Benha University   Electrical Department
Benha Faculty of Engineering   B. Sc. Course Exam
January, 2017   Electrical Measurement(B),E1207
Exam (Regular)   Allowed Time: 3 Hours
Examiner: Zinab Afifi ; Ph.D.

وحدة الجودة والاعتماد

Question.1   [*25 marks*]

A. How does the cathode ray tube CRT generate the electron beam until displaying it on its screen? (Explain briefly).

Solution:

1. **The glass envelope** is evacuated to a high vacuum to permit the electron beam to traverse the tube easily.

2. **The electron gun assembly** consists of (a. the triode section and b. the focus section).

The purpose of the electron gun assembly is to provide a source of electrons, converge and focus them into a well-defined beam, and accelerate them toward the fluorescent screen.

A. The Triode: (Heated Cathode + Grid Cap)

The electrons that make up the beam are given off by thermionic emission from the heated cathode.

The cathode is surrounded by a cylindrical cap that is set at –ve potential. So electrons are repelled away from the cylinder walls and, therefore, stream through the hole where they move into the-electric fields of the focusing anodes.

B. The focus ring consists of the first anode (focus ring) and second anode (astigmatism hole).

The purpose of this section is to converge and collimate the beam to obtain the minimum-size and best-defined spot on the phosphor screen of the CRT.

3. **The deflection system**.

• Waveforms can be displayed on the CRT's phosphor screen only if there is some means of deflection of the electron beam both horizontally and vertically. This is the function of the deflection plates.

• When the electron beam strikes the phosphor-coated face of the CRT, a spot of light is produced (<u>fluorescene</u>).

B. Drive the equation of the deflection sensitivity of an oscilloscope. What is the acceleration anode voltage if the deflection sensitivity of an oscilloscope is 35V/cm, the distance from the deflection plates to the CRT screen is 16 cm, the length of the deflection plates is 2.5 cm. and the distance between the deflection plates is 1.2 cm.

Solution:

During the period of acceleration in the electron gun assembly, the electrons have gained kinetic energy;

$$E_k = V_2 Q$$

Mechanical kinetic energy

$$\tfrac{1}{2}mv^2 = V_2 Q$$

The electric field between the plates is

$$E_d = \frac{V_d}{d}$$

A lateral force exerted on the electrons is

$$F = E_d Q$$

The deflecting force given as

$$F_d = \frac{V_d Q}{d}$$

Since $F = am$ (Newton's 2nd law), then $F_d = a_y m$

Then

$$a_y = \frac{V_d Q}{dm}$$

The deflection distance, expressed as a function of the time that the electron spends between the deflection plates, is given by the kinematic equation

$$h = \tfrac{1}{2} a t^2$$

Then we get

$$h = \frac{V_d Q t^2}{2dm}$$

The time, t. required for the electrons to pass between the plates is given as

$$t = \frac{L}{v}$$

And then

$$h = \frac{L^2 V_d}{4 V_2 d}$$

$$\theta = \frac{h}{L/2} = \frac{2h}{L}$$

$$\theta = \frac{y}{R}$$

$$\frac{y}{R} = \frac{2h}{L} \qquad y = \frac{2hR}{L} \qquad y = \frac{RLV_d}{2V_2 d}$$

$$\frac{V_d}{y} = \frac{2V_2 d}{RL} \qquad \text{...Deflecting sensitivity}$$

$V_2 = V_d\, R\, L\, / 2\, d\, y = 35*2.5*16/ 2*1.2 = 583.333$ V

C. Complete the missing words in the following sentences;
   i. The vertical input must be <u>equal</u> or <u>exact multiple</u> of the sweep generator signal to reach synchronization.
   ii. The <u>Graticule</u> is a grid of lines that serves as a scale when making time and amplitude measurements with an oscilloscope.
   iii. The product of <u>gain</u> times <u>bandwidth</u> is always constant for a given amplifier.
   iv. Push pull amplifier provides <u>the same voltage</u> at the output but <u>inverted by 180 degree</u> .
   v. The deflection may be applied <u>electrostatically</u> or <u>magnetically</u> as in TV.

