(Code for Paper) S021/

DUBLIN INSTITUTE OF TECHNOLOGY
KEVIN STREET, DUBLIN 8

Bachelor of Engineering Technology in Control and Automation Systems

Bachelor of Engineering Technology in Electrical Energy Systems

Year 2

SEMESTER 2 2008-2009

INSTRUMENTATION

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DAY / MONTH 2007 TIME

Question 1 is compulsory (40 marks)
Attempt any two other questions (30 marks per question)

The following should be available for this examination:

Q1. (a) A temperature sensor has a static gain of 0.15mV/°C and a time constant of 2.8 s.
If a step change of 28°C to 60°C is applied at t = 0, determine the output temperatures at t = 0.5 s.

(10 Marks)

(b) A 4-bit ADC is connected to the output of a liquid level transducer.
The ADC is set such that each bit change in the 4-bit ADC represents a level of 0.15 m.

(i) Construct a table of changes for the states of the 4-bit ADC and the corresponding liquid levels.

(6 Marks)

(ii) What would the 4 bit binary word be for a liquid level of 1.7 m?

(2 Marks)

(iii) Suppose the 4 bit binary word were 1000_2.
What is the range of possible liquid levels?

(2 Marks)

(c) In terms of instrumentation, explain what is meant by each of the following terms:

Hysteresis
Tolerance
Span
Accuracy
Drift

(10 Marks)

(d) Explain the principle of operation of a cup anemometer connected to a direct current generator to measure wind speed. Describe how the output changes with a change in input and list some of the good and bad features of the device.

(10 Marks)

Q2. A temperature transducer consists of a sensor, a Wheatstone bridge which has a supply voltage of 5 volts dc and an amplifier. The temperature transducer is to be designed to measure temperature from -10^0C to $+30^0$C. Tests on the sensor show that its resistance R4 is related to its temperature T in degrees Celsius by:

$$R4 = 10{,}000(1 + 0.0043T)$$

(a) Sketch a schematic diagram of your design for the temperature transducer.

(5 Marks)

(b) Calculate and select suitable values of resistors for the Wheatstone bridge.

(5 Marks)

(c) Determine the values of the amplifier resistors such the output of the temperature transducer is 0V at -10^0C and + 5V at $+30^0$C.

(10 Marks)

(d) If the temperature transducer output is 2.5V, what is the actual temperature of the sensor?

(10 Marks)

Q3. (a) A programmable logical controller provides an output current loop in which a current to voltage transducer is inserted. The current to voltage transducer has an input control signal of 4 – 20 mA and is loaded by a 100 Ω resistor in order to produce a 20 – 40 V output signal which is used to drive a motor. Obtain an equation that linearly relates the input current, I, of the transducer to the output voltage, Vo of the transducer.

(5 Marks)

(b) Implement the equation obtained in Q2 (a) above using a difference amplifier and a power amplifier.
Assume that the power amplifier can output 0-100 V and has a gain of 10.

(10 Marks)

(c) A weather station is fitted with a MPX4115A pressure sensor to measure air pressure in the range 950 to 1050 hPa. The data sheet for this sensor is supplied.

Explain what is meant by the term 'piezoresistor'. **(4 Marks)**

What is the entire pressure measurement range of the MPX4115A? Convert from kPa to hPa to show that it is capable of measuring the above air pressure range. **(4 Marks)**

What typical voltage output range from the MPX4115A will be measured for the input air pressure range of 950 to 1050 hPa? **(7 Marks)**

Q.4 A temperature measurement system with an input range of 0 to 100 ºC consists of a Type K thermocouple connected to a differential amplifier followed by a non inverting amplifier. The amplified signal, with a range of 0 to 10 V, is then passed to an analogue to digital card on a PLC.

(i) The overall system was tested and the following data were obtained:

Temperature °C	A/D card Counts
0	40
20	226
40	411
60	670
80	830
100	1025

Plot these results and determine the following:

Sensitivity,
Offset,
Maximum non linearity.

[10 marks]

(ii) If the sensitivity of the thermocouple is 40 μV/ºC what is the overall gain of the two amplifiers?
Suggest appropriate individual gains for each amplifier. **[4 marks]**

(iii) Draw a block diagram of this measurement system and make sure you include ranges and units of inputs to and outputs from each block as well as the sensitivity of each block. **[12 marks]**

(iv) Using the individual sensitivities of each block, determine the overall sensitivity of the measurement system.

How do you expect this to compare to the graph of the above results? **[4 marks]**