BUAS 1060
COURSE

GEORGIA PIEDMONT TECHNICAL COLLEGE
INDUSTRIAL & TRANSPORTATION TECHNOLOGIES

Building Automation Systems Program

BUAS 1060 Building Automation Systems
Advanced Electrical

National Science Foundation - National Center for Building Technician Education

updated 12/1/16

BUILDING AUTOMATION SYSTEMS FUNDAMENTALS

Course Documentation

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Table of Contents

Catalog description

Building Automation Systems (BAS) Advanced Electrical Concepts 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.

Class Hours

Lecture Hours: 27

Laboratory Hours: 42

Units

Semester Credit Hours: 3

Entry skills needed

- BUAS 1030 – Building Automation Systems Electrical Concepts II
- Basic electrical skills (this course is usually taken in conjunction with introductory electrical course)
- 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

Voltage Dividers

Understand what voltage dividers are and how they're used.

DC Voltage & Current Sources

Understand the concept of ideal DC voltage and current sources.

Simplification Theorems

Learn how to simplify electrical circuits with simplification theorems.

AC Current & Voltage

Understand the principles of AC current and voltage sources.

Oscilloscope Fundamentals

Learn the basic functions of oscilloscopes and how to use them.

Reactive Components

Learn how reactive components affect AC circuits and shift waveforms.

Basic Filters

Understand the purpose of filters and some of the more commonly encountered types.

Ladder Logic

Gain familiarity with interpreting ladder logic diagrams and constructing them.

Shop Drawings

Understand the elements which must be shown in shop drawings and commonly accepted methods of their use.

Microsoft Visio Fundamentals

Gain proficiency with Microsoft Visio in the creation of electrical and shop drawings.

Exit skills

Course content to achieve outcomes listed above:

Voltage Dividers

1. Define bleeder current.
2. Discuss the effect of a resistive load on voltage divider circuits.
3. Explain what is meant by the term bipolar voltage divider.
4. Deduce how voltage divider circuits are employed in building automation systems.
5. Construct a variable voltage divider circuit and make predictions as to how much voltage will be dropped across components under various conditions.

DC Voltage & Current Sources

1. Discuss common characteristics of DC voltage and current sources.
2. Convert a voltage source to a current source and vice-versa.
3. Compare ideal voltage and current sources to their ideal counterparts.
4. Use a voltage source and current source to power a 4-20 milliamp transmitter device under instructor supervision.

Simplification Theorems

1. Describe the superposition theorem, Thevenin's theorem, and Norton's theorem.
2. Apply the superposition theorem to a circuit.
3. Apply Thevenin's theorem to a circuit for simplification and analysis.
4. Apply Norton's theorem to a circuit for simplification and analysis.

AC Current & Voltage

1. Identify a sinusoidal wave and describe its characteristics.
2. Explain the following terms: period, frequency, wavelength, cycle, peak value, peak-to-peak value, rms, radians, degrees, and phase angle.

Oscilloscope Fundamentals

1. Identify the basic controls on an oscilloscope.
2. Use the oscilloscope to measure amplitude, period, and frequency of a sinusoidal waveform.

Reactive Components

1. Define what is meant by the term reactive components.
2. List various reactive components.
3. Define the terms capacitance and inductance and the units used for each.
4. Describe how capacitors store and release charge and the formula used to calculate energy storage in a capacitor.
5. Describe the basic construction and characteristics of capacitors and inductors.

6. Use the formulas for capacitive and inductive reactance to determine total impedance for a circuit.
7. Calculate the total capacitance and inductance if they are connected in series and parallel, respectively.

Reactive Circuits

1. Define RC, RL, and RLC circuits.
2. Determine the phase angle and impedance of an RC series and parallel circuit.
3. Determine the phase angle and impedance in a series and parallel RL circuit.
4. Determine the impedance of a series and parallel RLC circuit.

Basic Filters

1. Explain the differences between low-pass, high-pass, band-pass, and band-stop filters.
2. Explain the following terms: passband, roll-off, attenuation, center frequency, bode plot, critical frequency, and decade as they relate to basic filters.

Ladder Logic

1. Interpret a ladder logic diagram and explain how the circuit operates.
2. Draw a ladder logic diagram from a given sequence of operation using industry-accepted electrical symbols.
3. Construct a circuit from a ladder logic diagram.

