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^{60}Co Radioisotope in Medicine

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Radiotherapy is used in treatment of malignant diseases along with two other modalities, surgery and chemo therapy. The goal of Radiotherapy is to deliver accurately prescribed dose distribution to a well-defined target volume and spare the normal tissues.

Radiotherapy procedures fall into two main categories: External Beam Radiotherapy (EBRT) and Brachytherapy (BT). In EBRT the radiation source is at a certain distance from the patient and the target within the patient is irradiated with an EBRT. In BT, radiation sources are placed directly into the tumor volume (Intracavitary or Interstitial BT) or on to a tumor (Surface Mould or Intraoperative Radiotherapy). Mostly EBRT is carried out with photon beams, some with electron beams and a very small fraction with more exotic particles such as protons, heavier ions or neutrons.

Teletherapy machine with ^{60}Co source was first installed in the year 1954. It has been used for the treatment of cancers in the various sites. Teletherapy^{60}Co unit is simple to operate and its breakdown is very low, so in most of the developing country it plays a major role for the treatment of cancer. Gamma photons from ^{60}Co are directed into the patient's body to kill tumor tissue. Cobalt therapy was a revolutionary advancement in radiotherapy in the post-World War II period but is now being replaced by other technologies such as Medical Linear Accelerators.

The main component of the machine is the radioactive source. It is produced by the method of artificial radioactivity. ^{60}Co source is produced by bombarding the nucleus of ^{59}Co with the neutron. The target atom captures the neutrons and in turns emits two γ (Gamma) rays having energies 1.17 MeV and 1.33 MeV i.e. average of 1.25MeV.

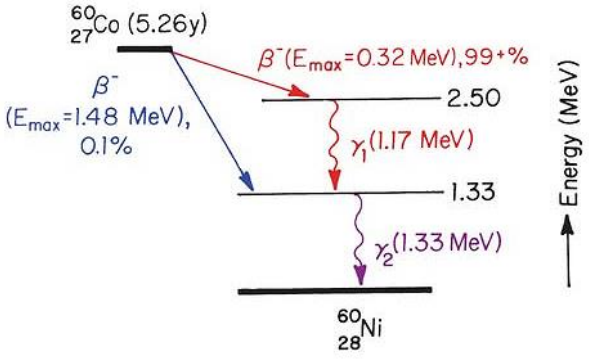

Fig.1:Energy-level diagram for the decay of ^{60}Co nucleus

The ^{60}Co source used in the unit is usually in the form of solid cylinder, discs or pellets. It is contained

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inside a standard stainless steel capsule. The active disc, pellet or cylinder is filled in the stainless steel capsule depending on the activity required. The remaining space is filled with spacing wafer to keep the source in position inside the capsule. This capsule is then placed into another steel capsule which is again sealed. The double welded seal is necessary to prevent leakage of the active material and to filter out β^- radiation. In addition to make possible the fabrication of source of different diameter all with the same external diameter with appropriate inner diameter can be placed in the capsule. The source capsule in turn is filled into the source drawer of international size .This facilitates the interchange of source of one unit to another and from one isotope production facility to another. The typical teletherapy^{60}Co source is a cylinder of diameter ranging from 1-2 cm and is positioned in the Cobalt unit with its circular end facing the collimator opening. A collimator system is designed to vary the size and shape of the beams to meet the requirements.

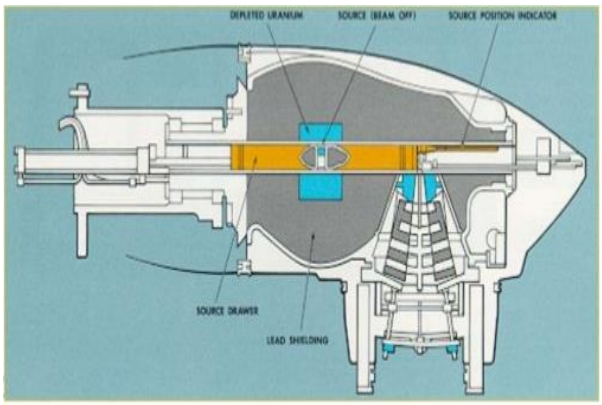

Fig.2: Schematic Diagram of Source Head of ^{60}Co unit.

The housing for the source is called the source head. It consists of a steel shell fitted with lead for the shielding purpose and devised for bringing the source in front of the opening in the head for which the useful beam emerges. Also a heavy metal alloy is provided to form an additional primary shield when the source is in 'OFF' position.

The most commonly used mechanism for source movement is that the source is mounted on a heavy metal drawer is moved horizontally by pneumatic system through a hole running through the source head. In the '**ON**' position the source faces the aperture for the treatment beam and in the '**OFF**' position the source moves to its shielded location and the light source mounted in the same drawer occupies the '**ON**' position of the source.

The main requirements for a teletherapy radio-nuclide are:

1. The isotope should have a fairly long half life so that frequent source replacement need not to be done – ^{60}Co is having a half life of 5.26 Yrs.
2. The gamma rays should have high energy so that the deep seated tumors can be treated, ^{60}Co have average gamma photon energy of 1.25 MeV.
3. The specific activity (activity per unit mass) should be high because higher the specific activity smaller will be the size of the source, ^{60}Co has higher specific activity compared to earlier used ^{226}Ra and ^{137}Cs.

In the last few years the use of ^{60}Co radioisotope for Brachytherapy has been increased enormously because of its longer half-life.

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A Brief Study of Effect of Surface Tension on Chaotic behaviour and Jet Breaking of Dripping Water From a Capillary Tube

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Abstract

Formation of drops of different liquid and their pinch-off from capillary tube under gravity is an important topic which is studied extensively. Formation and ejection process of liquid drops from capillary tube can be classified into different stages like (i) formation of drops and pinch off under static condition i.e., equilibrium of surface tension force of the liquid and gravity force (ii) periodic dripping under relatively low flow velocity, (iii) complex or chaotic dripping with satellite drop formation for intermediate flow velocity and (iv) breaking of jet into drops again for relatively higher flow velocity. Study of liquid drop formation and ejection from small bore tube and capillary has both theoretical and practical importance. Surface tension and viscosity of the experimental liquid and nature of the ambient medium (basically fluid) to which the liquid drops are leaking or entering are the main factors which play important role in determining most of the above stages of drop formation and ejection process. In this investigation we study the effect of surface tension on chaotic dripping and jet breaking along with satellite drop formation in case of water and soap solution having different surface tension.

1. Introduction

Study of dripping water from a tap or faucet demonstrates the possibility of different types of behaviour of dripping of different liquids from capillary and small bore tubes. In case of a dripping liquid formation of drops, their ejection, periodic dripping, onset of chaos, formation of satellite drops, breaking of jet into drops again etc are controlled by different factors like (i) surface tension and viscosity of the experimental liquid, (ii) its flow velocity, (iii) radius of the tube or capillary, (iv) pressure gradient inside the flow tube, (v) geometry of the nozzle and (vi) nature of the ambient fluid to which the liquid drops are leaking or entering. It is difficult to study the role of all these factors on dripping of liquids simultaneously. In our study we focus our attention to investigate the effect of surface tension and flow velocity on chaotic behaviour, satellite drop formation and breaking of jet into drops again due to hydrodynamic instability keeping radius and geometry of the nozzle fixed for horizontal flow of the liquid through flow tube to the nozzle.

For extremely small flow velocities the experimental liquid flows very slowly into the growing pendant drop and the drop grows uniformly. The drop grows until the gravitational and surface tension forces are balanced. The drop is released once this threshold is exceeded. This phenomenon was extensively studied by Harkins and Brown [1]. We consider this phenomenon for determination of surface tension of the experimental liquid.

For relatively low flow velocities when drag forces contributed by viscosity of the liquid and resistive force contributed by the medium are negligible (which are

dependent on velocity of the elongating drop at the nozzle after formation) relatively large size and uniform shaped (almost spherical at the beginning) drops are formed. As soon as the weight of the drop exceeds surface tension force the hanging drop starts to elongate moving downward. A neck is formed and elongates into an almost cylindrical column or ligament. Gradually the ligament becomes narrow enough and breaks in one or several places because of instability of the liquid cylinder formed by the ligament when its length exceeds circumference. In most of the cases it breaks at the lower end near the detaching drop and the primary drop is formed which continues to move downward. After this the ligament contracts vertically. In some cases it may break in several places forming smaller size satellite drops.

With increase in flow velocity dripping process continues but the size and the time between successive drops begin to vary non-linearly. The point of drop detachment also moves further from the nozzle. This regime of drop formation and ejection is called the chaotic dripping**.** Dreyer and Hickey (2) investigated the dynamics of chaotic dripping with different tube radii. At higher flow rates two or more drops were observed to leave the nozzle followed by a sequence of smaller drops. The transition between periodic and chaotic dripping is dependent on the Weber number which is defined as $We = \frac{\rho v^2 D}{T}$, where ρ is density of the liquid, v is flow velocity of the liquid, D is diameter of the nozzle and T is surface tension of the liquid.

With further increase in flow velocity the balance between surface tension and gravity force is disturbed and the liquid begins to emerge from the nozzle in a form of a jet. Perturbations and oscillations grow on the free surface of the liquid which leads the jet to disintegrate into drops. The detachment point of the droplets shifts downstream from the exit of the orifice. This process of drop formation is called jetting or jet breaking or jet disintegration. A great number of studies dedicated to jet disintegration exist due to its importance in a variety of industrial processes such as ink-jet printing, fuel combustion, spray painting etc.

2. Experimental Details

2.1. Theory

Surface tension and viscous force of the liquid play important role in the formation and ejection of drops at opening of a small bore or capillary tube when the liquid flow is uniform and slow. Basic forces acting on a drop formed at the nozzle of a small bore tube are-

(i) gravity force mg acting in vertically downward direction, where m is the mass of drop formed at nozzle and g is acceleration due to gravity

(ii) surface tension force πdT acting in vertically upward direction, where d is the diameter of the nozzle and T is surface tension of the liquid

(iii) upward drag force bv contributed by the viscosity of the liquid

Where, y is the position of the centre of mass of the drop as measured from the level of the nozzle at an instant of time t, b is the drag coefficient contributed by viscosity of the liquid.

v= $\frac{dy}{dt}$ velocity of the oscillating drop at the instant of time t. Thus the equations of motion of the drop can be written as

$$\frac{d(mv)}{dt} = mg - \pi dT - bv \qquad (1)$$

$$\frac{dm}{dt} = flow.rate \qquad (2)$$

Equation (1) describes the motion of the growing drop and equation (2) gives its rate of growth.

When the flow rate or velocity of the liquid into the forming drop is uniform or constant and the drop is static under the balanced condition of the gravity force and surface tension force equation (1) gives

$$mg = \pi dT \text{ Or } T = \frac{mg}{\pi d} \qquad (3)$$

Equation (3) can be used to calculate the surface tension of the experimental liquid.

