SRM VALLIAMMAI ENGINEERING COLLEGE

(An Autonomous Institution)

SRM NAGAR, KATTANKULATHUR – 603 203.

DEPARTMENT OF MEDICAL ELECTRONICS

REGULATION 2019

Third Year / Fifth Semester

LAB MANUAL

1910506 MEDICAL INSTRUMENTATION LABORATORY

ACADEMIC YEAR: 2022-2023 ODD SEMESTER

Prepared by

Dr J.Mohan, Associate Professor

SRM VALLIAMMAI ENGINEERING COLLEGE

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DEPARTMENT OF MEDICAL ELECTRONICS

VISION OF THE INSTITUTE

- Educate to excel in social transformation

MISSION OF THE INSTITUTE

- To contribute to the development of human resources in the form of professional engineers and managers of international excellence and competence with high motivation and dynamism, who besides serving as ideal citizen of our country will contribute substantially to the economic development and advancement in their chosen areas of specialization.
- To build the institution with international repute in education in several areas at several levels with specific emphasis to promote higher education and research through strong institute-industry interaction and consultancy.

VISION OF THE DEPARTMENT

- To develop an excellent progressive quality education, translational research through inventive collaborations as per industry requirements to improve the healthcare and well-being of humankind

MISSION OF THE DEPARTMENT

- To Acquaint students with the current technology to provide consultations and technical support to hospitals, healthcare and service sectors.
- To educate students with the fundamental knowledge, interdisciplinary problem solving skills and confidence required to excel in medical electronics through progressive learning.
- To propagate creativity, responsibility, commitment and leadership qualities and exhibit professional ethics and values.

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DEPARTMENT OF MEDICAL ELECTRONICS

PROGRAM OUTCOMES

1. **Engineering knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2. **Problem analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3. **Design/development of solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4. **Conduct investigations of complex problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5. **Modern tool usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6. **The engineer and society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7. **Environment and sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8. **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9. **Individual and team work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10. **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11. **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12. **Life-long learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES

PSO1: Ability to apply the acquired knowledge of basic skills, mathematical foundations, principles of electronics, Modeling and design of electronics-based systems in solving engineering Problems in healthcare.

PSO2: Ability to use the advanced technology for measurement and develop innovative sustained solutions in health care.

PSO3: Ability to examine indigenous clinical gadgets through the application of their core area ideas and emerging ICTs.

PSO4: Ability to perform effectively as a part of a team with professional behavior and ethics to achieve a successful career.

1910506 MEDICAL INSTRUMENTATION LABORATORY

L T P C
0 0 4 2

OBJECTIVES: The student should be made:

- To introduce the students to the application of biomedical instrumentation.
- To learn the practical aspects of various medical transducers and their characteristics.
- To impart knowledge in measurement of Resistance, Inductance and Capacitance using bridges.
- To explore the application of sensors and transducers in the physiological parameter measuring system.
- To understand the basic principles and phenomena in the area of medical diagnostic instrumentation.

LIST OF EXPERIMENTS:

Design and Testing of the following Circuits,

1. Simple Op Amp Circuit Measurements.
2. Design and analysis of biological pre-amplifiers.
3. Experiment of Thermistors.
4. Blood pressure measurement.
5. Experiment of Photo-plethysmography.
6. Recording of ECG signal and analysis.
7. Recording of EMG-Signal.
8. Recording of various physiological parameters using patient monitoring system and telemetry units.
9. Measurement of respiration rate.
10. Measurement and recording of peripheral blood flow.
11. Study of characteristics of optical Isolation amplifier.
12. Measurement of PH and Conductivity.
13. Measurement of Blood Glucose.

TOTAL PERIODS: 60

COURSE OUTCOMES: The student would be able to:

- Measure various physiological parameters of the body.
- Know the importance of Amplifier and the need of bio signal amplifications.
- Design the amplifier for Bio signal measurements.
- Examine the biochemical parameters.
- Perform Recording and analysis of bio signals.

List of Experiments:

Cycle -1

1. Simple Op Amp Circuit Measurements.
2. Design and analysis of biological pre-amplifiers.
3. Experiment of Thermistors.
4. Blood pressure measurement.
5. Experiment of Photo-plethysmography.
6. Recording of ECG signal and analysis.
7. Recording of EMG-Signal.

Cycle -2

8. Recording of various physiological parameters using patient monitoring system and telemetry units.

9. Measurement of respiration rate.

10.Measurement and recording of peripheral blood flow.

11. Study of characteristics of optical Isolation amplifier.

12. Measurement of PH and Conductivity.

13. Measurement of Blood Glucose.

CHARACTERIZATION OF OP-AMP

Ex No: 1

AIM:

To study the operation and the varies input out characterization of OP -AMP amplifier

DESCRIPTION

Input : Sinusoidal signal of 1Vp-p at 1 KHz

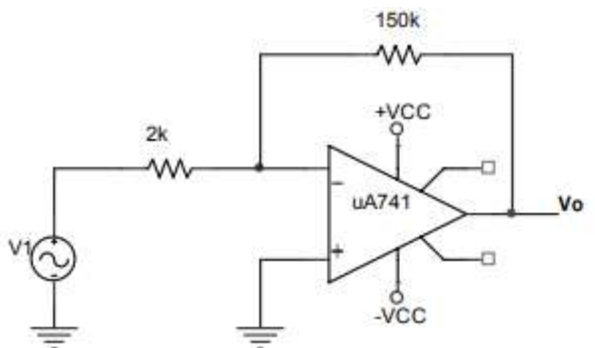
Output: Inverted Sinusoidal signal of 10 Vp-p at 1 KHz

APPARATUS REQUIRED :

S.NO	ITEM	RANGE	QUANTITY
1	Op-amp	IC741	1
2	Resistors	220K,100k,100	6
4	Multimeter	-	1
5	RPS	DUAL(0-30) V	2

PRE LAB QUESTIONS

1. Determine the output voltage of an op-amp for the input voltages of V_{i1}=150µV and V_{i2}=140µV. The amplifier has a differential gain of A_d=4000 and the value of CMRR is 100.
2. Calculate the output voltage of an inverting amplifier for values of V_S=1V, R_f=500K and R_1=100K. 3.
3. Calculate the output voltage of a non-inverting amplifier for values of V_S=1V, R_f=500K and R_1=100K.
4. Calculate the output offset voltage of the circuit in Fig (a). The op-amp spec lists V_{IO}=1.2mV.
5. Calculate the offset voltage for the circuit in fig (a) for op-amp spec listing I_{IO}=100nA.



6. Calculate the total offset voltage for the circuit of fig (a) for an op-amp with specified values of V_{IO}=1.2mV and I_{IO}=100nA.

7. Calculate the input bias current at each input of an op-amp and input offset current having specified values of IIO=5nA and IIB=30nA.
8. For an op-amp having a slew rate of 2 V/µs, what is the maximum closed loop voltage gain that can be used when the input signal varies by 0.5V in 20µs.
9. How long does it take the output voltage of an op-amp to go from -10V to +10V if the slew rate is 0.5V/µs.
10. Determine the input bias current and input offset current, given that the input currents of an op-amp are 8.3µA and 7.9µA.

The ideal op-amp

The ideal behaviour of an op-amp implies that

a) The output resistance is zero
b) The input resistance seen between the two input terminals (called the differential input resistance) is infinity.
c) The input resistances seen between each input terminal and the ground (called the common mode input resistance) are infinite.
d) op-amp has a zero voltage offset ie., for $V_1 = V_2 = 0$, output voltage $V_O = 0$
e) Common mode gain AC is zero.
f) Differential mode gain, A_d is infinity.
g) Common Mode Rejection Ratio (CMRR) is infinity
h) Bandwidth is infinite, ie., A_d is real and constant.
i) Slew rate is infinite.
j) Since $V_O = Ad\,(V_1 - V_2)$ and

$$Ad = \infty$$
$$V_1 - V_2 = V_O/A_d = 0$$
$$\text{ie., } V_1 = V_2$$

The above condition implies that the inverting and non-inverting terminals are at the same potential because of the very high (infinite) gain property. This condition along with the condition $i_1 = i_2 = 0$ are the keys to the simplified analysis of the op-amp circuits.

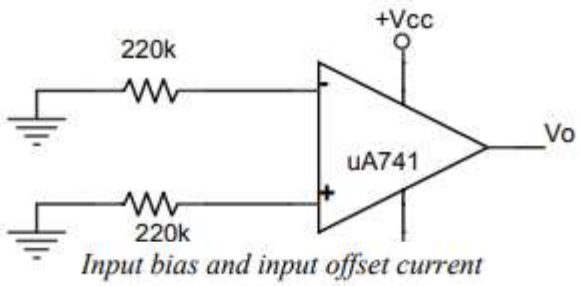
Use op-amp dc power supply voltages ±15V wherever not specified

Input bias current and input offset current

Procedure

1. Connect the circuit of figure 1-2-7.
2. Using a DMM, measure the dc voltage at the (-) terminal & record the values in Table

3 By ohm's law, calculate the input currents; IB^+ and IB^-. Average these values to find out the input Bias current. Also, find the difference between these two currents to know the input offset current. Record these values in Table.



Input bias and input offset current

DC voltage at the non-inverting terminal V^+	DC voltage at the inverting terminal V^-	$I_B^+ = \frac{V^+}{220K}$	$I_B^- = \frac{V^-}{220K}$	Input bias current $I_B = \frac{(I_B^+ + I_B^-)}{2}$	Input offset current $I_{OS} = \lvert I_B^+ - I_B^- \rvert$

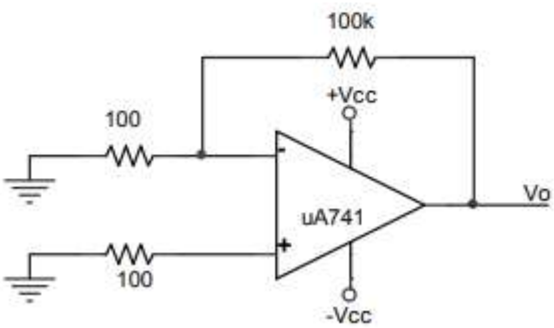
Input offset voltage

Procedure

1. Connect the circuit of Figure
2. Measure the DC output voltage at pin 6 using multimeter and record the result in Table
3.Calculate the input offset voltage using the formula

$$V_{in} = \frac{Vout}{1000}$$

and record the value in table



Input offset voltage

Slew rate and bandwidth

V_{out}	$V_{in} = V_{ou}t/1000$

1. Connect the circuit of Figure.

2 Using an AFO, provide a 1V peak to peak square wave with a frequency of 25 KHz.

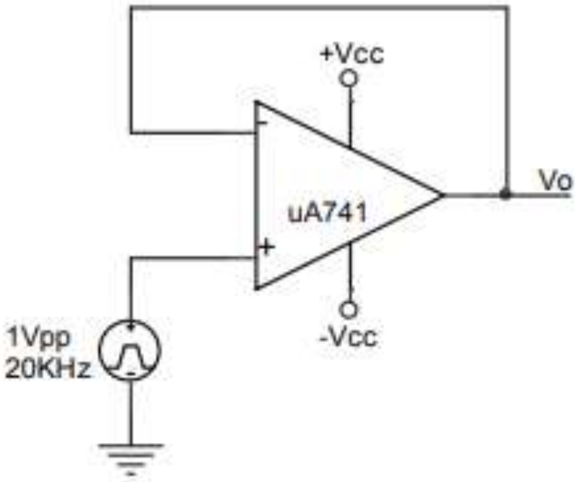
3 With an oscilloscope, observe the output of OPAMP. Adjust the oscilloscope timing the get a couple of cycles.

4 Measure the voltage change ΔV and time change ΔT of the output waveform. Record the results in Table.

5 Calculate the slew rate using the formula SR = ΔV / ΔT

6. Using the circuit of figure 3, set the AFO at 1KHz. Adjust the signal level to get 20V peak – to – peak (20 V_{PP}) out of the op-amp.

7. Increase the frequency and watch the waveform somewhere above 10 KHz, slew rate distortion will become evident. That maximum frequency *f* max at which the op-amp can be operated is called bandwidth of an op-amp record the value in Table



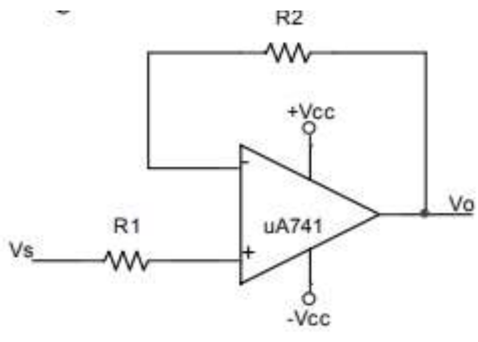
Slew rate and bandwidth

ΔV	ΔT	SR = ΔV/ΔT	BW

Input and output voltage ranges

1. Assemble the voltage follower circuit as shown in Figure 1-2-10 with R1 = R2 = 100 kΩ. Use op-amp dc power supply voltages of ±9 V.
2. Apply ±5 V, 100 Hz sinusoidal input, Vs. Observe on a CRO the voltages at the non-inverting input and output pins simultaneously. Increase the signal amplitude until distortion is observed at the peak value of the output. Measure the positive and negative input voltage peak values. This gives the op-amp input voltage range.
3. Change the circuit of Figure 1-2-10 to an inverting amplifier. Connect R1 between the source and inverting input. Ground the non-inverting input. Choose R1 = 10 kΩ, R2 = 100 kΩ. Repeat observations of step 3.2 starting with ±0.5 V, 100 Hz

sinusoidal input. Measure the positive and negative output voltage peak values. This gives the op-amp output voltage range.



Circuit to find the input voltage range

POSTLAB QUESTIONS

Check your understanding by answering these questions

1. The input stage of a 741 op-amp is a ---------------

2. The output stage of a 741 op-amp is a --------------

3. The input bias current of an op-amp is the --------------------- of the two input base currents under no-signal condition.

