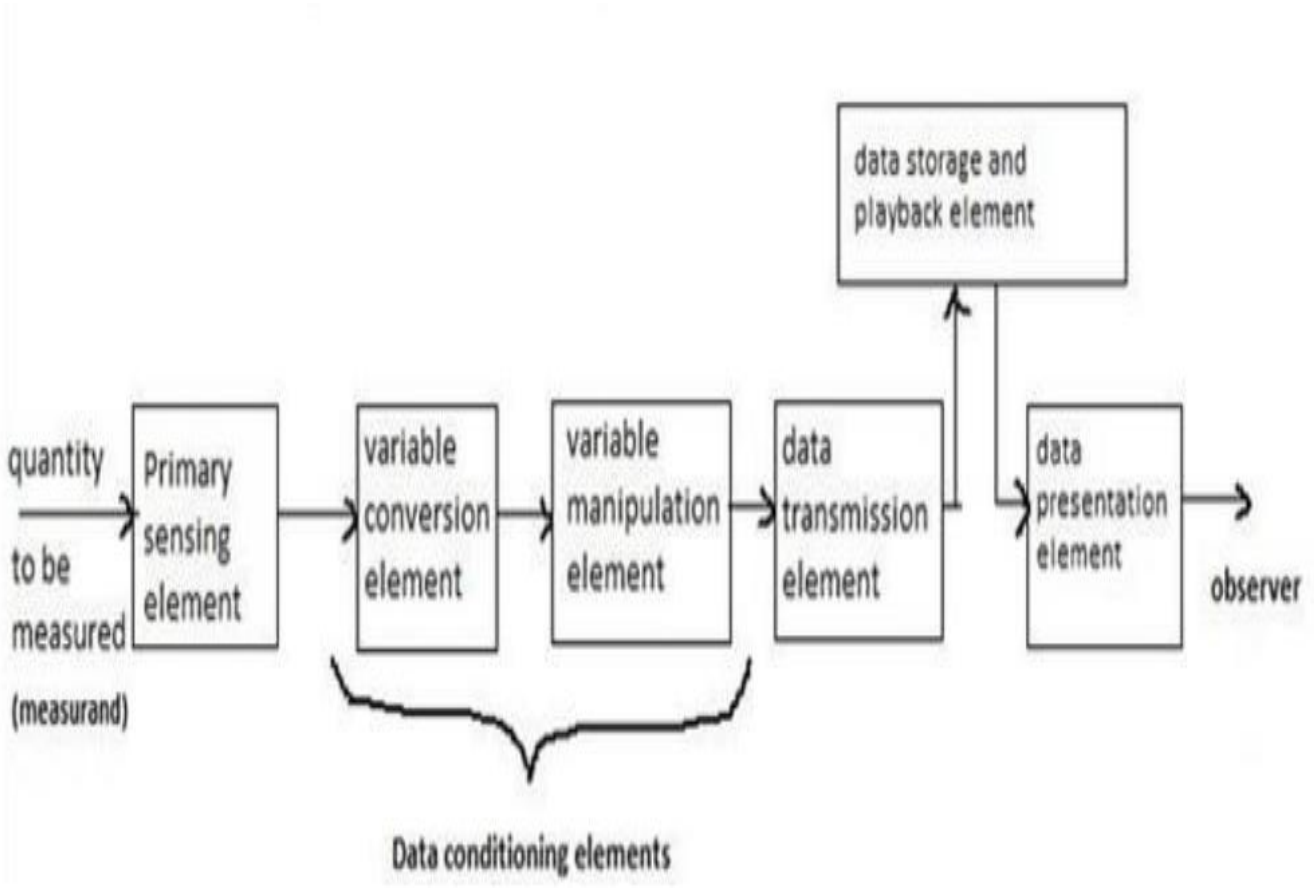
Basic Measurement system



A measurement system is used to quantify the physical variables. Generalized measurement system is a system that is comprised of the typical elements of a measurement system. It helps to understand how a measurement system works.

A generalized measurement system consists of the following components:

1.Primary Sensing Element

2.Variable Conversion Element

3.Variable Manipulation Element

4.Data Processing Element

5.Data Transmission System

6.Data Presentation Element

1. Primary Sensing Element

The Element (Part) of an instrument which makes first contact with the measurand is called the primary sensing element. The primary sensing element receives signal of the physical quantity to be measured as input. It converts the signal to a suitable form (electrical, mechanical or other form), so that it becomes easier for other elements of the measurement system, to either convert or manipulate it.

