B.SC. IV YEAR

Laboratory Work Manual

General & Electronics

Central Department of Physics
Tribhuvan University, Kirtipur

Content

To determine the wavelength of given source of light by Fresnel's Biprism.

THEORETICAL BASIS

The objective of this experiment is to find out the wavelength, λ, of a quasi-monochromatic beam emitted by a spectral Sodium (Na) lamp. The set-up we are going to use is similar to that of Young's double slit, though using a single slit followed by a Fresnel biprism. This arrangement was devised by Fresnel to obtain two beams overlapping in space and able to interfere (coherent beams). The biprism is cut in a single piece (see Fig.1), but the refraction of the light coming from the real source **S** is different at either side of the edge, producing two virtual images, $\mathbf{S_1}$ and $\mathbf{S_2}$, that are the effective sources for the illumination on a plane π at a distance *D* from S. [In other words, $\mathbf{S_1}$ and $\mathbf{S_2}$ are the images of **S** through each prism] The small angle α characterizes the prism, and, together with the distance to **S**, determines the separation, *d*, between the virtual sources $\mathbf{S_1}$ and $\mathbf{S_2}$.

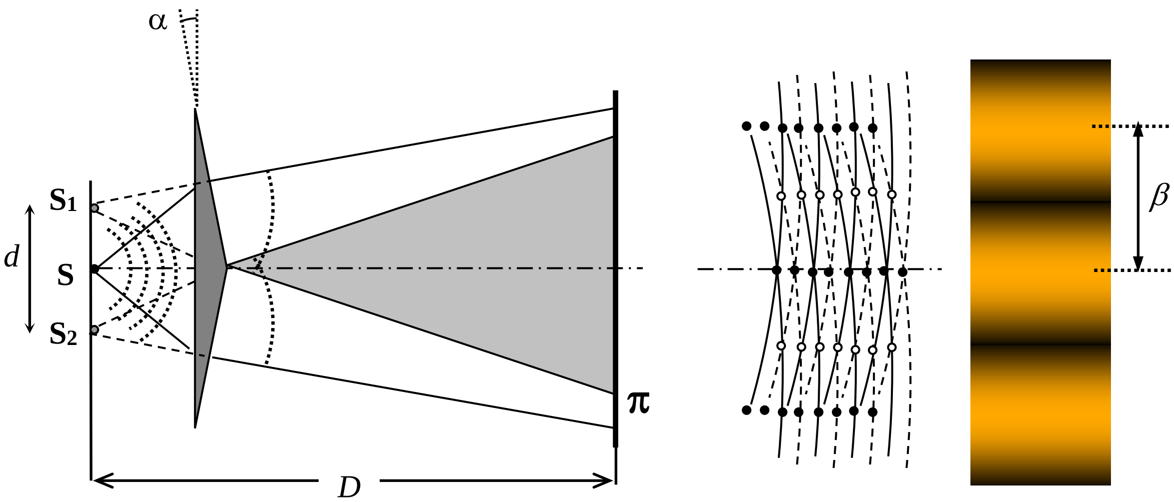


Figura 1. **Left**: Schematic top-view of the Fresnel biprism experiment. **S** is the slit-source and $\mathbf{S_1}$ and $\mathbf{S_2}$ the positions of the virtual slits (separation *d* is somewhat increased for the sake of clarity, a typical value of about 1mm being more realistic). The shadowed region is the beam superposition area, where the interferential fringes can be observed. The screen, $\boldsymbol{\pi}$, where the fringes are visualized, cut that area. **Centre**: Detail of the interfering condition on the screen. Wavefronts coming from either $\mathbf{S_1}$ and $\mathbf{S_2}$ are separated in $\lambda/2$ intervals. Black points indicate constructive addition, and hollow ones destructive. The first correspond to maxima in the interferential pattern, and the second to minima, producing the overall fringes (**Right**)

WORKING FORMULA

The distance between the virtual slits is denoted by "*d*", the distance from the plane containing $\mathbf{S_1S_2}$ to the plane π, where the interference is observed, is denoted by "*D*" and the distance between two consecutive bright fringes is denoted by "*y*". Then, from the interference condition the following relation is obtained:

$$\beta = \frac{D\lambda}{d} \qquad (1)$$

and this allows us to obtain the value of λ from the measurement of β, *D*, and *d*.

EXPERIMENTAL SET-UP

1. Place the Sodium (Na) lamp so that it conveniently illuminates the slit.

2. Place all the components in their approximate positions. This means that, for the raw eye, they are all hanging on the same axis, at the same height and perpendicular to the axis of the bench.

3. Focus the eyepiece of the microscope (that can move inside its frame, where it fits into) on its reference cross (drawn on a thin glass slide inside the metal cylinder), and rotate that frame so that one cross line gets vertical.

4. Focusing the microscope on the slit, align the vertical reference with it. This implies moving the microscope along the bench for focusing, vertically to see the slit centred in the field of view, and transversely to make the vertical line approximately overlap with the slit. From this moment, the microscope will serve as a transversal reference for other elements. Put apart the microscope and place the biprism near the slit (at a few centimetres). Now we focus the microscope on the biprism and try to observe the edge, seen as a vertical bright line. It is the biprism that must be moved transversely now till the vertical reference line overlaps with the image of the edge. To get a precise overlapping, rotate by hand the reference cross of the microscope. It is important to achieve a good overlapping in this part.

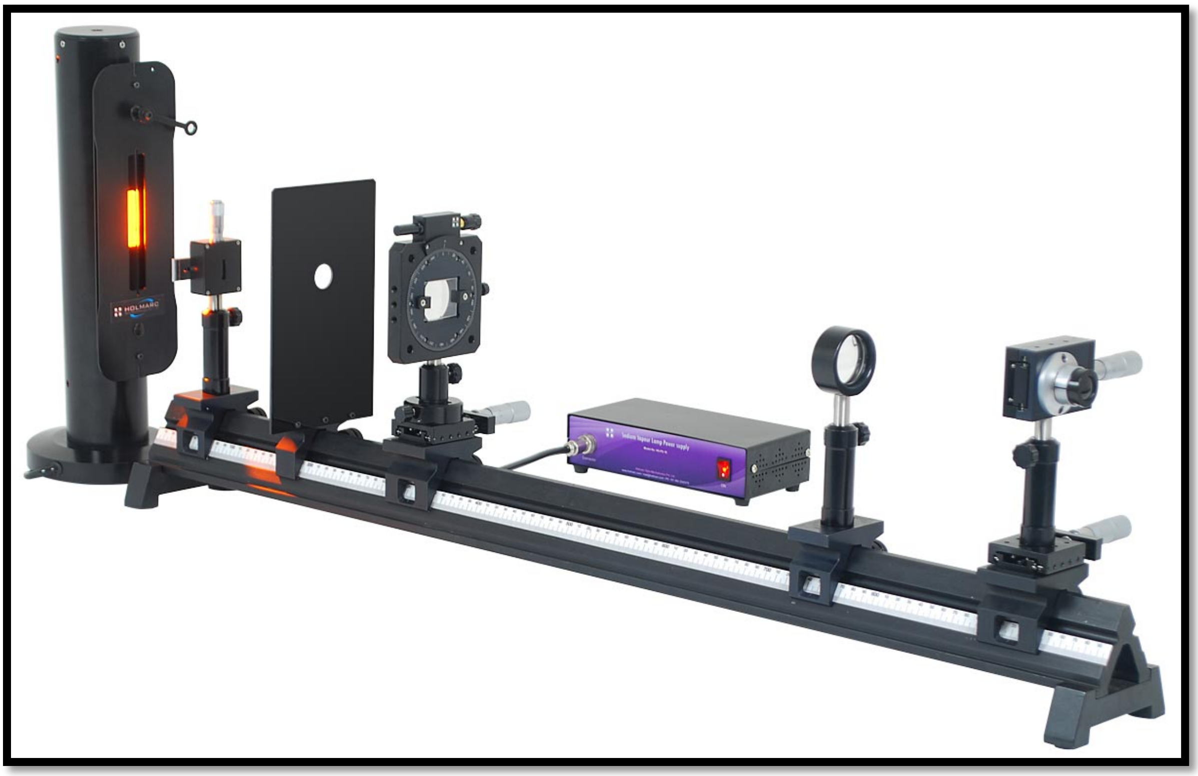


Figure 1: Experimental set up of Freshnel Biprism Experiment

5. We now put apart the biprism (handling it with great care) and focus the microscope again on the slit, moving carefully the microscope on the bench. We rotate the slit, either with the coarse (unblocked screw and hand rotation) or with the fine adjustment wheel (blocked screw), till it gets parallel to the vertical reference of the microscope. It may be necessary now to make a new transversal movement of the slit, to achieve a perfect overlapping. After this, the slit and the biprism edge should be well aligned. This can be checked with the microscope, and steps 4 and 5 might be repeated if the result is not considered satisfactory.

6. Place the converging lens on the bench, and try to centre it transversely so that it gets approximately aligned with the microscope.

7. Now we must centre the eyepiece with which to observe the actual interference fringes. This eyepiece must focus on a faint cross drawn on a thin glass slide, mounted in the same frame than the eyepiece itself. We first take the eyepiece out of its frame, and focus the microscope on the faint cross. This cross must be rotated and moved transversely and in height on its holder, so that it gets centred with the microscope reference. We can put again the eyepiece, focused on its faint reference cross.

8. We now can improve a little bit the alignment performed so far. We put the slit, then the biprism and then the eyepiece, at a certain distance, and look through it. If the fringes don't have good visibility (high contrast), we can either rotate the slit slowly, or make it narrower (with the open/close screw). This operation is properly carried out by two people.

9. A final check can be performed as follows: Put the eyepiece close to the biprism and centre its vertical reference on the central fringe. Then, we carry the eyepiece farther and farther while looking through it. Ideally, the same fringe should keep centred. We may change to another initial fringe to improve the result in case we had failed to take the central one. If the reference moves only one fringe we can consider the alignment acceptable.

OBSERVATION

10 smallest division of the main scale = ... cm

1 smallest division of the main scale = ... cm

a division of vernier coincides with ***b*** division of main scale.

1 division of vernier coincides with ***b/a*** division of main scale.

Thus, the least count of the scale is

$$L.C. = \left(1 - \frac{b}{a}\right) \times 0.1 \text{ cm}$$

(1) For fringe width (β)

Slit (S) cm	Eyepiece (E) cm	D = $S-E$ cm	1st Fringe			nth fringe			n	$\beta = \frac{\|b-a\|}{n}$	$\bar{\beta}$ mm
			MSR	VSR	Total (a)	MSR	VSR	Total (b)			
		(D_1)							10		(β_1)
									10		
									10		
									10		
									10		
		(D_2)							12		(β_2)
									12		
									12		

									12		
									12		
		(D_3)							**15**		$(\boldsymbol{\beta_3})$
									15		
									15		
									15		
									15		

(2) For slit width (*d*)

D cm	L1							L2							$d = \sqrt{L_1 L_2}$
	1st Fringe			nth fringe			$L_1 = \lvert Y - Z \rvert$	1st Fringe			nth fringe			$L_2 = \lvert M - K \rvert$	
	MS	VS	Total (Z)	MS	VS	Total (Y)		MS	VS	Total (K)	MS	VS	Total (M)		
(D_1)															$(\boldsymbol{d_1})$
(D_2)															$(\boldsymbol{d_2})$
(D_3)															$(\boldsymbol{d_3})$

CALCULATION

For a particular D, we have this expression: $\lambda = \frac{\beta d}{D}$.

For **D_1,**

$$\boldsymbol{\lambda_1} = \frac{\boldsymbol{\beta_1 d_1}}{\boldsymbol{D_1}} = \underline{\hspace{6cm}} = \square\square\ \ \square \qquad\qquad mm = \text{Å}$$

For **D_2,**

$$\boldsymbol{\lambda_2} = \frac{\boldsymbol{\beta_2 d_2}}{\boldsymbol{D_2}} = \rule{6cm}{0.4pt} = \square\square \quad \square \qquad mm =$$

Å

For **D3,**

$$\boldsymbol{\lambda_3} = \frac{\boldsymbol{\beta_3 d_3}}{\boldsymbol{D_3}} = \rule{6cm}{0.4pt} = \square\square \quad \square \qquad mm =$$

Å

ERROR ANALYSIS

Here we find the average value of the wavelength of sodium light, standard deviation and standard error.

S.N.	$\boldsymbol{\lambda}$(Å)	$\boldsymbol{\lambda^2}$
1		
2		
3		
	$\Sigma\lambda =$	$\Sigma\lambda^2 =$

The average value of

$$\bar{\lambda} = \frac{\Sigma\lambda}{n} = \rule{4cm}{0.4pt} = \qquad \text{Å}$$

The standard deviation

$$S.D. = \sigma(\lambda) = \sqrt{\frac{\Sigma\lambda^2}{n} - \left(\frac{\Sigma\lambda}{n}\right)^2} = \rule{4cm}{0.4pt} = \qquad \text{Å}$$

The standard error,

$$S.E. = (\Delta\lambda)_{SE} = \frac{\sigma}{\sqrt{n}} = \rule{4cm}{0.4pt} = \qquad \text{Å}$$

RESULTS

The wavelength of given monocromatic light was calculated using Freshnel Biprism and was found to be ………………………… ± ………………… with standard deviation ……………………

INTERPRETATION OF YOUR RESULT

You need to interpret your result yourself.

PRECAUTION

Write down precaution that you faced or experienced during the experiment.

To Determine Half Life of Given Radioactive Sample.

DESCRIPTION

This Cs-137/Ba-137 m Isotope Generator is used to demonstrate the properties of radioactive decay. Based on the original Union Carbide patented design, it offers exceptional performance, ease-of-use and safe operation. Each generator contains 10 µCi of Cs-137. The generator can produce up to 1000 small aliquots of the short-lived Ba-137m isotope with a half-life of 2.6 minutes. Each generator is supplied with 250 mL of eluting solution (0.9% NaCl in 0.04M HCl). The parent isotope Cs-137 with a half-life of 30.1 years beta decays (94.6%) to the metastable state of Ba-137m. This further decays by gamma emission (662 keV) with a half-life of 2.6 min. to the stable Ba-137 element. During elution, the Ba-137m is selectively "milked" from the generator, leaving behind the Cs-137 parent. Regeneration of the Ba-137m occurs as the Cs-137 continues to decay, re-establishing equilibrium in less than 1 hour.

Figure 1: Cs-137/Ba-137 m Isotope Generator Kit

Approximately 30 minutes after elution, the residual activity of the Ba-137m sample has decayed to less than one thousandth of its initial activity, making it safe for disposal. When used with the eluting solution supplied, bleed through of the parent Cs-137 is less than 50 Bq/mL, affording a long working life. Each kit is supplied with the generator, syringe, tube, 250 mL of solution and a storage case. A new cesium-137/barium-137m generator system was developed to produce high purity 137mBa with high efficiency when using acid, alkali, or saline as eluants.

WORKING FORMULA

The decay of unstable nuclei with the emission of particles or radiation is known as radioactivity. This decay is a random process. Though it can be studied using laws of radioactivity, which is based on the laws of probability.

It there are N radioactive atoms at any time 't', the probability for any one of these to decay at any instant is the same for all. A small fraction of such decays (dN) is obviously proportional to the total number of such atom (N) and required duration (dt) for the decay, i.e.,

$$dN \propto -N\, dt$$

After integrating we get the lows of radioactive decay as,

$$N = N_0\, e^{-\lambda t} \qquad (1)$$

Here, N_o and N represent number of radioactive atoms at time t = 0 sec and at time t = t. The λ is the disintegrating constant. The half life of radioactive material can be calculated by inserting N = N_o/2 in the above equation, we finally get,

$$T_{1/2} = \frac{ln2}{\lambda} = \frac{0.693}{\lambda} \qquad (2)$$

In this experiment, we intend to calculate halflife of unknown radioactive sample. The value of disintegrating constant will be calculated using best fit curve.

EXPERIMENTAL SET-UP

Go to C. L. Arora or any other B.Sc. Laboratory work book for the detail procedure. Your teacher will describe the method. [Note: You don;t need to prepare eluting solution!]

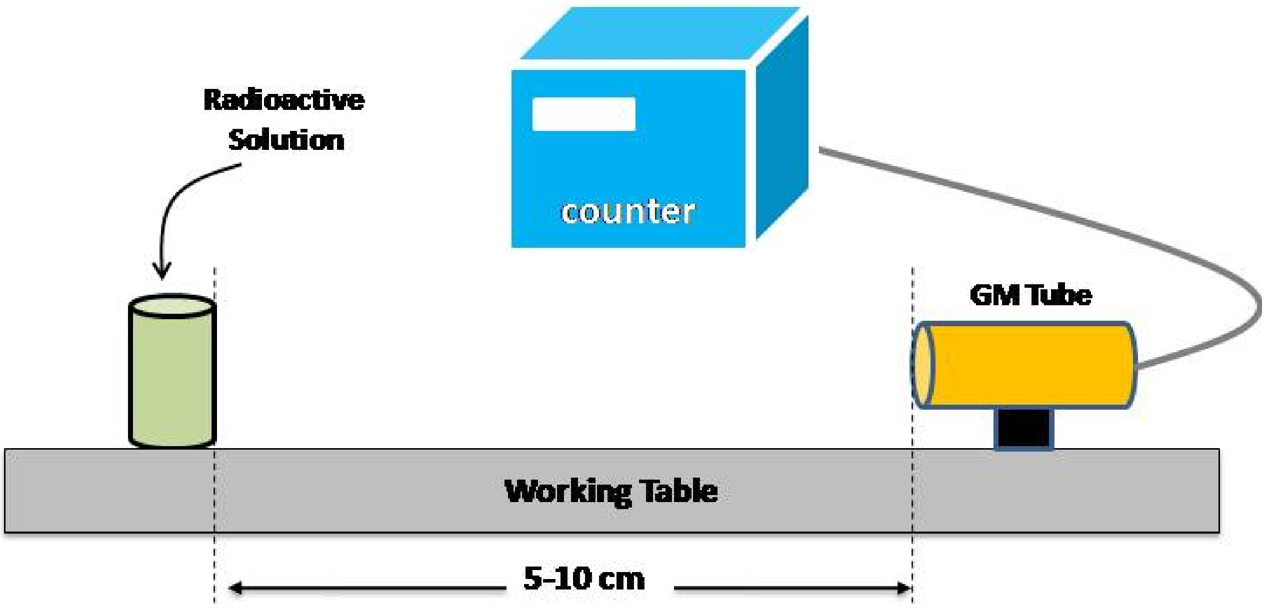


Figure 2: Experimental Set up

OBSERVATION

(a) For operating voltage of GM Tube (do NOT put any source for calibrating GM tube)

S.N.	Voltage (Volts)	Count rate per 30 seconds (at least 10 readings)	Average count/30 sec

1			
2			
3			
4			
5			
6			
7			
8			

The platue curve of GM tube describe its rosponce towards the decays, shown below:

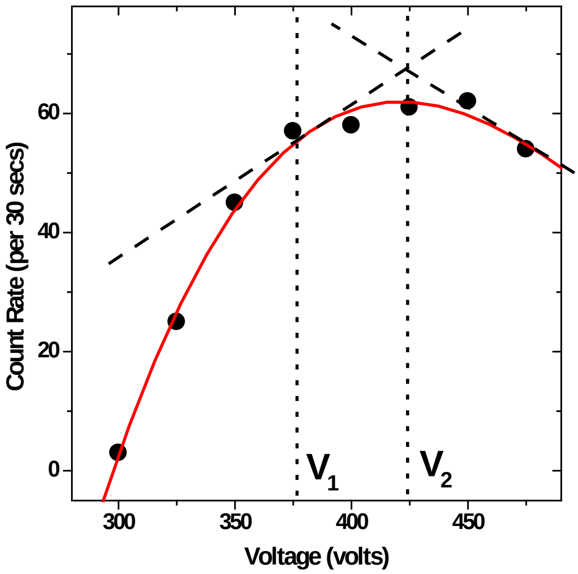


Figure 3: Platue Curve to calculate operating voltage of GM counter

(do NOT use any radioactive source!)