For periodic dripping the time interval between successive falling drops and the drop size are same. If the time interval between successive falling drops are measured experimentally a graph between Tn (time interval between two consecutive drops i.e. n th and (n+1)th drop) versus Tn+1 (time interval between(n+1)th and (n+2)th drop) called return map can be plotted to verify the periodic and chaotic regimes of dripping. On the other hand phase diagram which is a graph between time of falling and time interval between successive falling drops can be plotted to examine the repetition of periodicity. Number of different periods of

the falling drops for a particular liquid depends on surface tension and flow velocity of the liquid into the capillary tube. To verify change of number of periods with flow velocity a graph between flow velocity and number of periods called bifurcation graphs are plotted for different values of surface tension of soap solution obtained by mixing suitable detergent to distilled water. Surface tension force of the liquid plays an important role in the occurrence of chaotic behaviour as well as formation of satellite drops of the dripping liquid. A graph between surface tension of the liquid and flow velocity for occurrence of chaotic dripping and formation of satellite drop is also drawn.

2.2 Experimental details:

2.2.1. For study of Periodicity of Dripping Drops:

The experimental arrangement for study of periodicity of the dripping drops from a nozzle consists of two mechanisms:

A small bore rubber tube of sufficient length with a regulator and nozzle fitted to its one end is used to produce water drops at different rate. The other end of the tube is connected to a water reservoir. In our study we use an IV drip set (intervenes drip set) in which the drip rate can be controlled conveniently. It should be kept it mind that the water level in the reservoir should not change with time. Otherwise it will affect the flow velocity of the liquid. For this we have used two reservoirs-one as primary reservoir and the other as secondary reservoir. The IV set is connected to the primary reservoir while the secondary one helps in maintaining constant water level in the primary reservoir.

A highly accurate time counting mechanism is used to record the time interval between two successive falling water drops which an IR is sensing system interfaced with ATMEGA328PU microcontroller of an Arduino UNO board.

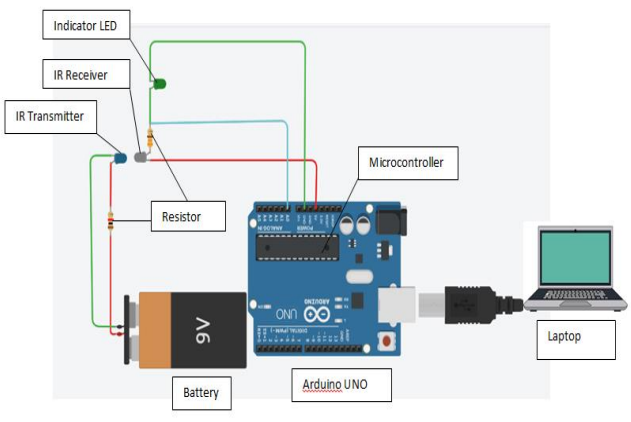


Figure 1: Circuit diagram of the transmitter and receiver

In the circuit shown in the Fig.1, the photo diode is connected in reverse biased. When it receives the IR beam emitted by the IR LED, the circuit is closed and the indicator LED glows. The positive and negative terminals of the photodiode are connected to the pin A0 and GND of the ATMEGA328PU Microcontroller of the Arduino UNO board, so that the voltage across the photodiode can be fed to the microcontroller. While the circuit remains closed i.e. the photodiode receives the IR beam, there exists a certain amount potential difference between the pins A0 and GND of the microcontroller. If the photodiode stops receiving the IR beam, the circuit is open and the voltage between the A0 and GND changes.

The nozzle of the capillary tube is placed in such a position that the water droplets fall through the gap between the IR LED and the photodiode. When a droplet blocks the IR beam, the circuit is open and the voltage drop between the pins A0 and GND changes from its previous value while the circuit was closed. The time interval between such two consecutive voltage changes gives the time interval between two consecutive falling water drops.

The microcontroller is programmed in such a way that it measures the time interval between two consecutive change of voltage drops between the pins A0 and GND. The Arduino UNO is interfaced with a computer and the time intervals between consecutive falling liquid drops are displayed on the computer screen and these data are saved for drawing different graphs.

2.2.2. *For Measuring Surface Tension of The Liquid:*

The required experimental arrangement for measuring the surface tension of the experimental liquid is shown in Fig.2. The liquid is allowed to enter into the capillary with minimum possible velocity so that the liquid drops fall almost under the balanced condition of gravity force and the surface tension force. Mass of known number of drops is measured which gives the average mass of a drop. Then by using the equation (3), we can calculate the value of surface tension of the liquid.

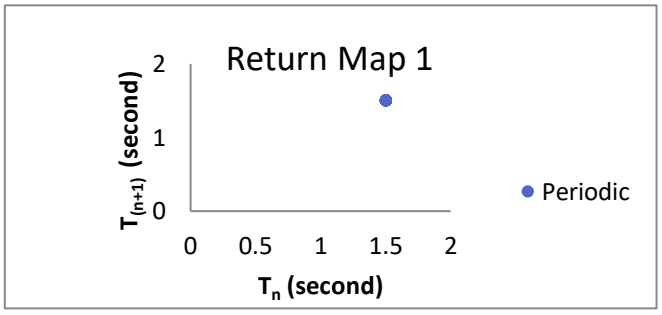
2.2.3. For Measuring the Flow Velocity of the Liquid:

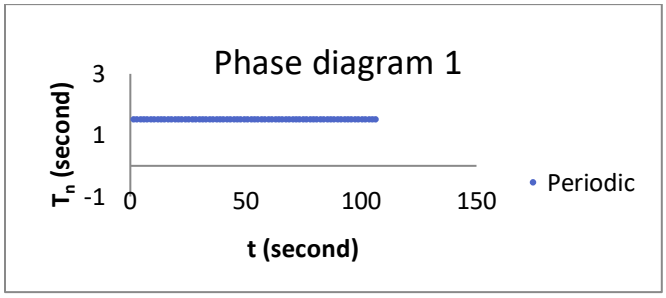
For this the flow pipe is placed horizontally to avoid the effect of gravity on the flow velocity of the liquid. Time taken by the liquid to travel a certain distance is recorded. Dividing this distance by the recorded time the flow velocity of the liquid can be calculated.

3. Results and Discussions

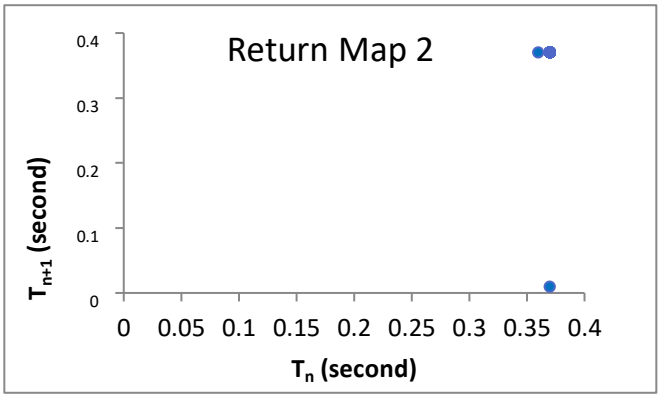
3.1. Graphical Analysis of data for distilled water with surface tension =69.91 dyne/cm

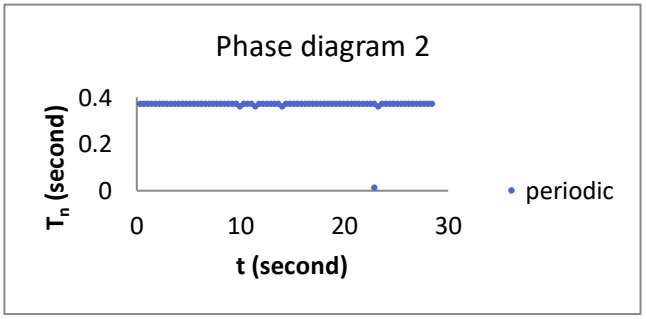
(i) Flow velocity = 0.54cm sec^{-1}, Average mass of a drop=0.05gm, Average volume of a drop =0.05cm^3, Average radius of a drop =0.2283cm.



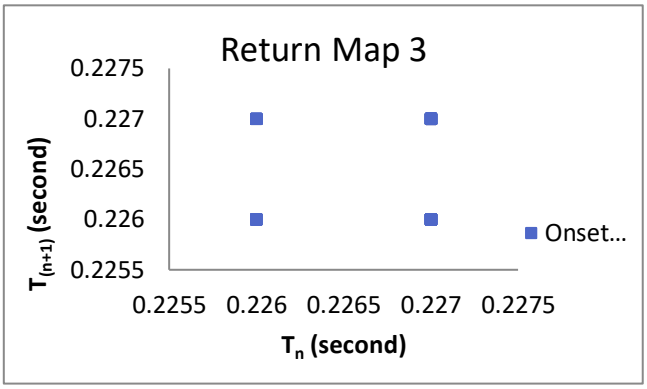


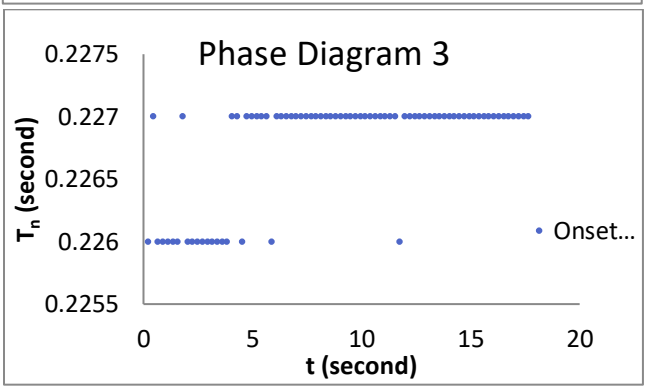
(ii) Flow velocity=1.56cm/sec, Average mass of a drop=0.05gm, Average volume of a drop=0.05cm^3 Average radius of a drop=0.2283cm



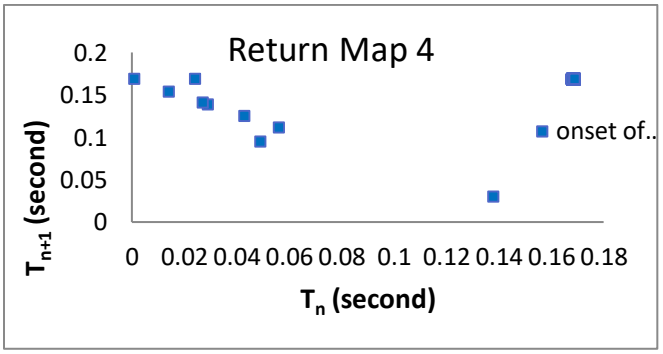


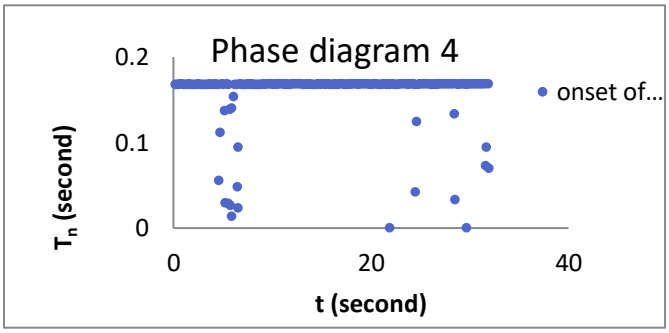
(iii) Flow velocity = 4cm sec^{-1}, Average mass of a drop=0.060gm, Average volume of a drop=0.06cm^3, Average radius of a drop=0.2410cm



