

# Study of Some Factors That Affect ECG Device

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**Abstract.** Changes are studied that appear on the electrocardiogram due to the effect of electromagnetic waves emitting by mobile devices. The research was carried out at Fallujah Teaching Hospital by using a MAC1600-Morta ECG device. The work included a study on the effect of the presence of mobile devices during the measurement of electrocardiograms and the discussion of all cases, as well as the impact of the ordinary watch near the electrodes. The results showed a disturbance in the electric waves and return wave will return to its normal shape after the demise of the effect.

## 1. Introduction:

Electrocardiography is the process of producing an electrocardiogram (ECG or EKG), a recording – 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].

The first attempts to record the electrical activity of the muscle by a number of the scientists began in 1666 by (Franciscuride), and in 1773 he managed (Walsh) to recognize the formation of some fish muscles for electricity, and in 1792 was completed published a report to the Italian world (Luigi Giuliani), which applied a preliminary registration process of the muscle. It followed six decades and until 1849, when the world showed that (Doubenez, Raymond) also recorded the activity of the involuntary muscle. In addition, he managed (MORI) recording the electrical activity of the working muscle. Use the worlds (Jasser, 1922) to display the electrical signals caused by constriction muscular. The methods of recording such electrical signals quickly and extensively evolved 1930 research then used advanced electrodes to capture signals broad when studying muscles.

The history of ECG returns to 1903 when Einthoven invented the electrocardiogram, which was very complex, and need five people to operate it [2]. Fig.1 shows the old machine of the EGC in 1901 [3].

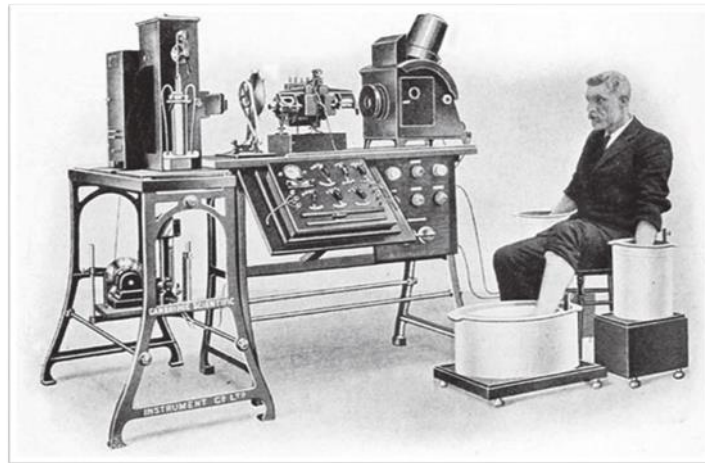


Figure 1. Old ECG machine [3].

## 2. Components of Cardiac Planning:

Heart-shaping devices share the same principle but differ slightly in terms of ingredients.

The device generally consists of the following parts[4]:

1. Calibration: This part effectively adjusts the device and calibrates it properly before starting the process of cardiac planning, if a square wave is made one millivolt (1mV), show that the device is in the state Good.[4]
2. Sensitivity point: This part is very important in maintaining the sensitivity of the device, as in its natural state (1mV) by using the sensitivity point, the wave can be amplified or reduced according to the patient's condition through which we connect the body and the device.
3. Ground: As usual, excessive charge deposition, and electrical shock protection.
4. Poles: The device consists of five electrodes placed in specific places in the body used.
5. Speed determination: The heart planner has two speeds (25-50 mm/s) used every speed according to the existing situation and determined by the doctor back to the heart if the patient is old age has a slightly weak pulse, so a low (25 mm/s). If the young is a fast pulse, use the high speed until we get keeping pace with the planning of the patient's condition.
6. Screen: When the doctor is absent from the paper or not needed for reading continuous to the heart.
7. The division: Of the protection circuits in the device, using a circuit of protection from high currents and voltages it is indeed a successful way in all organs.
8. The candidate: A currency is limited in the winding up of external influences that can affect cardiac planning, because side effects such as neurons and other devices in the same room testing has a big role in getting the wrong planning [4].

Anatomy of the heart:

The heart's wall is made up of three layers [4]:

The epicardium, myocardium, and endocardium

- The Epicardium is the outer layer
- The myocardium, the middle layer, makes up the largest portion of the heart's wall. This layer of muscle tissue contracts with each heartbeat.
- The endocardium, the heart's innermost layer.