From the graph, V_1 = ... volt

V_2 = ... volt

Operating voltage is,

$V = V_1 + (V_2-V_1)/3$ = ... volt (3)

The background count at the operating voltage (= .... volt):

The average background count per 30 sec is ....

The background count **(B)** per second is ....

(b) For calculating the half life of recently prepared eluting solution (Note: You need to take begin observation as soon as you prepare source sample and take observation or reading continuously without spare of time.)

Time (sec)	Count Rate per 10 Seconds (O)	Count Rate per Second (N)	Background Subtracted (N-B)
10			
20			
30			
40			
50			
60			
70			
80			
90			
100			
110			
120			
130			
140			
150			
160			
170			
180			
190			
200			
210			
220			
230			
240			

BEST FIT CALCULATION

Let ***y = ln(C)*** and ***x*** is the period of observation, then

$$\boldsymbol{y = mx + c} \qquad \textbf{(4)}$$

represents the best fitted line (shown in Figure 5), where *m* is the slope and *c* the intercept. In the Taking sum, equation (4) takes this form:

$$\boldsymbol{\Sigma y = m\Sigma x + nc} \qquad \textbf{(5)}$$

Multiplying (4) by Σ***x***,

$$\boldsymbol{\Sigma yx = m\Sigma x^2 + c\Sigma x} \qquad \textbf{(6)}$$

Multiplying (5) by Σ***x*** and (6) by ***n*** and solving these expression for the slope (***m***), we get,

$$\boldsymbol{m = \frac{n\Sigma yx - \Sigma y\Sigma x}{n\Sigma x^2 - (\Sigma x)^2}} \qquad \textbf{(7)}$$

and intercept is given by,

$$\boldsymbol{c = \frac{\Sigma y - m\Sigma x}{n}} \qquad \textbf{(8)}$$

In order to best fit, you need to calcúlate following variables in this tabular form:

SN	Count / 10 sec (O)	Count / sec (N)	Corrected *C*(N-B)	y_i = ln*C*	x_i	x_i^2	x_i y_i
1					10	100	
2					20	400	
3					30	900	
4					40	1600	
5					50	2500	
6					60	3600	
7					70	4900	
8					80	6400	
9					90	8100	
10					100	10000	
11					110	12100	
12					120	14400	
13					130	16900	
14					140	19600	
15					150	22500	
16					160	25600	
17					170	28900	

18					180	32400		
19					190	36100		
20					200	40000		
21					210	44100		
22					220	48400		
23					230	52900		
24					240	57600		
Sum (Σ) =								

PLOTTING

Figure 4 shows the expected plottings (students need to use graph papers with pencil) between calculated the refractive index with suger concentration.

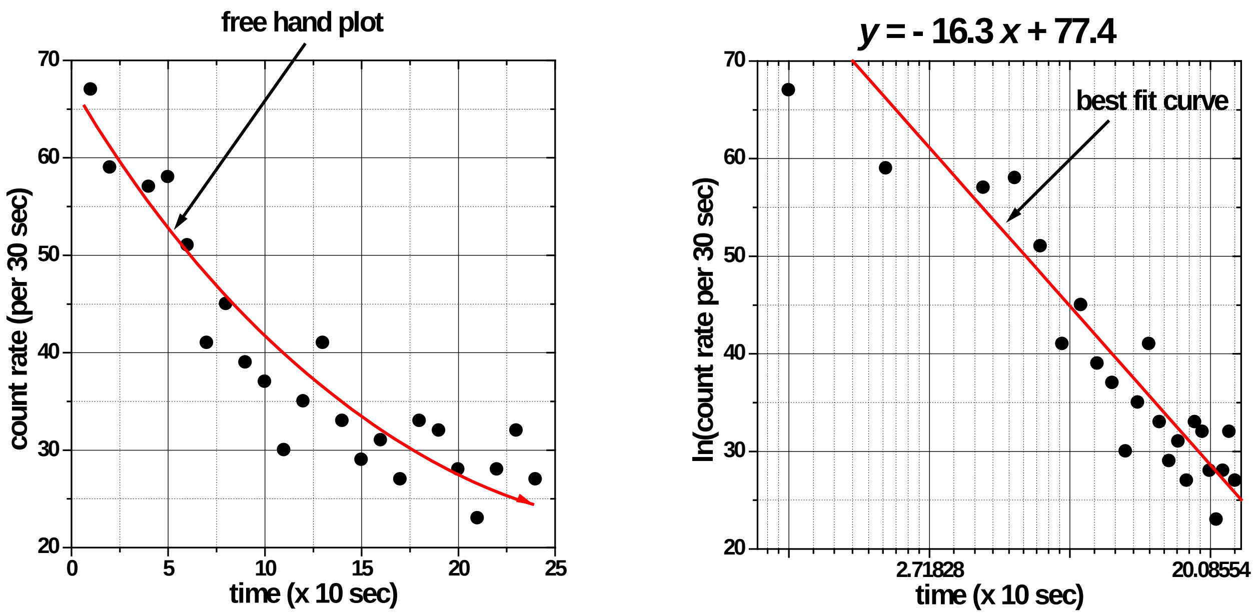


Figure 4: Count rate (in *linear* scale: left & in *logarithmic* scale: right) versus time [based on observed data at CDP]. The nature of the distribution seems like exponantial decay (left). The nature of the distribution fits the laws of radioactivity, lnC is proportional to time (b). You need to fit your observed data using (7) and (8).

We get

$$m = \frac{\qquad\qquad}{\qquad\qquad} =$$

and intercept

$$c = \frac{\qquad\qquad}{\qquad\qquad} =$$

We use the value of slope to find the value of half life of the prepared liquid source.

$$decay\ constant\ (\lambda) = -m =$$

And the half life

$$\text{Half Life}\ (T_{1/2}) = \frac{0.693}{\lambda} = \frac{0.693}{-m} = \frac{}{} = \qquad secs$$

RESULT

It is found that the half life of given liquid sample is ………………………………. secs.

INTERPRETATION OF YOUR RESULT

You need to interpret your result yourself.

PRECAUTION

Write down precaution that you faced or experienced during the experiment.

To study the absorption of β-particle by material to estimate the end-point energy of the β-particle.

DESCRIPTION

Strontium-90 is a commonly used beta emitter used in industrial sources. It is also used as a thermal power source in radioisotope thermoelectric generator power packs. These use heat produced by radioactive decay of strontium-90 to generate heat, which can be converted to electricity using a thermocouple. Strontium-90 has a shorter half-life, produces less power, and requires more shielding than Plutonium-238, but is cheaper as it is a fission product and is present in a high concentration in nuclear waste and can be relatively easily chemically extracted. Strontium-90 based RTGs have been used to power remote lighthouses.

Strontium-89 is a short lived beta emitter which has been used as a treatment for bone tumors, this is used in palliative care in terminal cancer cases. Both strontium-89 and strontium-90 are fission products.

In the radioactive decay of nuclides emitting beta particles, all beta particle energies are possible from zero to a maximum called the endpoint energy. The endpoint energy in beta decay corresponds to the mass difference between the parent and daughter nuclides. The average energy of the beta particles is less than one half of the endpoint energy. The remaining energy is carried away by the anti-neutrino (in the case of beta- decay) or the neutrino (in the case of beta+ decay).

WORKING FORMULA

The β-decay is a random process. Though it can be studied using laws of radioactivity, which is based on the laws of probability. The intensity of β-particle after passing the thickness '*x*' of any absorber material having β-absorption coefficient is given by,

$$I = I_0\, e^{-\mu x} \qquad (1)$$

Here I_0 is the intensity of β-particle at $x = 0$. The value of I is proportional to the number of β-particles in the beam which in turn proportional to the number of counts of β-particle per second given by GM counter. If N_0 and N are the number of counts corresponding to I_0 and I, then

$$N = N_0\, e^{-\mu x}$$

Taking log, we get

$$lnN = lnN_0 - \mu x \qquad (2)$$

If we make a plot between *lnN* versus distance, the negative slope of the line gives the absorption coefficient.

The maximum range R of the β-particle is determined by extrapolation of absorption curve for zero counting (or up to the level of background). The maximum range is related to the maximum particle energy E by this empirical formula,

$$E = \frac{R+0.133}{0.542} \qquad (3)$$

Where R is measured in gm/cm^2 (thickness x density) and E is in MeV.

EXPERIMENTAL SET-UP

Go to C. L. Arora or any other B.Sc. Laboratory work book for the detail procedure. Your teacher will describe the method. [Note: The distance between source and the absorber material should be less than that of the distance between GM tube and the absorber material]

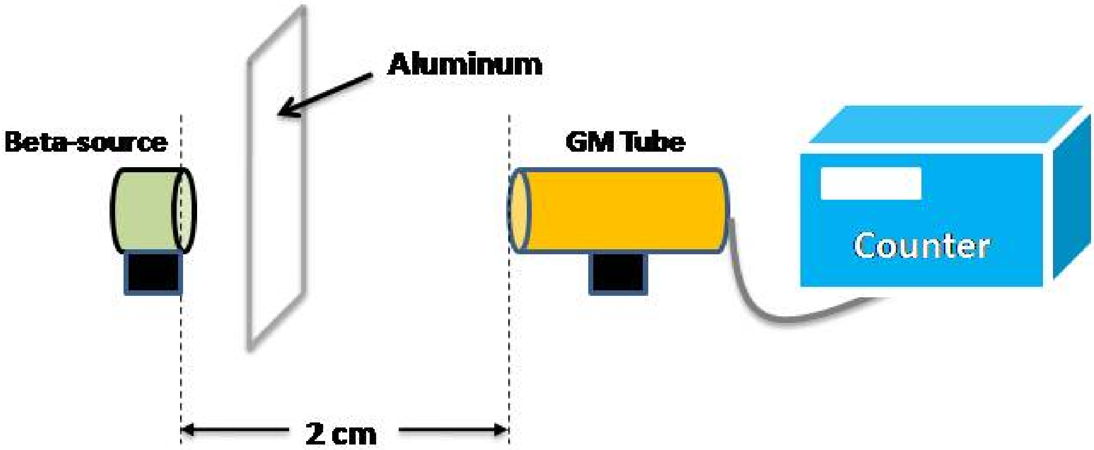


Figure 1: Experimental Set up

OBSERVATION

(a) **For operating voltage of GM Tube** (do NOT put any source for calibrating GM tube)

S.N.	Voltage (Volts)	Count rate per 30 seconds (at least 10 readings)	Average count/30 sec
1	300		
2	325		
3	350		
4	375		
5	400		
6	425		
7	450		
8	475		

The platue curve of GM tube describe its rosponce towards the decays, shown below:

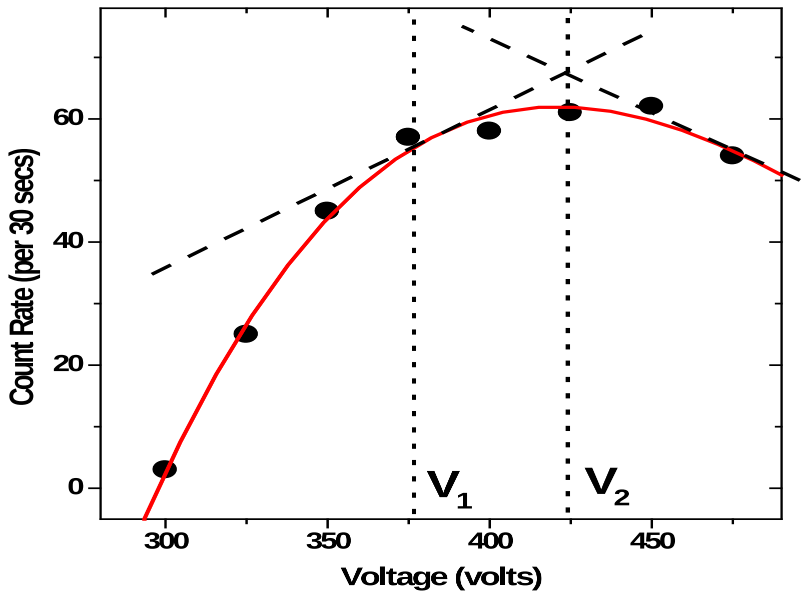


Figure 3: Platue Curve to calculate operating voltage of GM counter

(do NOT use any radioactive source!)

From the graph, V_1 = ... volt

V_2 = ... volt

Operating voltage is,

$V = V_1 + (V_2-V_1)/3$ = ... volt (3)

The background count at the operating voltage (= .... volt):

The average background count per 30 sec is ....

The background count **(B)** per second is ....

(b) Absorption by the Al absorber

Beta Source: ....

Distance between b-source and the window of GM tube = ...

(this distance should be less than 2 cm)

S.N.	Thickness of Al absorber (mm)	Count Rate / 30Seconds (N)					Average (N)	Background Subtracted (N-B)
1								
2								
3								
4								
5								

6								
7								
8								
9								
10								
11								
12								

BEST FIT CALCULATION

Let ***y = ln(C)*** and ***x*** is the thickness of the Alumunium absorber, then

$$\boldsymbol{y = mx + c} \qquad \textbf{(4)}$$

represents the best fitted line (shown in Figure 5), where *m* is the slope and *c* the intercept. Taking sum, equation (4) takes this form:

$$\boldsymbol{\Sigma y = m\Sigma x + nc} \qquad \textbf{(5)}$$

Multiplying (4) by Σ***x***,

$$\boldsymbol{\Sigma yx = m\Sigma x^2 + c\Sigma x} \qquad \textbf{(6)}$$

Multiplying (5) by Σ***x*** and (6) by ***n*** and solving these expression for the slope (***m***), we get,

$$\boldsymbol{m = \frac{n\Sigma yx - \Sigma y\Sigma x}{n\Sigma x^2 - (\Sigma x)^2}} \qquad \textbf{(7)}$$

and intercept is given by,

$$\boldsymbol{c = \frac{\Sigma y - m\Sigma x}{n}} \qquad \textbf{(8)}$$

In order to best fit, you need to calcúlate following variables in this tabular form:

SN	Count / 30 sec (O)	Count / sec (N)	Corrected Count (N-B)	y_i = ln*N*	x_i (mm)	x_i^2	$x_i\ y_i$
1							
2							
3							
4							
5							
6							
7							

8							
9							
10							
11							
12							
Sum (Σ) =							

PLOTTING

Figure 4 shows the expected plottings (students need to use graph papers with pencil) between calculated the refractive index with suger concentration.

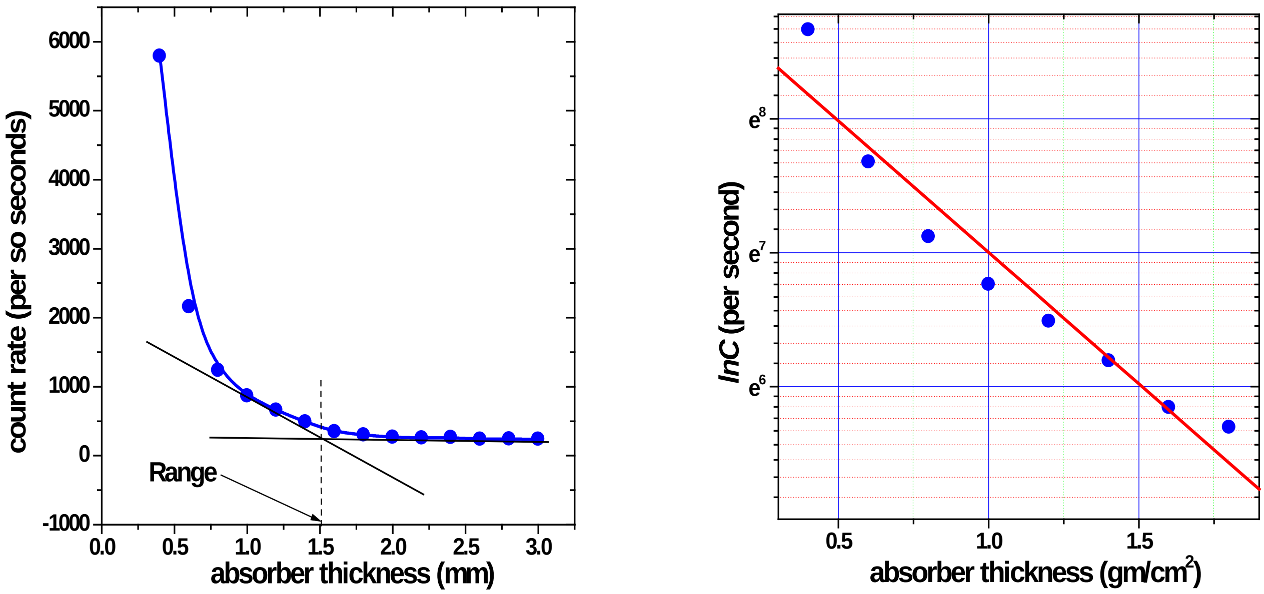


Figure 3: Count rate (in *linear* scale: left & in *logarithmic* scale: right) versus time [based on observed data at CDP]. The nature of the distribution seems like exponantial decay (left). The nature of the distribution fits the laws of radioactivity, lnC is proportional to absorber thickness (b). You need to fit your observed data using (7) and (8).

We get

$$m = \frac{\qquad\qquad}{\qquad\qquad} =$$

and intercept

$$c = \frac{\qquad\qquad}{\qquad\qquad} =$$

We use the value of slope to find the value of half life of the prepared liquid source.

$$\text{absorption coefficient } (\mu) = -m = \ldots\ldots\ldots\ldots\ldots.\ldots\ldots\ldots\ldots.\,\text{cm}^2/\text{gm}$$

To find the end point energy of given beam of β-particles, the range R (Figure 3) can be used.

$$E = \frac{R+0.133}{0.542} = \underline{\hspace{6cm}} = \cdots\ldots\ldots\ldots.. \quad \text{MeV}$$

ERROR ANALYSIS

SN	$y_i = \ln N$	x_i (mm)	$x_i - \bar{x}$
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
			$D =$

The error in the slope is

$$\Delta m = \left[\left(\frac{\Sigma {d_i}^2}{n-2}\right)\frac{1}{D}\right]^{1/2} = \underline{\hspace{8cm}} =$$

Here

$$D = \Sigma(\boldsymbol{x_i} - \boldsymbol{\bar{x}})^2 \text{ and } d = \Sigma y_i - m\Sigma x_i - c$$

RESULT

It is found that the absorption coefficient β-particles emitted from the given in the alumunium absorber of is ………………………………. ± …………………………... The end point energy of b-particle is found to be ………………… MeV.

INTERPRETATION OF YOUR RESULT

You need to interpret your result yourself.

PRECAUTION

Write down precaution that you faced or experienced during the experiment.

To study the variation of refractive index with concentration of sugar solutions using a hollow prism.

DESCRIPTION

The optical properties of a medium often manage the interaction of electromagnetic wave incident onto it. Thus an electromagnetic wave starts interacting with the electrons in a medium, when the wave is allowed to propagate through it. The electric field associated with the wave causing them to víbrate and this forced oscillations of the electrons in the medium start radiating light by offering secondary sources of radiation. However, the speed of new waves changes accordingly to the optical properties of the medium and it is always smaller than the speed of light in vacuum. All materials are characterized by their ability to slow down the waves, classified as optical refractive index. The refractive index of vacuum is unity and it is higher than unity for any other material (e.g. n = 1.33 for water).

