and click **Enter**.

       The production time and production units will reset. The production units will increase at a slower rate at 7.5 seconds than with the TAKT time of 5.3 seconds.
11. Perform the following substeps to launch the CCW PLC program software.
    A. Press the Windows key on the PC keyboard to open the start menu.
    B. Click on **CCW** in the Windows start menu.
    C. Click on the **File** tab to open the file menu.
    D. Click on **Discover** to open the connection browser.
    E. Click on the **+** symbol to expand the AB_ETHIP-1, Ethernet tree.
    F. Click on the Micro820 gateway to highlight it.
    G. Click on **OK** in the bottom right of the window.

12. Perform the following substeps to observe the operation of the Motor program.

    A. Double-click on **Motor**, located at the top lefthand side of the devices tree, as shown in figure 4-12.

       The Motor Control program uses the door interlock input and inputs from the HMI screen buttons to determine when to turn on the motor and the indicators.

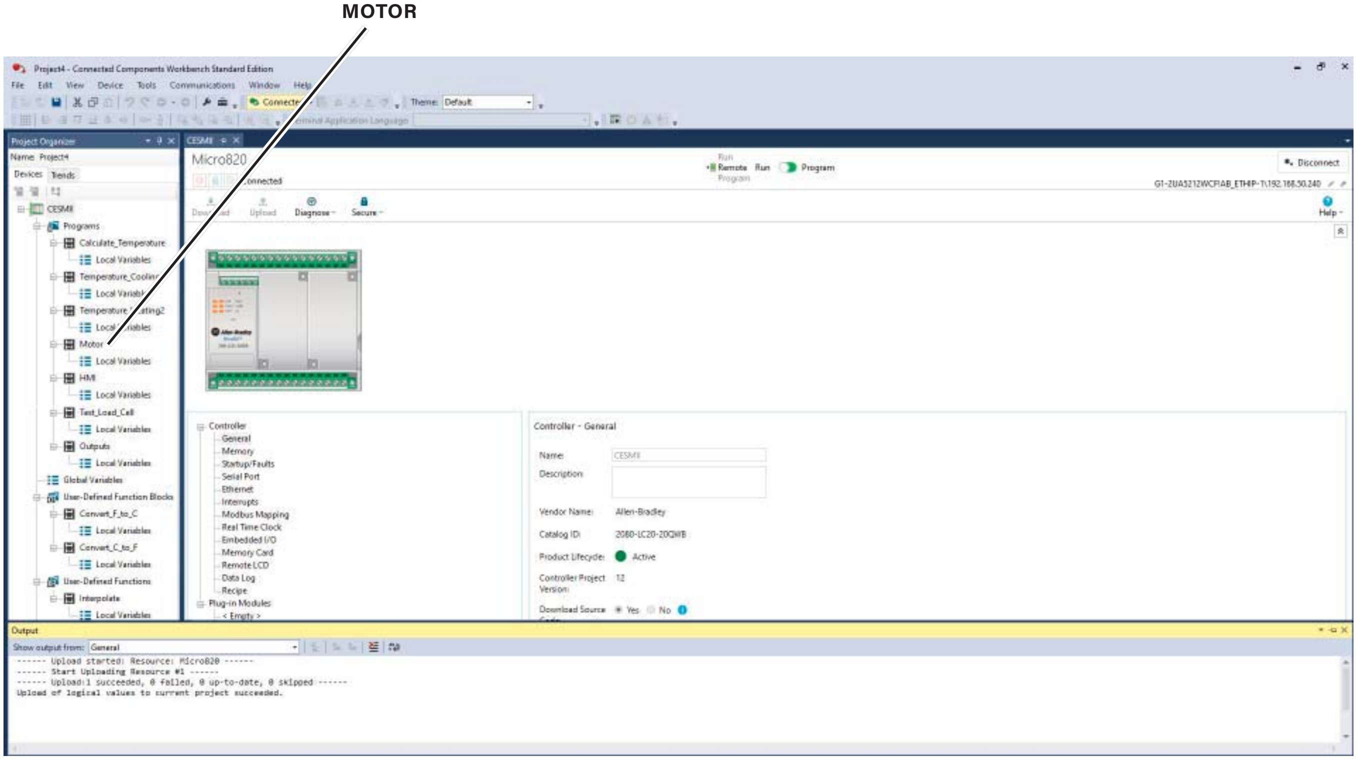

Figure 4-12. CCW with CESMII Program

The Motor program window will open as shown in figure 4-13.

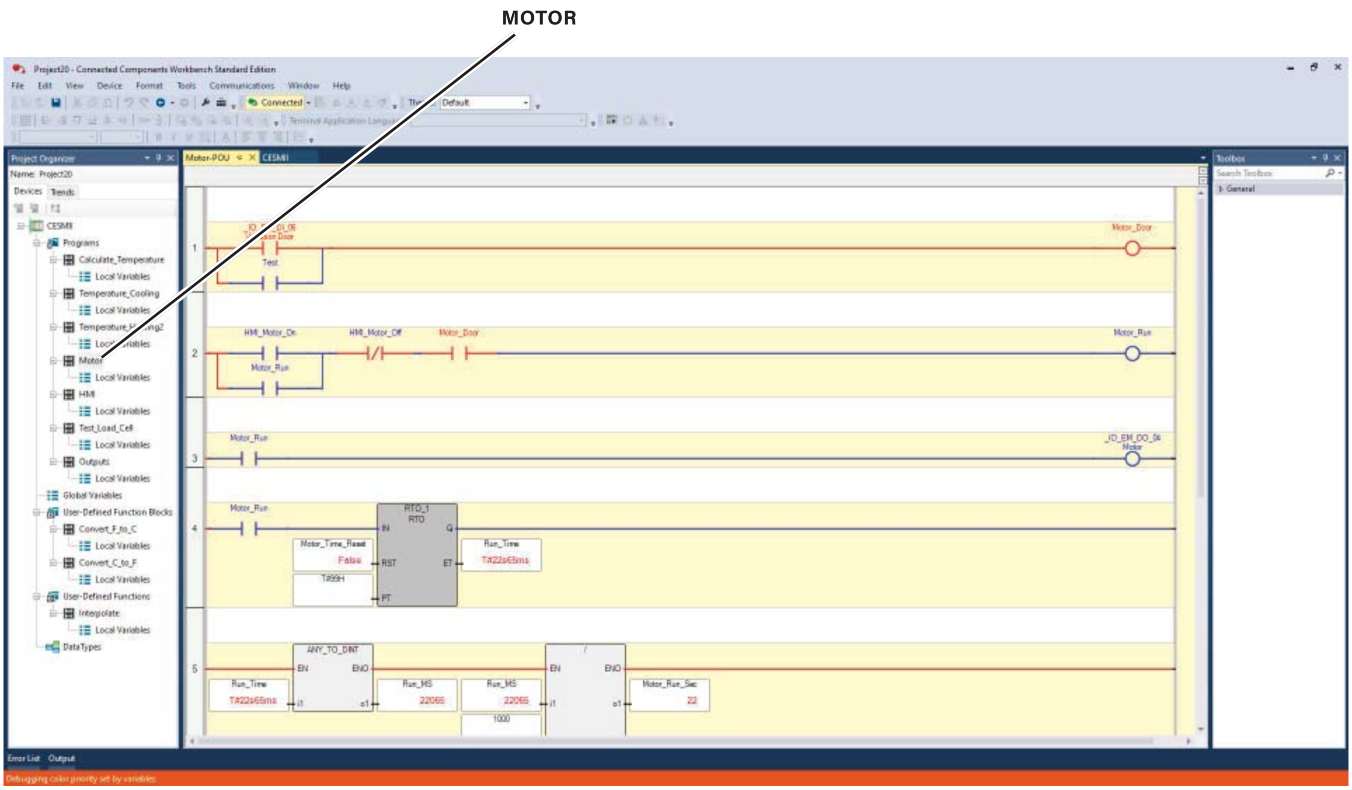

Figure 4-13. CCW Motor Ladder Logic

B. Observe rung 2 of the program.

The lines display red all the way across, similar to figure 4-14.

These lines proceed from left to right. The red lines indicate that the rail / instruction block statement to the left of the line is true.

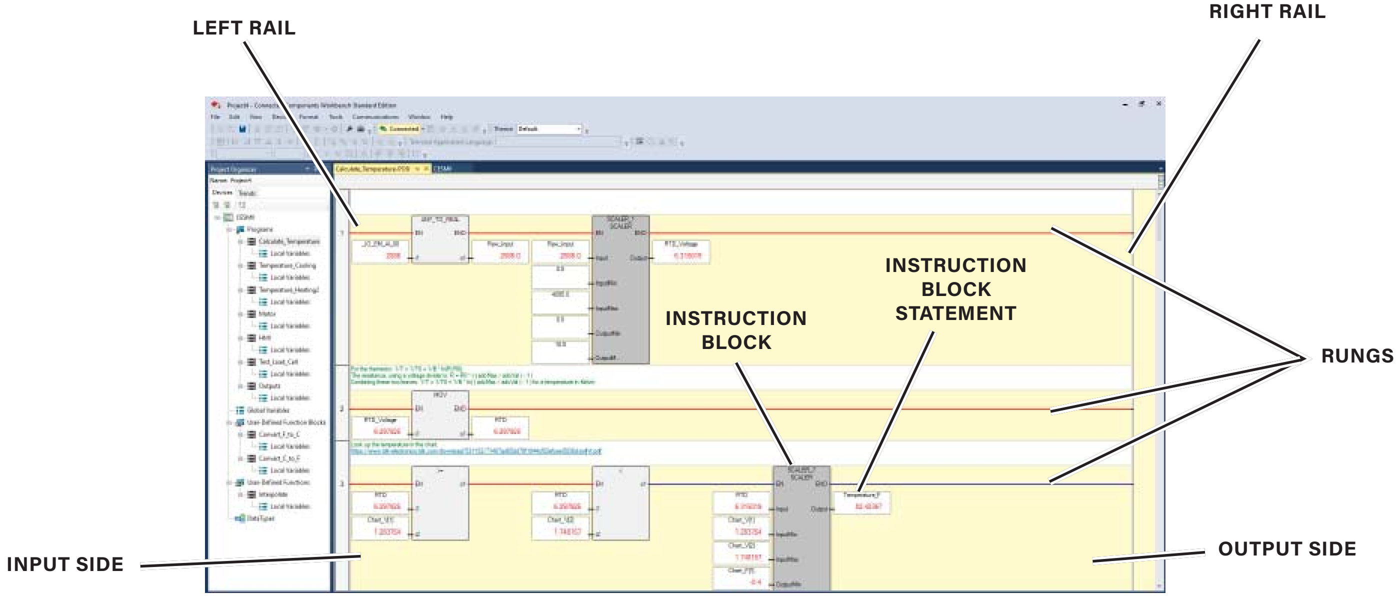

Figure 4-14.   CCW Red Line Ladder Rung

C. Notice in the Motor program that rung 1 is true when the interlock door is closed.

D. Using step 9 as a reference, open the interlock door and observe how the ladder rungs react in the Motor program to turn on the yellow indicator.

E. Close the interlock door and observe as the yellow indicator turns off.

F. Press **START** in the HMI application.

Notice that rung 2 becomes true and turns on the green indicator when the production application is running.

13. Click on (**X**) in the upper right corner of the screen to exit CCW.

14. Perform the following substeps to end the production application program and close the HMI application.

A. Press **STOP** to end the production control application.

In the production application, the status will change to OFF, the conveyor will change to OFF, and the rollers and pulley will stop rotating.

B. Press **MAIN MENU** to return to the main menu.

C. Press **SHUTDOWN** to end the HMI application.

15. Perform the following substeps to power down the Smart Manufacturing system.

A. Press the power button on the Hub to power down the Hub.

B. Place the workstation’s main power switch in the **OFF** position.

The PLC, switch, BorgConnect Node, and Wi-Fi temperature sensor should power down.

C. Turn off the PC and monitor.

ACTIVITY 5 REMOTE CONDITION MONITORING

PROCEDURE OVERVIEW

In this procedure, you will use the PC and a Wi-Fi temperature/humidity sensor to monitor temperature and humidity locally and then remotely.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system as shown in figure 5-1.

Figure 5-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the IEC connector on the workstation and to an AC wall outlet, as shown in figure 5-2.

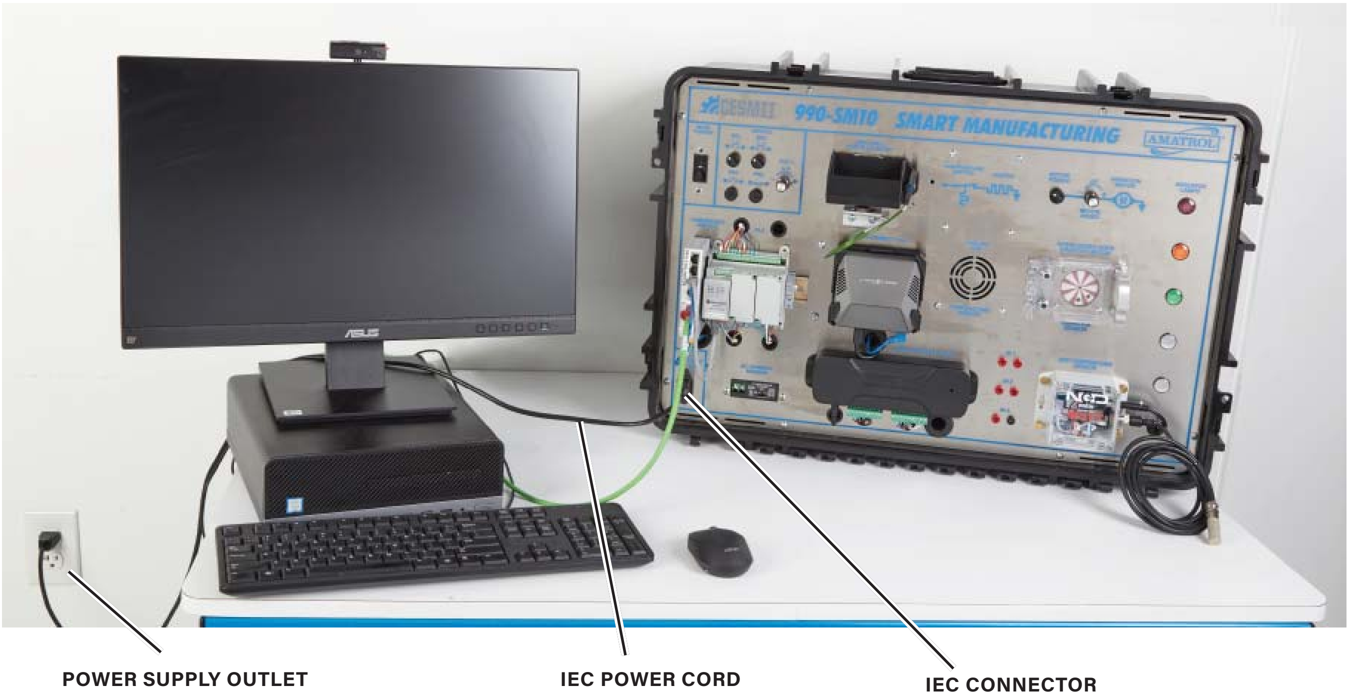

Figure 5-2. IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, the PLC, and the PC as shown in figure 5-3.

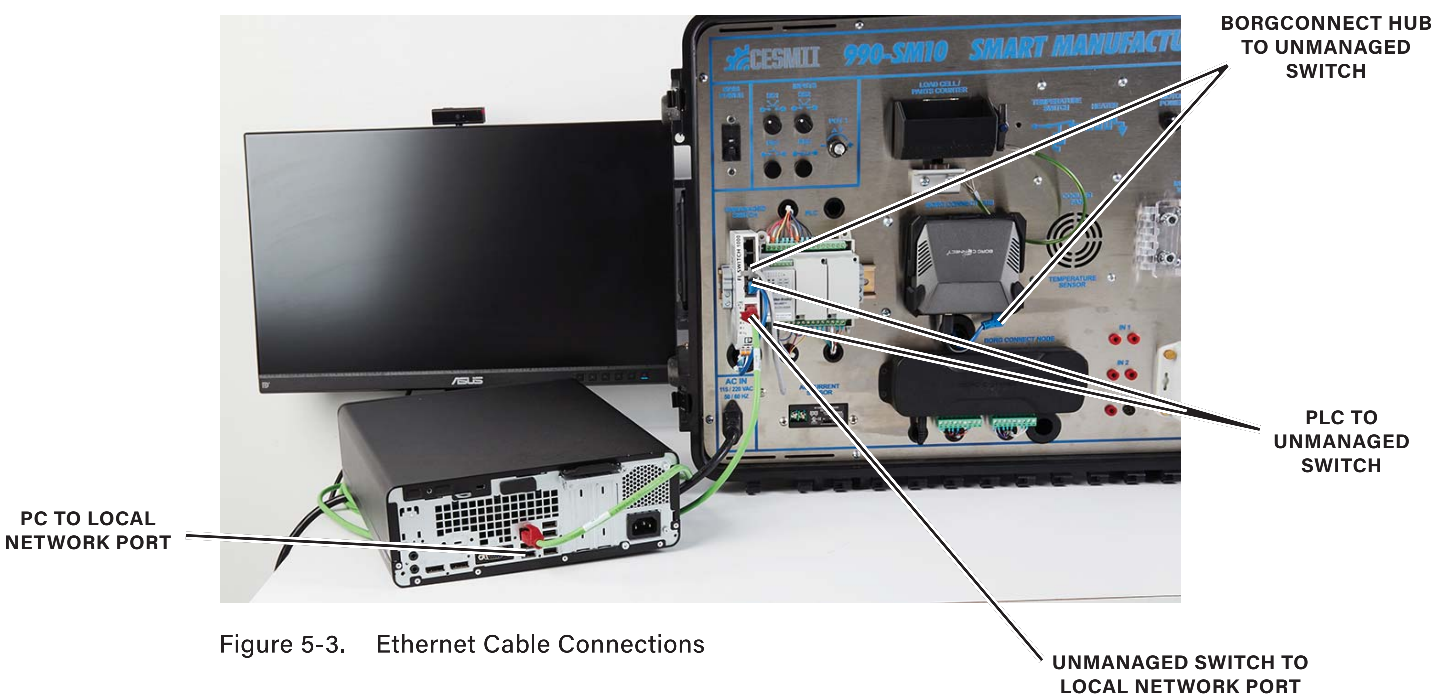

Figure 5-3. Ethernet Cable Connections

3. Turn on the PC and monitor.
4. Flip the main power switch on the 990-SM10 Workstation to **ON** to power up the system.

   The Ethernet switch, the PLC, the BorgConnect Node, and the Wi-Fi temperature/humidity sensor will each turn on an indicator on their enclosure to indicate that they are powered on.
5. Press the power button on the BorgConnect Hub as shown in figure 5-4.

Figure 5-4. BorgConnect Hub Power Button

Shortly after pressing the power button on the BorgConnect Hub, a red indicator light will turn on to indicate the unit is powered on as shown in figure 5-5.