### 2.1. Chambers of the heart:

The heart contains four chambers two atria and two ventricles. The right and left atria serve as volume reservoirs for blood being sent into the ventricles.

- The right atrium receives deoxygenated blood returning from the body.
- The left atrium receives oxygenated blood from the lungs through the four pulmonary veins [4].

The right and left ventricles serve as the pumping chambers of the heart.

- The right ventricle receives blood from the right atrium and pumps it through the pulmonary arteries to the lungs, where it picks up oxygen and drops off carbon dioxide.
- The left ventricle receives oxygenated blood from the left atrium and pumps it through the aorta and then out to the rest of the body [4].

## **2.2. The electricity of the heart:**

The conductive system of the heart consists of five specialized tissues [2]:

1. Sinoatrial node (SA node)
2. Atrioventricular node (AV node)
3. His bundle is a collection of heart muscle cells specialized.
4. Left bundle branch (LBB) and right bundle branch (RBB)
5. Purkinje fibers.

As impulses arise in SA node and traverse through atria, they cause depolarization of the atria, From the atria impulses reach AV node, where there is some delay, this delay will allow the atria to contract and pump blood into the ventricles.

This impulse is later spread along bundle of His, left and right bundle branch and finally, through Purkinje fibers causing ventricular depolarization. The dominant pacemaker is SA node. Atrial cells, AV node, bundle of His, bundle branch, Purkinje fibers and myocardial cells are the other pacemaker sites. When SA node fails, they can initiate impulse at a slow rate [2]. This entire process take a less than 200 parts from one second to form one beat.

## **2.3. How ECG Works:**

In a conventional 12-lead ECG, ten electrodes are placed on the patient's limbs and on the surface of the chest . The overall magnitude of the heart's electrical potential is then measured from twelve different angles ("leads") and is recorded over a period of time (usually ten seconds). In this way, the overall magnitude and direction of the heart's electrical depolarization is captured at each moment throughout the cardiac cycle [5].

The lead of ECG records the heart's electrical activity using a series of electrodes placed on the patient's extremities and chest wall. The 12 leads include three bipolar limb leads (I, II, and III) up, down, and across scanning up, down, and across the heart, each lead transmits information about a different area. The waveforms obtained from each lead vary depending on the location of the lead in relation to the wave of depolarization, or electrical stimulus, passing through the myocardium [4].

The six-limb leads record electrical activity in the heart's frontal plane. This plane is a view through the middle of the heart from top to bottom. Electrical activity is recorded from the anterior to the posterior axis [3]. The six precordial leads provide information on electrical activity in the heart's horizontal plane, a transverse view through the middle of the heart, dividing it into upper and lower portions. Electrical activity is recorded from either a superior or an inferior approach [4]. Each lead consists of metal strip that conduct the electricity from the heart.

## **2.4. The 12 leads:**

To record the bipolar limb leads I, II, III, the unipolar limb leads aVR, aVL, and aVF, place electrodes on both of the patient's arms and on his left leg. The right leg also receives an electrode, but that electrode acts as a ground and does not contribute to the waveform. Three limb leads (aVR, aVL, and aVF), and six unipolar precordial, or chest, leads (V1, V2, V3, V4, V5, and V6). These leads provide 12 different views of the heart's electrical activity [4]

The placement of electrodes (leads) [4]:

Placement of limb leads:

(RA) on the Right arm

(LA) on the Left arm

(RL) on the Right leg

(LL) on the Left leg

**Placement of Chest Leads:**

V1-fourth intercostal space at the right sternal border

V2- fourth intercostal space at the left sternal border

V4-fifth intercostal space at left mid clavicular line

V3- midway between V2 and V4

V5-at the same horizontal level as V4 in the anterior axillary line

V6- at the same horizontal level as V4 in the mid axillary line.

## **2.5. Monitoring the limb leads:**

Lead aVR: This lead connects the right arm (positive pole) with the heart (negative pole).

Lead aVL: This lead connects the left arm (positive pole) with the heart (negative pole).

Lead aVF: This lead connects the left leg (positive pole) with the heart (negative pole).

Lead I: This lead connects the right arm (negative pole) with the left arm (positive pole).

Lead II: This lead connects the right arm (negative pole) with the left leg (positive pole).

Lead III: This lead connects the left arm (negative pole) with the left leg (positive pole) [4].

