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SAULT COLLEGE OF APPLIED ARTS & TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

Course Title: INSTRUMENTATION & PROCESS CONTROL

Code No.: ELN 232-6

Program: COMPUTER/ELECTRICAL/ELECTRONIC TECHNOLOGY

Semester: 3

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APPROVED: L.P. Crozietti — Chairperson   Date 84/05/05

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per W. Filipowich

CALENDAR DESCRIPTION

INSTRUMENTATION & PROCESS CONTROL — Course Name

ELN 232-6 — Course Number

PHILOSOPHY/GOALS:

To provide a good understanding of the measurement, electrical, electronic, pneumatic and hydraulic features inherent in process control loops. In addition, to develop a sound theoretical understanding of stability, mode characteristics, and general process control loop dynamic characteristics.

METHOD OF ASSESSMENT (GRADING METHOD):

100 - 76	"A"
75 - 66	"B"
55 - 65	"C"
50 - 54	"X"
Less than 50%	"R"

There will be a test approximately every three weeks, with at least one week's notice, however, quizzes may be given without notice. The distribution of marks is 70% to theory, 30% to laboratory.

TEXTBOOK(S):

Process Control Instrument Technology
by Curtis D. Johnson

The student shall be capable of:

1. <u>Introduction to Process Control</u>

   a) Representing a process control loop by means of a block diagram.

   b) Defining the term dynamic variable and listing examples.

   c) Defining and explaining the following process control loop evaluatio criteria:

      i) system error
      ii) setpoint
      iii) dynamic response
      iv) transient response
      v) settling time
      vi) peak error
      vii) residual error
      viii) cycling
      ix) minimum area

   d) Defining and explaining analog and digital signal processing techniques.

   e) Defining the SI units of measure for length, time, mass, current, temperature, luminance, plane angle and solid angle.

   f) Explain the standard signals used in process control.

   g) Define the following terms:

      i) error
      ii) accuracy
      iii) transfer function
      iv) system accuracy
      v) sensitivity
      vi) hysteresis
      vii) reproducibility
      viii) resolution
      ix) linearity

   h) Producing process control drawings utilizing standard symbols.

   i) Define the types of measurement time response.

2. Analog Signal Conditioning

a) Recalling the principles of analog signal conditioning and explain t following types of signal conditioning:

i) signal level changes
ii) linearization
iii) conversions
iv) filtering and impedance matching

b) Recalling and apply the Wheatstone bridge circuit in ac and dc applications.

c) Recalling the characteristics, and the important specifications of operational amplifiers (op-amp).

d) Recalling the following applications of op-amps:

i) voltage follower
ii) inverter
iii) non-inverting amplifier
iv) differential amplifier
v) voltage to current converter
vi) current to voltage converter
vii) sample and hold
viii) integrator
ix) differentiator
x) summer
xi) linearization

e) Recalling principle of operation, VI characteristics and applicatio the SCR and TRIAC.

3. Digital Signal Conditioning

a) Recalling and applying the conversion of decimal numbers to binary, octal and hexidecimal.

b) Recalling and applying Boolean-algebra postulates and theorems to simple process control applications.

c) Drawing the block diagram of a DAC and describing its charcteristic

d) Determining the conversion resolution of a DAC.

e) Describing the principle of a successive approximation ADC.

f) Drawing and explaining the block diagram of a data acquisition syst (DAS).

4. <u>Thermal Transducers</u>

a) Defining thermal energy, the relation of temperature scales to therm energy, and temperature scale calibrations.

b) Converting between Kelvin, Rankine, Celsius and Fahrenheit temperatu scales.

c) Recalling the construction, characteristics and application of resistance temperature detectors (RTD's), thermistors, thermocouples bimetallic sensors, gas thermometers, vapor pressure thermometers an liquid expansion thermometers.

