

## Lead Systems

To record ECG 12 electrodes connected to the body of the patient. Electrodes connected to ECG machine using wires called leads. Leads are electrodes which measure the difference in electrical potential between either:

1. Two different points on the body (bipolar leads)
2. One point on the body and a virtual reference point with zero electrical potential, located in the center of the heart (unipolar leads).

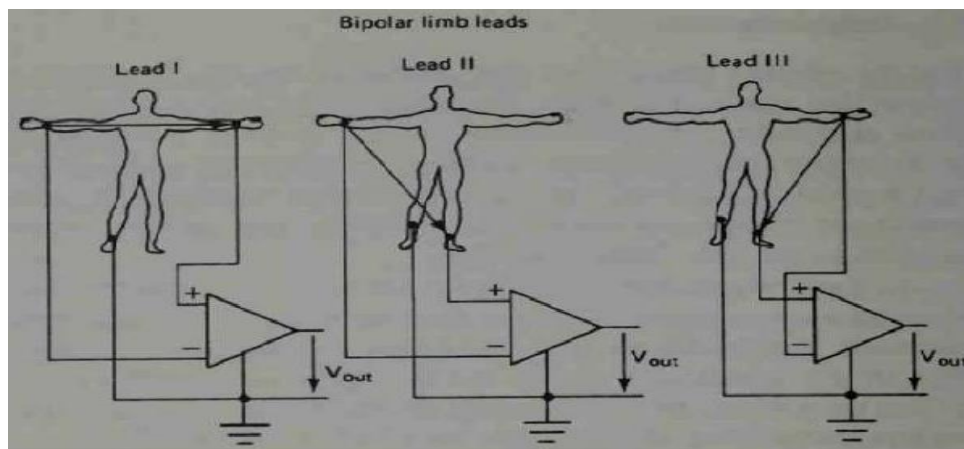
## **Classification**

1. Standard Limb Leads or Bipolar Leads or Einthoven Leads: I, II & III
2. Augmented Limb Leads (Unipolar): aVR, aVL & aVF
3. Precordial Leads: V1- V6

## **Standard Limb Lead or Bipolar Limb leads– Standard Lead I, Lead II and Lead III**

The Standard Limb Leads are used to display a graph of the potential difference recorded between two limbs at a time. In these leads, one limb carries a positive electrode and the other limb, a negative one. The three limb electrodes, I, II and III form a triangle (**Einthoven's Equilateral Triangle**), at the right arm (RA), left arm (LA) and left leg (LL).

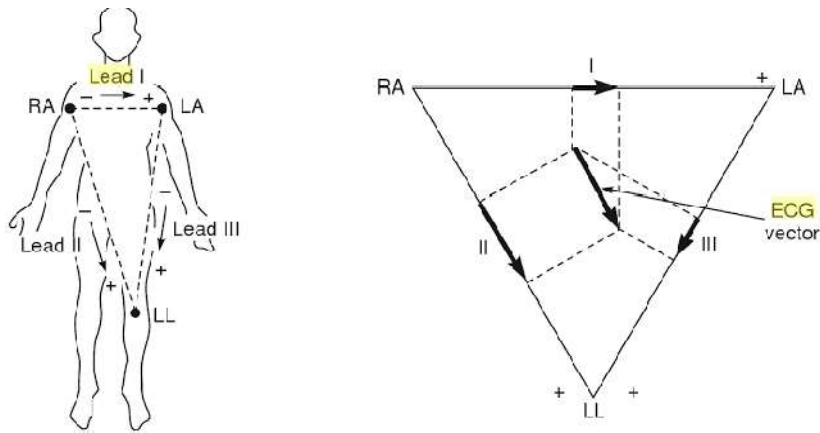
LEAD	Positive Electrode	Negative Electrode
I	LA	RA
II	LL	RA
III	LL	LA



- **Lead I** has a positive electrode on the left arm and a negative electrode on the right arm. Lead I is a bipolar, indirect lead.
- **Lead II** has a positive electrode on the right arm and a negative electrode on the left foot. Lead II is a bipolar, indirect lead.
- **Lead III** has a *positive* pole on the left *foot* and a negative pole on the left hand. Lead III is a bipolar, indirect lead.

