امتحانات قياسات التحكم (١)
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٤ اتصالات
الفصل الدراسي الأول
٢٠١٢ - ٢٠١٣

Answer model

Q1-a: **Expain** the basic requirements of a transducer?

A transducer should have the following basic requirements:

1. Linearity

Its input vs output characteristics should be linear and it should produce these characteristics in balanced way.

2. Ruggedness

A transducer should be capable of withstanding overload and some safety arrangements must be provided with it for overload protection.

3. Repeatability

The device should reproduce the same output signal when the same input signal is applied again and again under unchanged environmental conditions, e.g., temperature, pressure, humidity, etc.

4. High Reliability and Stability

The transducer should give minimum error in measurement for temperature variations, vibrations and other various changes in surroundings.

5. High Output Signal Quality

The quality of output signal should be good, i.e., the ratio of the signal to the noise should be high and the amplitude of the output signal should be enough.

6. No Hysteresis

It should not give any hysteresis during measurement while input signal is varied from its low value to high value and vice versa.

7. Residual Reformation

There should not be any deformation on removal of input signal after long period of use.

Q1-b: **What** is the differences between: * Sensor and transducer * LVDT and strain gauge transducers?

A sensor is a device that measures a physical quantity and converts it into a signal which can be read by an observer or by an instrument.

A transducer is a device, usually electrical, electronic, electro-mechanical, electromagnetic, photonic, or photovoltaic that converts one type of energy or physical attribute to another (generally electrical or mechanical) for various measurement purposes including measurement or information transfer (for example, pressure sensors).

LVDT and strain gauge transducers

LVDT ; is an inductive transducer to translate the linear motion into electrical signals and LVDT is the Linear Variable Differential Transformer

The strain gauge is an electrical transducer; it is used to measure mechanical surface tension. Strain gauge can detect and convert force or small mechanical displacement into electrical signals.

The strain gauges are used for measurement of strain and associated stress in experimental stress analysis.

Secondly, many other detectors and transducers, for example the load cell, torque meter, flow meter, accelerometer employ strain gauge as a secondary transducer.

Q1-c: The output of an LVDT is connected to a 5 V voltmeter through an amplifier of amplification factor 250. The voltmeter scales has 100 divisions and the scale can be read to 1/5th of a division. An output of 2 mV appears across the terminals of the LVDT when the core is displaced through a distance of 0.5 mm. **Calculate** :the sensitivity of the LVDT, that of the whole set up, and the resolution of the instrument in mm.

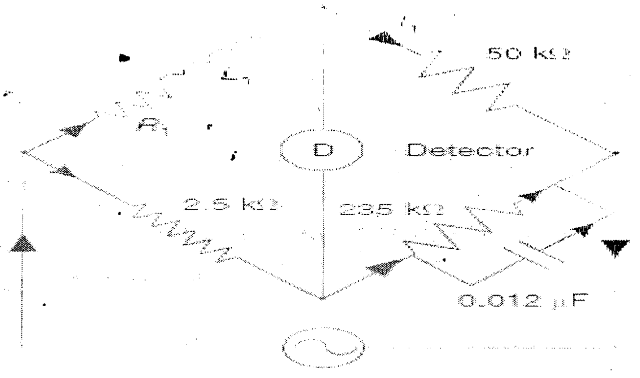
(a) For a displacement of 0.5 mm, the output voltage is 2 mV.

$$\text{Hence, the sensitivity of the LVDT is } \frac{2}{0.5}\text{mV/mm} = 4\text{ mV/mm}$$

(b) Due to the amplifier, this sensitivity is amplified 250 times in the set-up. Hence the sensitivity of the set-up is $4 \times 250 = 1$ V/mm.

(c) The output of the voltmeter is 5 V with 100 divisions Each divisions corresponds to $\frac{5}{100} = 0.05$ V Since $\frac{1}{5}$ th of a division can be read, the minimum voltage that can be read is 0.01 V which corresponds to 0.01 mm. Hence, the resolution of the instrument is 0.01 mm.

Q1-d: A Maxwells inductance–capacitance bridge in Fig. 1 is used to measure a unknown inductive impedance. I- Calculate R_1, L_1 ii- The source frequency if quality factor for a coil is 3.



