WAKE TECH
Building, Engineering, & Skilled Technologies

# Controller IO- Analog Lab

BAT-111: Building Automation Systems

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# Controller IO- Analog Lab

BAT-111: Building Automation Systems

## SYNOPSIS

In a previous lab, we started exploring the BAScontrol22 controller and looking at binary IO. We will now look at the analog IO of our controller.

## OBJECTIVES

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

- Understand input and outputs for a device.
- Understand the various inputs the BASControl22 can read.
- Wire a voltage source, thermistor, switch, and resistor as an input to our controller.

## PARTS AND EQUIPMENT

- Contemporary Controls BAScontrol22 or BAScontrol22S [https://www.ccontrols.com/basautomation/bascontrol.htm]
- Johnson Controls M9108-GGA-2 [https://cgproducts.johnsoncontrols.com/MET_PDF/1201429.pdf] (or similar actuator that utilizes a voltage loop & has feedback)
- Ethernet cable
- Windows Laptop
- Wiring of assorted colors
- 2 SPST switches
- Resister (510Ω or similar)
- Thermistor

## REFERENCES

- Contemporary Controls BAScontrol22 User Manual [https://www.ccontrols.com/pdf/um/UM-BASC2200.pdf]
- Johnson Controls M9108, M9116, M9124, and M9132 Series Electric Non-Spring Return Actuators Install Manual [https://cgproducts.johnsoncontrols.com/met_pdf/34636399.pdf]

# MANUALS

- Contemporary Controls BAScontrol22 User Manual
  [https://www.ccontrols.com/pdf/um/UM-BASC22V4.pdf]

# BACKGROUND

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## 1.1 - Inputs vs Outputs

An input or output is considered from the reference of the device being discussed.

### *Input*

An input is information coming into the device from another device. A good example of a controller 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 a controller 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.

## 1.2 - 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.

# PROCEDURES

## Part 1: Lab setup

1.1 - Controller

Wire the controller using 24 *VAC*.

Note: Previously we used 24 VDC to power our controller.

Stop! Before proceeding to the next step, have your instructor inspect your wiring.

Is our controller being powered by 24 VAC or VDC?_____

1.2 - Laptop

Set your ethernet adaptor to the following configuration:

- IP address: 192.168.92.30
- Subnet mask: 255.255.255.0
- Default gateway: 192.168.92.1

Verify the IP address was successfully changed by viewing the output from the dos command ipconfig.

1.3 - Peer-to-Peer lab

Set up the peer-to-peer network and verify you can see the controller's webpage.

Open the controller's webpage to verify that the peer-to-peer network is set up successfully.

What is your laptop's IP address?_____

What is your controller's IP address?_____

➢ The IP addresses should not be the same.

1.4 - Controller Lab configuration

Restore the lab configuration for this lab to the controller using BASbackup.

Refer to the previous lab if you need help running BASbackup.

1.5 - Verify lab configuration

Looking at the webpage, what is the label for UI1?_____

➢ If the label for UI1 is not "Actuator Feedback", then you have not properly RESTORED the configuration file. RESTORE the correct configuration file before continuing.

Looking at the webpage, what is the label for BI1?_____

- If the label for BI1 is not "Switch", then you have not properly RESTORED the configuration file. RESTORE the correct configuration file before continuing.

Looking at the webpage, what is the label for AO2?_____

- If the label for AO2 is not "Actuator Control", then you have not properly RESTORED the configuration file. RESTORE the correct configuration file before continuing.

## Part 2: Analog IO

2.1 - Analog Outputs (AO)

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

AOs represent a range of values with a voltage range.

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.

2.2 - Analog Inputs (AI)

Analog Inputs (AI) are used to produce a range of values. Analog Inputs represent data that is not just binary.

AIs represent a range of values with a voltage range.

For example, an AI can be used for feedback from a damper or valve to explain the percentage open.
AI could also represent 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

We are going to use an actuator to demonstrate AO (analog output) and AI (analog input).

## Part 3: Switch

Remove power from the controller.

We are going to use an actuator to demonstrate AO and AI. During out lab, the actuator will be moving based upon this lab's initial configuration that you installed on the controller.

We want the ability to stop the actuator moving during parts of the lab. We will use a switch that programmatically is required to be closed for the actuator to move.

Wire the SPST switch to BI1.

## Part 4: Actuator – power wiring

The actuator needs power to be able to actuate and it also needs control wiring so the controller can tell the actuator how much to open or close.