4. The input ----------------- current is the difference of the two input base currents.

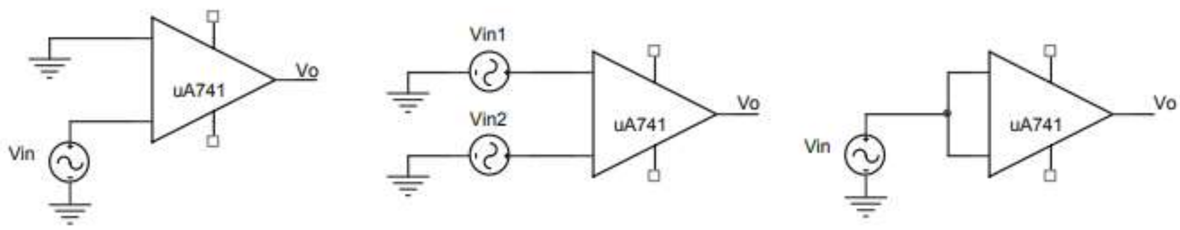
5. The input ---------------- voltage is the differential input voltage needed to null or zero the quiescent output voltage.

6. The CMRR of an op-amp is the ratio of ------------- voltage gain to ---------- voltage gain.

7. A 741 has a slew rate of ------------- V/µs.

8. The bandwidth is the ----------------- undistorted frequency out of an op-amp. It depends on the - ----------- rate of the op-amp and the --------------------- of the output signal.

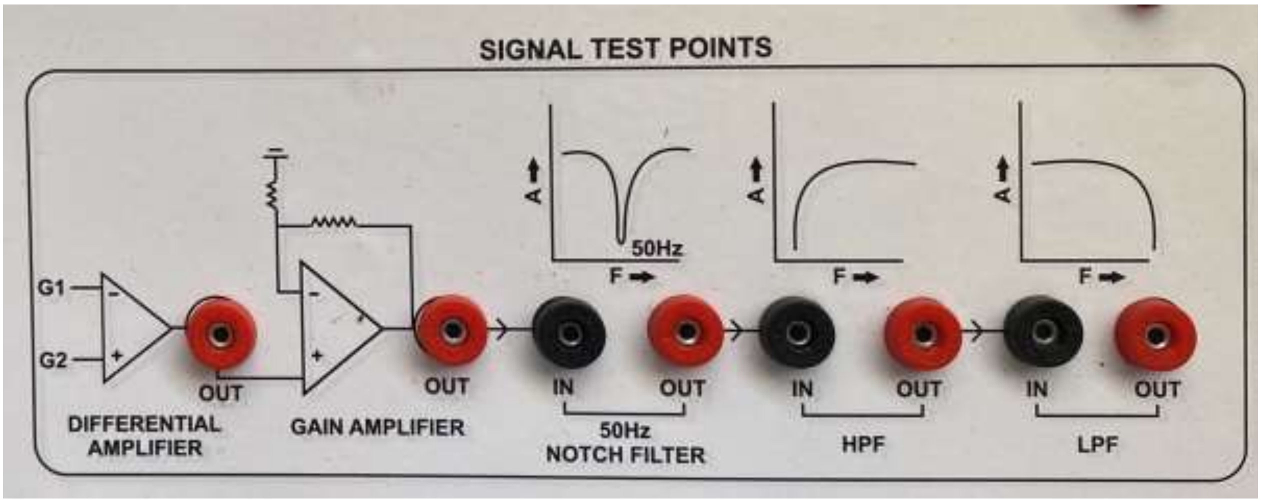
9. Identify the type of input mode for each op-amp in fig

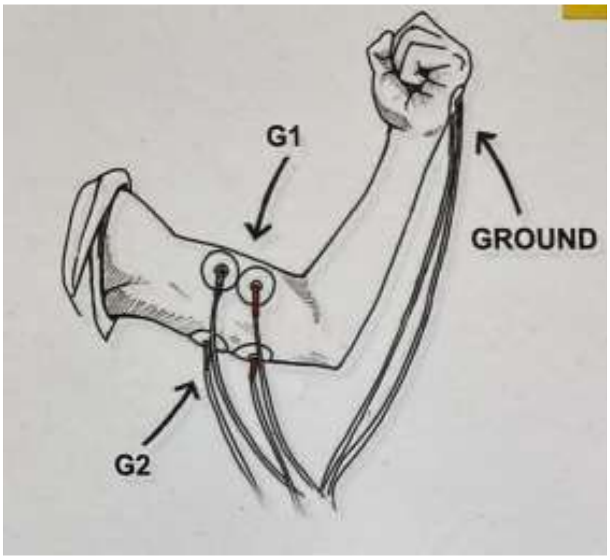


<u>RESULT :</u>

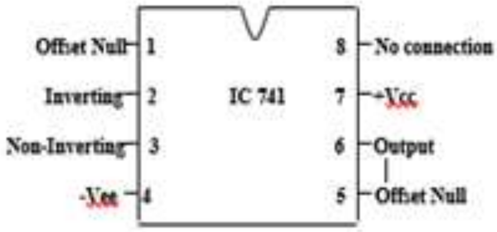
Thus the varies input out characterization of OP -AMP amplifier are verified, designed and output is verified for the given specification.

CIRCUIT DIAGRAM





PIN DIAGRAM



BIO AMPLIFIER

Ex No:2

Aim:

To design and setup a bioamplifier for a gain of 10and to calculatethe CMMR.

Preparatory Exercise:

1. What is an op-amp? Why it is called so?
2. Define the term input offset voltage, input bias current, gain bandwidth product.
3. Define slew rate in an op-amp.
4. List the ideal characteristics of an op-amp.
5. What are the building blocks of an op-amp?

DESCRIPTION

Input : Set the dc input voltage in both the input terminals V1 and V2.

Output : Vary the resistor R1 to obtain the output voltage with varying gain

APPARATUS REQUIRED :

S.NO	ITEM	RANGE	QUANTITY
1	Op-amp	IC741	1
2	Resistors	10kΩ	6
3	Decade Resistance box	-	1
4	Multimeter	-	1
5	RPS	DUAL(0-30) V	2

DESIGN:

Assume the resistors in the differential amplifier stage to be of the same value R =10kΩ

Using Superposition theorem the output of the Instrumentation amplifier is

$$V_o = -(R/R)\,Va + (1+R/R)\,Vb = V_b - V_a$$

Where $V_a = -R2/R1(V1-V2) + V2$

And $V_b = R2/R1\,(V1-V2) + V1$

Thus $V_o = V_b - V_a = (V1-V2)\,(1+2R2/R1)$

Gain of an Instrumentation amplifier is

$$Av = V_o/(V1-V2) = (1+2R2/R1)$$

For $Av = 3$

$$3 = (1+2R2/R1)$$

Then $R2 = R1$

Let R2 = 10kΩ then set the variable resistor R1 = 10kΩ

OBSERVATIONS :

V1 (Volts)	V1 (Volts)	R1 (Ohms)	Vo (Volts)	Gain	
				Theoretical 1+2R2/R1	Practical V0/V1-V2

Thus the gain of the instrumentation amplifier can be varied over a range of 1.5 to 1.2 by varying the variable resistance R1 from 20K to 50K.

PROCEDURE :

1. Connect the components as per the circuit diagram.
2. Initially set the variable resistor R1 to the minimum value and note down the output voltage and compute the gain.
3. Repeat the procedure in step 2 for various values of R1 and note down the corresponding output voltage to find the range of gain.

THEORY:

Instrumentation Amplifiers are high gain differential amplifiers with high input impedance and a single ended output. They are mainly used to amplify very small differential signals from strain gauges, thermocouples or current sensing resistors in motor control systems. They also have very good common mode rejection in excess of 100dB at DC. The negative feedback of the top op-amp causes the voltage at Va to be equal to the input voltage V1.

Likewise, the voltage at Vb is equal to the value of V2. This produces a voltage drop across R1 which is equal to the voltage difference between V1 and V2. This voltage drop causes a current to flow through R1, and as the two inputs of the buffer op-amps draw no current (virtual earth), the same amount of current flowing through R1 must also be flowing through the two resistors R2. This voltage drop between points Va and Vb is connected to the inputs of the differential amplifier which amplifies it by a gain of 1 (assuming that all the "R" resistors are of equal value). Then the overall voltage gain of the instrumentation amplifier circuit is

$$V_{out} = (V_1 - V_2)\left[1 + \frac{2R_2}{R_1}\right]$$

The differential gain of the circuit can be changed by changing the value of R1.

RESULT :

Thus by varying the variable resistor R1 a wide range of gain can be obtained from the instrumentation amplifier.

Review Questions :

1. What are the advantages of negative feedback in an op-amp?
2. List the linear and non-linear applications of an op-amp.
3. What is an instrumentation amplifier ?
4. List some applications of an instrumentation amplifier.

THERMISTOR CHARACTERISTICS

Ex No: 3

Aim:

To determine the resistance **vs**. temperature characteristics of a thermistor.

Objectives: On completion of this experiment the student will be able to:

1. Identify Thermistors.
2. Analyze the characteristics of a thermistor.

Preparatory Exercise:

1. What are the characteristics of thermistor?
2. What is IV characteristics of thermistor?
3. What are the applications of thermistor?
4. What is thermistor Mcq?
5. What are advantages of themocouple?
6. Explain temperature measurement using thermocouple?
7. Why gold & silver are not used for RTD?

Equipment / components:

Sl no	Name and Specification	Quantity required
1.	Bread board	1
2.	Variable power supply	1
3.	Thermistor	1
4.	Ammeter(0 - 50mA)	1
5.	Voltmeter (0 – 30V)	1
6.	Thermometer	1
7.	Water bath	1
8.	Heater	1
9.	Resistor(470Ω)	1

Theory:

Thermistors are the temperature sensitive resistors that exhibit a variation in resistance with temperature. In other words electrical resistance of a thermistor will vary when it is placed in an environment of changing temperature. The characteristics study of thermistor provides information about how its resistance changes with the changes in temperature.

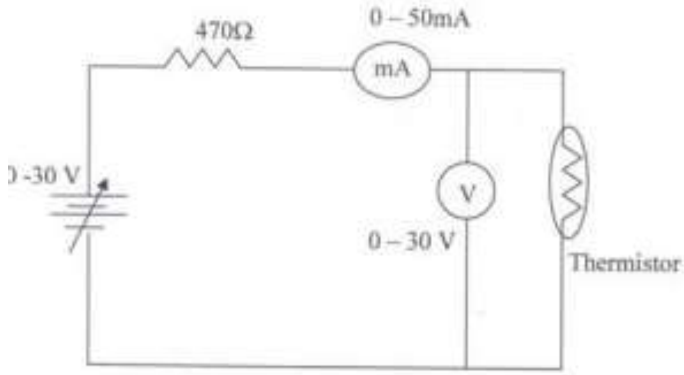
Based on the relationship between the resistance and temperature thermally sensitive resisters are of two types, one the positron and its resistance increases with increasing temperature (positive temperature coefficient) and second the thermistor and its resistance decreases with increasing temperature (negative temperature coefficient). Thermistors are very essential in temperature measurement and they are made up of the oxides of certain metals like manganese, cobalt and nickel which have negative temperature coefficient of resistance. They are formed into rods, discs, washers and bead to suite various applications.

The application of thermistor includes cardiac output measurements, continuous measurement of skin and core body temperature, blood flow measurement and respiratory measurement. They are also used as resistance thermometers in low temperature measurements.

Procedure:

1. Take water in a container and place over the heater.
2. Immerse thermistor and thermometer in the water bath.
3. Set up the measuring circuit on the bread board.
4. Switch on the heater.
5. Measure the temperature on the thermometer from room temperature to 98^{o} C and note down the corresponding resistance of thermistor.
6. Switch off the heater, and then take reading in decreasing order of temperature in an interval of 10^{o} C.
8. Plot a graph of temperature on X-axis and Resistance on Y-axis. This graph shows the characteristics of thermistor.

