WAKE TECH
Building, Engineering, & Skilled Technologies

# Controller IO Lab

BAT-111: Building Automation Systems


*This material is based upon work supported by the National Science Foundation Advanced Technical Education grant program, A New Technician Training Program for Advanced Building Technologies, DUE-2000190.*

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# Controller IO Lab

## SYNOPSIS

We have going to explore the functionality of a controller including the IO of the controller.

## OBJECTIVES

Upon completion of this activity the student will be able to:

1. Understand power requirements of the BAScontrol22 controller.
2. Understand binary inputs, analog inputs, binary outputs, & analog outputs.
3. Determine if all our controller's inputs and outputs are functioning correctly.

## PARTS AND EQUIPMENT

- Contemporary Controls BAScontrol22 or BAScontrol22S
- Ethernet cable
- Laptop
- DC multimeter
- Thermistor
- Resistor (510 Ω)
- Short piece of wire

## REFERENCES

- Contemporary Controls BAScontrol22 User Manual

## BACKGROUND

In a previous lab, we have successfully powered the BAScontrol22 controller, set up a peer-to-peer connection with the controller and have viewed the controller's webpage. This is where this lab begins.

1.1 - Controller

A controller is a device which has input and outputs functionality to and from an end device.

1.2 - Inputs vs Outputs

An input or output is considered from the reference of the controller.

### *Input*

An input is information coming into the controller from an end device. A good example of an input would be signaling to know whether a light is on or off.

### *Output*

An output is information or a control action leaving the controller to control an end device. An example of an output is signaling to turn the light on or off.

### *Feedback*

Often an input is used to verify an output is done correctly. Feedback is knowing/checking the state of the light, after you have signaled to turn the light off.

1.3 - Binary vs Analog

### *Binary*

Binary only has two states. It can be referred to as the following:

- True vs False
- Closed vs Open
- On vs Off
- 1 vs 0

We will refer to binary as any of these and use them interchangeably so note that:

- True = Closed = On = 1
- False = Open = Off = 0

### *Analog*

Analog values have a range of values. A subtle difference in an analog value might mean significant difference in what that value represents.

1.4 - Resistor

The color bands on a resistor state the size of the resistor. Find a chart on the internet showing the resistor color bands.

To read the color bands in the correct order, you start with the band that is closest to the edge of the resistor.

## PROCEDURES

## Part 1: Power Supply

Open the User Manual and find section 2.7: Power Requirements

Can the controller be powered by AC, DC, or either?_____

What are the voltage requirements for the controller defined by the user manual?_____

Are you powering your controller by AC or DC?_____

Using your voltmeter, what is the source voltage read at the power terminal screws?_____

## Part 2: Cabling

Open the User Manual and find section 3.2: Cabling considerations

Can you use solid, stranded, or both for I/O?_____

What are the specifications for solid conductors?_____

What are the specifications for stranded conductors?_____

## Part 3: Binary Outputs (BO)

A binary output is similar to a physical switch we control. We can flip the switch and open or close a connection. With a binary output instead of flipping a physical switch, we can have the controller open or close the relay through software. We can do this via the controller's webpage.

3.1 - Specifications

Open the User Manual and find section 2.4: Binary Outputs

Is the relay contact normally open or closed?_____

What is the maximum voltage allowed to flow through this relay?_____

What is the maximum amperage allowed to flow this relay?_____

3.2 - Continuity Tester

We are going to be using the continuity tester functionality of our multimeter to verify if our binary outputs are open or closed as expected.

Make sure your continuity checker is working by touching the probes together. Some continuity testers may emit a noise when there is continuity. Depending on your meter, when you separate your probes, you may see 'OL' for open load if there is no continuity.

3.3 - Check Binary Output

We are going to start by looking at BO1 which is Binary Output 1.

### *BO set to False*

Looking at the webpage find BO1. If BO1 is checked, uncheck the override. You should see a value of '0' to the right of BO1. '0' represents false or open or off.

There is an LED light on your controller which will physically tell you if the binary output is open or closed. The LED on the controller is located between the terminal block and cover.

Is the LED light illuminated for BO1?_____

Check the continuity of BO1 by placing one probe on A and the other probe on B.