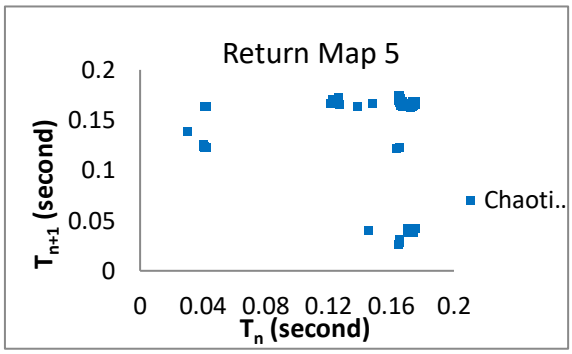


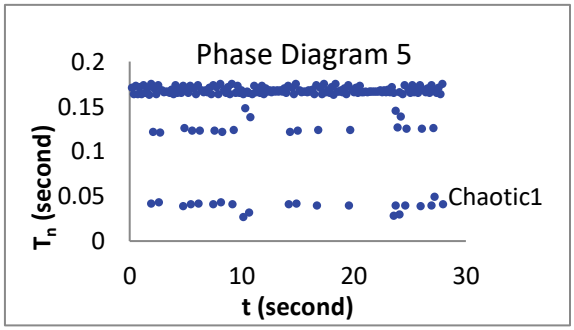
(iv) Flow velocity=4.76cm s^{-1} Average mass of a drop = 0.08085gm, Average volume of a drop=0.08085cm^3, Average radius of a drop=0.2682cm



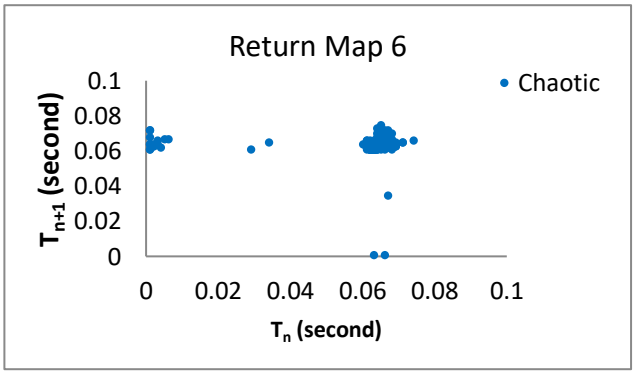


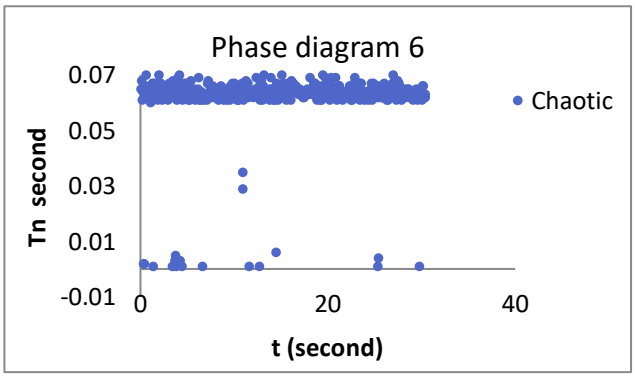
(v) Flow velocity=6.67cm sec^{-1}, Average mass of a drop=0.124gm, Average volume of a drop=0.124cm^3, Average radius of a drop =0.3093cm



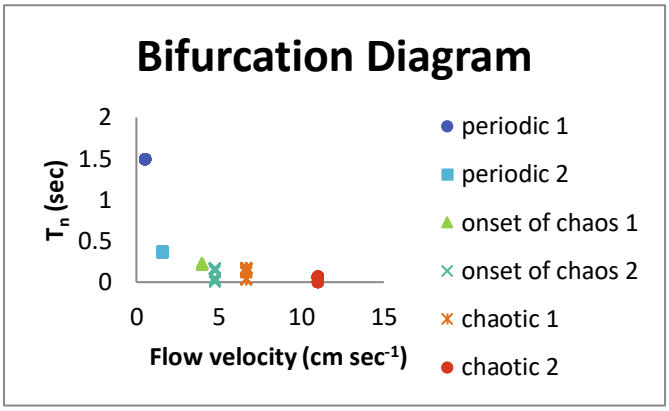


(vi) Flow velocity=10.989 cms^{-1}, Average mass of a drop=0.060gm, Average volume of a drop =0.06cm^3, Average radius of a drop =0.2410cm.



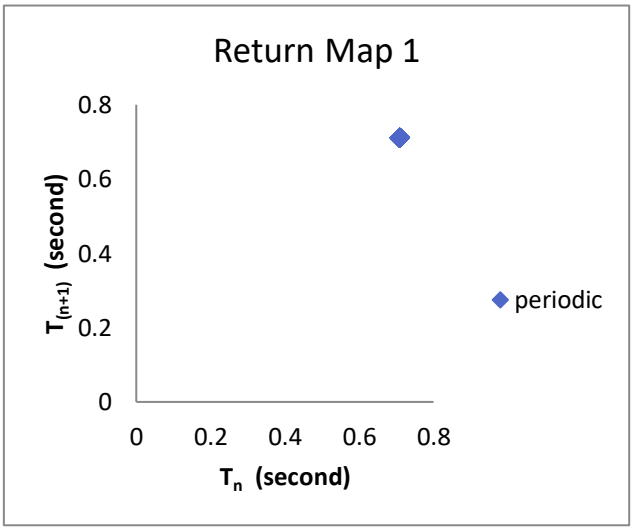


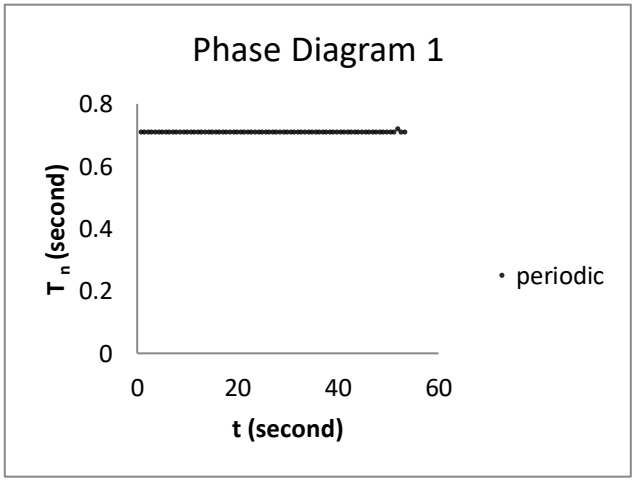
Bifurcation diagram for distilled water:



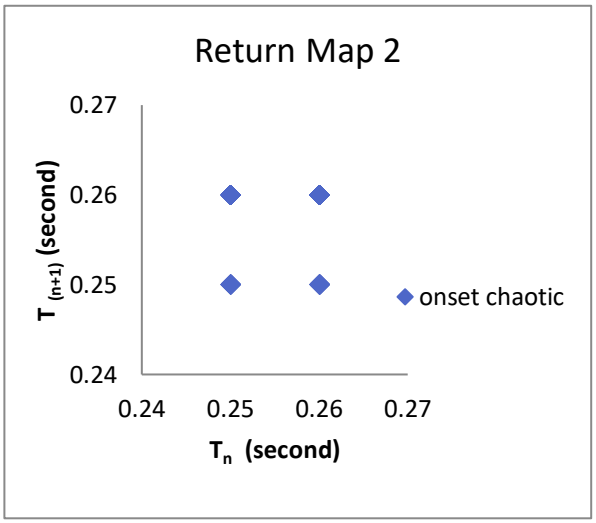
3.2 Graphical analysis of data for soap solution with surface tension = 58.259 dyne/cm

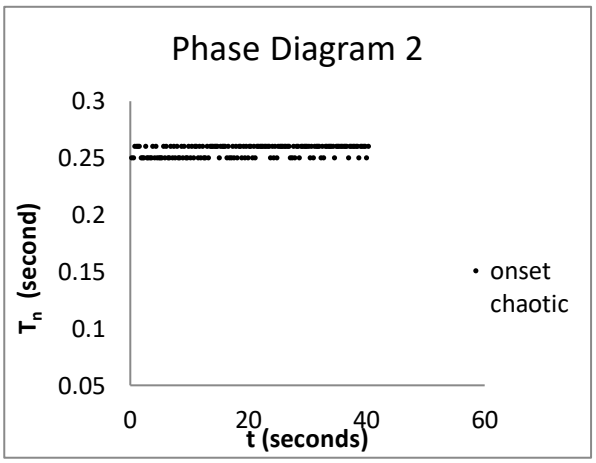
(i) Flow velocity= 0.535cm/sec, Average mass of a drop=0.029gm, Average volume of a drop =0.044cm^3 Average radius of a drop =0.2189cm



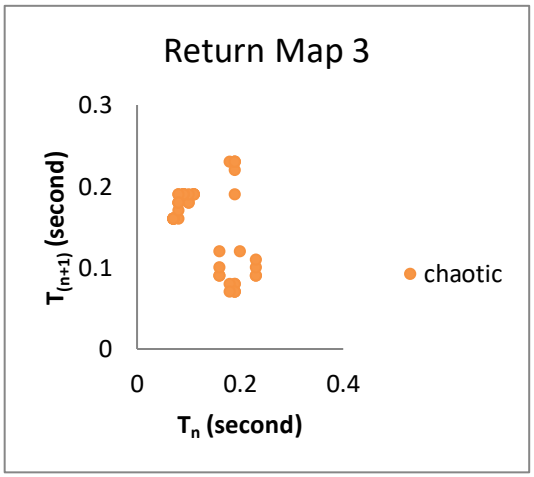


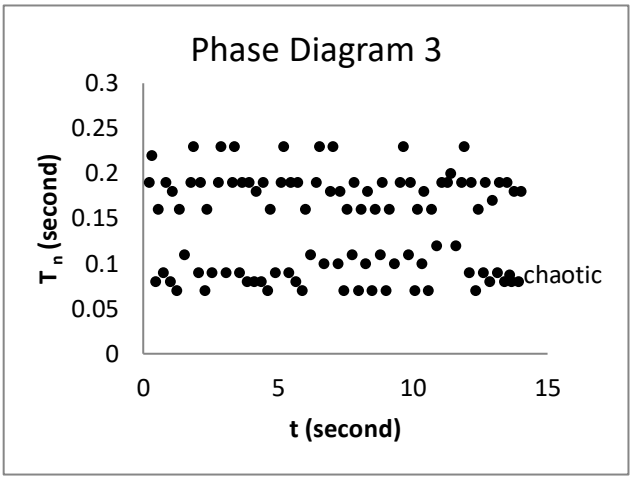
(ii) Flow velocity= 1.577cm/sec, Average mass of a drop=0.0356gm, Average volume of a drop=0.0547cm^3, Average radius of a drop=0.2351cm