2. Variable conversion Element

The output of the Primary sensing element may not be suitable for the actual measurement system. Variable conversion element converts the output of the primary sensing element to a more suitable form. It is used only if necessary.

3. Variable Manipulation Element

The level of the output from the Variable conversion element may not be enough for the next stage. This element manipulates and amplifies the output of the variable conversion element. It also removes noise (if present) in the signal.The Variable conversion element and the variable manipulation element are together called as Data conditioning element since they help to obtain the signal in pure and acceptable form from highly distorted form.

4. Data Transmission Element

If the elements of the system are physically separated, it is necessary to transmit the data from one stage to the other. It processes the data signal received from the variable manipulation element and produces suitable output. Data processing element may also be used to compare the measured value with a standard value to produce required output.

The data conditioning and the Data transmission are together called as the intermediate stage of an Instrument.

5. Data Transmission System:

Data Transmission System is simply used for transmitting data from one element to another. It acts as a communication link between different elements of the measurement system. Some of the data transmission elements used are cables, wireless antennae, transducers, telemetry systems etc.

6. Data Presentation Element:

It is used to present the measured physical quantity in a human readable form to the observer. It receives processed signal from data processing element and presents the data in a human readable form. LED displays are most commonly used as data presentation elements in many measurement systems.

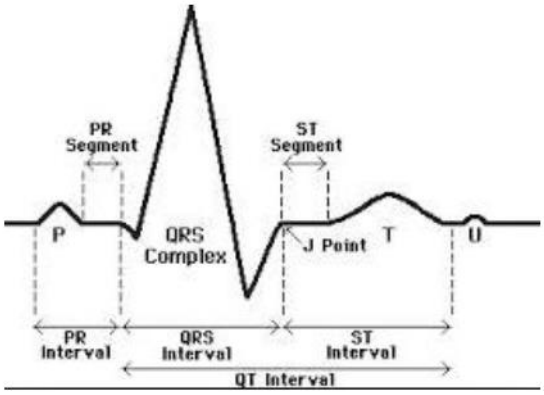
7. Data storage Element:

A measurement system may also have a data storage element to store measured data for future use.

1.2 Electrocardiography/ ECG

The electrocardiogram (ECG) is the recording on the body surface of the electrical activity generated by heart.
It was originally observed by Waller in 1889.
Potentials originated at individual fibers of heart muscles are added to produce waveform.
The ECG gives the rhythmic depolarization and repolarisation of the heart muscles associated with contraction and relaxation of atria and ventricles.

Any diseased condition is recognized by the shape, time interval and amplitude of the ECG.



Wave	Origin	Amplitude(mV)	Duration(sec)
P	Atrial contraction or depolarization	0.25	0.12-0.20
R(QRS complex)	Repolarisation of atia and depolarization of ventricles	1.60	0.07-0.1
T	Ventricular repolarisation(relaxation of myocardium)	0.1-0.5	0.05-0.15

1.2.1 Lead configuration

Electrical activity going through the heart can be measured by external (skin)electrodes. The electrocardiogram (ECG) registers these activities from electrodes which have been attached onto different places on the body.

Standard electrode positions are required for recording ECG.

There are three types of electrode systems-

1. Bipolar limb leads/ standard lead system
2. Augmented unipolar limb leads
3. Precordial leads/chest leads

Bipolar limb leads

In bipolar, ECG is recorded with two electrodes, Positive and negative. The Positive looks toward negative.

The final output is the potential difference between the two electrodes kept at different positions of the body.

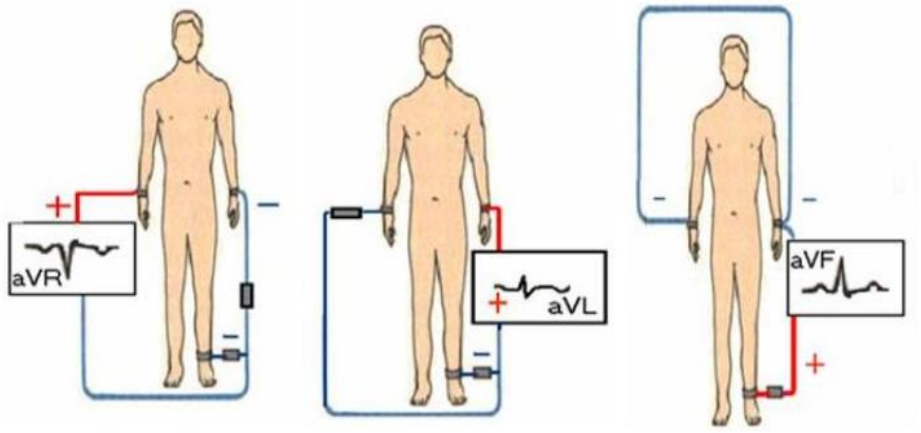
Lead I	Right Arm (RA)	Left Arm (LA)
Lead II	Right Arm (RA)	Left Leg (LL)
Lead III	Left Arm (LA)	Left Leg (LL)

Right leg (RL) is used as the reference electrode.

