Department of Biomedical Engineering

LAB MANUAL

BIOSENSORS AND MEASUREMENT DEVICES

HOD-BME- ECE

List of Experiments

1. Characteristics of temperature transducers.
2. Characteristics of pressure and optical transducers.
3. Characteristics of strain gauge.
4. Blood pressure measurement using sphygmomanometer.
5. Design of instrumentation amplifier.
6. Measurement PH using PH meter.
7. Galvanic Skin resistance measurement.
8. Recording of ECG using ECG simulator.
9. Recording of EEG using EEG simulator.
10. Recording of EMG using EMG simulator.

Ex. No.1 Characteristics of Temparature transducers

Aim: To study the characteristics of temperature transducers

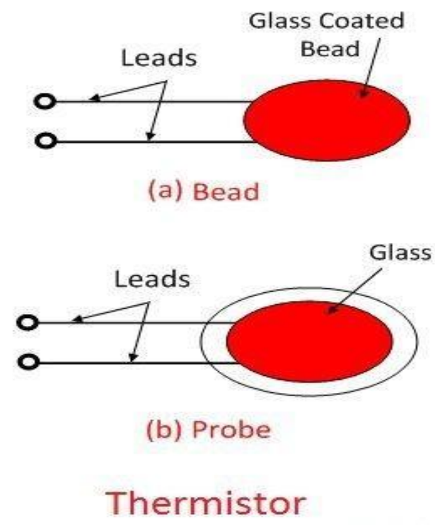
THEORY:

Thus, a temperature transducer is an instrument used to convert the thermal energy of the substances into electrical form. In other words, it is a piece of electrical equipment applied for automated measuring of temperature. The latest purpose of the temperature transducer is to measure the heat of the material in a readable format.

Principle Features of Temperature Transducers

Although there are various types and applications for temperature transducers, the basic principle and features of them are quite similar, which can be summarized as the following:

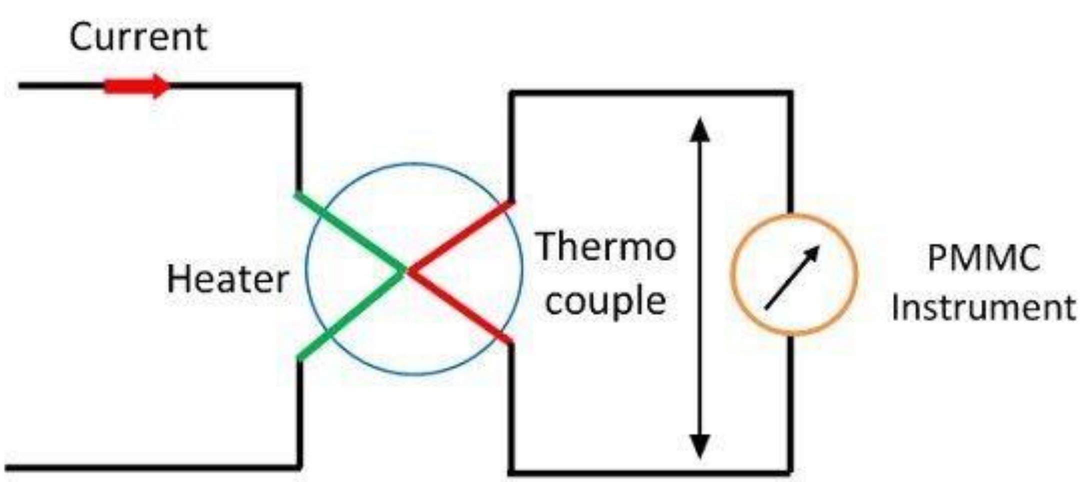
- The input to a temperature transducer is invariably the thermal quantities
- They regularly transform the thermal amount into an electrical one
- They are typically utilized for the determination of the temperature and heat flow



Main Characteristics of Thermocouples

Despite differences among various types of thermocouples, their characteristics generally lie among the following items:

- Their main advantage is the capability of vast temperature range measurement compared to RTDs and thermistors (-200 ^oC to over +2000 ^oC).
- They are the *Active Transducers*, which means they do not require any external source to measure temperatures like Thermistors and RTDs.



- They are more affordable than both Thermistors and RTDs.

They have lower accuracy compared to Thermistors and RTDs; thus, generally, they are not utilized for high accuracy applications.