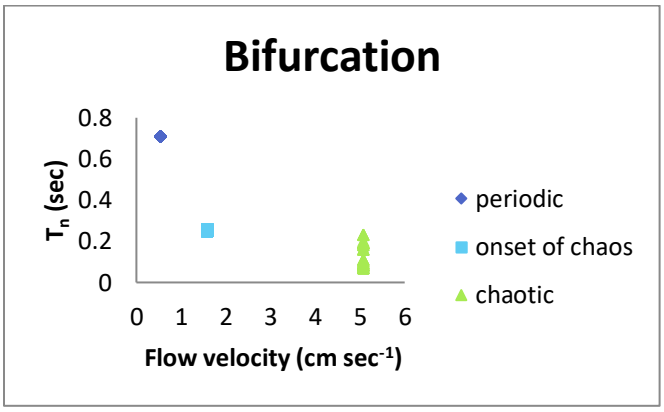


(iii) Flow velocity= 5.076 cm/sec, Average mass of a drop=0.051gm, Average volume of a drop=0.078cm^3, Average radius of a drop =0.2654cm

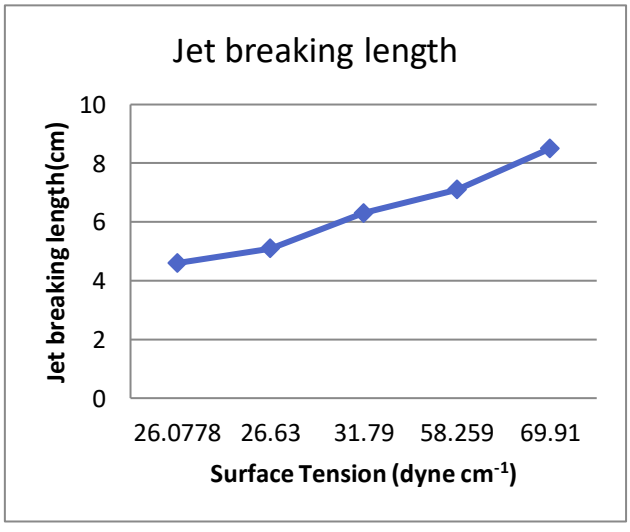




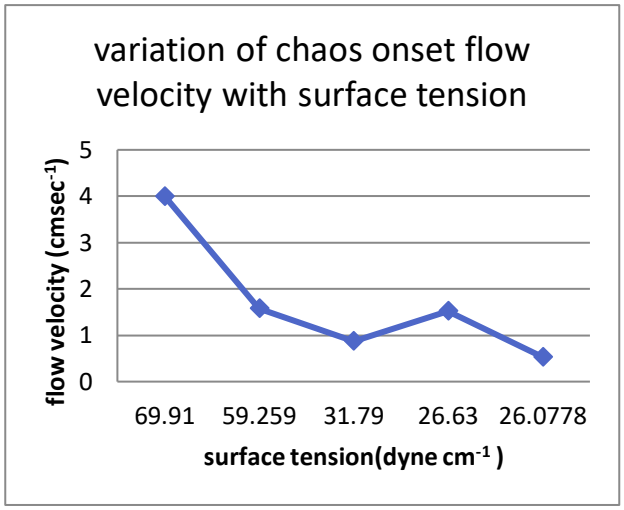
Bifurcation Diagram for soap solution with surface tension = 58.259 dyne/cm:



3.3 Variation of Jet breaking Length with surface tension:



3.4 Variation of chaos onset flow velocity with surface tension:



3.5 Discussion:

For water as well as for soap solution of different surface tension periodic and chaotic regimes are found to occur at different flow velocities. For water with surface tension 69.91 dyne cm^{-1} dripping remains periodic up to a flow velocity approximately 4cm sec^{-1} and thereafter becomes more and more chaotic as the flow velocity is increased. For soap solution with surface tension 58.259 dyne cm^{-1} dripping remains periodic up to a flow velocity 0.535cm sec^{-1} and becomes chaotic for flow velocity 1.577cm sec^{-1}. Similarly for soap solution with surface tension 31.79 dyne cm^{-1} and flow velocity 0.875cm sec^{-1} dripping becomes chaotic. Dripping becomes chaotic for soap solution with surface tension 26.63 dyne cm^{-1}. For soap solution of surface tension 26.0778 dyne cm^{-1} there is no periodic regime. The numbers of different periods between successive drops also increase with flow velocity which is clear from the bifurcation diagram for water as well as for soap solution of different surface tension. The curve between surface tension and flow velocity at which the dripping becomes chaotic clearly shows that surface tension is the main factor governing the chaotic behaviour of dripping liquids. As mentioned earlier for higher flow velocity liquid flows from the nozzle as a cylindrical jet. But the jet breaks or disintegrates into almost continuous drops due to an instability developed on the surface of the cylindrical jet which is in contact with the ambient medium (here air) to which the liquid is flowing out. The length between the nozzle level and at which the jet breaks into drops is called jet breaking length. The curve plotted between surface tension and jet breaking length clearly shows that the jet breaking length increases with increase with surface tension. Dependency of chaotic behaviour and jet breaking length on surface tension is obvious because surface tension is the main restoring force acting on the drop after its formation at the end of nozzle.

In the dripping phenomenon of a liquid from a capillary periodic doubling is an important observation. In periodic doubling the time interval between two successive falling drops is doubling that of the time interval between other two successive falling drops. Though periodic doubling is found to occur for water as well as soap solution of different surface tension no correlation can be established between surface tension and periodic doubling. This may be due to absence of proper mechanism to control the flow velocity of the liquid into the capillary.

Another important observation in dripping of liquid from a nozzle is the formation of satellite drops along with the main drop. During formation of the drop as soon as the weight of the drop exceeds the restoring surface tension force the hanging drop starts to elongate moving downward. A neck is formed and elongates into an almost cylindrical column or ligament. Gradually the ligament becomes narrow enough and breaks in one or several places because of instability of the liquid cylinder formed by the ligament when its length exceeds circumference. In this way a primary drop accompanied by smaller size satellite drops is formed. In this process an interesting thing found to happen. The sum of the time periods of the primary drop and the satellite drops is found to be equal to the time interval between two successive drops previous or next to the formation of satellite drop. This indicates that satellite drops are actually parts of a primary drop which are formed due to breaking of the ligament at more the one point caused by instability.

4. Conclusions:

Chaos is an unpredictable and irregularly regular phenomenon taking place in nature. Study of chaos is important not only from the point of view fundamental phenomenon of Physics but also from practical applications in scientific development. Studies are going on among the scientific community to explore the various aspects of chaos. This investigation establishes the importance of surface tension force on chaotic behaviour and jet breaking of dripping liquid from capillaries. Formation of satellite drops is also observed which is important from practical application in various technologies like ink-jet printing, slurry fuel combustion,

ceramics manufacture, textile printing, spray-drying etc. In these technologies formation of satellite drop is undesired because it causes non-uniform distribution of the ink or sprayed substances. In this study though the formation of satellite drops are observed a definite correlation regarding formation and their number could not be established. The size and number of satellite drops are found to change irregularly with surface tension of the liquid. In case of satellite formation further study is important from the point of view practical application.

In this sub-section the authors are expected to jot down their main findings. The authors can also include figures **(a maximum number of 8 figures are allowed)**, tables to justify their results. A proper discussion of the results in light of established physical principles and theories have to be written citing proper references [2]. The results can also be specifically explained in the form of sub-sub headings as given below.

5. Acknowledgement

The authors would like to thank our respected professors of the department for their support in completion of the work. Thank also goes to the Principal, B. Borooah College for his support. Moreover, the help from the laboratory assistant will remain in the mind forever.

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Construction of Digital Stopwatch for Laboratory use

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Abstract

Stopwatches find use as time keeping device in many fields, namely sports. Stopwatches may be analog or digital. Its function is to find out how long it takes in an activity .Digital stopwatches are much more common than analog version owing to their higher accuracy and ease of use. Here we have tried to realize a digital stopwatch of reasonable accuracy and reliability. This particular stopwatch can count up to 999 seconds and 99 centiseconds .It is accurate up to 1/100 of a second. The circuit is relatively simple and easy to realize. The heart of the circuit is an astable multivibrator followed by counter and decoder stages. The circuit is explained extensively in the following pages. The circuit operates on 9-v dc supply. It uses a seven segment LED display of common cathode type to show time

1. Introduction:

Stopwatches are handheld timepieces which can measure the time elapse between its activation and deactivation. Stopwatches can be classified into two categories: Type I if they have a digital design employing quartz oscillators and electronic circuitry to measure time intervals. Type II stopwatches have an analog design and use mechanical mechanisms to measure time intervals. Every stopwatch is composed of four elements: a power source, a time base, a counter, and a display. The design and construction of each component depends upon the type of stopwatch. Digital (Type I) Stopwatches — the power source of a type I stopwatch is usually a silver cell or alkaline battery, which powers the oscillator, counting and display circuitry. There are other ways of manufacturing stopwatches. Stopwatches can be made by using ICs whereas some other uses microcontroller for modeling stopwatches.

. The basic objective of the present study is to construct a battery operated digital stopwatch using 555 timer and decade counter ICs.

2. Methodology:

The block diagram of the methodology is shown in figure 1. The main parts of the timer consist of 555 timer IC, decade counter and seven segment display. The 555 timer is used to operate as an astable multivibrator that produces a 100 Hz frequency signal as output. This output signal is then fed to a decade counter followed by a seven segment display. Two decade counter is used to display millisecond (ms), from 0 to 99 ms and three decade counters are used to display second (s), from 0 to 999 s).