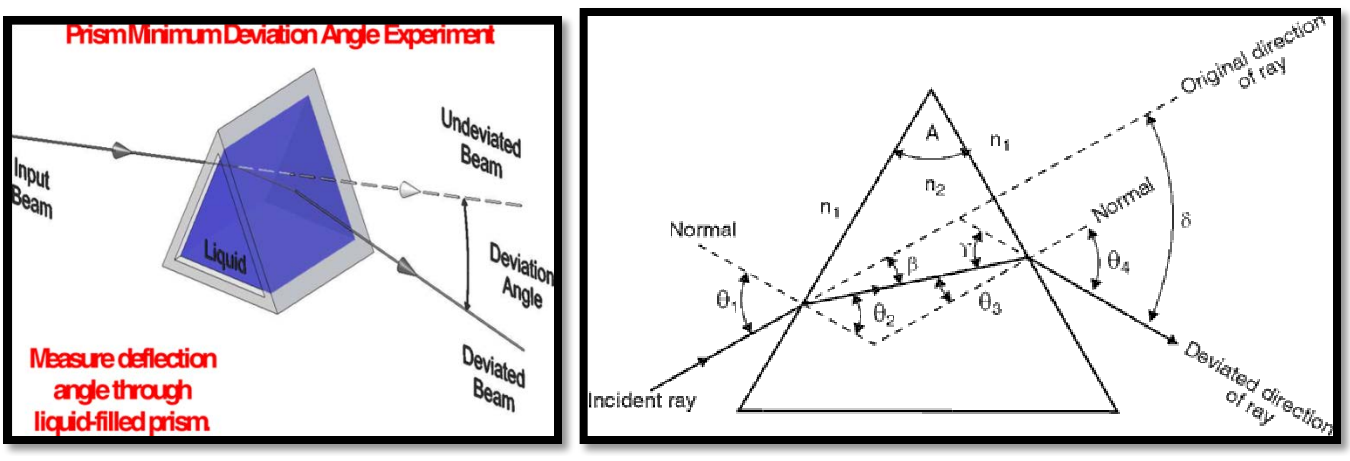


Figure 1: Minimum Deviation with Hollow Prism

Refractive index plays a vital role in many areas of material science with special reference to various optical technologies and measurement of refractive index of liquids is often required in physics and chemistry to determine the concentration of solutions. The refractive index of liquid is determined by various methods and a common method is the measurement of angle of minimum deviation produced by a light beam that passes through the liquid contained in a hollow prism made of glass. But, this method can be limited to visible light, because glass is opaque to infrared and ultraviolet radiations. The higher the sugar concentration, the more light bends (higher refractive index). The refractive index is increasing because the solution is getting thicker creating a denser medium with a higher refractive index. The resolution of the refractometer increases with Projection Distance. The relevance of these conclusions is that this kind of setup could be used in mass production of soft drinks and other liquids with dissolved sugar. Such a refractometer could be part of the pipes that the liquid flows through and measures the amount of sugar continuously. If there is too much, it signals to add more water, if there is too little, it signals to add more sugar.

WORKING FORMULA

When a beam of white light falls on one face of refraction side of triangle prism adjusted at minimum deviation position it dispersed into seven colors having different wavelengths called light spectrum. At the minimum deviation

$$\mu = \frac{\sin(\frac{Dmin + A}{2})}{\sin(\frac{A}{2})} \qquad (1)$$

The prism angle (A) is constant. The angle of minimum deviation (α_o) is directly proportional to the refractive index (m). The refractive index (n) is inversely proportional to the velocity of light in the medium ($\mu = \frac{C}{V}$). The velocity of the light in the media is directly proportional to the wavelength (λ) ($V = \lambda * \upsilon$). The refractive index of light (n) is inversely proportional to the wavelength (λ). So the angle of deviation (α) is inversely proportional to the wavelength (λ). The red color has max wavelength (λ) so has min deviation (α), but the violet color has min wavelength (λ) so has max deviation (α).

EXPERIMENTAL SET-UP

Go to C. L. Arora's book for the procedure.

Figure 2: Experimental Set up

OBSERVATION

20 smallest division of the main scale = ... degree

1 smallest division of the main scale (***m***) = ... degree

a division of vernier scale coincides with ***b*** division of main scale.

1 division of vernier coincides with ***b/a*** division of main scale.

Thus, the least count of the spectrometer is

$$L.C. = \left(1 - \frac{b}{a}\right) \times m$$

(3) For angle of prism (A)

SN	Vernier V_1				Vernier V_2			
	First face	Second Face	Difference $\theta = \lvert b - a \rvert$	A = θ/2	First face	Second Face	Difference $\theta = \lvert b - a \rvert$	A = θ/2

Thus, the mean value of the angle of prism (A) is

$$A = \frac{\Sigma A}{n} = \underline{\hspace{8cm}} = \qquad\qquad \text{degree}$$

(4) For the angle of minimum deviation

(A) 20% concentration of suger solution

SN	Vernier V_1			Vernier V_2		
	Direct (b)	dispersed (a)	Difference $D_{min} = \lvert b - a \rvert$	Direct (b)	Indirect (a)	Difference $D_{min} = \lvert b - a \rvert$

The mean value of D_{min} is given by

$$D_{min} = \frac{\Sigma D_{min}}{n} = \underline{\hspace{8cm}} = \qquad\qquad \text{degree}$$

(B) 10% concentration of suger solution

SN	Vernier V_1			Vernier V_2		
	Direct (b)	dispersed (a)	Difference $D_{min} = \lvert b - a \rvert$	Direct (b)	Indirect (a)	Difference $D_{min} = \lvert b - a \rvert$

The mean value of D_{min} is given by

$$D_{min} = \frac{\Sigma D_{min}}{n} = \underline{\hspace{6cm}} = \qquad \text{degree}$$

(C) 5% concentration of suger solution

SN	Vernier V_1			Vernier V_2		
	Direct (b)	Indirect (a)	Difference $D_{min} = \lvert b - a \rvert$	Direct (b)	Indirect (a)	Difference $D_{min} = \lvert b - a \rvert$

The mean value of D_{min} is given by

$$D_{min} = \frac{\Sigma D_{min}}{n} = \underline{\hspace{6cm}} = \qquad \text{degree}$$

(D) 2.5% concentration of suger solution

SN	Vernier V_1			Vernier V_2		
	Direct (b)	Indirect (a)	Difference $D_{min} = \lvert b - a \rvert$	Direct (b)	Indirect (a)	Difference $D_{min} = \lvert b - a \rvert$

The mean value of D_{min} is given by

$$D_{min} = \frac{\Sigma \mathrm{D_{min}}}{n} = \rule{5cm}{0.4pt} = \qquad \text{degree}$$

CALCULATION

(A) For **20% concentration** of suger solution:

$$\mu = \frac{sin\left(\frac{A+D_{min}}{2}\right)}{sin\left(\frac{A}{2}\right)} = \rule{6cm}{0.4pt} = \qquad .$$

(B) For **10% concentration** of suger solution:

$$\mu = \frac{sin\left(\frac{A+D_{min}}{2}\right)}{sin\left(\frac{A}{2}\right)} = \rule{6cm}{0.4pt} =$$

(C) For **5% concentration** of suger solution:

$$\mu = \frac{sin\left(\frac{A+D_{min}}{2}\right)}{sin\left(\frac{A}{2}\right)} = \rule{6cm}{0.4pt} =$$

(D) For **2.5% concentration** of suger solution:

$$\mu = \frac{sin\left(\frac{A+D_{min}}{2}\right)}{sin\left(\frac{A}{2}\right)} = \rule{6cm}{0.4pt} =$$

PLOTTING & BEST FIT

Figure 3 shows the expected plottings (students need to use graph papers with pencil) between calculated the refractive index with suger concentration.

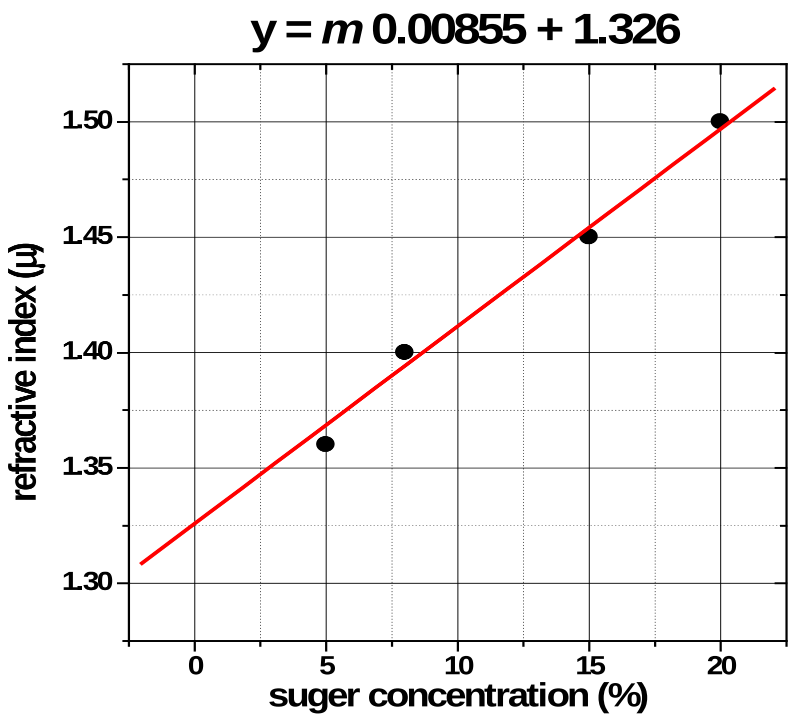


Figure 3: Refractive index versus suger concentration [based on observed data at CDP]

Let *y* = *m* (refractive index) and *x* is the suger concentration, then

$$y = mx + c \qquad \textbf{(2)}$$

represents the best fitted line (shown in Figure 3), where m is the slope and c the intercept. In the Figure 3, suger concentration is given in percentage. But students need to plot in V/V fraction of suger solution.

Use 20 gm of suger having density 1.587 gm/cm3 to make 20 ml of suger solution with wáter. The volume/volume fraction of suger solution of 20% concentration is ((1 + 1.60 gm/cm3)/(20) = 0.130. Similarly 10% = 0.065, 5% = 0.033 and 2.5% = 0.017 V/V fraction of suger solution.

Equation (2) can be written as,

$$\mu = mx + c \qquad \textbf{(3)}$$

Where x represents volumen fraction of suger solution.

Taking sum, equation (3) takes this form:

$$\Sigma\mu = m\Sigma x + nc \qquad \textbf{(4)}$$

Multiplying (4) by Σ***x***,

$$\Sigma\mu x = m\Sigma x^2 + c\Sigma x \qquad \textbf{(5)}$$

Multiplying (4) by Σ***x*** and (5) by ***n*** and solving these expression for the slope (***m***), we get,

$$\boldsymbol{m = \frac{n\Sigma\mu x - \Sigma\mu\Sigma x}{n\Sigma x^2 - (\Sigma x)^2}} \qquad \textbf{(6)}$$

And intercept is given by,

$$\boldsymbol{c = \frac{\Sigma\mu - m\Sigma x}{n}} \qquad \textbf{(7)}$$

x (V/V)	μ	$x\ \mu$	x^2
0.130			
0.065			
0.033			
0.017			
Sum =	**Sum =**	**Sum =**	**Sum =**

We get

$$m = \underline{\hspace{8cm}} =$$

and intercept

$$c = \underline{\hspace{8cm}} =$$

ERROR ANALYSIS

Here we find the error in the slope and intercept.

SN	μ_{cal}	μ_{obs}	difference, e_y $\mu_{obs} - \mu_{cal}$	e_y^2
1				
2				
3				
4				
sum				

The probable error in the slope is

$$\Delta m = \left[\left(\frac{n}{n-2}\right)\frac{\Sigma {e_y}^2}{n\Sigma x^2 - (\Sigma x)^2}\right]^{1/2} = \underline{\hspace{6cm}} =$$

The probable error in the intercept is,

$$\Delta c = \left[\left(\frac{\Sigma {e_y}^2}{n-2}\right)\frac{\Sigma x^2}{n\Sigma x^2 - (\Sigma x)^2}\right]^{1/2} = \underline{\hspace{6cm}} =$$

Thus, the error in the slope and intercept are ……………………….and …………………..…, respectively.

RESULTS

(1) The refractive index is found to increase with the increase of the suger concentration in the suger solution.

(2) The refractive index of suger solutions at different concentration are

μ_1 = ………………………………… for 20% concentration

μ_2 = ………………………………….. for 10% concentration

μ_3 = ………………………………….. for 5% concentration

μ_4 = ………………………………….. for 2.5% concentration

INTERPRETATION OF YOUR RESULT

You need to interpret your result yourself.

PRECAUTION

Write down precaution that you faced or experienced during the experiment.

To design and study the parallel LCR circuits for finding the quality factor of the elements.

DESCRIPTION

When the resistor R, inductor L and capacitor C are connected in series with a source of emf E , the circuit is called as the series resonant or series tuned circuit. This is an ***acceptor circuit***, that means it allows maximum current to flow through it at a particular (resonant) frequency and at all other frequencies it allows less current.

In A.C. circuits the voltage and the current are usually out of phase. Across the inductor, the current lags behind the voltage by 90^0, whereas across the capacitor, the current leads the voltage by 90^0. But across the resistor the voltage and current both are in phase. Under certain conditions, the voltage and current are in phase, even though the circuit consists of L , C and R and the circuit behaves as a pure resistor. This phenomenon is called resonance. This occurs at a single frequency known as resonant frequency. At this frequency the capacitive reactance($X_c = 1/\omega C$) and the inductive reactance($X_L = \omega L$) are equal and opposite in direction. So they get cancelled each other and only resistance acts.

Parallel resonant circuit is one in which one branch consists of an inductor L with associated resistor R and the other branch consists of a capacitor C. This is a ***rejector circuit***, that means it rejects the current or allows minimum current to flow through it, at a particular (anti-resonant) frequency and it allows more current at all other frequencies. So the circuit is not selective. But it is highly selective when energized from a high impedance generator.

WORKING FORMULA

In the parallel LCR circuit (as shown in Figure 1), the resonant frequency is given by,

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} \qquad (1)$$

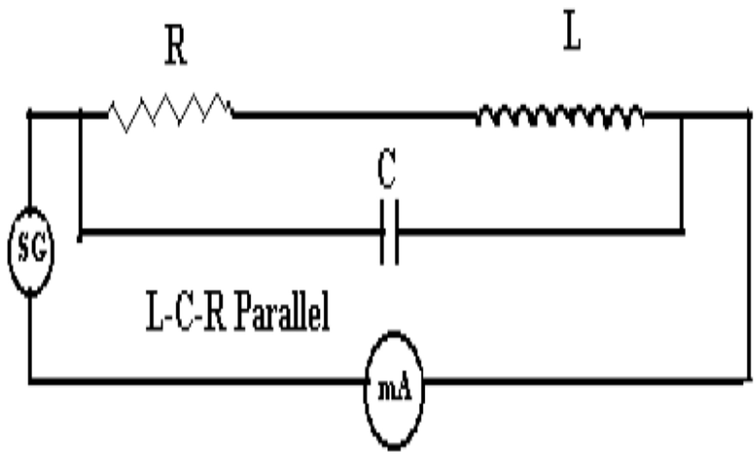
The bandwidth is a measure of shrapness of the resonance. The quality factor of parallel LCR circuit is given by,

$$Q.F. = \frac{f_r}{Bandwidth} = \frac{f_r}{f_2 - f_1} \qquad (2)$$

The bandwidth is measured by noting the frequencies at either side of the resonance peak at which the magnitude of the current (rms) value falls to 0.707 its peak value.

EXPERIMENTAL SET-UP

Go to C. L. Arora or any other B.Sc. Laboratory work book for the detail procedure. Connect parallel LCR circuit and use cathode ray oscilloscope (if available in your lab) in order to fix frequency.



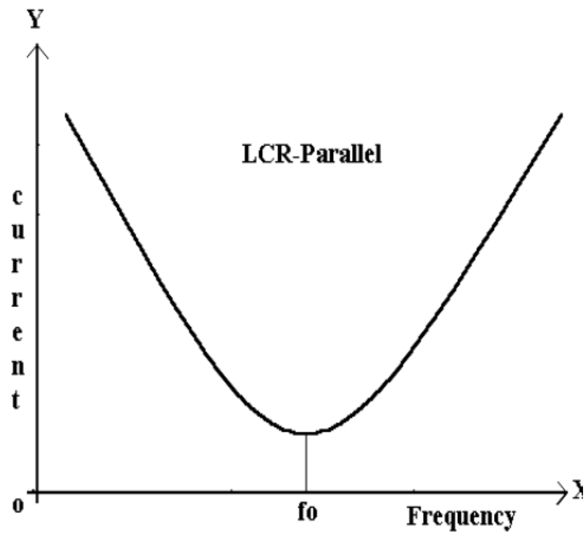


Figure 1: Circuit for experimental set up (left) and expected result (right)

OBSERVATION

Given,

Inductor (L) = ... mH = ... H

Capacitance (C) = ... mF = ... F

Output voltage of the audio oscillator = Input voltage of LCR circuit = ... volt

Least count of milli-ammeter = ... mA

Frequency Calibration:

5 division = ... ms

1 division = ... ms

(a) Current in the circuit

S.N.	Time Period (ms)	Frequency (kHz)	Current (in mA) in the circuit for		
			$R_1 = 0\ \Omega$	$R_2 = 500\ \Omega$	$R_3 = 1000\ \Omega$
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					

12					

PLOTTING

Figure 2 shows the expected plottings (students need to use graph papers with pencil) between the observed current and frequency.

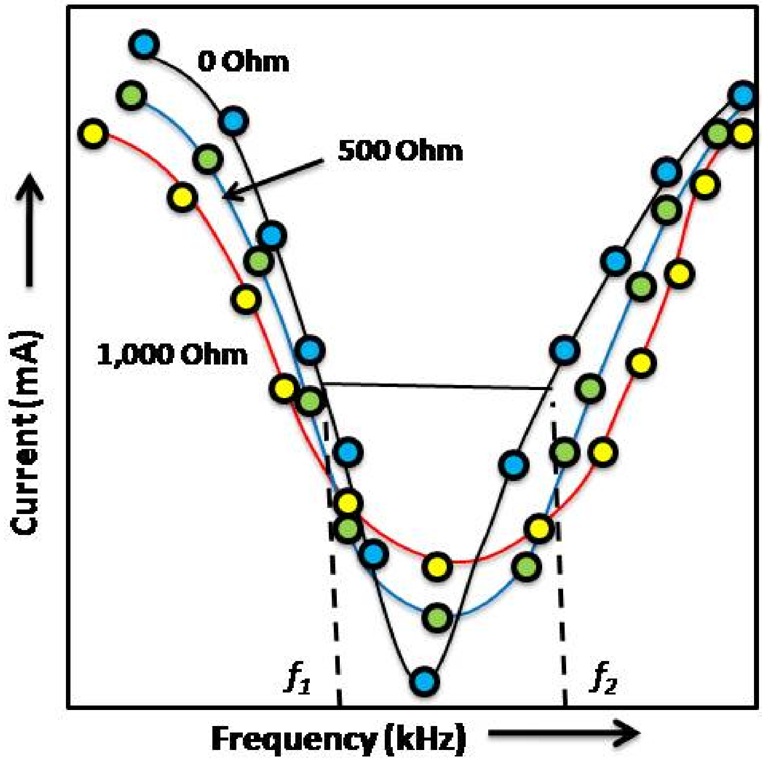


Figure 3: Observed current versus frequency plot for parallel resonant (anti-resonant) circuit. [based on observed data at CDP]. The value of f1 and f2 can be calculated by making $I_{max}/\sqrt{2}$.