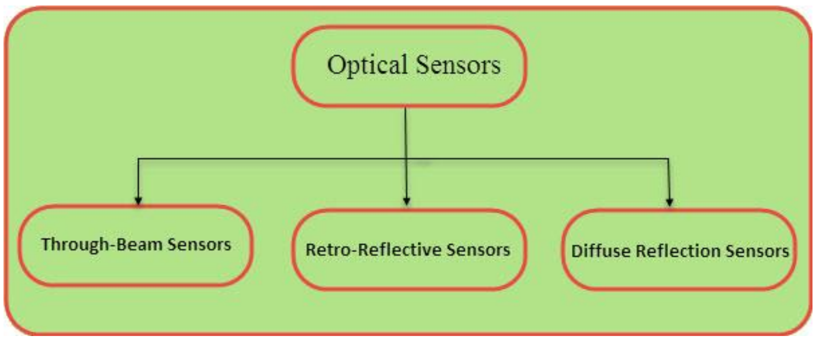
Result: Thus the characteristics of temperature transducers were analysed

Ex. No 2.characteristics of pressure and optical transduccers

Aim: To study the characteristics of characteristics of pressure and optical transducers

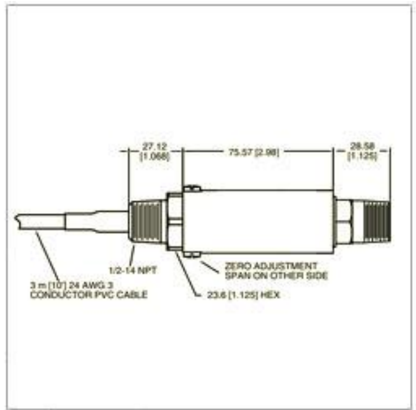
THEORY:

An optical sensor converts light rays into an electronic signal. The purpose of an optical sensor is to measure a physical quantity of light and, depending on the type of sensor, then translates it into a form that is readable by an integrated measuring device. Optical used for contact-less detection, counting or positioning of parts. Optical sensors can be either internal or external. External sensors gather and transmit a required quantity of light, while internal sensors are most often used to measure the bends and other small changes in direction.



A **pressure transducer**, often called a **pressure transmitter**, is a transducer that converts pressure into an analog electrical signal. Although there are various types of pressure transducers, one of the most common is the strain-gage base transducer.

The conversion of pressure into an electrical signal is achieved by the physical deformation of strain gages which are bonded into the diaphragm of the pressure transducer and wired into a Wheatstone bridge configuration. Pressure applied to the pressure transducer produces a deflection of the diaphragm which introduces strain to the gages. The strain will produce an electrical resistance change proportional to the pressure.



Pressure Transducer Design

Result: Thus the characteristics of optical transducers and pressure transducers were analysed

<u>Ex. No 3 characteristics of strain guage</u>

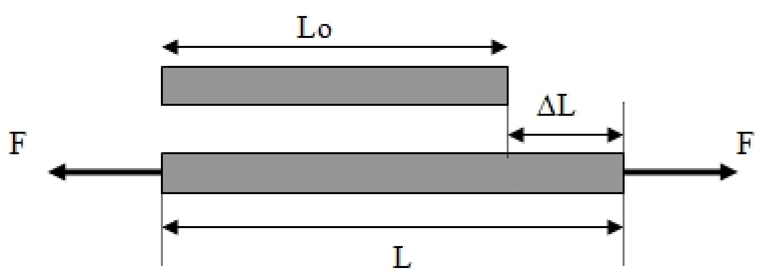
Aim: To study the characteristics of strain Gauge

THEORY:

The strain gauge is a passive transducer that converts the mechanical elongation and compression into the resistance strain. There are different types of strain gauges and they are used for finding the vibrations, used for the calculation of strain, and associated stress and sometimes it is also used to find applied force and pressure. In the geotechnical field, the strain gauges are the important sensors.

Strain

Let us take one object of length 'L0', apply force 'F' on both sides of an object. If we apply an equal amount of force to the object the length of the object will change.



Strain

Previously the length of the object is L0, after force applied to that object the length is L. The change in length is taken as dL, where dL=L– L0. The strain is defined as a ratio of change in length and original length.

Strain= Change in Length/Original Length=dL/ L0

Characteristics

The characteristics of the strain gauges are

- The strain gauges are highly precise
- For long-distance communication, they are ideal
- They require easy maintenance
- They have a long operating life
- For long term installation, the strain gauges are suitable

Applications

The applications of the strain gauge are

- Aerospace
- Cable bridges
- Rail monitoring
- Torque and power management in rotating equipment
- Residual stress
- Vibration and torque measurement
- Bending and deflection measurement
- Tension, strain, and compression measurement

Result: Thus the characteristics of strain Guages experiment were analysed

Ex. No 4 Blood Pressure Measurement

Aim: To Measure blood pressure using Sphygmomanometer and compare with digital blood pressure meter..

Apparatus Required:

1. Cuff
2. Inflator
3. Power supply

4. Stethoscope

5. Sphygmomanometer

6. Digital Blood pressure meter

THEORY:

Blood Pressure

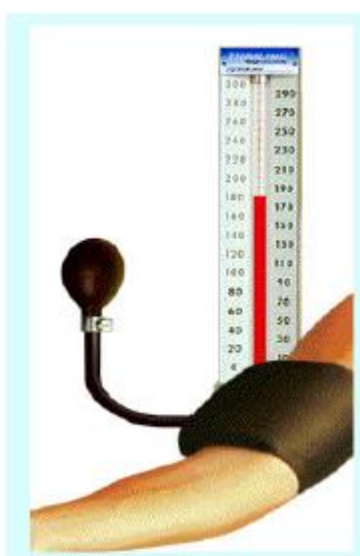
Blood pressure is a measurement of the force applied to the walls of the arteries as the heart pumps blood through the body. The pressure is determined by the force and amount of blood pumped, and the size and flexibility of the arteries. Blood pressure is continually changing depending on activity, temperature, diet, emotional state, posture, physical state, and medication

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 contract 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 145mm of Hg with the average being 120 mm of Hg. The diastolic pressure typically varies from 60mm of Hg to 90 mm of Hg and the average being 80mmofHg.