4.1 - Actuator set-up

The actuator uses jumpers to set its configuration. Jumpers are used to connect two pins from the circuit boards.

Set up actuator for the following conditions by changing the jumpers:

- DA (Direct Action)
- Input control loop: VDC
- Input: 0-10 VDC

What pins should jumper 1 connect?_____

What pins should jumper 2 connect?_____

What pins should jumper 3 connect?_____

4.2 - Power wiring

Some of the actuators can be powered using DC but all the actuators can be powered using AC. We are going to wire the actuators using AC.

We are going to install our actuator using 24 VAC and connect the wiring from the VAC terminal blocks to the actuator.

Looking at the actuator, which terminal number (numbered left to-right) is for +24?_____

Looking at the actuator, which terminal number (numbered left to-right) is for COM?_____

1. Connect 24 VAC to the proper connector on the actuator.
2. Connect Common to the proper connector on the actuator.

Is our controller being powered by 24 VAC or 24 VDC?_____

Is our actuator being powered by 24 VAC or 24 VDC?_____

➢ Both our controller and our actuator are being powered by 24 VAC.

## Part 5: Actuator control wiring – AO

While we have wired power to the actuator so it can actuate, we need to be able to tell the actuator how much to open or close.

## 5.1 - Analog Output (AO)

### *Controller POV (point of view)*

The controller is going to tell the actuator to change position. From the position of the controller, this is an Output. The controller is also telling the actuator to open a certain percentage, so this is an Analog Output (AO).

We have configured our actuator to use 0-10 VDC signal to tell the actuator how much to open.

Is the control signal using 24 VAC, 24 VDC, 10 VAC, or 10 VDC?_____

- We are using is 0 -10 VDC for the control signal for the actuator.

### *Actuator POV*

Most documentation is written from the point of view of the device that is being documented.

It is an AO for the controller when it is giving control signals to the actuator; however, from the actuators point of view this is an input because it is being told to do something. In the actuator documentation, the control wiring is referred to as Input. If there are multiple inputs, make sure you utilize the one that uses voltage as we are wiring a voltage loop.

## 5.2 - Wire AO

We have powered the controller and the actuator utilizing AC; however, the Input control signal is DC. The controller takes care of suppling the DC signal regardless of the power wiring of the controller and actuator.

At this point in the lab, we should *not* have wired anything directly to the DC terminal blocks.

Looking at the actuator, which terminal number (numbered left to-right) is for VDC input?_____

Connect one wire from AO2-A to the Actuator VDC input.

We are *not* going to connect a conductor from the AO2-C terminal as we have a shared common. Using the continuity function of your multi-meter, verify continuity between the controllers AO-C terminal and the controllers Power Com terminal. The controllers Power Com terminal is connected to the AC Common wiring block which is also wired to the actuators Common terminal so we should have continuity between the AO-C terminal and the actuator Common terminal. Since there is continuity between the AO-C terminal and the actuators Com terminal, we do not need to place a wire here.

If the actuator was powered by a separate power supply, we would have to connect the AO-C terminal as we need the same reference.

We now can control the actuator from our controller.

Is our controller being powered by 24 VAC or 24 VDC?_____

Is our actuator being powered by 24 VAC or 24 VDC?_____

- The controller and actuator are being powered by 24 VAC.

Is the control signal using 24 VAC, 24 VDC, 10 VAC, or 10 VDC?_____

- While we are powering our controller and actuator using 24 VAC, our control signal is 10 VDC.

## Part 6: Actuator Feedback - AI

We would like feedback so we can verify the current position of the actuator. This is important because we need to make sure our actuator is responding like it should.

Feedback is information coming into our controller, so it is an Input and since we are getting a range of values this is an Analog Input. The actuator feedback is 0-10 VDC.

6.1 - Wire AI

Looking at the actuator, which terminal number (numbered left to-right) is for Feedback (FB)?_____

_____

Connect one wire from UI1-A to the actuator Feedback (FB).

We are *not* going to connect a conductor from the AI-C terminal as we have a shared common. Using the continuity function of your multi-meter, verify continuity between the controllers AI-C terminal and the controllers Power Com terminal. The controllers Power Com terminal is connected to the AC Common wiring block which is also wired to the actuators Common terminal so we should have continuity between the AI-C terminal and the actuator Common terminal. Since there is continuity between the AI-C terminal and the actuators Com terminal, we do not need to place a wire here.