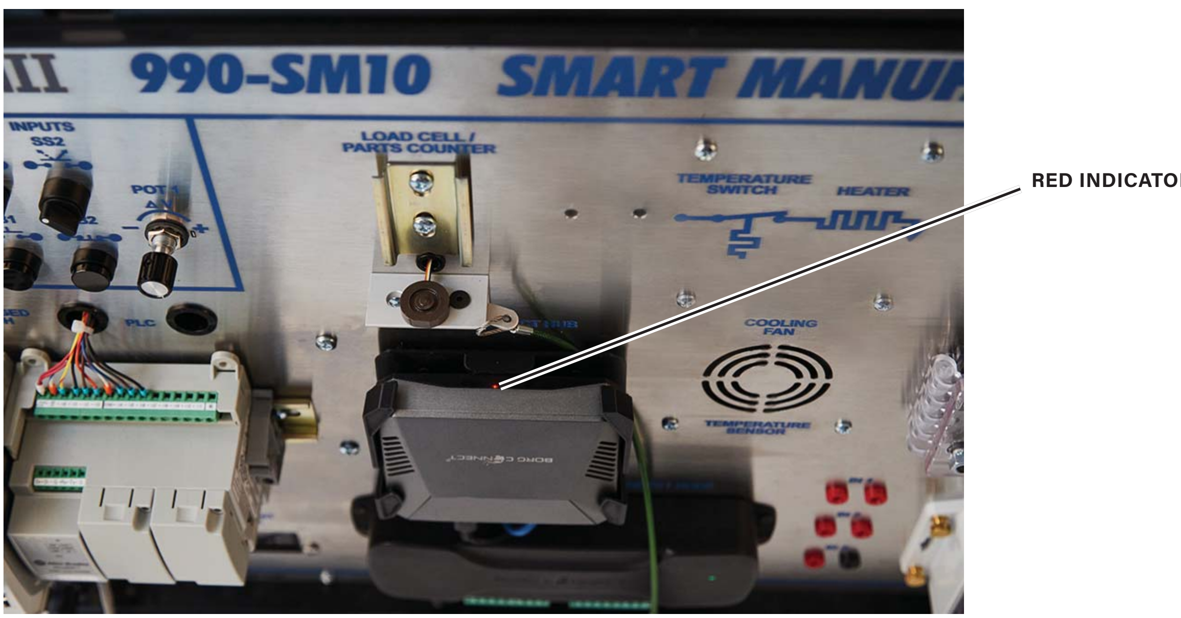

Figure 5-5. BorgConnect Hub Indicator

6. Perform the following substeps to review the system components.

   A. Examine the Wi-Fi temperature/humidity sensor on the workstation panel.

      The Wi-Fi temperature/humidity sensor measures temperature and humidity. It consists of two parts: a transmitter and a sensor head as shown in figure 5-6. The sensor head contains a temperature sensor and a humidity sensor. The Wi-Fi temperature/humidity transmitter connects to a DC power supply and to a 4-pin connection on the sensor enclosure. The transmitter uses an MQ Telemetry Transport (MQTT) application to wirelessly stream the data to the BorgConnect Hub via a Wi-Fi connection. The BorgConnect Hub then extracts the data so that the results can be monitored through the BorgConnect Dashboard on the MQTT sensor application.

      MQTT is used to publish data between devices because it requires a minimal network bandwidth and uses a small code footprint to share data.

      The Wi-Fi temperature/humidity transmitter has a red indicator light to display that the transmitter has power. A second indicator light informs the user of its status. The status states of the second indicator light are:

      - Flashing green: The transmitter has an established connection to Wi-Fi and MQTT Broker.
      - Solid white: The transmitter has a Wi-Fi connection but has not made an MQTT Broker connection.
      - Flashing white: The sensor is attempting to make a Wi-Fi connection.
      - Flashing blue: The transmitter is in configuration mode.
      - Flashing red: The transmitter has failed to connect/authenticate with MQTT Broker.

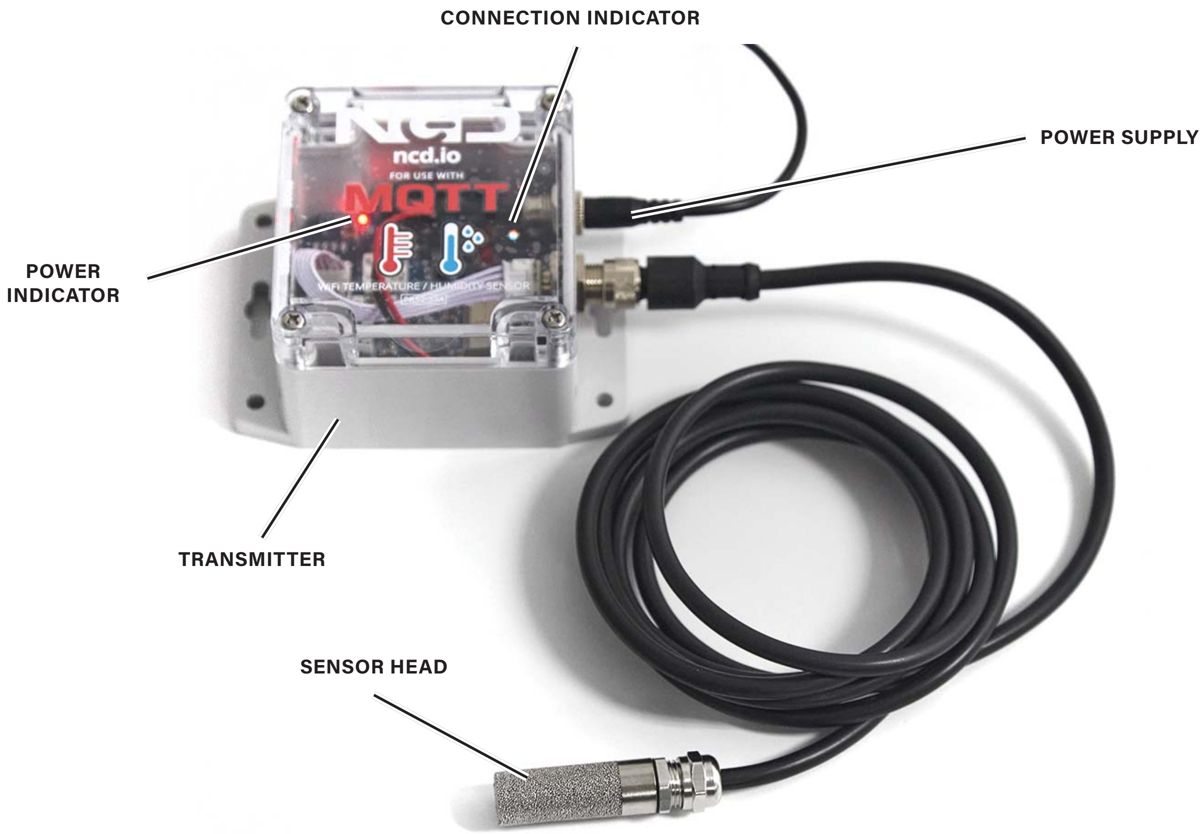

Figure 5-6. Wi-Fi Temperature/Humidity Sensor

An MQTT Broker receives messages published by clients, filters the messages by topic, and then distributes them to subscribers.

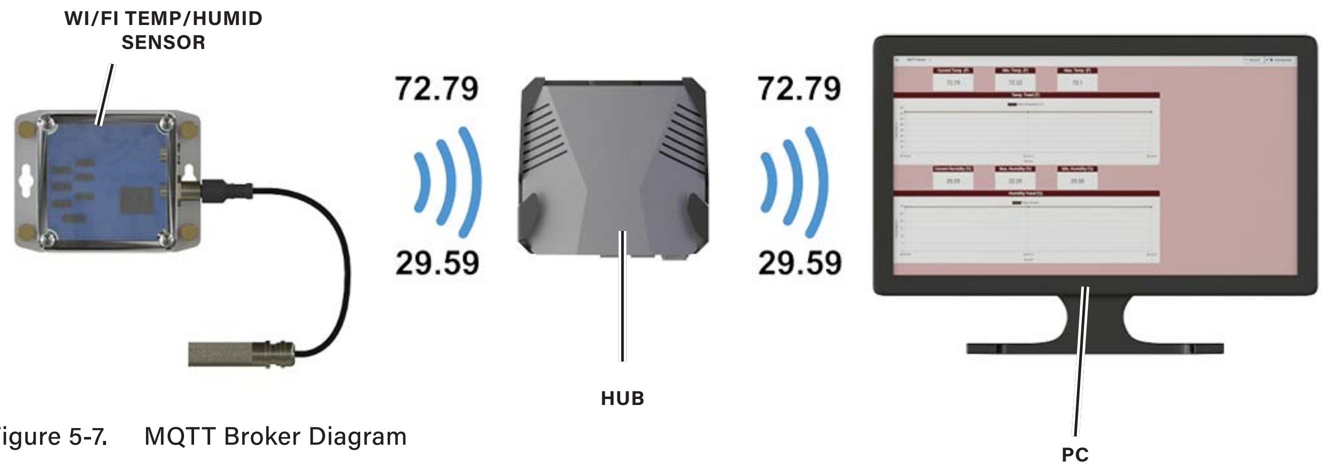

Figure 5-7. MQTT Broker Diagram

> **NOTE**
>
> The Wi-Fi temperature/humidity sensor is not for outdoor use or use in extreme temperatures. Avoid extreme humidity and smoky environments to prevent sensor damage.

B. Examine the communication diagram in Figure 5-8, which shows how data flows from the sensor to the BorgConnect Hub and Dashboard.

The Wi-Fi temperature/humidity sensor measures the ambient air temperature and humidity and then transmits that data to the BorgConnect Hub via a Wi-Fi connection. The data transmission shares the temperature in Celsius, the temperature in Fahrenheit (°F), the humidity percentage (%), and the transmission count. The BorgConnect Hub extracts the data from the MQTT application, so that the data can be used by the BorgConnect Dashboard on the PC. From the BorgConnect Dashboard, the user can observe current temperature (°F) and humidity (%), maximums and minimums, and graph trends.

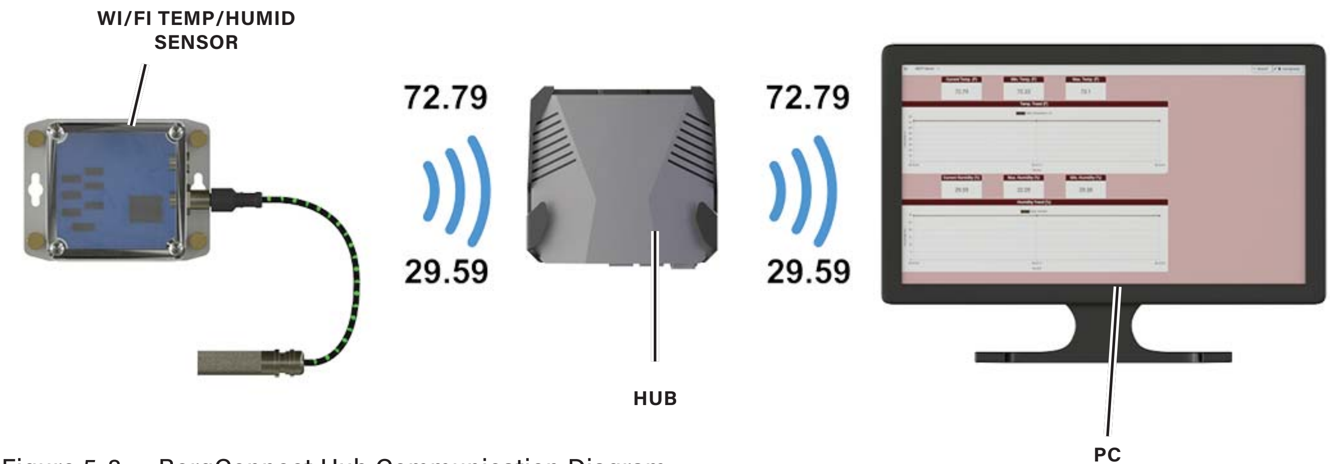

Figure 5-8. BorgConnect Hub Communication Diagram

7. Perform the following substeps to connect to the BorgConnect Dashboard on the PC.
   A. Open the internet browser on the PC.
   B. Enter http://10.3.141.1/ into the address bar and press **Enter** on the keyboard.
      This address is the pathway for connecting to the BorgConnect Hub via Wi-Fi.
   C. Enter the login credentials in the space provided.
      Username: admin
      Password: Welcome2BC
      After logging in, the BorgConnect Dashboard main screen will open similar to figure 5-9.
      The BorgConnect Dashboard is the used to view the data from the BorgConnect Hub from the PC.

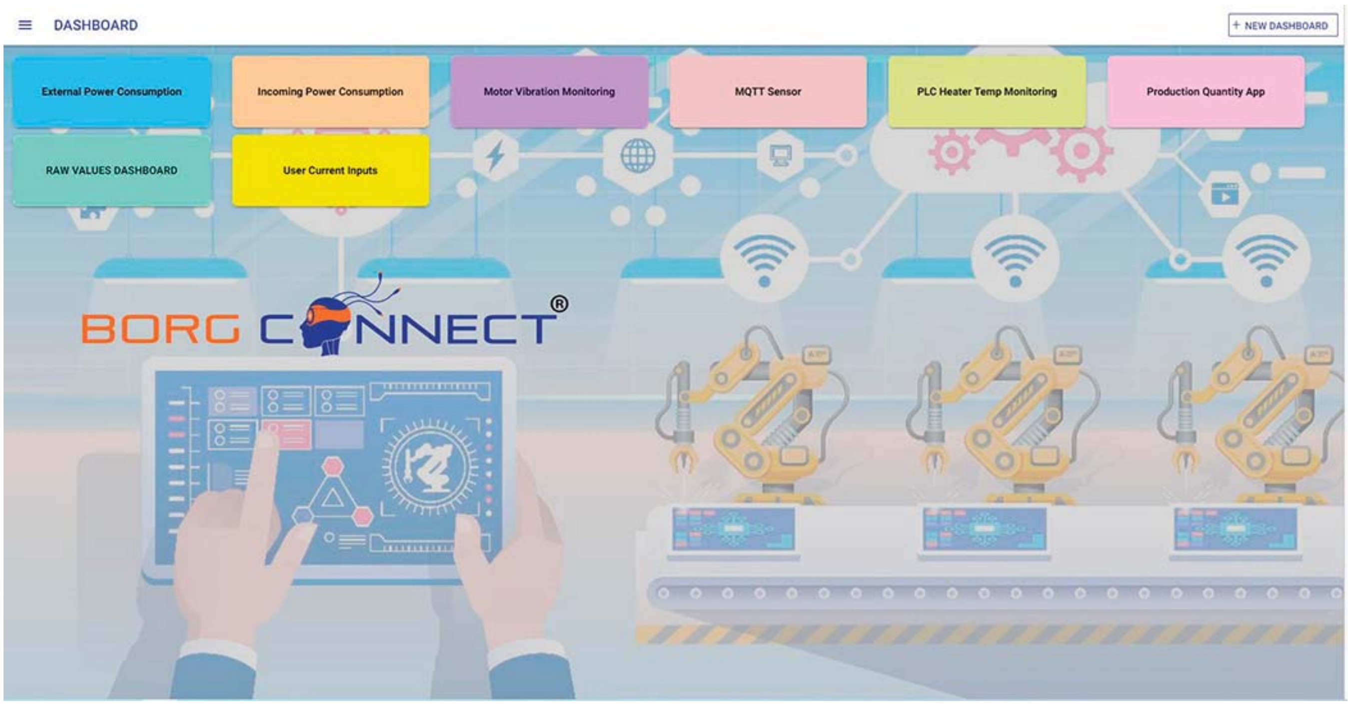

Figure 5-9. BorgConnect Dashboard Main Screen

8. Click the **MQTT Sensor** tab to observe the Wi-Fi temperature/humidity sensor connectivity.

   Ambient temperature (°F) and humidity (%) values will refresh because the Wi-Fi temperature/humidity sensor and the BorgConnect Hub are powered on and connected.

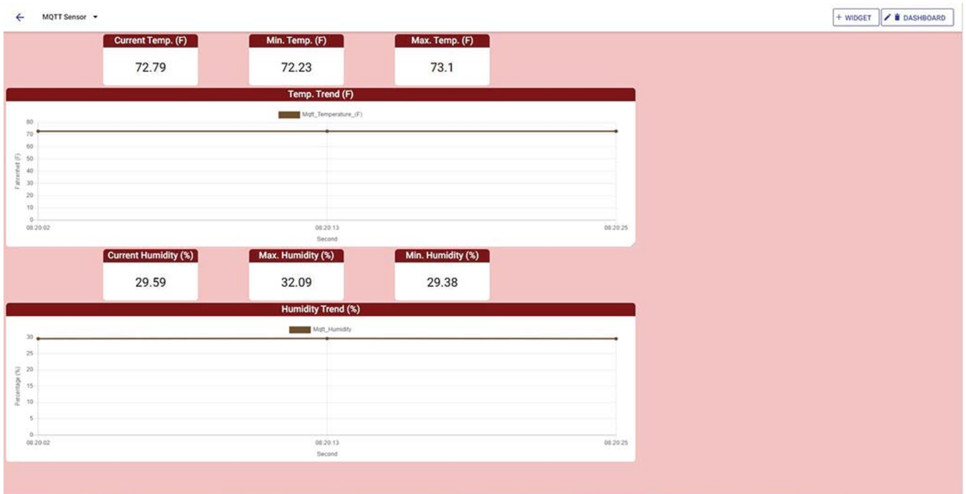

Figure 5-10. Wi-Fi Temperature Diagram

9. Perform the following substeps to familiarize yourself with the MQTT data transfer process.

   A. Examine the raw MQTT data that the Wi-Fi temperature/humidity transmitter sends using the MQTT application shown in figure 5-11. The MQTT application shares the data in a small data packet so that minimal resources are used to send and receive the data. The data that is shared looks similar to figure 5-11, but the values will vary as the temperature and humidity change.

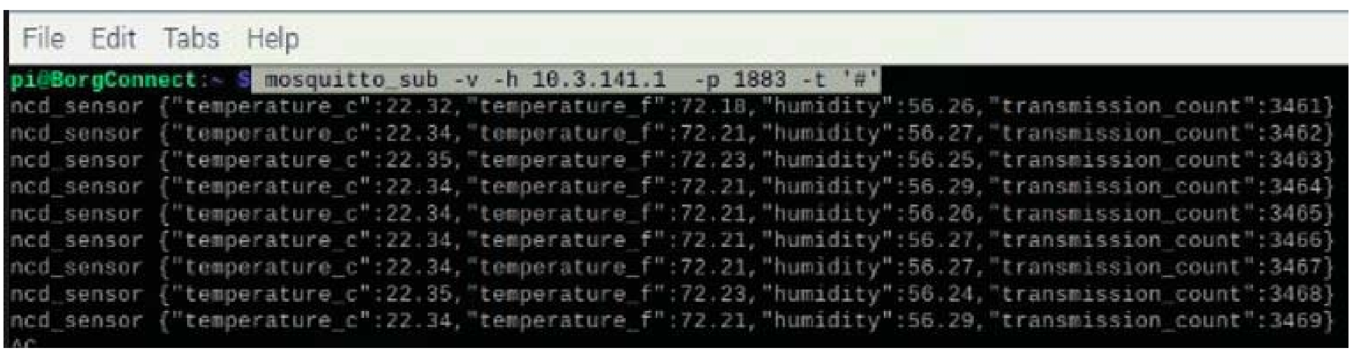

Figure 5-11. MQTT Raw Data

B. Examine the temperature and humidity data in figure 5-12 and observe how the MQTT data from the message format shared in figure 5-11 is displayed in the MQTT Sensor application on the BorgConnect Dashboard. The MQTT data must be extracted so that it can be imported into the BorgConnect Dashboard in a usable format.