1. SPHYGMOMANOMETER

Mercury Sphygmomanometer

This includes a mercury manometer, an upper arm cuff, a hand inflation bulb with a pressure control valve and requires the use of a stethoscope to listen to the Korotkoff sounds. Relies on the ausculatory technique.



2. Digital BP meter (Automated device)

This includes an electronic monitor with a pressure sensor, a digital display and an upper arm cuff. An electrically driven pump raises the pressure in the cuff. Devices may have a user-adjustable set inflation pressure or they will automatically inflate to the appropriate level, about 30 mmHg above the predicted systolic reading. On operation of the start button the device automatically inflates and deflates the cuff and displays the systolic and diastolic values. Pulse rate may so be displayed. Devices may also have a memory facility that stores the last measurement or up to 10 or more previous readings. It is battery powered and uses the ocillometric technique.

PROCEDURE

1. The upper arm is wrapped with the cuff belt connected to a mercury pressure gauge and air is pumped with a rubber ball to increase cuff pressure about 30 mmHg higher than the systolic blood pressure to block the artery and stop blood flow downstream.

2. Then, the cuff pressure is slowly lowered. The artery opens at the instant when the cuff pressure decreases below the systolic blood pressure and blood begins to flow on and off in synchrony with pulses causing the opening and closing of the artery. The sound emitted by the pulses is named Korotkoff's and continues until the cuff pressure decreases below the systolic blood pressure and the artery ceases the opening and closing.

3. The stethoscope placed closely to the artery downstream of the cuff is used to hear Korotkoff's sound; the blood pressures are measured. Cuff pressure when Korotkoff's sound begins to be

heard is defined as the highest blood pressure (Systole) and that when the sound disappears is defined as the lowest pressure(Diastole).

Tabulation:

S.No	Patient Name	Sphygmomanometer		Semi Automated			Automated		
		Systolic (mmHg)	Diastolic (mmHg)	Systolic (mmHg)	Diastolic (mmHg)	Pulse (bpm)	Systolic (mmHg)	Diastolic (mmHg)	Pulse (bpm)
1	X								
2	Y								
3	Z								
4	A								

Mean Arterial Pressure (MAP)

M A P = (1/3 X SBP) + (2/3XDBP)   ORMAP = DBP+((SBP-DBP/3))

Pulse pressure (PP) = SBP – DBP

Hyper tension – Above normal BP; Hypo tension – Below normal BP

Result: Thus the blood pressure measurements are done using mercury sphygmomanometer and digital automated device.

Ex No. 5 Design of Instrumentation amplifier

AIM:

To construct, test, and perform instrumentation amplifier by using operational amplifier.

APPARATUS REQUIRED:

1. Op-amplifier Ic- 741

2. Resistor 1k ohm – 7

3. Dual RPS (0-30V)

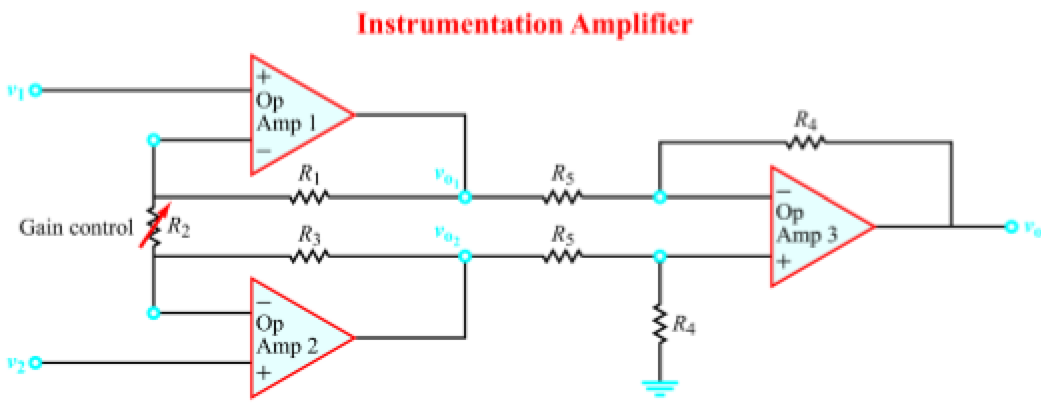
4. Bread board

5. Connecting wires

THEORY:

An instrumentation amplifier is an integrated circuit (IC) that is used to amplify a signal. This type of amplifier is in the differential amplifier family because it amplifies the difference between two inputs. The importance of an instrumentation amplifier is that it can reduce unwanted noise that is picked up by the circuit. The ability to reject noise or unwanted signals common to all IC pins is called the common-mode rejection ratio (CMRR). Instrumentation amplifiers are very useful due to their high CMRR. Other characteristics, such as high open loop gain, low DC offset and low drift, make this IC very important in circuit design.