## **Einthoven's Equilateral Triangle**

The three limb electrodes, I, II and III form a triangle (**Einthoven's Equilateral Triangle**), at the right arm (RA), left arm (LA) and left leg (LL).

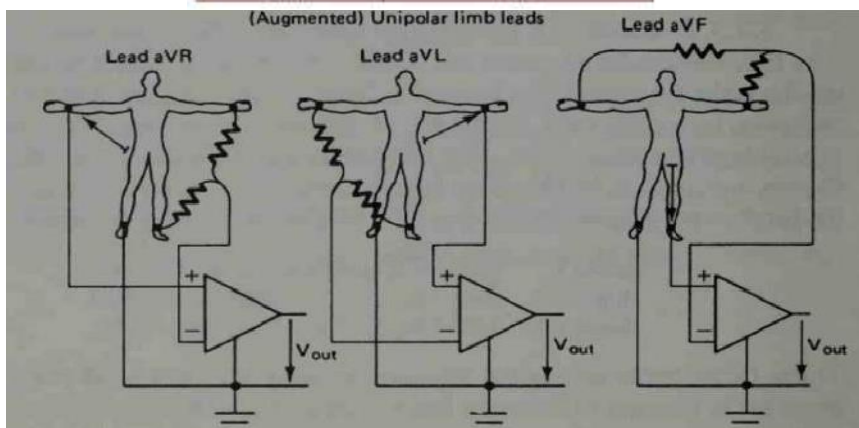


- In defining time bipolar leads, Einthoven postulate that at any given Instant of the cardiaccycle, the electrical axis of the heart can be represented as a two-dimensional vector.
- The ECGmeasured from any of the three basic limb leads is a time-variant single- dimensional componentof the vector.
- He proposed that the electric field of the heart could be represented diagrammaticallyas a triangle, with the heart ideally located at the centre. The triangle, known as the "Einthoventriangle". The sides of the triangle represent the lines along which the threeprojections of the ECG vector are measured.
- It was shown that the instantaneous voltage measuredfrom any one of the three limb lead positions is approximately equal to the algebraic sum of theother two or that the vector sum of the projections on all three lines is equal to zero.
- The I/wave is positive andIn all the bipolar lead positions, QRS of a normal heart is sis greatest in lead II.

**Augmented Limb Leads (Unipolar: aVR, aVL aVF)**

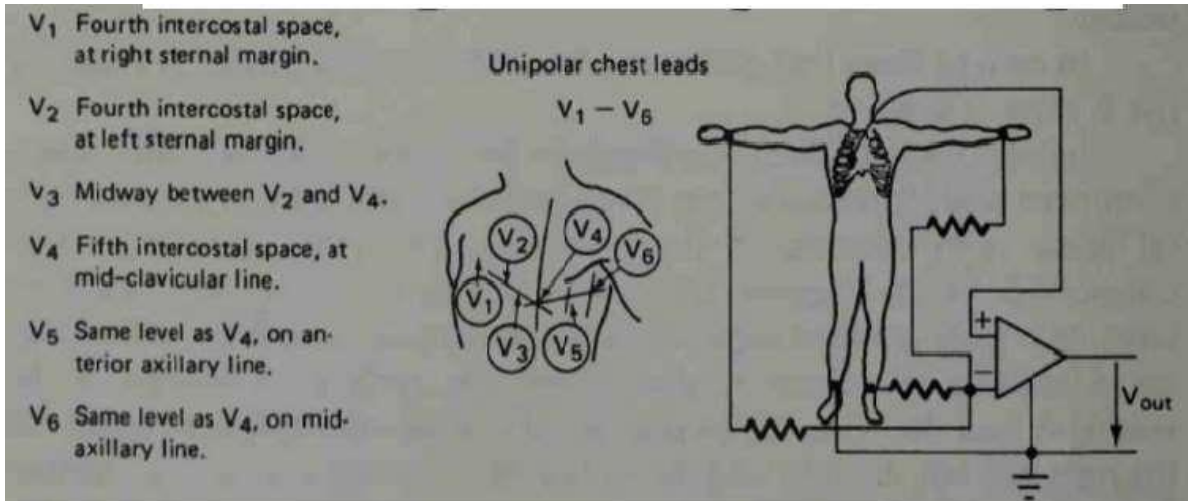
Limb leads In unipolar lmb leads two of the limb leads are tied together andrecorded with respect to the third limb. In the lead identified as AVR, the right arm is recorded with respect to a reference established by joining the left arm and left leg electrodes. In the A VL lead, the left arm is recorded with respect to the common junction of theright arm and left leg. In the AVF lead, the left leg is recorded with respect to the two armelectrodes tied together.They are also called augmented leads or 'averaging leads'. The resistances insertedbetween the electrodes-machine connections are known as 'averaging resistances'.