CALCULATION

(a) For R = 0 Ohm

Resonance frequency for R = 0 Ohm

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \rule{4cm}{0.4pt} = \qquad \text{kHz}$$

From the graph,

$$f_2 - f_1 = \qquad = \qquad \text{kHz}$$

Quality factor is given by,

$$Q.F. = \frac{f_r}{f_2 - f_1} = \rule{4cm}{0.4pt} =$$

(b) For R = 500 Ohm

Resonance frequency for R = 0 Ohm

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \rule{4cm}{0.4pt} = \qquad\qquad \text{kHz}$$

From the graph,

$$f_2 - f_1 = \qquad\qquad\qquad = \qquad\qquad \text{kHz}$$

Quality factor is given by,

$$Q.F. = \frac{f_r}{f_2 - f_1} \quad = \rule{4cm}{0.4pt} =$$

(c) For R = 1000 Ohm

Resonance frequency for R = 0 Ohm

$$f_r = \frac{1}{2\pi}\sqrt{\frac{1}{LC} - \frac{R^2}{L^2}} = \rule{4cm}{0.4pt} = \qquad\qquad \text{kHz}$$

From the graph,

$$f_2 - f_1 = \qquad\qquad\qquad = \qquad\qquad \text{kHz}$$

Quality factor is given by,

$$Q.F. = \frac{f_r}{f_2 - f_1}{}_2 = \rule{4cm}{0.4pt} =$$

ERROR ANALYSIS

The standard error in the resonant frequency is given by,

$$(\Delta f)_{SE} = \frac{\sigma_{\Delta f}}{\sqrt{n}}$$

where the standard deviation is given by,

$$\sigma_{\Delta f} = \sqrt{\frac{\Sigma(f_i - \bar{f})^2}{n-1}}$$

In the above section, you have calculated three f_r (i.e., f_i). Try yourself to calcúlate standard deviation and standard error.

RESULT

The resonant frequency of the parallel LCR circuit is found to be …………………± ……………with the quality factor = ……………………… It is found that the quality factor of parallel circuit increases with the increase of resistance.

INTERPRETATION OF YOUR RESULT

You need to interpret your result yourself.

PRECAUTION

Write down precaution that you faced or experienced during the experiment.

To study the temperature dependence of resistance of a given semiconductor.

DESCRIPTION

The termistor is a semiconductor device which consists of a bead or disc of various oxides manganese, Nickel, cobalt, iron or other metals. A word termistor is derived from termal resistor. A termistor is a device whose resistance varies quite makedly with temperatura depending upon their composition. The termistor can have either positive temperatura coefficient or a negative temperatura coefficient. The neagative temperatura coefficient type consists of a mixture of oxides of iron, nickel and cobalt. The positive temperatura coefficient type is base don Barium titanate and shows a temperatura increase of 50 to 200 times for a temperatura rise of few degrees. These are used in temperatura controlled switch.

WORKING FORMULA

A semiconductor material is characterized by the property that its conductivity increases sharply with rise in temperature. This is because the number of charge carrier is increased in an exponential manner as characterized by the factor exp{-*Eg*/K*T*}. The resistance (R) of semiconductor material is given by

$$\left(\frac{1}{R}\right) = \left(\frac{1}{R_0}\right)\, e^{-\left(\frac{Eg}{KT}\right)} \qquad (1)$$

Here R_0 is the resistance at highest temperature. Taking log both sides we get,

$$\log\left(\frac{1}{R}\right) = \log\left(\frac{1}{R_0}\right) - \frac{E_g}{KT} \qquad (2)$$

The slope of the plot between **log(1/R)** and **(1/T)** is **- (Eg/K).** Thus, band gap of the given semiconductor material can be calculated if we linearly fit our observations, according to equation (2). The value of resistance can be measured with the balanced condition of Wheatstone Bridge, i.e., null deflection in the Galvanometer. Under Balancing condition:

$$\frac{R_1}{R_2} = \frac{R_3}{R_4} \qquad (3)$$

Since $R_3 = R_4$, thus $R_1 = R_2$. Here R_1 is the resistance of thermistor and R_2 in the resistance of bridge. The temperature is measured with the help of thermometer. The slope of straight line gives the band gap E_g of given semiconductor material.

EXPERIMENTAL SET-UP

Go to C. L. Arora or any other B.Sc. Laboratory work book for the detail procedure.

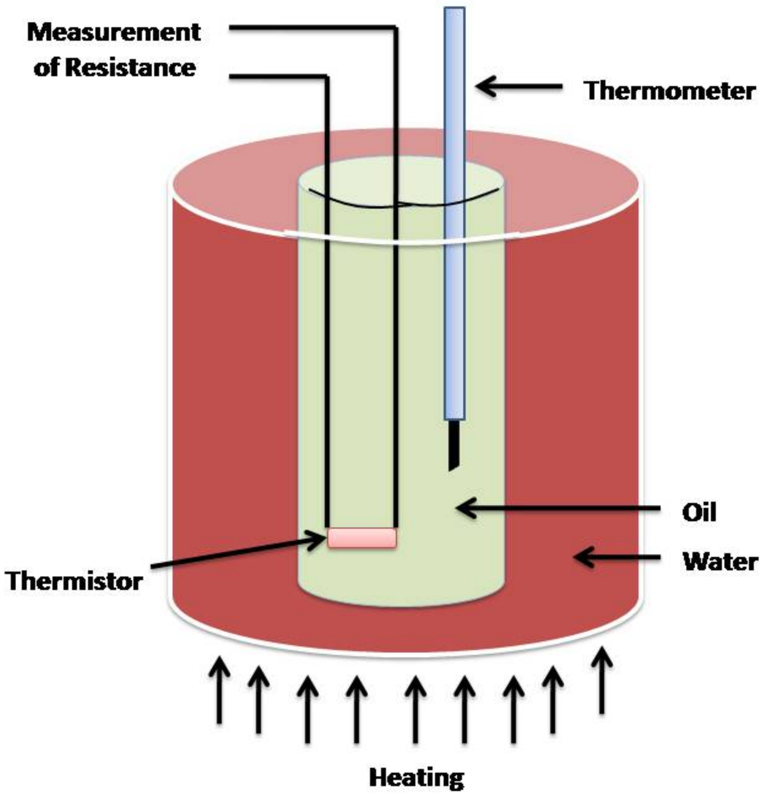


Figure 1: Experimental Set up

OBSERVATION

(a) For variation of resistance (*Note: Students need to keep 2 degree centigrade difference while taking observation. In addition, observation should be taken by increasing and decreasing temperature*)

S.N.	Temperature (°C)		Resistance (Ω)	
	Increasing (I)	Decreasing (d)	Value (for I)	Value (for d)
1	30	92		
2	32	90		
3	34	88		
4	36	86		
5	38	84		
6	40	82		
7	42	80		
8	44	78		
9	46	76		
10	48	74		
11	50	72		
12	52	70		

13	54	68		
14	56	66		
15	58	64		
16	60	62		
17	62	60		
18	64	58		
19	66	56		
20	68	54		
21	70	52		
22	72	50		
23	74	48		
24	76	46		
25	78	44		
25	80	42		
27	82	40		
28	84	38		
29	86	36		
30	88	34		
31	90	32		
32	92	30		

The variation of resistance with temperature is shown in Figure 2 (below).

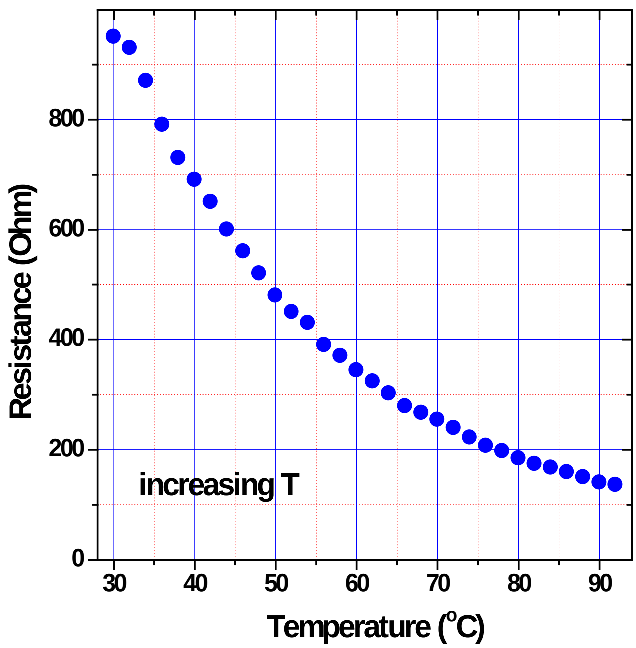


Figure 2: Variation of resistance with increasing temperature [students need to perform similar workout (observation, plotting and calculation) with decreasing temperature]

BEST FIT CALCULATION

Let ***y = log(1/R)*** and ***x* = 1/T**, then the working formula can be written in this form

$$y = mx + c \qquad \textbf{(4)}$$

which represents the best fitted line (shown in Figure), where *m* is the slope and *c* the intercept.

Taking sum, equation (4) takes this form:

$$\Sigma y = m\Sigma x + nc \qquad \textbf{(5)}$$

Multiplying (4) by **Σ*x***,

$$\Sigma yx = m\Sigma x^2 + c\Sigma x \qquad \textbf{(6)}$$

Multiplying (5) by **Σ*x*** and (6) by ***n*** and solving these expression for the slope (***m***), we get,

$$m = \frac{n\Sigma yx - \Sigma y\Sigma x}{n\Sigma x^2 - (\Sigma x)^2} \qquad \textbf{(7)}$$

and intercept is given by,

$$c = \frac{\Sigma y - m\Sigma x}{n} \qquad \textbf{(8)}$$

In order to best fit, we need to calcúlate following variables in this tabular form:

SN	Temperature (in Kelvin)	Resistance (in Ohm)	x = (1/T) x10^{-3}	y = ln(1/R)	x^2	xy
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						
11						
12						
13						

14						
15						
16						
Sum (Σ) =						

Note: Students need to perform second sets of calculation and best fit for the dataset taken by decreasing the temperature.

PLOTTING

Figure 4 shows the expected plottings (students need to use graph papers with pencil) between calculated the refractive index with suger concentration.

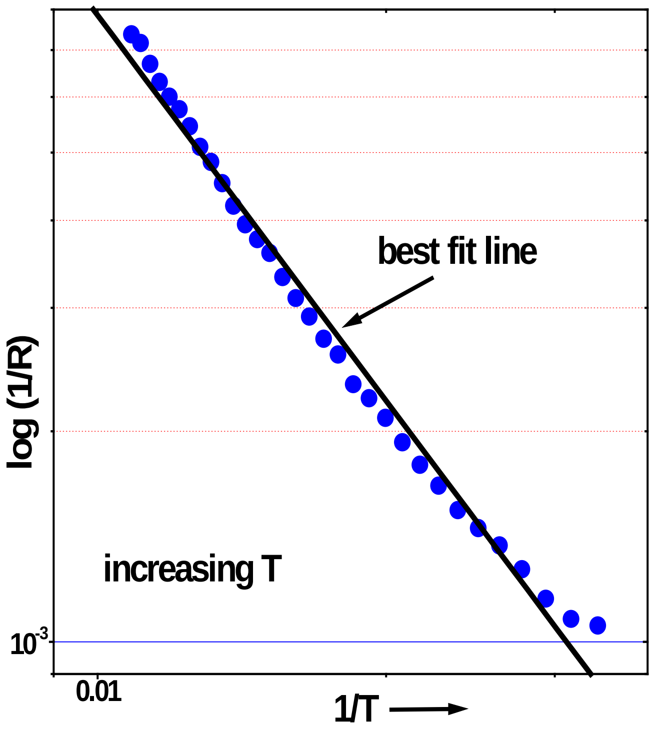


Figure 3: Inverse of resistance versus inverse of temperature plot with best fit line [based on observed data at CDP]. The slope of best fit line gives band gap of the given semiconductor.

We get

$$m = \frac{\quad}{\quad} =$$

and intercept

$$c = \frac{\quad}{\quad} =$$

We use the value of slope to find the value band gap in the given semiconductor.

$$slope\ (m) = \qquad\qquad\qquad\qquad = \frac{Eg}{K}$$

Thus,

$$Band\ Gap\ (Eg) = \quad K \times\ m\ = \cdots \ldots\ldots\ldots\ldots.\ldots..\ \mathbf{J} = \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots.\mathbf{eV}$$

Note: You will get two band gaps after taking first and second set of observations. These values can be average out.

RESULT

It is found that the resistance of given thermister increases with the decrease in the temperature.

In addition, we found that the band gap in the given semiconductor is ………………………**eV**.

INTERPRETATION OF YOUR RESULT

You need to interpret your result yourself.

PRECAUTION

Write down precaution that you faced or experienced during the experiment.

Tribhuvan University
Institute of Science and Technology
Physics Subject Committee
Central Department of Physics

Course Title: Physics Laboratory (General)	**Year:** IV
Course Code: PHY402	**Full Marks:** 50
Nature of Course: Practical	**Pass Marks:** 20

PHYSICS LAB (General) [180 hours]

7. **To determine the wave length of given source of light by Fresnel's Bi-Prism.**
8. To study Lloyd's mirror for the determination of wavelength of Hg light.
9. To study the formation of fringe pattern by wedge shape and find the thickness of mica sheet.
10. **To study the variation of refractive index with concentration of sugar solutions using a hollow prism.**
11. Use the measured dataset of experiment 4 and calculate the standard deviation, standard error and probable error with significant figures. Generate theoretical data and test how well the measured data agrees with the theoretical data in this experiment. Show the trend of measured and theoretical data in a graph and interpret it.
12. To determine the value of Stefan's constant.
13. To determine the ratio of Cp and Cv by Clement and Desorme's apparatus.
14. To determine the ratio of C_p / C_v by using Ruchardt's Method.
15. To study the absorption of X-ray by the materials.
16. **To determine the half-life period of a given radioactive substance using a G.M. counter.**
17. To study the phenomenon of Back-Scattering using a thin radioactive β-source.
18. **To study the absorption of β-particle by material to estimate the end-point energy of the β-particle.**
19. To study the phenomenon of hysteresis loss of the material and to determine the hysteresis loss of the material over a cycle.
20. **To design and study the parallel LCR circuits for finding the quality factor of the elements.**
21. To find the dielectric constant of a material using resonance method.
22. To study the specific heat capacity of the materials using Calorimetric method.
23. **To study the temperature dependence of resistance of a given semiconductor.**

Tribhuvan University
Institute of Science and Technology
Physics Subject Committee
Central Department of Physics

Course Title: Physics Laboratory (Electronics)	**Year:** IV
Course Code: PHY404	**Full Marks:** 50
Nature of Course: Practical	**Pass Marks:** 20

PHYSICS LAB (Electronics) [180 hours]

1. **Study the low frequency response circuits and calculate their cut-off frequencies.**
2. **Study the high frequency response circuits and calculate their cut-off frequencies.**
3. **To construct astable multivibrator using 555 timer and study its performance.**
4. **To construct monostable multivibrator using 555 timer and study its function.**
5. **To construct and to study the characteristics of RS flip-flop.**
6. **To construct and to study the characteristics of J-K flip-flop.**
7. **To construct a voltage multipliers (doubler) and study its characteristics.**
8. **To construct a voltage multipliers (tripler) and study its characteristics.**
9. **To construct and study the working of NOT, AND, OR gates using diodes and transistors.**
10. **Calculate the power loss in transistors in each case (NOT, AND and OR) wherever it is applicable.**
11. **To study operational amplifier for its input-output waveform and use it as an integrator and differentiator.**
12. **To construct differential amplifier and estimate it’s CMRR (Common mode rejection ratio).**
13. **To study the working of half adder.**
14. **To study the working of full adder.**
15. **To construct D/A converter and to study its working.**

ERROR ANALYSIS & PLOTTING

By e-mail

ELECTRONICS LAB MANUAL

B.Sc. IV Year

Contents

Experiment No.: 1

Study the low frequency response circuits and calculate their cut-off frequencies.

Apparatus Required:

- Bread board
- Resistors
- Capacitors
- Jumper wires
- AC signal generator
- Multimeter

Theory:

A low frequency response circuit or high pass filter circuit blocks all low frequency signals from DC up to its cutoff frequency (lower cutoff frequency) and allows all high frequency signals to pass above this point. A first order RC high pass filter circuit is constructed as follows:

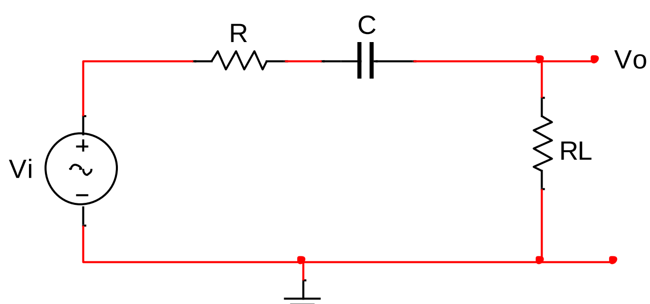


Fig.-1.1: Low frequency response circuit

The lower cutoff frequency (f_1) of the above circuit is given by:

$$f_1 = \frac{1}{2\pi(R + R_L)C}$$

The response curve of the circuit is:

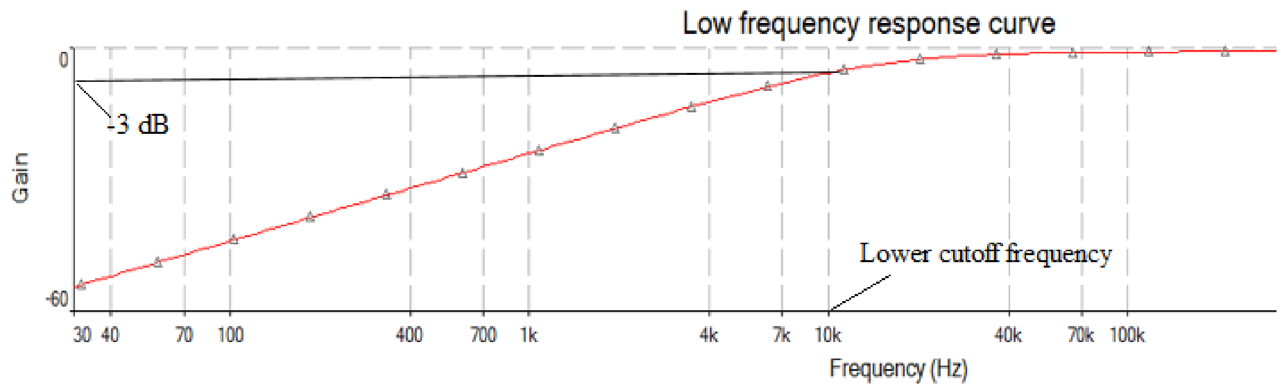


Fig.-1.2: Low frequency response curve

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-1.1.
2. Set the signal generator for 1 V or 2 V or as required. (**Note:** *keep this input voltage as constant throughout the experiment.*)
3. Set the signal generator for zero frequency.
4. Adjust the frequency of the signal generator for suitable low value and corresponding voltage across the resistor R_L is noted in the TABLE 1.1.
5. Repeat step 4 for different suitable input frequencies until output becomes constant for at least five times. [**Check:** *during each reading, input voltage should be kept constant; if not, adjust it*.]
6. Plot the decibel voltage gain with the input signal frequency and find the lower cutoff frequency.

OBSERVATIONS:

R =

R_L=

C =

TABLE 1.1

NOB	Frequency (Hz)	V_{in} (V)	V_o (V)	$A_v = \frac{\lvert V_o \rvert}{\lvert V_{in} \rvert}$	20 log A_v

CALCULATIONS:

Experimental: from graph

The lower cutoff frequency (f_1) =

Theoretical: from equation

$$f_1 = \frac{1}{2\pi(\mathrm{R} + \mathrm{R_L})\mathrm{C}}$$

ERROR ANALYSIS: (may add additional pages)

RESULTS:

The lower cutoff frequency of the above circuit is

	Experimental	Theoretical
Lower cutoff frequency		

DISCUSSIONS:

Experiment No.: 2

Study the high frequency response circuits and calculate their cut-off frequencies.