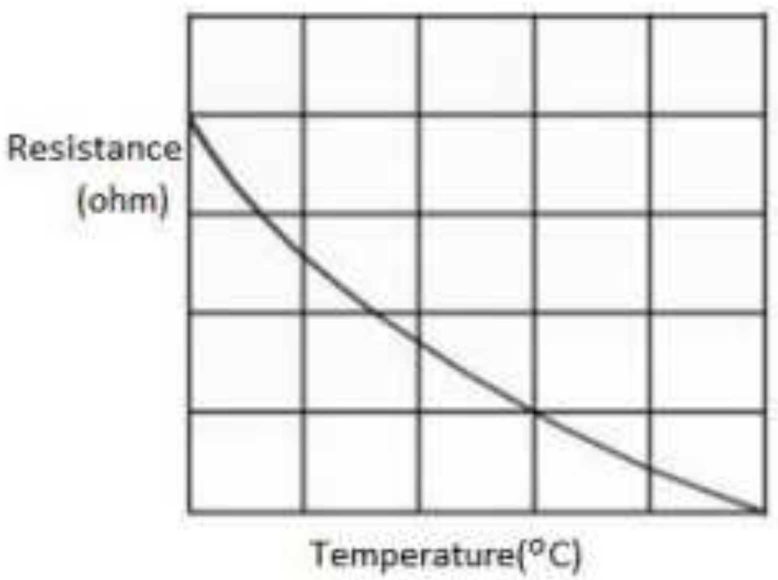
Circuit Diagram:



Observations:

Temp (°C)	Resistance(Ω) (Up)	Resistance(Ω) (Down)

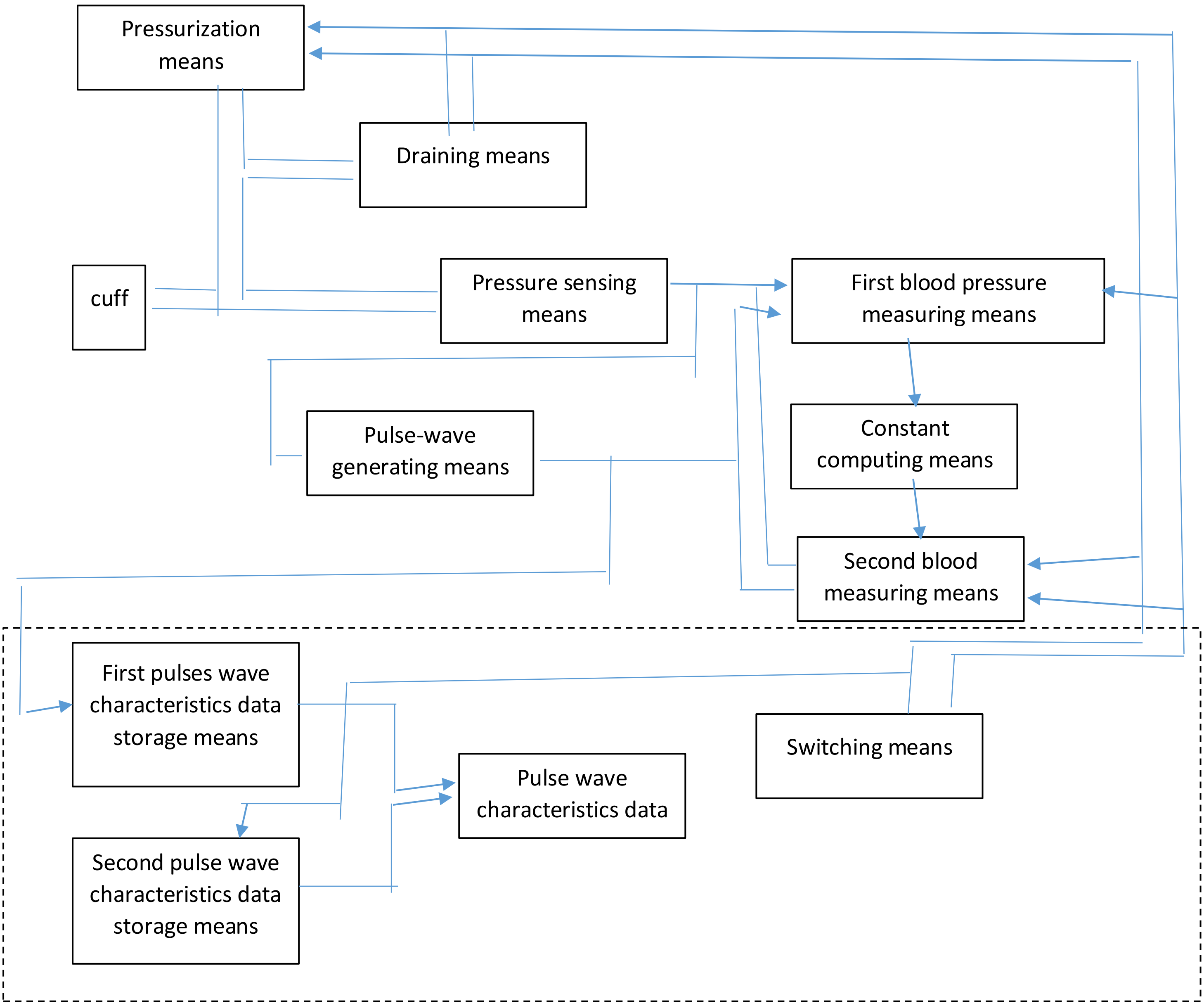
Graph:



Result: Set up the circuit and plotted the characteristics of thermistor.

Inference: Temperature and resistance relationship is non-linear for a thermistor.

(i.e. characteristics of thermistor are non-linear).



Pressurization means
Draining means
cuff
Pressure sensing means
First blood pressure measuring means
Pulse-wave generating means
Constant computing means
Second blood measuring means
First pulses wave characteristics data storage means
Pulse wave characteristics data
Switching means
Second pulse wave characteristics data storage means

BLOOD PRESSURE MEASUREMENT

Ex. No: 4

Aim:

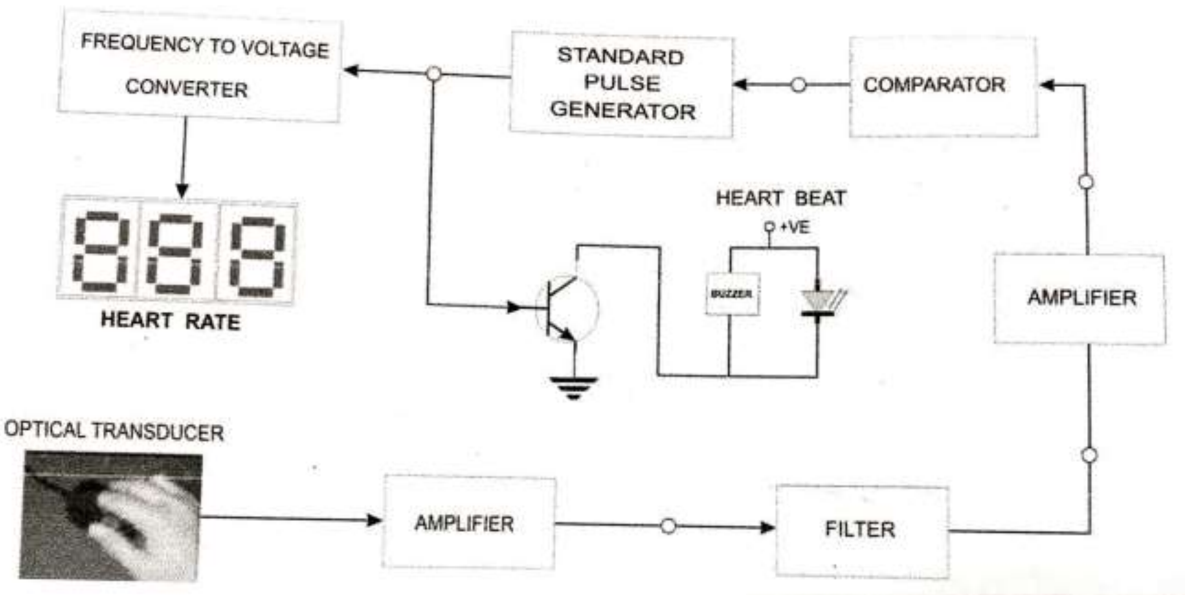
To measure blood pressure using sphygmomanometer semi-automatic blood pressure measuring instrument and automatic blood pressure measuring instrument.

Preparatory Exercise:

1. Compare the systole to diastole.
2. What equipment is used to measure heart rate? To measure blood pressure?
3. Why is using your thumb to measure pulse not ideal?
4. In your own words, describe how to use a blood pressure cuff (sphygomomanometer).

Apparatus Required:

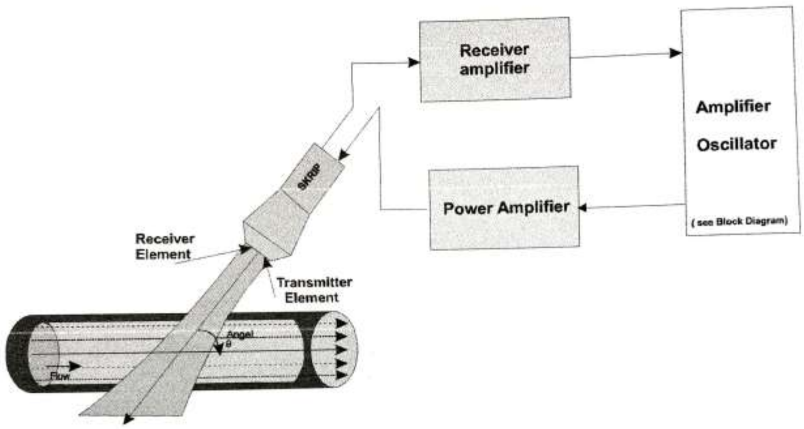
Cuff, Inflator, Power supply, Stethoscope, Sphygmomanometer, Semi-automatic BP measuring unit, Automatic BP, measuring unit terspirom.



Block Diagram

Theory:

Blood pressure is a measurement of the force applied to the walls of the arteries as the heart pumps blood through the body. The pressure is determined by the force and amount of blood pumped, and the size and flexibility of the arteries. Blood pressure is continually changing depending on activity, temperature, diet, emotional state, posture, physical state, and medication use. The ventricles of heart have two states: systole (Contraction) and diastole (Relaxation). During diastole, blood fills the ventricles and during systole the blood is pushed out of the heart into the arteries. The auricles contact anti-phase to the ventricles and chiefly serve to optimally fill the ventricles with blood. The corresponding pressure related to these states are referred to as systolic pressure and diastolic pressure. The range of systolic pressure can be from 90 mm of Hg to 145 mm of Hg with the average being 120 mm of Hg to 90 mm of Hg and the average being 90 mm of Hg.



Doppler Type Ultrasonic Flow Meter

Principle:

The sphygmomanometer works on the principle that when the cuff is placed on the upper side arm and inflated, arterial pressure exceeds the pressure in the cuff. Moreover, when the cuff is inflated to a pressure that only partially occludes the brachial artery, turbulence is generated in the blood as it spurts through the tiny artery opening during each systole. The sounds generated by this turbulence, Korotkoff sounds, can be heard through a stethoscope placed over the artery downstream from the cuff.

Procedure:

1. **Measurement of blood pressure using sphygmomanometer:**

To obtain a blood pressure measurement with a sphygmomanometer and a stethoscope, the pressure cuff on the upper arm is first inflated to a pressure well above systolic pressure, no sound is heard at this point. The pressure in the cuff is them gradually reduced. As soon as cuff pressure falls below the systolic pressure, small amount of blood spurt's part the cuff and Korotkoff sounds begin to be heard. The pressure of the cuff that is indicated on the nanometre when the first Korotkoff sound heard is recorded as the systolic blood pressure. As the pressure in the cuff continues to drop, the Korotkoff sounds continue until the cuff pressure is no longer sufficient to occlude the vessel during any part of the cycle. Below this pressure the Korotkoff sounds disappear, making the value of the diastolic pressure.

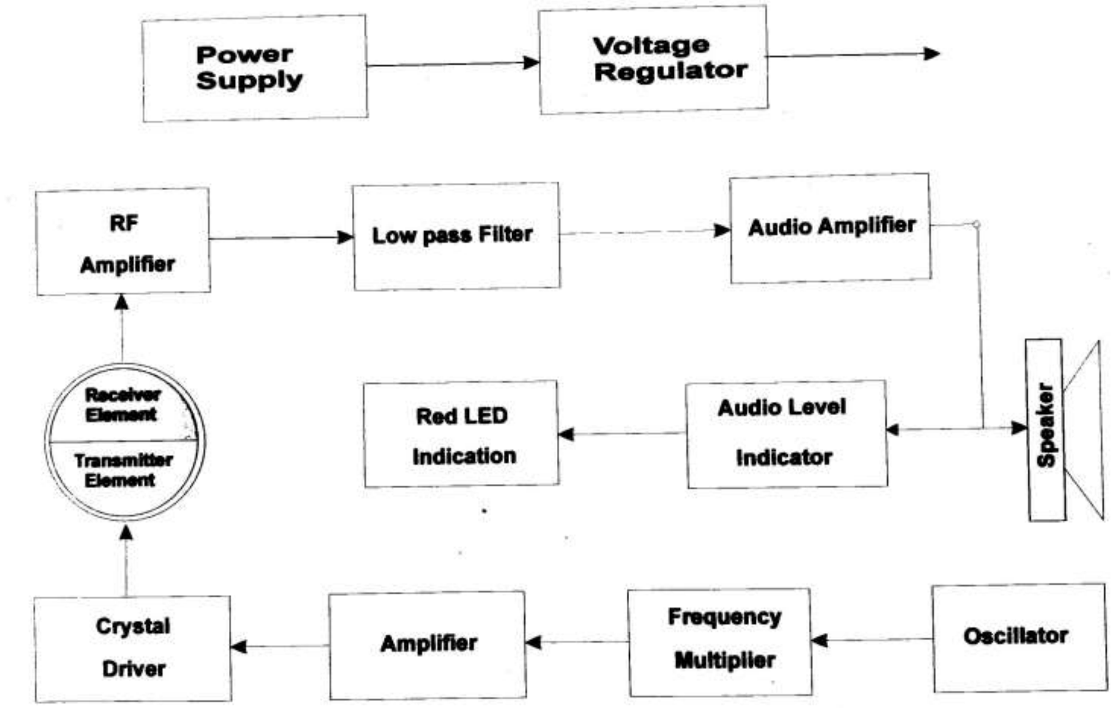
2. **Measurement of blood pressure using semi- automatic instrument:**

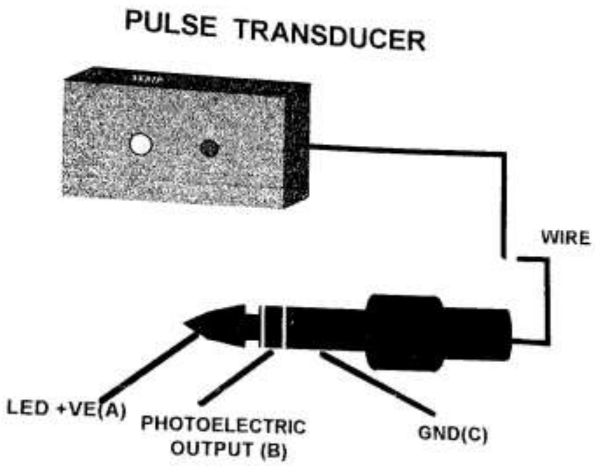
The pressure cuff is automatically inflated to about 120 mm Hg and allowed to deflate slowly. The microphone picks up the Korotkoff sounds from the artery near the surface, just below the compression cuff. The pressure reading at the time of the first sound represents the systolic pressure;
The diastolic pressure is the point on the falling pressure curve where the signal representing that last sound is seen.