Is there continuity for BO1?_____

Since the webpage has a ‘0’ for BO1, the LED light should not be lit and there should not be continuity on BO1.

### *BO set to True*

We are now going to change BO1 to be True.

On the webpage, override the current value by checking the checkmark to the right of BO1. We now have the ability to override and edit the value for BO1. We are going to change BO1 to True, by placing a ‘1’ in the textbox.

As soon as you hit Enter or click somewhere else on the webpage, you should hear an audible click from your controller.

Is the LED light illuminated for BO1?_____

Check the continuity of BO1 by placing one probe on A and the other probe on B.

Is there continuity for BO1?_____

Since the webpage has a ‘1’ for BO1, the LED light should be lit and there should be continuity on BO1.

Did BO1 behave correctly and if not, what was wrong?_____

_____

3.4 - Check the remaining Binary Outputs

Do the same test for each of the Binary Outputs and verify that each works as expected.

Did BO2 behave correctly and if not, what was wrong?_____

_____

Did BO3 behave correctly and if not, what was wrong?_____

_____

Did BO4 behave correctly and if not, what was wrong?_____

_____

Did BO5 behave correctly and if not, what was wrong?_____

_____

Did BO6 behave correctly and if not, what was wrong?_____

_____

Give a different example of what an BO could be used for?_____

_____

_____

_____

_____

## Part 4: Analog Outputs (AO)

Analog outputs are used to produce a range of values. Analog Outputs represent data that is not just binary.

For example, an AO can be used to tell a damper or valve to be a certain percentage open.

With an economizer, we want a percentage of the mixer air to come from the outside and the rest from the return. For example, we could have the outside air damper open 30% and the return air damper open 70%. If we used a BO to adjust the outside air damper, we could only tell the damper to be completely open or completely closed.

4.1 - Specification

Open the User Manual and find section 2.3: Analog Outputs

What is the output voltage range?_____

Is the output voltage AC or DC?_____

What is the maximum amperage?_____

4.2 - Check Analog Output

*AO with 0 volts*

We are going to start by looking at AO1 which is Analog Output 1.

Looking at the webpage find AO1. If AO1 is checked, uncheck the override.

The value represents the voltage at this output. You should see '0.000' which represents 0 volts dc.

There are no LEDs for the Analog outputs.

Check the voltage of AO1 by placing one probe on A and the other probe on C.

What is the voltage for AO1?_____

Since the webpage has a '0.000' for AO1, the voltage should be close 0 volts. I would expect some minor differences in voltage within 100 mV with your meter. A large difference could mean an issue with the controller or the meter. Check with a second meter if the voltage difference is large.

*AO with 5.25 volts*

We are now going to override AO1 to output 5.25 volts dc.

On the webpage, override the current value by checking the checkmark to the right of AO1. We are going to change AO1, by placing a '5.25' in the textbox which would represent 5.25 volts.

There is no audible click from your controller when your change analog outputs.

Using your meter, what is the voltage for AO1?_____

What was the difference voltage between the overridden voltage you set on the webpage and what your meter read?_____

Is the voltage difference reasonable (within 100 mV)?_____

Did AO1 behave correctly and if not, what was wrong?_____

_____

4.3 - Check the remaining Analog Outputs

Do the same test for each of the Analog Outputs and verify that each works as expected.

Did AO2 behave correctly and if not, what was wrong?_____

_____

Did AO3 behave correctly and if not, what was wrong?_____

_____

Did AO4 behave correctly and if not, what was wrong?_____

_____

Give a different example of what an AO could be used for?_____

_____

_____

_____

_____

## Part 5: Binary Inputs (BI)

With a binary input we are checking if there is relay closed.

Two examples of BI are motion sensors or water flow switches.

5.1 - Specification

Open the User Manual and find section 2.2: Binary Inputs

What is the Type?_____

5.2 - Checking continuity by examining the voltage

In a previous part of the lab, we used the continuity function on our multimeter to determine if a BO was open or closed, we cannot use the continuity checker to determine if the BI is open or closed.