Standard limb leads (bipolar)

I: Lateral wall

II: Inferior wall

III: Inferior wall

Augmented limb leads (unipolar)

avR: No specific view

aVL: Lateral wall

aVF: Inferior wall

Precordial, or chest, leads (unipolar)

V1: Septal wall

V2: Septal wall

V3: Anterior wall

V4: Anterior wall

V5: Lateral wall

V6: Lateral wall

## **2.6. Heart rate**

Heart rate is the number of times the heart beats per minute (bpm), and it varies according to physical needs such as the need to absorb oxygen and remove carbon dioxide, the heart rate is usually equal or close to the measured pulse at any endpoint.

- Activities that can affect the heart rate are exercise, sleep, anxiety, stress, illness, and ingestion of drugs like B-blockers and atropine [4].

On an ECG tracing, bpm is usually calculated as the number of QRS(wave) complexes. The rate is measured from the R-R interval, the distance between one R wave and the next. The atrial rate (the number of P waves) and the ventricular rate the number of QRS complexes wave the analysis may show them as different rates, one atrial and one ventricular. The method chosen to calculate HR(heart rate) varies according to rate and regularity on the ECG tracing [4]. Where the normal range of the heart rate for an adult at the rest time is 60-90 bpm and known the tachycardia when the heart rate exceeds 100 bpm at the rest time, and the heart rate goes down the 60 bpm also known bradycardia at the rest time.

### **2.6.1. Heart rate calculation:**

Heart rate has many advantages as a clinical parameter: It is inexpensive and quick to measure and is easily understandable. Although the accepted limits of heart rate are between 60 and 100 beats per minute, this was based for convenience on the scale of the squares on electrocardiogram paper; a better definition of normal sinus heart rate may be between 50 and 90 beats per minute[6].

Standard textbooks of physiology and medicine mention that heart rate (HR) is readily calculated from the ECG as follows:

$HR = 1,500/RR$  interval in millimeters,  $HR = 60/RR$  interval in seconds, or  $HR = 300/\text{number of large squares between successive R waves}$ . In each case, the authors are actually referring to instantaneous HR, which is the number of times the heart would beat if successive RR intervals were constant. However, because the above formula is almost always mentioned, students determine HR this way without looking at the ECG any further.

### 2.6.2. Paper of ECG graph:

Waveforms produced by the heart's electrical current are recorded on graphed ECG paper by a stylus. ECG paper consists of horizontal and vertical lines forming a grid. A piece of ECG paper is called an ECG strip or tracing [2]. The horizontal axis of the ECG strip represents time, each small block equals 0.04 second, and five small blocks form a large block, which equals 0.2 second. This time increment is determined by multiplying 0.04 second (for one small block) by 5, the number of small blocks that compose a large block. Five large blocks equal 1 second ( $5 \times 0.2$ ). When measuring or calculating a patient's heart rate [4].

The ECG strip's vertical axis measures amplitude in millimeters (mm) or electrical voltage in millivolts (mV). Each small block represents 1 mm or 0.1 mV; each large block, 5 mm or 0.5 mV. To determine the amplitude of a wave, segment, or interval, count the number of small blocks from the baseline to the highest or lowest point of the wave, segment, or interval [4].

#### Paper of ECG graph

For better understanding the ECG graph as shown Fig.2 [2]:

1 mm = 0.04 sec  
2 mm = 0.08 sec  
3 mm = 0.12 sec  
4 mm = 0.16 sec  
5 mm = 0.20 sec  
10 mm = 0.40 sec  
15 mm = 0.60 sec  
20 mm = 0.80 sec  
25 mm = 1.00 sec

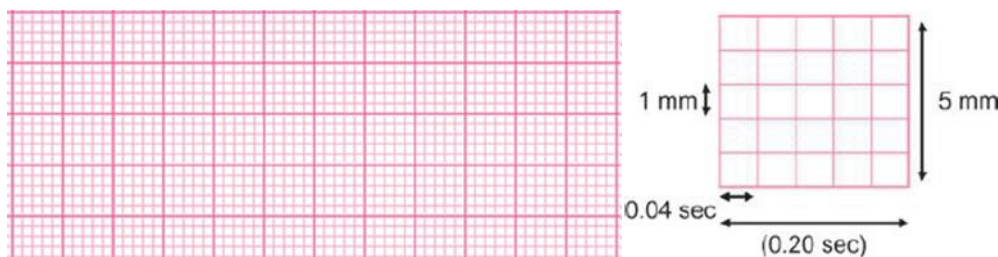


Figure 2. paper of ECG graph

### 2.7. A normal wave of ECG graph:

The wave of the ECG result consists of five waves (P, Q, R, S, and T).

