Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

1. Electrocardiogram (ECG or EKG)

- An electrocardiogram records the electrical signals in the heart. It's a common and painless test used to quickly detect heart problems and monitor the heart's health.
- An electrocardiogram — also called ECG or EKG — is often done in a health care provider's office, a clinic or a hospital room. ECG machines are standard equipment in operating rooms and ambulances. Some personal devices, such as smart watches, offer ECG monitoring.
- Electrodes (tiny, skin-sticking plastic patches) are applied to specific areas of the chest, arms, and legs. Lead wires connect the electrodes to an ECG machine. is then recording of the heart's electrical activity. And a graph of voltage versus time of the electrical activity of the heart using electrodes placed on the skin.
- These electrodes detect the small electrical changes that are a consequence of cardiac muscle depolarization followed by repolarization during each cardiac cycle (heartbeat).

1.2. What Does an Electrocardiogram Actually Measure?

The ECG recording plots voltage on its vertical axis against time on its horizontal axis. Measurements along the horizontal axis indicate the overall heart rate and regularity, and also the time intervals required for electrical activation to move from one part of the heart to another. Measurements along the vertical axis indicate the voltage measured on the body surface. This voltage represents the "summation" of the electrical activation of all of the cardiac cells. Some abnormalities can be

detected by measure ments on a single ECG recording, but others become apparent only by observing se rial recordings over time.

1.3. What Medical Problems Can Be Diagnosed with an Electrocardiogram?

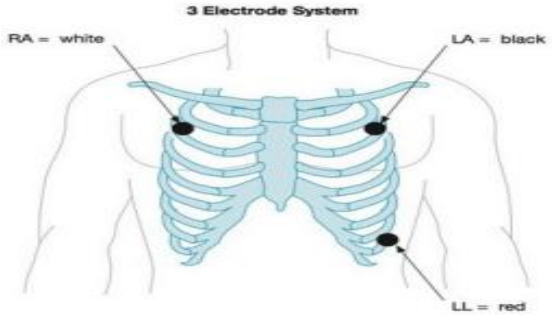
Many cardiac abnormalities can be detected by ECG interpretation, including enlargement of heart muscle, electrical conduction blocks, insufficient blood flow, and death of heart muscle due to a blood clot. The ECG can even identify which of the heart's coronary arteries contains this clot when it is still only threatening to destroy a region of heart muscle. The ECG is also the primary method for identifying problems with heart rate and regularity. In addition to its value for understanding cardiac problems, the ECG can be used to diagnose medical conditions throughout the body. For example, the ECG can reveal abnormal levels of ions in the blood, such as potassium and calcium, and abnormal function of glands such as the thyroid. It can also detect potentially dangerous levels of certain drugs. All of this information can be determined by the careful observations of an experienced electrocardiographer.

2. Types of ECG Electrodes

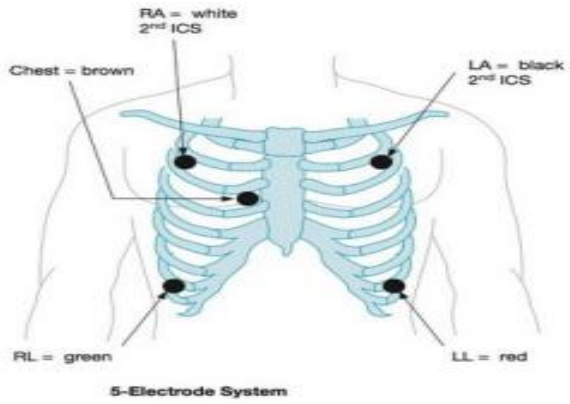
Electrodes come in a few different varieties, but the basis is the same. An ECG electrode is usually composed of a small metal plate surrounded by an adhesive pad, which is coated with conducting gel to help transmit the electrical signal. The wire that connects the ECG electrode to the ECG machine is clipped to the back of the electrode. Electrodes (small, plastic patches) are placed at certain locations on the chest, arms, and legs. The placement of the ECG electrodes on the patient has been established by medical protocols. The most common protocols require the

Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

placement of the electrodes in a 3-lead, a 5-lead or a 12-lead configuration. A 3-lead configuration requires the placement of three electrodes; one electrode adjacent each clavicle bone on the upper chest and a third electrode adjacent the patient's lower left abdomen. A 5-lead configuration requires the placement of the three electrodes in the 3-lead configuration with the addition of a fourth electrode adjacent the sternum and a fifth electrode on the patient's lower right abdomen. A 3-lead configuration requires the placement of three electrodes; one electrode adjacent each clavicle bone on the upper chest and a third electrode adjacent the patient's lower left abdomen. Figure (1)

