INSTRUMENTATION AND MEASUREMNTS

SELF ASSESSMENT QUESTIONS

BEng23 CoE

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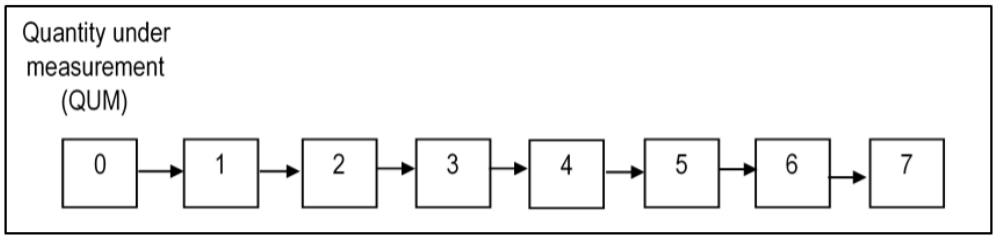
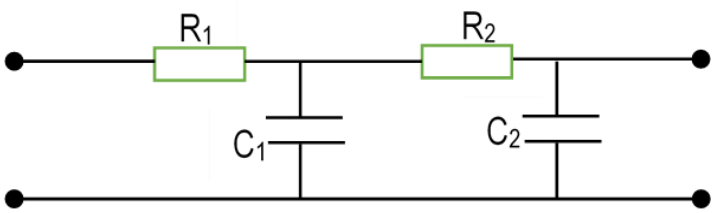
1. Figure below is a generalized block diagram of a measurement system that contains the following components: Quantity under measurement (QUM), amplifier, sensor, digital signal processor (DSP), anti-aliasing filter, analogue-to-digital inverter (ADC), signal conditioning filter, and data representation.
   a) Match the block number with the name of the component.
   Example: 0 - Quantity under measurement (QUM)
   b) Mention the block (shown in Figure) which is responsible for the following noise sources:
   i) n1 = noise accompanying the QUM
   ii) n2 = equivalent noise from electronics
   iii) n3 = equivalent quantization noise.



2. Resistance RX is measured by using voltmeter of 1000 Ω resistance and a milliammeter of 0.8 Ω resistance by voltmeter– ammeter method. If the voltmeter reads 12 V and milliammeter reads 62 mA, calculate the percentage error in the values of measured resistances if:
   a) The method case 1 is as shown in the figure above
   b) The method case 2, is as shown in Figure above
   c) Which method among the two is the appropriate?

3. Figure below is a second order passive low pass filter. Obtain the following:
   a) Transfer function
   b) Natural frequency, f_n .
   c) If R1 = 10 kΩ, R2 = 40 kΩ, C1 = 0.1 µF, and C2 = 0.1 µF, calculate the natural frequency,



Note that, for the standard second order system:

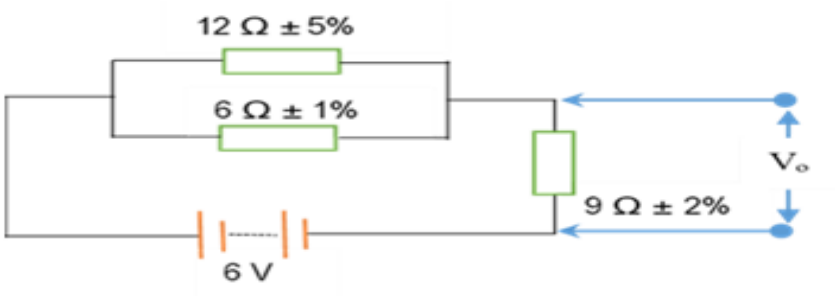
$$G(s)=\frac{\omega_n^2}{s^2+2\xi\omega_n s+\omega_n^2}, \text{ and } f_c=f_n\sqrt{1-2\xi^2+\left(4\xi^4-4\xi^2+2\right)^{\frac{1}{2}}}$$

4. List down four major applications of the ac potentiometers

a) A single-range laboratory-type potentiometer has 20 steps dial switch where each step represents 0.1 volt. The dial resistors are 10 Ω each. The slide wire of the potentiometer is circular and has 10 turns and a resistance of 1 Ω per turn. The slide wire has 100 divisions and interpolation can be done to one firth of a division. The working battery has a voltage of 12.0 volt. Calculate

(i) the measuring range of the potentiometer
(ii) the resolution
(iii) working current,
(iv) setting of the rheostat.

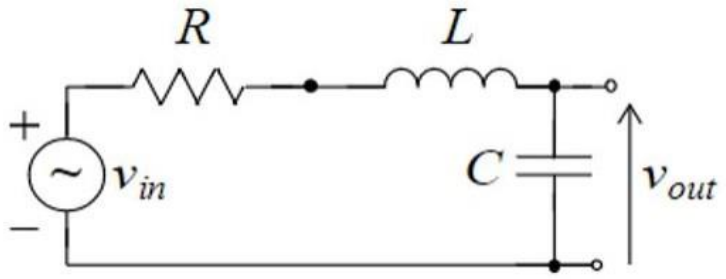
5. From Figure below, the voltage, current and dissipated power across the 9 Ω ± 2% resistor are to be measured using voltmeter and ammeter only.



a) Obtain the maximum percentage error of the measured voltage, current, and power, assume that:
i. The measuring instruments are error free.
ii. The accuracy of measuring instruments are as follows: voltmeter (±0.1%), ammeter (±0.1%), and power is obtained by using the formula V× I.

b) If the equivalent resistor is to be replaced, state the overall:
i. Absolute error. ii. Relative error
iii. Tolerance

6. From the given circuit shown in Figure below, if L = 0.1 mH, C = 1 μF, and R = 10 Ω, find the value of the following three parameters:



a) static sensitivity,
b) natural frequency, and
c) damping ratio.

where, the normalized (dimensionless) transfer function, G(s) is given as

$$G(s) = \frac{K}{s^2 + 2\xi\omega_n s + \omega_n^2}$$

7. **A.** With an aid of block diagram, list and explain the elements of a data acquisition system.

   B. An 8-bit ADC is used to convert a temperature signal which has a measuring range of 0 deg C to 800 deg C. find the following

   a) Number of quantization levels and the resolution of the temperature of an ADC
   b) Quantization level when the temperature is 512 deg C
   c) Determine the quantization error when the temperature input is 512 deg C.