CIRCUIT DIAGRAM:



Gain calculation
Vo = (V2-V1) Av
Where Av = R4/R5 (1+(R1+R3/R2))

PROCEDURE:

1. Connections are made as per circuit diagram
2. Check the connection correctly
3. Avoid loose connection and switch the power supply
4. Note down the output values for the given input and check the practical value with theatrical calculation

TABULATION

Sr. no	V1 volts	V2 volts	Theoretical Output Vo volts	Practical output Vo volts

1 2 3 4 5				

RESULT:

The instrumentation amplifier is designed and constructed and the output value was checked with theoretical calculation.

Ex NO. 6Measurement of pH using pH meter

AIM

To measure the pH of a given sample

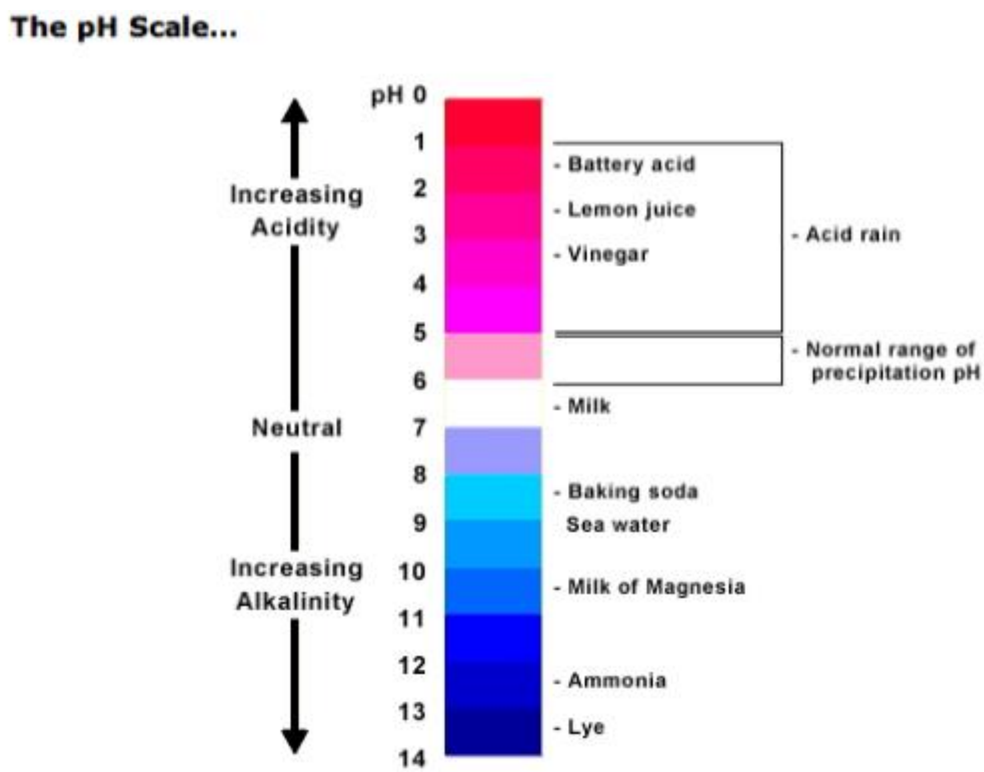
APPARATUS REQUIRED:

pH meter
pH Electrode
Duffer solution
Thermometer

THEORY:

Introduction: pH is a measure of the acidity of an aqueous solution. It is related to the concentration of hydrogen ion, H+. The pH scale can tell if a liquid is more acid or more base, just as the Fahrenheit or Celsius scale is used to measure temperature. The range of the pH scale is from 0 to 14 from very acidic to very basic. A pH of 7 is neutral. A pH less than 7 is acidic and greater than 7 is basic. Each whole pH value below 7 is ten times more acidic than the next higher value. The dissociation of water into hydrogen and hydroxide ions is the basis for the pH scale. The pH is related to the concentration of hydrogen ions by the formula, pH = -log[H+]. It is a logarithmic relationship. When the concentration of hydrogen ion changes by a factor of 10, the pH changes by a factor of 1. Many chemical processes are pH dependent and careful control of pH is important consideration. Solution pH is an important property that is measured by means of a pH meter.

A pH meter and its electrodes form a sensitive electrochemical device that will allow an accurate, reproducible, and reliable measurement of the pH of a solution (see Figure 1). A pH meter is essentially a voltmeter that measures the voltage of an electric current flowing through a solution between two electrodes. There is a direct relationship between the voltage and the pH of a solution. As a result, the meter on the instrument is calibrated directly in pH units. Two electrodes are required. One of them is called a glass electrode. This electrode is sensitive to the concentration of H+ ions in the solution. The other electrode is called the reference electrode and its operation is independent of the composition of the solution. The two electrodes are sometimes combined into a single entity called a combination electrode.



