SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: INDUSTRIAL ELECTRONICS

Code No.: ELN 213

Program: ELECTRICAL/ELECTRONIC TECHNICIAN

Semester: THREE

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APPROVED: J.P. Arzietto
Chairperson

Date

INDUSTRIAL ELECTRONICS	ELN 213
Course Name	Course Number

PHILOSOPHY/GOALS:

This course will provide the student with an understanding of fundamental control and trigger devices and their industrial applications. Emphasis is on solid-state devices; thyristors, unijunction transistors, optoelectronic devices and operational amplifiers. Also, the use of programmable logic controller (PLC's) will be studied.

METHOD OF ASSESSMENT:

Assessment will consist of two major theory tests and various quizzes for 50% of the overall grade.

Practical tests, lab quizzes, logbook, oral and written assignments and general lab assessment will make up the other 50%.

TEXTBOOK:

Industrial Solid-State Electronics - Maloney.

BLOCK NUMBER	PERIODS T-L	TOPIC DESCRIPTION	REFERENCE
A.	4-4	Transistor Switching, Timing Circuits and Relays 1. Transistor as a Switch 2. Transistor Switching Circuits 3. RC Time Delay Circuits 4. Relay Construction, Functions and Operations 5. Applications of Transistor Switches, Time-Delay Circuits and Relays in Control Circuits	*Text -Electronic Principles, *Industrial Solid-State Electronics, Maloney -Industrial Electronics Zbar
B.	4-6	Optoelectronics 1. Fundamentals of Light 2. Photoelectric Devices - - photovoltaic cell - photoconductor - photoemissive tube 3. Photoconductive Sensors - photo diode - photo transistors - photo IC's 4. Light - Emitters - LED's - IRED's - LASERS - LCD's - Nixie Tubes - Alphanumeric displays 5. Photocouplers 6. Fibre Optics 7. Application of Optoelectronic Devices in Industrial Control	

BLOCK NUMBER	PERIODS T-L	TOPIC DESCRIPTION	REFERENCE
C.	6-6	Operational Amplifiers	
		1. Introduction to Differential Amplifiers - symbol - circuit diagram - modes of operation 2. OPAMPS - Construction, operation, characteristics and specifications 3. OPAMP Circuits - operation, voltage gain - amplifiers - comparators - inverters and non-inverters - adders and subtractors - integrators and differentiators - converters (voltage/current) 4. Applications of OPAMPS in Control Circuits 5. The 555 Timer	
D.	2-3	Unijunction Transistors	
		1. Operation, Characteristics, Specifications and Ratings of UJT's 2. UJT Relazation Oscillator 3. UJT Timing Circuits and Triggering Devices 4. CUJT and PUT Devices 5. UJT Applications	
E.	10-10	PNPN (Thyristor) Devices	
		1. Introduction 2. PNPN Trigger Devices - symbol, operation, I-V curve, characteristics and applications (a) Schockley (Four-Layer Diode) (b) SUS (c) DIAC (d) SBS	

BLOCK NUMBER	PERIODS T-L	TOPIC DESCRIPTION	REFERENCE
E. (cont'd)	10-10	3. Silicon controlled Rectifiers (SCR's) - theory and operation - I-V anode and gate characteristics - SCR gate control circuits - AC and DC Switching Circuits - SCR Applications - phase control circuits - motor-speed control - alarm and lighting systems 4. Triacs - theory and operation - electrical characteristics - triggering methods 5. LASCR	
F.	4-4	Programmable Logic Controllers (PLC's) 1. Function, Operation, Application and Programming of PLC's	

BLOCK "A" - Transistor Switching, Timing Circuits and Relays

The student shall be able to:

1. Explain the operation of a transistor switch and how it differs from a linear transistor amplifier.

2. Calculate resistor sizes for a transistor switch.

3. Explain the advantages of some common variations of the basic transistor switch.

4. Define the term "time constant" as related to RC and RL circuits.

5. Use the Universal Time Constant Chart in determining the effects on circuit voltage and current with respect to time.

6. Become familiar with some applications of timing circuits in industry.

7. Define the term "relay".

8. Describe the basic construction of a simple d.c. relay with the aid of a schematic diagram.

9. Explain the effects on relay operation when:

   (a) spring tension is varied
   (b) distance between contact points is varied
   (c) using different sizes of coil windings and different coil core material
   (d) supply voltage to coil windings is varied

10. Define the following terms associated with relays:

    (a) Make or Break (NO, NC)
    (b) Energized, de-energized
    (c) "pick-up" value, "reset" value
    (d) Relay coil resistance
    (e) SPST, SODT, DPDT

11. State the characteristics, advantages and disadvantages of the three main types of relays:

    - Electromagnetic relays
    - Reed relays
    - Solid state switches

12. Explain (with the aid of circuit diagrams) the operation of various electro-magnetic relays, time-delay relays (vacuum tube and transistor).

13. Explain the function and circuit operation of the relay in the following applications:

    - circuit overload and underload protection
    - keying
    - remote switching
    - industrial controls
    - timing circuits
    - time-delay relay circuits (electronic and non-electronic).

