

(Code for Paper) S009/

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 II EXAMINATIONS 2010-2011

INSTRUMENTATION

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DAY / May 2011 TIME

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

The following should be available for this examination:

Motorola MPX4115A pressure sensor datasheet
Honeywell 24PCEFA2G pressure sensor datasheet
Mitsubishi FX4AD user manual

- Q1.** (a) Draw a diagram of the instrumentation amplifier and write the equation that defines the gain of this amplifier.

List some of the properties of the instrumentation amplifier.

(10 Marks)

- (b) Explain how you would determine the time constant of a thermometer.

Rank the following in order of increasing time constant:

Thermocouple, bare wire,
Pt 100 RTD, mounted in stainless steel and installed inside a thick thermowell in a pipe,
Thermistor, bead type, thin protective covering,
Pt100 RTD, mounted in stainless steel.

(10 Marks)

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

Span,
Drift,
Resolution,
Tolerance,
Hysteresis

(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 measurement system consists of a Pt100 contained in a Wheatstone bridge circuit with the output connected to a differential amplifier. The input temperature range is -20 to +50 °C and the corresponding voltage output range from the amplifier is 0 to 10 V. The Wheatstone bridge is connected to a 10V DC power supply.

- (i) Draw a fully labelled circuit diagram of the Wheatstone bridge and differential amplifier.

(6 Marks)

- (ii) Determine suitable values of resistors for the Wheatstone bridge. Comment on the choice of your resistors in terms of sensitivity and linearity.

(12 Marks)

- (iii) Calculate values for the resistors on the differential amplifier to satisfy the overall sensitivity of the measurement system. Comment on the sizes of the resistors in terms of loading the output from the Wheatstone bridge.

(12 Marks)

The relationship between resistance and temperature for the Pt100 is given by the following equation:

$$R = R_0(1 + \alpha T)$$

Where R is the resistance of the thermometer at any temperature T .

$R_0 = 100 \Omega$, is its resistance at 0 °C

$\alpha = 0.00385 \text{ } ^\circ\text{C}^{-1}$, is the temperature coefficient of resistance of the thermometer.

Q.3

A rainfall level measurement systems consists of small tank with a piezoresistive pressure sensor mounted at the base of the tank. The tank has a diameter of 6 cm and height of 60 cm. The pressure sensor contains a diaphragm with 4 piezoresistors connected in a Wheatstone bridge arrangement with a sensitivity of 10 mV/psi. A two stage amplification consisting of a differential amplifier in series with a non inverting amplifier is used to amplify this signal to give a 0 to 10 V output range corresponding to an input level range of 0 to 50 cm. This voltage signal is connected to an analogue input channel of a Programmable Logic Controller (PLC) running a signed 12 bit analogue to digital (A/D) conversion.

- (a) What are the gauge and absolute pressures at the base of the tank when it is full of water?

Note: The density of water is 1000 kg/m^3 .
Atmospheric pressure = $101,325 \text{ Pa}$

(6 marks)

- (b) Draw a block diagram of the system showing a block for each component, units and ranges of the input to and output from each block, and the sensitivity of each block. Suggest appropriate individual gains for each amplifier and calculate the overall sensitivity of the measurement system.

Note: $1 \text{ psi} = 6895 \text{ Pa} = 0.70 \text{ m H}_2\text{O}$.

(14 marks)

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

Level (cm)	A/D Result
0	5
10	335
20	675
30	980
40	1365
50	1695
60	2042

Plot these results and determine the following:

Sensitivity,
Offset,
Maximum non linearity.

(10 marks)

Q.4

- (a) Describe a piezoresistor and explain how it can be used to build a pressure transducer.

(4 marks)

- (b) A weather station is fitted with a Motorola MPX4115A pressure transducer to measure air pressure.

- (i) From the datasheet for this device determine the following:

Sensitivity,

Offset,

Pressure measurement range in units of hPa.

(6 Marks)

- (ii) Calculate or estimate the time constant for this device from the response time defined in the datasheet.

(10 Marks)

- (c) An atmospheric pressure measurement system has an input range of 900 to 1100 hPa and an output voltage range of 1 to 8 V which is connected to one channel on a Mitsubishi FX-4AD card.

What is the resolution of this measurement system and by how much could it be improved by using the full input range of the FX-4AD?

(10 marks)