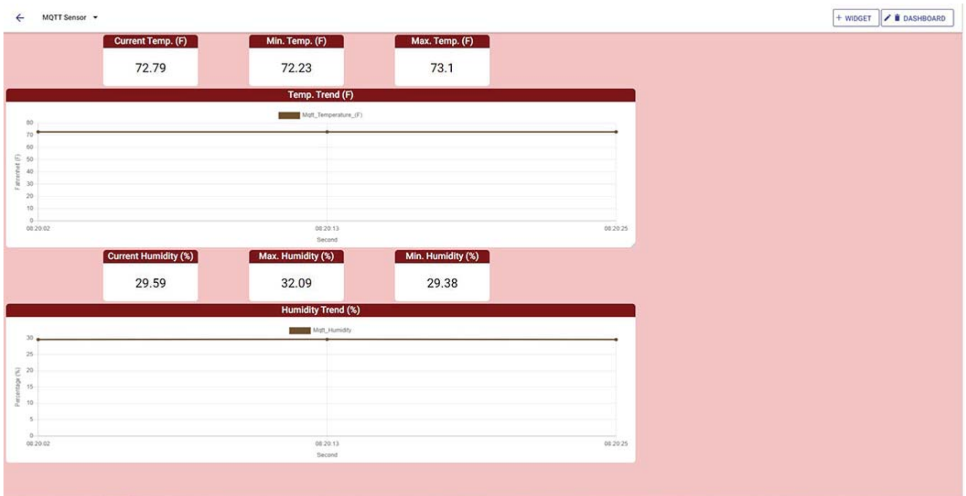

Figure 5-12. MQTT Sensor Dashboard Application

10. Perform the following substeps to familiarize yourself with the MQTT Sensor application in the BorgConnect Dashboard as shown in figure 5-13.

The BorgConnect Dashboard uses programmable tiles called widgets to display bar graphs, line graphs, or values. Multiple widgets can be displayed on one Dashboard application.

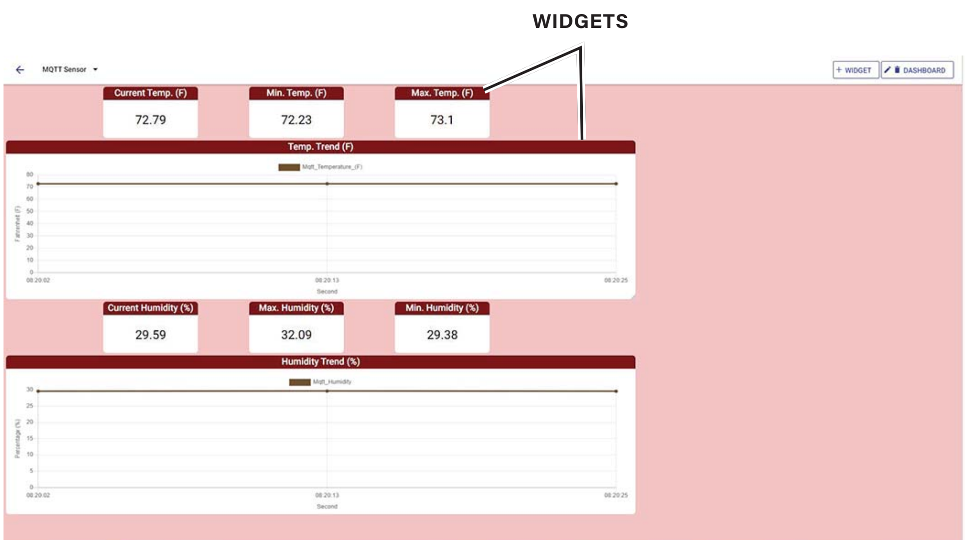

Figure 5-13. BorgConnect Dashboard MQTT Sensor Application

A. Observe the temperature and humidity current value widgets.

These values will refresh from the temperature/humidity transmitter approximately every 10 seconds.

B. Observe as the current values get added to the temperature trend line and humidity trend line widgets.

As the data refreshes, the trend line will add the data in chronological order. If changing from the MQTT sensor application, the trend lines will clear and start from the most current data. The trend graph holds up to 100 data points when the MQTT sensor application is open. Once the graph has filled all the data points, it will drop the oldest data point to record the most recent data.

C. Notice the maximum temperature and maximum humidity widgets.

The MQTT sensor application keeps track of the maximum values recorded by the Wi-Fi temperature/humidity sensor for the day. These maximum values are the highest temperature value and the largest humidity percentage observed. If you exit the MQTT application and return, and the maximum values will remain for that day.

D. Notice the minimum temperature and minimum humidity widgets.

The MQTT sensor application keeps track of the minimum values recorded by the Wi-Fi temperature/humidity sensor for the day. These minimum values are the lowest temperature value and the lowest percentage observed. If you exit the MQTT application and return, and the minimum values will remain for that day.

11. Perform the following substeps to change the frequency of data plotting on the temperature trend graph in the BorgConnect Dashboard application.

Plotting data more frequently is often done when the values change more rapidly. The disadvantage is that it requires more data points to be stored.

A. Mouse over the upper right corner of the temperature trend graph window. Shortcuts will appear, similar to figure 5-14. Click on the edit symbol.

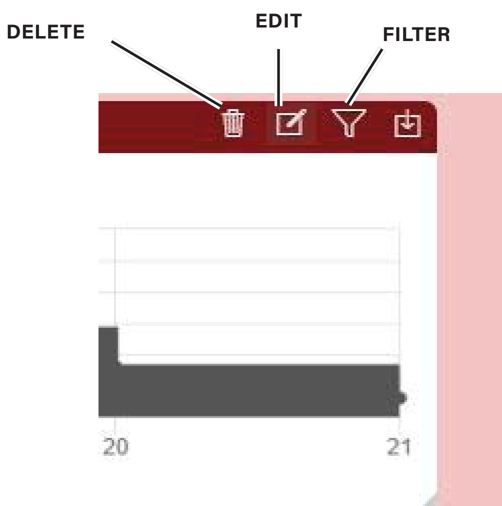

Figure 5-14. Changing Graph Data Point Rate

A temperature trend window will open as shown in figure 5-15.

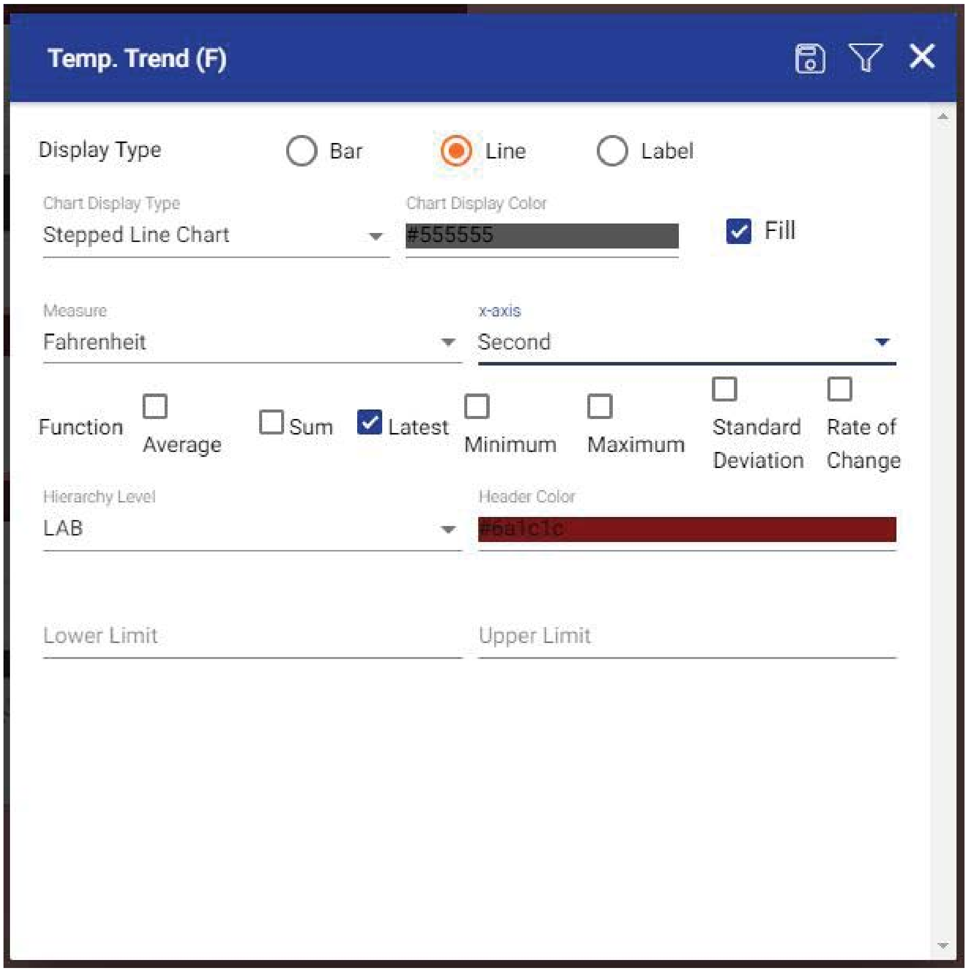

Figure 5-15. Temperature Trend Window

B. Click on the x-axis drop down menu to view the options.

C. Click **Minutes** to change the graph plotting from seconds to plotting once every minute.

   When plotting data in the seconds frequency, the graph will retain and display the temperature/humidity for 20 minutes as data plots once approximately every 10 seconds. When the frequency is changed to minutes, data will be plotted once a minute for 1 hour and 40 minutes. When the frequency of recording is changed to hours, data will be plotted for 4 days and 4 hours.

D. Click **Save**, located in the top-right corner to save your edits.

   The MQTT sensor application will refresh, plotting temperature points at the new rate.

12. Modify the humidity trend rate from seconds to minutes using step 11 as a guide.

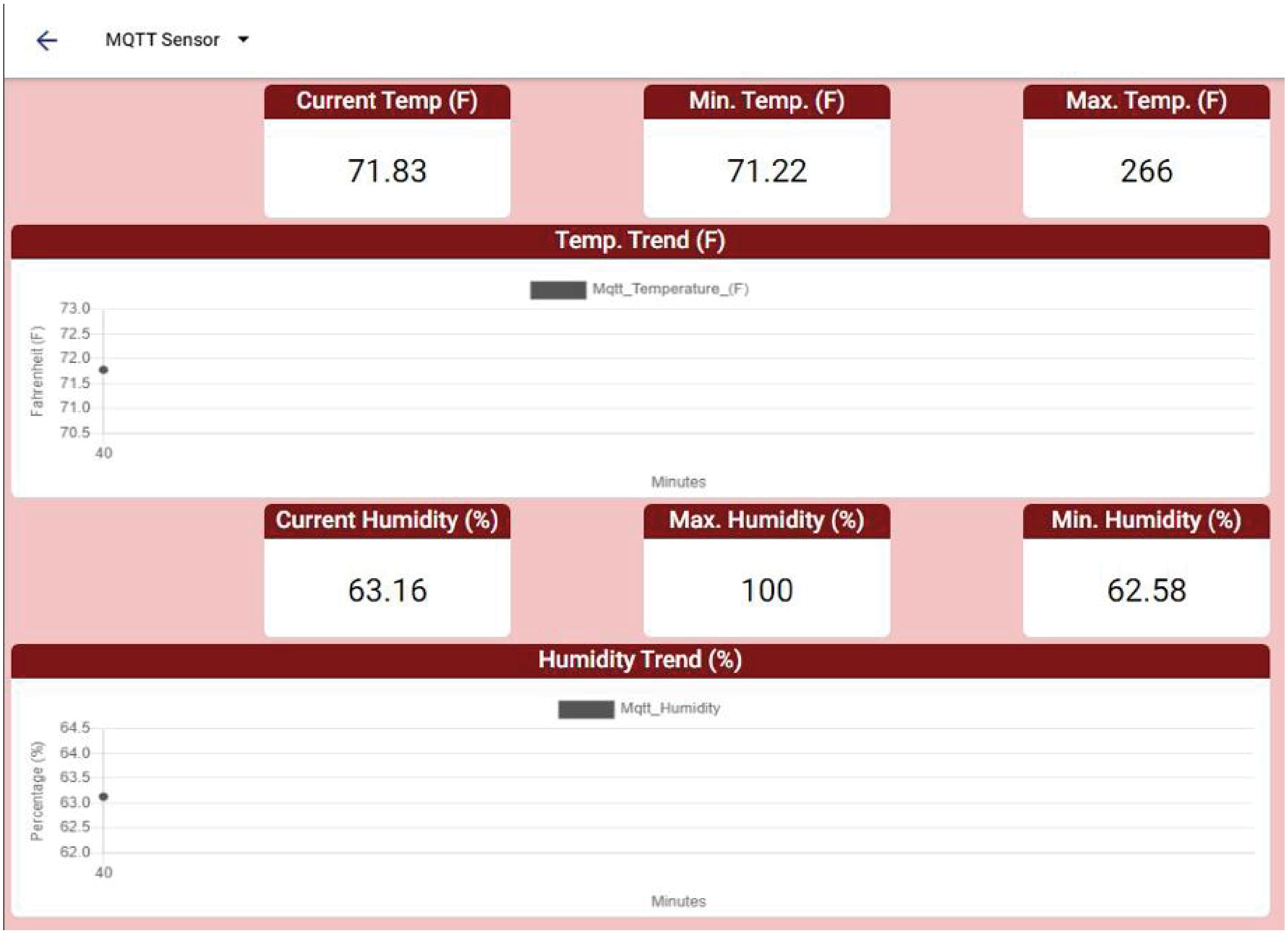

Figure 5-16. Updated Trend Graphs

13. Observe that the trend graphs will populate new graph points every minute now.

    When the graph gets refreshed or if changing to another application, the graph's data will be cleared and will start plotting from the time that application is opened.

14. Modify the temperature and humidity trend rates back to seconds using step 10 as a guide.

    This will return the graphs to plotting new points approximately every 10 seconds.

15. Observe as the trend graphs populates new graph points approximately every 10 seconds now.

16. Perform the following substeps to remove the Wi-Fi temperature/humidity sensor from the workstation for remote use.

    Using the Wi-Fi connection, the temperature/humidity sensor can be located remotely of the workstation. This gives the sensor the ability to be set in a location where a wired sensor might not reach. If a Wi-Fi connection can be made, the Wi-Fi temperature/humidity sensor will transmit the temperature and humidity of the ambient air in that location. This setup also works well if samples need to be taken from many areas. After receiving the samples, the sensor can be relocated without needing to run new wires for the connection.

    A. On the PC, close the Internet browser with BorgConnect Dashboard by clicking the (**X**) in the top right corner.

    B. Press the power button on the BorgConnect Hub to turn **OFF**.

       The red indicator will turn off showing that the Hub is now off.

    C. Place the workstation's main power switch in the **OFF** position.

    D. Remove the workstation power supply plug from the Wi-Fi temperature/humidity sensor.

Figure 5-17. Wi-Fi Temperature/Humidity Sensor Power Supply Disconnect

    E. Remove the 4 brass knurled thumbscrews that attach the Wi-Fi temperature/humidity sensor to the workstation.

17. Perform the following substeps to set up the Wi-Fi temperature/humidity sensor for remote monitoring.
    A. Locate the remote power supply for the Wi-Fi temperature/humidity sensor. With the remote power supply unplugged, connect it to the Wi-Fi temperature/humidity sensor.

Figure 5-18. Wi-Fi Temperature/Humidity Sensor Remote Power Supply

    B. Place the workstation's main power switch in the **ON** position.
    C. On the BorgConnect Hub, press the power button to turn on.
    D. Locate an AC wall outlet for the remote setup.

    The outlet must be within 30 meters (98 feet) of the workstation for the Wi-Fi connection. Place the Wi-Fi temperature/humidity sensor in a location that will prevent damage from falling or from an extreme environment.

NOTE

Walls and electrical interference can prevent good Wi-Fi connections.

E. Plug the remote power supply into the outlet and place the Wi-Fi temperature/humidity sensor in an area safe against dropping or receiving damage.

Once power is restored to the Wi-Fi temperature/humidity sensor, a red power indicator will turn on and there will be a flashing white indicator. Once a Wi-Fi connection has been made, the transmitter will display a green flashing indicator.

If after 5 minutes the indicator does not change to a green flashing indicator to indicate that a connection is made and the sensor is transmitting MQTT data, the sensor should be moved to a location closer to the workstation or a location free of interference and repeat this substep.

Figure 5-19. Remote Wi-Fi Temperature/Humidity Sensor Setup Example

F. Using step 6 as a guide, open the MQTT Sensor application.

Observe the temperature and humidity of the new location.

18. On the PC, close the internet browser with BorgConnect Dashboard by clicking the (**X**) in the top right corner.
19. Perform the following substeps to reattach the Wi-Fi temperature/humidity sensor to the workstation.
    A. Press the power button on the BorgConnect Hub to turn **OFF**.
    B. Place the workstation's main power switch in the **OFF** position.
    C. Unplug the remote power supply from the outlet and return the Wi-Fi temperature/humidity sensor back to the workstation area.
    D. Remove the remote power supply plug from the Wi-Fi temperature/humidity sensor.
    E. Place the Wi-Fi temperature/humidity sensor on the panel.
    F. Align and insert the 4 brass knurled thumbscrews that attach the Wi-Fi temperature/humidity sensor to the workstation.
    G. Connect the workstation power supply to the Wi-Fi temperature/humidity sensor.
20. Turn off the PC and monitor.

ACTIVITY 6 PLC TEMPERATURE MONITORING

PROCEDURE OVERVIEW

In this procedure, you will use the PLC Heater Temp Monitoring application in the BorgConnect Dashboard to view temperature data from the PLC. When viewing on the HMI, only the current temperature can be observed. Using this application, the minimum temperature, maximum temperature, and temperature trend graph will be used to provide historical data measured by the thermistor inside the workstation.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system, as shown in figure 6-1.

Figure 6-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the IEC connector on the workstation and to an AC wall outlet, as shown in figure 6-2.

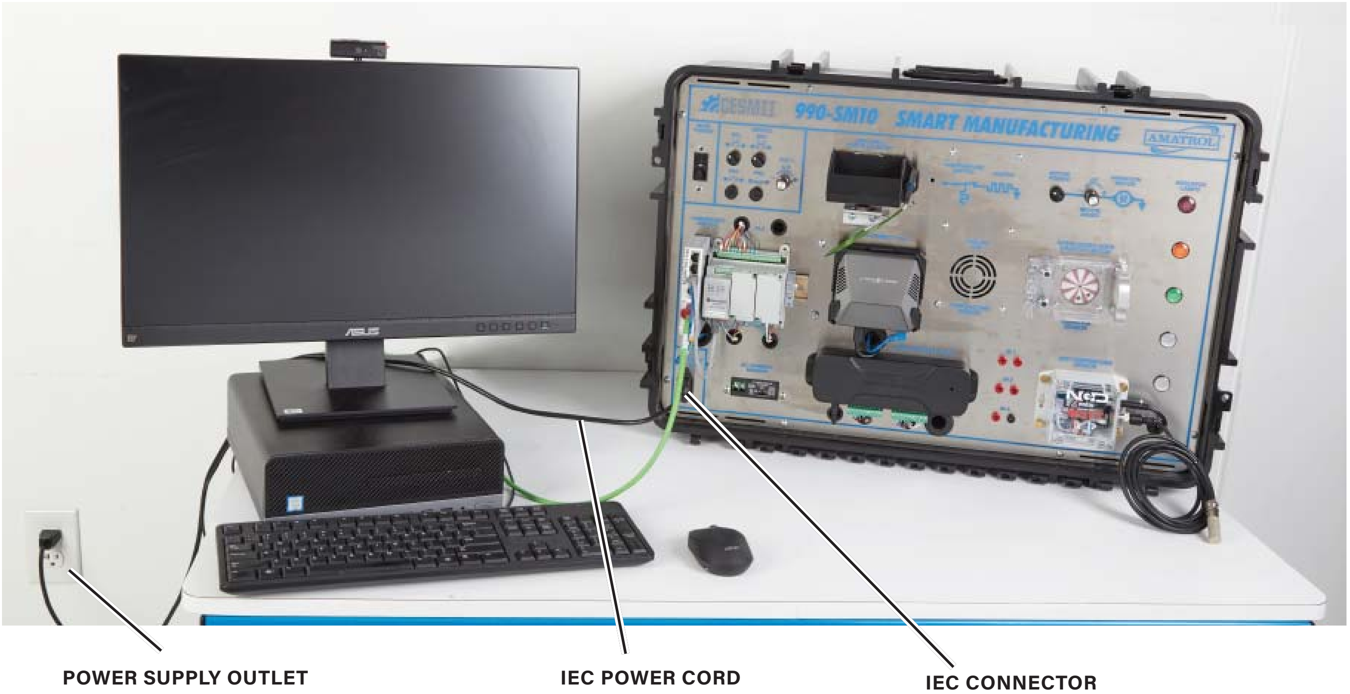

Figure 6-2. IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, the PLC, and the PC, as shown in figure 6-3.