Apparatus Required:

Bread board

Resistors

Capacitors

Jumper wires

AC signal generator

Multimeter

Theory:

A high frequency response circuit or low pass filter circuit allows all low frequency signals to pass from DC up to its cutoff frequency (upper cutoff frequency) and blocks all high frequency signals above this point. A first order RC low pass filter circuit is constructed as follows:

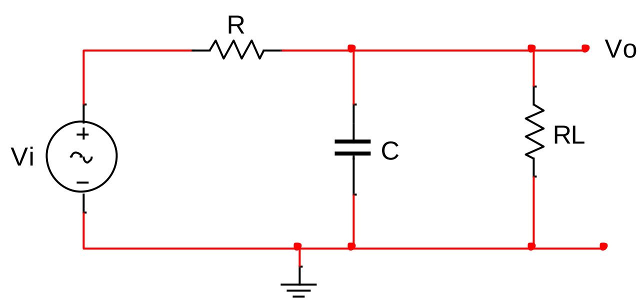


Fig.-2.1: High frequency response circuit

The upper cutoff frequency (f_2) of the above circuit is given by:

$$f_2 = \frac{1}{2\pi(R \parallel R_L)C}$$

The response curve of the circuit is:

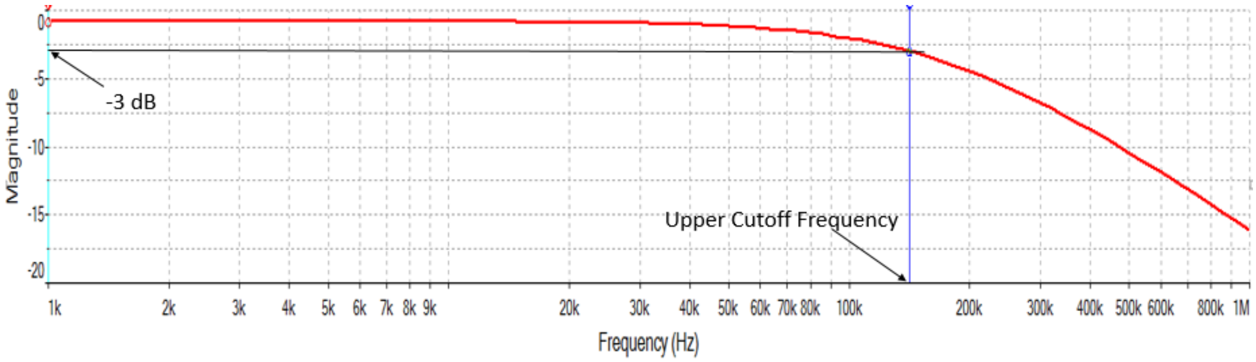


Fig.-2.2: High frequency response curve

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-2.1.
2. Set the signal generator for 1 V or 2 V or as required. (**Note:** *keep this input voltage as constant throughout the experiment.*)
3. Set the signal generator for zero frequency.
4. Adjust the frequency of the signal generator for suitable low value (i.e. *at least for 4 to 5 constant high output*) and corresponding voltage across the resistor R_L is noted in the TABLE 2.1.
5. Repeat step 4 for different suitable input frequencies until output becomes low as zero. [**Check:** *during each reading, input voltage should be kept constant; if not, adjust it*.]
6. Plot the decibel voltage gain with the input signal frequency and find the upper cutoff frequency.

OBSERVATIONS:

R =

R_L=

C =

TABLE 2.1

NOB	Frequency (Hz)	V_{in} (V)	V_o (V)	$\boldsymbol{A_v = \frac{\lvert V_o \rvert}{\lvert V_{in} \rvert}}$	20 log A_v

CALCULATIONS:

Experimental: from graph

The upper cutoff frequency (f_2) =

Theoretical: from equation

$$f_2 = \frac{1}{2\pi(R \parallel R_L)C}$$

ERROR ANALYSIS: (may add additional pages)

RESULTS:

The upper cutoff frequency of the above circuit is

	Experimental	Theoretical
Upper cutoff frequency		

DISCUSSIONS:

Experiment No.: 3

To construct astable multivibrator using 555 timer and study its performance

Apparatus Required:

Timer 555

Resistors

Capacitors

Bread board

Jumper wires

Oscilloscope

Power supply (5 V DC)

Theory:

An astable multivibrator has no stable states and therefore changes back and forth between two unstable states without any external triggering. A 555 timer connected as in Fig.- 3.1 to operate as an astable multivibrator and its output is obtained as Fig.-3.2.

RST: Reset
DIS: Discharge
THR: Threshold
TRI: Trigger
CON: Control
OUT: Output
VCC: +5 V
GND: Ground

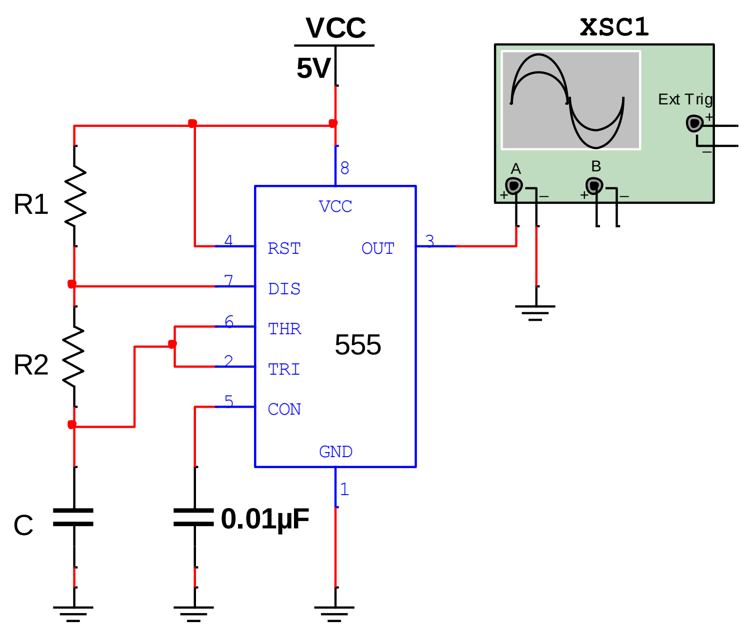


Fig.-3.1: Astable multivibrator using 555 timer.

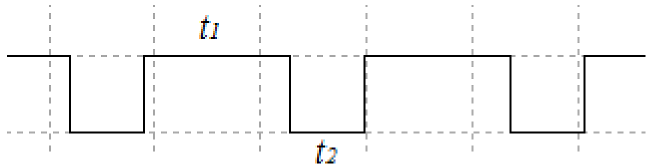


Fig.-3.2: Output waveform of astable multivibrator

The timing capacitor C is charged towards $+V_{cc}$ through resistors R_1 and R_2. The charging time t_1 is given as

$$t_1 = 0.693(R_1 + R_2)C$$

The timing capacitor C is then discharged towards ground (GND) through resistors R_2. The discharging time t_2 is given as

$$t_2 = 0.693R_2C$$

The period T of the resulting clock waveform is the sum of t_1 and t_2. Thus

$$T = t_1 + t_2 = 0.693(R_1 + 2R_2)C$$

The frequency of oscillation is then found as

$$f = \frac{1}{T} = \frac{1.44}{(R_1 + 2R_2)C}$$

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-3.1. [**Note:** *0.01 μF capacitor is optional, only use it if necessary*]
2. Observe and trace the output of astable multivibrator from oscilloscope and note the value of t_1 and t_2 in TABLE 3.1.
3. Repeat step 2 for four more times with different combinations of R_1, R_2 and C.

OBSERVATIONS:

TABLE 3.1

NOB	C (μF)	R_1 (KΩ)	R_2 (KΩ)	t_1 (ms)	t_2 (ms)	$f = \frac{1}{T}$ (Hz) (experimental)
1						
2						
3						
4						
5						

CALCULATIONS:

TABLE 3.2

NOB	C (μF)	R_1 (KΩ)	R_2 (KΩ)	$t_1 = 0.693(R_1 + R_2)C$ (ms)	$t_2 = 0.693R_2C$ (ms)	$f = \frac{1}{T}$ (Hz) (theoretical)
1						
2						
3						
4						
5						

ERROR ANALYSIS: (may add additional pages)

RESULTS:

The oscillation frequencies of the astable multivibrator are

NOB	C (μF)	R_1 (KΩ)	R_2 (KΩ)	$f = \frac{1}{T}$ (Hz)	
				Experimental	Theoretical
1					
2					
3					
4					
5					

DISCUSSIONS:

Experiment No.: 4

To construct monostable multivibrator using 555 timer and study its function

Apparatus Required:

Timer 555 - 2

Resistors

Capacitors

Bread board

Jumper wires

Oscilloscope

Power supply (5 V DC)

Theory:

A monostable multivibrator has two output states, only one of which is stable. Its normal mode of operation is to trigger the circuit into its quasistable state, where it will remain for predetermined length of time. The circuit will then switch itself back into its stable state, where it will remain until it receives another input trigger pulse.

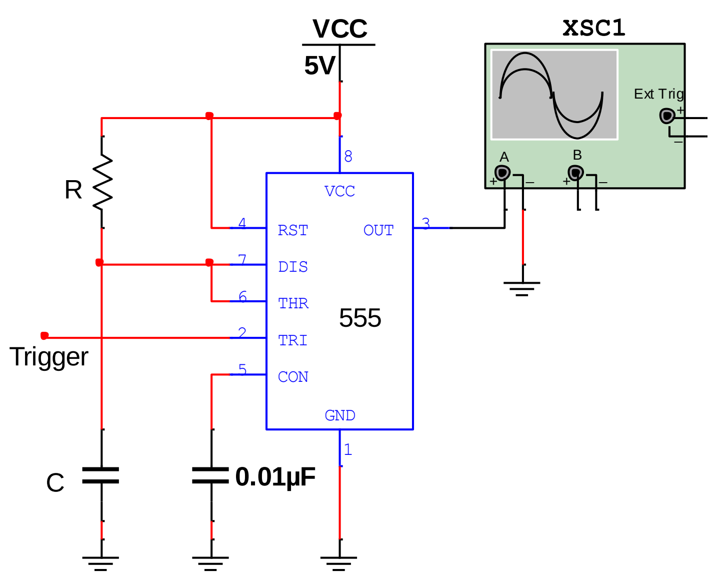


Fig.-4.1: Monostable multivibrator using 555 timer.

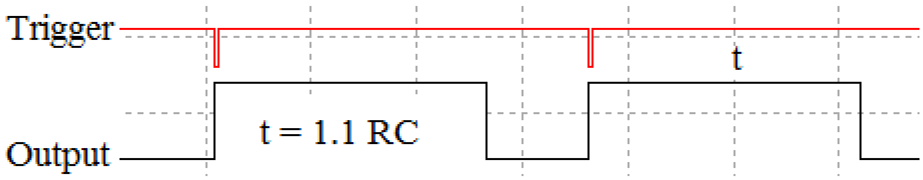


Fig.-4.2: Output waveform with trigger of monostable multivibrator

An external resistor R and capacitor C connected as shown in Fig.-4.1 are used to set up the 555 timer as monostable multivibrator and its output is obtained as Fig.-4.2. The pulse width of the output is determined by the time constant of R and C according to the following formula:

$$t = 1.1\,RC$$

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-4.1. [**Note:** *0.01 μF capacitor is optional, only use it if necessary*]
2. For trigger: output of astable multivibrator [Expt.3] is used with $t_1 >>> t_2$.
3. Observe and trace the output of monostable multivibrator from oscilloscope and note the value of t in TABLE 4.1.
4. Repeat step 3 for four more times with different combinations of R and C.

OBSERVATIONS:

TABLE 4.1

NOB	C (μF)	R (KΩ)	t (ms) (experimental)
1			
2			
3			
4			
5			

CALCULATIONS:

TABLE 4.2

NOB	C (μF)	R (KΩ)	$t = 1.1\,RC$ (ms) (theoretical)
1			
2			
3			
4			
5			

ERROR ANALYSIS: (may add additional pages)

RESULTS:

The pulse widths of monostable multivibrator are

NOB	C (μF)	R (KΩ)	$t = 1.1\ RC$ (ms)	
			Experimental	Theoretical
1				
2				
3				
4				
5				

DISCUSSIONS:

Experiment No.: 5

To construct and to study the characteristics of RS flip-flop

Apparatus Required:

IC: 7400

Bread board

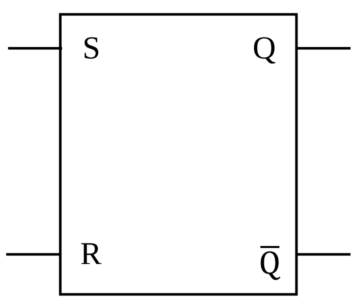
Jumper wires

Multimeter

Power supply (5 V DC)

Theory:

A flip-flop is a bistable electronic circuit which has two complementary stable outputs. RS flip-flop has two inputs R and S represents reset and set respectively. And its two complementary stable outputs are Q and $\overline{Q}$ (or Q′). The logic symbol and truth tables are as Fig.-5.1.



Logic symbol

S	R	Q	$\overline{Q}$
0	0	No change	
0	1	0	1
1	0	1	0
1	1	Forbidden	

Truth Table

Fig.-5.1: RS flip-flop

The experimental circuits of RS flip-flop by using NAND gates and NOR gates are connected as Fig.-5.2 and Fig.-5.3 respectively.

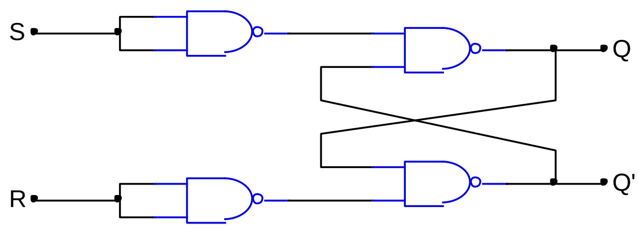


Fig.-5.2: RS flip-flop by using NAND gates

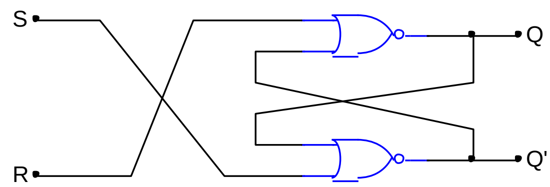


Fig.-5.3: RS flip-flop by using NOR gates

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-5.2. [**Note:** *terminals of IC should be carefully checked.*]
2. Set, measure and record the different input conditions of it as observation table Table 5.1. [**Note:** *<u>For input:</u> '0' means connect the terminal to Ground and '1' means connect the terminal to +5V. <u>For output:</u> '0' means output voltage less than 0.8V and '1' means output voltage greater than 3.0V. Do not write '0' and '1' in Observation Table but write observed voltage.*]
3. Make the connections as per circuit diagram, Fig.-5.3. [**Note:** *terminals of IC should be carefully checked.*]
4. Set, measure and record the different input conditions of it as observation table Table 5.2.

OBSERVATIONS:

Least count of volt meter =

TABLE 5.1: Using NAND gates

NOB	INPUTS (V)		OUTPUTS (V)		Remarks
	S	R	Q	$\bar{Q}$	
1	5	0			
2	0	0			
3	0	5			
4	0	0			
5	5	5			

TABLE 5.2: Using NOR gates

NOB	INPUTS (V)		OUTPUTS (V)		Remarks
	S	R	Q	$\overline{Q}$	
1	5	0			
2	0	0			
3	0	5			
4	0	0			
5	5	5			

RESULTS:

DISCUSSIONS:

Experiment No.: 6

To construct and to study the characteristics of J-K flip-flop

Apparatus Required:

IC: 7410 -2,

7402 -1

Bread board

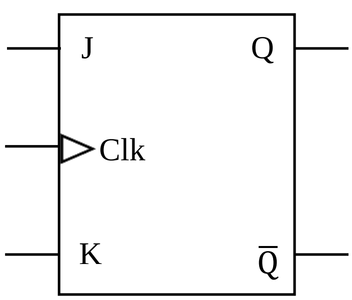
Jumper wires

Multimeter

Power supply (5 V DC)

Theory:

A flip-flop is a bistable electronic circuit which has two complementary stable outputs. JK flip-flop is a modified version of an S-R flip-flop with no “forbidden” or “illegal” output state. The logic symbol and truth tables are as Fig.-6.1.



Logic symbol

Clk	J	K	Q	$\overline{Q}$
x	0	0	No change	
↑	0	1	0	1
↑	1	0	1	0
↑	1	1	Toggle	

Truth Table

Fig.-6.1: JK flip-flop

The logic circuit and experimental circuits of JK flip-flop by using NAND gates are connected as Fig.-6.2 and Fig.6.3 respectively.

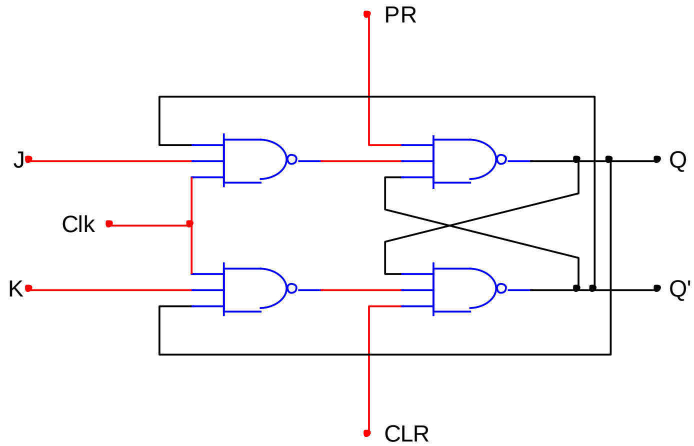


Fig.-6.2: Logic circuit of JK flip-flop

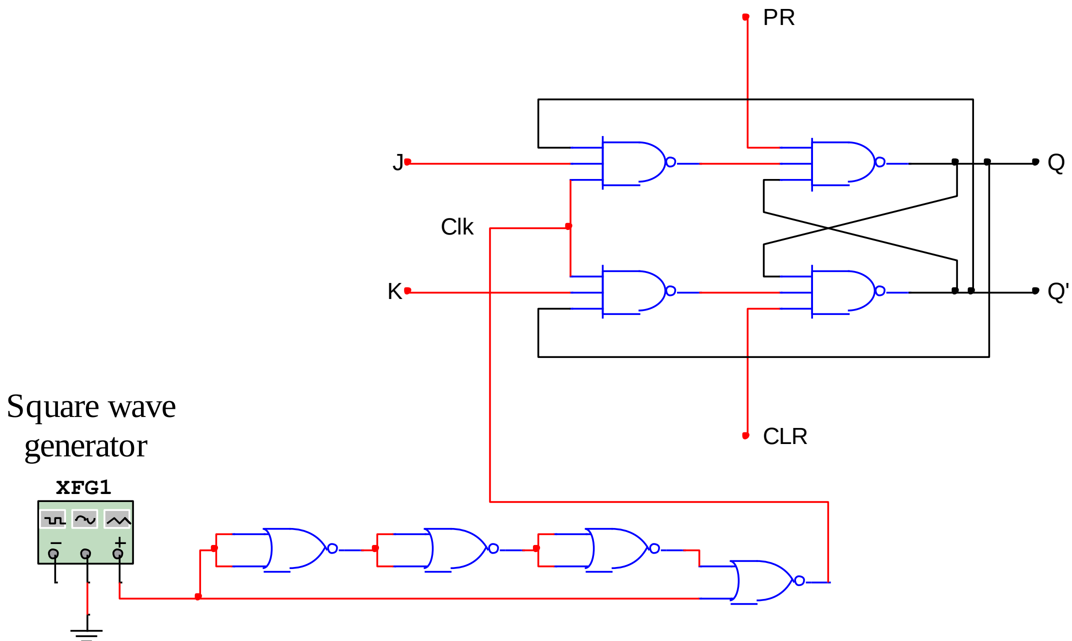


Fig.-6.3: Experimental circuit of JK flip-flop

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-6.3. [**Note:** *terminals of IC should be carefully checked. Instead of square wave generator one may use astable multivibrator*.]
2. Set, measure and record the different input conditions of it as observation table Table 6.1. [**Note:** *<u>For input:</u> '0' means connect the terminal to Ground and '1' means connect the terminal to +5V. <u>For output:</u> '0' means output voltage less than 0.8V and '1' means output*

voltage greater than 3.0V. Do not write ‘0’ and ‘1’ in Observation Table but write observed voltage.]