3. **Measurement of blood pressure using automatic instrument:**

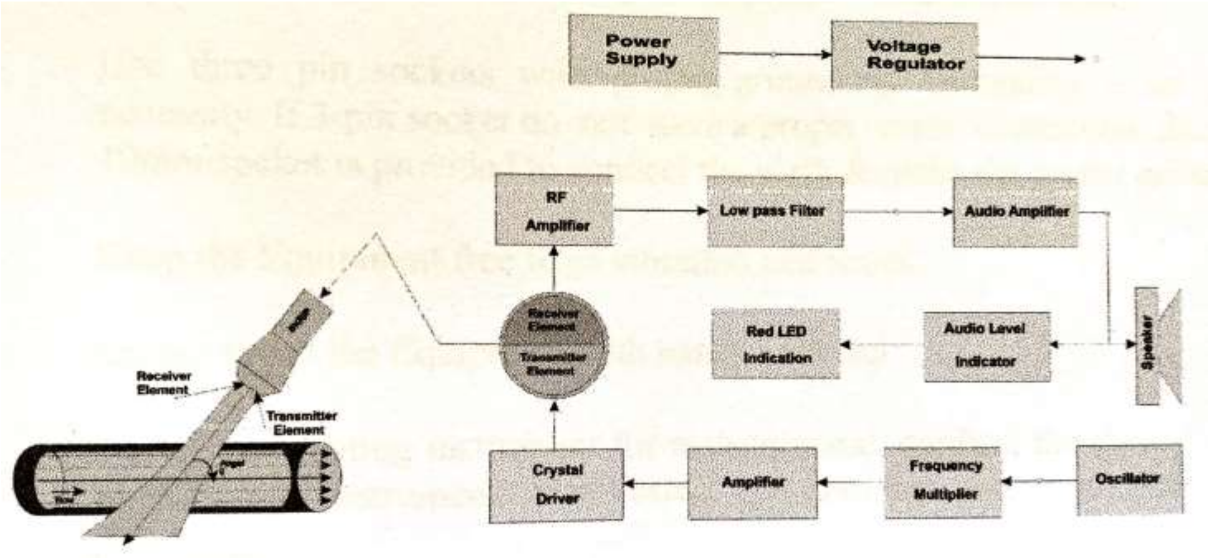
In fully automatic devices, use some type of signal detecting circuit to determine the occurrence of the first and the last Korotkoff sounds and retain and display the cuff pressure readings for these points, electricity or with mercury nanometer. The pump can be regulated by a front panel control. The cuff is placed on the arm in the same way as he sphygmomanometer except that these is a transducer array under the cuff. the motion of the artery produces a doppler shift, which identifies the instant the artery is opened and closed with each other heat between systolic and diastolic pressures.

The instrument is switched on manually by a control button. As the device gets weitched on, it inflates and deflates automatically on its own. If inflates to a pressure higher than the blood pressure of the patient. Then, it automatically displays the systolic pressure and the diastolic pressure digitally on the display screen in the instrument.





Photoelectric Transducer



FUNCTIONAL BLOCK DIAGRAM OF BLOOD PRESSURE MEASUREMENT USING ULTRASONIC FLOW METER

Tabulation:

S. No.	Patient name	Sphygmomanometer		Automated		
		Systolic (mm Hg)	Diastolic (mm Hg)	Systolic (mm Hg)	Diastolic (mm Hg)	Pulse (mm Hg)

Result:

Thus the blood pressure measurements are performed using mercury sphygmomanometer and automated instruments for humans.

REAL TIME MONITORING OF ELECTROCARDIOGRAPHY (ECG)

Ex No: 5

Aim:

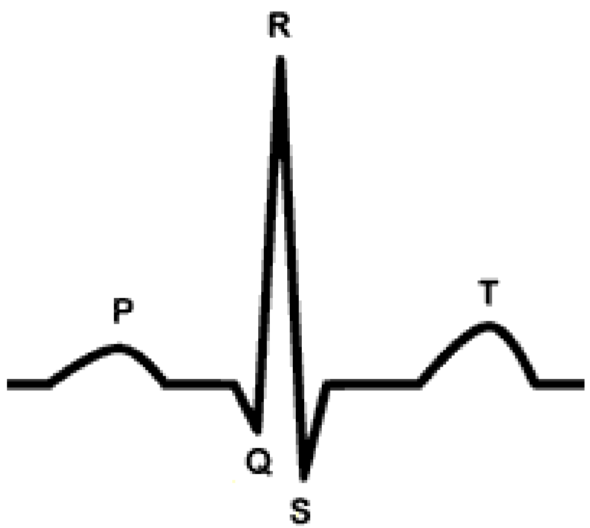
To acquire real time ECG of 12 lead ECG system and analyse the signals.

Components Required:

Description	**Range**	**Quantity**
ECG sensor with leads (electrode patches)	10 lead	1
Computer interface	-	1
PC	-	1
Gel	-	some

Principle:

- An electrocardiogram (ECG/EKG) is a reading of the electrical activity of the heart.
- These are electrical signals that can be detected from two different types of cardiac muscles, the auto-rhythmic fibers that make up the electrical conduction system of the heart and the cardiac muscles that produce muscle contraction.
- A typical ECG is taken using 10 wires and is referred to as a 12 lead ECG.
- Electrodes are placed on each limb and are referred to as augmented limb leads and 6 precordial leads are placed directly on the chest.
- The final lead is the ground lead and is generally placed on the right leg, although it can be placed anywhere on the body.



	Origin	Amplitude (mV)	Duration (sec)
P wave	Atrial depolarization or contraction	0.25	0.12 to 0.22
QRS complex	Repolarization of the atrial and the depolarization of the ventricles	1.60	0.07 to 0.10
T wave	Ventricles Depolarization (Relaxation of myocardium)	0.10 to 0.50	0.05 to 0.50
S-T interval	Ventricular contraction		-
U wave	Slow repolarization of the intraventricular (Purkinje fibers) system	< 0.10	0.20 (T – U interval)

ECG Lead Configuration:

1. **Bipolar Limb leads – Standard Leads I, II, and III:**
   - In standard leads, the potentials are tapped from four locations for the body.
   - They are right arm, left arm, right leg, and left leg.
   - Usually, the right left electrode acts as ground reflex electrode.
   - According to Einthoven, in the fontal plane of the body the cardiac electric field vector is 2D.
   - The ECG measured from anyone, of the three limb leads is a time invariant single dimensional component of the vector.
   - For example, the R wave nominal range voltage is given below:

	Lead I V I (mV)	Lead II V II (mV)	Lead III V III (mV)
R wave	0.53	0.71	0.38
Amplitude	0.07 to 0.13	0.18 to 1.68	0.03 to 1.31

The voltages given in the brackets indicate the range of the measured voltage
V II ~ V I + V III

2. **Augmented unipolar limb leads:**
   - The ECG is recorded between a single exploratory electrode and the central terminal which has a potential corresponding to the center of the body. The augmented lead connections are augmented voltage foot (avF), augmented voltage right arm (avR) and augmented voltage left arm (avL).
   - By Kirchhoff's law, the augmented voltages can be written in terms of standard leads voltages:
     aVR = -V I – V III / 2
     aVL = V I – V II / 2
     aVF = V II – VI / 2
3. **Unipolar chest leads:**
   - The exploratory electrode is obtained from one of the chest electrodes.
   - The ECGs are recorded from these 12 leads selection such that 3 standard bipolar leads, 3 augmented unipolar leads and 6 chest leads.
   - The ECG potentials are measured with coloured leads according to the conventions:

White -> right arm
Black -> left arm
Green -> right leg
Red -> left leg
Brown -> chest

- This is internationally adopted for easy reference.

4. **Frank lead system:**
    - Further using this lead system, the hearts dipole field is revolved into 3 mutually perpendicular components and hence the state of the heart is studied 8D.

Procedure:

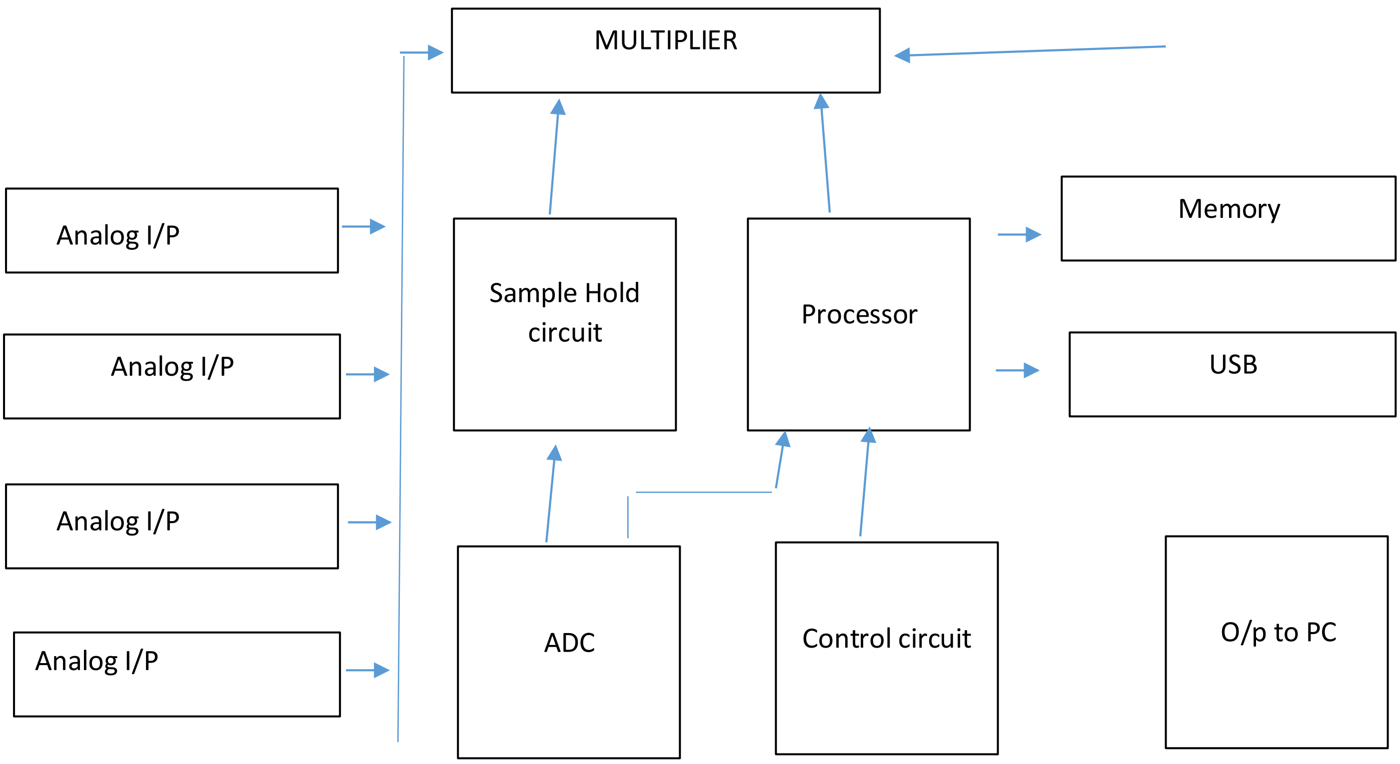
- Choose one member of your group to be the subject and apply the electrode patches.
- Record the ECG of your subject at rest on the required internal times.
- Record the ECG of your subject after three minutes of deep, slow breathing. Record the breathing rate and the acquired time internal.
- Record the ECG of your subject after three minutes of wild exercise.
- Choose three representative ECG traces and measure the intervals at different condition.
- Calculate the average, heart rate and the average heart rate at different condition.

Tabulation:

Parameters	I	II	III	avR	avL	avE	V	Max	In lead
Ramp (micro V)									
R'amp (micro V)									
Pamp (micro V)									
P'amp (micro V)									
Tamp (micro V)									
T'amp (micro V)									
Qamp (micro V)									
Samp (micro V)									
ST elevation (mm)									
ST depression (mm)									
ST slope (mv/sec)									
QR time (m /sec)									

Result:

Thus the real time ECG is recorded and the signal is analysed for the subject.


MULTIPLIER
Analog I/P
Analog I/P
Analog I/P
Analog I/P
Sample Hold circuit
Processor
Memory
USB
ADC
Control circuit
O/p to PC

REAL TIME PATIENT MONITORING SYSTEM

Ex. No: 6

Aim:

To display ECG, temperature, respiratory rate, SpO2 with pulse rate using patient monitoring.

Apparatus Required:

Display ,
Leads,
Electrodes.

Theory:

Patient monitoring systems are used for measuring automatically the value of the patient's important physiological parameter during a surgical operation. The patient is deprived of several manual reaction mechanisms which normally restores abnormalities in his physical conditions or alert other people. Harm done to the patient can be prevented.

Principle:

ECG:

The biopotential by muscles of heart results in ECG. The voltage difference at any two sites due to electrical activity of the heart iss called 'lead'. There are basically two leads:

Unipolar leads
Bipolar leads.

Unipolar lead:

There are two types, one is limb lead in which two of the limb leads are tied together and accorded with respect to the third. The other one is pericardial lead which employs an exploring electrode to record the potential of the heart action on the chest at six different positions.

Bipolar leads:

ECG is recorded by using two electrodes such that the final trace corresponding to the difference of electrical potential existing between these two are called standard leads.

EEG:

The recorded representation of bio electric potential generated by the neuron activity of the brain is called EEG. Modern machines make the use of computerized EEG signal processing.

Frequency Analyser:

It takes the low EEG wave mathematically, analyzer them and breaks them into their component frequencies. Hence EEG signal is converted into simplified waveform called spectrum.

Compressed Analyser:

The amplitude changes result in power of resulting frequency system.