14. Use manufacturer's specification manuals and data sheets in order to select the proper relay for the required job.

15. Explain the operation, advantages and disadvantages of solid-state relays.

BLOCK "B" - OPTOELECTRONICS

The student shall be able to:

1. Recall the characteristic of optoelectric devices.

2. Recall how light is related to the electromagnetic spectrum.

3. Recall the relationship between frequency, wavelength and speed of light and the units of measurement for each.

4. Understand the spectral response of the human eye to various colours.

5. Recall how light at various frequencies affects photoelectric devices.

6. List the three main types of photoelectric (PE) devices, draw the symbol diagram and state the principle characteristic of each.

7. With the aid of a Resistance vs Illumination curve for a typical photo-conductive cell, to state the affect on cell resistance for various light intensity.

8. Calculate the circuit current and voltage when a cell is subjected to light.

9. Draw the symbol diagram, explain the operation and state the characteristics, specifications, ratings and application of the following devices:

   (a) Photoelectric Devices:
   - (i) Photovoltaic cell
   - (ii) Photoconductive cell
   - (iii) Photoemissive tube

   (b) Photoconductive Sensors:
   - (i) Photodiode
   - (ii) Phototransistor, FET, Darlington
   - (iii) Photo IC

   (c) Light-Emitters:
   - (i) LED's
   - (ii) IRED's
   - (iii) LCD's
   - (iv) LASERS
   - (v) Nixie Tube
   - (vi) Alphanumerical displays

9. (d) Photocouplers (Optocouplers)

   (e) Solid-State Relays

BLOCK "C" - Operational Amplifiers (OPANPS)

The student shall be able to:

1. Draw a block diagram of a basic differential amplifier and state its characteristics.

2. With the aid of a basic circuit diagram of a differential amplifier, explain circuit operation.

3. Explain the operation and characteristics of the following differential amplifier configurations.

   (a) single-ended input
   (b) double-ended input (differential input) with in-phase and out-of-phase signals.

4. Draw a block diagram of an OPAMP and state the approximate values of each important amplifier characteristic typical of an OPAMP, such as:

   (a) Power rating
   (b) Open-loop voltage gain
   (c) Differential voltage gain
   (d) Input and output impedance
   (e) Common-mode rejection ratio (CMRR)

5. Describe the offset problem of OPAMPS and show how it can be corrected.

6. Explain the concept of "virtual ground".

7. For the following OPAMP circuits, draw the circuit diagram, explain its operation, recall the voltage gain formula and list its characteristics.

   (a) Constant-gain amplifier
   (b) Inverting Amplifier
   (c) Con-inverting Amplifier
   (d) Emitter-follower
   (e) Comparator
   (f) Adder (Summer)
   (g) Subtractor
   (h) Add/Substract
   (i) Integrator
   (j) Differentiator
   (k) Voltage-to-current converter

8. To extract data on operation, specifications, ratings, applications and electrical characteristics on OPAMPS from manufacturers data sheets.

9. To study the operation, characteristics and applications of the 555 Timer I.C.

BLOCK "D" - Unijunction Transistor (UJT)

The student shall be able to:

1. Draw the symbol and structural diagram of a UJT and explain how it operates.

2. Interpret the I-V characteristics curve of a UJT and identify the peak voltage, peak current, valley voltage, valley current, saturation voltage, and negative resistance region.

3. Relate the UJT variables of peak voltage (Vp), intrinsic stand of ratio (?), interbase resistance (R_{BB}) and voltage (V_{BB}), and calculate any one of these, given the other two.

4. With the aid of a circuit diagram and waveforms, explain the operation of a UJT relaxation oscillator and properly size the timing resistors and capacitors in these circuits and calculate the frequency of oscillation.

5. Explain the problem of UJT latch-up, why it occurs, and how to avoid it.

6. State the characteristics, operation, application of a programmable UJT (PUT) and draw its fully labelled circuit diagram.

7. State the characteristics, operation, application of a 555 Timer.

BLOCK "E" - PNPN (Thyristor) Devices

The student shall be able to:

1. Recall that the term "thyristor" refers to all members of the PNPN family that have a control mechanism.

2. For the following PNPN trigger devices, draw the symbol diagram, explain operation, draw the I-V characteristic curve, and state the main characteristics:

   (a) PNPN (Schockley) Diode
   (b) SUS
   (c) Diac
   (d) SBS

3. Draw the symbol diagram, structural diagram, and the I-V characteristic curve for the SCR, indicating the "off" region, "on" region, forward breakover voltage, holding current and voltage and gate trigger current and voltage.

4. Explain the operation of an SCR power control circuit for controlling resistive loads with AC/DC supplies and various gate triggering methods.

5. Explain the operation of an SCR.

6. Define firing delay angle and conduction angle and show how they affect the load current.

7. Define some of the important electrical parameters associated with SCR's, such as gate trigger current and voltage, holding current, forward ON-state voltage, forward breakover voltage, maximum power dissipation, etc., and give the approximate range of values expected for these parameters using data sheets and specification manuals.

8. Explain the operation and advantages of breakover trigger devices used with SCR's.

9. With the aid of circuit diagrams and waveforms, explain the principles of phase shift control using an AC supply voltage and a gate pulse voltage. State how the firing angle causes the conduction angle to vary.

10. For the following thyristor control devices, draw the symbol diagram, explain operation, state turn-on and turn-off methods, draw the I-V characteristics and applications of:

10. continued -

    (a) TRIAC
    (b) LASCR
    (c) GCS
    (d) SCS

11. Explain circuit operation, function of components, etc. for various industrial control cirits using all the devices covered in this course.