Each wave of these represents the electrical events as shown below:

- Wave P represents atrial depolarization conduction of an electrical impulse through the atria, the first wave seen small, upright (positive wave indicating atrial contraction) and its amplitude is 2 to 3 mm high and its duration it is 0.06-0.12 seconds [7].
- PR interval: Distance between the beginning of P wave and beginning of QRS complex Measures time during which a depolarization wave travels from the atria to the ventricles and its duration 0.12 - 0.20 second [7].
- QRS complex: Three deflections following P wave indicates ventricular depolarization and contraction Q Wave: First negative deflection, R Wave: First positive deflection, S wave: First negative deflection after R wave and its amplitude is 5 to 30 mm high and its duration 0.06-0.10 second.
- ST-segment: Distance between S wave and the beginning of T wave measures time between ventricular depolarization and the beginning of repolarization and its duration less than 0.10 second.
- T wave: Rounded upright (positive) wave following ORS represents ventricular repolarization and its amplitude 0.5 mm in leads I, II, III, and up to 10 mm in the precordial leads.

- QT interval: Distance between beginnings of QRS to end of T wave represents total ventricular activity and its Duration varies; usually lasts from 0.36 to 0.44 second as shown Fig.3.
- U waves: Small rounded, upright wave following T wave most easily seen with a slow HR (heart rate) represents repolarization of Purkinje fibers [7].

The wave's height indicates the strength of the voltage exerted and the wave's width indicates the time required, distance between the waves symbolizes the time needed to transfer the electricity from one point to another [4].

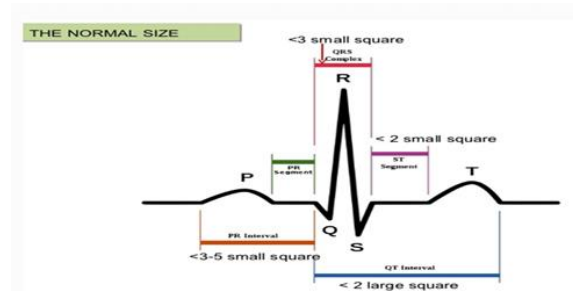


Figure 3. ECG of a heart in normal (Heart's wave) sinus rhythm [6].

### 2.7.1. Normal ECG pattern:

Fig.4 shows the normal waves in each lead



Fig.4. Normal waves of leads [2]

The heart of a normal human being was examined at Al Fallujah Teaching Hospital by using a MAC1600-Morta ECG device as shown in Fig. 5.

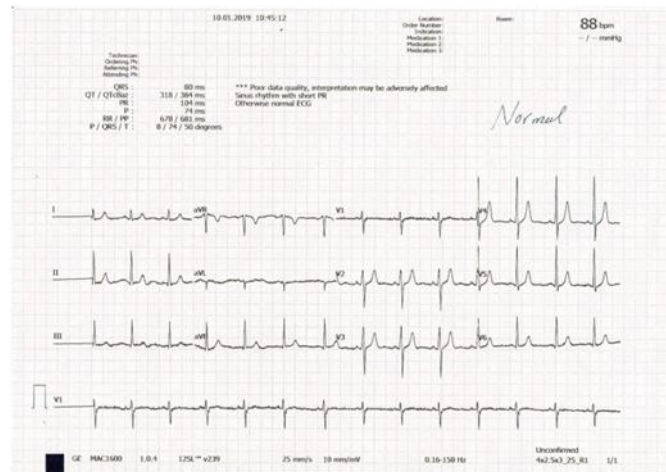


Figure 5. Normal record for the ECG of the patient in Fallujah Teaching Hospital.

## 3. Result and discussion

### 3.1. Effect of the phone:

In recent years, there has been an increase in the use of telecommunication devices, which has become an easy means of communication [8]. During the last decade, the use of mobiles has become more conspicuous. Thus, it has led to the construction of transmission towers in large numbers, both in the urban, as well as in rural areas including other sparsely populated areas. Many attempts are made to investigate the effect of mobile phones (MP) on human health [8].



Electromagnetic radiation is a form of energy exhibiting wave-like behaviour as it travels through space, electromagnetic radiation has both electric and magnetic field components, which oscillate in phase perpendicular to each other and perpendicular to the direction of energy propagation, Although the amount of electromagnetic energy due to cell phones is quite small in comparison to other radiofrequency sources, the increased use of wireless mobile phones worldwide (3.8 billion mobile users) has focused interest on its possible side effects, and the potential health impacts [8]. Mobile phones can affect the heart rate, TP segment and time of T wave. Therefore, it seems that long term use can affect the heart. Based on several reports on the effects of these waves on biological processes, precautionary measures should be taken about using mobile phones [9].