LEAD	Positive Electrode
aVR	RA
aVL	LA
aVF	LL



### **Precordial Leads: V1- V6**

Precordial leads the second type of unipolar lead is a precordial lead. It employs an exploring electrode to record the potential of the heart action on the chest at six different positions. These leads are designated by the capital letter 'V' followed by a subscript numeral, the positions of which represent the position of the electrode on the pericardium chest leads are shown



### **Recorder Methods**

The recorder is required in any instrumentation system to record data which has been acquired. Data can be in analog or digital form hence the 2 types of recorders namely:

- Analog recorder
- Digital recorder

Analog recorders can be:

- Graphic
- Oscillographic
- Magnetic tape recorder

The graphic recorder is a device which records some physical event on chart paper with stylus as tracing which is the variation of input signal along time on moving chart paper.

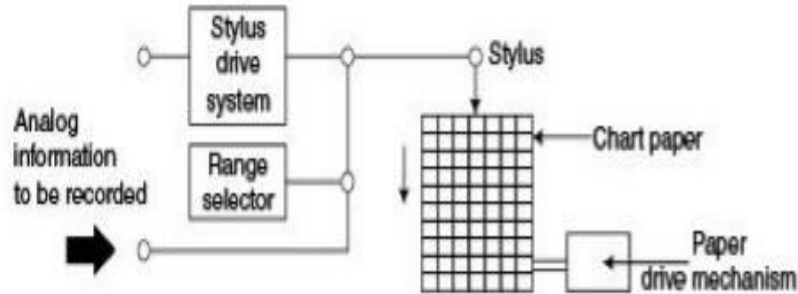
**Digital recorders** use a linear fixed array of small recording elements under which the paper moves. This is in contrast with the conventional recorders that use a moving pen or stylus. The stylus in the digital recorder is a large number of fixed styli, each one of which corresponds to one amplitude of signal to be recorded. Signals are thus reproduced as discrete values at discrete times. Analog as well as digital signals can be processed. In the case with analog signals, sampling and digitization are part of the recording process.

### **Strip Chart Recorder**

A strip chart recorder consists of:

- A long strip of chart paper which can move vertically

- A drive system to move the chart paper at some selected speed
- A stylus for making trace on the moving chart paper
- Stylus drive system to move the stylus horizontally on a moving chart paper or in proportion to the quantity or input to be recorded.
- A range selector switch to limit the horizontal move of the stylus



An electronic stepper motor or synchronous motor or a spring wound mechanism is used for driving the strip chart paper. There are many ways to move the stylus to make the marks on the paper. The marking can be done with:

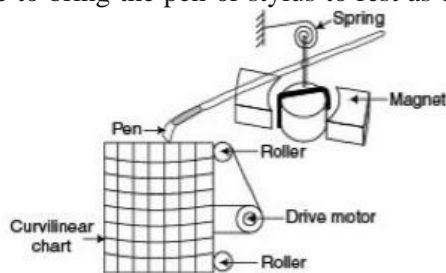
- Ink filled stylus
- Heated stylus
- Chopper bars
- Electric stylus marking
- Optical marking

An **Ink filled stylus** contains a capillary connection between the pen (stylus) and ink reservoir. This type of stylus is unsuitable at high speed and it also develops clogging of ink when the stylus is set. The **heated stylus** melts a thin coating of white wax on a black recording paper while working. In a **chopper bar**, the stylus marks on a paper with special coating which is sensitive to current. The **optical stylus** uses a beam of light to write on a photosensitive paper.