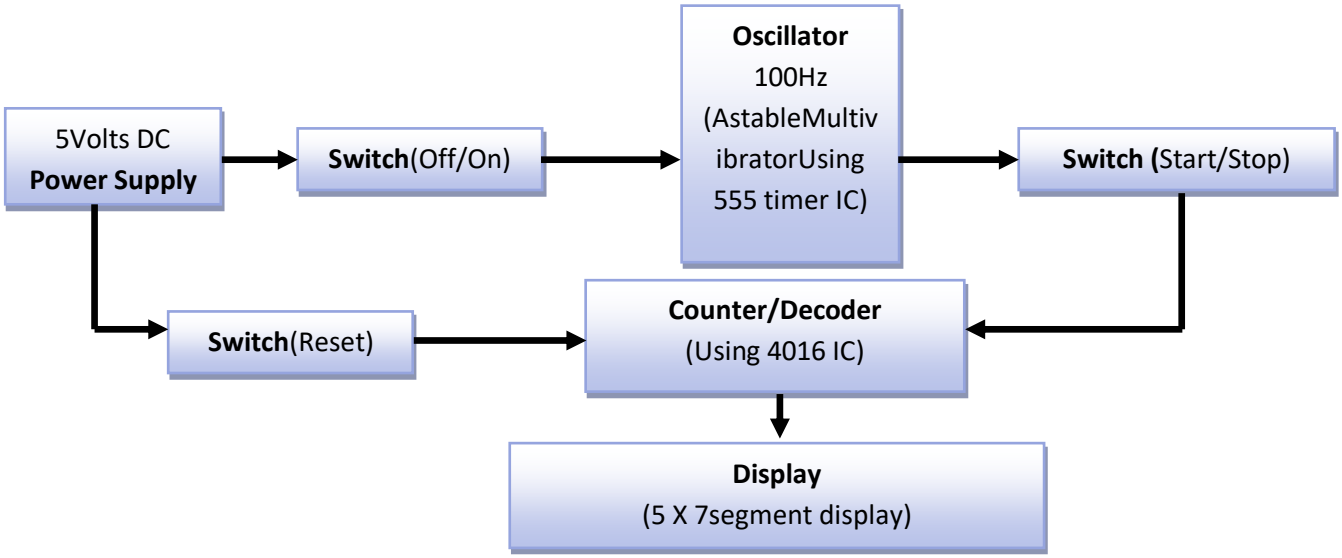

Figure 1: Block diagram of the methodology

3. System Description:

3.1. Power Supply: A 5 volt DC power supply is used for the present study to operate the different ICs including the 555 timer.

3.2. Switches: Some switches are connected to the oscillator for controlling its working. Three switches are used for on/off, stop/start and reset respectively.

3.3. 555 timer IC: The 555 timer IC is used in the astable multivibrator mode. The oscillator is an astable type multivibartor. An Astable Multivibrator or a Free Running Multivibrator is the multivibrator which has no stable states. Its output oscillates continuously between its two unstable states without the aid of external triggering. The time period of each states are determined by Resistor Capacitor (RC) time constant. In this study the values of R and C are so adjusted to generate a 100 Hz frequency. This 100 Hz frequency signal can produce a minimum time of 10 ms.

The astable function is achieved by charging/discharging a capacitor through resistors connected, respectively, either to V_{CC} or GND (Figure 2). Switching between the charging and discharging modes is handled by resistor divider R1-R3, two Comparators, and an RS Flip-Flop in IC 555.

The upper or lower comparator simply generates a positive pulse if V C goes above 2/3 V_{CC} or below 1/3 V_{CC} . And these positive pulses either SET or RESET the Q output.

The time for charging C from 1/3 to 2/3 Vcc, i.e, **ON Time = 0.693 ($R_A + R_B$). C**

The time for discharging C from 2/3 to 1/3 Vcc, i.e. **OFF Time = 0.693 R_B . C**

To get the total oscillation period, just add the two:

$\mathbf{T_{osc} = 0.693 \cdot (R_A + R_B) \cdot C + 0.693 \cdot (R_B) \cdot C = 0.693 \cdot (R_A + 2 \cdot R_B) \cdot C}$

Thus, $\mathbf{f_{osc} = 1/T_{osc} = 1.44/(R_A + 2 \cdot R_B).C}$ and **Duty cycle** = $\mathbf{R_A + R_B / R_A + 2 \cdot R_B}$

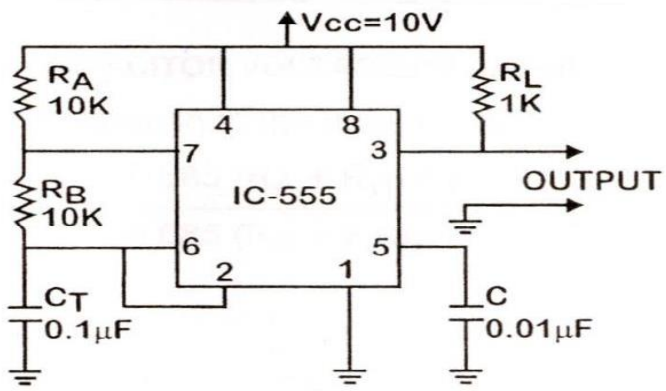

Figure 2: Circuit diagram of astable multivibrator

3.4. Counter/Decoder:

A counter is a device which stores (and sometimes displays) the number of times a particular event or process has occurred, often in relationship to a clock signal. The values on the output are represented in the binary number system. Each pulse applied to the clock input increments or decrements the number in the counter. A counter circuit is usually constructed of a number of flip-flops connected in cascade. Counters are a very widely used component in digital

circuits, and are manufactured as separate integrated circuits and also incorporated as parts of larger integrated circuits.

A binary decoder is a combinational logic circuit that converts binary information from the n coded inputs to a maximum of 2n unique outputs. They are used in a wide variety of applications, including data demultiplexing, seven segment displays, and memory address decoding. Decade counter 4016 is used in the present study to decode the input signal fed to it. The 4026 is a decade counter integrated circuit (IC) with decoded outputs for driving a common-cathode seven-segment LED display. An advantage of this IC is that it has decade counter functionality together with 7-segment decoder driver. The CD4026BE, manufactured by the Texas Instruments Corporation, is the chip currently utilized for simple GCSE type project circuits. It comes in a 16-pin plastic dual-in-line package, for use with strip boards and breadboards. This IC is based on CMOS technology and will operate from as little as 3 V (minimum), to 18 V maximum, and the absolute maximum rating is 20 V.

The IC can work from 3V to 15V, but normally powered with +5V to the Vdd/Vcc pin and the Ground/Vss pin is connected to ground. We have 7 output pins naming from Out A to Out G which is directly connected to the 7-segment display. The clock inhibit pin (pin 2) has to be held low (ground/0V) so that the clock signals can be sent to the IC also the Enable Input pin (pin 3) should be made high (+5V) so that the output pins (Out A to G) can be made active.

The 7-segment pins will increment the count by one number each time when the clock pin (pin 1) is made high. This clock source can either be obtained from a 555 IC or any other digital IC. They simply have to generate a pulse of low voltage 0V and high voltage 5V.

In this study a clock source of 100Hz is used to increment the count. So the number will get incremented for every (T=1/F) 0.01 second.

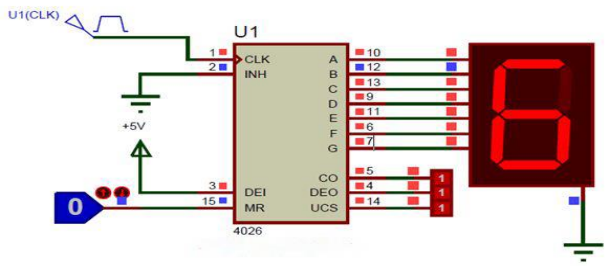

Figure 3: Working of the 4016 counter IC

3.5. Seven-Segment Display:

A seven-segment display or seven-segment indicator is a form of electronic display device for displaying decimal numerals that is an alternative to the more complex dot matrix displays. Seven-segment displays are widely used in digital clocks, electronic meters, and other electronic devices for displaying numerical information. A common cathode 7-segment display is used here.

The Common Cathode (CC) – In the common cathode display, all the cathode connections of the LED segments are joined together to logic "0" or ground. The individual segments are illuminated by application of a "HIGH", or logic "1" signal via a current limiting resistor to forward bias the individual Anode terminals (a-g).

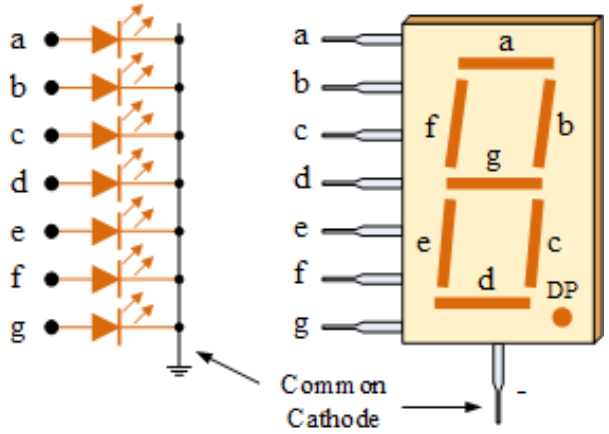

Figure 4: The common cathode 7-segment display

4. Circuit Design:

4.1 The Printed Circuit Board (PCB):

The PCB is constructed using copper plate, Ferric Chloride, mini drill machine, a bottle of thinner and Some plastic tweezers. The PCB making process takes a about a 30-45 minutes. Following steps are carried out to complete the construction of the PCB.

I. The required circuit is simulated using software's like DipTrace (Figure 5).

II. This simulated circuit is then printed using a laser printer in a glossy paper. The layout of the circuit (Figure 6) is ironed over the copper side of the PCB, ironing it above the copper side of the board will transfer the ink, from the glossy paper to the PCB board. The ink serves as the protective layer to cover the copper part that shouldn't be etched.

III. The PCB is then dipped in Ferric Chloride solution for about 15 minutes. After etching, the PCB boardis rinsed with water to remove the etching solution. Then thinner is

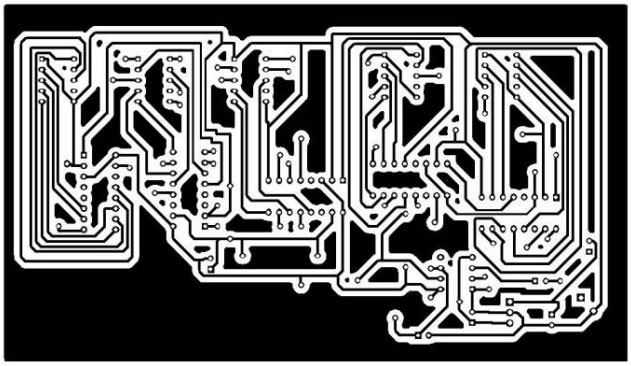

Figure 5: The circuit layout to be printed.

