BUAS 2030 COURSE

GEORGIA PIEDMONT TECHNICAL COLLEGE
INDUSTRIAL & TRANSPORTATION TECHNOLOGIES

Building Automation Systems Program

BUAS 2030 Building Automation Systems Design & Installation

National Science Foundation - National Center for Building Technician Education

GEORGIA PIEDMONT TECHNICAL COLLEGE

BEST
Building Efficiency for a Sustainable Tomorrow

NSF

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BUILDING AUTOMATION SYSTEMS FUNDAMENTALS

Course Documentation

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Table of Contents

Catalog description

Building Automation Systems (BAS) Design & Installation introduces the student to the fasteners, equipment, tools, and methods for installing building automation system components. The course also brings together the concepts and principles of previous courses and apply them to the design of and commissioning of automation systems.

Class hours

Lecture Hours: 24

Laboratory Hours: 75

Units

Semester Credit Hours: 3

Entry skills needed

- BUAS 2010 – Building Automation Systems HVAC & Controls Fundamentals
- Basic computer skills
- College-level reading and writing skills
- College-level math skills

Syllabus

See Appendix A for sample syllabus, course schedule, and policies. For lesson topics to include in course, see Exit Skills.

Student learning outcomes

The exit skills listed in the next section support these outcomes:

BAS Contracting

Understand the important aspects of contracting in building automation.

NEC Codes

Understand the most important codes which apply to electrical and mechanical systems and low voltage installations in buildings.

Installation Tools

Identify and discuss the types of tools commonly used in the installation of building automation systems.

Installation Devices & Methods

Identify and discuss the functions of various connectors and mounting devices as well as the proper methods utilized for installing them.

Control System Installation Techniques

Learn how to install control system components and conduit.

Control System Design Process

Describe the method for designing a building control system.

Control System Installation Process

Describe and execute a process for installing building automation systems.

Control System Commissioning

Describe the proper steps in commissioning a building automation system.

Control System Praxis – Design, Install and Commission a Control System

Design, install, program, and properly commission a building automation system as per provided drawings and specifications.

Exit skills

Course content to achieve outcomes listed above:

BAS Contracting

1. Describe the method of bid and spec contracting as it pertains to building automation contractors.

2. Describe the method of design / build contracting as it pertains to building automation contractors.

3. Describe how building automation system contracting firms execute projects from start to commissioning.

4. Explain the ways contracting law impacts building automation contractors.

National and Local Codes

1. Discuss how the national and local codes apply to low voltage contracting.

2. Select proper conductor size for conductor cabling for an application assigned by the instructor using the NEC codebook.

3. Calculate voltage drop based on parameters given by an instructor using the proper formula.

4. Tab the most recent version of the NEC codebook with sections appropriate to building automation contracting.

Installation Tools

1. Identify and discuss the purpose of the major tools used in low voltage contracting.

2. Use an electrical meter, power hammer drill, Phillips-head screwdriver, control screwdriver, wire strippers, fish-tape, electrical tape, and needle-nose pliers to mount a sensor, pull conductors to it, terminate to a controller, and check it for proper resistance and calibration.

Installation Devices & Methods

1. Identify installation devices and various conduit and pipe connectors.

2. Demonstrate the ability to use a ¾" conduit bender, conduit reamer, and hacksaw to make offset, kick-out, stud, and saddle bends to prescribed measurements and connect them appropriately to an electrical junction box.

Control System Installation Techniques

1. Explain what is meant by right of way on a project.

2. Discuss how the installation process should be times and coordinated with the general contractor

3. Demonstrate the ability to install various types of block wall anchors

4. Demonstrate the proper method for installing network cabling J-hooks and install an RS-485 network secured by J-hooks and cable ties.

5. Demonstrate the ability to mount, wire, power-up, and terminate a communications network to various zone-level application specific controllers.

Control System Design Process

1. Explain what section of bid and spec documents set the requirements for the controls systems on the project.
2. Explain the purpose of a submittal package and what it consists of.
3. Explain what shop drawings are and everything they should include.
4. Gain proficiency with Microsoft Visio.
5. Create a complete submittal package with MS Visio shop drawings based upon instructions given by the instructor.