5. <u>Mechanical Transducers</u>

a) Describing the principle of operation, characteristics and applicati of the following types of linear motion sensors:

i) potentiometric
ii) capacitive
iii) inductive
iv) linear variable differential transformer (LVDT)
v) strain gauges
vi) incremental and absolute encoders

b) Describing the principle of operation, characteristics and applicati of the following types of angular motion sensors:

i) potentiometric
ii) rotory variable differential transformer (RVDT)
iii) synchros
iv) resolvers
v) synchro converters
vi) shaft angle encoders

c) Describing the principle of operation, characteristics and applicat of acceleration and vibration sensors.

d) Describing the principle of operation, characteristics and applicat of the following types of pressure transduers:

i) bourdon tube
ii) bellows; diaphragm
iii) pirani
iv) thermocouple
v) ionization

e) Describing the principle of operation, characteristics and applicati‹
of the following types of fluid flow sensors:

i) restriction flow
ii) obstruction flow
iii) magnetic flow
iv) turbine

6. Optical Transducers

a) Defining electromagnetic radiation in terms of frequency, wavelength
speed of propagation, and the spectrum.

b) Defining the energy of electromagnetic radiation in terms of:

i) the intensity in watts per unit area
ii) divergence
iii) chromacity
iv) coherence

c) Defining luminous energy in terms of:

i) standard source
ii) luminous intensity
iii) luminous flux
iv) illimination
v) efficacy

d) Describing photodetectors in terms of:

i) spectral response
ii) time constant
iii) detectivity

e) Describing the principle of operation, characteristics and applicatio
of the following types of photodetectors:

i) photoconductive
ii) photovoltaic
iii) photoemissive

f) Describing the principle of operation, characteristics and applicati
of the following types of pyrometers:

i) broadband
ii) narrow band
iii) optical

g) Describing the principle of operation, characteristics and applicati of the following types of optical sources:

i) incandescent
ii) atomic
iii) fluorescence
iv) laser

7. Final Control

a) Recalling that final control operation requires:

i) signal conversion
ii) an actuator
iii) a control element

b) Recalling that signal conditioning involves changing a control signa into the form and power level necessary to energize an actuator, and be able to describe typical signal conversion methods.

c) Recalling that an actuator is the intermediate step between the converted control signal and the final control element, and be able describe the operation and characteristics of solenoids, stepper motors, ac and dc motors, as well as pneumatic and hydraulic actuators.

d) Recalling examples of mechanical, electrical and fluid types of cont elements.

8. Controller Principles

a) Defining process load, process lag and self-regulation.

b) Defining the following control system parameters:

i) error
ii) variable range
iii) control parameter range
iv) control lag
v) dead time
vi) cycling
vii) controller modes

c) Explaining the followin discontinuous controller modes:

i) two-position
ii) multiposition
iii) floating control

d) Explaining the following continuous controller modes:

i) proportional
ii) integral
iii) derivative
iv) proportion-integral
v) proportional-derivative
vi) proportional-integral-derivative (three mode)

9. <u>Analog Controllers</u>

a) Explaining with the aid of schematics the implementation of two position, proporional and integral control using op-amps.

b) Explaining with the aid of schematics the implementation of proportional-integral, proportional-derivative, and three-mode control using op-amps.

c) Describing the operation of a three-mode pneumatic controller.

d) Designing simple process control loops.

10. <u>Digital Control Principles</u>

a) Applying digital techniques to simple and multivariable alarms to process control systems.

b) Recalling the principles of a data logging system as applied to process control.

c) Explaining the principle of computer supervisory control as applied t process control loops.

d) Explaining the principles of direct digital control as applied to process control loops.

e) Discussing the relative merits of applying and networking micro-computers, minicomputers and large scale computers to process contrc loops.

f) Explaining the implementation of control modes by direct digital control.

11. <u>Control Loop Characteristics</u>

a) Explaining the characteristics of single variable, compound, cascade and multivariable.

b) Defining the quality of a control system in terms of stability, minimum deviation and minimum disturbance.

c) Defining control loop stability criteria and using a BODE plot t analyze a system.

d) Explaining the principle of process loop tuning and specifically bei able to apply:

i) open loop transient response method
ii) Ziegler-Nichols method
iii) frequency response methods