We do use the continuity checker or read the resistance of a live circuit. We check the BI, by checking the voltage drop across the BI

- Voltage drop = open
- No voltage drop = closed

We are going to be examining the voltage to determine if there is continuity. If there is continuity, there should be 0 volts.

5.3 - Check Binary Input

We are going to start by looking at BI1 which is Binary Input 1.

*BI is open*

Looking at the webpage find BI1. If BI1 is checked, uncheck the override

Is the LED light illuminated for BI1?_____

Check the voltage of BI1 by placing one probe on A and the other probe on C.

**Do NOT use the continuity checker function of the multimeter.**

Using your meter, what is the **voltage** of BI1?_____

Is BI1, open or closed?_____

*BI is closed*

We are now going to change BI1 to be closed by placing a wire between A and C on BI1

Is the LED light illuminated for BI1?_____

**Do NOT use the continuity checker function of the multimeter.**

Using your meter, what is the **voltage** of BI1?_____

Is BI1, open or closed?_____

Did BI1 behave correctly and if not, what was wrong?_____

_____

5.4 - Check the remaining Binary Inputs

Do the same test for each of the Binary Inputs and verify that each works as expected.

Did BI2 behave correctly and if not, what was wrong?_____

_____

Did BI3 behave correctly and if not, what was wrong?_____

_____

Did BI4 behave correctly and if not, what was wrong?_____

_____

Give a different example of what a BI could be used for?_____

_____

_____

_____

_____

## Common on the controller.

Power down your controller.

Using your continuity tester, you will notice all the Cs on the board should have continuity.

Is there continuity between BI1-C and BI2-C?_____

Is there continuity between U11-C and UI2-C?_____

Is there continuity between AO1-C and AO2-C?_____

Is there continuity between AO1-C and Power COM?_____

Are there C terminals for Binary Output?_____

Power your controller back up.

Refresh the webpage by pressing Ctrl-F5. Ctrl-F5 forces a refresh and ignores any cached data by your browser.

## Part 6: Analog Inputs (AI)

An AI is a range of values.

For example, an AI could represent the how full a tank is. A voltage from 0 to 10 VDC could represent the percentage of liquid in a tank, where:

- 0 vdc = 0% full or empty
- 5 vdc = 50% full
- 10 vdc = 100% full or completely full

An AI can represent anything such as temperature, pressure, humidity, percentage, etc.

There AI can either be represented by a voltage or an amperage.

For the Bascontrol22, there are Universal Inputs (UI) that can be configured to be AI or BI

## Part 7: Universal Inputs (UI)

For the BAScontrol22, Universal Inputs are a general input that can be configured to the following inputs:

- Analog – V or mA
- Temperature
- Binary
- Pulse
- Resistance

The Channel Type must be selected to determine how the Universal Input (UI) will behave. To configure the channel type for a UI, click on the title link above the textbox. The Channel Type default defaults to AI unless it is changed

7.1 - Specification

Open the User Manual and find section 2.1: Universal Inputs

For an analog input, what is the voltage range?_____

For an analog input, what is the amperage range?_____

For temperature input, what type of thermistors are allowed?_____

7.2 - Universal Input using Resistance

We are going to use UI1 to read a resistor.

Do not add the resistor to the controller until directed to do so in the next step.

### *UI Channel Type configuration for Resistance*

On the webpage, click "Universal Input 1" to open UI1's configuration.

Make the following changes:

- Channel Type: Resistance
- Object Name: Resistor

Click Submit button and then click Close button.

### *UI without a resistor*

For UI1, what does the title link say?_____

For UI1, what is the value?_____

You should see a value of "-NAN", because there is no resistance there as UI1 is open without the thermistor being in place.

### *UI with a resistor*

What are the colors of the bands on the resistor?_____

Using the color bands, what is the resistor's resistance?_____

Using your multimeter, what is the resistor's resistance?_____

Add the resistor between A and C for UI1.

According to the web page, what is the resistor's resistance?_____

7.3 - Universal Input using Thermistor

We are going to use UI2 to read a thermistor.

Do not add the thermistor to the controller until directed to do so in the next step.