Figure 6-3. Ethernet Cable Connections

3. Turn on the PC and monitor.
4. Flip the main power switch on the 990-SM10 Workstation to **ON** to power up the system.

   The Ethernet switch, the PLC, the BorgConnect Node, and the Wi-Fi temperature/humidity sensor will turn on an indicator on their enclosure to indicate that they are powered on.
5. Press the power button on the BorgConnect Hub.

   Shortly after pressing the power button on the BorgConnect Hub, a red indicator light will turn on to display the unit is powered on.

   The BorgConnect Hub is connected to the PLC via an Ethernet cable connection.
6. Perform the following substeps to connect to the BorgConnect Dashboard from the PC.

   A. Open the Internet browser on the PC.

   B. Enter http://10.3.141.1/ into the address bar of the Internet browser.

   This address is the pathway for connecting to the BorgConnect Hub via Wi-Fi.

   C. Press the **Enter** key on the keyboard.

   D. Enter the login credentials in the space provided.

   Username: admin

   Password: Welcome2BC

   After logging in, the BorgConnect Dashboard main screen will open as shown in figure 6-4.

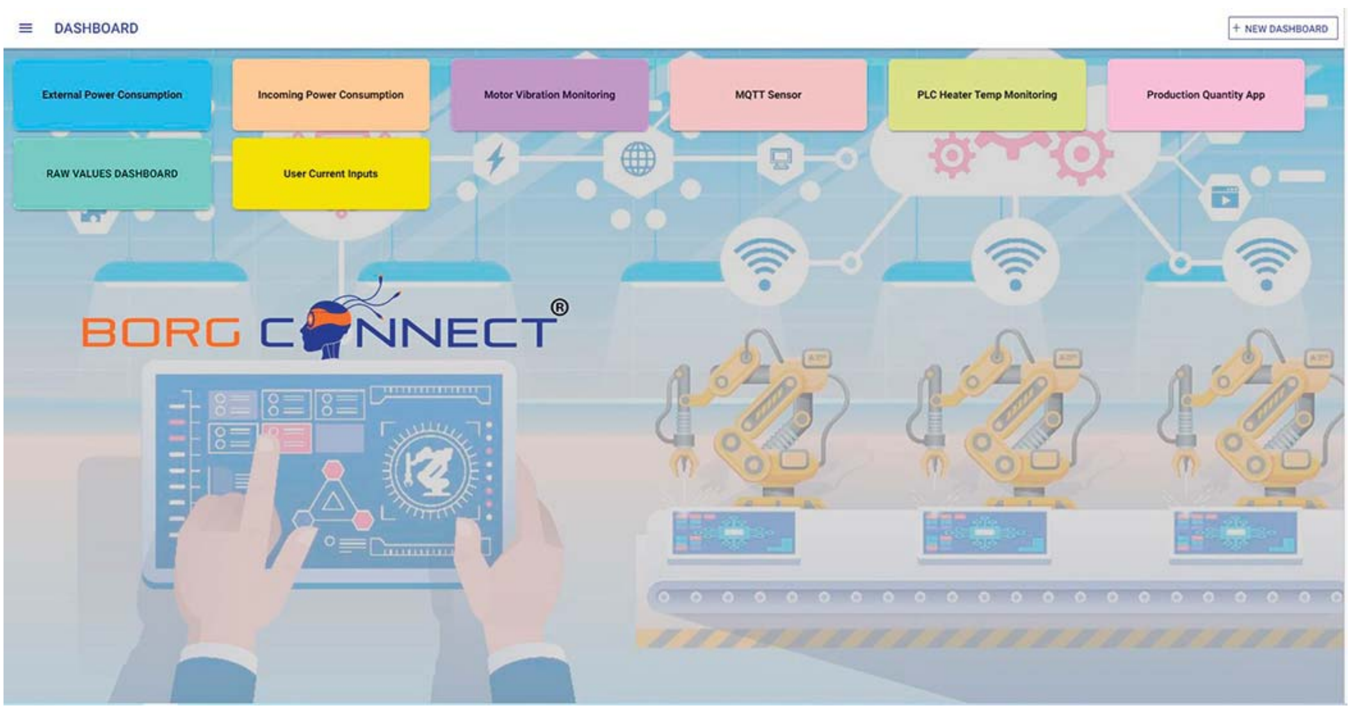

Figure 6-4. BorgConnect Dashboard Main Screen

   E. Minimize the internet browser by clicking minimize **(-)** in the upper right corner of the screen to view the Desktop.

7. Perform the following substeps to open the PLC Heater Temp Monitoring application on your PC.
   A. Click on the FactoryTalk View ME Station 990 SM10 runtime icon in the desktop of the PC as shown in figure 6-5.

Figure 6-5. FactoryTalk View ME Station 990 SM10 Runtime Icon

A dialog will appear prompting "Do you want to allow this app to make changes to your device?", as shown in figure 6-6.

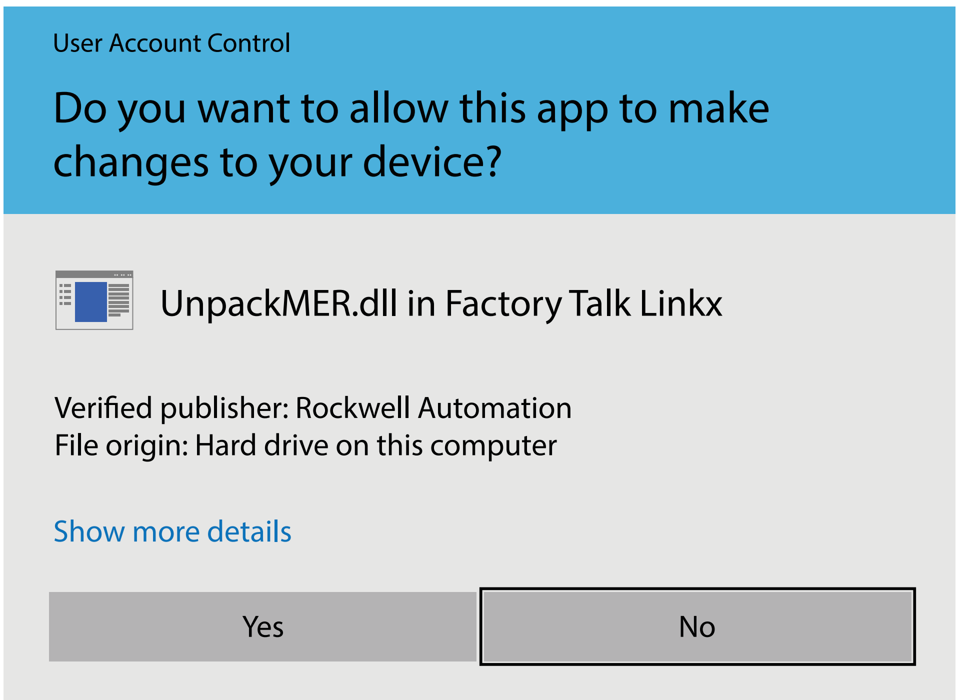

Figure 6-6. Administrative Permission Window

   B. Click **Yes.**

   After a short load time, the Smart Manufacturing System main screen will appear.

8. In the Smart Manufacturing System main screen, press the **Heating Application** tab.

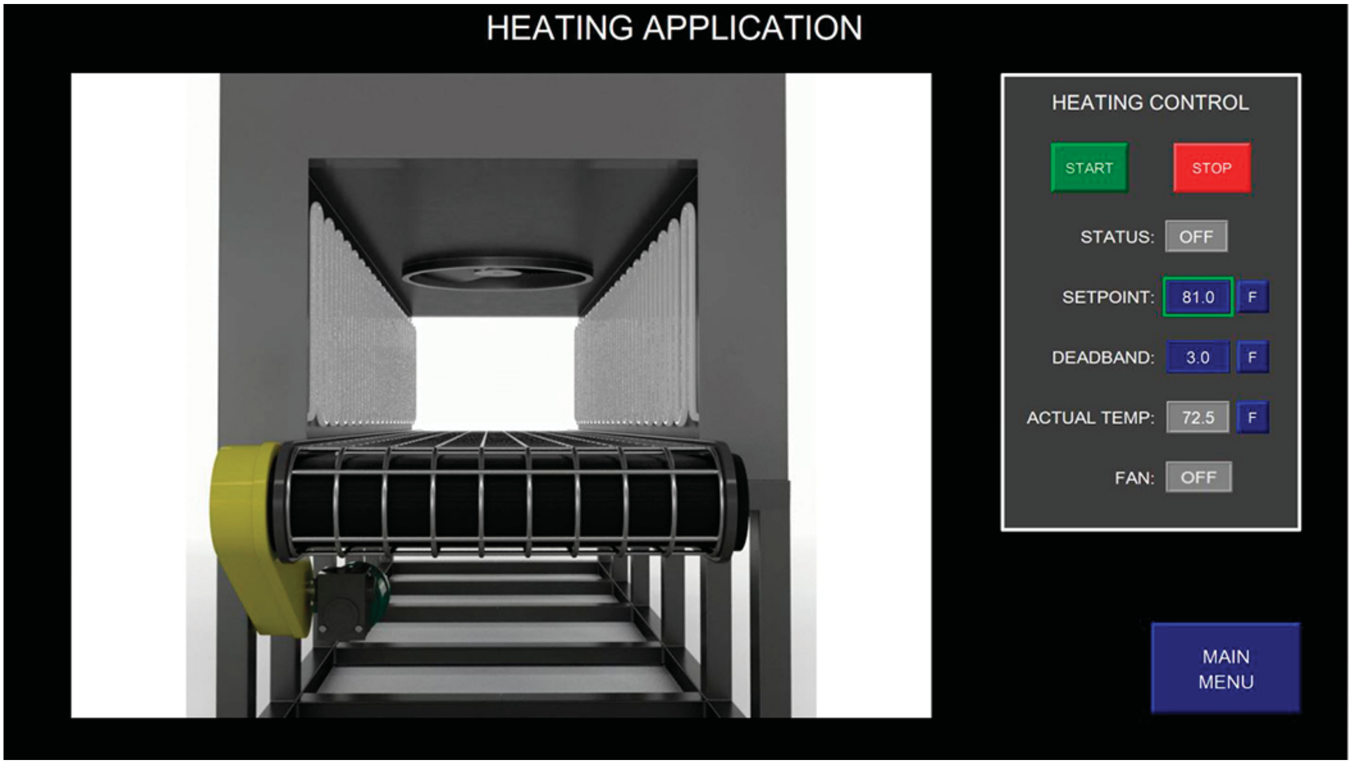

Figure 6-7. Heating Application

9. Press **START** to initiate the heating program.
10. Observe the actual temperature from the gray temperature box.

    The PLC also sends the temperature data to the BorgConnect Hub through an Ethernet connection. With this connection, the temperature can be viewed through the Borg Connect Dashboard. The ability to share with the Borg Connect Dashboard allows for temperatures to be observed on a graph and to record maximum and minimum temperatures.
11. Press the **Windows** key on the keyboard to open the taskbar at the bottom of the screen.
12. Maximize the Internet browser that was previously minimized.

13. From the BorgConnect Dashboard main screen, click on the **PLC Heater Temp Monitoring** tab.

    A screen as shown in figure 6-8 will appear.

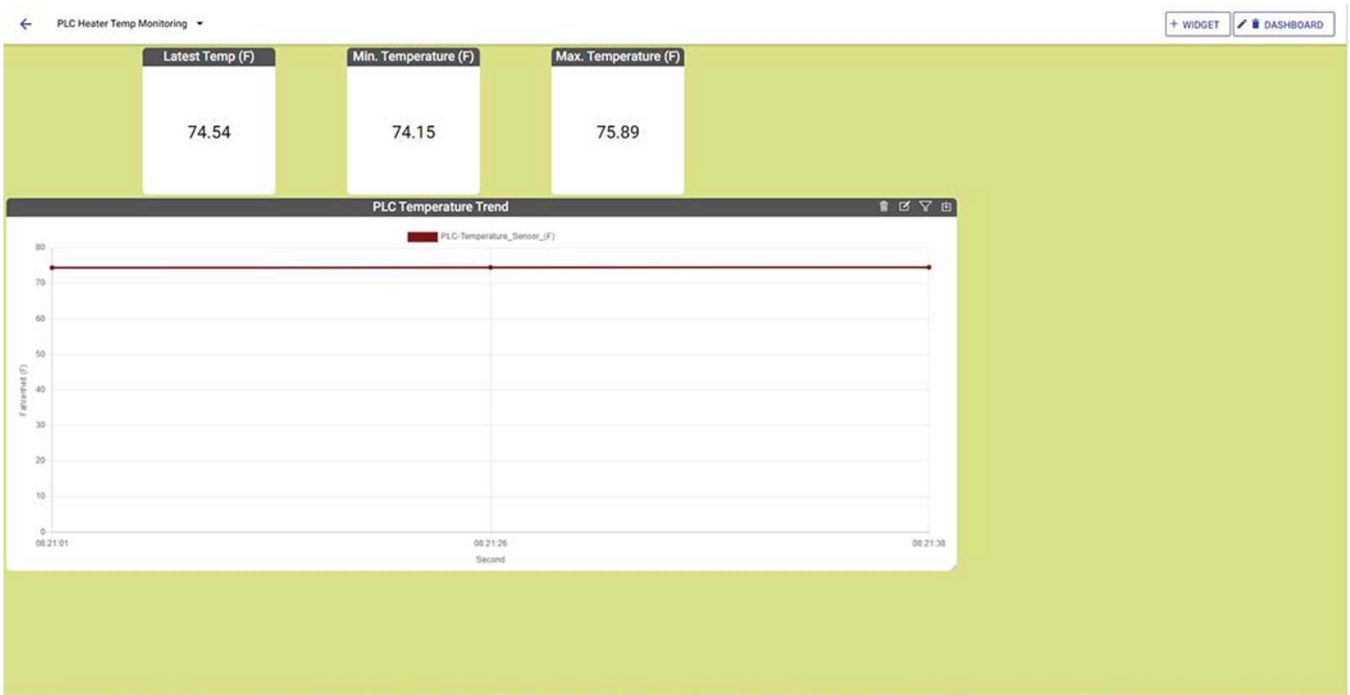

Figure 6-8. PLC Heater Temp Monitoring Tab

14. Perform the following substeps to familiarize yourself with the PLC Heater Temp Monitoring application in the BorgConnect Dashboard.

    A. Observe the Latest Temp widget that displays the latest temperature measured inside the workstation, displayed in Fahrenheit (F).

    The latest temperature widget will display the latest temperature measured by the thermistor from inside the workstation. As the heating program cycles, a reporting delay will be observed as the PLC heater temperature monitoring application refreshes approximately every 10 seconds.

    B. Observe the PLC Temperature Trend widget.

    The latest widget graphs the trend of the temperature measured by the thermistor. This graph can be used to observe the thermal cycle. Using the graph, the user can determine if the heating/cooling cycles occur as designed. The user can also determine how long the temperature remains at a certain value.

    The designed cycle for the heating program will show a quick heating cycle, with a slower cooling cycle. After the cycle has repeated, a similar graph should be observed.

    C. Notice the Min. Temperature widget.

    The minimum temperature is the lowest temperature measured by the thermistor inside the workstation. The PLC Heater Temp Monitoring application will retain the minimum temperature for the day, even if the application is changed.

    D. Notice the Max. Temperature widget.

    The maximum temperature is the highest temperature measured by the thermistor inside the workstation. The PLC Heater Temp Monitoring application will retain the maximum temperature for the day, even if the application is changed.

15. Perform the following substeps to launch Connected Components Workbench (CCW).

    The CCW software will be used to observe the ladder logic of the Temperature_Heating2 PLC program in real time.

    A. Click on **CCW** in the Windows start menu.

    B. Click on the **File** tab to open the file menu.

    C. Click on **Discover** and this will open the connection browser.

    D. Click on the **+** symbol to expand the AB_ETHIP-1, Ethernet tree.

    E. Click on the Micro820 gateway to highlight it.

    F. Click on **OK** in the bottom right of the window.

16. Perform the following substeps to view the temperature sensor in ladder logic.

    A. Double-click on Calculate_Temperature, located at the top lefthand side of the devices tree, as shown in figure 6-9.

CALCULATE_TEMPERATURE

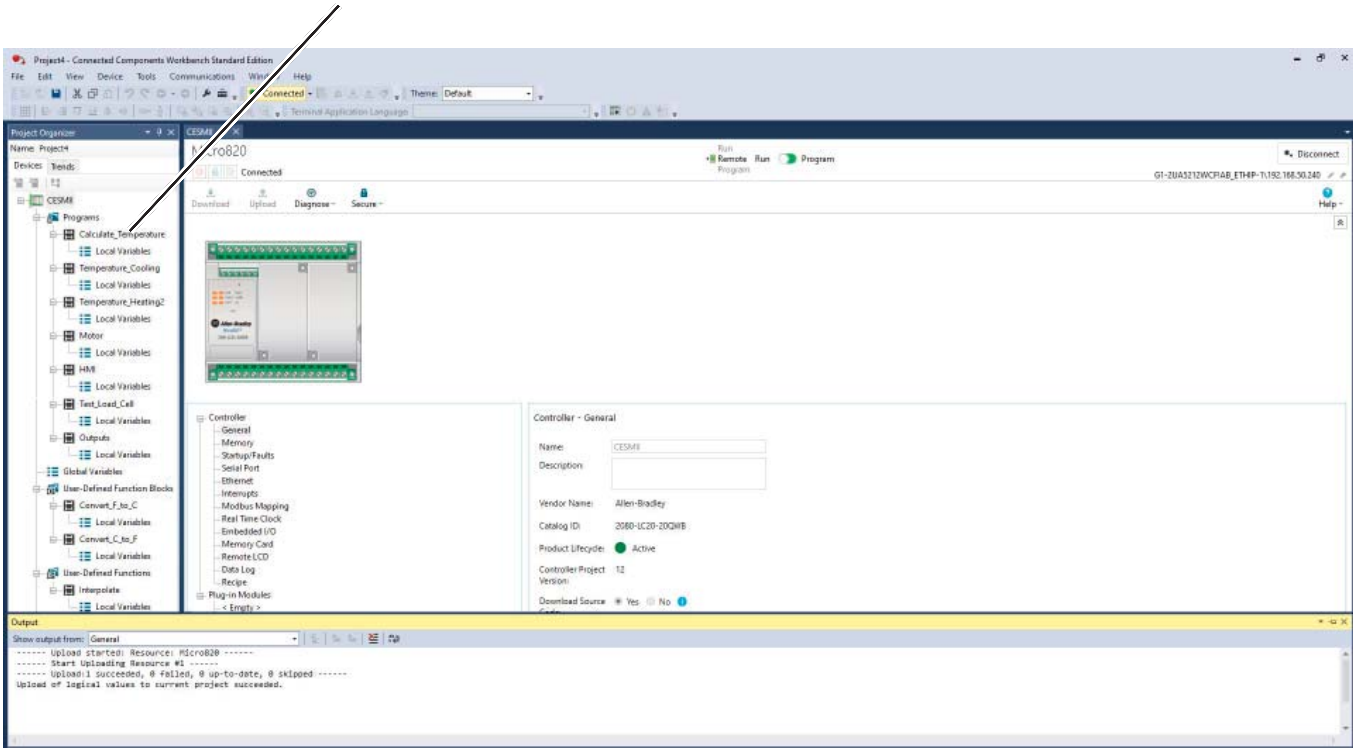

Figure 6-9. CCW with CESMII Program

The Calculate_Temperature program window will open as shown in figure 6-10.