The cell phone is not a safety device, so, we must use it as little as possible, and in necessary situations. Keeping in mind, don't put it behind heart or ear for long receiving call time, since its effects on human body temperature, as a result, the temperature has been increased so the mobile effect on human rhythm, heart rate...etc. Mobile phone cells send electromagnetic waves and these waves interfere with the electricity wave of the human sent by the heart and therefore affected the signal received by the ECG device [10]. It has been shown that during the ECG recordings must be turned off the mobile phone or should be 7.5cm from any pole of ECG electrodes [10].

It should be noted that even when the mobile phone is not used for any voice or data communication it is periodically transmitting low-frequency bursts during the phone ring, the cell phone sent high electromagnetic waves that cause interference to the signal received by the ECG [10] therefore inaccurate planning when the ECG is recording and the mobile phone ringing. As shown in this Fig.6 and Fig.7.

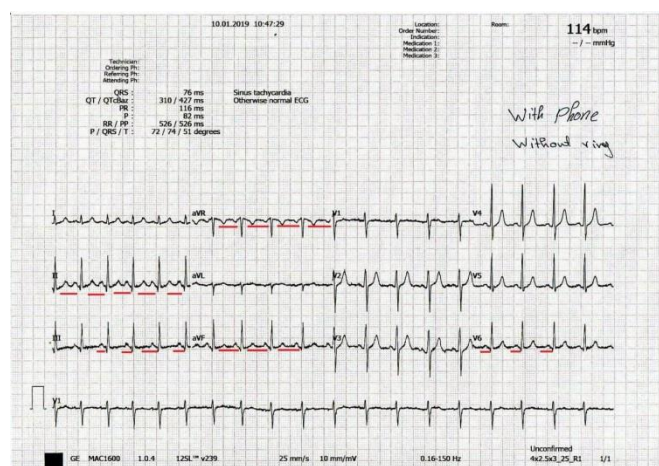


Figure 6. ECG record with effect of phone without ring

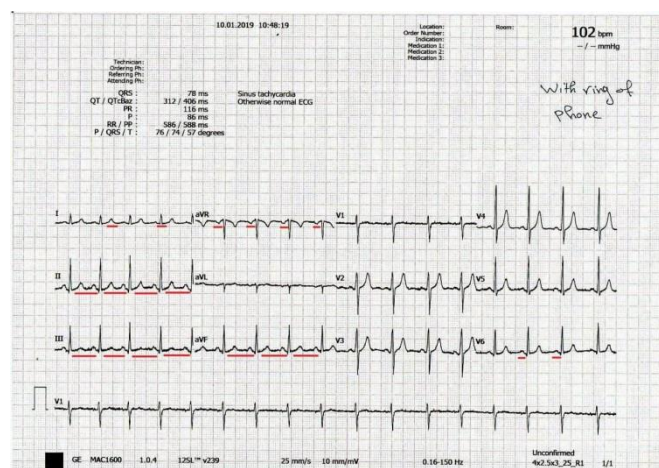


Figure 7. Effect of the ring of phone on ECG

### 3.2. Effect of the watch:

The ECG readable patient must get rid of all metals including the ordinary or digital clock because they effect there adding of the ECG due to the interference of the wave. In the present work not effect from the watch on ECG as shown in Fig.8.

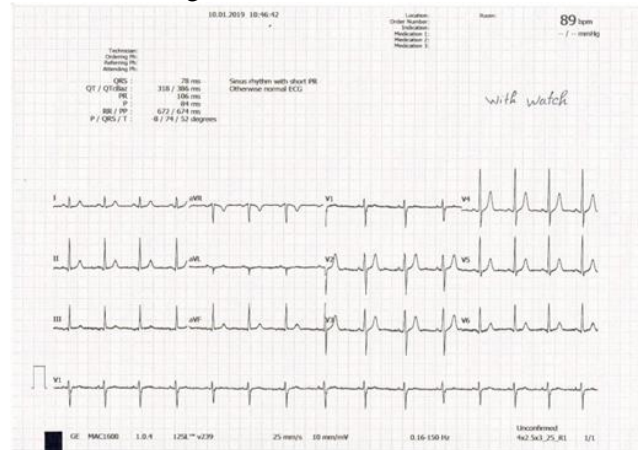


Figure 8. ECG record show little effect of ordinary watch

### 3.3. Effect of the hair:

Before beginning the ECG recording, the hair on the chest should be shaved off it. Because the presence of hair causes an improperly electric field, it results because the electrodes do not stick well on the skin. Hair causes a resistance between the skin and the leads so all of this referred above occur.