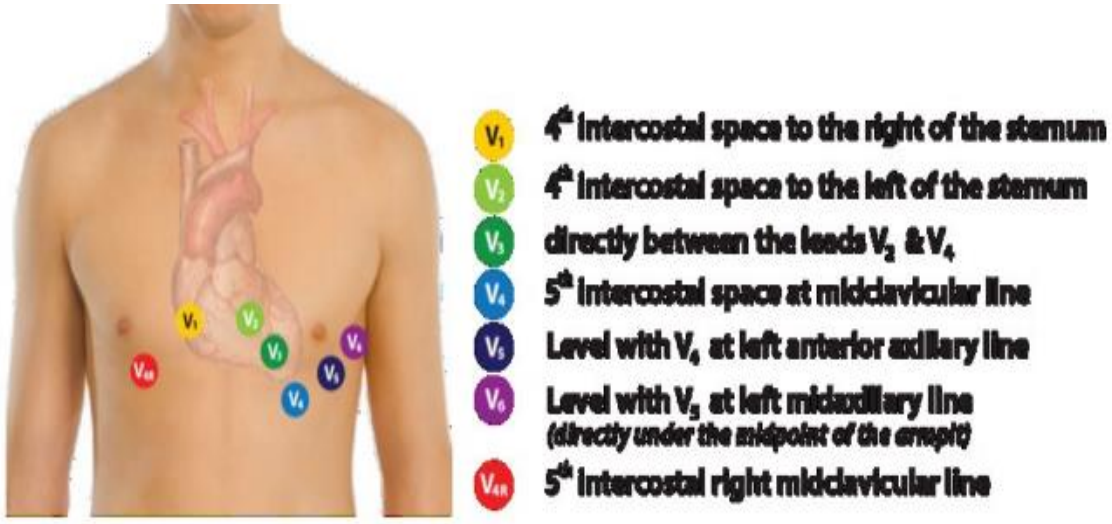


A 5-lead configuration requires the placement of the three electrodes in the 3-lead configuration with the addition of a fourth electrode adjacent the sternum and a fifth electrode on the patient's lower right abdomen. Figure (2)



Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

A 12-lead configuration requires the placement of 10 electrodes on the patient's body. Four electrodes, which represent the patient's limbs, include the left arm electrode (LA lead), the right arm electrode (RA lead), the left leg electrode (LL lead), and the right leg electrode (RL lead). Six chest electrodes (V1-V6 leads) are placed on the patient's chest at various locations near the heart. Three standard limb leads are constructed from measurements between the right arm and left arm (Lead I), the right arm and the left leg (Lead II) and the left arm to left leg (Lead III). The ten electrodes provide 12 measurement points consisting of Leads I, II, III, AVL, AVR, AVF, and V1-V6 with the right leg electrode typically used as a ground. Figure (3)



Email: forqan.ali.wahhab@uomus.edu.iq

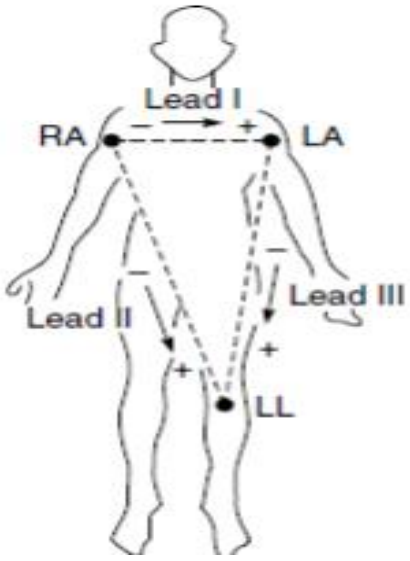
Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

3. ECG Leads:

Definition **The electrocardiograph (ECG)** is a device, which records the electrical activity of the heart. ECG provides valuable information about a wide range of cardiac disorders such as the presence of an inactive part (infarction) or an enlargement (cardiac hypertrophy) of the heart muscle. Two electrodes placed over different areas of the heart and connected to the galvanometer will result in the potential difference between them. The resulting tracing of voltage difference at any two sites due to electrical activity of the heart is called a **"LEAD".**

3.1. Bipolar leads:

In 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 or Einthoven leads. Figure (4)



Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

I = VLA – VRA

II =VLL - VRA

III=VLL - VLA

RA = right arm, LA = left arm, and LL = left leg with the right leg as the reference point.