If the actuator was powered by a separate power supply, we would have to connect the AI-C terminal as we need the same reference.

Is our controller being powered by 24 VAC or 24 VDC?_____

Is our actuator being powered by 24 VAC or 24 VDC?_____

- The controller and actuator are being powered by 24 VAC.

Is the control signal using 24 VAC, 24 VDC, 10 VAC, or 10 VDC?_____

Is the feedback signal using 24 VAC, 24 VDC, 10 VAC, or 10 VDC?_____

- While we are powering our controller and actuator using 24 VAC, our control and feedback signal is 10 VDC.

Stop! Before proceeding to the next step, have your instructor inspect your wiring.

## Part 7: Actuator

After your instructor has verified your wiring, power on your controller and actuator.

The lab's configuration file that you restored at the beginning of the lab is programmed to open the actuator 20% every 15 seconds and then once it is fully open close 20% every 15 seconds and repeat the cycle.

The percentage the actuator is open is communicated by 0-10 VDC signal, with 0 VDC being fully closed and 10 VDC being fully opened.

- 0% open = 0 VDC
- 20% open = 2 VDC
- 40% open = 4 VDC
- 60% open = 6 VDC
- 80% open = 8 VDC
- 100% open = 10 VDC

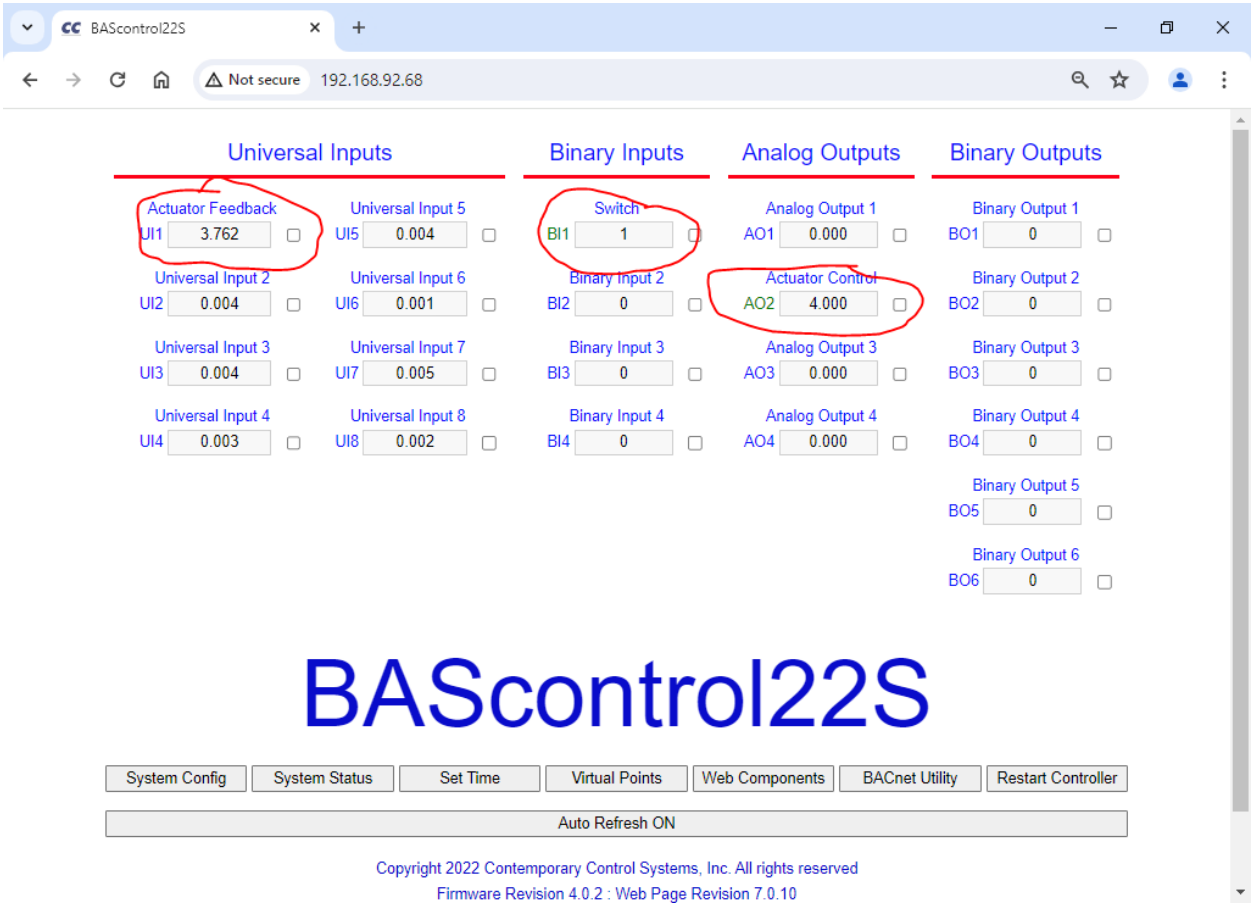
What percentage open would a voltage of 7.5 VDC represent?_____