OBSERVATIONS:

Least count of volt meter =

TABLE 6.1

NOB	INPUTS (V)				OUTPUTS (V)		Remarks
	CLR	PR	J	K	Q	$\overline{Q}$	
1	5	0	0	0			
2	5	5	0	0			
3	5	5	0	5			
4	5	5	0	0			
5	5	5	5	0			
6	5	5	0	0			
7	5	5	5	5			
8	0	5	0	0			
9	5	5	0	0			
10	5	5	0	5			
11	5	5	0	0			
12	5	5	5	0			
13	5	5	0	0			
14	5	5	5	5			

RESULTS:

DISCUSSIONS:

Experiment No.: 7

To construct a voltage multipliers (doubler) and study its characteristics

Apparatus Required:

Diodes – 1N4007-2

Capacitors – 100 µF/50 V- 3

Resistor – 100 Ω, 10 KΩ

Bread board

Jumper wires

Multimeter

Step-down transformer (3-0-3)

Theory:

A voltage multiplier is a rectifier circuit that produces a dc output voltage equal to a multiple of the peak input ac voltage. Voltage multipliers may be classified as voltage doublers, triplers, or quadruples etc. A voltage multiplier that produces dc output voltage equal to the double of the input peak voltage is called a voltage doubler. A full wave voltage doubler is connected as Fig.-7.1.

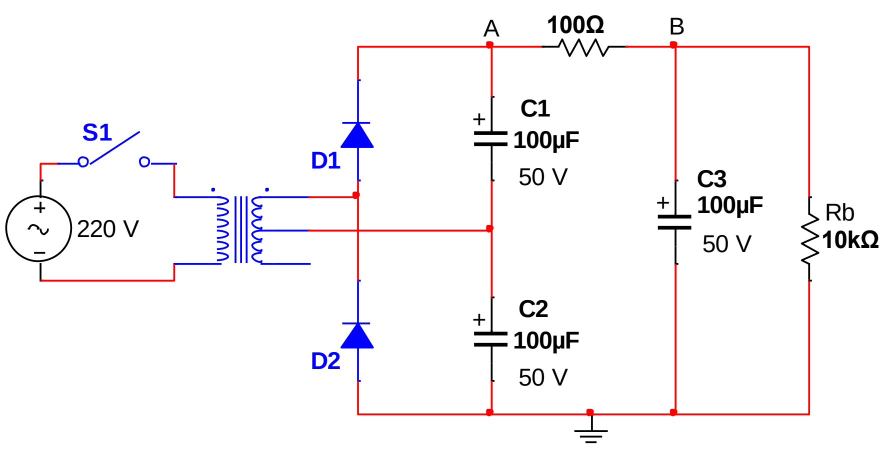


Fig.-7.1: Experimental circuit of full-wave voltage doubler

If peak voltage of ac source is V_p then output is 2 V_p, i.e.

$$V_{out} = 2\ V_{p\ (DC)}\ \text{Where,}\ V_p = \sqrt{2}\ V_{rms}$$

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-7.1. [**Note:** *terminals of diodes and capacitors should be carefully checked. Also V_p should not be greater than 6V if so then capacitor rating should change accordingly*.]
2. Before switch S1 ON, discharge all capacitors.
3. Switch S1 ON: measure and record voltage across R_b (bleeder resistor) in Table 7.1.
4. Switch S1 OFF: discharge all capacitors.
5. Add load resistor R_L across R_b
6. Switch S1 ON: measure and record load voltage in Table 7.1
7. Repeat steps 4 to 6 for other loads.

OBSERVATIONS:

Least count of volt meter =

TABLE 7.1

NOB	R_L (Ω)	Voltage across B-GND (V)
1	No load	
2	10000	
3	4700	
4	1000	
5	500	

RESULTS:

DISCUSSIONS:

Experiment No.: 8

To construct a voltage multipliers (Tripler) and study its characteristics

Apparatus Required:

Diodes – 1N4007-2

Capacitors – 100 µF/50 V- 3

Resistor – 100 Ω, 10 KΩ

Bread board

Jumper wires

Multimeter

Step-down transformer (3-0-3)

Theory:

A voltage multiplier is a rectifier circuit that produces a dc output voltage equal to a multiple of the peak input ac voltage. Voltage multipliers may be classified as voltage doublers, tripler, or quadruples etc. A voltage multiplier that produces dc output voltage equal to the triple of the input peak voltage is called a voltage tripler. A voltage tripler is connected as Fig.-8.1.

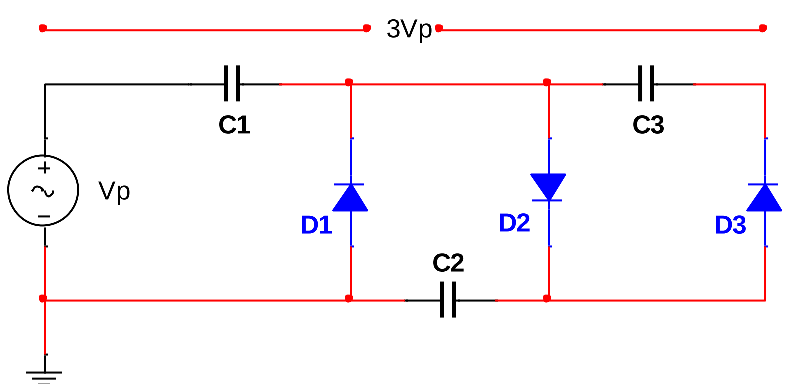


Fig.-8.1: A voltage tripler circuit, as shown.

If peak voltage of ac source is V_p then output is 3 V_p, i.e.

$$V_{out} = 3\,V_{p\,(DC)} \text{ Where, } V_p = \sqrt{2}\,V_{rms}$$

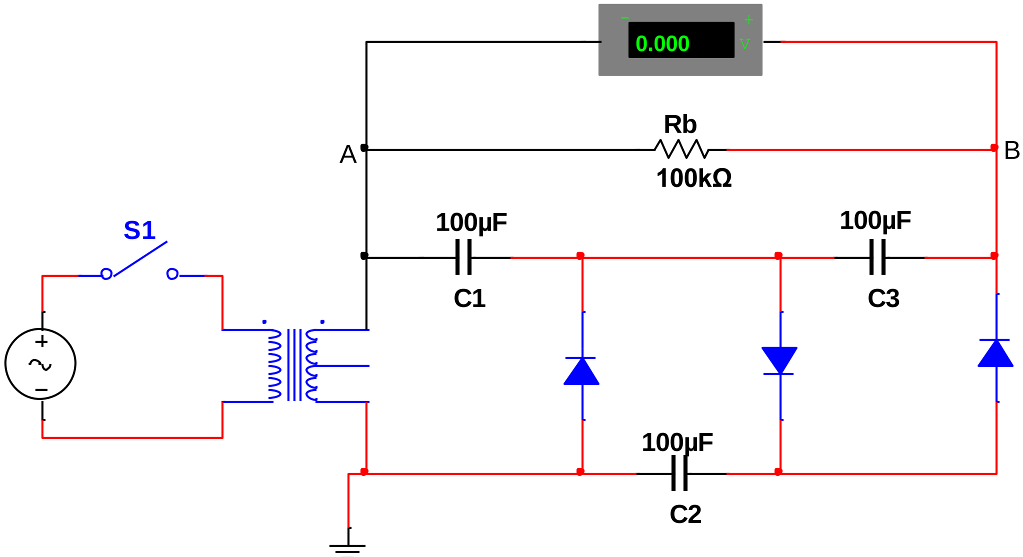


Fig.-8.2: Experimental circuit of voltage tripler

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-8.2. [**Note:** *terminals of diodes and capacitors should be carefully checked. Also* V_p *should not be greater than 6V if so then capacitor rating should change accordingly*.]
2. Before switch S1 ON, discharge all capacitors.
3. Switch S1 ON: measure and record voltage across R_b (bleeder resistor) in Table 8.1.
4. Switch S1 OFF: discharge all capacitors.
5. Add load resistor R_L across R_b (or across point BA)
6. Switch S1 ON: measure and record load voltage (B to A) in Table 8.1
7. Repeat steps 4 to 6 for other loads.

OBSERVATIONS:

Least count of volt meter =

TABLE 8.1

NOB	R_L (Ω)	Voltage across B to A (V)
1	No load	
2	47000	
3	33000	
4	22000	
5	10000	

RESULTS:

DISCUSSIONS:

Experiment No.: 9

To construct and study the working of AND and OR gates (2 and 3 inputs) using diodes.

Apparatus Required:

Diodes – 1N4007-6

Resistor – 1 KΩ -2

Bread board

Jumper wires

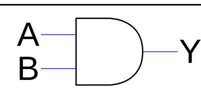
Multimeter

Power supply (5 V)

Theory:

A logic gate is an electronic circuit which makes logic decisions. It has only one output but one or more inputs. The logic gates are basic building block in digital system and responds only to HIGH voltages (called 1s) or LOW (ground) voltages (called 0s).

AND gate: The AND gate is sometimes called the “all or nothing gate”. When all inputs are HIGH then output is HIGH otherwise output is LOW.

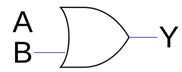
Boolean expression	$Y = A \cdot B \cdot C \cdot$……..	Logic Symbol	

Truth Table

Inputs		Output
A	B	Y
0	0	0
0	1	0
1	0	0
1	1	1

A two and three input AND gates are connected in Fig.-9.1 and Fig.-9.3 respectively.

OR gate: The OR gate is sometimes called the “any or all gate”. When all inputs are LOW then output is LOW otherwise output is HIGH.

Boolean expression	Y = A+B+C+…….	Logic Symbol	

Truth Table

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

A two and three input OR gates are connected in Fig.-9.2 and Fig.-9.4 respectively.

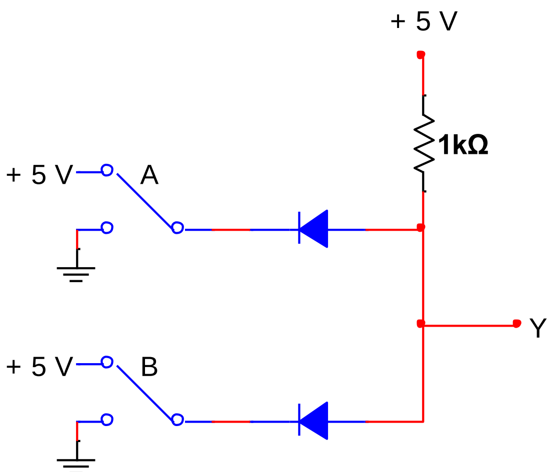


Fig.-9.1: 2-input AND gate

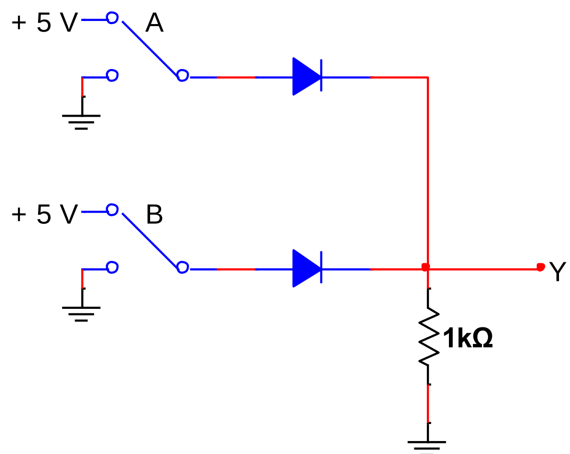


Fig.-9.2: 2-input OR gate

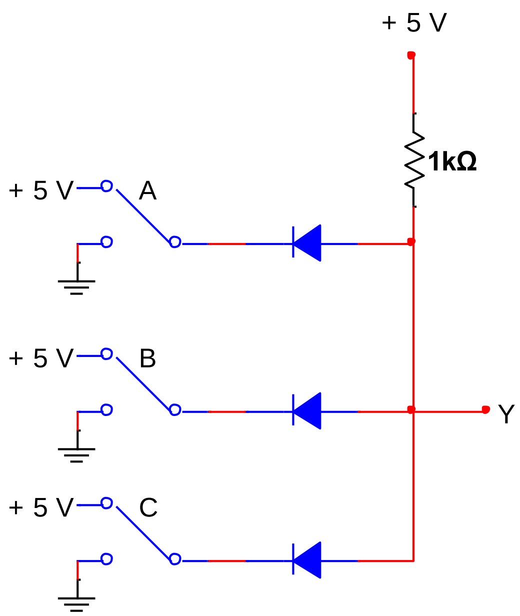


Fig.-9.3: 3-input AND gate

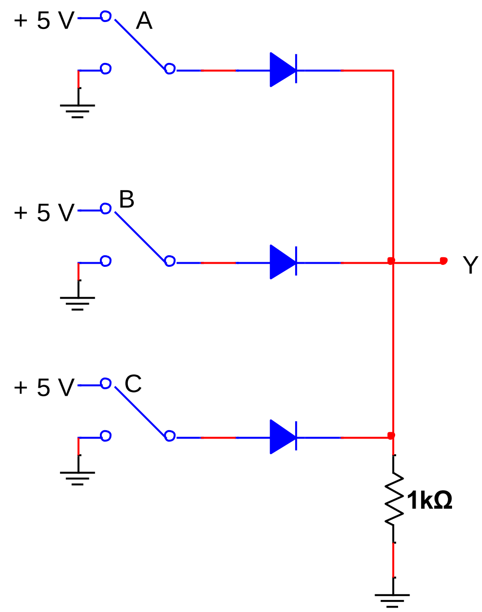


Fig.-9.4: 3-input OR gate

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-9.1. [**Note:** *terminals of diodes should be carefully checked.*]
2. Set, measure and record the different input conditions of it as observation table Table 9.1. [**Note:** *<u>For input:</u> '0' means connect the terminal to Ground and '1' means connect the terminal to +5V. <u>For output:</u> '0' means output voltage less than 0.8V and '1' means output voltage greater than 3.0V. Do not write '0' and '1' in Observation Table but write observed voltage.*]
3. Make the connections as per circuit diagram, Fig.-9.2, Fig.-9.3, Fig.-9.4,
4. Set, measure and record the different input conditions of it as observation table Table 9.2, Table 9.3 and Table 9.4 respectively.

OBSERVATIONS:

Least count of volt meter of multimeter =

TABLE 9.1: AND gate

INPUTS (V)		OUTPUT (V)
A	B	Y
0	0	
0	5	
5	0	
5	5	

TABLE 9.2: OR gate

INPUTS (V)		OUTPUT (V)
A	B	Y
0	0	
0	5	
5	0	
5	5	

TABLE 9.3: AND gate

INPUTS (V)			OUTPUT (V)
A	B	C	Y
0	0	0	
0	0	5	
0	5	0	
0	5	5	
5	0	0	
5	0	5	
5	5	0	
5	5	5	

TABLE 9.4: OR gate

INPUTS (V)			OUTPUT (V)
A	B	C	Y
0	0	0	
0	0	5	
0	5	0	
0	5	5	
5	0	0	
5	0	5	
5	5	0	
5	5	5	

RESULTS:

DISCUSSIONS:

Experiment No.: 10

To construct and study the working of NOT, AND and OR gates using transistors and calculate the power loss in transistor of NOT gate.

Apparatus Required:

Transistors- BC547-3

Resistor – 1 KΩ -2, 10 KΩ

Bread board

Jumper wires

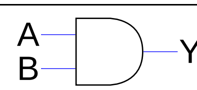
Multimeter

Power supply (5 V)

Theory:

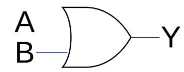
A logic gate is an electronic circuit which makes logic decisions. It has only one output but one or more inputs. The logic gates are basic building block in digital system and responds only to HIGH voltages (called 1s) or LOW (ground) voltages (called 0s).

AND gate: The AND gate is sometimes called the “all or nothing gate”. When all inputs are HIGH then output is HIGH otherwise output is LOW.

<table>
<tr><td>Boolean expression</td><td>Y = A·B</td><td>Logic Symbol</td><td>
</td></tr>
<tr><td>Truth Table</td><td colspan="3">
<table>
<tr><th colspan="2">Inputs</th><th>Output</th></tr>
<tr><th>A</th><th>B</th><th>Y</th></tr>
<tr><td>0</td><td>0</td><td>0</td></tr>
<tr><td>0</td><td>1</td><td>0</td></tr>
<tr><td>1</td><td>0</td><td>0</td></tr>
<tr><td>1</td><td>1</td><td>1</td></tr>
</table>
</td></tr>
</table>

A two input AND gates is connected in Fig.-10.1.

OR gate: The OR gate is sometimes called the “any or all gate”. When all inputs are LOW then output is LOW otherwise output is HIGH.

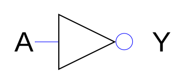
Boolean expression	$Y = A+B$	Logic Symbol	

Truth Table

Inputs		Output
A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

A two input OR gate is connected in Fig.-10.2.

NOT gate: The NOT gate is often called an inverter. The NOT gate, however, has only one input and one output. The job of the NOT gate is to give an output that is not the same as the input.

Boolean expression	$Y = \bar{A}$	Logic Symbol	

Truth Table

Input	Output
A	Y
0	1
1	0

A NOT gate is connected in Fig.-10.3 and for calculation of power loss in transistor is connected as Fig.-10.4.