3.2. Unipolar leads:

The unipolar leads are better than the bipolar for the following reasons:

1. The bipolar leads record the difference in electrical potential between two points on the body and this voltage will show smaller changes than either of the potentials, so a single electrode shows better sensitivity.
2. If the electrode is placed on the chest close to the heart, higher potentials can be detected than normally available at the limbs. In this arrangement, the electrocardiogram is recorded between a single electrode and the central terminal, which is obtained by a combination of several electrodes tied together at one point. Two types of unipolar leads are employed which are:

(i) **Limb leads**

Two of the limb leads are tied together and recorded with respect to the third limb. Example: 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. They are also called augmented leads or ‘averaging leads’. Figure (5)

Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

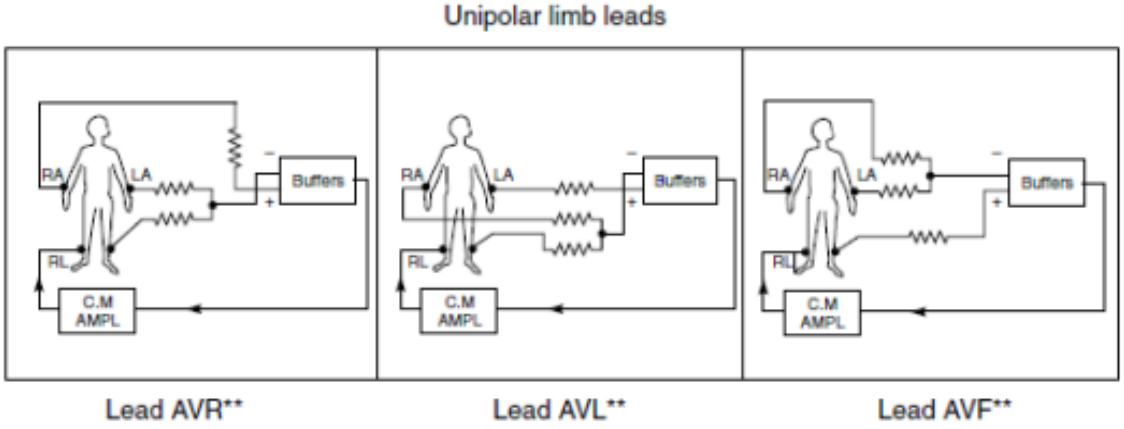


Fig (5) Limb, augmented or averaging leads

(ii) Chest leads (Precordial leads)

It employs electrodes 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 number, this number represents the position of the electrode. Figure (6)

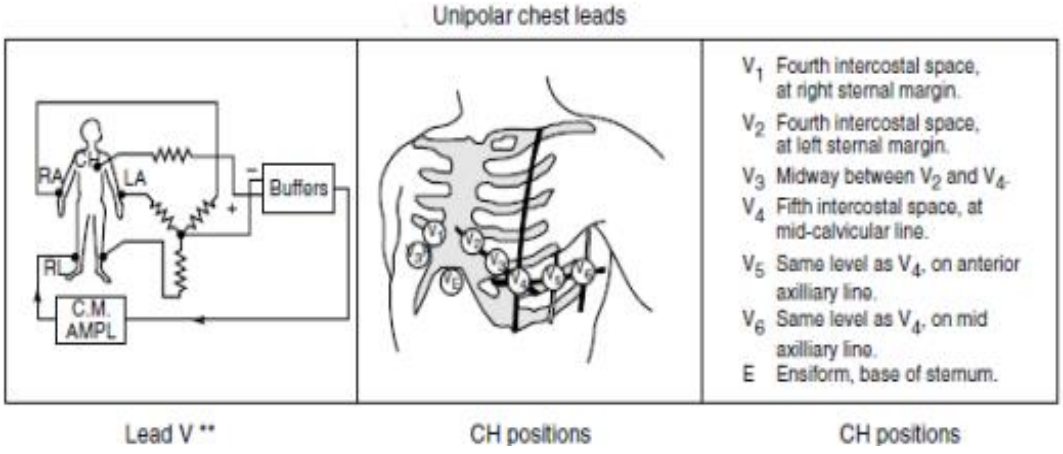


Fig (6) chest or precordial leads.

Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

Placement of precordial leads is as follows:

V1 and **V2** are on either side of sternum at 4th intercostal space.

V4 is midclavicular line, 5th intercostal space.

V3 is halfway between **V2** and **V4** .

V6 is at midaxillary line, 5th intercostal space .

V5 is halfway between **V4** and **V6**, 5th intercostal space.

As in figure (7).

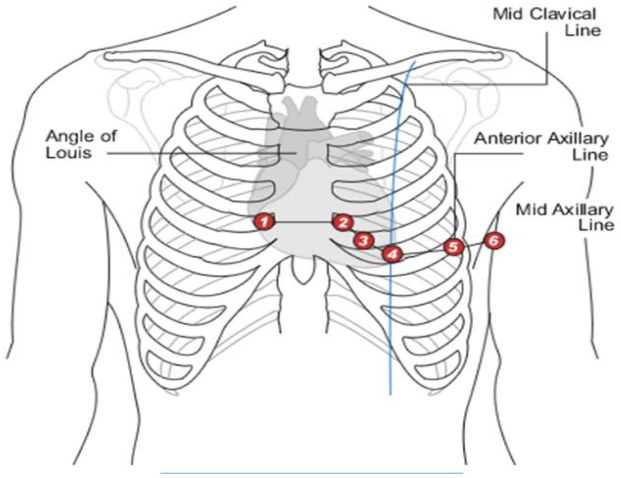


Fig (7) Placement of precordial leads

4. Parts of the ECG explained

- **P waves**

  P waves represent atrial depolarisation.

In healthy individuals, there should be a P wave preceding each QRS complex.

- **PR interval**

The PR interval begins at the start of the P wave and ends at the beginning of the Q wave.

It represents the time taken for electrical activity to move between the atria and the ventricles.

- **QRS complex**

The QRS complex represents depolarisation of the ventricles.

It appears as three closely related waves on the ECG (the Q, R and S wave).

- **ST segment**

The ST segment starts at the end of the S wave and ends at the beginning of the T wave.

The ST segment is an isoelectric line that represents the time between depolarisation and repolarisation of the ventricles (i.e. ventricular contraction).

- **T wave**

The T wave represents ventricular repolarisation.

It appears as a small wave after the QRS complex.

- **RR interval**

The RR interval begins at the peak of one R wave and ends at the peak of the next R wave.

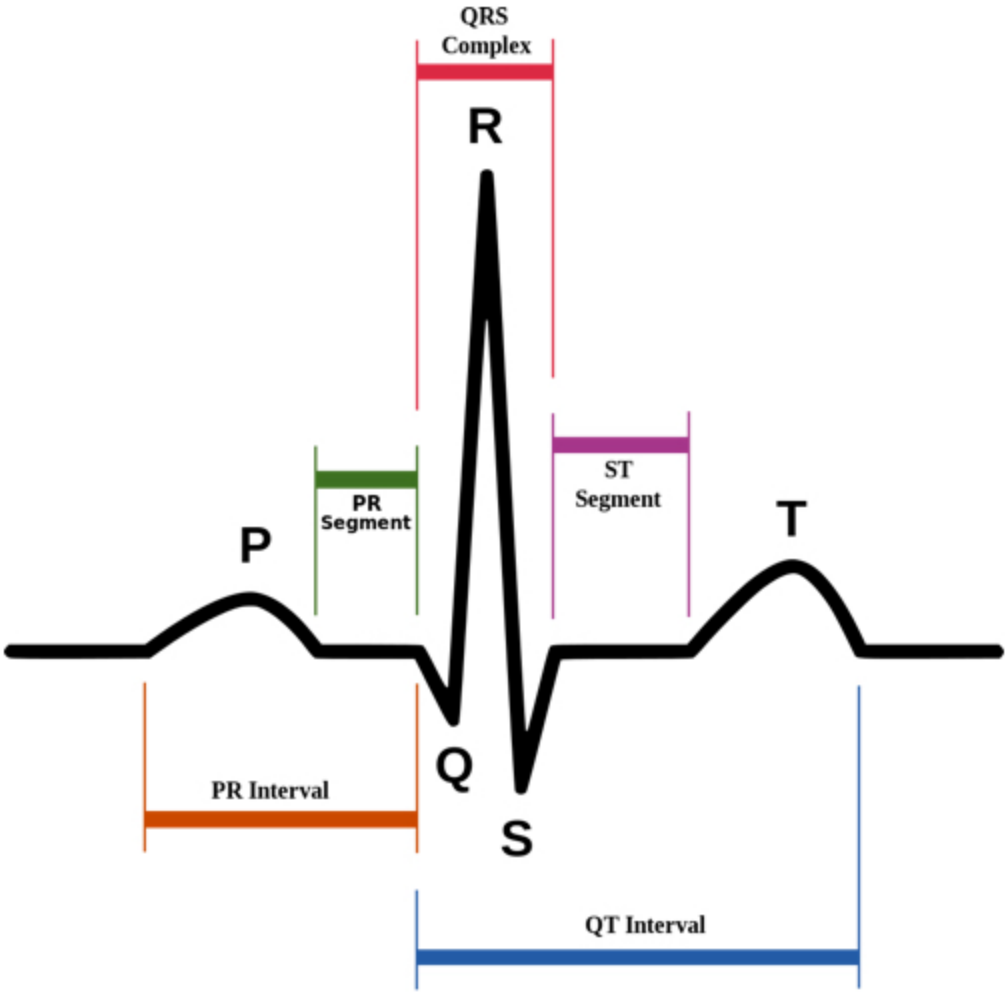
It represents the time between two QRS complexes.

Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

- **QT interval**

The QT interval begins at the start of the QRS complex and finishes at the end of the T wave.

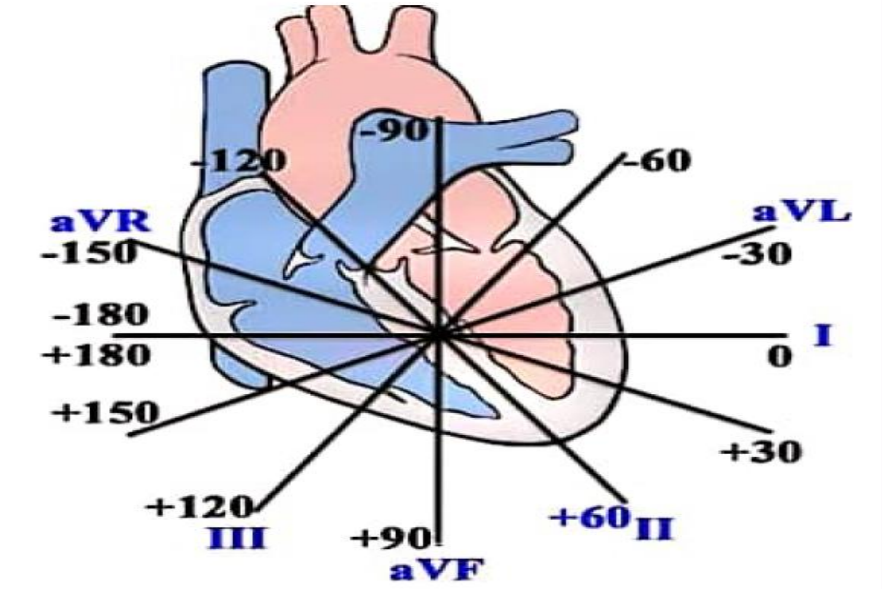
It represents the time taken for the ventricles to depolarise and then repolarise