### *UI Channel Type configuration for Thermistor*

For UI2, make the following changes:

- Channel Type: <choose the appropriate thermistor type>
- Object Name: Thermistor

### *UI without a thermistor*

For UI2, what does the title link say?_____

For UI2, what is the value?_____

You should see a value of "-NAN", because there is no resistance there as UI2 is open without the thermistor being in place.

### *UI with a thermistor*

Add the thermistor between A and C for UI2.

For UI2, what is the temperature?_____

For UI2, is this the approximate air temperature?_____

### *UI with a thermistor configured incorrectly*

We are now going to set the wrong thermistor type in the Channel Type, to see how this changes the value.

For UI2, what is the value when the Channel Type is "Therm 10KT2"?_____

For UI2, what is the value when the Channel Type is "Therm 10KT3"?_____

For UI2, what is the value when the Channel Type is "Therm 20K"?_____

For UI2, what is the value when the Channel Type is "Therm 100K"?_____

Changing the thermistor type, should significantly change some of the values. It is important to correctly set the correct thermistor type in the Channel Type.

Set UI2 Channel Type to the correct thermistor type.

## 7.4 - Universal Input as Binary Input

We are going to use UI3 as a Binary Input (BI).

### *Channel Type configuration for Binary Input*

For UI3, make the following changes:

- Channel Type: Binary Input
- Object Name: Binary Input

The test for this is exactly the same as we did for the other Binary Inputs previously.

### *UI is open*

Looking at the webpage find UI3. If UI3is checked, uncheck the override

Is the LED light illuminated for UI3?_____

**Do NOT use the continuity checker function of the multimeter.**

Using your meter, what is the **voltage** of UI3?_____

Is UI3, open or closed?_____

### *UI is closed*

We are now going to change UI3 to be closed by placing a wire between A and C on UI3.

Is the LED light illuminated for UI3?_____

**Do NOT use the continuity checker function of the multimeter.**

Using your meter, what is the **voltage** of UI3?_____

Is UI3, open or closed?_____

Did UI3 behave correctly and if not, what was wrong?_____

_____

Why would configure a Universal Input to be a Binary Input when you already have four Bis on this controller?_____

_____

## 7.5 - Universal Input as Analog Input

We are going to use UI4 as an Analog Input (AI).

### *UI Channel Type configuration for Analog Input*

The UI Channel Type defaults to Analog Input, so there are no changes required for the Channel Type.

For UI4, make the following changes:

- Object Name: Analog Input

### *UI with 0 volts*

Looking at the webpage find UI4. If UI4 is checked, uncheck the override.

The value represents the voltage at this input. You should see a voltage which is close to 0 volts dc.

Check the voltage of UI4 by placing one probe on A and the other probe on C.

Using your meter, what is the voltage for UI4?_____

I would expect your meter to read close to 0 mV.

I would expect some minor differences in voltage within 100 mV with your meter. A large difference could mean an issue with the controller or the meter. Check with a second meter if the voltage difference is large

### *UI with 7.62 volts*

We are now going to supply a voltage to our input by using one of our Analog Outputs. Choose an AO that was functioning properly.

Power down your controller, wire a connection between your functioning AO-A terminal and UI5-A. You do not need to connect a wire between AO-C and UI4-C as they are already connected on the board.

Power your controller back up. Refresh the webpage by pressing CTRL-F5.

Looking at the webpage find the AO you decided to use. If AO has been checked, uncheck the override.

Using your meter, what is the voltage for that AO?_____

Using your meter, what is the voltage for UI4?_____

Is the voltage similar between you AO and U45?_____

Override AO voltage by checking the override checkmark and setting a value of 7.62 volts.

Using your meter, what is the voltage for that AO?_____

Using your meter, what is the voltage for UI4?_____

Is the voltage similar between you AO and UI4?_____

Change the voltage for your AO to another value, does UI4 show the expected voltage?_____

7.6 - Check the remaining Universal Inputs

Check the remaining Universal Inputs using either a resistor, thermistor or as a binary or analog input.

How did you test UI5 and did it behave correctly and if not, what was wrong?_____

_____

How did you test UI6 and did it behave correctly and if not, what was wrong?_____

_____

How did you test UI7 and did it behave correctly and if not, what was wrong?_____

_____

How did you test UI8 and did it behave correctly and if not, what was wrong?_____

_____