Shop Drawings

1. Describe the purpose of shop drawings as they pertain to building automation systems.
2. Produce a hand-drawn set of shop drawings from a sequence of operation, provided components, and engineering sheets detailing the components.

Microsoft Visio Fundamentals

1. Summarize the capabilities of Microsoft's Visio software package.
2. Draw a ladder logic diagram using Microsoft Visio.
3. Create a library of control components for Microsoft Visio.
4. Design shop drawings in Microsoft Visio as a student project.

5. Anticipate how the Microsoft Visio software package might save you money as a building automation systems contractor.

6. Observe an instructor building a small library of control components in MS Visio.

7. Construct a library of control valves and electrical symbols in MS Visio.

Course materials

Principal text

Shultz, P. T. (2007). *AC/DC Principles*. Homewood, IL: American Technical Publishers. ISBN #: 978-0-8269-1350-0

Shultz, P. T. (2007). *AC/DC Principles Workbook*. Homewood, IL: American Technical Publishers. ISBN #: 978-0-8269-1351-7

Mazur, G. A., & Proctor, T. E. (2010). *Troubleshooting Electrical / Electronic Systems*. Orland Park, IL: American Technical Publishers. ISBN #: 978-0-8269-1791-1

Lundquist, L. (2000). *Industrial Electrical Troubleshooting*. Albany, NY: Cengage Learning. ISBN #: 978-0-7668-0603-0

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

All About Circuits materials & videos: http://www.allaboutcircuits.com/vol_1/index.html

Other reference materials

None required

Software needed

Microsoft Visio – free download

Lab setup and materials

- Various electrical motors
- Variable frequency drives
- Motor starters
- Relays in a box (RIBs)
- Protractor
- Straight edge
- Mechanical Pencils
- Workstations with electrical outlets
- DC power supply
- 120/24 volt, 40 VA transformer
- 8-bit adder trainer
- Electrical symbols plastic tracing templates
- Perforated backplate boards for mounting din rail & devices
- Electromechanical relays (SPDT, DPDT)
- 14, 16, & 18 gauge THHN wire of various colors
- Fork terminals of various sizes
- Blue, orange, & yellow wire nuts
- Wire strippers
- Control screwdrivers / regular size screwdrivers
- Electrical tape
- Assorted resistor types & values
- Pushbutton switches
- Thermistors of various types
- Assorted types and sizes of capacitors
- Assorted types and sizes of inductors

Equipment & instruments required

- Breadboard
- Multi-meter & clamp-on meter
- Voltage proximity sensor
- Function generator
- Scopemeter
- Oscilloscope

Samples of weekly assignments

BUAS 1060 – BAS Advanced Electrical Assignment # 1 –

Location: C-building BAS/Refrigeration laboratory

Purpose: Apply concepts learned in the classroom in the real world, using real-world components and devices.

Materials: Assorted resistors / assorted capacitors / assorted inductors / oscilloscopes

Description: Individual students are assigned appropriately-sized resistors, capacitors, and inductors and are provided a schematic diagram for constructing RL, RC, and RLC circuits. The value of the inductors and capacitors vary per student, but the values used have been solved for by the professor prior to the exercise.

Student groups solve the phase angle for each of the RL, RC, and RLC circuits, specifying whether the current leads or lags the source voltage.

Once the problems have been solved mathematically, students construct the circuits using the provided schematics and test their results using benchtop oscilloscopes.

Grading: Grading is based upon completeness and accuracy of student work. Did the student correctly solve the phase angle problems for each provided circuit based upon the values of the capacitors and inductors assigned? Did the student properly use the oscilloscope to verify the results?

Project

BUAS 1060 – BAS Advanced Electrical Course Project

Location: B, C, D buildings on Clarkston Campus of GPTC

Purpose: Apply principles of advanced AC theory to practical problems in the laboratory.

Materials: Scopemeter, power analyzer, basic hand tools, composition book for recording values

Description: Students will work in groups of three to record and analyze watt transducer readings in the B, C, and D buildings of the Clarkston campus of GPTC over a period of one month. This work will inform a comparative mini-energy study of the three buildings of identical size, construction, and orientation.

Students will be escorted to the electrical rooms of the B, C, and D buildings on class days to record current readings and retrieve historical data accumulated during the week. Students will be provided plans for each of the buildings, detailing the major loads in each.