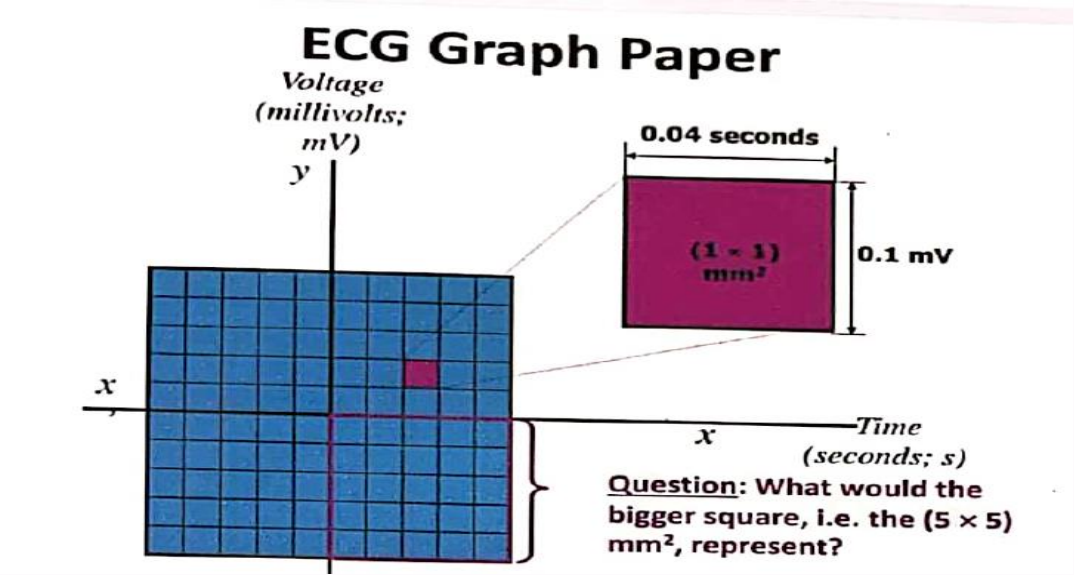
The components of an ECG

Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

5. How to Calculate the Heart Axis



6. ECG Graph Paper

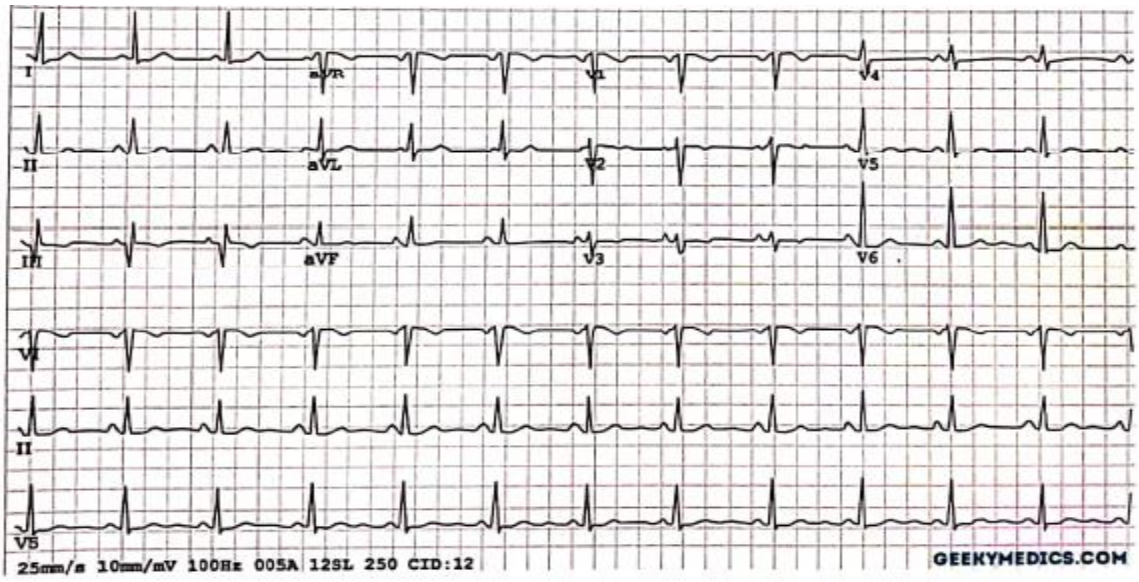


Al-Mustaqbal University College
Department of Medical Instrumentation Techniques Engineering
Class:Third
Subject: Medical Instrumentation (II)
Lecturer: Forqan Ali Wahhab
Lecture: Cardiac Function Recorder (ECG) and monitor

7. How to read ECG Graph Paper

The paper used to record **ECGs** is **standardised** across most hospitals and has the following characteristics:

- Each **small square** represents **0.04 seconds**
- Each **large square** represents **0.2 seconds**
- **5 large squares** = **1 second**
- **300 large squares** = **1 minute**



Normal ECG

8. ECG device problems

It is possible to face many problems while using EKG devices. Some people think that it is very difficult to repair the electrocardiogram machine, while

nowadays in the reputable repair centers, they repair the electrocardiogram machine in the shortest possible time.

The most important and major problems that you may encounter while working with the EKG device may be one of the following problems:

- ECG machine not turning on.
- Error display after turning on the device.
- Not displaying received waves.
- The printer part is not working or it is illegible.
- Fast emptying or not working battery.
- Stopping or turning off the device after a period of use.

But other problems may happen to the EKG machine by accident, the most important of which are shocks, spills, keyboard problems and keys not working properly, cable failure, grounding wire failure, failure of the socket connecting the cable to the device. Screen breaking, power board problems, etc. also mentioned. However, all these problems can be solved and return to their original state by repairing the EKG machine.