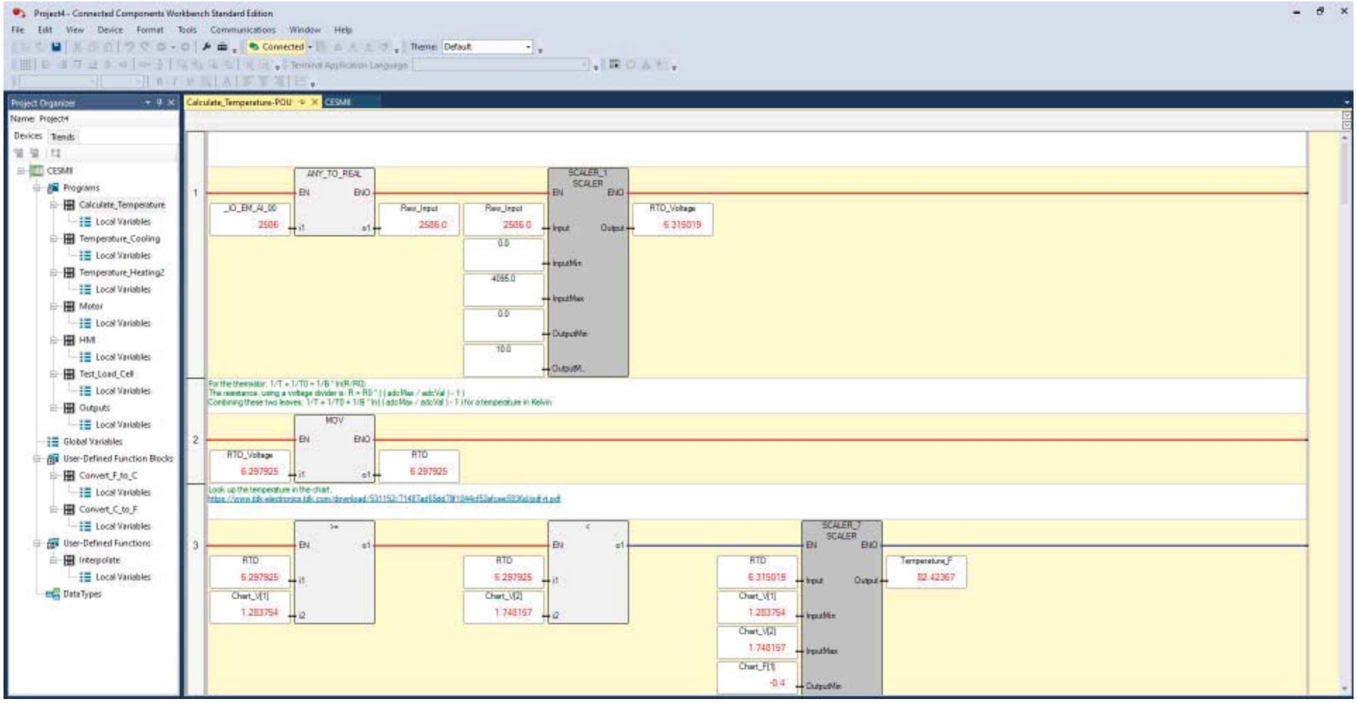

Figure 6-10. CCW Displaying Ladder Logic

B. Scroll down to ladder rung 10 and observe the lines display red all the way across, as shown in figure 6-11.

These lines proceed from left to right. The red lines indicate that the rail / instruction block statement to the left of the line is true. When the red line goes from rail to rail, the far-right instruction block will be displaying the temperature that is determined to be the most accurate for the voltage output by the thermistor.

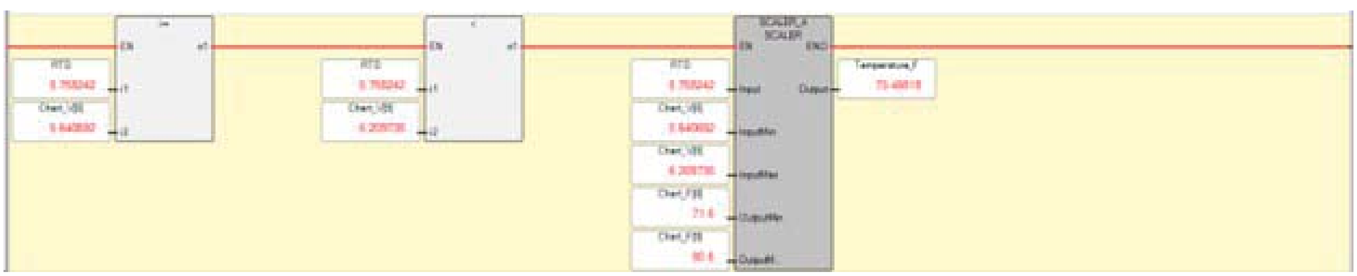

Figure 6-11. CCW Red Line Ladder Rung

17. Observe and compare the temperatures displayed in the CCW software and on the HMI.

    Both the CCW software and the HMI screen show a real-time view of the temperature.

18. Compare the temperatures seen in CCW with the temperatures seen in the PLC Heater Temp Monitoring application in the BorgConnect Dashboard.

    The current temperatures will be similar to one another. Variation may exist with the time that each program pulls temperature data from the PLC and its refresh rate. The refresh rate is how often the program pulls in new data to get its current temperature. The PLC uses real time values, where it constantly monitors the inputs and sends outputs. The BorgConnect Dashboard values refresh approximately every 10 seconds.

    While knowing the current temperature is beneficial, a temperature trend over time provides a wider range of information. Determining the maximum and minimum temperatures conveys the range of temperature variation. With the PLC sharing the current temperature with the BorgConnect Hub, we can track the temperature and build a historical graph. This temperature trend graph reveals how the temperature fluctuates over time.

19. Close CCW by clicking the (**X**) in the top right-hand corner of the software.

20. Close the internet browser by clicking the (**X**) in the top right-hand corner of the screen.

21. Perform the following substeps to end the heating application program and to close the HMI window.

    A. Press **STOP** in the heating control box to end the application.

    B. Press **MAIN MENU** in the bottom right of the screen.

    C. From the Smart Manufacturing System screen, press **SHUTDOWN** in the bottom right of the screen.

22. Perform the following substeps to power down the Smart Manufacturing system.

    A. Press the power button on the BorgConnect Hub to turn OFF.

    B. Place the workstation’s main power switch in the **OFF** position.

       The PLC, switch, BorgConnect Node, and Wi-Fi temperature sensor should power down.

    C. Turn off the PC and monitor.

ACTIVITY 7	WEB-BASED CONDITION MONITORING

PROCEDURE OVERVIEW

In this procedure, you will use the BorgConnect Dashboard to monitor the vibration created by the motor. Vibration can indicate when a motor needs maintenance before it completely fails. By monitoring vibration sensors on motors, maintenance can be scheduled on a planned basis and avoid unplanned maintenance due to breakdowns.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system, as shown in figure 7-1.

Figure 7-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the IEC connection on the workstation and to an AC wall outlet, as shown in figure 7-2.

Figure 7-2.   IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, PLC, PC, and local network port, as shown in figure 7-3.

Figure 7-3.   Ethernet Cable Connections

NOTE

The local network port may be different than the port shown. Contact your IT department if assistance is required.

3. Turn on the PC and monitor.
4. Switch the workstation's main power switch to the **ON** position.
5. Press the power button to turn on the BorgConnect Hub.

   Shortly after pressing the power button on the BorgConnect Hub, a red indicator light will turn on to display the unit is powered on.
6. Examine the control diagram of the production application and the motor vibration monitoring application in figure 7-4.

   The motor is controlled by a 24 VDC digital output (on/off) from the PLC. The white indicator is connected to the motor circuit, after the motor switch. The PLC controls the green and yellow indicator lights using individual 24 VDC digital outputs for each indicator.

   The only digital input to the PLC is an induction sensor, which is connected to a 24 VDC digital on/off input of the PLC.

   The three indicators indicate system status. If the induction sensor is off, indicating an open door, the PLC turns on the yellow indicator. If the door is closed and the production control start button has been pressed, the PLC turns on the green indicator. When the PLC output to motor is on and the motor switch is on, the white indicator will also be on.

   The motor vibration monitoring application uses a piezo vibration sensor attached to the motor that measures vibration in gravitational force equivalent, or g-force (G). These vibrations are caused by an imbalanced load on the shaft of the motor. The piezo vibration sensor will generate voltage as it experiences small oscillations from vibrations. As the oscillations increase at the sensor, the voltage output increases in proportion.

   Since the piezo vibration sensor outputs voltage, a resistor is added to the circuit to convert the analog signal from voltage (V) to current (mA) using Ohm's law (I=V/R). This sensor circuit is wired to one of the BorgConnect Node 50 milliamp (mA) analog inputs, as shown in figure 7-4. The BorgConnect Node converts the analog signal from the sensor circuit into a digital signal. The BorgConnect Node transmits the digital signal through a Wi-Fi connection with the BorgConnect Hub as shown in figure 7-5.

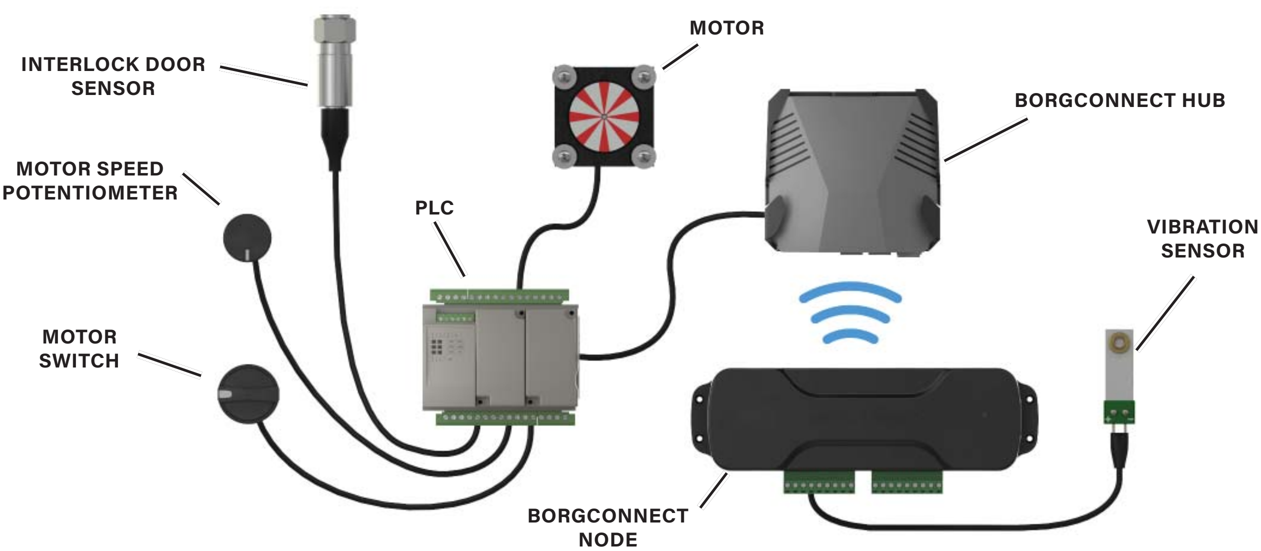

Figure 7-4. Diagram of Production Application Inputs and Outputs with Vibration Sensor

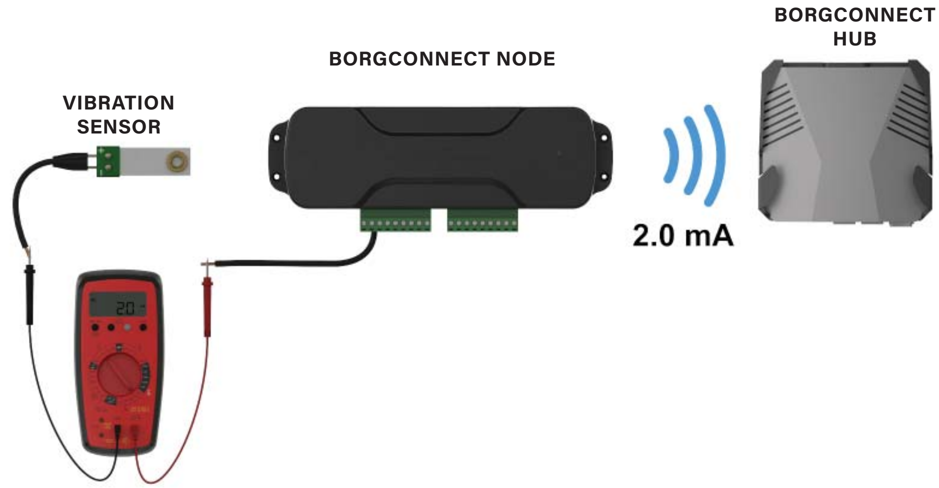

Figure 7-5. Diagram of BorgConnect Node Sharing Data with the BorgConnect Hub

The BorgConnect Hub measures the change in current from the piezo sensor circuit. This change in current is used to determine the g-force.

The g-forces can then be monitored through the BorgConnect Dashboard Motor Vibration Monitoring application as shown in figure 7-6.

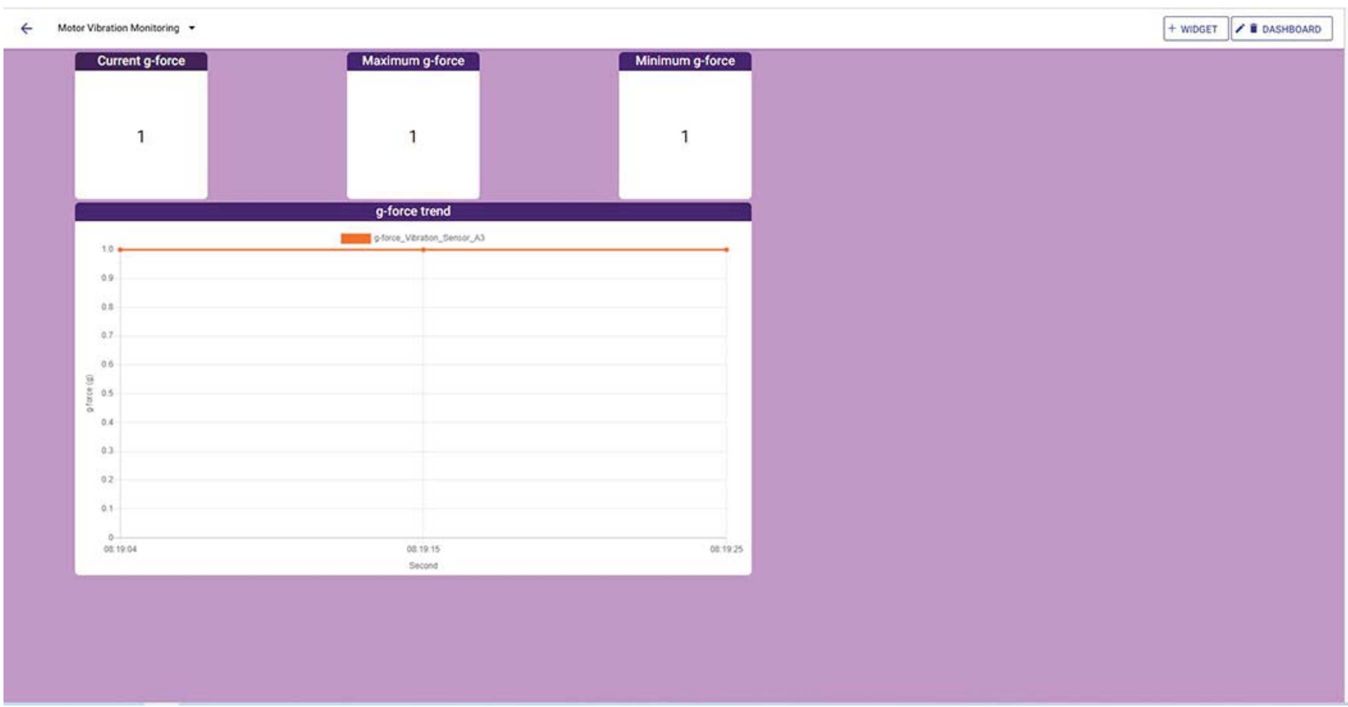

Figure 7-6. Dashboard Motor Vibration Monitoring Application

7. Perform the following substeps to connect to the BorgConnect Dashboard from the PC.
   A. Open the Internet browser on the PC.
   B. Enter http://10.3.141.1/ into the address bar of the Internet browser.
   C. Press the **Enter** key on the keyboard.
   D. Enter the login credentials in the space provided.

      Username: admin

      Password: Welcome2BC

      After logging in, the BorgConnect Dashboard main screen will open similar to figure 7-7.

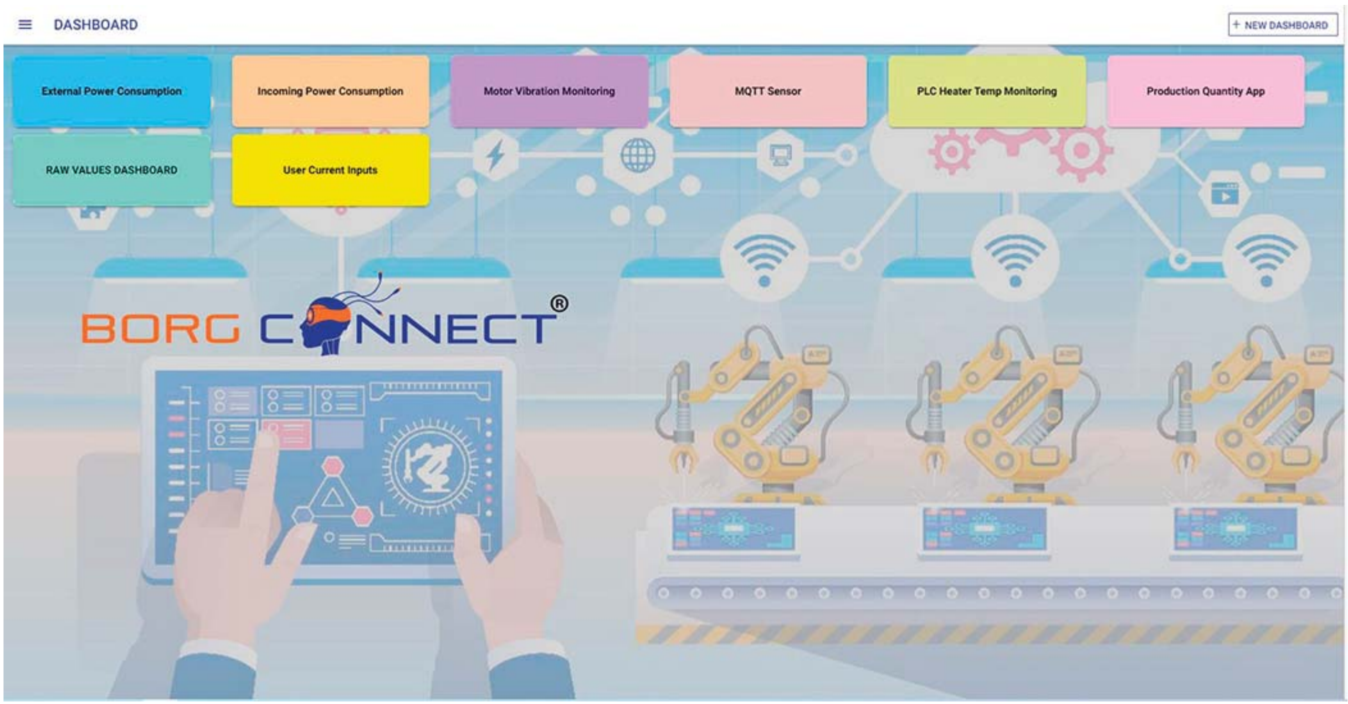

Figure 7-7. BorgConnect Dashboard Main Screen

8. Click on **RAW VALUES DASHBOARD**.

   The raw values that are attached to the six inputs of the BorgConnect Node are viewed here. For this activity, the values given by the piezo vibration sensor are connected to the Raw A3 widget.

