SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: INDUSTRIAL ELECTRONICS

Code No.: ELN 213 - 4

Program: ELECTRICAL/ELECTRONIC TECHNICIAN

Semester: THREE

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APPROVED: J.P. Arsenault
Chairperson

Date

INDUSTRIAL ELECTRONICS	ELN 213
Course Name	Course Number

PHILOSOPHY/GOALS:

This course will provide the student with a detailed study of switching, timing, trigger and control devices and circuits together with their applications in industry. Topics covered will include timers, solid-state switches, digital control, relays, optoelectronics, operational amplifiers, trigger devices (UJT, Diac, 555 Timer), control devices (SCR, TRIAC). An introduction to solid-state single phase dc motor control is included. Related practical exercises consist of circuit design, analysis, testing and troubleshooting.

METHOD OF ASSESSMENT (GRADING METHOD):

Assessments will consist of three major tests and various quizzes for 60% of the overall mark.

Practical tests, lab quizzes, logbook, oral and written assignments, and general lab assessment will make up the other 40%.

Grading	A - 80 to 100%	(Outstanding achievment)
	B - 66 to 79%	(Consistently above average achievment)
	C - 55 to 65%	(Satisfactory or acceptable achievment)
	R - Repeat	(Objectives have not been achieved)

TEXT:

Industrial Solid-State Electronics - Maloney

REFERENCE TEXTS:

Industrial Electronics - Patrick/Fardo
Electronic Principles - Malvino
Solid-State Industrial Electronics - Pearman

BLOCK	PERIODS	TOPIC DESCRIPTION
A	6--6	Switching, Timing, Relay and Digital Circuits

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. Determine the value of voltage and current, across various components in an RC circuit, at different time intervals using the following basic formulas:

$$V_B = Vc + V_R$$

$$Vc = V_F + (Vi - V_F), \epsilon^{-t/RC}$$

and $i = VR/R$

where V_B = source (battery) voltage

Vc = voltage across C at anytime t
V_R = voltage across R at anytime t

V_F = final (maximum) value of voltage the capacitor may charge to
Vi = initial voltage on the capacitor
RC = time constant in seconds if
R = resistance in ohms
C = capacitance in farads
= base of natural logarithm (2.718)
i = current at any time t

7. Describe the basic construction of a simple electromagnetic relay with the aid of a schematic diagram.
8. Define the following terms associated with electromagnetic relays and contactors

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

9. 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).
10. Explain the operation, advantages and disadvantages of solid-state relays. (SSR)
11. Explain the operation of solid-state timers based on a RC charging circuit.
12. Describe the operation of digital gates, flip-flops, registers and counters.

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 photo-electric 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

   (d) Photocouplers (Optocouplers)

   (e) Solid-State Relays

BLOCK "C" - OPERATIONAL AMPLIFIERS (OPAMPS)

The student shall be able to:

1. 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)

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

3. Explain the concept of "virtual ground".

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

   (a) Inverting Amplifier
   (b) Non-inverting Amplifier
   (c) Comparator
   (d) Adder (Summer)
   (e) Subtractor
   (f) Voltage-to-current converter
   (g) Current-to-Voltage Converter

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

BLOCK "E" - PNPN (THYRISTOR) CONTROL 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. Explain the operation of an SCR.

3. Draw the symbol 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. Define firing delay angle and conduction angle and show how they affect the load current.

6. 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 specifications manuals.

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

8. 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.

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

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

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

11. Explain the two basic methods of adjusting the speed of a dc shunt motor.

12. Discuss the relative advantages and disadvantages of speed adjustment of a dc motor from the field and from the armature.

BLOCK "D" - SOLID-STATE TRIGGER DEVICES

The student shall be able to:

1. Draw the symbol diagram, list characteristics, explain operation, testing and application of the following trigger (switching) devices:

   (a) Four Layer (Shockley) diode
   (b) Diac
   (c) SUS
   (d) SBS
   (e) PUT

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

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

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

5. 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.

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

7. Explain the operation and application of the 555 Timer IC in monostable and astable mode.

13. Explain why armature control with thyristors is superior to all other dc motor speed control methods.

14. Discuss how counter-EMF feedback can be used to improve a motor's load regulation.

15. Explain the operationof a single-phase thyristor speed control system for a dc shunt motor.