STATE UNIVERSITY OF NEW YORK
COLLEGE OF TECHNOLOGY
CANTON, NEW YORK

MASTER SYLLABUS

COURSE NUMBER – COURSE NAME
ACHP 201 –Building Controls

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Updated by:

Canino School of Engineering Technology

Department: Mechanical & Energy Systems

Semester/Year: Spring 2023

A. **TITLE**: **Building Controls**

B. **COURSE NUMBER:** ACHP 201

C. **CREDIT HOURS: (Hours of Lecture, Laboratory, Recitation, Tutorial, Activity)**

 # Credit Hours: 3
 # Lecture Hours: 2 **per week**
 # Lab Hours: (1) two-hour labs **per week**
Other: per week

Course Length: 15 **Weeks**

D. **WRITING INTENSIVE COURSE**: Yes ☐ No ☒

E. **GER CATEGORY: None:** ☒ **Yes:** GER
***If course satisfies more than one*:** GER

F. **SEMESTER(S) OFFERED: Fall Spring X☐ Fall & Spring ☐**

G. **COURSE DESCRIPTION:**

Introduces students to building automation systems and building controls, with an emphasis on HVAC. It covers wiring sensors and actuators to controllers and programming the controllers.

H. **PRE-REQUISITES: None** ☒ **Yes** ☐ **If yes, list below:**

CO-REQUISITES: None ☒ **Yes** ☐ **If yes, list below:**

I. STUDENT LEARNING OUTCOMES: (*see key below*)

By the end of this course, the student will be able to:

Course Student Learning Outcome [SLO]	***Program Student Learning Outcome [PSLO]***	***GER*** *[If Applicable]*	***ISLO & SUBSETS***	
Demonstrate the proper technique for stripping wire, crimping connectors, and terminating wires.	ABET SO # 1		3-Found Skills ISLO5 ISLO	Subsets Subsets Subsets Subsets
Identify HVAC Sensors, Actuators, and Controllers and their functions, and be able to find and interpret datasheets for them.	ABET SO# 1 & # 2		3-Found Skills ISLO3 ISLO5	Subsets Subsets Subsets Subsets
Demonstrate the ability to program simple control functions in the Sedona control language.	ABET SO# 1 & #4		3-Found Skills ISLO2 ISLO5	Subsets Subsets Subsets Subsets
Read and create basic wiring diagrams	ABET SO# 1 & #3		ISLO2 ISLO3 ISLO5	Subsets Subsets Subsets Subsets
Read and interpret sequences of operation	ABET SO# 1 & #3		ISLO2 ISLO3 ISLO5	Subsets Subsets Subsets Subsets
Demonstrate the ability to safely check and start up a newly wired control system	ABET SO# 1		ISLO2 ISLO3 ISLO5	Subsets Subsets Subsets Subsets

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KEY	**Institutional Student Learning Outcomes [ISLO 1 – 5]**
ISLO #	**ISLO & Subsets**
1	**Communication Skills** Oral [O], Written [W]
2	**Critical Thinking** *Critical Analysis [CA] , Inquiry & Analysis [IA] , Problem Solving [PS]*
3	**Foundational Skills** *Information Management [IM], Quantitative Lit,/Reasoning [QTR]*
4	**Social Responsibility** *Ethical Reasoning [ER], Global Learning [GL], Intercultural Knowledge [IK], Teamwork [T]*
5	**Industry, Professional, Discipline Specific Knowledge and Skills**

*Include program objectives if applicable. Please consult with Program Coordinator

J. **APPLIED LEARNING COMPONENT:** Yes ☒ No ☐

If YES, select one or more of the following categories:

☒ Classroom/Lab
☐ Internship
☐ Clinical Placement
☐ Practicum
☐ Service Learning
☐ Community Service

☐ Civic Engagement
☐ Creative Works/Senior Project
☐ Research
☐ Entrepreneurship
(program, class, project)

K. TEXTS:

BASE Labs teaching modules (provided)