   Using the value from the A3 input, the BorgConnect Hub will scale the current value with the equation $G=(0.0561\times mA) + 1.1488$ to output the relevant g-force measured by the piezo vibration sensor to the Motor Vibration Monitoring application in the Dashboard. This equation was determined from measuring the current and voltage from the vibration sensor and using the sensor sensitivity of 1.1 V/G.

Figure 7-8. BorgConnect Dashboard Raw Values Dashboard Application

9. Click on the drop-down menu in the top left of the screen.
10. Click on **Motor Vibration Monitoring**.
11. Perform the following to familiarize yourself with the Motor Vibration Monitoring application.
    A. Locate the Current G-force widget and observe the value.

       These values from the piezo vibration sensor will refresh approximately every 10 seconds.

    B. Locate the Maximum G-force widget and observe the value.

       The motor vibration monitoring application keeps track of the maximum g-force (G) observed for that day. When the application is exited, the maximum value will be retained for that day.

    C. Locate the Minimum G-force widget.

       The motor vibration monitoring application keeps track of the minimum g-force (G) observed for that day. When the application is exited, the minimum value will be retained for that day.

    D. Locate the G-force Trend widget.

       The motor vibration monitoring application plots the current g-force values on the g-force trend graph. The graph allows the user to observe the g-force experienced by the motor while it is running. This graph displays the g-force measured over the past 20 minutes.

12. Minimize the internet browser to prepare for step 10.
13. Perform the following substeps to launch FactoryTalk View Station and the HMI test application window.
    A. Click on the **FactoryTalk View ME Studio Shortcut** from the desktop, as shown in figure 7-9.

Figure 7-9. FactoryTalk View ME Studio Shortcut

A dialog will appear prompting, “Do you want to allow this app to make changes to your device?”, as shown in figure 7-10.

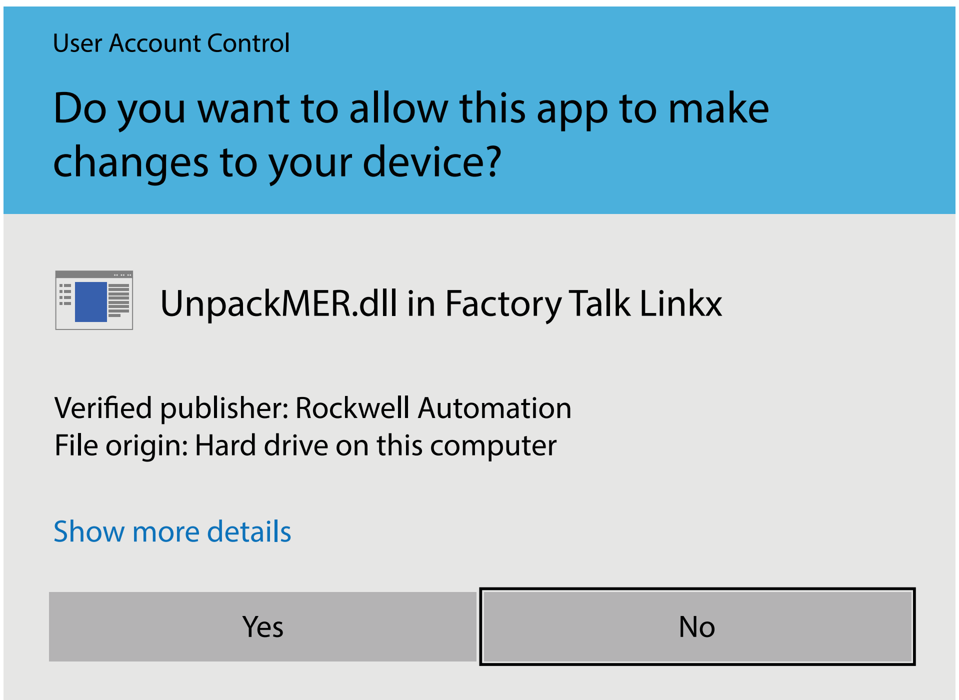

Figure 7-10. Administrative Permission Window

B. Click **Yes.**

After a short load time, the HMI window will open to the Smart Manufacturing System main screen.

14. In the Smart Manufacturing System main screen, press the **Production Application** tab.
15. On the workstation, switch the motor power switch clockwise to the **ON** position.

    The white indicator will turn ON showing that the manual motor switch is turned on. The motor will still not start because the PLC output has not been turned on. The current vibration widget will continue to display approximately 1 g-force, which is the normal gravitational force exerted on Earth.
16. Perform the following substeps to start the motor program and to observe the initial values of the Motor Vibration Monitoring application.
    A. Press **START** in the production application HMI screen to start the motor control program.

       On the workstation and in the production application, the green indicator will turn on. In the production application HMI graphic, the roller and pulley will start rotating. In the production control window, the status and conveyor tabs will change to ON. The production time and production units will start increasing in value. Any changes in motor speed should be given 20 seconds to allow the motor vibration application time to refresh and display the values after the change.

    B. Notice that on the workstation the motor is not turning.

    C. Press the **Windows** key on the PC keyboard to open the taskbar at the bottom of the screen.

    D. Click on the Internet browser icon from the taskbar to maximize the BorgConnect Dashboard.

    E. Observe that the current g-force value is approximately 1 g-forces.
17. Perform the following substeps to change the motor rotational speed and observe the change in vibration values.
    A. Rotate the MOTOR SPEED potentiometer clockwise to the midpoint to increase the rotation speed of the motor on the workstation.

       Observe the current g-force widget after 20 seconds to allow the g-force values time to refresh. The g-forces will remain close to the motor stopped values.

    B. Rotate the MOTOR SPEED potentiometer fully clockwise to maximize the rotational speed of the motor and to increase the vibration.

       Observe the current g-force widget after 20 seconds to allow the g-force values time to refresh. The g-forces should peak above 1.37 g-forces.

       The motor assembly is designed to simulate a motor experiencing an imbalance, bearing failure, misalignment, or other mechanical failures requiring attention. Initially, in the motor vibration monitoring application in the BorgConnect Dashboard, you should notice that there is little deviation from 0 g-forces for the current vibration widget. This demonstrates the results of a motor functioning properly. As rotational speed is increased, the vibration will increase. As vibration increases, the current g-forces and g-force trend will spike above 1.37 g-forces. These results indicate a motor that requires attention and diagnosis. An example of the g-force trend spike is shown in figure 7-11.

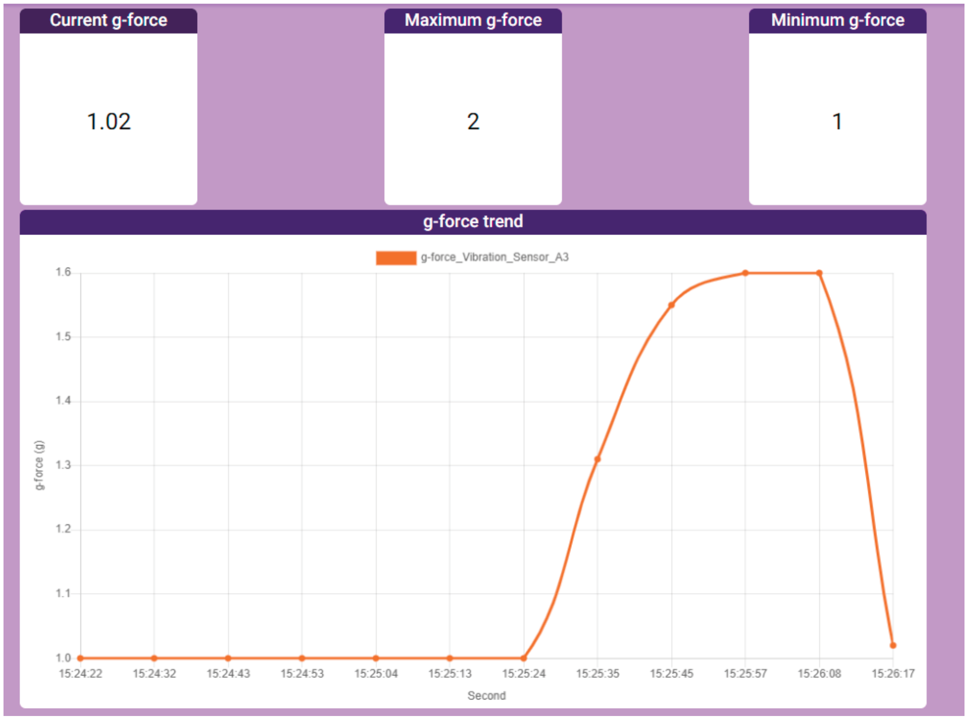

Figure 7-11. Dashboard G-force Spike Example

C. Press **STOP** on the HMI and observe the current g-force readings.

When the motor is turned off, the current g-force readings will return to an average of 0 g-forces.

D. Press **START** on the HMI and observe the current g-force readings.

The motor will start rotating at the same speed that it was prior to switching power off. Shortly after starting the motor, the current g-force readings will increase to the g-force readings that were observed previously.

18. Perform the following substeps to end the motor vibration application and to close the HMI window.

A. Press **STOP** to end the motor control program.

After stop has been clicked, the motor will stop, the green indicator lamp will turn off, the status and conveyor will change to off, the rollers and pulley will stop rotating, and the production time and production units will stop increasing in value.

B. Press **MAIN MENU** in the bottom right of the screen.

C. From the Smart Manufacturing System screen on the HMI, press **SHUTDOWN** in the bottom right of the screen.

19. Perform the following substeps to return the workstation to the home settings.

A. Rotate the motor speed potentiometer fully counterclockwise to full stop.

B. Rotate the motor power switch counterclockwise to the off position.

The white indicator will turn OFF showing that the manual motor switch is off.

20. Close the BorgConnect Dashboard and the internet browser by clicking the (**X**) in the top right-hand corner of the screen.

21. Perform the following substeps to power down the Smart Manufacturing system.

A. Press the power button on the BorgConnect Hub to turn **OFF**.

B. Switch the workstation's main power switch to the **OFF** position.

C. Turn off the PC and monitor.

PROCEDURE OVERVIEW

In this procedure, you will monitor the AC current sensor in the 990-SM10 Smart Manufacturing System from the Borg Dashboard. If you have the Amatrol 43110 Remote Current Sensor, you will be able to perform an additional task to measure devices outside of the 990-SM10 Smart Manufacturing System.

1. Position yourself in front of the 990-SM10 Smart Manufacturing System so that it appears as shown in figure 8-1.

Figure 8-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the IEC connection on the workstation and to an AC wall outlet, as shown in figure 8-2.

Figure 8-2. IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, PLC, PC, and local network port, as shown in figure 8-3.

Figure 8-3. Ethernet Cable Connections

3. Turn on the PC and monitor.
4. Flip the main power switch on the 990-SM10 Workstation to **ON** to power up the system.

   The Ethernet switch, the PLC, the BorgConnect Node, and the Wi-Fi temperature/humidity sensor will each turn on an indicator on their enclosure to indicate that they are powered on.
5. Press the power button to turn ON the BorgConnect Hub.

   Shortly after pressing the power button on the BorgConnect Hub, a red indicator light will turn on to display the unit is powered on.

   The BorgConnect Hub is connected to the PLC via an Ethernet cable connection.
6. Perform the following substeps to connect to the BorgConnect Dashboard from the PC.
   A. Open the internet browser on the PC.
   B. Enter http://10.3.141.1/ into the address bar of the internet browser.

      This address is the pathway for connecting to the BorgConnect Hub via Wi-Fi.
   C. Press the **Enter** key on the keyboard.
   D. Enter the login credentials in the space provided.

      Username: admin

      Password: Welcome2BC

      After logging in, the BorgConnect Dashboard main screen will open as shown in figure 8-4.

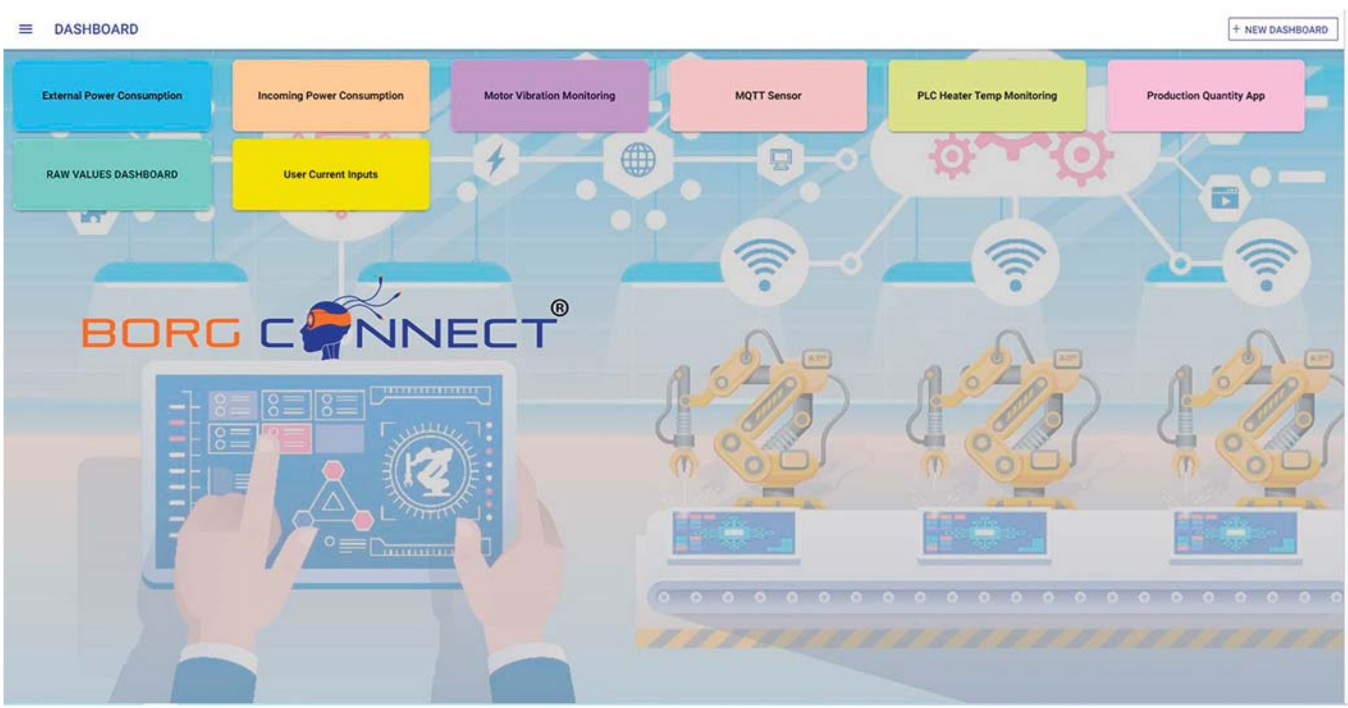

Figure 8-4. BorgConnect Dashboard Main Screen

7. Click **Incoming Power Consumption.**

   This will open the Incoming Power Consumption application on the Dashboard to view the power usage of the 990-SM10 Smart Manufacturing workstation, as shown in figure 8-5.

   This application is used to observe the current power consumption (in watts), power consumption trendline, and total power consumed in units of watt-hours for the day.

   Before starting any applications on the workstation, the displayed information will represent the state when the system is idle. The workstation will see a current draw of 0.04 amps and a power consumption of approximately 4.4 watts while the heater, fan, and/or motor are not running.

Figure 8-5. Incoming Power Consumption Application

The incoming power consumption application uses a current transformer to measure the current draw of the workstation, as shown in figure 8-6. One of the wires in the incoming power cord is run through the current transformer. As current flows through the power wire, an AC voltage that is proportional to the line current in the wire is induced in the transformer windings. A transducer inside the current transformer converts the AC voltage to DC voltage.

The current sensor voltage output is connected to the BorgConnect Node 0-5 VDC input. The BorgConnect Node sends the data to the BorgConnect Hub, which divides the VDC by a resistance to calculate the current draw. This current is multiplied by the 110 VAC line voltage to display the power in watts on the BorgConnect Dashboard.

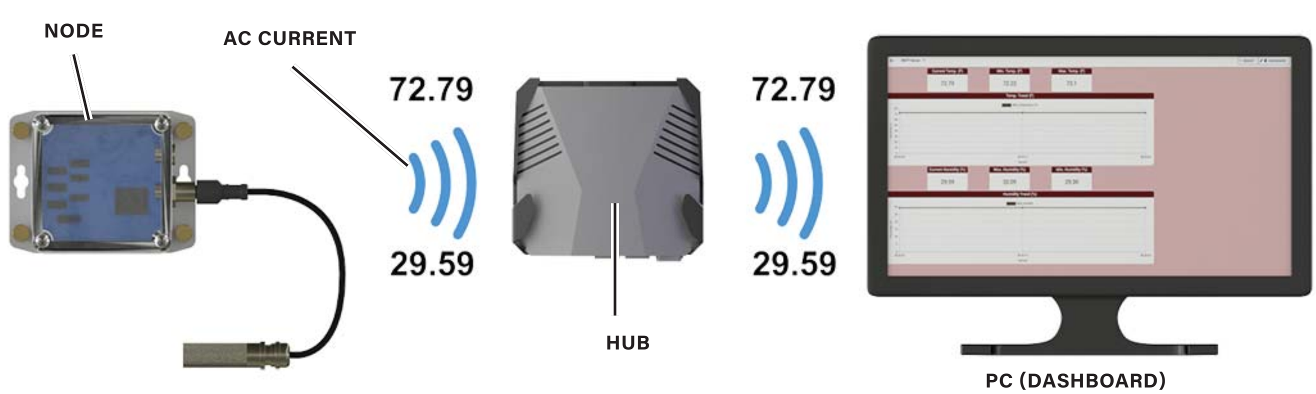

Figure 8-6. Diagram of Current Sensor Layout

8. Perform the following steps to observe the raw values for the internal current sensor.
   A. Click the drop-down menu in the top-left corner of the screen to display the Dashboard applications.
   B. Select **RAW VALUES DASHBOARD** to display the values observed by the BorgConnect Node.
   C. Observe the internal current sensor VDC values displayed in V1 as shown in figure 8-7.

      These are the raw values sent from the internal current sensor.

Figure 8-7. Raw Values Dashboard

9. Minimize the internet browser by clicking minimize **(-)** in the upper right corner of the screen to view the Desktop.
10. Perform the following substeps to open the PLC Heater Temp Monitoring application on your PC.

    To observe the workstation under the current load during operation, the heater program will need to be started.
    A. Click on the **FactoryTalk View ME Studio Shortcut** in the desktop of the PC.

       A dialog will appear prompting "Do you want to allow this app to make changes to your device?".
    B. Click **Yes.**

       After a short load time, the Smart Manufacturing System main screen will appear.
11. In the Smart Manufacturing System main screen, press the **Heating Application** tab.
12. Press **START** to initiate the heating program.
13. Perform the following substeps to view the power consumption of the workstation.
    A. Return to the incoming power consumption application on the dashboard.
    B. Observe current power consumption.

       While the heater and red indicator are ON, the current power consumption will display approximately 24 W. When the fan and blue indicator are ON, the current power consumption will be approximately 7 W.
    C. Observe maximum power consumption.

       If no larger values have been observed today, the 24 W will become the maximum power consumption value. Maximum power consumption value will update to the largest power value, when the value is observed that day.

D. Observe the current draw.

While the heater and red indicator are ON, the current draw will display approximately 0.22 A. When the fan and blue indicator are ON, the current draw will be approximately 0.06 A.

E. Observe the power consumption trend.

You should observe changes in current power consumption and in the power consumption trend as the red and blue indicators turn on and off with the heater and fan. During operation, the heater will consume more power than the fan.

14. Press **MAIN MENU** on the HMI to view the main menu.

In the following steps, you will operate the motor to increase the power drawn by the workstation.

15. Perform the following substeps to run the motor.

A. Switch the MOTOR POWER switch **ON** at the workstation.

The white indicator will turn ON showing that the manual motor switch is on.