What voltage would represent opening the damper 35%?_____

The actuator will only be given a signal when the physical switch is closed.

7.1 - Controller webpage

Open up the controller webpage and make sure you turn Auto Refresh ON.




7.2 - Switch

Close the switch.

Does the actuator move every fifteen seconds?_____

- If not, ask your instructor for assistance.

Is the switch a BO, BI, AO, or AI?_____

Which channel is the switch connect to the controller?_____

With the switch closed, is the controller LED for the channel illuminated?_____

With the switch closed, what is the value of BI1 on the webpage?_____

7.3 - Actuator – AO

AO2 is giving the actuator a 0 – 10 VDC control signal.

*Webpage*

Looking at the webpage, watch the values of A02 change for a few minutes.

Looking at the webpage, what is the smallest value of AO2?_____

- If AO2 does not change value and the actuator is moving, verify that you have Auto Refresh turned ON for the webpage.

Looking at the webpage, what is the largest value of AO2?_____

According to the webpage, what is the range of AO2?_____

Looking at the webpage, what increments does AO2 change by?_____

### *Controller*

Does the AO terminals on the controller have an LED?_____

### *Multi-meter*

Using your multimeter, read the voltage of AO2. At the same time, you are reading the multimeter, take notice of the value of AO2 on the webpage.

Using your multimeter, what is the voltage of A02?_____

On the webpage, what is the value of A02?_____

Are they similar?_____

- If they are not similar, verify that you have Auto Refresh turned ON for the webpage.

## 7.4 - Actuator – AI

The actuator feedback tells us the actual position of the damper. While we are dictating to the actuator what position we want to move the damper to, it does take some time for the actuator to move to that position.

### *Webpage*

Looking at the webpage, when AO2 changes does UI1 change immediately?_____

Why does UI1 not change immediately?_____

_____

_____

_____

### *Multi-meter*

Using your multimeter, read the voltage of UI1. At the same time, you are reading the multimeter, take notice of the value of UI1 on the webpage.

Using your multimeter, what is the voltage of UI1?_____

On the webpage, what is the value of UI1?_____

Are they similar?_____

## Part 8: Points List

Fill out the Points List for every input and output connected to the controller. For Universal Inputs include the Channel Type. Sum the columns to give the number of Points used per Point Type.

The point for UI1 is already include in the Points List.

| | Point Type | | | | | | |
|---|---|---|---|---|---|---|---|
| | Universal Input | | | | | Virtual | |
| Point Description | Analog Input | Channel | Binary Input | Analog Output | Binary Output | Analog | Binary |
| Actuator Feedback | UI1 | Voltage | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| Point Totals: | | | | | | | |

- If you do not have 1 UI, 1 BI, 1 AO, and 0 BO, go back and fix the Points List.

## Part 9: Instructor Verification

Have the instructor sign your lab demonstrating that you have completed the lab.

Instructor Signature?_____

## Part 10: Tear-down

10.1 - Controller Factory Reset

Factory reset the controller using BASbackup.

After the controller restarts, show your instructor the controller's webpage.

Instructor Signature?_____

10.2 - Laptop IP address

Set the ethernet adaptor to receive its IP address dynamically from DHCP.

*Instructor Signature*

Show your instructor that you have successfully changed the IP address to use DHCP.

Instructor Signature:_____

## 10.3 - Controller Tear-down

When disassembling your work, make sure there is no power to the controller or any other device.

When removing conductors from the terminal blocks, unscrew them enough so you can gently remove the wires. Do not forcefully yank the wires out as this will damage the terminals.

After removing a conductor, please make sure the screw is seated in the threads by tightening the screw two turns.