D. Draw the simplest sweep generator circuit and the associated input and output waveforms, then describe its function.

   Solution:
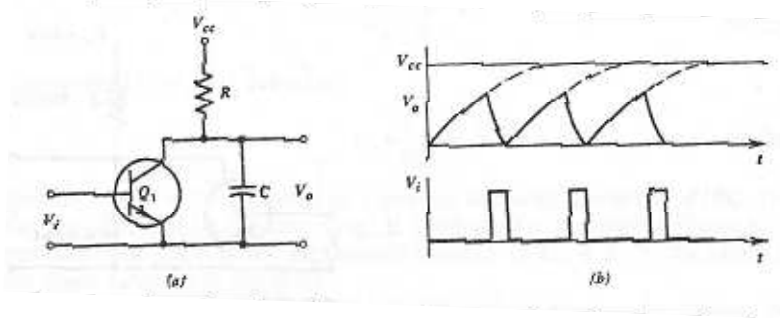
   At T_S , (Charge)
   $Vo = Vcc (1- \exp^{(-t/RC)})$
   • **At Tr , (Discharge)**
   $Vo' = Vo * \exp^{(-tr/R1C)}$

The sweep generator develops unit ramp voltage, sawtooth wave, (increases linearly with time) at the horizontal deflection plate, causes the beam to be deflected equal distances horizontally per unit of time

E. An oscilloscope is to have an input resistance of 8MΩ as shown in Fig.1, a sensitivity of 50mV and attenuation factors of 4, 10, 40, 100 and 400. Compute the value of the attenuating resistors and the volts/division corresponding to each attenuation factor.

   Solution:
   Position A:
   Attenuation Factor A = 400 = R_T/R_A= 8M/ R_A
   R_A= 20KΩ
   Volt/div (A)=400*50m = 20 V/div
   Position B:
   Attenuation Factor B = 100 = R_T/R_A+R_B= 8M/ R_A +R_B
   R_B= 60KΩ

Volt/div (B)=100*50m = 5 V/div

Position C:

Attenuation Factor C = 40 = $R_T/R_A+ R_B + R_C$= 8M/ $R_A+ R_B + R_C$

R_C= 120KΩ

Volt/div (C)=40*50m = 2 V/div

Position D:

Attenuation Factor D = 10 = $R_T/R_A+ R_B + R_C+R_D$= 8M/ $R_A+ R_B + R_C +R_D$

R_D= 600KΩ

Volt/div (D)=10*50m = 0.5 V/div

Position E:

Attenuation Factor E = 4 = $R_T/R_A+ R_B + R_C+R_D+R_E$= 8M/ $R_A+ R_B + R_C +R_D +R_E$

R_E= 1200KΩ

Volt/div (E)=4*50m = 0.2 V/div

$R_F=R_T-(R_A+ R_B + R_C+R_D+R_E)$= 6MΩ

Volt/div (F)=1*50m = 50m V/div

F. The pulse train shown in Fig.2a triggers a sweep generator, causing the display shown in Fig.2b to appear on the CRT screen. What is the setting of the Time/Div switch?

Solution:

Time/Div= one Cycle time/one Cycle # div = 10m/ 5div = 2m sec/div

Question.2   [*25 marks*]

A. What are the parameters of concern when selecting a transducer for certain application then give the difference between self-generating and passive transducers?

Solution:

The parameters are:

1. operating range
2. Sensitivity
3. Frequency response and resonant frequency
4. Environmental compatibility
5. Minimum Sensitivity-
6. Accuracy
7. Usage ad ruggedness
8. Electrical wiring

Passive Transducers they require external power supply and their output is a measure of some variation such as R and C.

The self-generating type does not require the application of external energy. They produce an analog voltage or current stimulated by some physical form of energy.