These three bipolar limb leads roughly form an equilateral triangle (with the heart at the center) that is called Einthoven's triangle.

Einthoven postulated that at any given instant of the cardiac cycle, the frontal plane representation of the electrical axis is a 2D vector.

Also assumed that heart is near the centre of an equilateral triangle,the apexes of which are the right and left shoulder and crotch.



Lead II produces greatest R wave amplitude and is commonly used.

Augmented unipolar leads

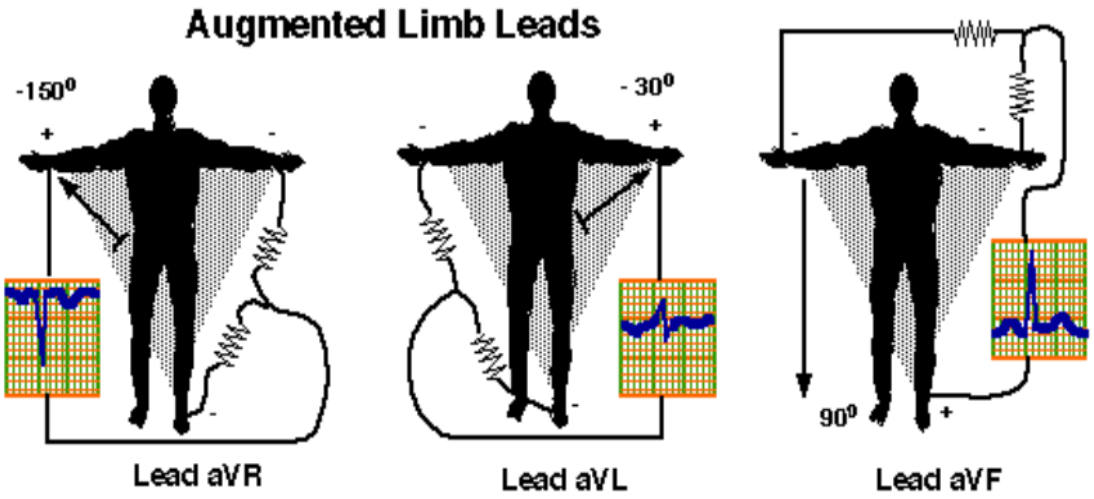
It was introduced by Wilson in 1944.

ECG is recorded between single measuring electrode and a central reference electrode.

It is termed Unipolar leads because there is a single positive electrode that is referenced against a combination of the other limb electrodes.

The positive electrodes for these augmented leads are located on the left arm (aVL), the right arm (aVR), and the left leg (aVF).

Two equal and large resistors are connected to a pair of limb electrodes and the centre of this resistive network acts as central terminal and remaining limb electrode acts as the exploratory electrode.