L. REFERENCES:

M. EQUIPMENT: None ☐ Needed: Basic toolkit

N. GRADING METHOD: A-F

O. SUGGESTED MEASUREMENT CRITERIA/METHODS:

Lab reports, projects & participation

P. DETAILED COURSE OUTLINE (Tentative):

1. Basics of Wire Termination
    a. Learning objectives
        i. Describe the importance of wire terminating to the BAS industry
        ii. Strip wires to the appropriate length without damaging conductors
        iii. Secure 10 wires to a terminal block to an appropriate standard
        iv. Crimp a fork connector and butt splice to a stranded 18-gauge wire
        v. Secure 10 wires with a fork connector and butt splice to a terminal block
    b. Importance of Exercise
        i. Repeatable, reliable terminations are critical to the BAS industry
        ii. Inputs, outputs, power, communications
        iii. Most common cause of service calls, bar none
        iv. This supposedly simple skill is oftentimes undervalued in technical training programs
    c. Exercises
        i. Strip 10 wires, one end for terminal block, and one end for a crimped wye connector
        ii. Attach the wires with one end to a terminal block and the wye attached to a terminal block designed for wye connectors
        iii. Continue practicing wire termination throughout the class
2. BAS ICT Devices 10 minutes with a inventory document
    a. Learning Objectives
        i. Identify the devices in the ICT trainer
        ii. Explain the function and purpose of the devices in the ICT trainer
        iii. Describe the how the devices in the ICT trainer would be utilized in the field
        iv. Interpret commonly encountered BAS device data sheets.
    b. Importance
        i. BAS technicians regularly deal with various product devices, and should be able to identify classes of products and their function
        ii. BAS technicians commonly have need to download engineering / data sheets on device products and should be able to interpret them
    c. Exercise
        i. Identify each device in the ICT
            1. Find the datasheet
            2. Identify the function

3. Identify the inputs and outputs of the device
4. Give examples of where the device would be used in HVAC

3. Wiring a Belimo Modulating Actuator w/Feedback & Signal Generator
    a. Learning Objectives
        i. Wire a Belimo modulating actuator properly
        ii. Explain how the AC and DC power are referenced together in the circuit
        iii. Demonstrate the use of the voltage and ramp functions of a CVC digital signal generator
        iv. Explain the concept of the direct and reverse acting switch on an actuator
        v. Monitor the feedback indication on a Belimo actuator in various positions
    b. Importance
        i. BAS technicians regularly encounter modulating actuators in the field and must be able to wire them properly, troubleshoot them, and commission them as part of a system
        ii. Signal generators are an important troubleshooting and commissioning tool for BAS technicians to utilize
    c. Exercise: Wire up Belimo actuator and use the signal generator to control while monitoring it with the DVM
        i. Wire the power on the Belimo to 24 VAC
        ii. Use the signal generator to provide a signal to the Belimo actuator
        iii. Ramp the signal to observe the actuator change position
        iv. Monitor the feedback signal with a multimeter
        v. Demonstrate the ability to turn on and off the ramp time function on the signal generator
4. Introduce Sedona and use the pushbutton to control a panel light
    a. Learning Objectives
        i. Demonstrate the capabilities of the FS-20
        ii. Demonstrate the capabilities of Sedona
    b. Exercise
        i. Introduction to Sedona
            1. Setup the hardwire ethernet instance on the computer
            2. Connect the computer to the FS-20
            3. Load CPT
            4. Connect to the FS-20
            5. Familiarize yourself with the various kits and kit libraries
        ii. Connections
            1. Wire the PB to a UI
            2. Wire a PL to a UO
        iii. Controls
            1. Program the PL to come on when the button is pushed and off when the button is released
            2. Program the PL to come on when the button is pushed and stay on when it's released and to go off when it's pushed again
            3. Add a minimum time that the light will stay on before pushing the button will turn it off
            4. Add a minimum time the light will stay off before pushing the button will turn it on
5. Use Sedona to control the Belimo
    a. Learning Objectives
        i. Wire a Belimo modulating actuator properly to the FS-20
        ii. Demonstrate how to use the ramp function in Sedona
        iii. Demonstrate how to connect the ramp kit to the UO connected to the Belimo
        iv. Demonstrate how to monitor the position of the Belimo in Sedona
    b. Importance

i. BAS technicians regularly encounter modulating actuators in the field and must be able to wire them properly, troubleshoot them, and commission them as part of a system
ii. Programming controllers in the field is something BAS technicians need to do on a regular basis

c. Exercise: Wire up Belimo actuator to power and the FS-20
i. Connections
1. Wire the power on the Belimo to 24 VAC
2. Wire the signal of the Belimo to a UO on the FS-20
3. Wire the feedback signal from the Belimo to a UI on the FS-20
4. Connect the ramp to the UO
ii. Ramps, etc.
1. Open a ramp and change the parameters on it until you understand what it does
2. Open the UI from the Belimo feedback
3. Open the UO to the Belimo
4. With the ramp set between 2 and 10, connect the output to the UO
iii. Test and Inquire
1. Watch the Belimo and see what it does
2. Monitor the feedback signal on the UI
3. Demonstrate the ability to control the ramp time function on the FS-20