B. Explain how the piezoelectric transducer works giving examples of its types. How much mechanical energy (in joules) must be applied to produce electrical output energy of 50 mJ, knowing that the crystal has a coupling coefficient of 0.25?

Solution:

Principle: When a mechanical pressure is applied to a crystal (a Rochelle salt, quartz, or tourmaline type), causes a potential difference will occur.

Coupling Coefficient K= *Output (Electrical or Mechanical) / Input (Mechanical or Electrical)*

Output electrical energy = 0.25*50m = 12.5mJ = 0.0125 J

C. Name five different types of photoelectric transducers. And explain in details the theory of operation of photomultiplier tube with aid of sketch.

1. *Photomultiplier tube*

- *Principle:*
  Photoemissive devices, radiation falling on cathode causes electrons to be emitted from cathode surface.

- *Construction:*

- *It consists of evacuated glass envelope containing a photo cathode, an anode and additional electrodes called dynodes, each at higher voltage.*

- *When electrons strike an electrode, it emits a greater number of electrons (electron multiplication).*

- *High sensitivity.(1 A per lumen, 1000 A per lumen,…..)*

Photomultiplier Tube

Figure 1
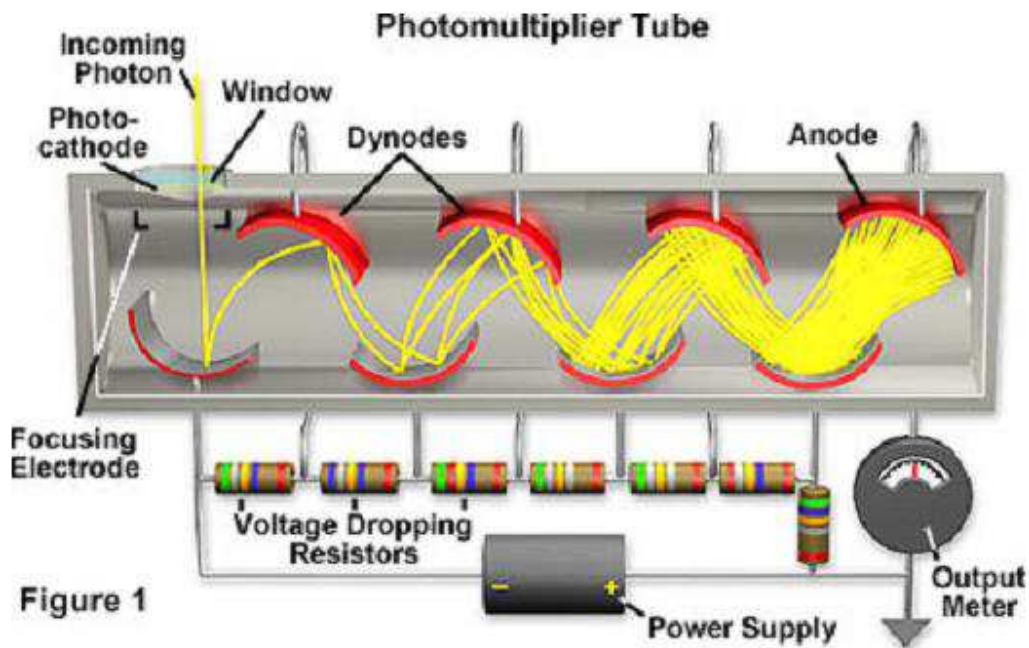
2. *Photoconductive cells*
3. *Photovoltaic cells*
4. *Semiconductor Photo diode*
5. *Semiconductor Photo transistor*

D. "The strain gauge is used to sense the weight but it is so sensitive for temperature". What can be done to avoid this problem?