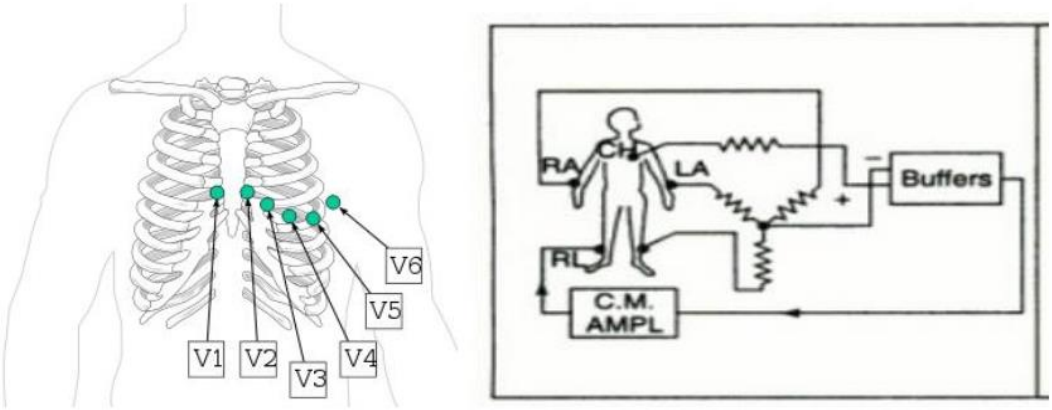


Unipolar chest leads/12 lead system

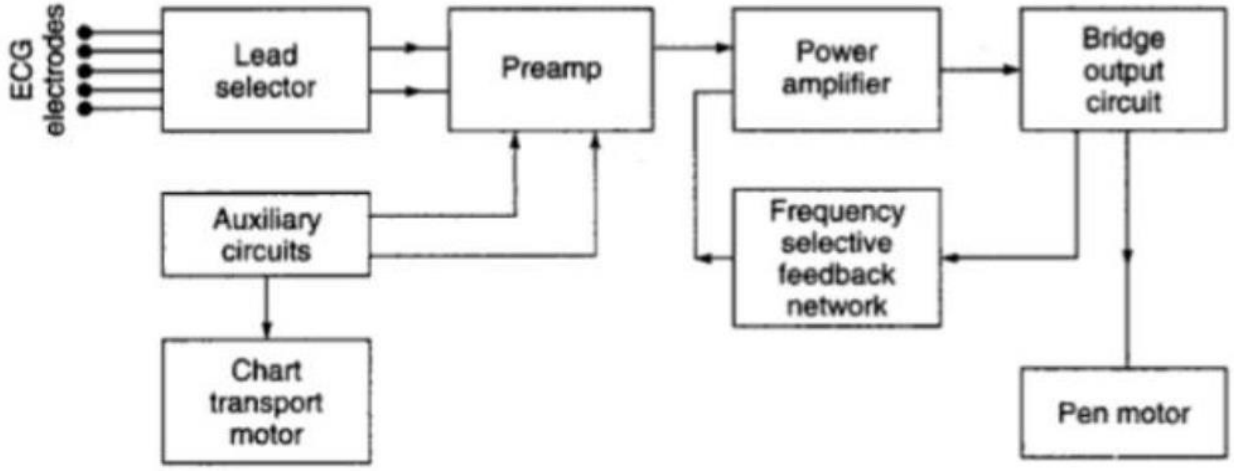
In addition to the three standard limb leads and the three augmented limb leads that view the electrical activity of the heart from the frontal plane, there are six precordial, unipolar chest leads. This configuration places six positive electrodes on the surface of the chest over different regions of the heart in order to record electrical activity in a plane perpendicular to the frontal plane (see figure at right). These six leads are named V1 - V6.

The chest leads provide a different view of the electrical activity within the heart. Therefore, the waveform recorded is different for each lead compared to the limb leads.

These leads measure electrical activity in the traverse plane instead of the frontal plane. Similar to the unipolar limb leads, a neutral reference lead is created, this time using all 3 limb leads connected to the negative ECG lead, which basically puts it in the center of the chest. These chest leads are also known as the precordial leads.



1.2.2 Instrumentation set-up



The ECG signals are characterized by high source impedances, very small signal voltage, significant interference and noise, and a modest frequency range.
Patient cables originating from patient electrdes plug into the ECG recorder.

Lead selector switch is used to feed the input voltage from the appropriate electrode to the preamplifier.

The calibrator is a push button which has a standardization voltage of 1mV.
From lead selector, the ECG signals goes to the preamplifier,a differential amplifier with high CMRR, high gain factor, high input impedance and low output impedance.
A pen amplifier is used to provide power to the pen motor.
Recordings can be viewed on a CRO or a paper chart recorder.

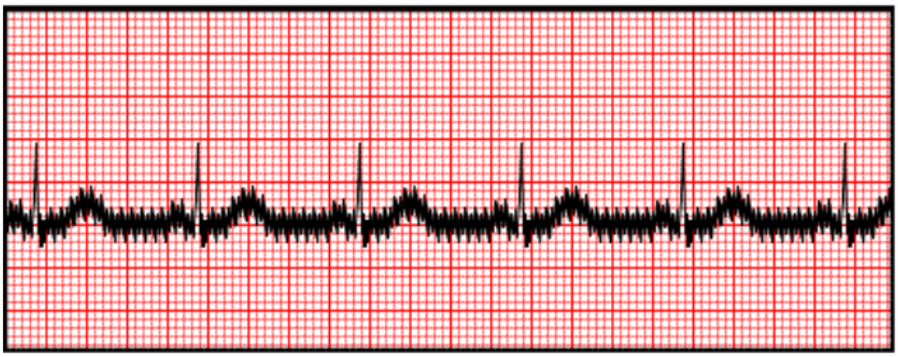
1.2.3 Effects of artifacts

Artifacts are the disturbances that occur when ECG recording are done.
Artifacts are due to

- Interference from power line
- Shifting of base line
- Solid base line

Interference from baseline

Alternating current (AC) describes the type of electricity that we get from the wall.
When an ECG machine is poorly grounded or not equipped to filter out this interference, a thick looking ECG line is obtained.