The principle of working of galvanometric recorder is that when a current flow as per the input signal through the coil kept in a strong magnetic field, the coil with the pen or stylus deflects proportionally to the input quantity as shown in the diagram below:

There are 3 forces which act on the moving system i.e.

- The deflecting force which results from the current flowing in the coil.
- The controlling force as applied by the spring action to control the limit of deflection.
- Damping force to bring the pen or stylus to rest as quickly as possible.



### Galvanometric recorder system

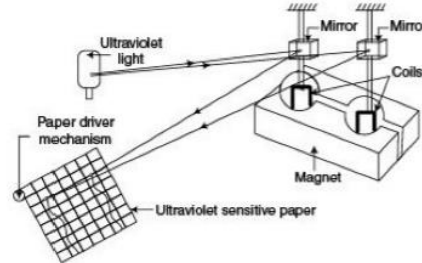
The chart paper is driven at a constant speed by an electric or stepper motor. The ink recording method is widely used in which pen or stylus marks on the moving chart paper. The demerits of a galvanometric recorder include:

- A low input impedance
- limited sensitivity

## Ultraviolet Recorder

Ultraviolet recorder can record events or physiological signals with frequencies in the range of zero to several kHz. Note, galvanometric and potentiometric recorders are unsuitable when the signal has high frequencies.

The ultraviolet recorder consists of a number of moving coils mounted in a single magnet block

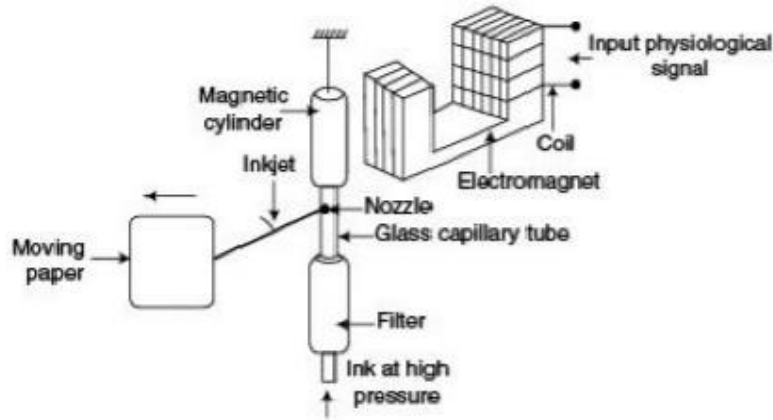


### Ultraviolet Recorder

- A silvered mirror is attached to each galvanometer coil. A paper sensitive to ultraviolet light is used for producing a trace for the purpose of recording.
- The ultraviolet light is projected on this paper with the help of the mirror attached to each coil. The coil is deflected if any current flows through the coil as coils are subjected to magnetic field.
- The ultraviolet light is also deflected by the mirror in proportion to the deflection of coil. As the current flow in the coil depends upon physiological inputs, hence the deflection of the ultraviolet light through mirror is in proportion to physiological inputs.
- The moving ultraviolet light falling on the moving light sensitive paper forms a trace of variation of input signal on the paper.
- The trace of variation on the paper is the record of the variation of input signal with time. The ultraviolet recorder may be single channel or multichannel.

## Inkjet Recorder

The principle of working of Inkjet recorder is that a very fine Inkjet is made to mark the physiological events or signals.



- The recorder has a glass capillary tube placed between the poles of an electromagnet. The coil of the electromagnet is connected to the amplified physiological signals. A small cylindrical magnet is attached to this ink capillary tube.
- The variation of current corresponding to physiological signals in the electromagnetic coil produce a varying magnetic field in it which interacts with the field of the cylindrical magnet attached to the capillary.
- The interaction of the magnetic field deflects the cylindrical magnet and the capillary tube attached with it as per the strength of the physiological signals.
- The capillary tube is supplied with ink at high pressure, and the ink comes out of the nozzle provided on the capillary tube in the form of a jet. The waveform is traced on the paper.
- Using more capillaries of different colours,