Formula:
Ph= - log(H+)

Figure 1. pH meter and a schematic diagram of a glass electrode.

PROCEDURE:

1. Prepare buffer solution of PH4 and Ph 9.2 by dissolving the respective buffer tablets
2. Measure the temperature of the buffer solution and adjust the temperature to penetrate.
3. Dip the electrode in the buffer solution.
4. Swich on the pH meter.
5. Push the Ph/Mv switch to ph positive and STBV/READ switch to read position and adjust CAL control to set on the read out and wait for 30 seconds
6. Set STBV/READ switch to STBV position to move the container with pH and buffer solution.
7. Wash the electrode with distilled water and clean with tissue paper.

PH MEASUREMENT OF GIVEN SAMPLE:

1. Measure the temperature of the given sample and set the temperature control and immersed electrode in the given sample.

2. Set the Ph/Mv switch to Ph position and STBV/READ switch to read position and wait for 30 seconds.

3. The pH value of the sample will be displayed in the read out.

Tabulation:

Sl.no	**sample**	**pH**
1	Sample 1	4
2	Sample 2	9.2
3	Sample 3	7

RESULT:
The PH value of the given solution was measured.

Ex No.7. Galvanic skin resistance measurements

AIM: To measure and display the galvanic skin resistance variations of skin.

APPARATUS REQUIRED:

1. GSR Simulator
2. GSR instrument
3. Electrode
4. DSO

PROCEDURE:

1. Connect the GSR meter to the main supply
2. Connect the resistance simulator to GSR meter
3. Set the resistance in simulator to 10 k ohms
4. Adjust the GSR meter to zero.
5. Increase the resistance value in simulator
6. Record the GSR meter and tabulated
7. Increase the resistance in simulator step wise and measure the deflection and tabulated.
8. Connect the electrodes in finger

9 Connect the output of electrodes to GSR meter

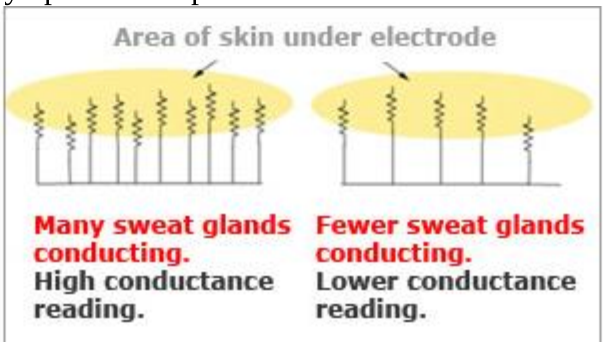
10. Measure the resistance change
11. Ask the patient for different emotions and record the change in GSR value.
12. Connect the DSO with GSR meter
13. Get the waveform of chages in GSR with respect to time.

THEORY:

Human skin offers resistance to electric current just like a resistor do in an electronic circuit. This transient change in the electrical conductivity of the skin followed by an arousal or oriented response is referred to as **Galvanic skin response or GSR** .The skin acts as a resistive layer and readily passes electric current. In normal Skin tone, the resistance varies from **25 Kilo Ohms to a few Mega Ohms**. This permits little current to pass through it. Sweating in the high emotional state or stress causes increased blood flow to the skin and reduces the skin resistance and increases its electrical conductivity.

Electrodermal activity (**EDA**), is the property of the human body that causes continuous variation in the electrical characteristics of the skin. Historically, EDA has also been known as **skin conductance**, **galvanic skin response** (**GSR**), **electrodermal response** (**EDR**), **psychogalvanic reflex** (**PGR**), **skin conductance response** (**SCR**), **sympathetic skin response** (**SSR**) and **skin conductance level** (**SCL**). The long history of research into the active and passive electrical properties of the skin by a variety of disciplines has resulted in an excess of names, now standardized to **electrodermal activity** (**EDA**).[1][2][3]

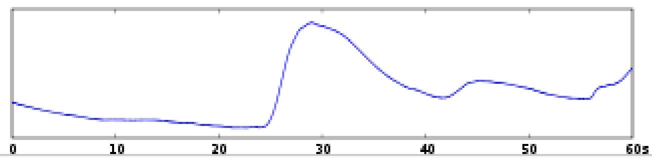
The traditional theory of EDA holds that skin resistance varies with the state of sweat glands in the skin. Sweating is controlled by the sympathetic nervous system,[4] and skin conductance is an indication of psychological or physiological arousal. If the sympathetic branch of the autonomic nervous system is highly aroused, then sweat gland activity also increases, which in turn increases skin conductance. In this way, skin conductance can be a measure of emotional and sympathetic responses



Procedure: Skin conductance (SC) is normally measured with 8mm diameter silver/silver chloride electrodes positioned on the medial phalanx of the index and middle fingers held in position by double sided sticky electrode collars. A non-saline jell is used. SC response (SCR) provides an indication of arousal.