Control System Commissioning

1. Illustrate how to properly develop a commissioning plan for a project.
2. Develop a plan to efficiently and accurately perform a wire-to-wire commissioning project.
3. Observe an instructor demonstrate the proper way to conduct a functional performance test.
4. Perform a wire-to-wire commissioning of a control system.

Control System Praxis – Design, Install & Commission a Control System

1. Collaborate with classmates to design, install, and commission an operable building automation system based on constraints and specs provided by an instructor.

Course materials

Principal text

Barnett, R. (2009). *Commercial and Industrial Wiring*. Homewood, IL: American Technical Publishers, Inc. ISBN #: 978-0826920751

Hart, G., & Hart, S. (2011). *Ugly's Electrical References*. Sudbury, MA: Jones and Bartlett Publishers. ISBN #: 978-0763790998

National Fire Protection Association. (2011). *National Electrical Code 2011 Handbook* (12th ed.). Boston, MA: Cengage Learning. ISBN #: 978-0877659167

National Fire Protection Association. (2010). *Ugly's Electric Motors and Controls*. Sudbury, MA: Jones and Bartlett Publishers. ISBN #: 978-0763772543

Stanfield, A. (2012). *Ugly's Conduit Bending*. Sudbury, MA: Jones and Bartlett Publishers. ISBN #: 978-0763783143

Stauffer, H.B. (2009). *Ugly's Electrical Safety and NFPA 70E*. Sudbury, MA: Jones and Bartlett Publishers. ISBN #: 978-0763768553

Lecture materials and handouts

This course is strictly an overview course and makes significant use of online resources

DDC Online (Intro. to digital control systems, Input/Output tutorials): www.ddc-online.org

Purdue Owl writing & style resources: https://owl.english.purdue.edu

Presentation tools by Prezi: www.prezi.com

Other reference materials

Kele website for submittal package development www.kele.com

Software needed

www.controlspecbuilder.com

Microsoft Visio

Lab setup and materials

- Workstations with electrical outlets
- DC power supply
- 120/24 volt, 40 VA transformer
- Enclosures – NEMA 1
- Block wall mounting fasteners
- Unistruct
- ½" and ¾" conduit
- Conduit bender
- Hacksaw or portable band saw
- Conduit reamer
- 12, 14, 16 gauge electrical conductors of various colors
- Fishtape
- Hammer drill

- Personal Protective Equipment (PPE)
- Conduit connectors and fittings of various sizes
- Various communication media
- Cable trays
- Wire ties
- Communication cabling mounting hooks
- Control enclosures with back plate perforated boards
- Set of project plans – particularly the electrical section
- Electrical symbols plastic tracing templates
- Fork terminals of various sizes
- Blue, orange, & yellow wire nuts
- Wire strippers
- Control screwdrivers
- Regular size screwdrivers
- Electrical tape
- Space sensors for mounting

Equipment & instruments required

- Multi-meter & clamp-on meter
- Voltage proximity sensor
- Scopemeter

Samples of weekly assignments

BUAS 2030 – BAS Design & Installation Assignment # 1

Location: C-building BAS / Refrigeration laboratory

Purpose: Demonstrate proficiency in four common conduit bends

Materials: ¾" EMT conduit, conduit reamer, conduit bender, hacksaw, conduit fittings

Description: Student will, to prescribed dimensions, demonstrate the following four conduit bends;

- Saddle bend
- Offset bend
- 90^0 stub-up bend

- Kick-out bend

Grading: Students will be graded by the closeness of their final conduit bends to the prescribed dimensions

BUAS 2030 – BAS Design & Installation Assignment # 2

Location: Anywhere

Purpose: Demonstrate proficiency with Microsoft Visio

Materials: Microsoft Visio

Description: Students will develop a library of stencils which represents each of the following control system devices;

- Space temperature sensor
- Duct temperature sensor
- Differential pressure sensor
- Static pressure sensor
- Current transformer
- Flow switch
- Indicator light
- 2-way control valve
- 3-way control valve
- Motor starter
- Application-specific controller
- Air-handling supply ductwork
- Air-handing return ductwork
- Air-handling unit fan
- Variable frequency drive
- DC power supply
- Terminal blocks

Grading: Grading will solely be based on the student completing all of the required stencils and organization into a library of stencils.

