Suggested Questions for the final and alternative/rescheduled exams
Data Acquisition and Distribution **Spring 2001**

Question 1:

Explain the following terms in relation to a measurement system. Given an example for each error.

a. Static error
b. Dynamic error
c. Intrinsic error
d. Influence error
e. Systematic error
f. Random error
g. Absolute error
h. Relative error

Question 2:

a. Explain the term 'loading effect'.

b. An amplifier with an opamp is used to measure the output of a weak source such as a transducer. Explain what you understand from the term 'weak source'. Would you use an inverting amplifier or a non-inverting amplifier ? Justify your answer.

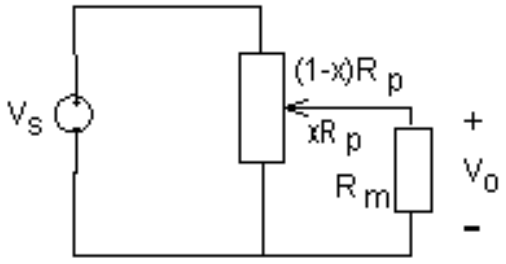

Fig. 2

c. A potentiometric displacement transducer is used to measure the displacement x, where $0 \le x \le 1$. The circuit used is shown in Fig.2. Prove that the non-linearity error, N(x), due to the loading of the voltmeter is

$$N(x) = V_S \frac{x^2(1-x)\left(R_p / R_m\right)}{1 + x(1-x)\left(R_p / R_m\right)}$$

The resistance of the voltmeter is shown to be R_m . Find the value of x for which N(x) is maximum, assuming $R_p << R_m$.

Question 3:

List and describe the static and dynamic characteristics of DAS components.

Question 4:

Describe the following terms with suitable sketches:

a. Responsivity
b. Repeatability
c. Backlash
d. Nonlinearity
e. BSL (how to obtain the coefficients given a set of data)

Question 5:

Describe the following terms:

a. Sensor and transducer (the distinction between them)
b. Self-generating transducers with examples
c. Modulating transducers with examples
d. Doebelin's Generalized input-output model of a transducer
e. The differential, ratiometric and feedback measurement structures.

Question 6:

a. Describe the functioning of a piezoelectric transducer.
b. Draw the equivalent circuit of a piezoelectric transducer and show how a charge amplifier to measure the output of a piezoelectric transducer.
c. Derive the transfer function of the system consisting of the piezoelectric transducer and the charge amplifier.

Question 7:

What are the empirical laws of thermocouple circuits ? List the three laws and explain them.

Question 8:

a. How can a diode or a bipolar transistor be used as a temperature sensor? Illustrate with suitable diagrams and equations.

b. What is a PTAT sensor ? Describe the functioning of AD590 IC temperature sensor.

Question 9:

a. Distinguish between photodiodes and photovoltaic cells. Describe how they operate.

b. Draw the circuit model of a photodiode in the photovoltaic mode of the operation. Explain the model. What is the open-circuit voltage that can be obtained ? What is the voltage that is delivered to a load resistor if a load resistor is connected across the photovoltaic cell ?

c. Draw the circuit model of a photodiode in photocurrent mode. Draw the voltage/current characteristics at different values of irradiance.