During the first week, the basic parameters of watt transducers will be discussed and related to course topics covered throughout the semester. Each subsequent week will find students escorted through each of the B, C, and D buildings to investigate the major mechanical and electrical systems of each building. Upon completion of the building investigations and data collection from the watt transducers, students will develop charts and graphs comparing the parameters of kW, kWH, power factor, peak demand, load profiles, and phase imbalances.

Each building's data will be reconciled against the loads in the building and then compared to the other buildings of like design, but different usage. These results will be presented at the end of the semester during an open-invitation event at the conference center where other students, educators, industry partners, and community members will be invited.

Grading:

Grading will be by rubric which is available for review in Angel LMS. Elements of the rubric include completeness of report, accuracy of findings, descriptions of methods, neatness, conclusions drawn, returning all materials and controllers to their original state.

Presentation grading will be by standard communications rubric and available on Angel LMS. Each group will have 10 minutes at the end of the semester to present their findings.

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. The amount of time required for a capacitor to charge to 63% of the voltage across an RC circuit is known as _____. (ANS: RC time constant)

2. What is the amount of stored energy in a 500 uF, 240V capacitor that is fully charged? (ANS: E = ½ * C * V^2 14.4 Joules)

3. What is the capacitance of two series capacitors with an equivalent capacitance of 20 uF? (ANS: 10 uF)

4. What is the mathematical relationship between wavelength and frequency? (ANS: Inversely proportional)

5. Vectors used to represent electrical quantities are known as _____. (ANS: Phasors)

6. Choose one of the following that is a recognized graphical solving method used for problems containing up to two phasors.

- ☐ Regression method
- ☐ Parallelogram calculation method (correct answer)
- ☐ Additive method

7. Calculate the effective voltage if V_p = 300 volts. (ANS: 212 volts)

8. The product of voltage and current in a circuit, without regard for any phase shift, is known as _____. (ANS: Apparent power)

9. Capacitors cause opposition to current flow, true or false? (ANS: True)

10. If current lags source voltage by 90^0, the circuit must be purely _____. (ANS: Inductive)

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

Georgia Piedmont Technical College
BAS ADVANCED ELECTRICAL CONCEPTS
COURSE BUAS 1060 CRN 48940
SEMESTER FALL 2011
OUTLINE, SYLLABUS, & ORIENTATION INFORMATION

FACULTY INFO

Mr. Brian Lovell
Clarkston Campus Office: C-13 Email: lovellb@gptc.edu Phone: 404-297-9522 Ext.: 1265
Office Hours: M, T 9:00 - Noon (By Appointment)

Division Chair: Ms. Natalie Kostas
Clarkston Campus Office: Industrial Dept.
Email: kostasn@gptc.edu Phone: 404-297-9522 Ext.: 1216

CLASS TIMES

Tuesday / Thursday 5:30 pm - 6:45 pm

CREDIT HOURS & PREREQUISITES

3 / BUAS 1030

INTRODUCTION & COURSE DESCRIPTION

This 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

See Exit Skills in this document.

STUDENT LEARNING OUTCOMES

See Learning Outcomes in this document.

TEXTBOOK TITLE (required)

AC/DC Principles" / Pub: ATP / Author: Paul T. Shultz / ISBN #:978-0-8269-1350-0
"AC/DC Principles Workbook" / Pub: ATP / Author: ATP Staff / ISBN #:978-0-8269-1351-7
"Troubleshooting Electrical / Electronic Systems" / Pub: ATP / Authors: Mazur & Proctor / ISBN #:978-0-8269-1791-1

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

9/1 - Lecture: Introduction | Homework: Read Ch. 13 in "AC/DC Principles" | Ch. 13 workbook exercises (Due 9/15)

Quiz 1 - Due Sunday, 9/18 NLT 11:55pm (Chapter 13)

9/6 - Lab 1 (Pre-lab in Angel LMS)

9/8 - Lecture: Ch. 13 "AC/DC" | Homework: Read Ch. 14 "AC/DC" | Ch. 14 workbook exercises (Due 9/15)

Quiz 2 - Due Sunday, 9/18 NLT 11:55pm (Chapter 14)

9/13 - Lab 2 (Pre-lab in Angel LMS)