Project

BUAS 2030 – BAS Design & Installation Course Project Assignment –

Location: Anywhere

Purpose: Demonstrate knowledge of how to create a complete controls submittal package

Materials: Kele website, control spec builder, printer, paper, presentation binder

Description: Students will be provided with the specifications and control list from control spec builder for a specified system. Students will develop a controls submittal package utilizing an assigned DDC control manufacturer as the basis of their design, and select specific products which meet the specifications from the Kele website.

Students will develop control shop drawings utilizing the stencils created earlier in the course, and detailing all wired connections from the controller to the control devices selected from the Kele website.

Students will assemble the specifications sheets for the products selected, the control shop drawings, communications network diagram, and specific information as to how the sequences of operation will be met into a submittal package bound in a presentation binder.

Grading:

Grading will be by rubric according to the following elements;

- Title page
- Network communications drawing
- Control shop drawings with detailed wiring terminations
- Product selections and Kele specification sheets
- Use of Microsoft Visio stencils in the drawings
- Clear presentation of material
- Timeliness of submission

Assessment

Methods

- Discussion board participation (Each week in Angel learning management system)
- Homework – Pre-lab completion prior to class
- Classroom participation & attendance
- Quizzes (12) – Delivered through Angel learning management system & due by Sunday night of each respective week
- Course exams (2, mid-term & final exams) – Delivered through Angel learning management system & due by Sunday night of each respective week
- Student team presentations (1 at term end, using Prezi) – Presenting their project findings

- Course project (1 assigned at mid-term) – Turned in prior to student team presentations at the end of the term

Sample test questions

From final exam:

1. If a contractor wanted to know the minimum and maximum airflow of a PIU box on a project, where could he or she most easily find this information?

- ☐ The specifications
- ☐ The box schedule on the plans (correct answer)
- ☐ Directly from the designer

2. Please select the BAS conglomerate companies from the following list.

- ☐ 14
- ☐ 50 (correct answer)
- ☐ 42
- ☐ 16

3. In the CSI MasterFormat prior to 2004, under what major division of labor would controls specifications appear? (ANS: Division 15 – Mechanical)

4. If a section of EMT conduit needed to clear a pipe affixed to a wall, and continue in the same direction, what type of conduit bend would be most appropriate? (ANS: Saddle bend)

5. Where should one turn for the most accurate guidelines for the installation and proper application of conduit types? (ANS: NEC codebook)

6. Who approves control submittals? (ANS: The engineer)

7. Microsoft Visio software allows the user to develop their own thumbnail images for use in a library. What term does Microsoft Visio use for these thumbnails? (ANS: Stencils)

8. When can a controls contractor bill for a project's materials? (ANS: Once they arrive at the jobsite)

9. Functional performance tests are conducted on a control system during which phase of the project? (ANS: Commissioning)

10. Once a project is turned over to the owner, how long is the typical warranty phase? (ANS: 1 year)

11. What tool assists technicians in running cables through conduit? (ANS: Fishtape)

12. When installing RS485 or similar subnetwork communications cabling, what is the most common source of problems?

- ☐ Unreliable network terminations (correct answer)
- ☐ Cables which are run too long
- ☐ Use of the wrong cable type

13. What documents are left behind on a jobsite that detail everything about the controls project?

- ☐ Warranty documents
- ☐ Users manuals for the controls system
- ☐ Operation and maintenance manuals (correct answer)

14. A NEMA 1 enclosure provides protection against which of the following?

- ☐ Wind-blown dust
- ☐ Rain
- ☐ Contact with equipment (correct answer)
- ☐ Non-corrosive liquids

15. A NEMA 3 enclosure is intended primarily for

- ☐ Indoor use
- ☐ Outdoor use (correct answer)
- ☐ Explosion protection
- ☐ Oil-laden environments

Adaptability to on-line format

Much of this course content can be delivered online with links to soft skills videos, manufacturer's presentations, tutorials, wholesaler websites, and others.