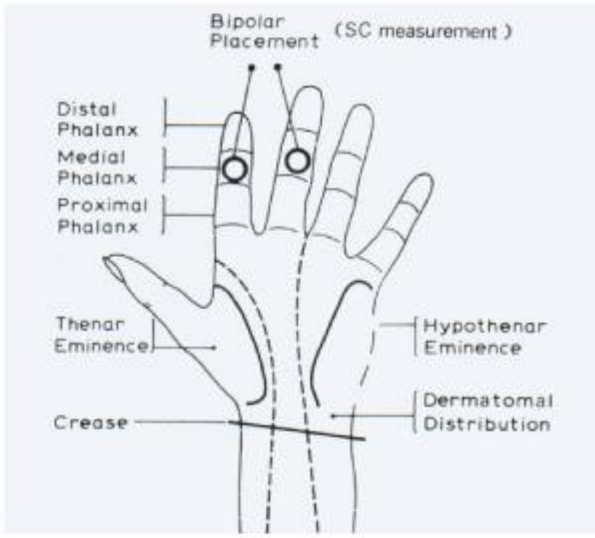
Electrode placement for measurement of GSR is as shen in the fig. The output of electrode is given the op amp input as shown in the circuit diagram.

The output of the amplifier if given to CRO to display the variations of skin resistance with respect to time. The sample waveform is as shown in the figure



A sample GSR signal of 60 seconds duration

Electrode placement diagram:



Tabular Colum Basal Skin Resistance -

Sl.no	Simulator Skin resistance	Theoretical GSR	Measured GSR
1			
2			
3			
4			
5			

RESULT:

The galvanic skin resistance was recorded and analyzed the GSR for various emotions.

Ex. No 8: Generation and analysis of ECG wave using simulator

Aim:

To simulate ECG signal and analyze the signal parameters.

Apparatus Required:

ECG simulator, ECG Amplifier, Digital storage oscilloscope, connecting cables

Procedure

1. The ECG simulator is provided with 8 pattern selection

2. Connect the unit to mains.

3. Connect the simulator with ECG Amplifier

4. Connect the output of ECG amplifier to DSO.

5. Switch ON the Units.

6. Set the DSO setting to visualize the waveforms on DSO.

7. Note down the reading

8. Change the patterns to study different ECG waveforms

Theory:

The electrocardiogram is an instrument which records to electrical activity of heart. Electrical signals from the heart, characteristically placed the normal mechanical functions and monitoring of these signal has great clinical significance. Electrographs are used in authorization laboratories, coronary care units and for routine diagnostic applications in cardiology. The diagnostically useful frequency range is usually accepted as 0.05-150hz.

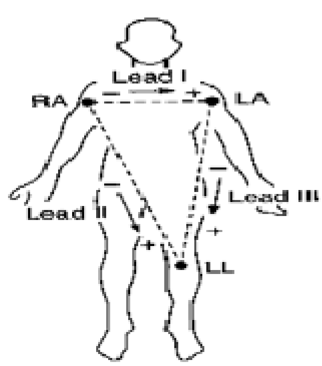
Einthoven Triangle:

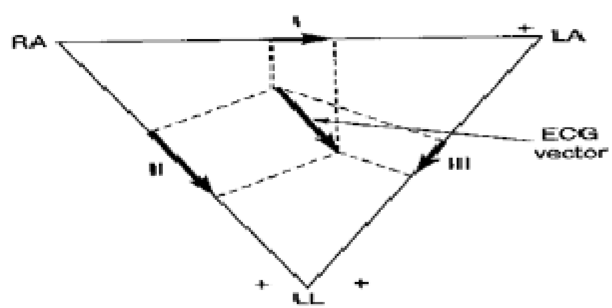
It starts the vector sum of the projection of the frontal phase cardiac to vector to the 3 axis of the Einthoven triangle will be zero.

Lead 1: Left arm and right arm

Lead 2: Left leg and right leg

Lead3: Left and right arm





Bipolar Leads:

ECG is recorded by using two electrodes such that the final trace corresponds to the difference of electrical potentials existing between them, they are called standard leads and have been universally accepted. They are also called as einthoven lead.

Unipolar Lead:

If the electrode is placed close to the heart , higher potentials can be obtained, that normally available at limbs. ECG is recorded between a single exploratory electrode and the central terminal, which has
a potential corresponding to the centre of the body. The reference electrode is obtained by combination of several electrodes tied together at one point, it is of 2 types
1 Limb lead 2Pericordial leads

LEAD 1

WAVE	AMP(V)	TIME(s)
P		
QRS		
T		

LEAD 2

WAVE	AMP(V)	TIME(s)
P		
QRS		
T		

Result:

The ECG was recorded and analyzed using simulator.

Ex. No. 9. Generation of EEG signals using EEG simulator.

Aim:

Generation of EEG signal using EEG simulator and measure the amplitude, frequency and to find the nature of the EEG.