Compressed spectrum array:

This is explained as, in this format a series of computer smoothed spectral array are sketched vertically at several intervals. The origin of plot shifts vertically with time which procedures dimensional graph.

DSA:

It displays power spectrum.

Procedures:

1. Place the electrodes on the hands and legs as required. The connect it to the monitor.
2. Then put on the BP cuff where the brachial artery is and secure it highly.
3. Put the pulse oximeter on the index finger and give that connection
4. Place the temperature probe on the palm of the hand and tell the subject to hold it tight
5. Give all connections and ON the monitor and click on NIBP.
6. Take down the readings

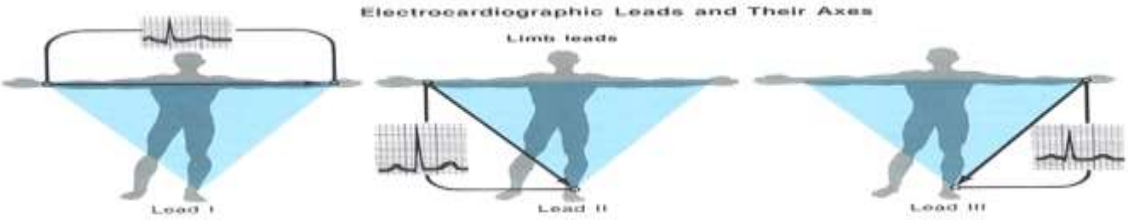
Observations:

S. No.	Patient name	ECG (bpm)	respiration	NIBP (mm/Hg)		Temp (`C)	%SpO2
				Systolic	diastolic		
1.							
2.							
3.							
4.							
5.							
6.							

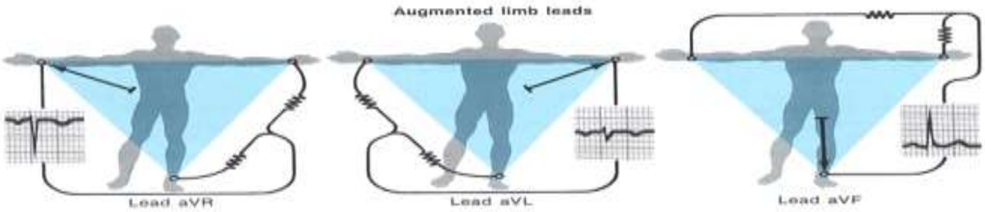
Result:

Display of ECG, SpO2, temperature, NIBP and respiratory rate along with respective waveform was studied and verified using patient monitoring system.

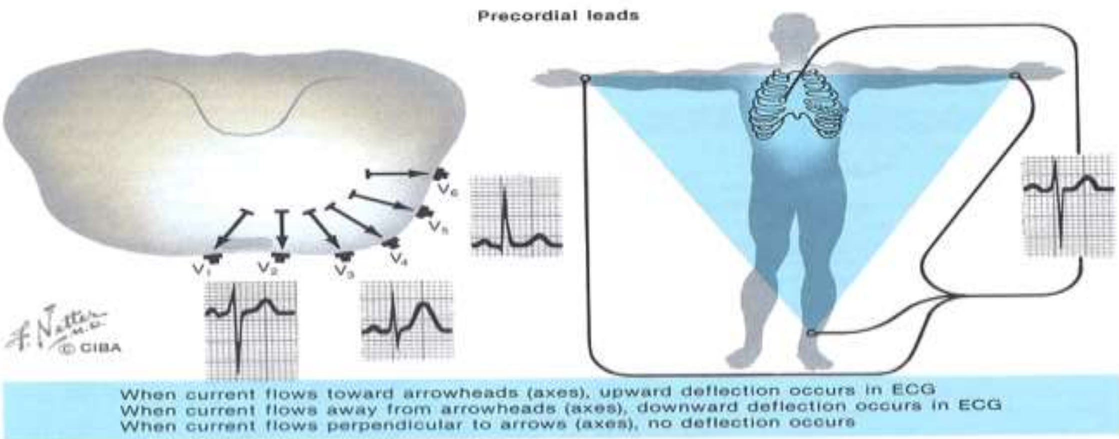
ECG Limb Leads



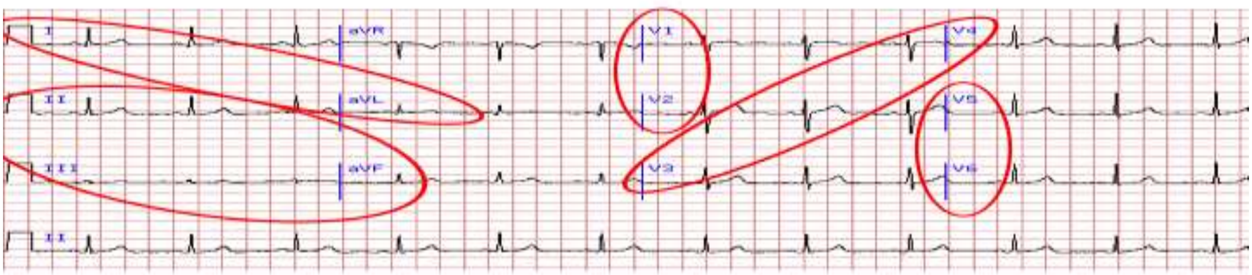
ECG Augmented Limb Leads



ECG Precordial Leads



The 12 lead ECG:



STUDY OF ECG MEASUREMENT

Ex. No: 7

AIM:

To study to trace the ECG waveform and measure the various time interval and amplitude of ECG waveform to make a diagnosis.

APPARATUS REQUIRED:

ECG analyser kit, chest electrodes, clamp electrodes, computer with cardiowin software, conductivity gel.

THEORY:

ECG/EKG- Nomenclature:

Normal EKG tracings consist of waveform components that indicate electrical events during one heartbeat. These waveforms are labelled P, Q, R, S, T and U.

P wave is the first deflection and is normally a positive (upward) waveform. It indicates atrial depolarization.

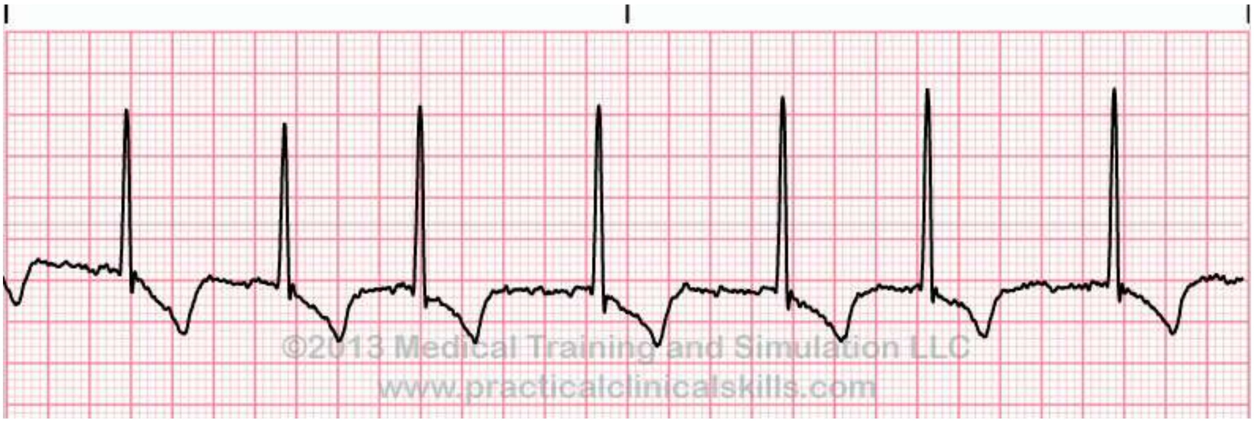
In a normal EKG, the P-wave precedes the QRS complex. It looks like a small bump upwards from the baseline. The amplitude is normally 0.05 to 0.25mV (0.5 to 2.5 small boxes). Normal duration is 0.06-0.11 seconds (1.5 to 2.75 small boxes). The shape of a P-wave is usually smooth and rounded.

QRS complex follows the P wave. It normally begins with a downward deflection, Q; a larger upward deflection, R; and then a downward S wave. The QRS complex represents ventricular depolarization and contraction.

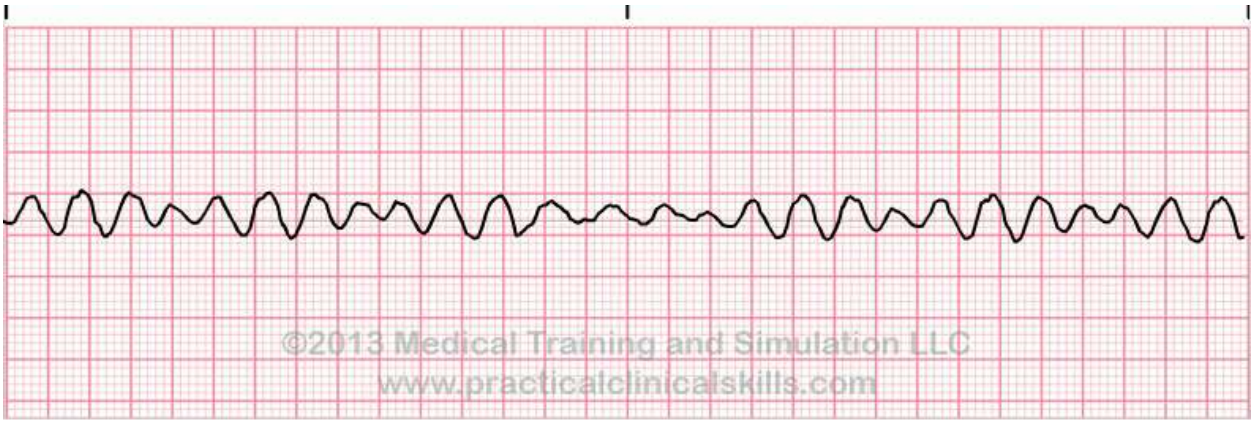
T wave is normally a modest upward waveform, representing ventricular repolarization. It is a slightly asymmetrical waveform that follows (after a pause), the QRS complex. Take note of T waves that have a downward (negative) deflection or of T waves with tall, pointed peaks.

U wave indicates the recovery of the Purkinje conduction fibers. This wave component may not be observable. The U-wave is a small upright, rounded bump. When observed, it follows the T-wave.

Atrial Fibrillation



Ventricular Fibrillation

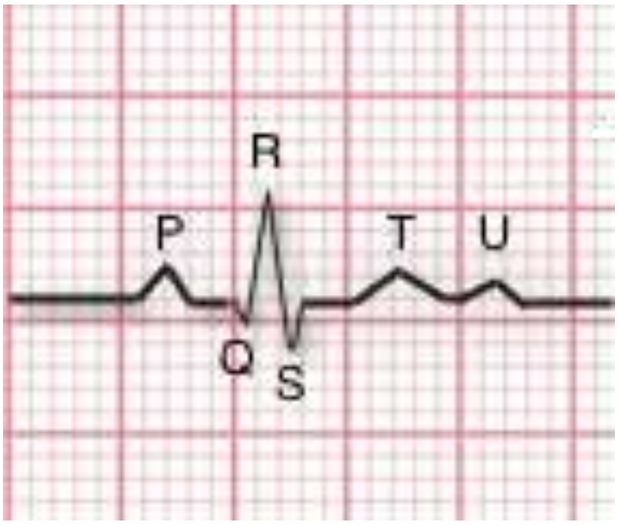


Sinus Bradycardia

ECG Interpretation:

An electrocardiogram or ECG, records electrical activity in the heart. An ECG machine records these electrical signals across multiple heart beats and produces an ECG strip that is interpreted by a healthcare professional.

Normal ECG:



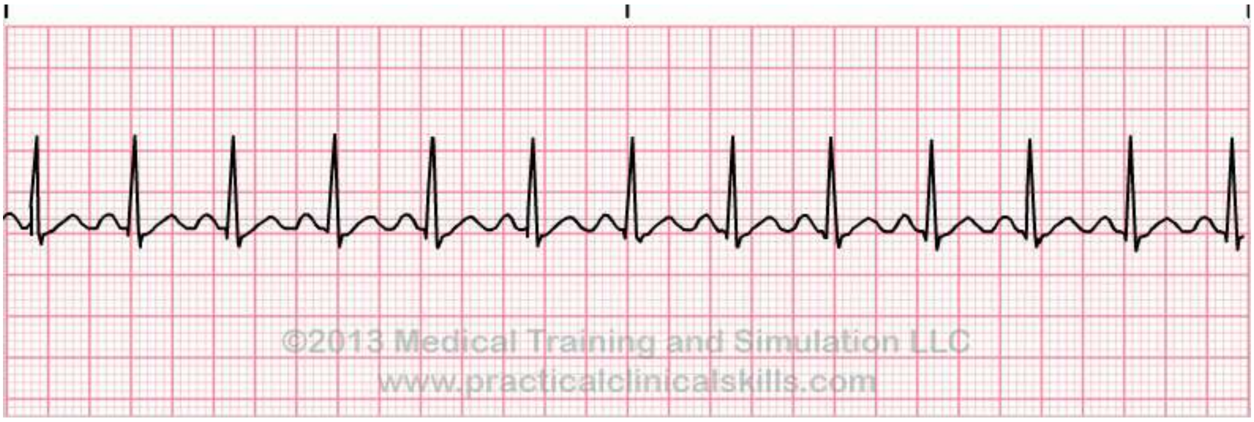
- Pulse rate lies between 60 and 100 beats/minute
- Rhythm is regular except for minor variations with respiration.
- P-R interval is the time required for completion of aerial depolarization; conduction through the AV note, bundle of His, and bundle branches; and arrival at the ventricular myocardial cells. The normal P-R interval is 0 12 to 0.20 seconds.
- The QRS interval represents the time required for ventricular cells to depolarize. The normal duration is 0.06 to 0.10 seconds.
- The Q-T interval is the time required for depolarization and repolarization of the ventricles.