Appendix A – Sample syllabus

BUILDING AUTOMATION SYSTEMS DESIGN & INSTALLATION

COURSE BUAS 2030 CRN 52511 SEMESTER FALL, 2012

OUTLINE, SYLLABUS, & ORIENTATION INFORMATION

FACULTY INFO

Mr. Brian Lovell

Clarkston Campus Industrial Div. Office Email: lovellb@gptc.edu Phone: 404-297-9522 Ext.: 1265

Office Hours: By appointment only

Division Chair :Ms. Natalie Kostas

Clarkston Campus Industrial Div. Office Email: kostasn@gptc.edu Phone: 404-297-9522 Ext.: 1216

CLASS TIMES

Wednesdays 5:30pm - 9:45pm (8/27 - 12/13) Room C-21

CREDIT HOURS & PREREQUISITES The federal definition of a semester credit hour is one hour of classroom instruction and two hours out of class student work each week.

4 / Pre-requisite: BUAS 1030 / Co-requisite: BUAS 2010

INTRODUCTION & COURSE DESCRIPTION

This course deals with how BAS systems are designed and properly installed and commissioned. Topics include BAS contracting, GA Lien Law, NEC code, low voltage contractor's licencse requirements, GA state & local codes, cabling practices, selecting device locations, network considerations, conduit requirements, developing a commissioning plan, and BAS system commissioning. is course builds upon electrical concepts covered in BAS Electrical Concepts II. Topics include voltage dividers, DC voltage & current sources, simplification theorems, AC current & voltage, oscilloscope fundamentals, reactive components & reactive circuits, basic filters, ladder logic, and shop drawings.

COURSE COMPETENCIES

BAS industry contracting / NEC code / GA state codes / Local codes / Control system design process / Control system installation process / Control system commissioning process / Control system praxis

STUDENT LEARNING OUTCOMES

Explain what is meant by division of labor

Explain what is meant by right-of-way on a project

Give examples of the types of tools necessary for an efficient BAS installation

Observe an instructor properly mount various anchors in a block wall

Demonstrate the ability to install various types of block wall anchors with instructor supervision

Observe an instructor bending ½" and ¾" conduit to prescribed dimensions

Perform 45 degree, 90 degree, kick-out, offset, and saddle bends on ½" and ¾" conduit to prescribed dimensions under instructor supervision

Observe an instructor demonstrate the proper way to use a fish-tape to pull cables in conduit

Observe an instructor wire 1-5VDC, 0-10VDC, thermistor, 4-20ma, and dry contact inputs

Observe an instructor wire 0-10VDC, 24VAC, tri-state, modulating, and dry contact outputs

Draw wiring diagrams for all BAS standard inputs

Draw wiring diagrams for all BAS standard outputs

Demonstrate the ability to wire all BAS standard inputs

Demonstrate the ability to wire all BAS standard outputs

Demonstrate the ability to convert a 4-20ma input to a 1-5VDC input using a 250 ohm resistor

Observe an instructor wire two- position, tri-state, and modulating actuators with power and signal

Demonstrate the ability to wire two-position, tri-state, and modulating actuators with power and signal

Demonstrate the ability to wire a modulating actuator for position feedback

Observe an instructor adjusting an actuator for direct and reverse action, and also adjust the travel of the actuator

Demonstrate the ability to adjust an actuator for direct and reverse action, and also adjust the travel of the actuator

Observe an instructor demonstrate how to properly terminate control wires to a starter

Observe an instructor demonstrate how to properly wire an H-O-A switch on a combination starter

Identify electrically-held and mechanical-held starters

Describe the purpose of overload heaters in starters

Identify the coil and auxiliary contacts on a starter

Demonstrate the ability to properly terminate control wires on a starter

Demonstrate the ability to properly wire an H-O-A switch on a combination starter

Describe what is meant by 'hard-wire interlock' and the purpose of it

Observe an instructor properly wire a smoke detector and high limit interlock to a fan starter

Demonstrate the ability to properly wire a smoke detector and high limit interlock to a fan starter

Illustrate how to properly develop a commissioning plan for a control system

Develop a plan to efficiently and accurately perform a wire-to-wire commissioning process

Observe an instructor demonstrating the proper way to perform a wire-to-wire commissioning process

Perform a wire-to-wire commissioning process of an installed control system

Collaborate with classmates to design, install, program, and commission a real-world control system

Describe how bid and spec contracting typically works on a new project for a contracting firm

Describe how design/build projects are typically handled by a BAS contracting firm