APPARATUS REQUIRED:

1.EEG Simulator

2.EEG Amplifier

3. DSO

4. Connecting Cables

PROCEDURE

1. Connect the EEG Simulator to main

2. Connect the simulator output to eeg amplifier

3. Connect the EEG amplifier to DSO.

4. Switch ON the Units

5. Put the DSO on storage mode

6. Put the switch on DC mode

7. Time / Div Knob on the mS& S division

8. Voltage /Div Knob on the 5Mv

9. Now vary the amplitude as per requirement

10 If any noise on DSO, Check the ground

THEORY:

Electroencephalography (EEG) is the recording of electrical activity along the scalp produced by the firing of neurons within the brain. In conventional scalp EEG, the recording is obtained by placing electrodes on the scalp with a conductive gel or paste. Electrode locations and names are specified by the International 10–20 system for most clinical and research applications. Each electrode is connected to one input of a differential amplifier (one amplifier per pair of electrodes); a common system reference electrode is connected to the other input of each differential amplifier. These amplifiers amplify the voltage between the active electrode and the reference.

A typical adult human EEG signal is about 10µV to 100 µV in amplitude when measured from the scalp and is about 10–20 mV when measured from subdural electrodes.

EEG WAVE PATTERNS:

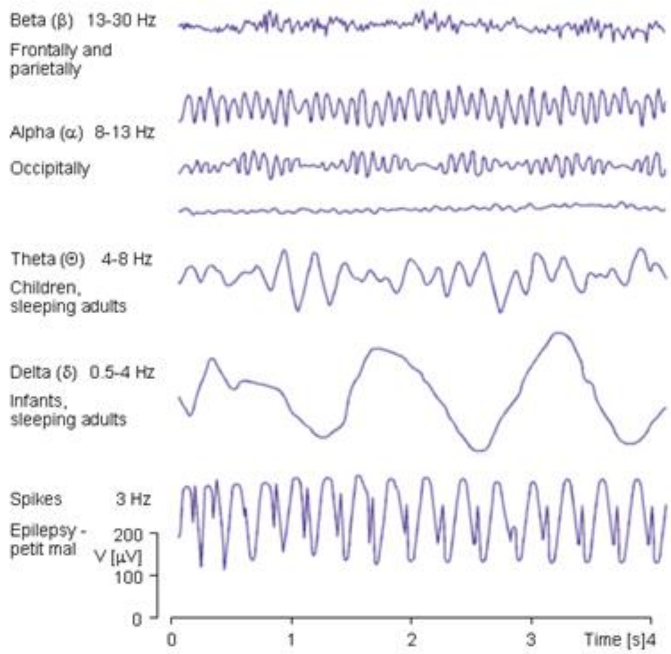
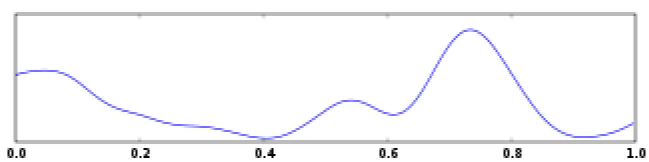


Fig. 13.5. Some examples of EEG waves.

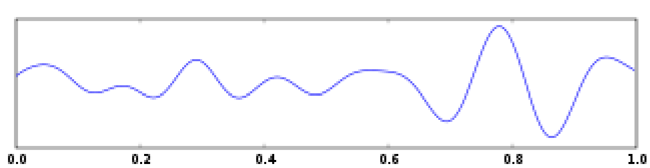
DELTA WAVE:

Delta is the frequency range up to 4 Hz. It tends to be the highest in amplitude and the slowest waves. It is seen normally in adults in slow wave sleep. It is also seen normally in babies.



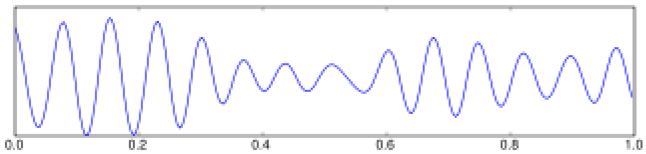
THETA WAVE:

Theta is the frequency range from 4 Hz to 7 Hz. Theta is seen normally in young children. It may be seen in drowsiness or arousal in older children and adults; it can also be seen in meditation.



ALPHA WAVES:

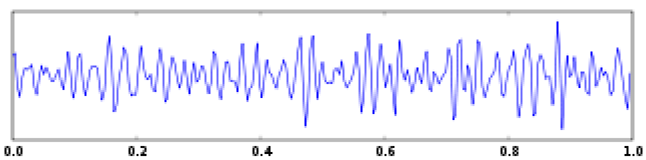
Alpha is the frequency range from 8 Hz to 12 Hz. Hans Berger named the first rhythmic EEG activity he saw, the "alpha wave. It emerges with closing of the eyes and with relaxation, and attenuates with eye opening or mental exertion. The posterior basic rhythm is actually slower than 8 Hz in young children.



BETA WAVES:

Beta is the frequency range from 12 Hz to about 30 Hz Beta activity is closely linked to motor behaviour and is generally attenuated during active movements. It is the dominant rhythm in patients who are alert or anxious or who have their eyes open.

Since an EEG voltage signal represents a difference between the voltages at two electrodes, the display of the EEG for the reading encephalographer may be set up in one of several ways. The representation of the EEG channels is referred to as a montage.