Heart rate:

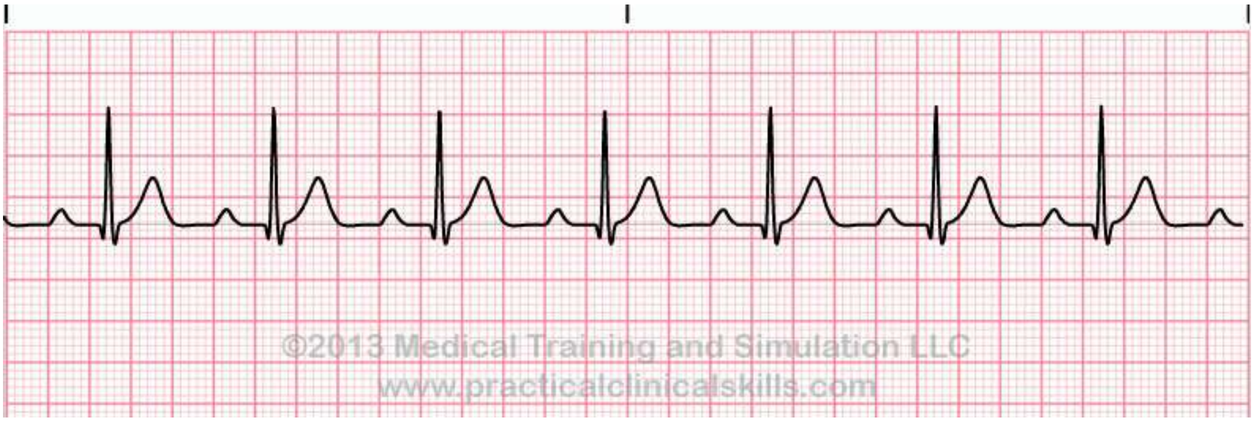
There are several methods for determining heart rate. Our first method is simple. Count the number of QRS complexes over a 6 second interval. Multiply by 10 to determine heart rate. This method works well for both regular and irregular rhythms. In the first image, we can count 7 QRS complexes, so the heart rate is 70.

The second method uses small boxes. Count the number of small boxes for a typical R-R interval. Divide this number into 1500 to determine heart rate. In the above shown image, the number of small boxes for the R-R interval is 22.5. The heart rate is 1500/21.5, which is 69.8.

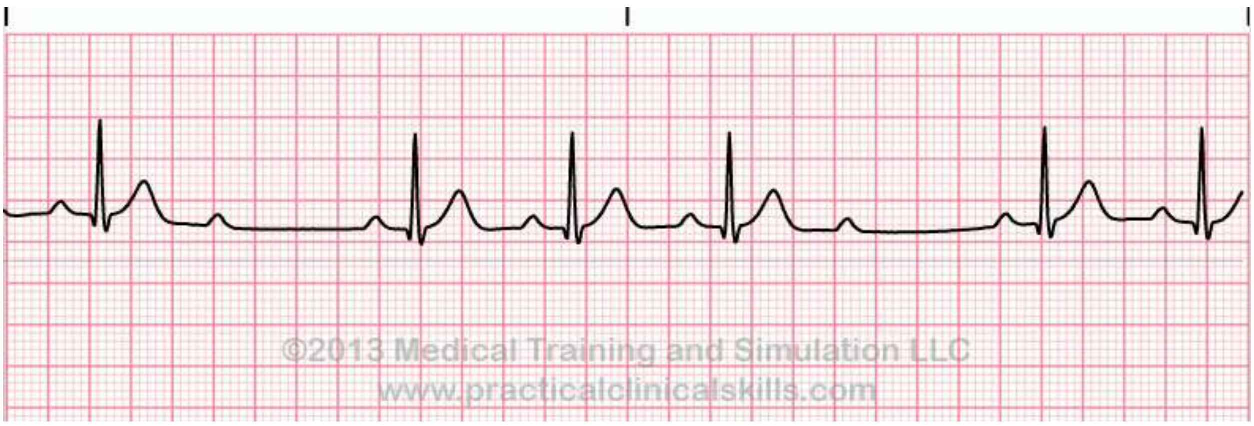
Sinus Tachycardia



First Degree Heart Block



Second Degree Heart Block Type II



ECG Electrodes:

Two arrangements, bipolar and unipolar leads.

Bipolar Lead: One in which the electrical activity at one electrode is compared with that of another. By convention, a positive electrode is one in which the ECG records a positive (upward) deflection when the electrical impulse flows toward it and a negative (downward) deflection when it flows away from it.

Unipolar Lead: One in which the electrical potential at an exploring electrode is compared to a reference point that averages electrical activity, rather than to that of another electrode. This single electrode, termed the *exploring electrode,* is the positive electrode.

Limb Leads: I, II, III, aVR, aVL, aVF explore the electrical activity in the heart in a frontal plane; i.e., the orientation of the heart seen when looking directly at the anterior chest.

Standard Limb Leads: I, II, III; bipolar, form a set of axes 60° apart

Lead I: Composed of negative electrode on the right arm and positive electrode on the left arm.

Lead II: Composed of negative electrode on the right arm and positive electrode on the left leg.

Lead III: Composed of negative electrode on the left arm and positive electrode on the left leg.

Augmented Voltage Leads: aVR, aVL aVF; unipolar ; form a set of axes 60° apart but are rotated 30° from the axes of the standard limb leads.

aVR: Exploring electrode located at the right shoulder.

aVL: Exploring electrode located at the left shoulder.

aVF: Exploring electrode located at the left foot.

Reference Point for Augmented Leads: The opposing standard limb lead; i.e., that standard limb lead whose axis is perpendicular to the particular augmented lead.

Chest Leads: Vl, V2, V3, V4, V5, V6, explore the electrical activity of the heart in the horizontal plane; i.e., as if looking down on a cross section of the body at the level of the heart. These are exploring leads.

Reference Point for Chest Leads: The point obtained by connecting the left arm, right arm, and left leg electrodes together.

Vl: Positioned in the 4th intercostal space just to the right of the sternum.

V2: Positioned in the 4th intercostal space just to the left of the sternum.

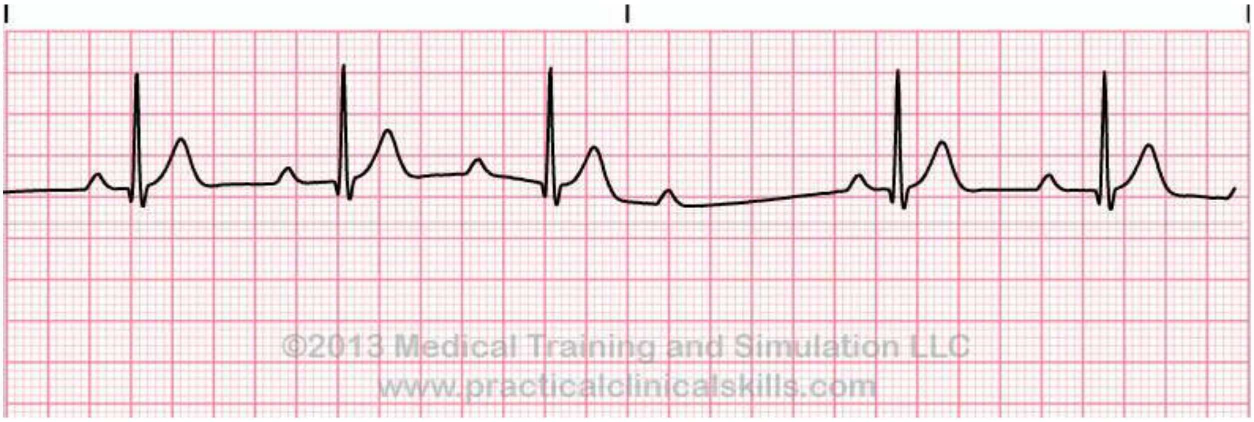
V3: Positioned halfway between V2 and V4.

V4: Positioned at the 5th intercostal space in the mid-clavicular line.

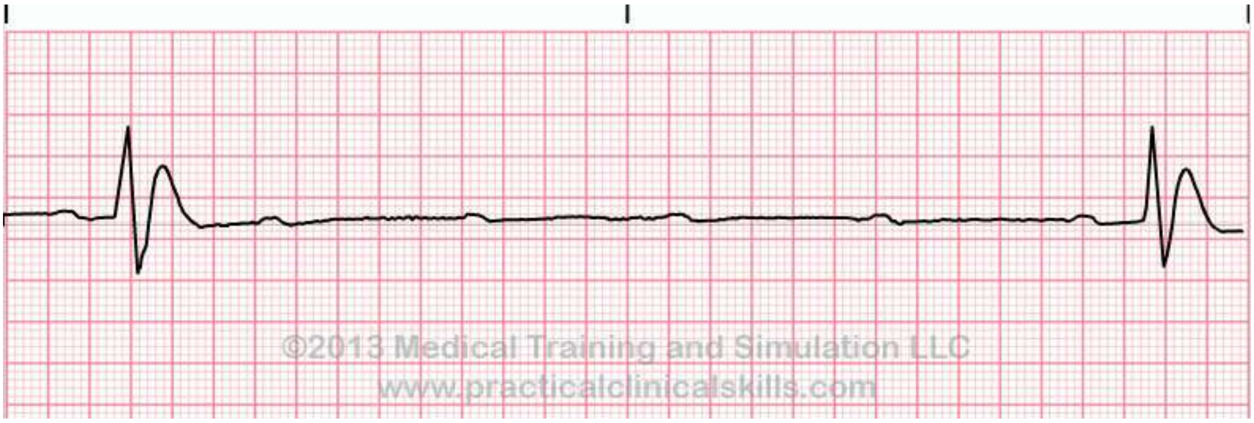
V5: Positioned in the anterior axillary line at the same level as V4.

V6: Positioned in the mid axillary line at the same level as V4 and V5.

Second Degree Heart Block Type I



Third Degree Heart Block



Vl and V2*: Monitor electrical activity of the heart from the anterior aspect, septum, and right ventricle.

V3 and V4*: Monitor electrical activity of the heart from the anterior aspect.

V5 and V6*: Monitor electrical activity of the heart from the left ventricle and lateral aspect.

ABNORMALITIES INTERPRETATION USING ECG

Atrial Fibrillation

Rhythm	Irregular
Rate	Very fast (> 350 bpm) for Atrial, but ventricular rate may be slow, normal or fast

P Wave	Absent - erratic waves are present
PR Interval	Absent
QRS	Normal but may be widened if there are conduction delays

Ventricular Fibrillation

Rhythm	Highly irregular
Rate	Unmeasurable
P Wave	Absent
PR Interval	Not measurable
QRS	None
	EKG tracings is a wavy line

Sinus Bradycardia

Rhythm	Regular
Rate	Slow (< 60 bpm)
P Wave	Normal
PR Interval	Normal (0.12-0.20 sec)
QRS	Normal (0.06-0.10 sec)

Sinus Tachycardia

Rhythm	Regular
Rate	Fast (> 100 bpm)
P Wave	Normal, may merge with T wave at very fast rates
PR Interval	Normal (0.12-0.20 sec)
QRS	Normal (0.06-0.10 sec)

First Degree Heart Block

Rhythm	Regular
Rate	The underlying rate

P Wave	Normal
PR Interval	Prolonged (>0.20 sec)
QRS	Normal (0.06-0.10 sec)
Notes	A first degree AV block occurs when electrical impulses moving through the Atrioventricular (AV) node are delayed (but not blocked). First degree indicates slowed conduction without missed beats.

Second Degree Heart Block Type II

Rhythm	Regular (atrial) and irregular (ventricular)
Rate	Characterized by Atrial rate usually faster than ventricular rate (usually slow)
P Wave	Normal form, but more P waves than QRS complexes
PR Interval	Normal or prolonged
QRS	Normal or wide

Second Degree Heart Block Type I

Rhythm	Irregular but with progressively longer PR interval lengthening
Rate	The underlying rate
P Wave	Normal
PR Interval	Progressively longer until a QRS complex is missed, then cycle repeats
QRS	Normal (0.06-0.10 sec)

Third Degree Heart Block

Rhythm	Regular, but atrial and ventricular rhythms are independent
Rate	Characterized by Atrial rate usually normal and faster than ventricular rate
P Wave	Normal shape and size, may appear within QRS complexes
PR Interval	Absent: the atria and ventricles beat independently.
QRS	Normal, but wide if junctional escape focus

PROCEDURE:

1. Connect the leads appropriately.
2. Obtain the waveform from computer.
3. Find the PQ, QRS complex, ST interval, TU interval.
4. Measure the amplitude of P wave, T wave, ST interval and U wave.

Name of the wave	Amplitude(mV)	Duration (sec)
P wave	0.25	0.12 to 0.22
R wave	1.6	0.07 to 0.1
T wave	0.1 to 0.5	0.05 to 0.15
U wave	<0.1	0.2

DIAGNOSIS:

1. If PQ segment >0.22 Sec – First degree AV block
2. If QRS complex > 0.1 Sec – Bundle block
3. If ST segment is elevated – Myo Cardial fraction
4. If ST segment is depressed – Coronary insufficiency
5. If PQRST waveform is absent and only a train of pulses is present – VentriculFibrillation

RESULT:

Thus, study to trace the ECG waveform and measure the various time intervals and amplitude of ECG waveform to make a diagnosis was done.

MEASUREMENT OF CONDUCTIVITY

Ex. No: 8 (a)

AIM:

To measure the specific conductivity of the given biological sample using a conductivity meter.

Preparatory Exercise:

1. What is the measurement of conductivity?
2. What is the use of conductivity measurement?
3. What is conductivity Mcq?
4. How do you measure conductivity in an experiment?