Quarter-bridge strain gauge circuit with temperature compensation
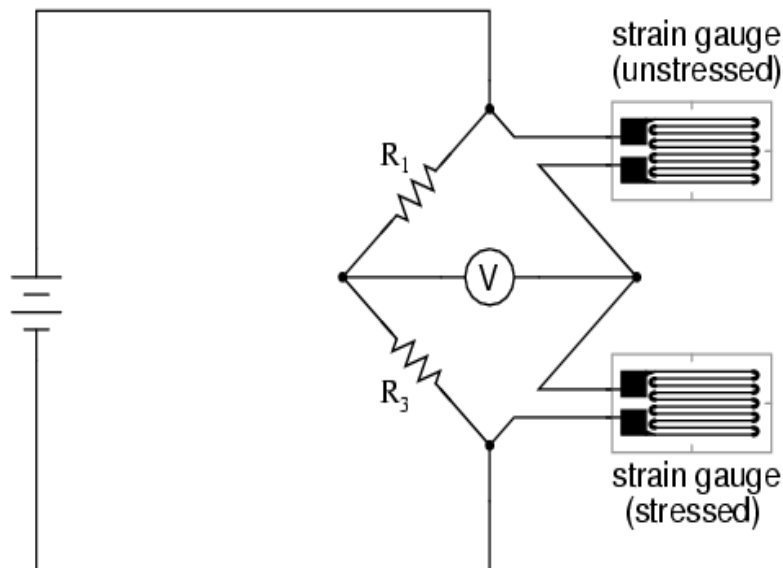
E. Complete the missing words in the following sentences;

i. The <u>flowmeter</u> transducer is the most suitable transducer for detecting the flow rate of a conductive fluids whereas the <u>ultrasonic</u> transducer is suitable for nonconductive fluids.

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ii. The resistive position transducer is used to sense <u>the position</u> or <u>the distance that the object has moved</u>

iii. A temperature sensor its controller shouldn't be 4m far from it unless the sensed signal will be distorted. This is called <u>Electrical wiring</u> in selecting transducer parameters.

F. A certain thermocouple provides outputs in the vicinity of $0.05 mV/^oC$ with a constant $K=5\times10^{-5}$ $mV/^oC$ and the cold junction is kept in ice. If the output voltage is 5mV find the temperature of the hot junction.

Solution:

$E = c(T_1-T_2) + k(T^2_1-T^2_2) = 5m = 0.05\,T_1 + 5\times10^{-5}\,T^2_1$

$T_1 = 91.61\ ^oC$

G. We are given the circuit of Fig.3 using 10 V supply voltage. A current of 5mA flows when the cell is illuminated with about $400\ lm/m^2$. And de-energized when the cell is dark. Find

    a. The required resistance R_1.

    Solution:

    $R_1 + R_{PC} = V/I = 10/5m = 2\ K\Omega$

    $R_1 = 2\ K\Omega - R_{PC} = 2 - 1K = 1\ K\Omega$

    b. The level of dark current.

    Solution:

    $I(dark) = V/R_1 + R_{PC} = 10/\,1\ K\Omega +100\ K\Omega = 39\ \mu A$

Question.3   [*25 marks*]

A. Explain the principle of operation and construction of single slope analog to digital converter with its timing diagram**.**

The fundamental concept of single slope converter is to make a linear conversion of unknown voltage to time.

Conversion to time is needed for counting circuits.

Obtaining linear relationship between voltage and time.(t αV)

(a)