9/15 - Lecture: Ch. 14 "AC/DC" | Homework: Read Ch. 15 "AC/DC" | Ch. 15 workbook exercises (Due 9/22)

Quiz 3 - Due Sunday, 9/18 NLT 11:55pm (Chapter 15)

9/20 - Lab 3 (Pre-lab in Angel LMS)

9/22 - Lecture: Ch. 15 "AC/DC" | Homework: Read Ch. 16 "AC/DC" | Ch. 16 workbook exercises (Due 9/29)

Quiz 4 - Due Sunday, 9/25 NLT 11:55pm (Chapter 16)

9/27 - Lab 4 (Pre-lab in Angel LMS)

9/29 - Lecture: Ch. 16 "AC/DC" | Homework: Read Ch. 17 "AC/DC" | Ch. 17 workbook exercises (Due 10/6)

Quiz 5 - Due Sunday, 10/2 NLT 11:55pm (Chapter 17)

10/4 - Lab 5 (Pre-lab in Angel LMS)

10/6 - Lecture: Ch. 17 "AC/DC" | Homework: Read Ch. 18 "AC/DC" | Ch. 18 workbook exercises (Due 10/13)

Quiz 6 - Due Sunday, 10/9 NLT 11:55pm (Chapter 18)

10/11 - Lab 6 (Pre-lab in Angel LMS)

10/13 - Lecture: Ch. 18 "AC/DC" | Homework: Read Ch. 15 "Troubleshooting…" | Ch. 15 activities (Due 10/20)

Mid-term Assessment 1 - Due Sunday, 10/16 NLT 11:55pm (Chapter 15 "Troubleshooting")

10/18 - Lab 7 (Pre-lab in Angel LMS)

10/20 - Lecture: Ch. 15 "Troubleshooting…" | Homework: Read Ch. 16 "Troubleshooting" | Ch. 16 activities (Due 10/27)

Quiz 7 - Due Sunday, 10/23 NLT 11:55pm (Chapter 16 "Troubleshooting…")

10/25 - Lab 8 (Pre-lab in Angel LMS)

10/27 - Lecture: Ch. 16 "Troubleshooting…" | Homework: Read Ch. 17 "Troubleshooting" | Ch. 17 activities (Due 11/3)

Quiz 8 - Due Sunday, 10/30 NLT 11:55pm (Chapter 17 "Troubleshooting…")

11/1 - Lab 9 (Pre-lab in Angel LMS)

11/3 - Lecture: Ch. 17 "Troubleshooting…" | Homework: Read Ch. 18 "Troubleshooting" | Ch. 18 activities (Due 11/10)

Quiz 9 - Due Sunday, 11/6 NLT 11:55pm (Chapter 18 "Troubleshooting…")

11/8 - Lab 10 (Pre-lab in Angel LMS)

11/10 - Lecture: Ch. 18 "Troubleshooting…" | Homework: Read Ch. 22 "Troubleshooting" | Ch. 22 activities (Due 11/17)

Quiz 10 - Due Sunday, 11/13 NLT 11:55pm (Chapter 22 "Troubleshooting…")

11/15 - Lab 11 (Pre-lab in Angel LMS)

11/17 - Lecture: Ch. 22 "Troubleshooting…" | Homework: Read Ch. 23 "Troubleshooting" | Ch. 23 activities (Due 12/1)

Quiz 11 - Due Sunday, 11/20 NLT 11:55pm (Chapter 23 "Troubleshooting…")

11/22 - Lab 12 (Pre-lab in Angel LMS)

11/24 - Thanksgiving Holiday - No class

11/28 - Lab 13 (Pre-lab in Angel LMS)

12/1 - Lecture: Ch. 23 "Troubleshooting…" | Homework: Read Ch. 24 "Troubleshooting" | Ch. 24 activities (Due 12/8)

Quiz 12 - Due Sunday, 12/4 NLT 11:55pm (Chapter 24 "Troubleshooting…")

12/8 - Lecture: Ch. 24 "Troubleshooting…" / Review for Final

12/15 - Written Final Exam and Course Project Due by 11:55 pm - No Exceptions or Extensions

COLLEGE POLICIES

Please refer to documentation for courses BUAS 1010, 1020, 1030 or 1040 for specifics of GPTC's policies re: grading, attendance, etc.

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