Tabular Column

WAVES	AMPLITUDE(V)	TIME(S)	FREQUENCY(Hz)
ALPHA			
BETA			
THETA			
DELTA			

Result:

Thus the EEG waves are studied and the amplitude and time for each waveforms are noted for a Subject.

Ex No.10.Recording of EMG using using EMG simulator

Aim

To record and analyze EMG signal using EMG simulator.

APPARATUS REQUIRED.

1. EMG simulator

2. Emg amplifier

3. DSO

4. Connecting Cables.

PROCEDURE

1. Connect the Biosignal amplifier to main supply.

2. Connect the EMG simulator to EMG amplifier

3. Switch on the Amplifier.

4. Connect the EMG amplifier out to DSO.

5. Switch ON the DSO.

6. Set Time/ Div knob ON THE mS division

7. Voltage division knob at 5Mv

8. Now vary the amplitude and frequency knobof EMG simulator

9. If any noise in signal check for proper ground.

10. Measure amplitude and frequency from the waveform.

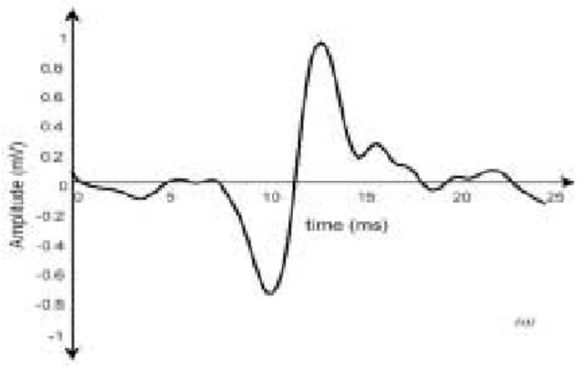


Figure 2-2: Action potential (AP) of one motor unit

THEORY

The muscle cells are roughly cylindrical, with diameters between 10 and 100 um but up toafew centimeters long. They may be arranged in parallel and bound by a connective tissue envelope into a homogeneous bundle. A myofiber is a multinucleated single muscle cell. It's basically water with some dissolved ions separated from the extra-cellular space that is mostly water with some dissolved ions. It generates a potential difference across its cell membrane by having different concentrations of ions. The fibers are excitable cells. Excitation signals are received at the synapse. Then a rapid depolarization occurs and is coupled with a contraction. It's a process during which electrochemical events occur. The action potentials are propagated along the sarcolemma, or cell membrane, toward the end of the fiber and downward from the surface into the transverse tubular system. The propagation of the action potential along a nerve or muscle fiber includes the flow of ions and gives rise to extra-cellularly recordable potential gradient. These potential gradients, moving in both time and space, constitute the electricity as recorded from active muscle fibers. Thus the small currents are generated prior to the generation of muscle force

Acquisition of EMG

As the brain's signal for contraction increases, it both recruits more motor units and increases the "firing frequency" of those units already recruited. All muscle cells within one motor unit become active at the same time. By varying the number of motor units that are active, the body can control the force of the muscle contraction. When individual motor contract, they repetitively emit a short burst of electrical activity known as the motor unit action potential (MUAP). It is detected by electrodes on the surface of the skin in proximity of the motor. The detection is illustrated in the following figure.

The function unit of a muscle is the motor. All the fibers which belong to one motor are activated at the same time. The motor unit action potential (MUAP) is the electrical response to the impulse from the axon. A MUAP looks like the following figure.

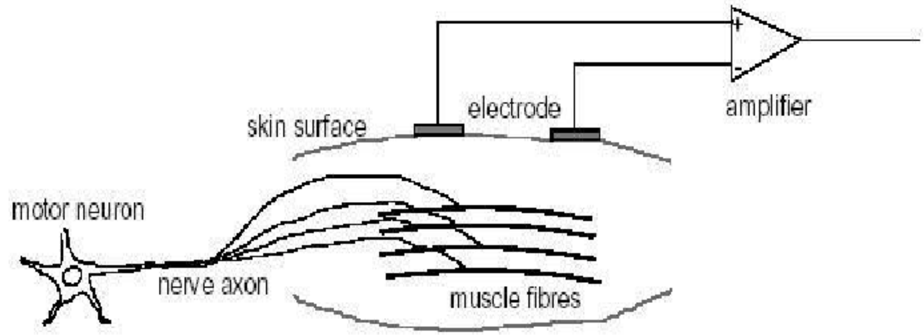


Figure 2-1: Detection of the motor unit action potential (MUAP)

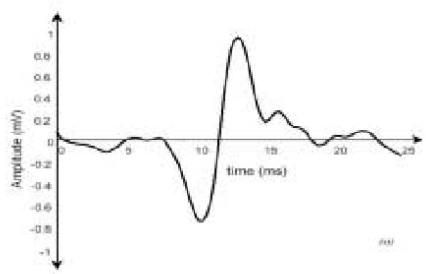


Figure 2-2: Action potential (AP) of one motor unit

RESULT:

The EMG signal is recorded and analyzed the waveform.