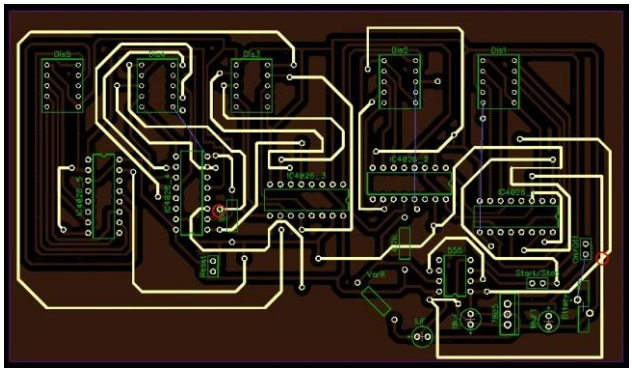

Figure 6: Layout of the circuit in DipTrace software.

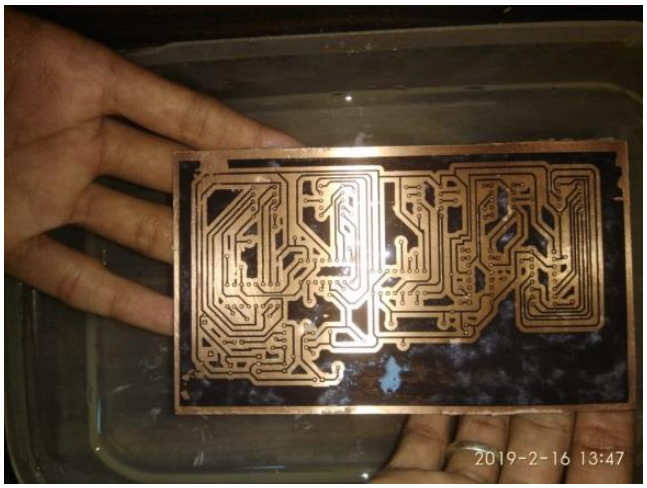

Figure 7: The constructed PCB Figure.

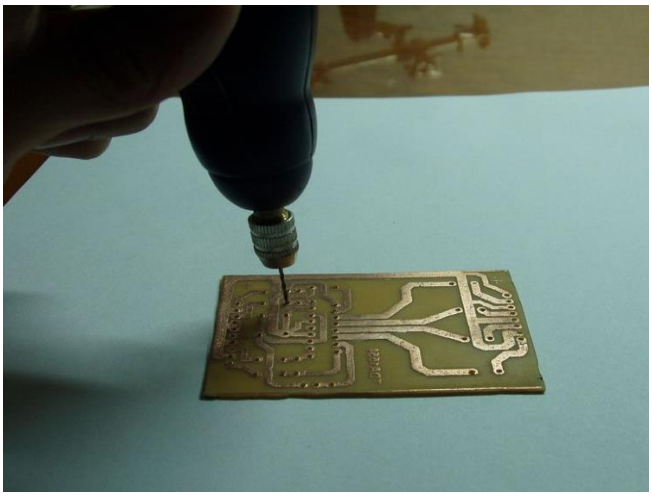

Figure8: Drilling of the PCB

used to remove the remaining ink to complete the PCB (Figure 7)

IV. Now drill machine is used to make holes in the PCB to solder the different components (Figure 8).

5. Results and Discussions

In our project we have four major segments. They are:

1. Power supply
2. Oscillator
3. Counter/ Decoder
4. Display

Figure 9 shows the circuit diagram of the constructed electronic timer. The power supply gives a constant 5volts dc supply from a 9volts dc supply. This is accomplished by a 7805 voltage regulator IC and two capacitors.

The oscillator circuit is made (configured) so as to provide a 100 Hz frequency with 50% duty cycle. This is mainly accomplished by a RC circuit coupled to the 555 timer IC. The RC circuit coupled to the 555 timer IC is configured so as to obtain a frequency 100Hz. The frequency is mainly controlled by the discharge time of the capacitor.

The output of the oscillator goes into the counter IC1 as clock pulse. Then this counter IC i.e. CD 4026 counts from 0 to 9 simultaneously decoding it for a 7 segment display. When the counter counts above 9 it sends a divide by 10 pulse to the other cascading 4026 IC. Then IC2 counts 1 and again the IC1 starts counting from 0. Again when the IC1 hits 0 again IC2 will count 2. Similarly when then IC2 counts 0 after 9 IC3 will count 1 and so on. In our project we have 5 seven segment display and corresponding to it 5 timer IC. Each segments displays from 0 to 9. This stopwatch can count upto 999.99 seconds. The calibration of the stopwatch is done by comparing it with a fully calibrated stopwatch. When the stopwatch is compared to a fully calibrated stopwatch, the stopwatch is lagging behind by few centiseconds i.e. about 0.07sec. This error may occur due to the resistors and

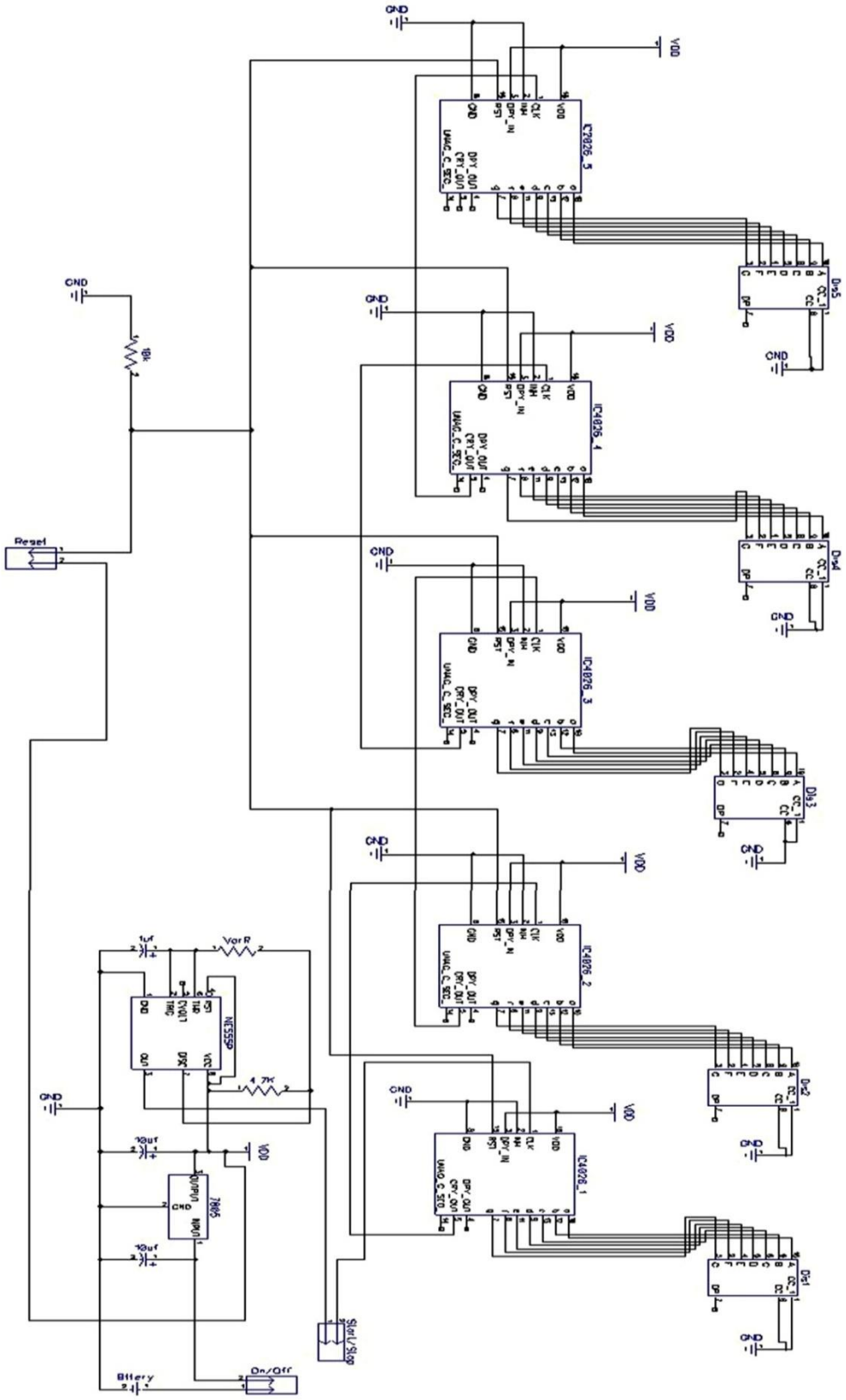

Figure 9: Circuit diagram of the electronic timer

capacitors used in the circuit or it may be an observational error. The capacitor used are not of the exact value.

6. CONCLUSION

After completion of this digital stop watch project i have gained some knowledge in designing the circuit.The circuit has been implemented on breadboard and soldiered on general purpose PCB. This circuit can operate in two modes with start and stop button accompanied by a reset button and a on and off button.

7. Further scope

There are further scopes for working in this project. They are listed below:

- It can be made more useful by making it to display minute and hour.
- More accuracy can be acquired.
- The circuit size may be reduced so that it can be handy.

6. Acknowledgement:

The authors would like to thank our respected professors of the department for their support in completion of the work. Thank also goes to the Principal, B. Borooah College for his support. We also would like to thank Madhurjya Saikia from Tezpur University for his help in doing this project. Moreover, the help from the laboratory assistant will remain in the mind forever.

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Construction of CD spectroscope and study of different diffraction patterns of light

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Abstract

In this paper diffraction patterns are generated from a laser pointer to measure the pitch (spacing) of the data tracks on Compact disc (CD) and Digital Versatile Disk (DVD). Using CD as reflection grating, the inter- track spacing of compact disc is obtained as 1.47 μm and the average track per mm is 678.27. Similarly using DVD disc as reflection grating we have obtained the inter-track spacing of DVD disc as 0.7418 μm and the average tracks per mm is 1347.96. Furthermore, using CD as transmission grating, the inter-track spacing of compact disc is measured to be 1.47 μm and the average track per mm is 679.88. Similarly using DVD disc as reflection grating, we have obtained the inter-track spacing of DVD disc as 0.7317 μm and the average tracks per mm is 1366.58. A simple and inexpensive spectroscope with resolution can also be constructed using CD as reflection grating. Construction details and a brief analysis of emission spectra observed with the spectroscope are presented in this paper.

1. Introduction

The phenomenon of diffraction that was first documented in 1665 by Maria Grimaldi is due to wave properties of light and it is defined as bending of light around the corners of an obstacle or aperture into the region of geometrical shadow of the obstacle or the aperture [1, 2]. Diffraction grating is an optical component with a periodic structure that splits and diffracts light into several beams travelling in different directions. The closely spaced tracks on a Compact disc (CD) or Digital Versatile Disk (DVD) can act as a diffraction grating.

The compact disc records the audio information in digital form via a spiral sequence of shallow pits in the surface of the CD. The pitch of the spiral, i.e. the distance between adjacent tracks, is the same for all CD's and equal to 1.6 μm. The inter-track spacing of CD or DVD is equivalent to the slit of standard grating. In case of reflective grating, the metal coating and the parallel groove lines gives rise to the diffraction pattern when light falls upon it as shown in Fig1.