B. Press **PRODUCTION APPLICATION** on the HMI.

C. Press **START**.

The green indicator will turn ON showing that the motor is on.

D. Rotate the MOTOR potentiometer to the midpoint.

The motor will start rotating.

16. Perform the following substeps to view the power consumption of the workstation.

A. Return to the incoming power consumption application on the dashboard.

B. Observe current power consumption.

While the heater and red indicator are ON, the current power consumption will now display approximately 27 W. This higher power consumption is due to the heater and motor operating at the same time. When the fan and blue indicator are ON, the current power consumption will now be approximately 9 W.

C. Observe maximum power consumption.

If no larger values have been observed today, the 27 W will become the maximum power consumption value.

D. Observe current draw.

While the heater and red indicator are ON, the current draw will display approximately 0.24 A, due to the addition of the motor. When the fan and blue indicator are ON, the current draw will be approximately 0.08 A.

E. Observe the power consumption trend.

You should observe changes in current power consumption and in the power consumption trend as the red and blue indicators turn on and off with the heater and fan. During operation, the plotted points will be slightly higher than the values plotted without the motor running.

17. Perform the following substeps to stop the motor and end the production application.

A. Press **STOP** on the HMI.

The green indicator will turn OFF and the motor will stop.

B. Rotate the MOTOR SPEED potentiometer fully counterclockwise.

C. Rotate the MOTOR POWER switch counterclockwise to disable the motor.

The white indicator will turn OFF.

18. Perform the following substeps to end the heating application program and to close the HMI window.
    A. Press **MAIN MENU** on the HMI.
    B. Press **HEATING APPLICATION**.
    C. Press **STOP** to end the heating application.
       The red and blue indicators will turn OFF, indicating the heater and fan are now off.
    D. Press **MAIN MENU** in the bottom right of the screen.
    E. From the Smart Manufacturing System screen, press **SHUTDOWN** in the bottom right of the screen.

NOTE

The following instructions are for the optional Amatrol 43110 Remote Current Sensor as shown in figure 8-8. If the remote current sensor is not a part of your 990-SM10 Smart Manufacturing Learning System, continue to step 33.

The remote current sensor uses the same current transformer that is used in the workstation.

Figure 8-8. 43110 Remote Current Sensor

20. Perform the following substeps to connect the remote current sensor for measurement.

A. Connect the remote current sensor leads to the IN 3 jacks on the workstation panel, as shown in figure 8-9.

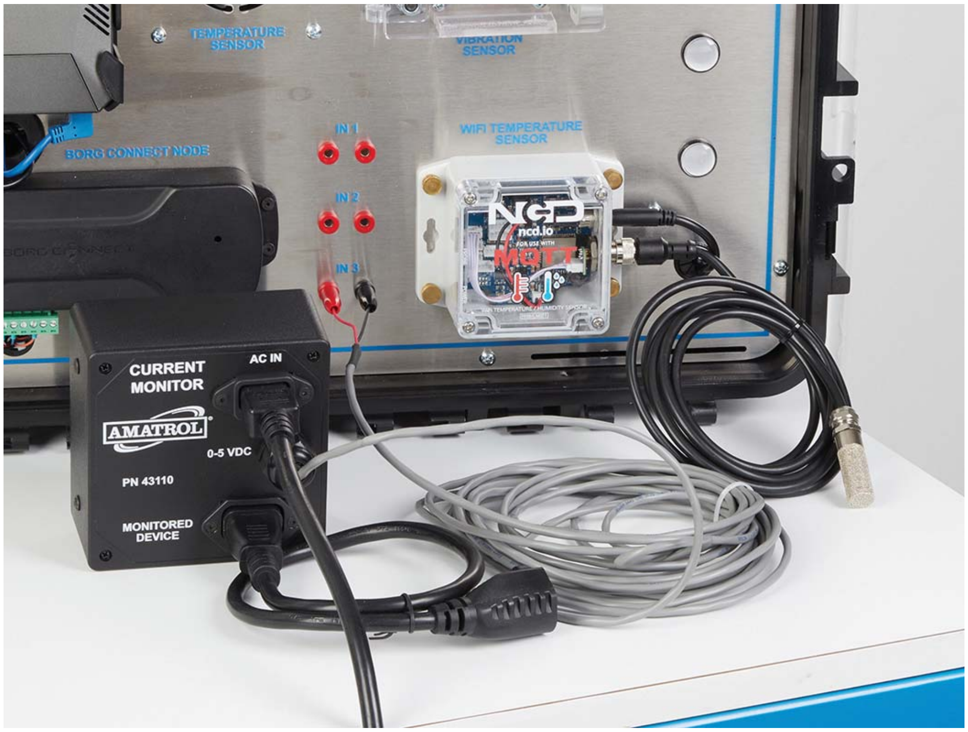

Figure 8-9. 43110 Remote Current Sensor Connection to Workstation

B. Plug the remote power cord into an AC wall outlet.

C. Plug the sample device to be measured into the remote current sensor as shown in figure 8-10.

Examples of devices that can be measured:

- Computer
- Desk fan
- Cell phone charger
- Hand tools
- Any AC device that does not exceed 15A

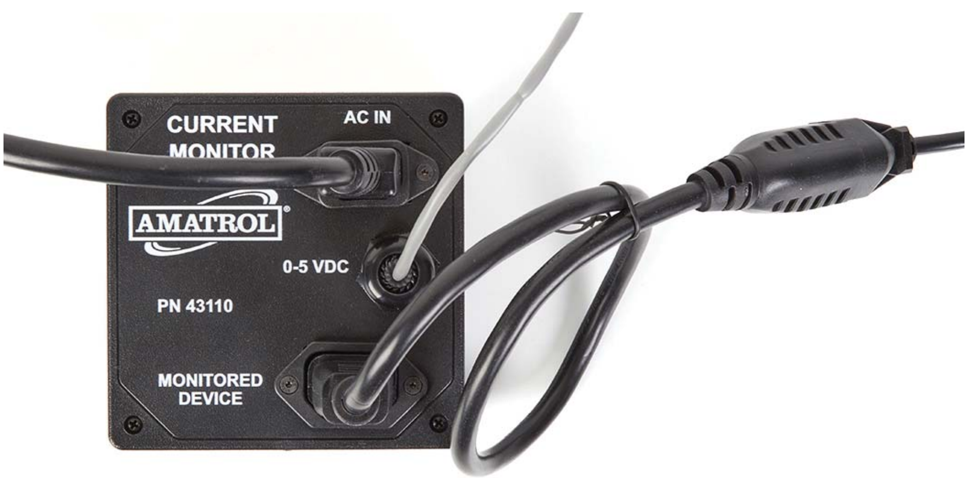

Figure 8-10. Power Connection into Remote Current Sensor

NOTE

If the selected device uses a motor, it must use less than 15 A to function. Exceeding 15 A will trip the circuit breaker in the remote sensor enclosure because of the elevated inrush current of the motor.

21. Maximize the internet browser to view the BorgConnect Dashboard.
22. Click the drop-down menu in the upper left corner of the screen.
23. Perform the following substeps to navigate and view the power consumption data.
    A. Select **External Power Consumption** on the Dashboard software.

       Like the incoming power consumption application, the external power consumption application records power consumption, today's total energy consumption in watt-hours (W-h), current draw, and the power consumption trend.

    B. Observe the current power consumption displayed on the dashboard.

       You should observe that the current power consumption is 0 W.

    C. Observe the maximum power consumption displayed on the dashboard.

       The maximum power consumption will display the largest wattage value observed from the remote current sensor for today.

    D. Observe the overall energy consumption displayed on the dashboard.

       The overall energy consumption in W-h today will display the W-h consumed by the remote current sensor today.

       You should observe that current draw is 0 A.

    E. Observe the power consumption trend displayed on the dashboard.

       The power consumption trend will display the recent power consumption values.
24. Perform the following steps to observe the raw values for the remote current sensor.
    A. Click the drop-down menu in the top-left corner of the screen to display the Dashboard applications.
    B. Select **RAW VALUES DASHBOARD** to display the values observed by the BorgConnect Node.
    C. Observe the remote current sensor VDC values displayed in V2.

       These are the raw values sent from the remote current sensor.
25. Turn the external device ON.

    Observe the external power consumption application. If the external device has a motor, the motor will take more power to start than to run at rated speed. There will be an initial power spike when a motor is started. Following the spike, you should observe a stable power consumption as the motor reaches full speed. The full-speed power consumption will be less than the start-up power consumption. If the external device does not use a motor, you will not see the initial power spike.
26. Turn the external device OFF.

    Current power consumption will return to zero.
27. Perform the following substeps to change the power trend setting.
    A. Mouse over the top of the power trend widget.
    B. Click the **Edit** option.
    C. Click the pull-down tab for x-axis.
    D. Select **Minutes**.
    E. Click **Save**.

       The BorgConnect Dashboard will refresh and plot values in the power consumption trend graph every minute. Using minutes in the power consumption trend, take the latest value and multiply by 1.44 (60 seconds x 24 hours / 1000 W) to get the kWh that the device would use if run for a full day.

28. Repeat steps 22 to 25 to observe the trendline changes then skip to step 28.
29. Unplug the device from the remote current sensor.
30. Repeat from step 19 to measure another device or continue to step 30.
31. Unplug the remote current sensor from the AC wall outlet.
32. Unplug the remote current sensor leads from the workstation.
33. Using step 26 as a reference, return the setting to display seconds.
34. Close the internet browser by clicking the **(X)** in the top right-hand corner of the screen.
35. Perform the following substeps to power down the Smart Manufacturing system.
    A. Press the power button on the BorgConnect Hub to turn OFF.
    B. Place the workstation's main power switch in the **OFF** position.
    The PLC, switch, BorgConnect Node, and Wi-Fi temperature sensor will power down.
    C. Turn off the PC and monitor.

PROCEDURE OVERVIEW

In this procedure, you will use the BorgConnect Dashboard to provide a count of the bolts placed into the load cell hopper. The Bluetooth scanner will be used to select the bolt type/size. This process shows how a bulk quantity can be counted using weight through a network of wireless devices.

1. Position yourself in front of the 990-SM10 Smart Manufacturing system as shown in figure 9-1.

Figure 9-1. 990-SM10 Smart Manufacturing System with PC

2. Perform the following substeps to connect the cords and cables to the workstation for operation.

   A. Connect the IEC power cord to the IEC connection on the workstation and to an AC wall outlet, as shown in figure 9-2.

Figure 9-2. IEC Power Cord Plugged into AC In Port and Power Supply Outlet

   B. Connect the Ethernet cables between the unmanaged switch, PLC, PC, and local network port, as shown in figure 9-3.

NOTE

The local network port may be different than the port shown. Contact your IT department if assistance is required.

Figure 9-3. Ethernet Cable Connections

3. Turn on the PC and monitor.
4. Switch the workstation's main power switch to the **ON** position.
5. Press the power button to turn ON the BorgConnect Hub.

   Shortly after pressing the power button on the BorgConnect Hub, a red indicator light will turn ON to display the unit is powered on.
6. Perform the following substeps to prepare the load cell for measurement.

   A. Grasp the load cell hopper with one hand to hold it in position.

Figure 9-4. Load Cell Hopper

B. Press the button of the T-handle and remove the quick-release pin from the load cell hopper so it can be moved from the shipping position.

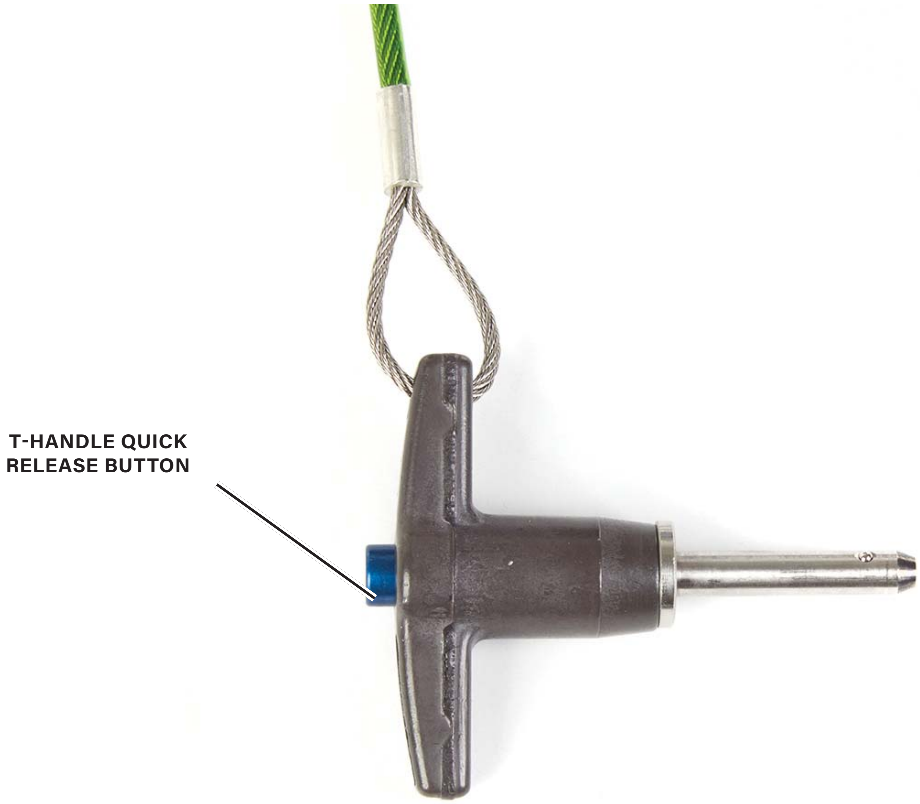

Figure 9-5. T-Handle Quick-Release Pin

C. Insert the quick-release pin into the pin storage location.

The pin storage location secures the pin and allows movement of the load cell hopper.

Figure 9-6. Quick-Release Pin Storage

D. Slowly lower the load cell hopper down onto the load cell and release the hopper.

The load cell produces an analog voltage that is proportional to the force on the load cell from the weight of the bolts. This voltage is converted to weight by the BorgConnect Hub.

For the purposes of this activity, the load cell is set up to measure in grams. The Hub divides the load cell force by the standard weight for a given part type to provide the part count.

$$Part\ Count = \frac{Load\ Cell\ Measured\ Weight\ (grams)}{Individual\ Standard\ Part\ Weight\ (grams)}$$

Figure 9-7.   Load Cell Hopper Ready Position

7. Examine the control diagram of the production counting application in figure 9-8.

   The load cell is wired into the BorgConnect Node at analog input V3. The Node coverts the analog signal to a digital signal and transmits the data to the BorgConnect Hub via Wi-Fi connection.

   The PC communicates with the Hub through the BorgConnect Dashboard software using a Wi-Fi connection to view the part count data from the load cell.

   The Bluetooth scanner communicates with the PC through a wireless Bluetooth connection to identify the bolt type to be counted.

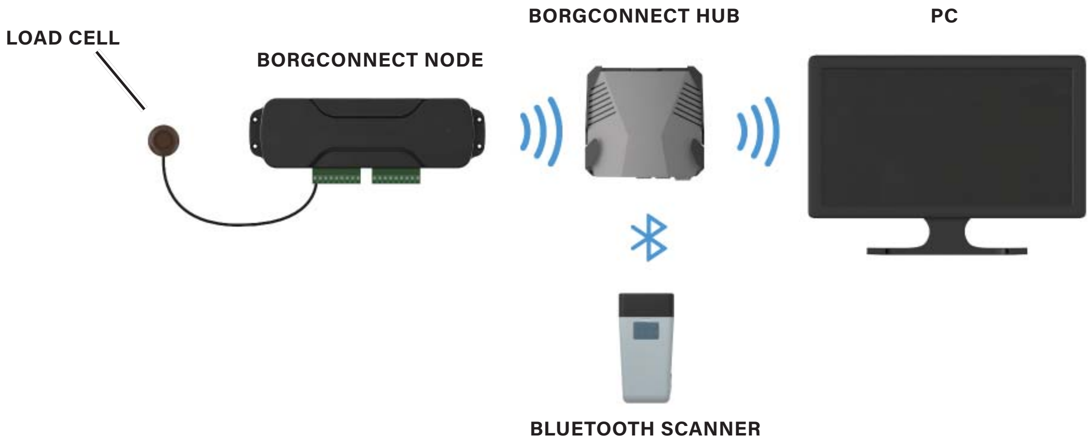

Figure 9-8. DIagram of Production Counting Application

8. Perform the following substeps to connect the PC to the BorgConnect Dashboard.
   A. Open the internet browser on the PC.
   B. Enter http://10.3.141.1/ into the address bar of the internet browser.
   C. Press the **Enter** key on the keyboard.
   D. Enter the login credentials in the space provided.

      Username: admin

      Password: Welcome2BC

      After logging in, the BorgConnect Dashboard main screen will open similar to figure 9-9.

Figure 9-9. BorgConnect Dashboard Main Screen

   E. Open a second tab in the internet browser.
   F. Repeat the process starting with substep B to open a second Dashboard main screen, as two Dashboard tabs will be needed for this activity.

9. From the first browser tab, click on **RAW VALUES DASHBOARD**.

   The raw voltage values measured at the inputs of the BorgConnect Node are viewed here. The values given by the load cell are connected to the Raw V3 widget.

   The load cell produces a signal between 0 VDC to 5 VDC to indicate the force measured by the load cell, which is created by the weight of parts in the hopper. As more force/weight is applied to the load cell, the output voltage increases proportionally. The voltage is converted from an analog signal to a digital value by the Borg Node. Through a Wi-Fi connection, the Borg Node sends the digital value to the Borg Hub.

10. Click **Menu**, which is shown in figure 9-9.

11. Click on **Production Quantity App**.

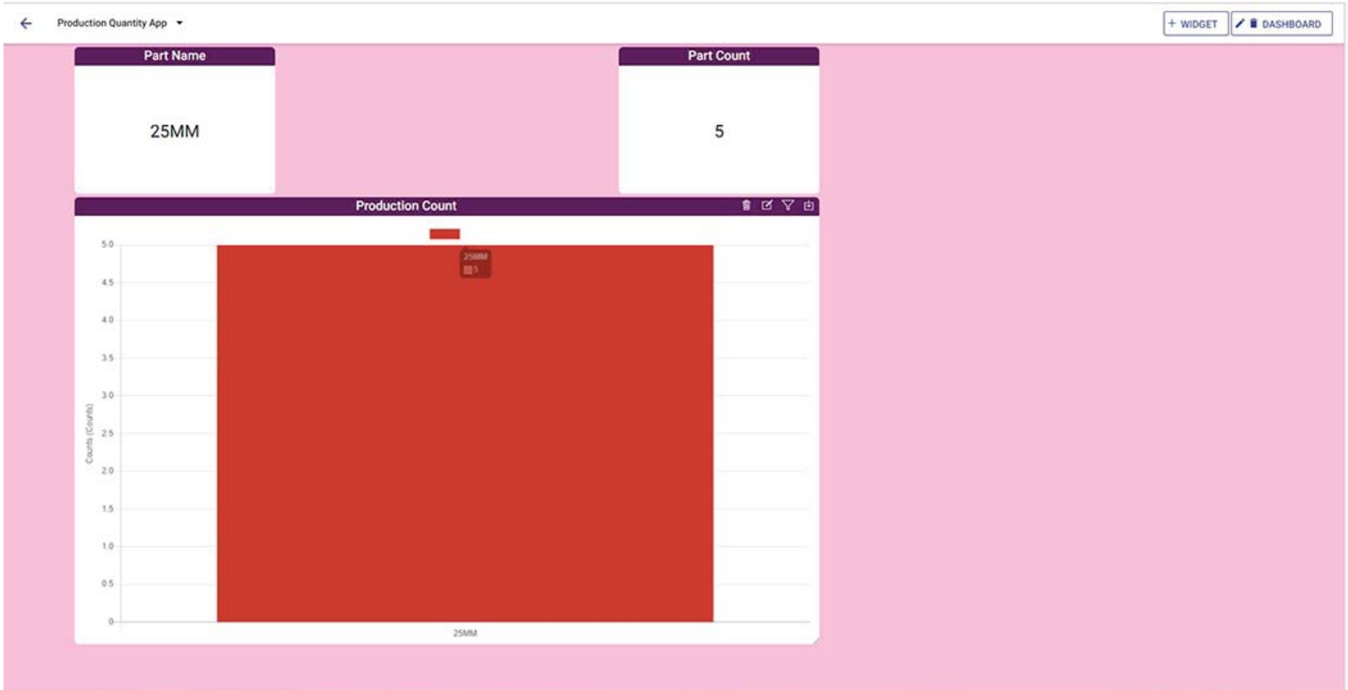

Figure 9-10. Production Quantity Application

12. Perform the following substeps to familiarize yourself with the Production Quantity application in the BorgConnect Dashboard.