6. Timer and 3-wire control
a. Learning Objectives
i. Create a 3-wire control circuit
ii. Describe a 3-wire control circuit's function
iii. Describe the operation of a Peltec 102 timer
iv. Commission circuit parameters to a specific sequence of operation
v. Demonstrate proper wire management techniques (color codes, terminal utilization, secure wires) Get wire number tape
b. Importance
i. BAS technicians encounter timing devices in various applications and should be familiar with them
ii. BAS technicians need to understand the wiring of 3 wire control circuits
iii. BAS technicians should always utilize effective wire management techniques
iv. BAS technicians regularly set up controls and circuits to meet sequences of operation
c. Exercise
i. Study Sequence of Operations
ii. Study the schematic
iii. Make sure you understand what is happening in the SoO and the schematic
iv. Continuity check
v. Wire up the circuit
vi. Run the circuit

7. Timer and 3-wire control in Sedona
a. Learning objectives
i. Demonstrate how to emulate a Peltor 102 timer in Sedona
b. Exercise
i. Connect 2 panel lights to the FS-20
ii. Connect the pushbutton to the FS-20
iii. Use Sedona to create the Sequence of Operations from the Peltor exercise
iv. Reprogram it so that pushing the button a second time stops the sequence

8. UMX 4 Multiplexor as a Sequencing Device
a. Learning Objectives
i. Explain the purpose and function of a sequencing device
ii. Wire a UMX 4 multiplexor device as a 4-stage sequencer

iii. Interpret a data sheet to appropriately set the DIP switches on a control device
iv. Demonstrate good wiring management techniques

b. Importance
i. BAS technicians encounter various types of staging equipment and should understand the principles of sequencing devices, trigger points, and the concept of differential
ii. BAS technicians should be able to interpret a technical data sheet and use it to properly set up a device to established parameters

c. Exercise
i. The UMX-4 multiplexor unit will be set up to function as a 4-stage sequencer to simulate control of a 4-stage boiler.
ii. Use a 1 – 10 VDC power supply to provide a signal.
iii. The first stage will trigger at 4.5V, 6.0V, 7.5V, and 9.0V.
iv. Interpretation of a data sheet will be required for proper DIP switch settings and initialization.
v. Trigger voltages for each stage should be recorded, as well as drop out voltages for each stage.
vi. The voltage signal to the UMX-4 unit shall be supplied by the signal generator.
vii. Note the voltage where each stage triggers. Does it correspond to the datasheet?
viii. Wire the UMX-4 input to the FS-20
ix. Program the FS-20 ramp function to provide the signal

9. Emulate the UMX-4 in Sedona
a. Learning Objectives
i. Emulate a sequencer in the FS-20
ii. Understand why one would use the UMX-4 instead of the FS-20

b. Importance
i. BAS technicians will find different ways of implementing the same results in the field

c. Exercise
i. The FS-20 controller will be set up to function as a 4-stage sequencer to simulate control of a 4-stage boiler.
ii. Connect the panel lights to UO1 – UO4.
iii. Program the FS-20 to turn on each panel light at 4.5V, 6.0V, 7.5V, and 9.0V.
iv. Program the FS-20 ramp function to emulate a voltage input between 1 and 10 VDC
v. Connect a 1 – 10 VDC signal generator to UI1.
vi. Replace the ramp function with the input from the signal generator.
vii. Test the functioning of the panel lights with the signal generator

10. RES 1E Resistance Transducer Device
a. Learning Objectives
i. Explain the function of a resistance transducer
ii. Wire a signal to a resistance transducer and create a table of feedback resistance
iii. Explain the purpose of resistive feedback

b. Exercise
i. For this exercise, you'll run power to the RES-1E transducer, and use the signal generator to send the device a voltage signal.
ii. Starting at 0VDC, increase the voltage to the RES-1E,
iii. Recording resistant outputs
1. between the B R terminals on (Res Output), and
2. between the R W terminals on (Res Output)
3. Record at each voltage level.
iv. What happens to resistance based on input voltage?
v. Which one is direct acting, and which one is reverse acting?

11. LPI 1C Display Calibration
a. Learning Objectives

i. Describe the importance of properly calibrating a device
ii. Calibrate an LPI-1C 4-20ma panel indicator
iii. Use the 4-20ma signal generator to calibrate a device

b. Importance
i. BAS technicians regularly have need to calibrate devices based upon manufacturer's guidelines
ii. BAS technicians must be able to interpret technical data sheets

c. Exercise
i. The LPI-1Cs were ordered with a calibration of 0 100% corresponding to a 0 10VDC input signal.
ii. The display digits should be set for XXX.X, with one digit beyond the decimal point.
iii. Move the jumper to J6, observe and record the effect, and then move it back to J7
iv. Connect the signal generator and use the mA source output port.
v. Follow the cut sheet calibration specs to calibrate the display to read 0 at 4mA, and 140.0 at 20.0mA