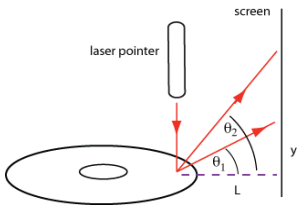


Figure 1: CD / DVD as a reflective grating.

Maxima will produce at

$$a \sin\theta = m\lambda$$

Here a= Track spacing between the track lines
θ=Angle between central maxima and different orders of maxima
m= Order no.
λ= Wavelength of LASER used

If the reflective surface is removed from a compact disc, the remaining pattern of pits in the transparent plastic will produce maxima and minima as shown in Fig 2.

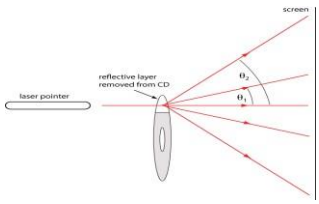


Figure 2: CD / DVD as a transmission grating.

In the last part of our project work CD spectroscope is designed in a way such that it splits up the light source provided into its constituent wavelengths and gives us the resultant spectrum.

2. Materials and Methods:

In case of reflective grating, the presence of grooves and lands gives rise to the diffraction pattern. In CD or DVD, there is a similar structure of groove and lands in the form of tracks. The silver layer on one side of the disc makes the disc a good reflective grating. So we can measure its inter-track spacing using reflective diffraction grating method. For using as transmission grating the reflective surface is removed from the compact disc and DVD.

CD spectroscope is designed in a way such that it splits up the light source provided into its constituent wavelengths and gives us the resultant spectrum.

At first the PVC pipe has been cut to the desired length. 20-30 cm is suitable for optimum result. The whole surface area inside the PVC pipe is covered with black cloth using glue and tape. The reason to cover the inside of the pipe with black cloth is because of the fact that the surface of PVC pipe is very reflective and it lights up the whole interior once light enters the tube through the slit. A section of the compact disc is marked in an elliptical way and the marked portion is cut out by melting the section using soldering rod. The use of soldering rod is more advantageous as the risk of breaking down of the CD disc is negligible. The silver layer on the upper side of the CD disc is kept intact as the CD is being used as reflective grating. The curved portion of knee-cap is marked in accordance with the size of the cut-out portion of the compact disc. Now the curved portion is smoothly cut using hawk saw blade. Utmost care is taken while cutting so that the edges become smooth and both sides are equally cut. The angle at which the curved portion is cut depends on the field-of-view of the observer. The cut-out portion of the compact disc is placed above the elliptical hole of the knee-cap. The reflective side of the CD disc is placed inside so that it can reflect the light passing through the slit .Glue and tape is used to fix the CD disc on the knee-cap hole.

Then the knee-cap is joined with the PVC pipe by attaching one open end the knee-cap with one open end of the PVC pipe. Cardboard paper is used to make the slit. Fine adjustment of the alignment of the compact disc is carried out so that the collimated beam of light passing through the slit directly falls on the reflective portion of the compact disc and diffracts into its constituent component and comes out through the open end of the knee-cap providing us the image of the spectrum.

The whole arrangement is mounted on a movable stand (as shown in Fig 3.) made of steel pipes. The stand is designed in a way that it can be moved in upward and downward direction. The PVC pipe can be rotated according to the direction of source of light.

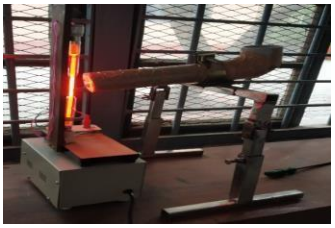


Figure 3 Arrangement of CD spectroscope

3. Results and Discussions

Fig.4& Fig.5 shows the diffraction pattern produced by a laser source of wavelength 633 nm illuminating a compact disk. The diffraction pattern on the screen is widely spaced due to the small distance between the rulings on the CD. The diffracted images are visible in the photograph. If the screen were moved closer to the CD, higher orders would become visible.

3.1 Determination of inter-track spacing of CD with the help of laser source using reflection grating phenomenon:

Using CD as reflection grating, the inter-track spacing of compact disc is obtained as 1.47 μm and the average track per mm is 678.27. Similarly using DVD disc as reflection grating we have obtained the inter-track spacing of DVD

disc as 0.7418 µm and the average tracks per mm is 1347.96.

Figure 4: *A laser beam reflecting from the rulings of an audio compact disk and producing a diffraction pattern on a screen.*

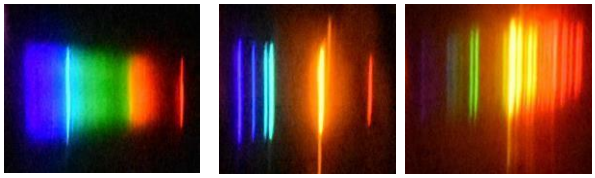
3.2. CD and DVDs as transmission grating:

Using CD as transmission grating, the inter-track spacing of compact disc is measured to be 1.47 µm and the average track per mm is 679.88. Similarly using DVD disc as transmission grating, we have obtained the inter-track spacing of DVD disc as 0.7317 µm and the average tracks per mm is 1366.58.

Figure 5: *A laser beam transmitting from the rulings of an audio compact disk* (left) and DVD (right) *and producing a diffraction pattern on a screen.*

3.2 Observation of emission spectrum:

The CD spectroscope that we have constructed has been used to study the different spectra of light for hydrogen, helium and neon. Different spectral lines are observed that has been shown in Fig 6 when the spectroscope is pointed at different light sources. The observed spectrum is compared with the theoretical profiles and is presented in Table 1.



(a) (b) (c)

Figure 6: *Diffraction pattern obtained from hydrogen, helium and neon using CD spectroscope*

Table1: Comparison of wavelength of hydrogen spectrum:

Order No.	Colour of the Spectral lines	Wavelength(nm)		Wavelength range(nm)
		Using Spectrometer	Using CD-spectroscope	
1	Violet	433.0	415	~380-440
2	Blue	451.5	450	~440-485
3	Green	523.3	530	~500-565
4	Red	654.3	655	~625-740

From our analysis, the track spacing of the CD is 1.47µm, the CD track spacing is said to be 1.6 µm. The experimental value we obtained is 8.12% off compared to the 1.6 µm. And for the DVD the spacing we determined is 0.7317µm, while the theoretical value is 0.74µm. The experimental value for the DVD is only 1.12% off compared to the spacing that was given. Since both our experimental spacing values for the CD and DVD are within 10% of error, we have obtained a good approximate value. From the values given for the spacing of the CD and DVD comparatively, the spacing for the DVD is smaller than the CD.

4. Conclusion

A simple and economic technique was used to analyse the diffraction pattern of light. The difference in diffraction pattern and spacing contributes to the fact that the DVD has more storage than the CD. It is often necessary to measure the diameter of fine wire, hair, yarn and filaments. In industry, the diffraction of a laser beam can be used to make these measurements.

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Study Of Structural, Elemental And Thermal Properties Of Pencil Graphites And Their Applications As Electrodes

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Abstract

Graphite pencil is one of the easily available hetero-structured graphite based materials that people use in their daily life for writing, sketching, coloring, designing, makeup, technical field, etc. In this work, we have investigated the elemental compositions of different grades of graphite pencils(HB, 2B, 4B, 5B, 6B, 7B, 8B). X-Ray diifraction stuides of the samples show that the besides graphite, some other elements like graphite oxide phases are also present in the graphite pencil. Thermogravimetric analysis shows that thermal stability decreases from HB to 8B. Electrical conductivity of the samples increases from HB to 8B which may be due to increase of graphite content from HB to 8B. The performance of the graphite pencils as electrodes has been investigated.

1. Introduction

Graphite is one of the most interesting elements found on the earth. It is found naturally in its mineral form as well as produced in synthetic processes. The earliest use of graphite dates back to primitive man, who used it to draw on cave walls. It was also used by Egyptians to decorate pottery. During the Middle Ages, graphite was used as a refractory to line molds for the purpose of making smoother cannon balls, which could be fired farther.Graphite is gray to black in color, opaque with a metallic luster. It is a fairly soft crystalline form of carbon with a Mohs hardness of 1 to 2. Stable and chemically inert at normal temperatures, graphite has a very high sublimation point, in the absence of air. In its pure form, it is odorless, tasteless and nontoxic.

Graphite has a giant covalent structure in which each carbon atom is joined to three other carbon atoms by covalent bonds. It has a hexagonal, multi-layer planar microstructure which gives it a number of unique characteristics, the sum of which is not found in any other single material. The layers are alternating and honeycomb in structure, and are spaced at 1.42 angstroms apart (strong bonds), with 3.354 angstroms between layers (weak bonds). Graphite has both metallic and nonmetallic properties which make it useful as electrode material. According to Chehreh Chelgani et al. [1] 4% of the world graphite is used to produce pencils consisting of fine graphite powder in an inorganic (resin) or organic matrix (clay or a high polymer, e.g., cellulose). The pencil graphite leads are composite materials containing graphite (~65%), clay (~30%), and a binder (wax, resins, or high polymer) [2]. According to the

European Letter Scale graphite pencils are marked with letters H (hardness) and B (blackness) and numbers indicating the degree of hardness or blackness from 9H (the hardest) to 8B (the softest). B type leads contain more graphite and are softer, and the harder H-type leads have more lead, whereas HB type pencil leads contain equal portions of graphite and clay [3–7]. Kariuki [5] showed that the added clay has an important influence on the chemical (e.g., ion exchange) and structural properties (e.g., degree of disorder and surface morphology) of the pencil graphite leads.

Graphite has a layered, planar structure. The individual layers are called graphene. In each layer, the carbon atoms are arranged in a honeycomb lattice with separation of 0.142 nm, and the distance between planes is 0.335 nm [2]. Atoms in the plane are bonded covalently, with only three of the four potential bonding sites satisfied. The fourth electron is free to migrate in the plane, making graphite electricallyconductive. Bonding between layers is via weak van der Waals bonds, which allows layers of graphite to be easily separated, or to slide past each other[3].Graphite's high thermal stability and electrical and thermal conductivity facilitate its widespread use as electrodes and refractories in high temperature material processing applications. However, in oxygen-containing atmospheres graphite readily oxidizes to form carbon dioxide at temperatures of 700 °C and above[4].Graphite has high melting temperature, low hardness and high thermal conductivity. Graphite's high thermal stability and electrical and thermal conductivity facilitate its widespread use as electrodes and refractories in high temperature material processing applications. However, in oxygen-containing atmospheres graphite readily oxidizes to form carbon dioxide at temperatures of 700 °C and above[20].Pencil graphite leads used as working electrodes are currently known as pencil graphite electrodes (PGEs). Besides the fact that they are cheap, PGEs are also easy to use and more convenient and there is no time-consuming electrode surface cleaning/polishing step. These electrodes have proven to provide good sensitivity and reproducibility, being a viable, renewable, and economical tool. It can conduct electricity due to the vast electron delocalization within the carbon layers (a phenomenon called aromaticity). These valence electrons are free to move, so are able to conduct electricity.