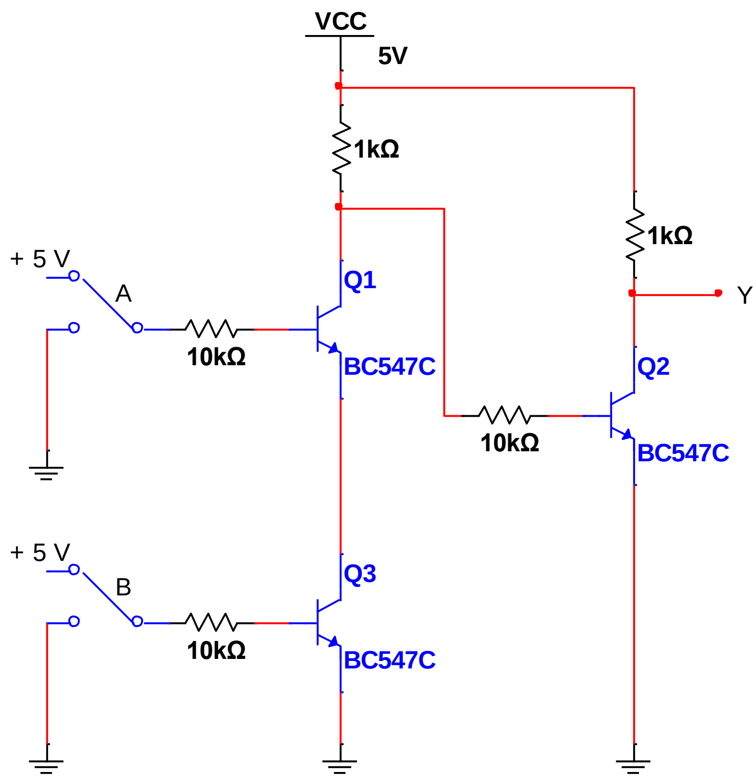


Fig.-10.1: 2-input AND gate

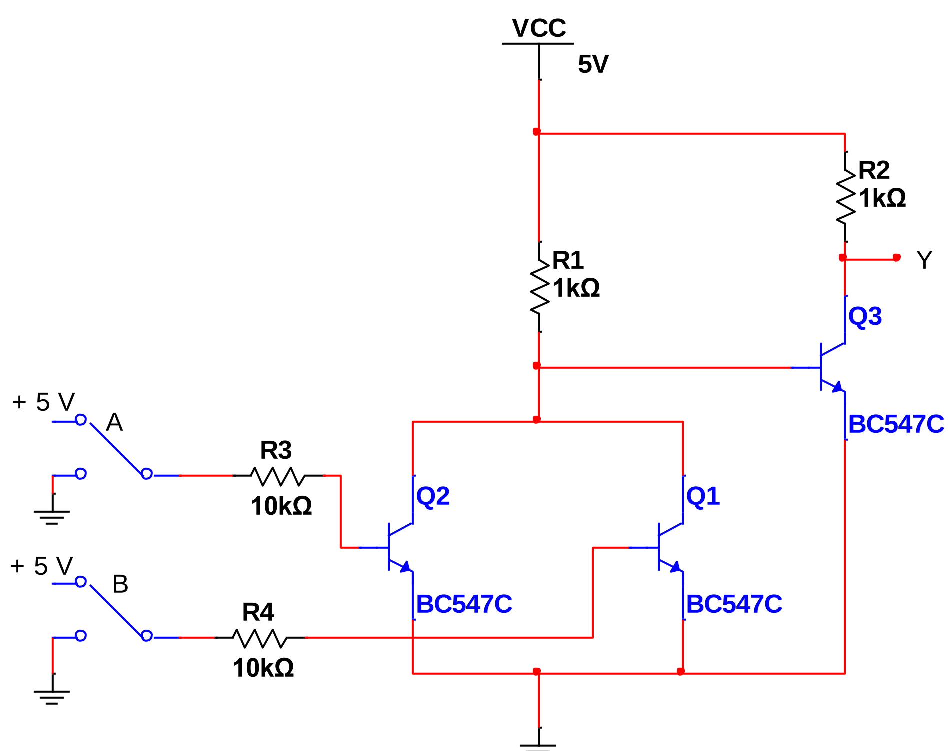


Fig.-10.2: 2-input OR gate

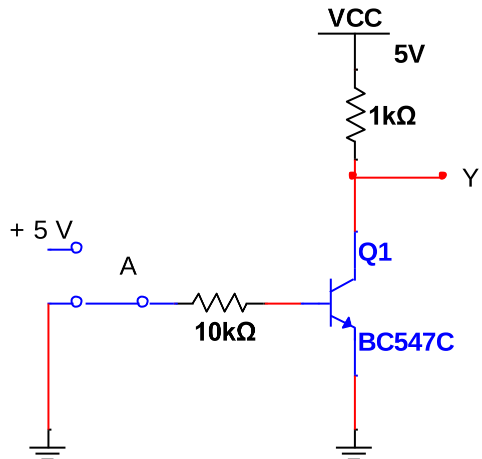


Fig.-10.3: NOT gate

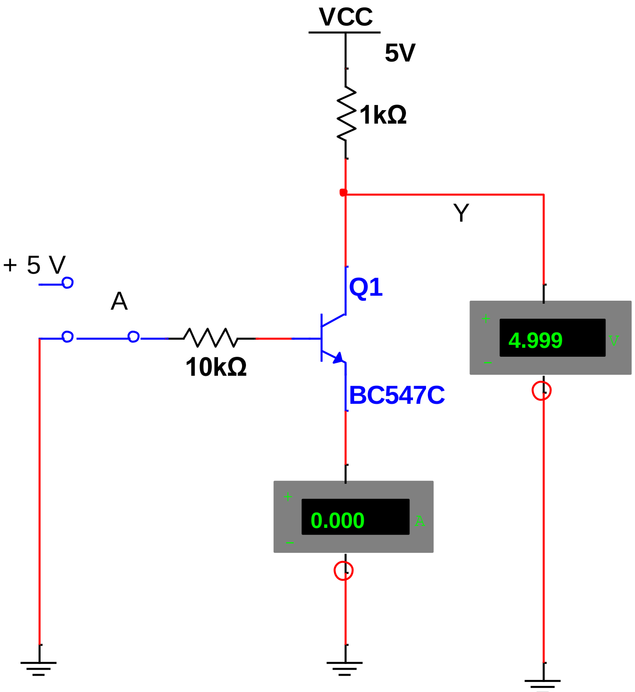


Fig.-10.4: NOT gate for power loss calculation

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-10.1. [**Note:** *terminals of transistors should be carefully checked.*]
2. Set, measure and record the different input conditions of it as observation table Table 10.1. [**Note:** *<u>For input:</u> '0' means connect the terminal to Ground and '1' means connect the terminal to +5V. <u>For output:</u> '0' means output voltage less than 0.8V and '1' means output voltage greater than 3.0V. Do not write '0' and '1' in Observation Table but write observed voltage.*]
3. Make the connections as per circuit diagram, Fig.-10.2, Fig.-10.3 and Fig.-10.4.
4. Set, measure and record the different input conditions of it as observation table Table 10.2, Table 10.3 and Table 10.4 respectively.

OBSERVATIONS:

Least count of volt meter of multimeter =

TABLE 10.1: AND gate

INPUTS (V)		OUTPUT (V)
A	B	Y
0	0	
0	5	
5	0	
5	5	

TABLE 10.2: OR gate

INPUTS (V)		OUTPUT (V)
A	B	Y
0	0	
0	5	
5	0	
5	5	

TABLE 10.3: AND gate

INPUT (V)	OUTPUT (V)
A	Y
0	
5	

TABLE 10.4: Power Loss in NOT gate

INPUT A (V)	For transistor		
	Voltage V (V)	Current I (mA)	Power P =VI (W)
0			
5			

RESULTS:

DISCUSSIONS:

Experiment No.: 11

To study operational amplifier for its input-output waveform and use it as an integrator and differentiator

Apparatus Required:

IC- 741

Resistors –

Bread board

Jumper wires

Oscilloscope

Signal generator

Power supply -12 V – 2 (or Dual Power supply)

Theory:

An operational amplifier (op-amp) is a high-gain, direct-coupled differential linear amplifier whose response characteristics are externally controlled by negative feedback from the output to the input. Op-amp has two inputs, inverting and non-inverting, and one output which is shown in Fig.-11.1.

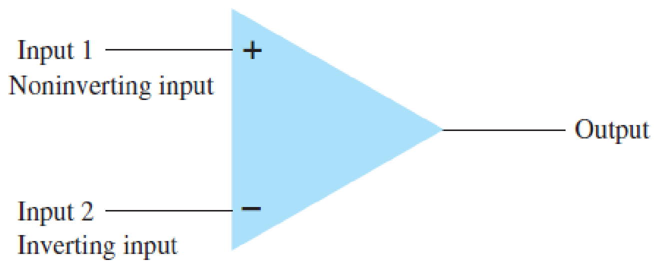
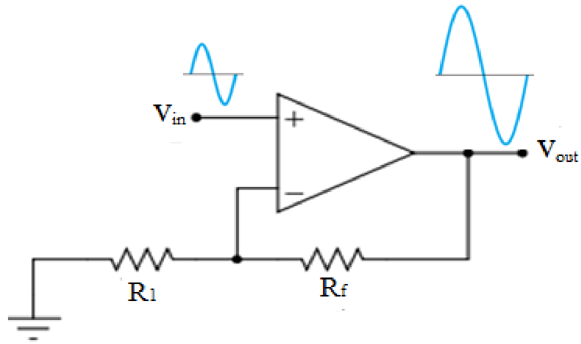
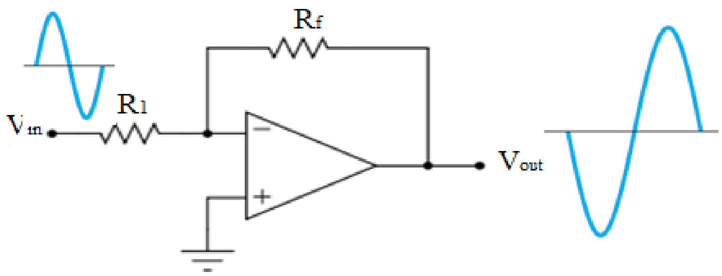
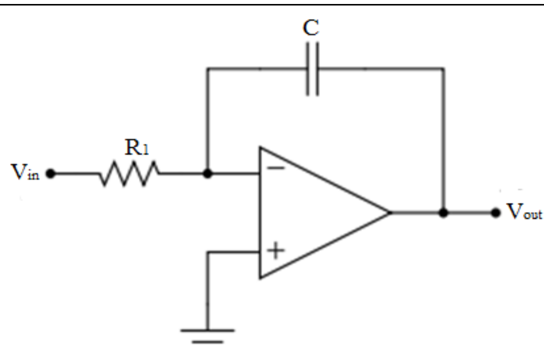
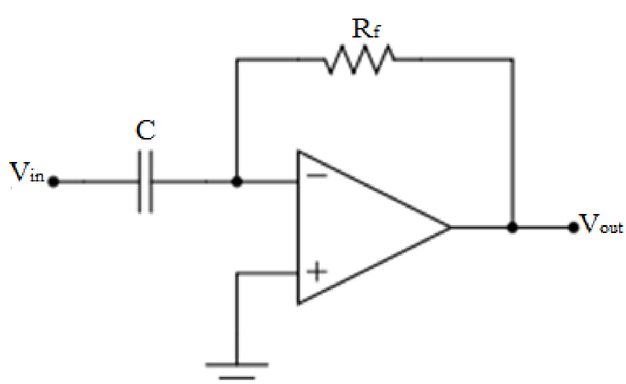


Fig.-11.1: Operational amplifier

One can use op-amp as non-inverting amplifier, inverting amplifier, integrator and differentiator as shown in Fig.-11.2, Fig.-11.3, Fig.-11.4 and Fig.-11.5 respectively. Also the experimental circuits are shown in Fig.-11.6, Fig.-11.7, Fig.-11.8 and Fig.-11.9 respectively.

Non-inverting amplifier	 Fig.-11.2	Gain = $1 + \frac{R_f}{R_1}$
Inverting amplifier	 Fig.-11.3	Gain = $-\frac{R_f}{R_1}$
Integrator	 Fig.-11.4	Gain = $\frac{1}{\omega R_1 C}$ Output leads the input by 90^O
Differentiator	 Fig.-11.5	Gain = = $\omega R_f C$ Output lags the input by 90^O

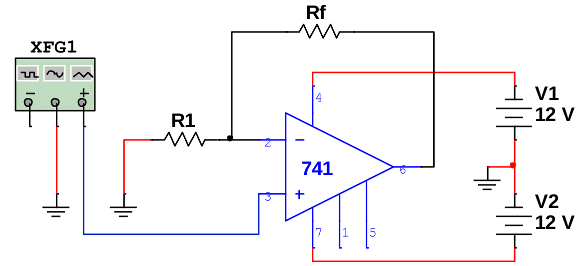


Fig.-11.6: Experimental circuit for Non-inverting amplifier

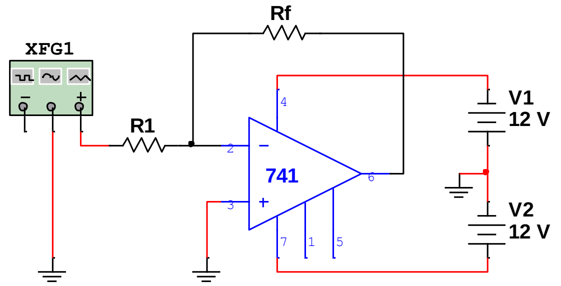


Fig.-11.7: Experimental circuit for Inverting amplifier

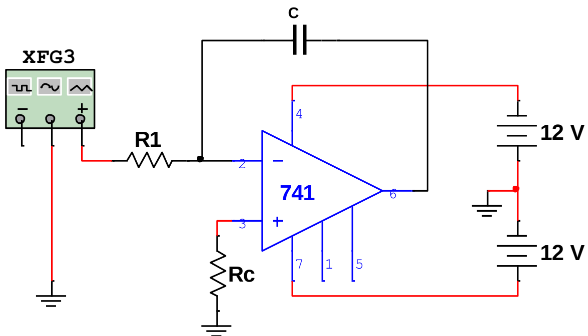


Fig.-11.8: Experimental circuit for Integrator

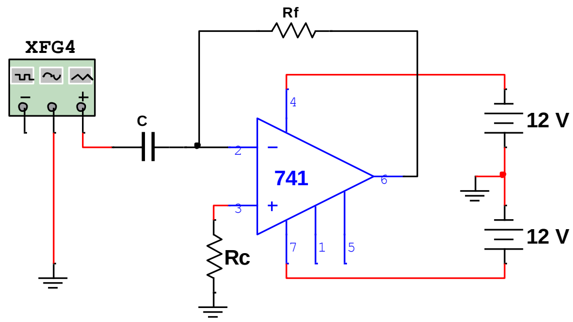


Fig.-11.9: Experimental circuit for Differentiator

PROCEDURE

1. **Non-inverting Amplifier:**
   (a) Make the connections as per circuit diagram, Fig.-11.6. [**Note:** *terminals of IC should be carefully checked. The value of components should be chosen from respective Table.*]
   (b) Set the signal generator for 1Kz and adjust it for maximum undistorted output signal.
   (c) Measure and record in Table 11.1 for different combination of R_1 and R_f.
2. **Inverting Amplifier:**
   (a) Make the connections as per circuit diagram, Fig.-11.7.
   (b) Measure and record in Table 11.2 for different combination of R_1 and R_f.
3. **Integrator:**
   (a) Make the connections as per circuit diagram, Fig.-11.8. [**Note:** choose Rc = R_1]
   (b) Measure and record in Table 11.3 for different combination of R_1, C and f.

4. **Differentiator:**

(c) Make the connections as per circuit diagram, Fig.-11.9. [**Note:** choose Rc = R_f]

(d) Measure and record in Table 11.4 for different combination of R_f, C and f.

OBSERVATIONS:

Table.-11.1: Non-inverting amplifier

R_f (kΩ)	R_1 (kΩ)	V_{p-p} Output (V)	V_{p-p} Input (V)	Gain $1+\frac{R_f}{R_1}$	Gain $\frac{V_{out}}{V_{in}}$	Phase
10	22					
	18					
	10					
	4.7					
	3.3					

Table.-11.2: Inverting amplifier

R_f (kΩ)	R_1 (kΩ)	V_{p-p} Output (V)	V_{p-p} Input (V)	Gain $-\frac{R_f}{R_1}$	Gain $\frac{V_{out}}{V_{in}}$	Phase
10	22					
	18					
	10					
	4.7					
	3.3					

Table.-11.3: Integrator

Frequency F (kHz)	C (μF)	R_1 (kΩ)	V_{p-p}		Gain $\frac{1}{\omega R_1 C}$	Gain $\frac{V_{out}}{V_{in}}$	Phase
			Output (V)	Input (V)			
0.5	0.1	1					
1.0							
1.5							
0.5	0.01	10					
1.0							
1.5							

Table.-11.4: Differentiator

Frequency F (kHz)	C (μF)	R_f (kΩ)	V_{p-p}		Gain $\omega R_f C$	Gain $\frac{V_{out}}{V_{in}}$	Phase
			Output (V)	Input (V)			
0.5	0.1	1					
1.0							
1.5							
0.5	0.01	10					
1.0							
1.5							

RESULTS:

DISCUSSIONS:

Experiment No.: 12

To construct differential amplifier and estimate it's CMRR (Common mode rejection ratio)

Apparatus Required:

Transistor: BC 547-2

Resistors–

Bread board

Jumper wires

Oscilloscope, multimeter

Signal generator, Transformer

Variable Power supply -12 V - 2

Theory:

A differential amplifier (diff-amp) is that which amplifies the difference between two input signals. It consists of two CE amplifiers having emitter directly coupled to each other. The basic circuit of diff-amp is shown in Fig.-12.1.

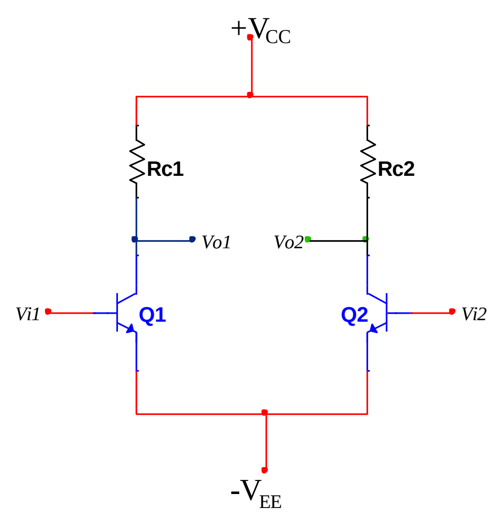


Fig.-12.1: Differential Amplifier

Difference mode diff-amp: in this mode the inverted signals are applied in the inputs. If V_{i1} and V_{i2} are two inputs & V_{o1} and V_{o2} are outputs then difference mode gain is

$$A_{DM} = \frac{V_{o1} - V_{o2}}{V_{i1} - V_{i2}}$$

Common mode diff-amp: in this mode same (common) signal is given to the inputs. The common mode gain is

$$A_{CM} = \frac{V_{12}}{V_{CM}}$$

Where, V_{12} is the output from 1 and 2 output terminals. Also V_{CM} is the applied signal.

Common mode rejection ratio (CMMR) of a diff-amp is

$$CMRR = \left|\frac{A_{DM}}{A_{CM}}\right|$$

The experimental circuits are shown in Fig.-12.2 and Fig.-12.3.

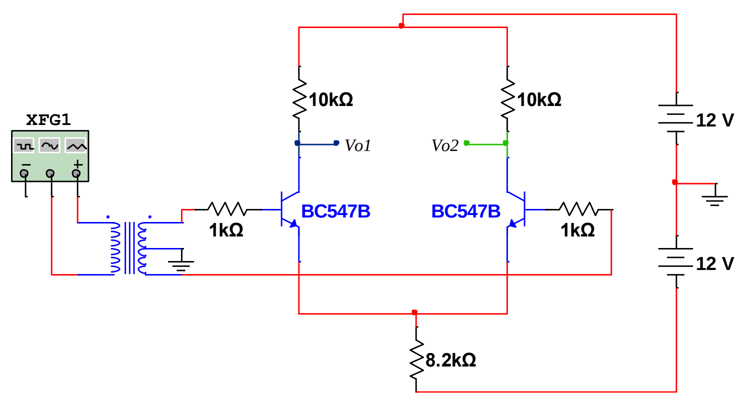


Fig.-12.2: Experimental circuit for Difference-mode Diff-amp

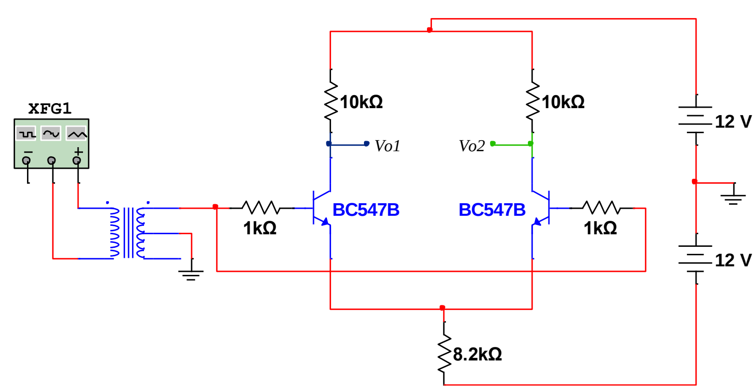


Fig.-12.3: Experimental circuit for Common-mode Diff-amp

PROCEDURE

1. **1.** Make the connections as per circuit diagram, Fig.-12.2. [**Note:** *terminals of transistors should be carefully checked.*]. But V_{i2} should be grounded. Set the Signal generator for 1 kHz and switched it OFF.
2. **2.** Set Vcc, the collector supply, at 10 V and set V_{EE}, the collector supply, to 9 V.
3. **3.** Measure the dc voltage from the collector of Q_1 to ground (V_{c1}) and from the collector of Q_2 to ground (V_{c2}). These voltages should be approximately equal to 5 V. If the collector voltages are not 5 V, adjust V_{EE} until they are. Now record in Table 12.1 accordingly. [**Note:** *Do not change these settings throughout the experiment*]
4. **4. Difference-mode Diff-Amplifier:**
   (a) Make the connections as per circuit diagram, Fig.-12.2 and switched ON the signal generator and adjust the output of it for 50 mV.
   (b) Measure and record in Table 12.2 accordingly. The input signal voltages vi_1 and vi_2 from the base to the ground of Q_1 and Q_2 respectively. [**Check!** Should vi_1 and vi_2 measure 50 mV p-p]
5. **5. Common-mode Diff-Amplifier:**
   (a) Make the connections as per circuit diagram, Fig.-12.3.
   (b) Measure and record in Table 12.3 accordingly.