### 3.4. ECG Gel:

The ECG gel is a water-based conduction (transport) gel with high conductivity properties. ECG gel generation has been formulated with high viscosity and is specifically designed to reduce resistance between the skin and electrodes in most cardiac electrical processes. It is also designed to transmit weak electrical signals in a high-precision manner to improve the accuracy of ECG testing. High conductivity remains constant even during long procedures [11]. The ECG gel contains non-toxic components and non-toxic preservatives tested in terms of toxicity by an independent third party [11]. The gel put on the skin to reduce the resistance between the skin and the electrodes.

### 3.5. Apple watch:

Recently Apple company detected watch measures the rhythm of the heart and heart rate that allow the patient to observe his/her heart [12].

Principle work of apple watch:

The optical sensor used to measure the pulse of the heart in Apple watch uses what a known as scaling. This technology is based on a very simple fact: the blood is red because it reflects red and absorbs green. Apple Watch uses green LED lights as well as light-sensitive light diodes to detect the amount of blood flowing through the wrist at any given moment. When the heartbeats, the blood flows in the wrist and the green absorption is greater. While lower between each pulse and others. Apple Watch calculates the number of heartbeat times per minute by flashing the LED lights hundreds of times every second, thus calculating the pulse rate of your heart. The light sensor for pulse measurement supports a range of 30 to 210 pulses per minute. In addition, this light sensor is designed to compensate for low signal levels by increasing the LED light rate and sampling rate [12].

## 4. Conclusions:

There are many interventions that affect the quality of the ECG recording process and will indicate to each other in summary the most important of them is the electrical interference.

All mobile devices effect on the ECG recording process because overlapping the waves that are sent from the device that leads to adding on the ECG wave recorded so the patient should get rid of mobile



devices. Also all metals including the ordinary or digital clock because they effect there adding wave on the ECG due to the interference of the waves.

### References

- [1] Lilly, Leonard S, ed.. Pathophysiology of Heart Disease: A Collaborative Project of Medical Students and Faculty (sixth ed.). Lippincott Williams & Wilkins. 74. 2016.
- [2] Sajjan M, "Learn ECG in a day systematic" ,Jaypee,2013
- [3] Einthoven W. Un nouveau galvanometer. Arch Neerl Sc Ex Nat; 6: 62533. 1901.
- [4] Chris Burghardt. ECG interpretation made incredibly easy fifth editions", Lippincott Williams & Wilkins. 2011.
- [5] Aswini Kumar MD. "ECG- simplified". LifeHugger. Archived from the original on. 2. 2017.
- [6] Spodick, DH "Operational definition of normal sinus heart rate". Am J Cardiol. 69 (14): 1245. 1992.
- [7] Shirley A. Jones, MS Ed, MHA, EMT-P , "ECG notes interpretation and management guide second edition", F.A.Davis company .philadelphia, 2010. ertsch, Marc. 2004.
- [8] Dawser Hussain, Alyaa H. Ali, Sabah N. Mazhir, Aya Juma .Study the Effect of Mobile (Cell Phone) on the Heart Electricity. Int. J. of Appl. Inf. Sys. (IJ AIS), FCS, New York, USA, 2014.
- [9] Gholamreza Komeili ,Sima Nabizadeh Sarabandi, Studying the Effects of Mobile phone waves on Electro Cardiogram Parameters of Students in Zahedan University of Medical. Int J High Risk Behav Addict., 1(2): 75, 2012.
- [10]T. Buczkowski, D. Janusek, H. Zavala-Fernandez, M. Skrok, M. Kania, A. Liebert, "Influence of Mobile Phones on the Quality of ECG Signal Acquired by Medical Devices", measurement science review, 13, 5, 2013
- [11] Telepaper magazine in website: [www.telepaper.com/ar/products/medical-paper/gel-liquid/ecg-gel/](http://www.telepaper.com/ar/products/medical-paper/gel-liquid/ecg-gel/)
- [12] Apple's company website: [www.support.apple.com/ar-sa/HT204666](http://www.support.apple.com/ar-sa/HT204666).