In this work, structural, elemental and thermal properties of pencil graphite samples have been studied. The performance of pencil graphite electrodes in potassium chloride (KCl) solution has also been carried out.

2. Experimental Details

Pencil graphites were purchased from Camlin with different grades of hardness i.e. HB, 2B, 3B, 4B, 6B and 8B. The graphite leads were taken out from the wooden case and ground into fine powder using pestle morter and powders have been used in studying structural, elemental and thermal properties. Some graphite leads have been used to study electrical conductivity. The X-ray diffractograms have been recorded using PANalytical EMPYREAN powder X-ray diffractometer using CuKα radiation (λ=1.54016 Å). EDX analysis was carried out using Oxford instruments Energy dispersive X-ray spectrometer model 7582. Thermogravimetric (TG) measurements were carried out in nitrogen atmosphere with a flow of 20 mL min-1 and a heating rate of 30oC min-1 using a Perkin Elmer model STA 6000 thermal analyzer.

Two HB Pencils bought from the local market and their leads were taken out by removing the wooden part. The experimental set up is as shown in the figure1. Two HB pencils with leads of diameter about 0.22cm were pared to let 2cm pencil leads in one end exposed to 3 molar aqueous KCl solution . While about 4cm lead in other end exposed to air ,which is connected by two copper wire to resistance box (1KΩ) that was used as an input to an OP-AMP circuit in Inverting mode with a gain of 1000.

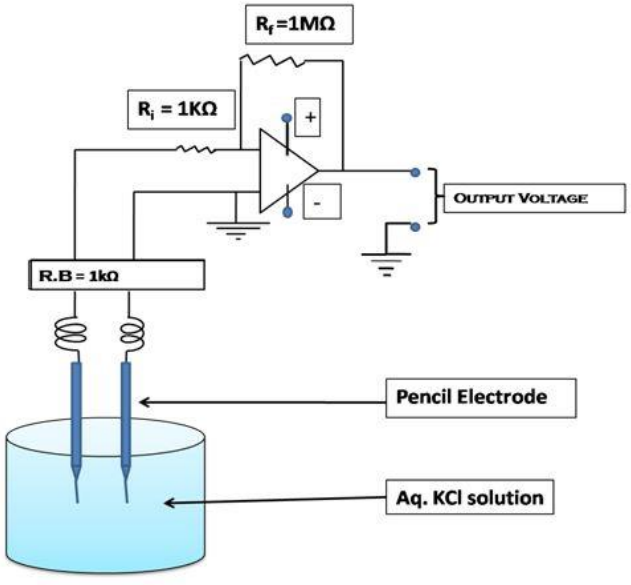

Fig. 1: Figure showing experimental set-up for studying the performance of graphite electrodes

3. Results and Discussions

3.1. Structural analysis

X-ray diffraction patterns of graphite sample obtained from Camlin pencils are presented in the following figure 2. It is clear from the figure that all diffractograms contains peaks of graphite at crystal planes with Miller indices (002), (101), (004), (103), (110), (112) and (006). In samples (3B-8B) two more small peaks at low Bragg angles are found. These two peaks may be attributed to formation of graphite oxide with crystal planes (001) and (002).

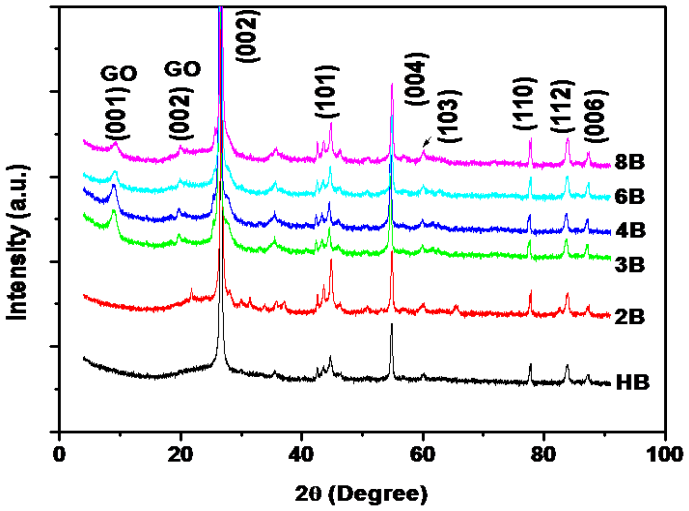

Fig. 2: XRD patterns of pencil graphite samples

3.2. Elemental analysis

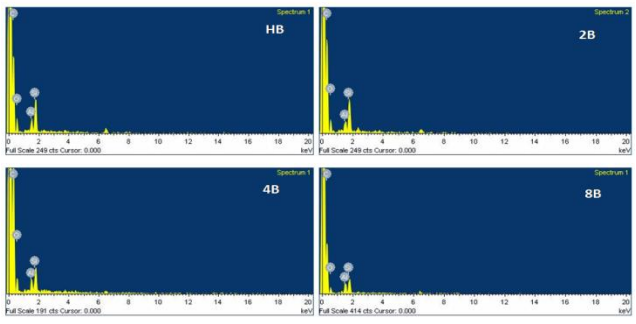

Fig. 3 . EDX spectra of pencil graphite samples

EDX spectra of pencil graphite samples are shown in Fig.3 From the Figure, it is observed that the samples contain carbon, oxygen, aluminium and silicon. Thus it is confirmed that pencil graphite contains graphite and kaolin clay with chemical composition of $Al_2Si_2O_5(OH)_4$. From the analysis of EDX data, it is clear that with the decrease of hardness of the pencil (from HB to 8B), the carbon content increases in the samples and weight percentage of aluminium and silicon slightly decreases.

3.3. Thermogravimetric analysis

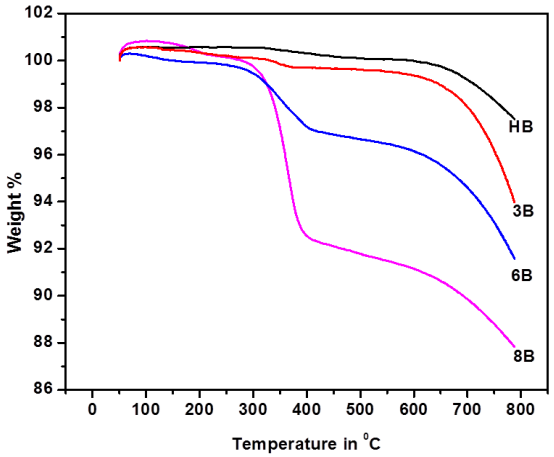

Fig. 4 . Thermogravimetrc plots of pencil graphite samples

Thermogravimetric (TG) measurements were carried out in nitrogen atmosphere with a flow of 20 mL min^{-1} and a heating rate of 30°C min^{-1} . Thermogravimetric (TGA) plots of pencil graphite samples are presented in Fig. 4. All samples exhibit a two stage decomposition pattern as is observed from three distinct slope changes. The first stage from room temperature to 100 °C corresponds to loss of water molecules or low molecular weight volatile polymer segments of the samples. The weight loss after 600°C is due to degradation and decomposition of the pencil graphite samples. It is observed that residue left after decomposition increases with the increase of hardness of the pencil graphites which suggests that thermal stability of the pencil graphite samples are increasing with decrease of carbon content.

3.4. Pencil graphite as electrode

When 25 mL aqueous KCl (3 molar) Solution was poured into the beaker the multimeter shows an output voltage of 0.175 mV. The voltage gradually decreases with time. Performance of electrodes has been studied by varying the concentration of KCl and also varying the pair of electrodes. When 3M KCl solution was heated from the room temperature 32ºC it is found that voltage starts increases slowly , but from 80ºC the voltage increases

almost steeply up-to 110ºC . With a solution of greater concentration 6M, an increase of voltage is observed from 30ºC to110ºC. The reason for which can accounted as the liberation of more and more electron with increase in temperature between the electrodes.

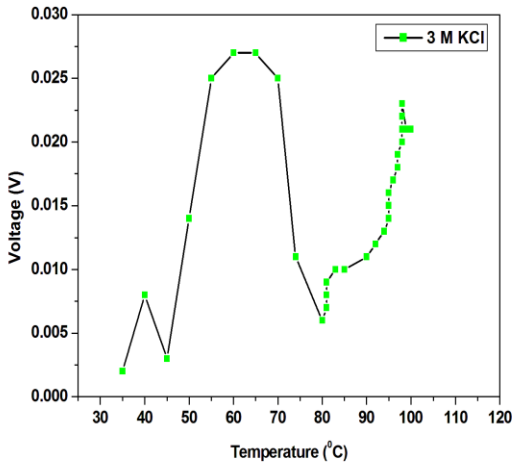

Fig. 5. Graph depicting the variation of voltage with temperature in HB electrodes

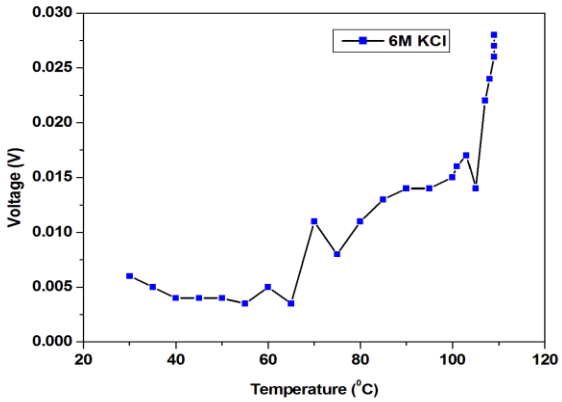

Fig. 6. Graph depicting the variation of voltage with temperature in HB electrodes

4. Conclusions

In this work, we have stuided structural, elemetal and thermal properties of pencil graphites bought from local market. From XRD patterns it observed that pencil graphite samples contain crystalline phases of graphite. From FTIR spectra, it claer that due to presence of kaolin clay with graphite, there is streching of bonds in 2B and HB samples. EDX spectra confirms the presence of carbon, oxygen, silicon and aluminium in pencil graphite samples in different weight percentage. Thermogravimetric analysis of the samples show that with the increase of carbon cotent, thermal stability decreases. Temeprature dependence of resistivity shows that with the increase of temeperature, resistivity is decreasing which suggests that pencil graphite shows semiconducting behavior. Pair of pencil graphites have been used as electrodes in aqueous KCl solution which shows a voltage drop between the eletrodes. With the increase of temeperature, voltage drop shows an increasing trend.This may attributed to production of thermal motion of ions.This method can be of use in developing self charging tecthnology to harvest energy from ambient heat.

5. Acknowledgement

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