Describe how BAS contracting firms typically handle negotiated projects

Explain how contracting law applies to BAS contracting firms

Discuss how the NEC code applies to BAS contractors

Choose the proper conductor size using the NEC codebook given amperage requirements, environmental conditions, and length of the run

List all Georgia state codes that pertain to electrical, mechanical, or control systems in commercial buildings

Discuss Georgia state codes which impact BAS contractors

Cite local codes which impact BAS contractors in the city of Atlanta

Define the purpose and utility of control system specifications

Prepare a cost/benefit analysis in selecting control system components taking into consideration specification requirements and future expansion opportunities

Describe the purpose of the submittal process

Explain the required information which must be included in control drawing submittal packages

Identify sections of the engineered plans which pertain to the control contractor

Identify physical points needed to support control system specifications and plans

Describe what things should be included in acceptable shop drawings

Create a submittal package given sample project specifications and drawings

Explain why Microsoft Visio 2007 is a common tool used by controls contractors

Describe what is meant by the word "shapes" in MS Visio 2007

Observe an instructor select, move, add text to, resize, format, rotate, copy, and add dynamic gridlines to shapes

Observe an instructor create a basic diagram by setting the drawing page size, scale, borders & titles, background, gridlines, and snap & glue

Explain the value of "stencils" in MS Visio 2007

Observe an instructor use existing stencils and create a new stencil

Construct a basic control drawing of an air-handling unit with associated control points using MS Visio 2007

Collaborate with classmates to design a real-world control system

TEXTBOOK TITLE (required)

"NEC 2011 Handbook" | Author: Early & Sargent | ISBN 13#:978-0-8776-5916-7

"Commercial and Industrial Wiring" | Author: Barnett | ISBN 13#: 978-0-8269-2075-1

"Ugly's Electrical Reference 2011" | Publisher: Jones & Bartlett | ISBN 13#: 978-0-7637-9099-8

"Ugly's Electrical Safety & NFPA 70E" | Publisher: Jones & Bartlett | ISBN 13#: 978-0-7637-6855-3

"Ugly's Electric Motors & Controls" | Publisher: Jones & Bartlett | ISBN 13#: 978-0-7637-7254-3

"Ugly's Conduit Bending" | Author: Stanfield | ISBN 13#: 978-0-7637-8314-3

OTHER TEXTBOOK INFORMATION

N/A

ADDITIONAL RESOURCES

Throughout the semester, additional resources may be used. They may include the Internet, newspapers, and professional publications.

EVALUATION

Discussion Board Activity……10%

Classroom Participation……10%

Homework Assignments……. 20%

Weekly Quizzes….....10%

Course Assessments……..….20%

Written Final…….15%

Course Project……...15%

SCHEDULE

8/29 - Review Syllabus

9/5 - Lecture: Introduction to BAS 2030

Introduction to BAS Contracting

Major BAS Companies

Homework: "Commercial and Industrial Wiring" - Read Chapter 1, Turn in Ch. 1 exercises on 9/12

Homework: Develop Powerpoint Presentation to be delivered on 9/12 on assigned BAS company (5 min.)

Quiz 1 - Due Sunday, 9/11 NLT 11:55 pm

9/12 - Lecture: Ch. 1 Electrical Saftey

BAS Project Progression / BAS Project Tools

Student Presentations of BAS companies

Homework: "Commercial and Industrial Wiring" - Read Chapter 2, Turn in Ch. 2 exercises on 9/19

Quiz 2 - Due Sunday, 9/18 NLT 11:55 pm

9/19 - Lecture: Ch. 2 Tools & Test Instruments

BAS Contracting Bid & Spec & Design Build Process

Conduit Bending, Fittings Identification, Anchors, Cable Identification, Pulling Cable

Homework: "Commercial and Industrial Wiring" - Read Chapter 3, Turn in Ch. 3 exercises on 9/26

Homework: "Commercial and Industrial Wiring" - Read Chapter 4, Turn in Ch. 4 exercises on 9/26

Quiz 3 - Due Sunday, 9/25 NLT 11:55 pm

9/26 - Lecture: Ch. 3 Electrical Standards & Codes & Ch. 4 Drawings & Specifications

Schematics Review, Meter Reading Review

Students demonstrate 4 major conduit bends in class

Introduction to Standard Input, Output (I/O) Wiring

Homework: "Commercial and Industrial Wiring" - Read Chapter 5, Turn in Ch. 5 exercises on 10/3