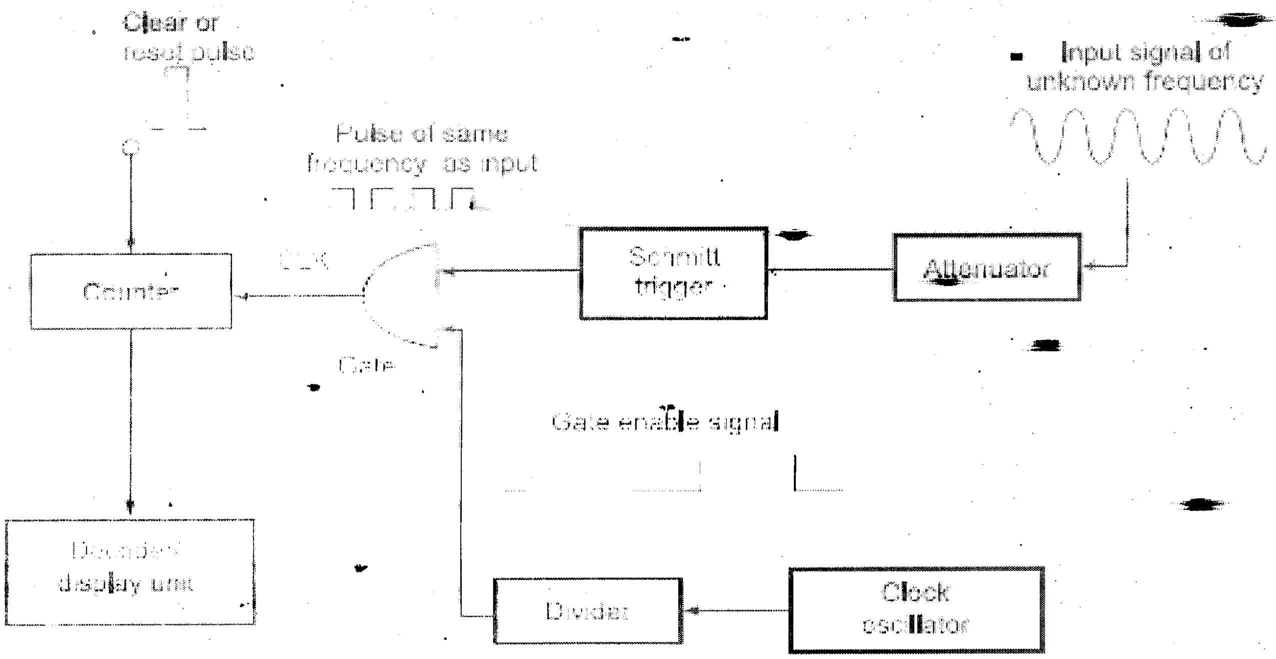
$$L_1 = C_4 R_2 R_3 = 0.012\times10^{-6}\times2.5\times10^{3}\times50\times10^{3} = 1.5\text{ H}$$

$$\text{and } R_1 = R_2\times\frac{R_3}{R_4} = 2.5\times10^{3}\times\frac{50\times10^{3}}{235\times10^{3}} = 0.53\text{ k}\Omega$$

Q= wL/R = 2*pi*f*L/R then f= 3* 530/(6.28*1.5) = 168.8 Hz

Q2-a: Sketch and explain the basic principle of digital frequency meter?

Ans. A frequency counter is a digital instrument that can measure and display the frequency of any periodic waveform. It operates on the principle of gating the unknown input signal into the counter for a predetermined time. For example, if the unknown input signal were gated into the counter for exactly 1 second, the number of counts allowed in the counter would be precisely the frequency of the input signal. The term gated comes from the fact that an AND or an OR gate is employed for allowing the unknown input signal into the counter to be accumulated. For instance if the gate signal is of a time of exactly 1 second and the unknown input signal is a 600-Hz square wave, at the end of 1 second the counter will counts up to 600, which is exactly the frequency of the unknown input signal.



Q2-b.

i. Signal attenuation $= 10\ log_{10}\frac{P_i}{P_0} = 10\ log_{10}\frac{120\times10^{-6}}{3\times10^{-6}} = 16\ dB$

(ii) The signal attenuation per kilometer $\qquad \alpha_{dB}L = 16\ dB$

Hence:

$$\alpha_{dB} = \frac{16\ dB}{L} = \frac{16\ dB}{8\ km} = 2\ dB\ km^{-1}$$

(iii) As α dB = 2 dB km^{-1}, the loss incurred along 10 km of the fiber is given by: $\quad \alpha$ dB L = 2 × 10 = 20 dB

However, the link also has nine splices (at 1 km intervals) each with an attenuation of 1 dB. Therefore, the loss due to the splices is 9 dB.