(b)
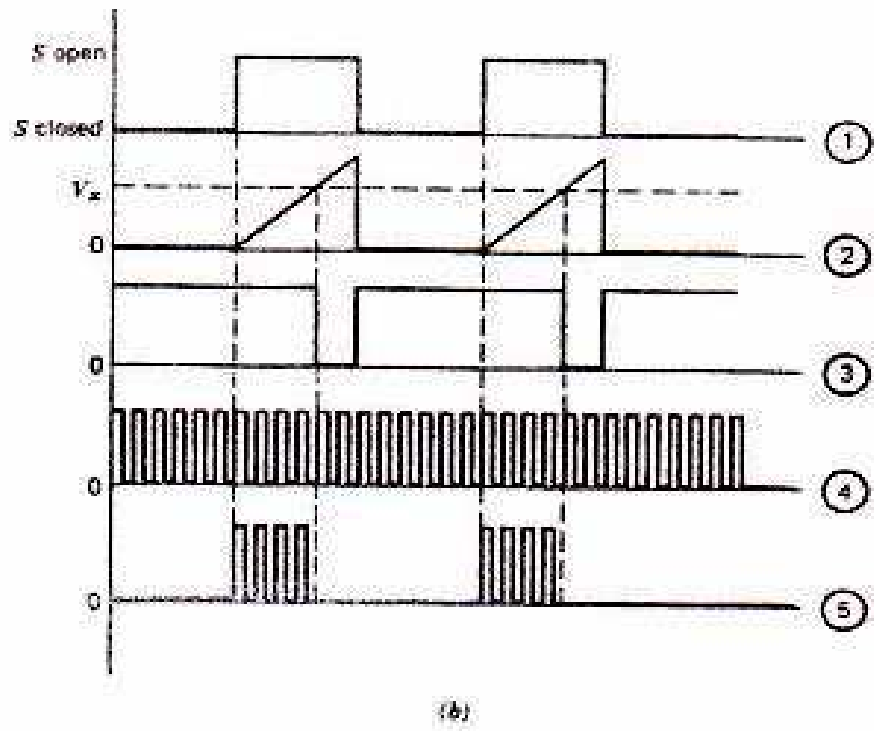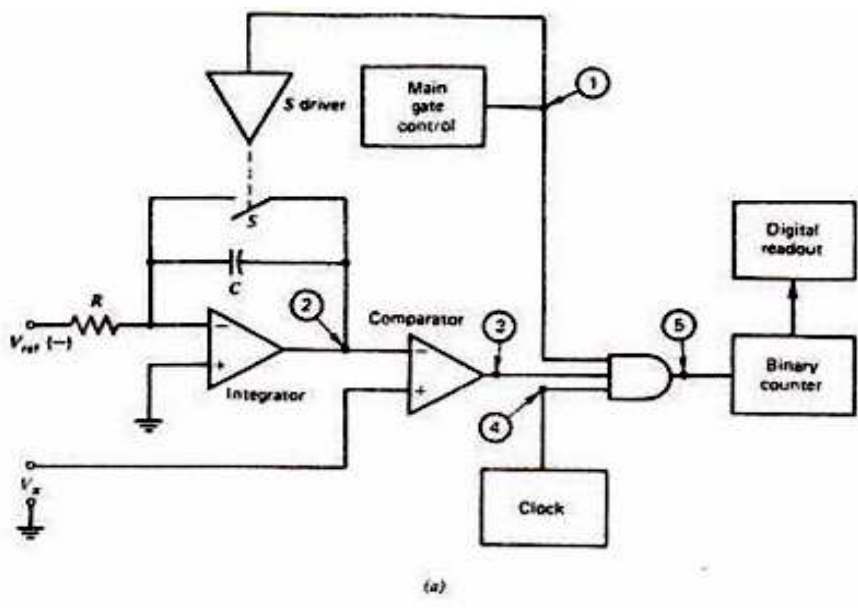
B. What are the limitations of single slope A/D converters.

   Solution:

1. It can measure only voltages with one polarity.
2. Accuracy depends on the stability of the capacitor.
3. Accuracy depends on the stability of the differential voltages that trips the comparator.
4. Susceptible to noise on the analog voltage.
5. Susceptible to oscillator frequency drift.
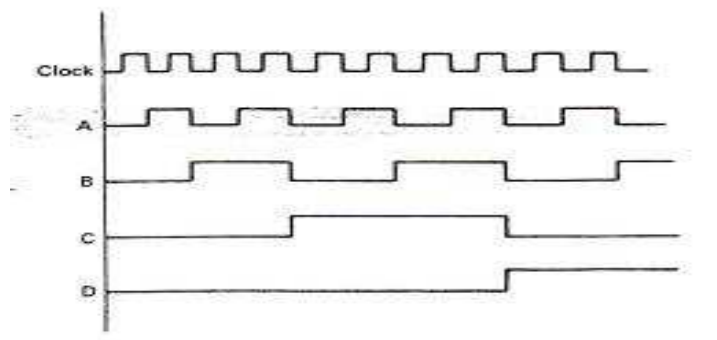6. Susceptible to drift in the constant current source.