Homework: "Commercial and Industrial Wiring" - Read Chapter 6, Turn in Ch. 6 exercises on 10/3

Quiz 4 - Due Sunday, 10/2 NLT 11:55 pm

Quiz 5 - Due Sunday, 10/2 NLT 11:55 pm

10/3 - Lecture: Ch. 5 Conductors & Cables / Ch. 6 Raceway Systems

Practical I/O Wiring

Introduction to Starters

Starter wiring / Interlock wiring

Students demonstrate the ability to properly wire assigned interlocks to starter or contactor

Homework: "Commercial and Industrial Wiring" - Read Chapter 7, Turn in Ch. 7 exercises on 10/10

Quiz 6 - Due Sunday, 10/9 NLT 11:55 pm

Quiz 7 - Due Sunday, 10/9 NLT 11:55 pm

Mid-term Assessment - Due Sunday, 10/9 NLT 11:55 pm (Covers all material through 10/3)

10/10 - Lecture: Ch. 7 Encl, Boxes, Conduit Boxes, and Fittings

Homework: "Commercial and Industrial Wiring" - Read Chapter 8, Turn in Ch. 8 exercises on 10/17

Student Project Assigned

Quiz 8 - Due Sunday, 10/16 NLT 11:55 pm

10/17 - Lecture: Ch. 8 Commercial and Industrial Distribution Systems

Introduction to Commissioning

Introduction to MS Visio

Microsoft Visio Principles (Shop Drawings)

Building Submittal Packages

Homework: "Commercial and Industrial Wiring" - Read Chapter 9, Turn in Ch. 9 exercises on 10/24

Quiz 9 - Due Sunday, 10/24 NLT 11:55pm

10/24 - Lecture: Ch. 9 Devices and Circuits

Homework: "Commercial and Industrial Wiring" - Read Chapter 10, Turn in Ch. 10 exercises on 10/31

Quiz 10 - Due Sunday, 10/30 NLT 11:55pm

10/31 - Lecture: Ch. 10 Commercial and Industrial Installations

Homework: "Commercial and Industrial Wiring" - Read Chapter 11, Turn in Ch. 11 exercises on 11/7

Homework: Chapter 25 - (Prin. of Elec.) "Mech. & Elec. Equip. for Bldgs" (read pages 1165-1184)

Quiz 11 - Due Sunday, 11/6 NLT 11:55pm

11/7 - Lecture: Ch.11 Structured Cabling Systems, BAS Contracting Firm Internal Design Process / Ch. 25 "M&E.."

BAS Device Selection / Interpreting "Cut" Sheets

Homework: Chapter 26 - (Elec. Sys. & Matls.) "Mech. & Elec. Equip. for Bldgs" (read pages 1185 - 1219)

Homework: Read Chapter 1 BAS Design Guide <www.peci.org/ftguide>

Homework: Chapter 27 - (Wiring & Raceways) "Mech. & Elec. Equip. for Bldgs" (read pages 1245-1279)

Homework: Chapter 2 BAS Design Guide <www.peci.org/ftguide>

Quiz 12 - Due Sunday, 11/13 NLT 11:55pm

11/14 - Lecture: Ch. 26, 27 "Mech. & Elec. Equip. for Bldgs."

BAS Design Guide Ch. 1 & 2

11/21 - Thanksgiving Holiday (No class)

11/28 - Student Project Work / Starnes Center Work

12/12 - Turn in Student Project Assignment: Submittal Package (Must be turned in at the start of class, no exceptions)

12/13 - Final Assessment (Cumulative)

BEST Center Curricula, Resources & Recordings

Academic Programs
Georgia Piedmont Technical College - Building Automation Systems
Milwaukee Area Technical College - Sustainable Facilities Operations
Laney College - Commercial HVAC Systems
City College San Francisco - Commercial Building Energy Analysis & Audits

Professional Development Materials, Presentations & Videos
National Institutes
Building Automation Systems Instructor Workshops
Webinars (e.g., BEST Talks)

Faculty Profile Videos
Reports & Case Studies
Marketing Resources

BEST
Building Efficiency for a Sustainable Tomorrow

NSF National Science Foundation