    The Hub converts the digital voltage data transmitted from the Node into grams for the BorgConnect Dashboard production counting application. The application divides the voltage value by the standard unit weight of one part to calculate the part count.

    A. Locate the Part Name widget and observe the displayed name.

       Initially, the part name may be displayed as Not Connected if a part type has not been scanned and counted. After this, the part type being counted will be named here.

    B. Locate the Part Count widget and observe the displayed count.

       Initially, the part count may be displayed as Not Connected if a part type has not been scanned and counted. After this, the quantity of parts will be displayed here.

    C. Locate the Production Count widget and observe the displayed graph.

       Initially, the graph may be void of information until a part type and count has been provided. Once the graph populates a result, it will retain the last count from each part type until the screen is refreshed.

13. Select the second web browser tab to set up the part type for measurement.

Figure 9-11. Internet Second Browser Example

14. Perform the following substeps to select the part type unit weight and select the desired bolt.

    A. Click **Menu** to open the menu.

    B. Click **DATA ENTRY** as shown in figure 9-12.

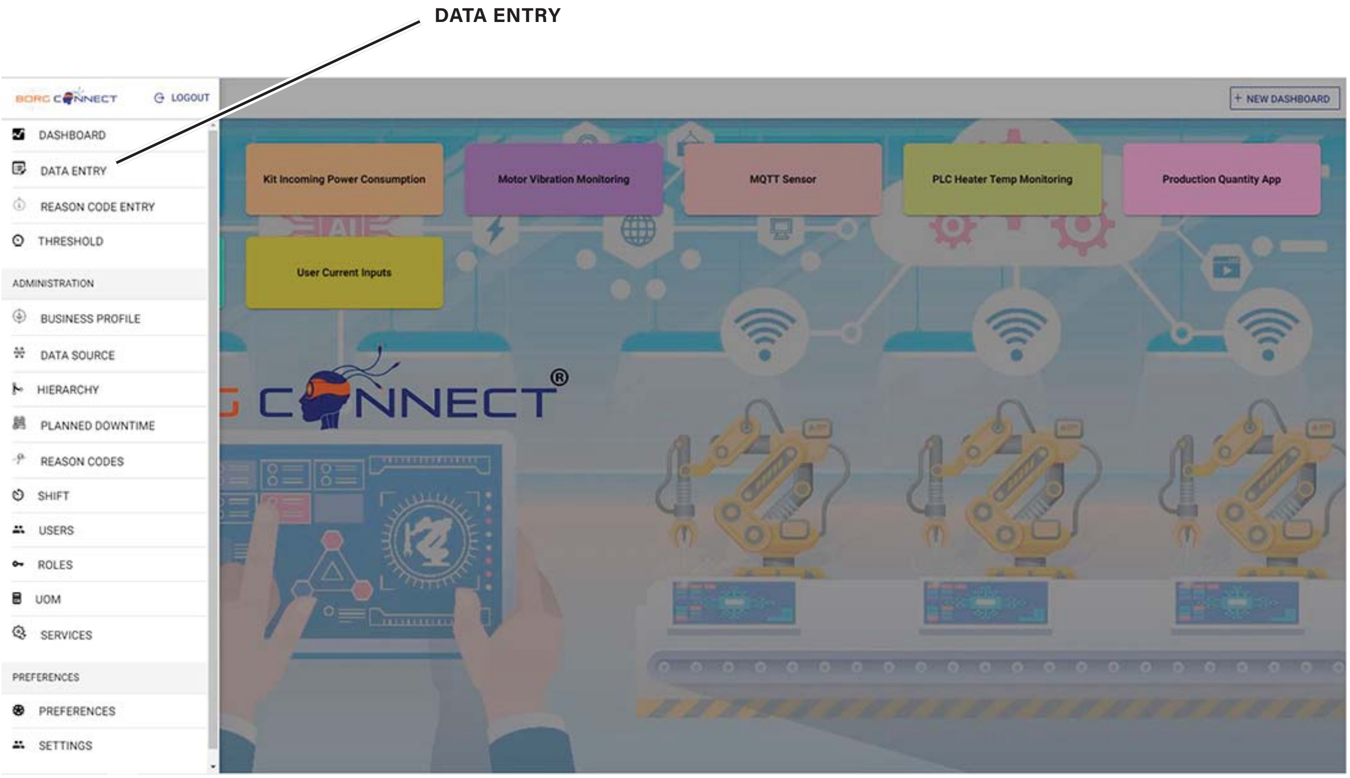

Figure 9-12. BorgConnect Dashboard Menu

C. Click the greater-than symbol **(>)** to expand the tree for Smart Manufacturing Institute.

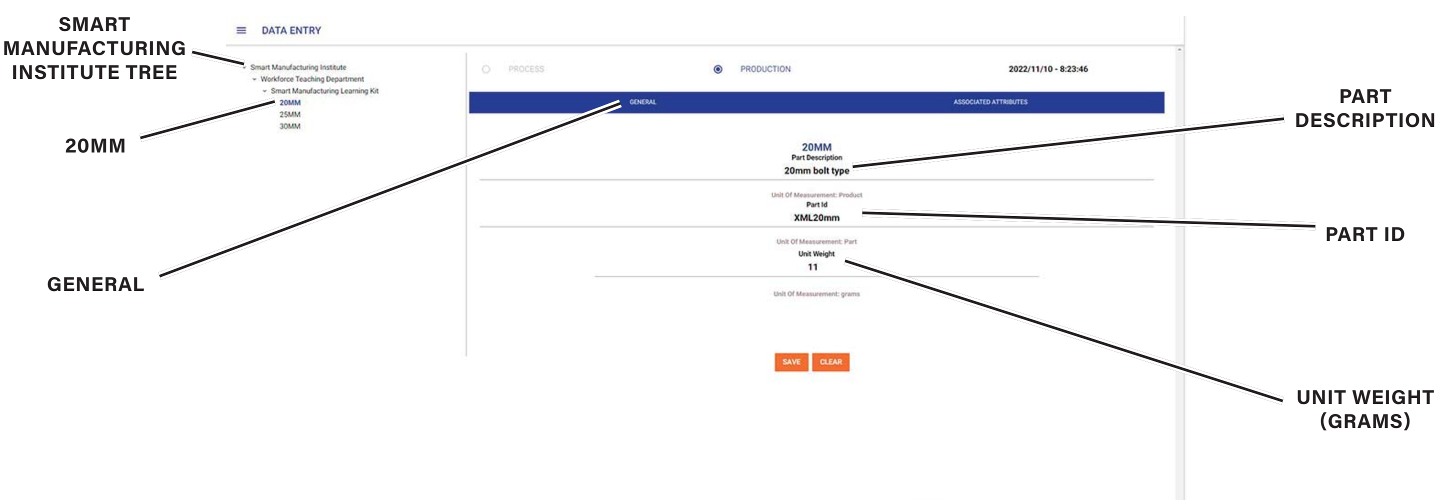

Figure 9-13. 20MM Bolt Unit Weight

D. Click the greater-than symbol **(>)** to expand the tree for Workforce Teaching Department.

E. Click the greater-than symbol **(>)** to expand the tree for Smart Manufacturing Learning Kit.

F. Select **20MM** to choose the 20 mm bolt setup.

G. Click **GENERAL** to display the 20 mm bolt page.

This page displays the part name, part description, part ID, unit weight, and unit of measurement.

This process can also be performed for the 25 mm bolts (25MM), the 30 mm bolts (30MM), and any other parts configured by the instructor.

15. Perform the following substeps to reset or zero the load cell through Dashboard to prepare for measurement.

The weight of the hopper must be subtracted from the calculation for determining the number of bolts in the hopper. Otherwise, the count would be incorrect. By zeroing out the load cell with the empty hopper resting on it, the hopper weight does not affect the calculation.

A. Click **Menu** to open the menu.

B. Click **DATA ENTRY.**

C. Click **ASSOCIATED ATTRIBUTES.**

D. Click **HOW MANY** as shown in figure 9-14.

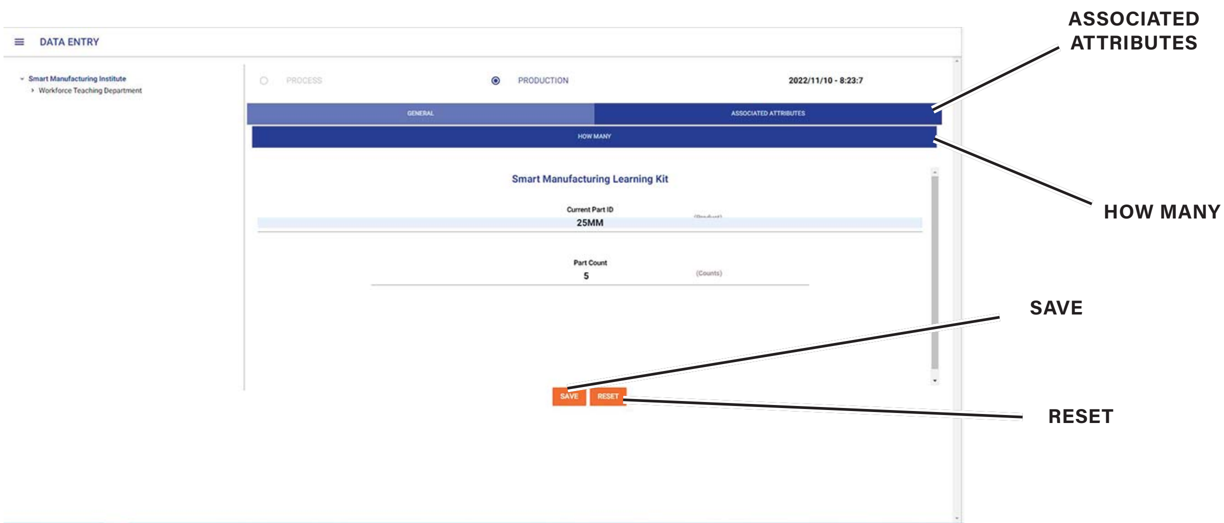

Figure 9-14. BorgConnect Dashboard Data Entry Main

E. With an empty load cell hopper and after waiting for 5 seconds, click **RESET** to zero the part count.

Clicking reset negates the weight of the load cell hopper from the part count by setting the weight with an empty load cell hopper to zero. Allow 5 seconds after emptying or replacing the load cell hopper onto the load cell before clicking reset. This will give the load cell time to stabilize after changes. Failure to do so may result in the displayed part count varying from the actual count.

16. Click the Dashboard web browser tab to view the production quantity application.

17. Perform the following substeps to view the Raw Data to observe the V3 value after resetting the load cell.

A. Click the Dashboard **Back** arrow to return to the main menu.

B. Click **Raw Values Dashboard.**

V3 should display a value close to 0 if the load cell has been properly reset. If any other value is displayed, repeat the reset process in step 15.

18. Perform the following substeps to return to the Production Quantity Application.
    A. Click the Dashboard **Back** arrow to return to the main menu.
    B. Click on **Production Quantity App**.
19. Perform the following substeps to refresh the Dashboard page to prepare for counting.
    A. Click **Menu** to begin refreshing the page after reset.
    B. Click **Dashboard** to change from the data entry page.
    C. Click **Menu**.
    D. Click **Data Entry**.
20. Perform the following substeps to prepare the part ID for barcode scan input.
    A. Click **Associated Attributes.**
    B. Click **How Many**.
    C. Click **Current Part ID**.

       This will allow you to enter the part ID with the Bluetooth scanner. The Bluetooth scanner transmits data to the PC wirelessly.
21. Press the pushbutton on the Bluetooth scanner, shown in figure 9-15, to power up the scanner and prepare for the next step.

    The scanner will beep one long beep when initializing, followed by a quick double beep to signal that it is connected and ready to scan. The scanner has a rechargeable battery and will automatically power down to preserve battery life after a few minutes of inactivity. Repeat this step when necessary to power the scanner up.

Figure 9-15. Bluetooth Scanner Push Button

22. Scan the 20MM barcode, shown in figure 9-16, with the Bluetooth scanner to set the production quantity application for weighing the 20 mm bolts.

    This inserts 20MM in the current part ID and sets the unit weight to 11 gm, which is the standard weight of the 20 mm bolt. The 25 mm bolt, when selected, is set to 20 gm and the 30 mm bolt, when selected, is set to 34 gm. These weights have been pre-measured by and adjusted for count accuracy.

NOTE

Due to the manufacturing process of the hardware, the individual weights between parts can vary. As the quantity of hardware increases, so does the chance that the quantity can become over or under counted.

20MM

Figure 9-16. Barcode – 20MM

23. Add five of the 20 mm bolts to the load cell hopper.
24. Press **Tab** on the PC keyboard.

    After approximately 5 seconds, the part count line should display a part count of 5. This allows time for the load cell to stabilize and for the Hub to receive the latest data.
25. Click **SAVE** to save the part ID and part count to the production quantity application for display.
26. Click the Dashboard web browser tab to view the production quantity application.

    The part name should display 20MM to show that the 20 mm bolts are being counted. The part count should display 5 to show that there are five bolts in the hopper. The production count graph should show that the 20 mm bolts have a quantity of 5.
27. Perform the following substeps to refresh the production quantity application.

    The production quantity application may time-out without producing an error message. This is demonstrated by the application not displaying the most recent part count and part ID saved in the data entry browser tab. Should this occur, the following substeps will restart the application.

    A. Click the Dashboard **Back** arrow to return to the Dashboard main menu.

    B. Click **Production Quantity App**.
28. Empty the load cell hopper.

29. Return to the data entry web browser tab.

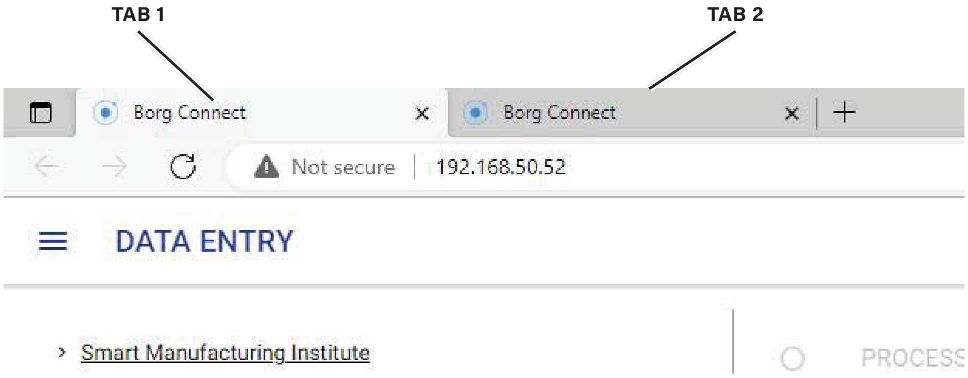

Figure 9-17. Web Browser Tabs

30. Allow the load cell time to stabilize and then click **RESET** to zero the part count.
31. Navigate to refresh the Dashboard page.
32. Navigate to the Current Part ID.
33. Add another sample of 20 mm bolts to measure.

    This should be a random amount between 1-10 bolts to test the part counting process.
34. Scan the 20MM barcode with the Bluetooth scanner.
35. Press **Tab** on the PC keyboard.

    After 5 seconds, the part count line will display a part count that represents the number of 20 mm bolts in the load cell hopper.
36. Click **SAVE** to save the part count to the production quantity application for display.
37. Click the Dashboard web browser tab to view the production quantity application.

    If the application fails to update, refresh the application by repeating step 27.
38. Repeat starting at step 28 to test more samples or proceed to step 39 to count other bolt types once you are comfortable with the process for counting 20 mm bolts.
39. Empty the load cell hopper.
40. Return to the data entry web browser tab.
41. Allow the load cell 5 seconds to stabilize and then click **RESET** to zero the part count.
42. Navigate to refresh the Dashboard page.
43. Navigate to the Current Part ID.

44. Using the barcode scanner, scan the 25MM barcode for the 25 mm bolts, as shown in figure 9-18.

25MM

Figure 9-18. Barcode – 25MM

45. Add five of the 25 mm bolts into the load cell hopper.
46. Press **Tab** on the PC keyboard.

    After 5 seconds, the part count line will display a part count of 5.
47. Click **SAVE** to save the part count to the production quantity application.
48. Click the Dashboard web browser tab to view the production quantity application.

    If the application fails to update, refresh the application by repeating step 27.
49. Empty the load cell hopper.
50. Click the data entry web browser tab.
51. Click **RESET** to zero the part count.
52. Navigate to refresh the Dashboard page.
53. Navigate to the Current Part ID.
54. Add another sample of 25 mm bolts to measure.

    This should be a random amount between one to 10 bolts to test the part counting process.
55. Scan the 25MM barcode with the Bluetooth scanner.
56. Press **Tab** on the PC keyboard to obtain the part count.

    After 5 seconds, the part count line will display a part count approximate to the number of 25 mm bolts in the load cell hopper.
57. Repeat starting at step 49 to test more samples or proceed to step 58 once comfortable with the process for counting 25 mm bolts.
58. Empty the load cell hopper.
59. Navigate to reset the load cell.
60. Navigate to refresh the Dashboard page.
61. Navigate to the Current Part ID.
62. Using the barcode scanner, scan the 30MM barcode for the 30 mm bolts, as shown in figure 9-19.

30MM

Figure 9-19. Barcode – 30MM

63. Add five of the 30 mm bolts into the load cell hopper.
64. Press **Tab** on the PC keyboard.

    After 5 seconds, the part count line will display a part count of 5.
65. Click **SAVE** to save the part count to the production quantity application.
66. Click the Dashboard web browser tab to view the production quantity application.

    The application will display a part name of 30MM, a part count of 5, and the production count will display the 30MM count of 5. Refresh the page if needed.
67. Click the data entry web browser tab.
68. Empty the load cell hopper.
69. Click **RESET** to zero the part count.
70. Navigate to refresh the Dashboard page.
71. Navigate to the Current Part ID.
72. Scan the 30MM barcode to set up counting.
73. Add another sample of 30 mm bolts to measure.

    This should be a random amount between one to 10 bolts to test the part counting process.
74. Press **Tab** on the PC keyboard to obtain the part count.

    After 5 seconds, the part count line will display a part count approximate to the number of 30 mm bolts in the load cell hopper.
75. Click **SAVE** to save the part count to the production quantity application for display.
76. Click the Dashboard web browser to view the production quantity application.
77. Click the data entry web browser tab.
78. Repeat starting at step 68 to test more samples or proceed to step 79 once comfortable with the process for counting 30 mm bolts.
79. Empty the load cell hopper.
80. Perform the following to shut down the workstation.
    A. Raise the load cell hopper into shipping position.
    B. Push the button on the T-handle and remove the quick-release pin.
    C. Insert the quick-release pin into the hopper and the panel to secure the hopper in shipping position.
    D. Close the BorgConnect Dashboard and the internet browser by clicking the **(X)** in the top right-hand corner of the screen.
    E. Press the power button on the BorgConnect Hub to turn OFF.
    F. Switch the workstation’s main power switch to the **OFF** position.
    G. Turn off the PC and monitor.