EQUIPMENTS AND ACCESSORIES REQUIRED:

1. Conductivity meter.
2. Conductivity cell.
3. Thermometer.

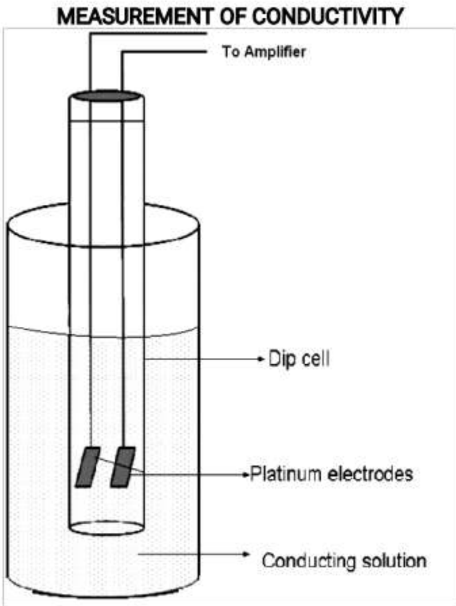
THEORY:

The conductometry is employed to study the behavior of electrolytic solutions to determine solubility of sparingly soluble salts and to evaluate the dissociation constants of weak acids.
If two platinum electrodes are immersed into a solution of an electrolyte and connected to source of electricity, the current which flows is determined both by the applied voltage and by the electrical resistance of that portion of the solution between the electrodes. This relationship is expressed mathematically by Ohm's law

$$I = E/R$$

Where 'I' is in amperes, 'E' in volts , 'R' in ohms

Conductance:
The conductance 'L' of electricity through the solution depends upon the migration of the cations and anions of the electrodes and different potentials. All ionic species in a solution contribute to the ability of that solution to conduct electricity, both intrinsic mobility and concentration of anions deciding the extent of participation of each individual species. This property of the electrolytic solution is known as conductance and is non specific in nature. The conductance, which is a measure of the current that results from the application of a given electrical force, is directly dependent upon the number of charged particles in the solution.



TABULATION:

S.NO	SAMPLESOLUTION	CONDUCTIVITYVALUE

PROCEDURE:

Calibration:

1.Afters witching on the instrument, adjust the 'SET100'controltoread100on DPM and then calibrate the instrument.

2.After thoroughly cleaning, immerse the cell in standard solution, say 0.1Nkcl (Aqueous) which has specific conductivity of the order 0.01412 at 30◦C.

3.Putthe SET/CAL/READ switch to CAL/READ position.

4.Select20mMHOrange.

5.After finding the temperature of the given solution with a thermometer, refer the conductivity of standard solutions chart and adjust the CELL CONSTANT to the corresponding value.

Measurement of conductivity of the given sample:

1.Putthe SET/CAL/READ switch to SET position. Remove the conductivity cell from the.1Nkcl solution and was hit with distilled water, blot with tissue paper and immerse it in the unknown solution. 2.Select CAL/READ position and select appropriate range control and the DPM will display the conductivity of unknown solution.

RESULT:

Measured the conductivity of the Given Biological sample using conductivity meter

MEASUREMENT OF pH

Ex No: 8 (b)

AIM:

To Measure the pH of The Given Biological Samples.

Preparatory Exercise:

1. Define pH.
2. What do you mean by pOH ?
3. What is pH of pure water at 25°C ?
4. What is pH of a solution if it is acidic ?
5. Describe th self ionisation of water. ...
6. What is ionic product of water ?
7. Is pH of pure water affected by rise in temperature ?

Equipment's And Accessories Required

1.pHmeter

2.pHelectrode

3.Buffersolutions.

4.Thermometer.

THEORY:

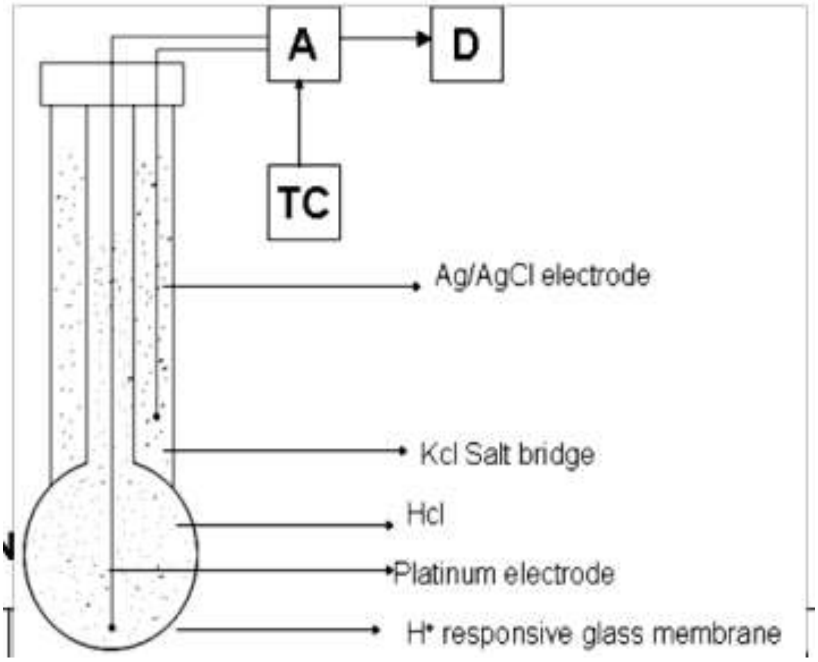
pH describes the degree of acidity or alkality of a solution. pH is defined as the negative logarithm of the hydrogen ion concentration.

$$pH = -\log[H^+]$$

The pH value is measured on a scale of 0-14. If the value is less than 7 the sample is said to be acidic and greater than 7 the sample is said to be alkaline. The sample is neutral with a pH of 7. A pH measurement system consists of a pH measuring electrode, a reference electrode, and a high input impedance meter.

The basic approach is to place a solution of known pH on the inside of the membrane and the unknown solution on the outside. Hydrochloric acid is generally used as the solution of known pH. A reference electrode usually an Ag/AgCl or a saturated calomel electrode, is placed in this solution. A pH measuring electrode (glass pH electrode) is placed in the specimen chamber. The pH measuring electrode is a hydrogen ion sensitive glass bulb, with a millivolt output that varies with the changes in the relative hydrogen ion concentration inside and outside of the bulb. The reference electrode output does not vary with the activity of the hydrogen ion.

pH electrode is temperature dependent and this is shown by the Nerst equation. This temperature correction can be made by setting the temperature control knob to the temperature at which pH is being made



TABULATION:

S.NO	Sample solution	pH Value

PROCEDURE:

Calibration:

1. Switch the instrument ON.
2. Prepare buffer solutions of pH 4 and pH 9.2 by dissolving the respective buffer tablets separately in 100ml of fresh distilled water.
1. Measure the temperature of the buffer solution and adjust the TEMP
2. COMPENSATE CONTROL to the value of the temperature of the buffer solutions.
3. Keep the container with 4 pH buffer solution on the base plate of the electrode stand. Clip the electrode holding clamp at the appropriate height on the rod of the electrode stand such that the electrode is immersed in the buffer solution.
4. Push the pH /mV switch to pH position and push the STBY/READ switch to READ position and adjust CAL control to set 4 on the READOUT and wait for 30 seconds. Set the STBY/ READ switch to STBY position.
5. Remove the container with 4 pH buffer solution.
6. Wash the electrode with distilled water and blot clean with tissue paper.
7. Set STBY/READ switch to STBY position and place the electrode in the pH 9.2 buffer.
8. A pH value of 9.2 will be displayed on the READOUT. Remove the beaker with 9.2 pH buffer solution.
9. Clean the electrode with distilled water and blot clean with tissue paper.

pH Measurement of Given Sample:

1. Measure the temperature of the given sample and set the TEMP COMPENSATE CONTROL and then immerse the electrode in the given sample.
2. Set the pH/mV switch to pH position and STBY/READ switch to READ and wait for 30seconds.
3. The pH value of the sample will be displayed on the READOUT.

Buffer Solutions:

Buffers are solutions that have constant pH value and the ability to resist the changes in that pH value. They are used to calibrate the pH measurement system (electrode and meter).

RESULT:

Measured the pH of The Given Biological Samples.

MEASUREMENT OF RESPIRATION RATE

Ex. No: 9

Aim:

To measure the respiration rate of a human being using respiration rate meter.

Apparatus Required:

Respiration rate meter-1

Belt buckle with transducer-1

DSO.-1

Theory:

The respiration rate is the number of breathes taken per minute. The rate is usually measured when a person is at rest position and simply involves counting the number of breaths for one minute or counting how many times the chest rises.

Respiration monitoring is fall into two categories

- Devices such as spirometers and nasal thermocouples measure air flow into an out of the lungs directly.
- Reparation can also be monitoring indirectly.

This piezoelectric sensor measures the changes in thoracic or abdominal circumference due to respiration inhalation and exhalation.

Transducer:

Piezoelectric transducer, transduces output is 0 to 10 mv.

Amplifier:

The transducer can detect expansion and contraction of the circumference due to changes in pressure.

Filter:

Output of the amplifier is further processed by a 2^{nd} order high pass filter with unity gain.

Amplifier:

This amplifies, the output of hee high pass filter.

Comparator:

Comparator compares the signal with threshold and here is at output clock pulse 5V.

Standard pulse Generator:

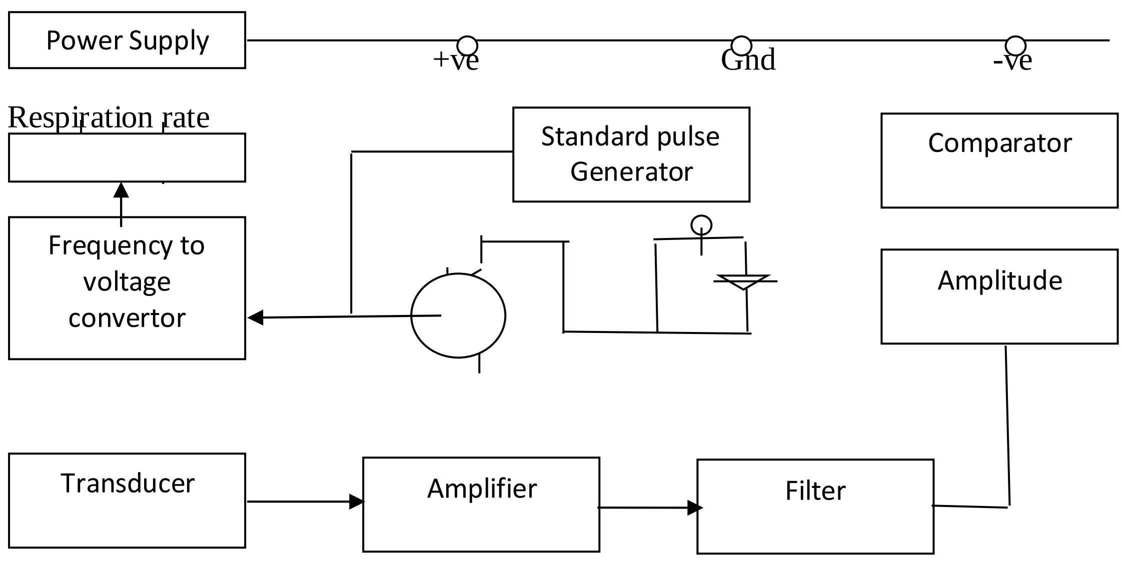
Pulse from comparator to standard pulse generator.

Frequency to voltage generator:

This is F to V converter block.

Power supply:

+_ 5 regulated power supply.



Procedure:

1. Connect the instrument to main by mains cord. Use proper ground connections.
2. Plug the transducer to transducer socket. Insert the transducer plug into the transducer socket.
3. Putting the sensor belt. The belt should be wrapped around upper abdomen, halfway between navel and chest, and buckled.
4. Now switch ON the instrument.
5. Use storage oscilloscope.
6. Now connect the DSO to the instrument. Connect DSO probe to instrument at 4mm red socket marked as pulse and block socket ground, and DC signal at output socket.
7. See signal pattern on DSO.
8. Display shown the respiration rate.
9. If pulse duration or pulse rate up and down change the place of transducer.
10. Check the ground.

Sample Name	Amplitude		Rise line	Pulse
	Min	Max		

Result:

The respiration rate of a human being is measured using respiration rate meter and tabulated.

PULSE RATE MONITORING

Ex.No : 10

AIM

To measure the pulse rate of a human using pulse rate monitor.

APPARATUS REQUIRED

1. Pulse Rate Monitor,
2. DSO,
3. Transducer

THEORY

AMPLIFIER:

This is very high again non-inverting amplifier. Amplifier the change in resistance output in form of voltage is approx. 500ml.This amplified output to the filter section.

FILTER:

Output of amplifier is further processed by 2^{nd} order low pass filter. This filter passes only low frequency with unity gain amplifier.

COMPARATOR:

Amplifier increase gain and output to input of amplifier is compare with threshold level for detecting the pulse. This pulse to standard pulse generation.

STANDARD PULSE GENERATOR:

Standard pulse generator converts pulse in standard pulse in standard pulse width for frequency to voltage convertor.

FREQUENCY TO VOLTAGE CONVERTOR:

Frequency to voltage convertor converts standard pulse output into DC voltage.

DISPLAY:

This is ADC, Analog DC voltage and digital 7 segment LED. Indication of heart rate BPM.

TRANSDUCER:

The common method use to measure pulse is by photoelectric method. In this instrument heart rate measurement photoelectric method is used. In photoelectric mounted in an enclosure, that is bitted on finger of patient, light is transmitted through the finger tip and there is change in photoresistor.