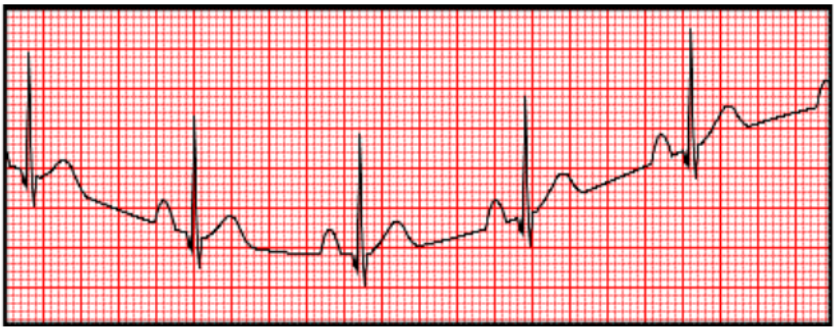


This can be reduced by using high CMRR bioamplifier. Patients can be isolated from other electrical appliances.

Shifting of baseline

Improper attachment of electrodes, movement of electrodes or patient, less electrode paste.

Avoided by selecting proper electrode paste and also strapping of the electrodes.



Solid baseline

Improper heating of stylus

1.3 Electroencephalography/EEG

Electroencephalograms (EEGs) are recordings of the minute (generally less that 300μV) electrical potentials produced by the brain.

The brain's electrical activity is picked up by electrodes attached on the patient's scalp and amplified on the EEG machine to be viewed as brain waves.

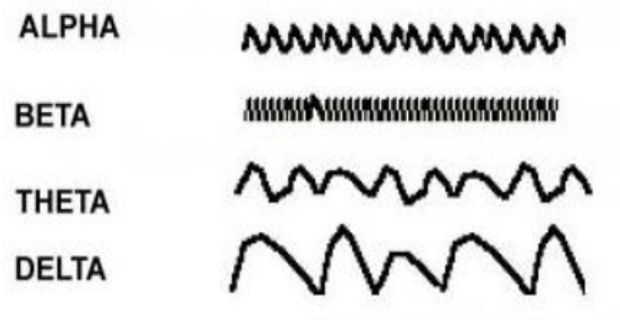
Brain waves are the summation of neural depolarization in the brain due to the stimuli from the five senses as well as from thought processes.

Electrodes used are peel and stick electrodes, silver plated cup electrodes, needle electrodes. These electrodes are very small. They maybe directly applied to the scalp or maybe mounted on special bands or caps that are placed on the patients head.

Signals are picked up either by unipolar recordings or bipolar recordings. In the first method the potential difference between a pair of electrodes is measured. In the latter method the potential of each electrode is compared either to a neutral electrode or to the average of all electrodes

Brain waves

EEG waveforms are generally classified according to their frequency, amplitude, and shape, as well as the sites on the scalp at which they are recorded. The EEG waveform are alpha, beta, theta, delta and gamma waves.



Wave	Frequency	Region obtained	Occurence
Delta	0.5- 4Hz	Cortex	deep sleep stages of normal adults
Theta	4-8Hz	Parietal and temporal region	normal infants and children as well as during drowsiness and sleep in adults
Alpha	8-13 Hz	Occipital	relaxed and mentally inactive awakeness
Beta	13-30Hz	Parietal and frontal	Tension
Gamma	>30 Hz		No significance

Principle

The EEG signal is closely related to the level of consciousness of the person. As the activity increases, the EEG shifts to higher dominating frequency and lower amplitude. When the eyes are closed, the alpha waves begin to dominate the EEG. When the person falls asleep, the dominant EEG frequency decreases. In a certain phase of sleep, rapid eye movement called (REM) sleep, the person dreams and has active movements of the eyes, which can be seen as a characteristic EEG signal. In deep sleep, the EEG has large and slow deflections called delta waves. No cerebral activity can be detected from a patient with complete cerebral death.