7. Additional circuitry is needed for overrange conditions.

C. Describe how ABCD four flip-flops used to count when the input pulses were as shown in Fig.4. Which LEDs will be ON in this case.

Fig.4

Solution:

AD ON

D. List six modes of operation of electronic counter and describe the time – interval mode in details.

Solution:

1.The totalizing mode

2.The frequency mode

3.The period mode

4.The ratio mode

5.The time-interval mode

6. Averaging Mode

⊙ Measure the elapsed time between two events.

⊙ The start event (signal or input) opens the AND gate and the counter starts counting the clock pulses.

⊙ The stop event (signal or input) closes the AND gate.

During the time interval between the start and stop signals clock pulses accumulate in the register indicating the time interval between the start and stop signals
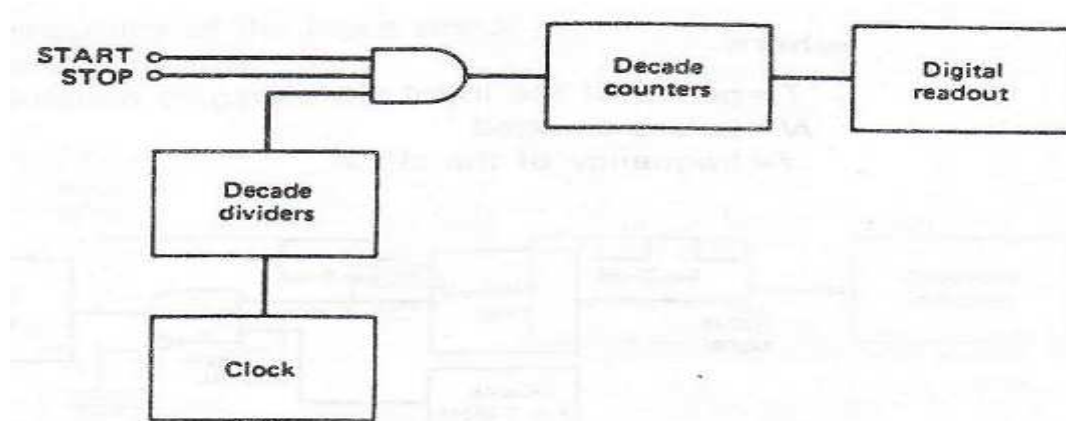
E. The DVM uses 1 V reference voltage, 1 KHz clock, and three-decade electronic counter. The integrating capacitor charges to 6 V in 1 sec. and discharges at a rate of 10V/sec.

    a. What are the amplitude and the frequency of the input voltage if the counter has stored 1600 pulses?

    Solution:

    $(T3- t2) = (t2 – t1)\ Vi/Vref$

    $Vi = 0.6\ V$

    $T = N/f = 1600/\ 1K = 1.6\ sec$

    $F = 1/T = 625\ mHz$

    b. In What mode of operation does this electronic counter operate?

    Solution:

    Time Mode

    c. What are the final numbers appearing in the used counter.

Solution:600

F. The ratio of input voltage to output frequency for the VCO is 0.2. If 405 pulses are stored by the counter during one gate pulse. If the input voltage was 50 V what is the duration of the gate pulse.

Solution:

$0.2 = V/\ F =t\ V/\ N = 50*t\ /\ 405$

$T= 1.62\ sec.$

Good Luck