BLOCK DIAGRAM:

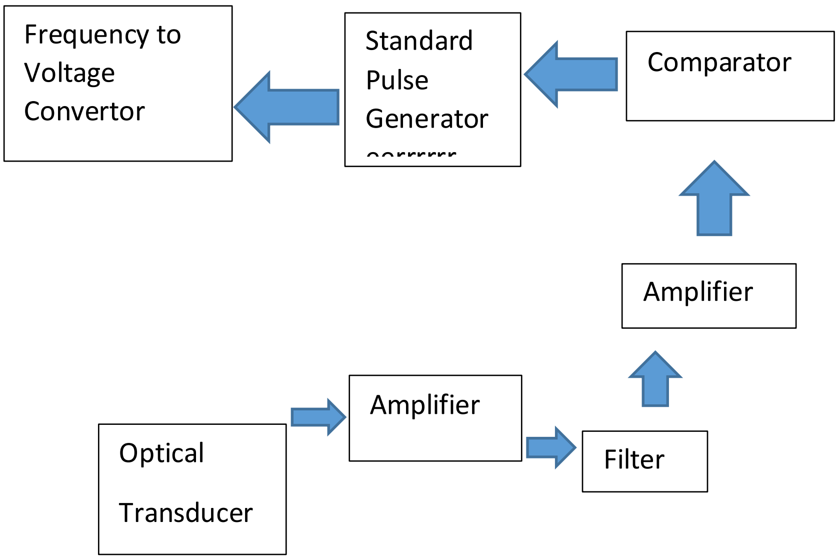


TABLE:

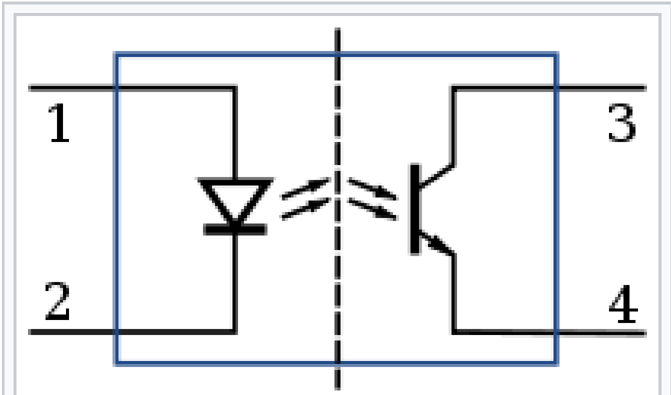
Name	**Reading on Instrument**	**Manual Account Reading**	**Calculated Reading from DSO**
Saran	94	96	95
Sathish	95	95	95
Susil	89	89	89
Chandra	77	75	79

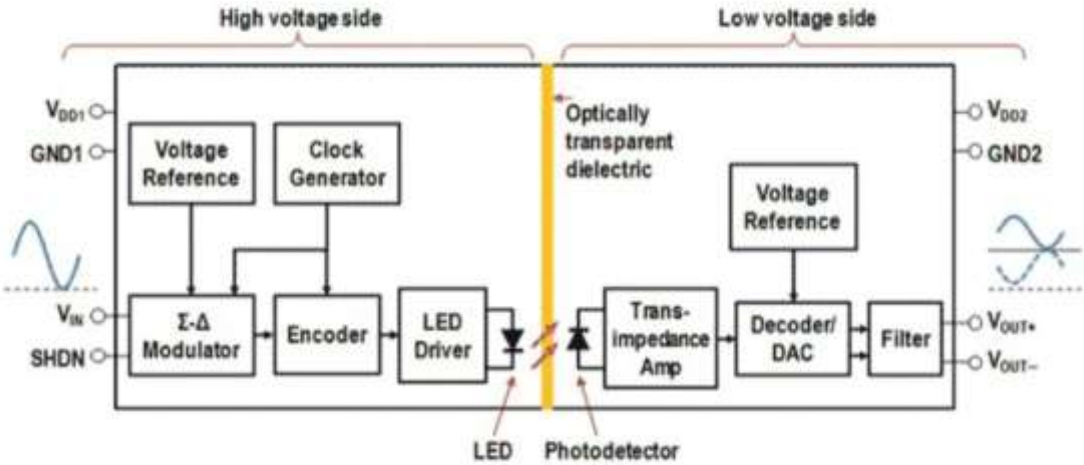
PROCEDURE:

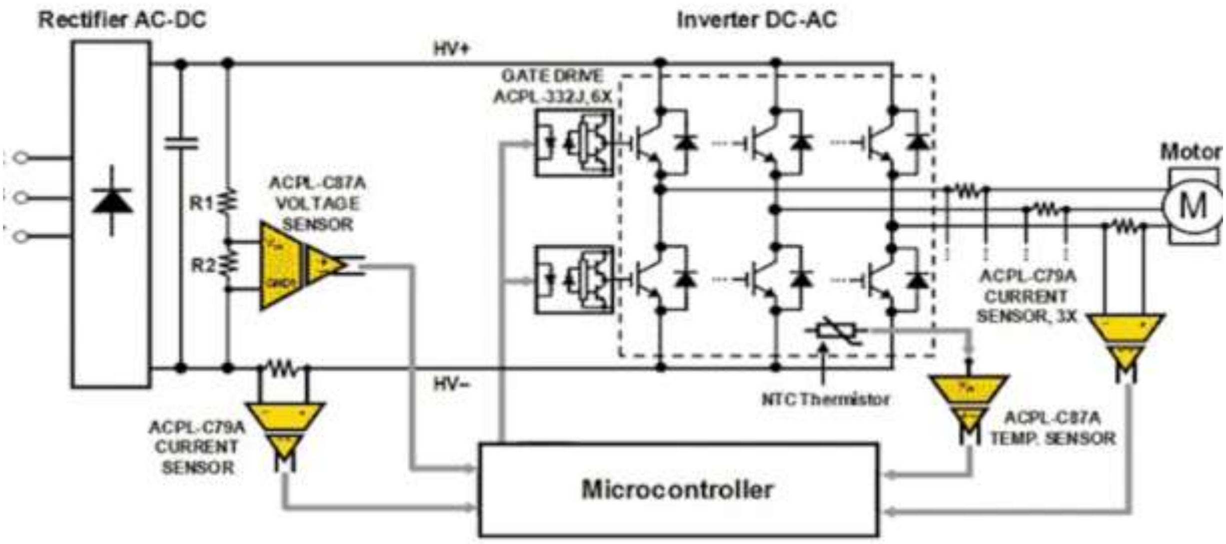
1. Study of the Plethysmography.
2. Using the heart rate indicator measure the rate and using study the signal.
3. Draw the block diagram of the system.
4. Plot the graph at each test point.
5. Measure the heart rate BPM using DSO.

RESULT:

Thus the experiment to study the pulse rate of human being using pulse rate monitor is done and reading is noted.


1
2
3
4


High voltage side
Low voltage side
V_{DD1}
GND1
V_{IN}
SHDN
Voltage Reference
Clock Generator
Σ-Δ Modulator
Encoder
LED Driver
Optically transparent dielectric
Voltage Reference
Trans-impedance Amp
Decoder/ DAC
Filter
V_{DD2}
GND2
V_{OUT+}
V_{OUT-}
LED
Photodetector


Rectifier AC-DC
Inverter DC-AC
HV+
GATE DRIVE ACPL-332J, 6X
Motor
M
R1
R2
ACPL-C87A VOLTAGE SENSOR
ACPL-C79A CURRENT SENSOR, 3X
HV-
NTC Thermistor
ACPL-C87A TEMP. SENSOR
ACPL-C79A CURRENT SENSOR
Microcontroller

Study of characteristics of the optical isolation amplifier

Ex.No.11

Aim:

To study the characteristics and operation of a optical isolation amplifier.

Theory:

An optoisolator is an electronics device that transfers electrical energy from one circuit to another through a short optical transmission path while providing electrical isolation between two circuits. An optoisolator couples high voltages from one side of the circuit to the other without any direct electrical contact.

The devices convert the electrical energy into a beam of light using a light emitting diode, and then directing the light towards a light sensor such as a photodiode or phototransistor which converts the optical energy back into electrical energy. This isolate the two circuits, prevents voltage spikes, and decreases noise and interference associated with communication connections.

Optoisolators are widely used in power supplies, control and monitoring systems, communications, and other systems to safely couple one circuit section to another electrically, while preventing direct contact and high voltages from affecting the lower voltage side.

Operation:

The voltage from the primary circuit is applied to the power source to produce a near-infrared light beam which travels across the closed channel until it hits the photo sensor which converts the optical energy to electrical energy. Since the LED and the phototransistor or photodiode are separated and have no direct electrical connection, the device provides isolation of the two sections of a circuit while enabling transfer of the electrical energy from one section to the other.

Once the light from the LED strikes the phototransistor, it starts conducts electricity depending on the state and duration of the light. The optoisolators are packaged in a wide variety of styles which includes cylinders, rectangles or other special configurations. These are designed to allow for the isolation of higher voltages than what the optocoupler SMD and DIP packages can handle.

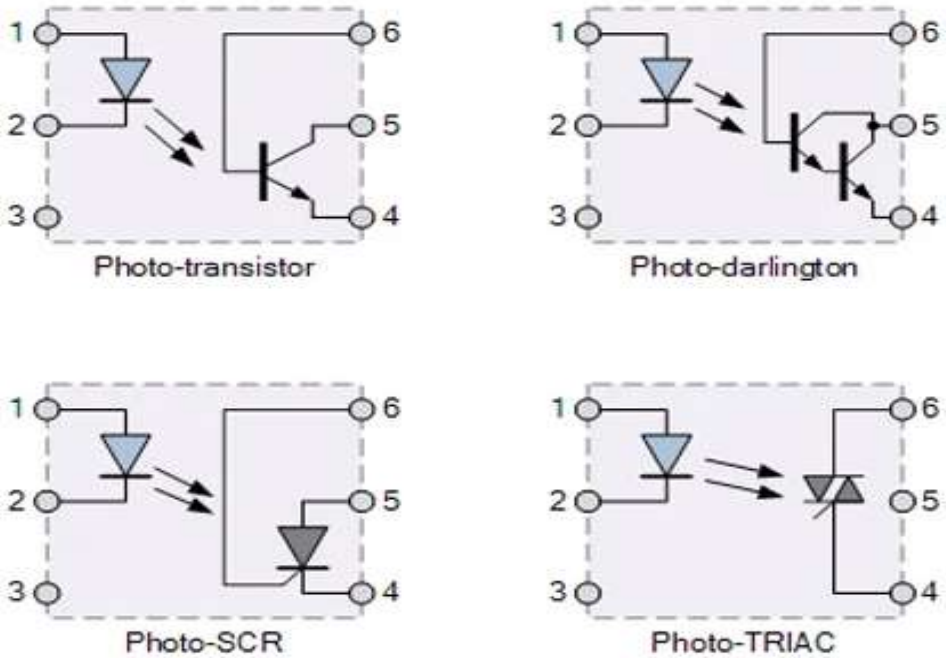
Optopcouplers and optoisolators are sometimes used interchangeably; however, the optocouplers handle voltages of up to about 5000V while the optoisolators handle voltages of over 5000V.

An opto-isolator contains a source (emitter) of light, almost always a near infrared light-emitting diode (LED), that converts electrical input signal into light, a closed optical channel (also called dielectrical channel), and a photosensor, which detects incoming light and either generates electric energy directly, or modulates electric current flowing from an external power supply. The sensor can be a photoresistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a triac. Since LEDs can sense light in addition to emitting it,

Types of opto-isolators [edit]

Device type[note 5]	Source of light[7]	Sensor type[7]	Speed	Current transfer ratio
Resistive opto-isolator (Vactrol)	Incandescent light bulb	CdS or CdSe photoresistor (LDR)	Very low	<100%[note 6]
	Neon lamp		Low	
	GaAs infrared LED		Low	
Diode opto-isolator	GaAs infrared LED	Silicon photodiode	Highest	0.1–0.2%[22]
Transistor opto-isolator	GaAs infrared LED	Bipolar silicon phototransistor	Medium	2–120%[22]
		Darlington phototransistor	Medium	100–600%[22]
Opto-isolated SCR	GaAs infrared LED	Silicon-controlled rectifier	Low to medium	>100%[23]
Opto-isolated triac	GaAs infrared LED	TRIAC	Low to medium	Very high
Solid-state relay	Stack of GaAs infrared LEDs	Stack of photodiodes driving a pair of MOSFETs or an IGBT	Low to high[note 7]	Practically unlimited

construction of



symmetrical, bidirectional opto-isolators is possible. An optocoupled solid-state relay contains a photodiode opto-isolator which drives a power switch, usually a complementary pair of MOSFETs. A slotted optical switch contains a source of light and a sensor, but its optical channel is open, allowing modulation of light by external objects obstructing the path of light or reflecting light into the sensor.

Factors that affect Optoisolator operations

The breakdown potential exterior to the optoisolator depends on factors such as the temperature, humidity, distance, barometric pressure, type and concentration of the contaminants in the air. The devices are therefore affected by humidity and in particular at higher voltages of about 50,000 DC. High humidity in the air may lead to arcing around the isolator or along the surface of the circuit board, resulting to a conductive path and possible short circuit around the optoisolator.

Advantages of optoisolators include:

- Providing electrical and physical isolation of two sections of a circuit and Hence the safety
- Minimizing noise susceptibility and EMI and reducing interference such as From electrical interference
- Relatively small and inexpensive
- Ability to limit voltage across multiple circuits
- Provide isolation

Disadvantages of optoisolators

- Have limitations and cannot be used in some electrical systems
- Affected by factors such as humidity, air pollution and barometric pressure, each if which can cause arcing and interference with the isolation. There requires that the devices be used in climate controlled areas.

Applications of Optoisolators

The Optoisolators are used in a variety of optical applications including the power supplies to provide isolation, in the recording industry to reduce interference, and in computer systems to transfer data. Applications include:

- Power supply feedback systems
- Medical, industrial, applications
- Isolating ground loop currents
- High voltage level shifting
- Signal isolation
- Electrical power and noise isolation

Results:

Thus the characteristics and operation of a optical isolation amplifier is studied.