Question 10

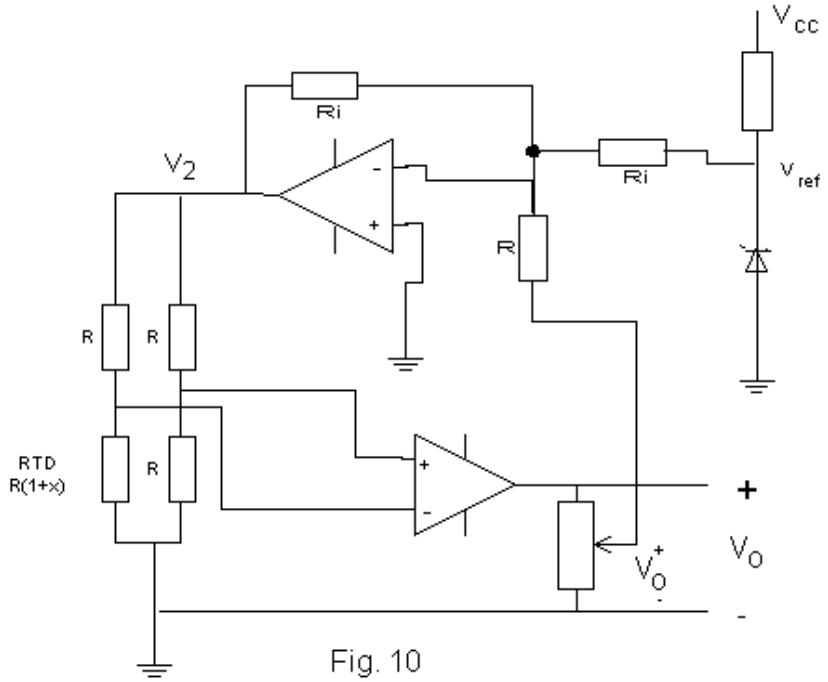

Fig. 10

For the circuit in Fig. 10 prove that

$$\frac{V_o}{V_{ref}} = \frac{AX}{4\left(1+\frac{x}{2}\right)\left(1-\frac{A\beta x}{4\left(1+x/2\right)}\right)}$$

What is the value of β if $V_o = A.V_{ref}\frac{x}{4}$?

Question 11:

Draw the equivalent circuit of a differential inductive pressure transducer. Describe how this transducer functions with the help of phasor diagrams for different unbalanced conditions.

Question 12:

In a system, it is necessary to sample eight analogue signals simultaneously and the values sampled are passed through to a multiplexer and analogue-to-digital converter in turn and the digital outputs from the ADC are collected by a microcontroller system for further processing.

a. Draw the block diagram of the proposed DAS and explain how the proposed DAS would meet the requirement that the signal are sampled simultaneously.
b. Indicate the various delays that can occur in the proposed DAS.
c. Assign suitable values to those delays and compute the highest sampling rate per channel of the DAS.

Question 13:

Explain the operation of a Delta-Sigma ADC with the help of a block diagram and suitable waveforms.

Question 14:

Explain what is meant by zero-order and first-order reconstruction when an analogue signal is recovered from the output of a DAC.

Question 15:

Explain the following terms:

a. Effective Number of bits, ENOB
b. Anti-aliasing filter
c. Signal-to-Noise Ratio, SNR
d. Aperture error for ADC
e. Non-Monotonicity

Question 16:

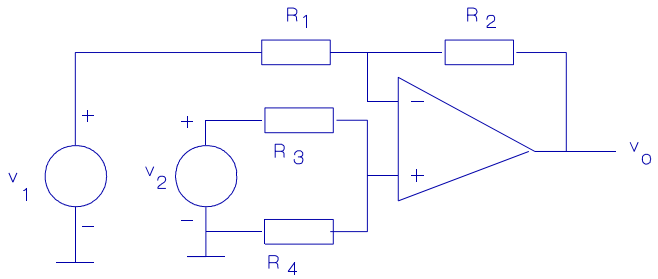

Fig. 16 : Difference Amplifier

For the difference amplifier in Fig. 16, the CMR_R, prove that the common mode rejection determined by the resistance network is given by

$$CMR_R = \frac{1}{2} \times \frac{R_1 R_4 + R_2 R_3 + 2R_2 R_4}{R_1 R_4 - R_2 R_3}$$

Question 17:

An opamp is used as a non-inverting amplifier. The resistance connected between the source and the non-inverting input is 330 kΩ. The gain of the circuit is set to be 10 and the feedback resistor connected between the output and the inverting input terminal is 810 kΩ.

The source voltage is 5 V. The offset voltage of the opamp is 5 μV. The bias current flowing into the inverting input terminal is 800 nA and the bias current flowing into the non-inverting input terminal is 500 nA. The open-loop gain of the opamp is 10^5.

a. Draw the equivalent circuit that includes the bias currents, the offset voltage, the gain of the opamp.
b. Obtain the output voltage of the opamp.
c. What is the error in percentage due to the non-ideal parameters?

Question 18:

Explain the following terms:

a. Anti-aliasing filter
b. Quantisation error
c. Aperture time and aperture error
d. Reed relay
e. Static MUX errors
f. Dynamic MUX errors
g. Acquisition Time for Sample and Hold circuit
h. Differential non-linearity for DAC
i. ENOB
j. THD
k. Glitch in relation to a DAC

Question 19:

Given that the signal fed to ADC is a sinusoidal signal and the number of bits of conversion is n, derive an expression for the signal-to-noise ratio, SNR. Illustrate your answer with the help of suitable diagrams.

Question 20:

How is the digital output of ADC coded ? Specify the popular codes used and show how they represent the output.

Question 21:

Draw the circuit of a 6-bit R-2R ladder DAC and explain its working.

Question 22:

Draw the circuit diagram of a 4-bit flash ADC and explain its working. How does an ADC with pipeline architecture work ?

Question 23:

Draw the block diagram of a typical DAS. List the common dc and ac errors. Show how you would work out an error budget.