12. Input / Output Device Wiring
a. Learning Objectives
i. Cite the most commonly encountered inputs and outputs used in the commercial controls industry
ii. Wire the common inputs and outputs of the controls industry to a controller
iii. Design a simple wiring plan from a simple listing of points

b. Importance
i. BAS technicians must be able to wire all the standard inputs and outputs they will encounter in the controls industry
ii. BAS technicians should be able to create a wiring plan for standard control devices
iii. BAS technicians should be able to demonstrate good cable management techniques

c. Exercise
i. Wire all the components in the box according to the schematic provided

13. Start Up of a Control Panel
a. Learning Objectives
i. State a procedure for checking out and starting up a control panel
ii. Identify potential shorts using a multimeter
iii. Perform a visual safety inspection

b. Importance
i. BAS technicians regularly start up control devices, and should have a standard procedure they follow to minimize damage of controls, electrical, and mechanical equipment

c. Exercise: Safe Start Up Procedure
i. With the power off, remove all the terminals from the controller
ii. With the power off, use your multimeter to test for any potential shorts between 24V Hot and 24V common, and similarly check for shorts between 24V DC+ and 24V DC-
iii. Turn all loads with manual switches to off position
iv. Visually identify any stray, frayed, or loose wires
v. Check AC voltage (120V) with your multimeter prior to applying power to the kit
vi. Apply power to the kit, and check 24V AC power, as well as 24V DC power if wired up
vii. With one lead attached to 24V common, test all input and output wires for 24V hot potential
viii. Once all the following checks have been performed, turn the power to the kit off, and plug all the terminal connectors back into the controller
ix. Power up the kit, and observe the controller – you should see the STS light begin to blink approximately once per second. If the ERR or SVC light come on, turn off power immediately

14. Calibrating the TU91 XR

a. Learning objective
    i. Demonstrate ability to calibrate a transmitter device
b. Exercise
    i. The Model T91U-XR is a fully rangeable transmitter device which is field adjustable.
    ii. You will be using one of the potentiometers to set the minimum reference ohms, and
    iii. then the maximum reference ohms as per the instructions in the cut sheet.
    iv. 0.0F will correspond to 930.0 ohms, and 100.0F will correspond to 1150.0 ohms.
    v. Prior to calibrating the T91U-XR, we will be calibrating the LPI-1C to 0.0 F (4mA) – 100.0 F (20mA).
    vi. Once completed, the LPI-1C will function as the VOM in the calibration diagram on the T91U-XR cut sheet.

15. Wiring an RS-485 Subnetwork
    a. Learning Objectives
        i. Describe the BACnet MS/TP 485 subnetwork
        ii. Compare and contrast the physical characteristics of a BACnet MS/TP 485 network with a BACnet IP network
        iii. Terminate communication cabling for a BACnet MS/TP 485 network
    b. Importance
        i. Network communications is extremely important in BAS
        ii. Technicians must be capable of reliably establishing subnetwork communications
        iii. Poor network communications are often a result of poor network terminations
    c. Exercise
        i. Strip 2 ends of Shielded Twisted Pair cable
        ii. Fold the shield foil back and wrap it around the sheath of the cable out of the way
        iii. Connect the similar wires in of each cable to “D1+” and “D1-“ on the FS-20
        iv. Twist the bare wires together and connect them to the “S” terminal of the FS-20
        v. Trim the nylon string back to the edge of the sheathing
        vi. Use the cables to daisy chain FS-20s together
        vii. Put a 75 ohm resistor across the “D1+” and “D1-“ terminals of the controllers on both ends of the bus.

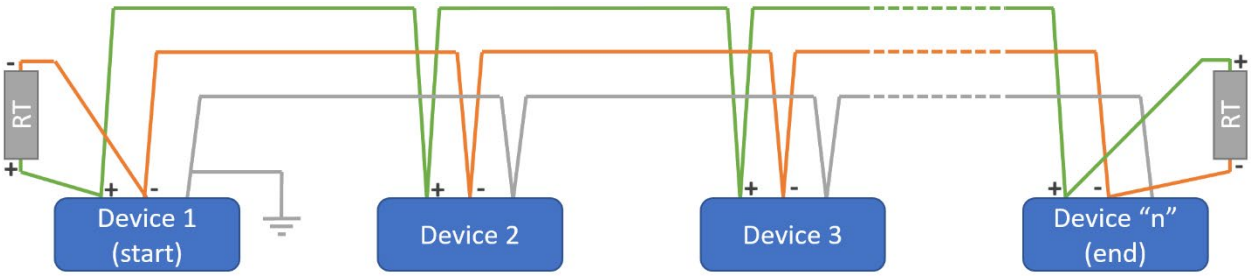

Figure 1 https://know.innon.com/bias-termination-rs485-network

Q. <u>LABORATORY OUTLINE</u>: None ☐ Yes ☒