Hence, the overall signal attenuation for the link is:

Signal attenuation = 20 + 9 = 29 dB

(iv) To obtain a numerical value for the input/output power ratio,

$$\frac{P_i}{P_0} = 10^{29/10} = 794.3$$

Q2-c-

$$\gamma_R = \frac{8\pi^3}{3\lambda^4} n^8 p^2 \beta_c K T_F$$

$$= \frac{248.15 \times 20.65 \times 0.082 \times 7 \times 10^{-11} \times 1.381 \times 10^{-23} \times 1400}{3\lambda^4}$$

$$= \frac{1.895 \times 10^{-28}}{\lambda^4} m^{-1}$$

At a wavelength of 0.63 μm:

$$\gamma_R = \frac{1.895 \times 10^{-28}}{0.158 \times 10^{-24}} = 1.199 \times 10^{-3}\ m^{-1}$$

The transmission loss factor for 1 kilometer of fiber may be obtained using

$$\mathcal{L}_{km} = \exp(-\gamma_R L) = \exp(-1.199 \times 10^{-3} \times 10^3) = 0.301$$

The attenuation due to Rayleigh scattering in decibels per kilometer may be

$$Attenuation = 10\ log_{10}\left(\frac{1}{\mathcal{L}_{km}}\right) = 10 \log_{10}(3.322) = 5.2\ dBkm^{-1}$$

At a wavelength of 1 μm:

$$\gamma_R = \frac{1.895 \times 10^{-28}}{10^{-24}} = 1.895 \times 10^{-4}\ m^{-1}$$

$$\mathcal{L}_{km} = \exp(-\gamma_R L) = \exp(-1.895 \times 10^{-4} \times 10^3) = 0.827$$

using Eq. (3.1) where:

$$Attenuation = 10\ log_{10}\left(\frac{1}{\mathcal{L}_{km}}\right) = 10 \log_{10}(1.209) = 0.8\ dBkm^{-1}$$

At a wavelength of 1.3 μm:

$$\gamma_R = \frac{1.895 \times 10^{-28}}{2.856 \times 10^{-24}} = 0.664 \times 10^{-4}\ m^{-1}$$

$$\mathcal{L}_{km} = \exp(-\gamma_R L) = \exp(0.664 \times 10^{-4} \times 10^3) = 0.936$$

using Eq. (3.1) where:

$$Attenuation = 10\ log_{10}\left(\frac{1}{\mathcal{L}_{km}}\right) = 10 \log_{10}(1/0.936) = 0.3\ dBkm^{-1}$$

Q2-d:

$$\gamma_R = \frac{8\pi^3}{3\lambda^4} n^8 p^2 \beta_c K T_F$$

$$\mathcal{L}_{km} = \exp(-\gamma_R L)$$

$$Attenuation = 10\ log_{10}\left(\frac{1}{\mathcal{L}_{km}}\right)$$

n= 1.49

Q3-a

Explain two types of power losses in optical fibers and how to face these factors?
material absorption losses divided into two phases
The absorption of the light may be intrinsic (caused by the interaction with one or more of the major components of the glass) or extrinsic (caused by impurities within the glass)
Intrinsic absorption: causes a power losses in UV region, near IR region
The strong absorption bands occur due to oscillations of structural units such as Si–O (9.2 μm), P–O (8.1 μm), B–O (7.2 μm) and Ge–O (11.0 μm) within the glass.
Extrinsic absorption
from transition metal element impurities. Some of the more common metallic impurities found in glasses are shown in the Table 3.1, together with the absorption losses caused by one part in 10^9

Linear scattering Losses

This process tends to result in attenuation of the transmitted light as the transfer may be to a leaky or radiation mode which does not continue to propagate within the fiber core, but is radiated from the fiber
Overcoming or reducing power losses

1- Reducing the absorption lossess due to atomic defects by making the material without crystalline defects
2- Reducing the absorption lossess due to intrinsic losses by using the optical fiber with light interaction in range from 800nm to 1550nm
3- Reducing the absorption lossess due to extrinsic losses by decreasing the impurities in fiber.
4- Avoid the scattering losses by making the fiber more homogeneous medium and the geometry perfect cylinder.

Q3-e:

Ans.

$$I_o = I_1 + I_2 = I_1 + \frac{V_2}{R_2} = I_1 + \frac{I_1 R_1}{R_2} =$$

$$I_0 = I_1\left[1 + \frac{R_1}{R_2}\right]$$

$V_o = -[I_1 R_1 + I_0 R_L]$