OBSERVATIONS:

Least count of volt meter of multimeter =

Table.-12.1: DC voltages in Diff-amp

V_{C1}	V_{C2}	V_E	V_{EE}	V_{B1}	V_{B2}

Table.-12.2: AC in Diff-amp- Differential Mode

v_{i1}	v_{i2}	v_{o1}	v_{o2}	v_{12}	v_E	$A_{DM} = \frac{v_{o1} - v_{o2}}{v_{i1} - v_{i2}}$
Trace no.	Trace no.	Trace no.	Trace no.	Trace no.	Trace no.	

Table.-12.3: AC in Diff-amp- Common Mode

$v_{i1} = v_{CM}$	v_{o1}	v_{o2}	v_{12}	v_E	$A_{CM} = \frac{v_{12}}{v_{CM}}$
Trace no.	Trace no.	Trace no.	Trace no.	Trace no.	

CALCULATIONS:

The common mode rejection ratio (CMMR) of a diff-amp is

$$CMRR = \left|\frac{A_{DM}}{A_{CM}}\right|$$

ERROR ANALYSIS: (may add additional pages)

RESULTS:

DISCUSSIONS:

Experiment No.: 13

To study the working of half adder.

Apparatus Required:

IC: 7400 -2, 7402 -2

Bread board

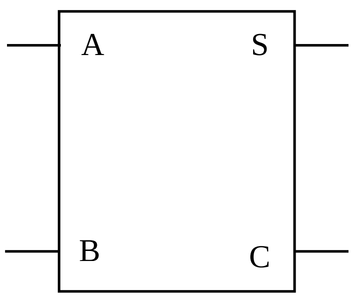
Jumper wires

Multimeter

Power supply (5 V DC)

Theory:

The Half-adder is a logic circuit that adds two one bit binary numbers a time. It has two inputs as A and B, and the outputs as sum and carry denoted by S and C respectively. The logic symbol and truth tables are as Fig.-13.1.



Logic symbol

Inputs		Outputs	
A	B	C	S
0	0	0	0
0	1	0	1
1	0	0	1
1	1	1	0

Truth Table

Fig.-13.1: Half-Adder

The logic circuit of Half-adder is shown in Fig.-13.2 and experimental circuits of it by using NAND gates and NOR gates are connected as Fig.-13.3 and Fig.-13.4 respectively.

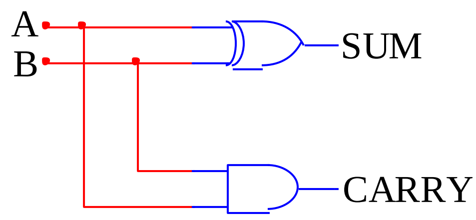


Fig.-13.2: Logic circuit of Half-adder

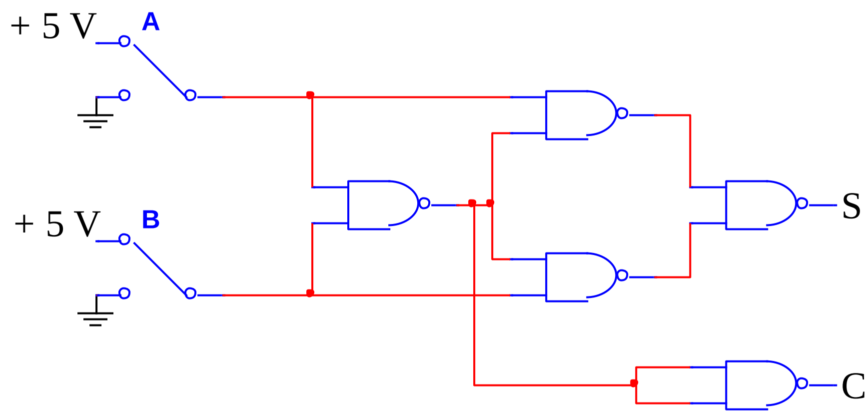


Fig.-13.3: Experimental circuit of Half-adder by using NAND gates

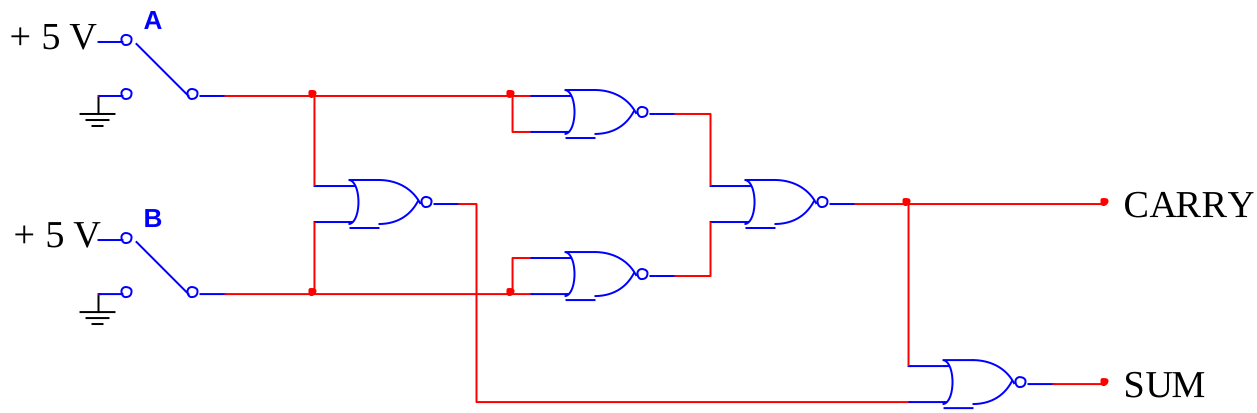


Fig.-13.4: Experimental circuit of Half-adder by using NOR gates

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-13.3. [**Note:** *terminals of IC should be carefully checked.*]
2. Set, measure and record the different input conditions of it as observation table Table 13.1. [**Note:** *<u>For input:</u> '0' means connect the terminal to Ground and '1' means connect the*

terminal to +5V. <u>*For output:*</u> *'0' means output voltage less than 0.8V and '1' means output voltage greater than 3.0V. Do not write '0' and '1' in Observation Table but write observed voltage.*]

3. Make the connections as per circuit diagram, Fig.-13.4. [**Note:** *terminals of IC should be carefully checked.*]
4. Set, measure and record the different input conditions of it as observation table Table 13.2.

OBSERVATIONS:

Least count of volt meter of multimeter =

TABLE 13.1: Using NAND gates

Inputs (V)		Outputs (V)	
A	B	C	S
0	0		
0	5		
5	0		
5	5		

TABLE 13.2: Using NOR gates

Inputs (V)		Outputs (V)	
A	B	C	S
0	0		
0	5		
5	0		
5	5		

RESULTS:

DISCUSSIONS:

Experiment No.: 14

To study the working of full adder.

Apparatus Required:

IC: 7400 -3, 7402 -3

Bread board

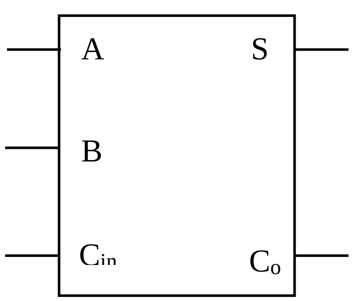
Jumper wires

Multimeter

Power supply (5 V DC)

Theory:

The Full-adder is a logic circuit that adds three one bit binary number a time. It has three inputs and two outputs. Two of the input variables, denoted by A and B, represent the two significant bits to be added. The third input, C_{in}, represents the carry from the previous lower significant bit. The two outputs are denoted by the symbols S for sum and C_o for carry. The logic symbol and truth tables are as Fig.-14.1.



Logic symbol

Inputs			Outputs	
A	B	C_{in}	C_o	S
0	0	0	0	0
0	0	1	0	1
0	1	0	0	1
0	1	1	1	0
1	0	0	0	1
1	0	1	1	0
1	1	0	1	0
1	1	1	1	1

Truth Table

Fig.-14.1: Full-Adder

The logic circuit of Full-adder is shown in Fig.-14.2 and experimental circuits of it by using NAND gates and NOR gates are connected as Fig.-14.3 and Fig.-14.4 respectively.

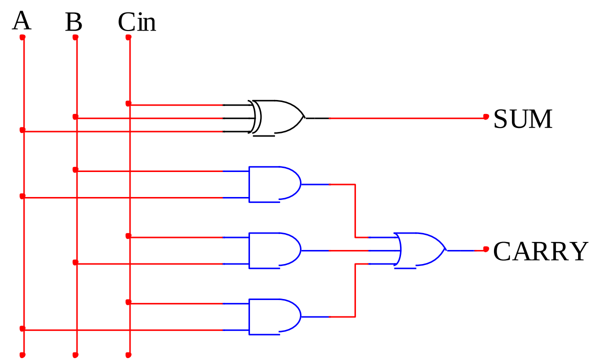


Fig.-14.2: Logic circuit of Full-adder

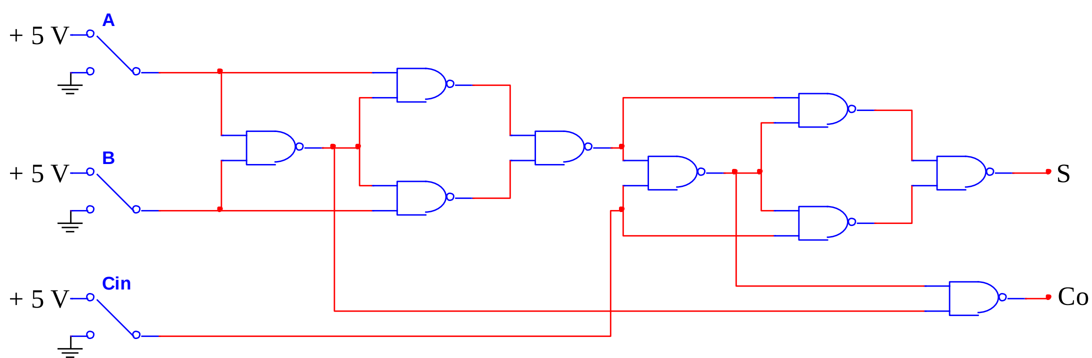


Fig.-14.3: Experimental circuit of Full-adder by using NAND gates

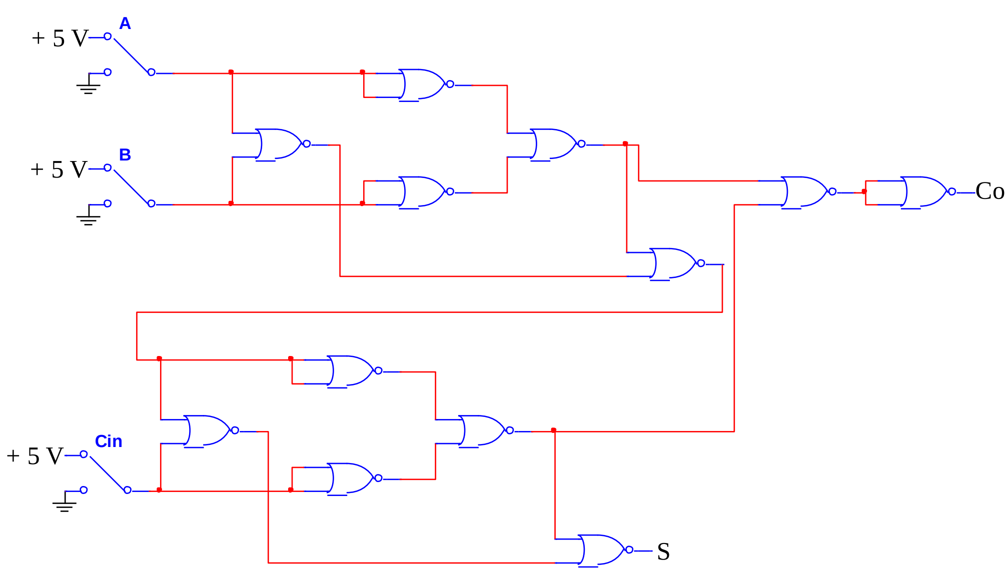


Fig.-14.4: Experimental circuit of Full-adder by using NOR gates

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-14.3. [**Note:** *terminals of IC should be carefully checked.*]
2. Set, measure and record the different input conditions of it as observation table Table 14.1. [**Note:** *<u>For input:</u> '0' means connect the terminal to Ground and '1' means connect the terminal to +5V. <u>For output:</u> '0' means output voltage less than 0.8V and '1' means output voltage greater than 3.0V. Do not write '0' and '1' in Observation Table but write observed voltage.*]
3. Make the connections as per circuit diagram, Fig.-14.4. [**Note:** *terminals of IC should be carefully checked.*]
4. Set, measure and record the different input conditions of it as observation table Table 14.2.

OBSERVATIONS:

Least count of volt meter of multimeter =

TABLE 13.1: Using NAND gates

Inputs (V)			Outputs (V)	
A	B	C_{in}	C_o	S
0	0	0		
0	0	5		
0	5	0		
0	5	5		
5	0	0		
5	0	5		
5	5	0		
5	5	5		

TABLE 13.2: Using NOR gates

Inputs (V)			Outputs (V)	
A	B	C_{in}	C_o	S
0	0	0		
0	0	5		
0	5	0		
0	5	5		
5	0	0		
5	0	5		
5	5	0		
5	5	5		

RESULTS:

DISCUSSIONS:

Experiment No.: 15

To construct D/A converter and to study its working

Apparatus Required:

IC: 741

Resistors

Bread board

Jumper wires

Multimeter

Power supply (DC: 5 V -1, 12 V -2)

Theory:

The binary ladder is a resistive network whose output voltage is a properly weighted sum of the digital inputs. A binary ladder having four input bits (V_0, V_1, V_2, and V_3) is shown in Fig.-15.1.

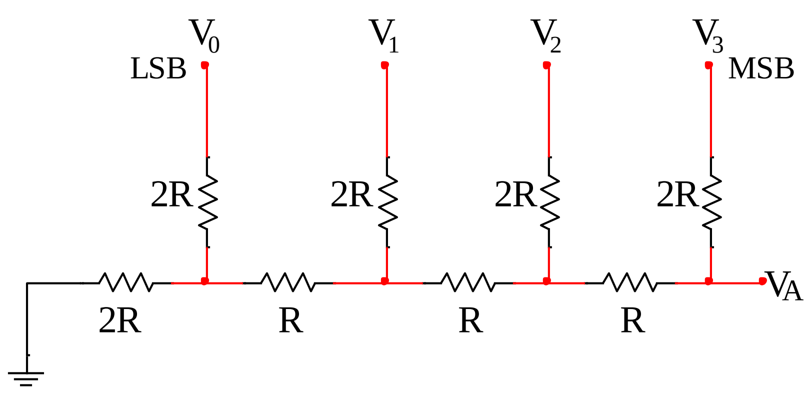


Fig.-15.1: 4-bit binary ladder

The ladder output voltage V_A for any combination of inputs is

$$V_A = \frac{V_3}{2} + \frac{V_2}{4} + \frac{V_1}{8} + \frac{V_0}{16}$$

Where V_0, V_1, V_2, and V_3 are input voltages which are either 0 V dc or +V V dc. The experimental circuit for 4-bit binary ladder is shown in Fig.-15.2.

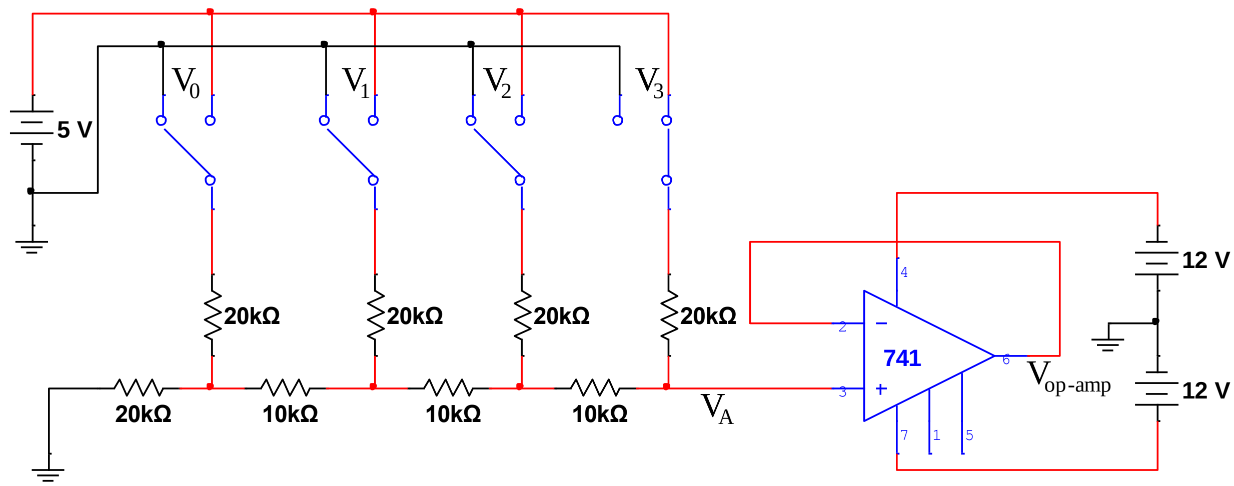


Fig.-15.2: Experimental circuit for 4-bit binary ladder

PROCEDURE

1. Make the connections as per circuit diagram, Fig.-15.2. [**Note:** *terminals of IC should be carefully checked.*]
2. Set, measure and record the different input conditions of it as observation table Table 15.1 [**Note:** *Use voltmeter for voltage measurement insteed of multimeter.*

OBSERVATIONS:

Least count of volt meter =

TABLE 15.1

Inputs (V)				Outputs (V)		Theoretical value
V_3	V_2	V_1	V_0	V_A	$V_{op\text{-}amp}$	V_A (V)
0	0	0	0			
0	0	0	5			
0	0	5	0			
0	0	5	5			
0	5	0	0			
0	5	0	5			
0	5	5	0			
0	5	5	5			
5	0	0	0			
5	0	0	5			
5	0	5	0			
5	0	5	5			
5	5	0	0			
5	5	0	5			
5	5	5	0			
5	5	5	5			

ERROR ANALYSIS: (may add additional pages)

RESULTS:

DISCUSSIONS: