Heart Monitor Project

أطروحة مقدمة من كلية هندسة الحاسوب والمعلوماتية

للمتطلبات الجزئية لمشروع الشبكات والاتصالات في الجامعة السورية الخاصة

بإشراف الدكتور

علي عواضه

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للعام الدراسي
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كلمة شكر

بالأمس فتحت لنا الأبواب لننهل من علومها

واليوم وبعد مضي اربع سنوات

لا يسعني هنا الا أن أتقدم بالشكر والعرفان بالجميل لكل من ساهم في تقديم

العلم والعطاء

وبذل جهوداً وجهوداً لنكون مهندسين اقوياء مستنيرين بعلمنا ومخلصين بعملنا

وأخص بالشكر :

الدكتور علي عواضه الذي اشرف على هذا البحث

وعميد كليتنا **الدكتور علي سكاف** الذي بوجوده تألقت الكلية

كما اشكر كافة الأساتذة والمهندسين والمشرفين في الجامعة

راجياً ربي ان يديم عليهم الخير والتوفيق الدائم.

الإهداء

من أوصاني ربي به احساناً..........

من كان لسانه لا يفتر بالدعاء لي بالنجاح..........

من علمني معنى الخير والعطاء..........

وسقاني من ينابيع الحب والتقوى..........

والدي الحبيب..........

قلب رحيم أتعب نهاره وأضاء ليله من أجلنا..........

ينبوع الحب والحنان الذي لا ينضب..........

من غسلت بدموعها أحزاننا..........

يامن حبك أحب إلي من نفسي..........

إليك.......... إليك..........

والدتي الحنون..........

هم من شاركوني أفراحي وأحزاني..........

وهم من مسك بيدي لأسلك طريق المعرفة..........

رسموا لي درويًا بخطوط الأمل والمحبة..........

من فاح عطر ياسمينهم في حياتي..........

إخوتي وأخواتي..........

هم قلوب عامرة بالحب والصدق..........

رفاق درب أحببتهم وأحبوني..........

مشاعل مضيئة كانت على الطريق الذي أخى الله بيني وبينهم بلا نسب..........

الــى أصدقــائـــي..........

Abstract

The project is considered as a simple circuit consisting of resistors and capacitors and operational amplifier in order to Schema View of the heart beats on the computer.

The microphone records the audio output for blood flow in the heart between the ventricles and atria. The operational amplifier is used in order to enlarge amplitude signal. The filter is used to eliminate any unwanted signal like noise. After, we take this signal and introduced into "Adobe Audition" software which is able to display on the computer and compare them with referring normal human being to detect if there is a problem in the heart or not

Introduction

The devices display the heart rate of the most important in the history of engineering equipment and is one of the medical diagnosis devices These devices offer the heart beats on the computer, according to its strength and can be used to diagnose diseases and the most important of heart disease, and also possible to take advantage of them in the development of mathematical tools walk agencies A heart rate monitor is a personal monitoring device that allows a subject to measure their heart rate in real time or record their heart rate for later study. Early models consisted of a monitoring box with a set of electrode leads that attached to the chest. Heart rate measurement is one of the very important parameters of the human cardiovascular system. The heart rate of a healthy adult at rest is around 72 beats per minute (bpm). Athletes normally have lower heart rates than less active people. Babies have a much higher heart rate at around 120 bpm, while older children have heart rates at around 90 bpm. The heart rate rises gradually during exercises and returns slowly to the rest value after exercise. The rate when the pulse returns to normal is an indication of the fitness of the person. Lower than normal heart rates are usually an indication of a condition known as bradycardia, while higher than normal heart rates are known as tachycardia. Heart rate is simply and traditionally measured by placing the thumb over the subject’s arterial pulsation, and feeling, timing and counting the pulses usually in a 30 second period. Heart rate (BPM) of the subject is then found by multiplying the obtained number by 2. This method although simple, is not accurate and can give errors when the rate is high. More sophisticated methods to measure the heart rate utilize electronic techniques. Electro-cardiogram (ECG) is one of frequently used and accurate methods for measuring the heart rate. ECG is an expensive device and its use for the measurement of the heart rate only is not economical. Low-cost devices in the form of wrist watches are also available for the instantaneous measurement of the heart rate. Such devices can give accurate measurements but their cost is usually in excess of several hundred dollars, making them uneconomical. Most hospitals and clinics in the UK use integrated devices designed to measure the heart rate. So this heart rate monitor with a temperature sensor is definitely a useful instrument in knowing the pulse and the temperature of the subject or the patient.

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Chapter 1

Bibliographic study

1.1 -The First Written Documents and First Experiments in Bioelectromagnetism

The first written document on bioelectric events is in an ancient Egyptian hieroglyph of 4000 B.C. The hieroglyph describes the electric sheatfish (catfish) as a fish that "releases the troops." Evidently, when the catch included such a fish, the fish generated electric shocks with an amplitude of more than 450 V, which forced the fishermen to release all of the fish. The sheatfish is also illustrated in an Egyptian sepulcher fresco (Morgan, 1868). The Greek philosophers Aristotle (384-322 B.C.) and Thales (c.625-547 B.C.) experimented with amber and recognized its power to attract light substances (Smith, 1931). The first written document on the medical application of electricity is from the year A.D. 46, when Scribonius Largus recommended the use of torpedo fish for curing headaches and gouty arthritis (Kellaway, 1946). The electric fish remained the only means of producing electricity for electrotherapeutic experiments until the seventeenth century. William Gilbert (1544-1603), physician to Queen Elizabeth I of England, was the first to subject the attractive power of amber to planned experiment. Gilbert constructed the first instrument to measure this power. This electroscope was a light metal needle pivoted on a pin so that it would turn toward the substances of attracting power (see Figure 1.4). Gilbert called the substances possessing this power of attraction electricks, from the Greek name for amber. Thus he coined the term that eventually became the new science of electricity. Gilbert published his experiments in 1600 in a book entitled De Magnate (Gilbert, 1600). (The reader may refer to Figure 1.20 at the end of this chapter. It presents a chronology of important historical events in bioelectromagnetism from the year 1600 until today)

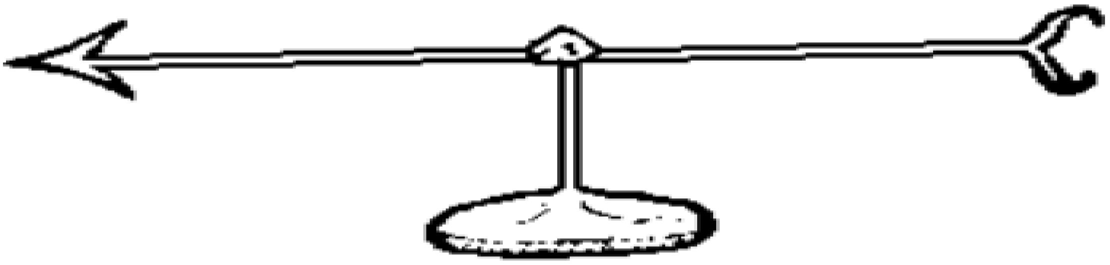


Figure 1.1 Electroscope

The first instrument to detect electricity was the electroscope invented by William Gilbert. (Gilbert 1600). The first carefully documented scientific experiments in neuromuscular physiology were conducted by Jan Swammerdam (Dutch; 1637-80). At that time it was believed that contraction of a muscle was caused by the flow of "animal spirits" or "nervous fluid" along the nerve to the muscle. In 1664, Swammerdam conducted experiments to study the muscle volume changes during contraction Swammerdam placed a frog muscle (b) into a glass vessel (a). When contraction of the muscle was initiated by stimulation of its motor nerve, a water droplet (e) in a narrow tube, projecting from the vessel, did not move, indicating that the muscle did not expand. Thus, the contraction could not be a consequence of inflow of nervous fluid.

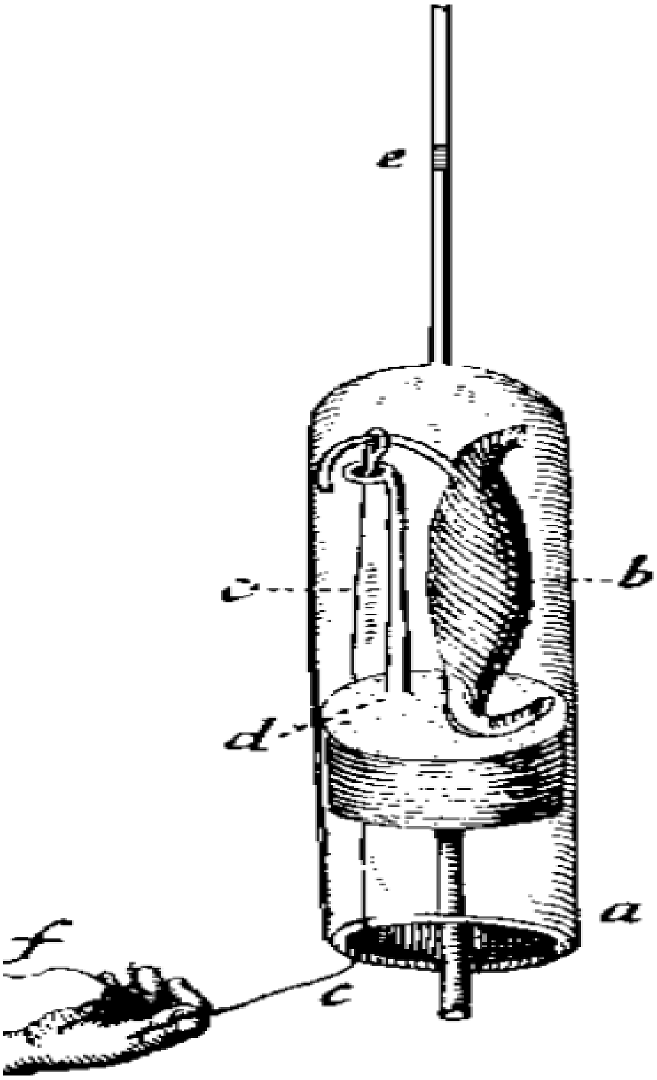


Figure 1.2 Frog Muscle

Stimulation experiment of Jan Swammerdam in 1664. Touching the motoric nerve of a frog muscle (b) in a glass vessel (a) with silver wire (c) and a copper loop (d) produces stimulation of the nerve, which elicits a muscular contraction; however, it is uncertain as to whether the stimulation was produced as a result of electricity from the two dissimilar metals or from the mechanical pinching. See also text. (Swammerdam, 1738.).

In many similar experiments, Swammerdam stimulated the motor nerve by pinching it. In fact, in this experiment stimulation was achieved by pulling the nerve with a wire (c) made of silver (filium argenteum) against a loop (d) made of copper (filium aeneum). According to the principles of electrochemistry, the dissimilar metals in his experiment, which are embedded in the electrolyte provided by the tissue, are the origin of an electromotive force (emf) and an associated electric current. The latter flows through the metals and the tissue, and is responsible for the stimulation (activation) of the nerve in this tissue preparation. The nerve, once activated, initiates a flow of current of its own. These are of biological origin, driven from sources that lie in the nerve and muscle membranes, and are distinct from the aforementioned stimulating currents. The active region of excitation propagates from the nerve to the muscle and is the immediate cause of the muscle contraction. The electric behavior of nerve and muscle forms the subject matter of "bioelectricity," and is one central topic in this book. It is believed that this was the first documented experiment of motor nerve stimulation resulting from an emf generated at a bimetallic junction (Brazier, 1959). Swammerdam probably did not understand that neuromuscular excitation is an electric phenomenon. On the other hand, some authors interpret the aforementioned stimulation to have resulted actually from the mechanical stretching of the nerve. The results of this experiment were published posthumously in 1738 (Swammerdam, 1738).The first electric machine was constructed by Otto von Guericke (German; 1602-1686). It was a sphere of sulphur ("the size of an infant's head") with an iron axle mounted in a wooden framework, as illustrated in Figure 1.6. When the sphere was rotated and rubbed, it generated static electricity (von Guericke, 1672). The second electric machine was invented in 1704 by Francis Hauksbee the Elder (British; 1666-1713). It was a sphere of glass rotated by a wheel (see Figure 1.7). When the rotating glass was rubbed, it produced electricity continuously (Hauksbee, 1709). It is worth mentioning that Hauksbee also experimented with evacuating the glass with an air pump and was able to generate brilliant light, thus anticipating the discovery of athode rays, x-rays, and the electron.

Figure 1.3 Evacuating the glass

Otto von Guericke constructed the first electric machine which included a sphere of sulphur with an iron axle. When rotating and rubbing the sphere it generated static lectricity. (Guericke, 1672).

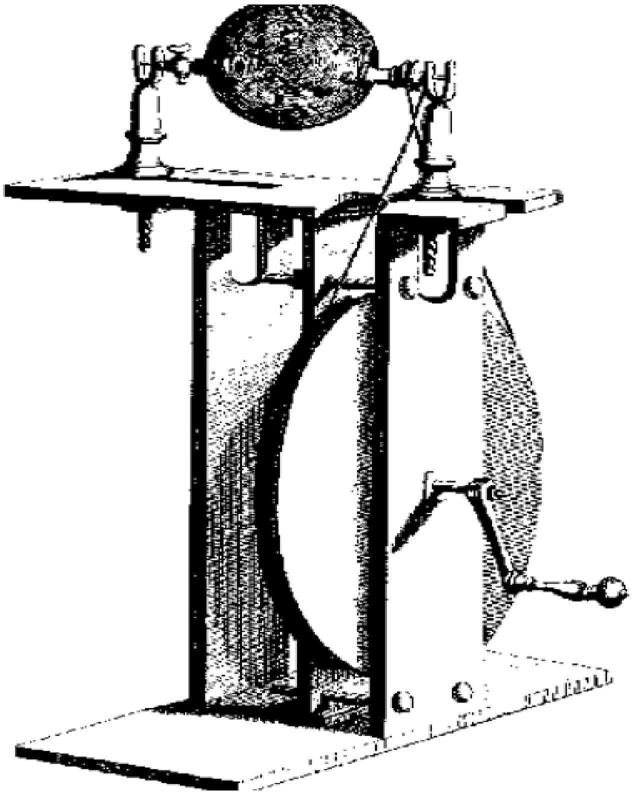


Figure 1.4 Sphere of sulphu

Electric machine invented by Hauksbee in 1704. It had a sphere of glass rotated by a wheel. When the glass was rotated and rubbed it produced electricity continuously. If the glass was evacuated with air pump it generated brilliant light. (Hauksbee, 1709). At that time the main use of electricity was for entertainment and medicine. One of the earliest statements concerning the use of electricity was made in 1743 by Johann Gottlob Krüger of the University of Halle: "All things must have a usefulness; that is certain. Since electricity must have a usefulness, and we have seen that it cannot be looked for either in theology or in jurisprudence, there is obviously nothing left but medicine." (Licht, 1967)

1.2 Electric and Magnetic Stimulation

Systematic application of electromedical equipment for therapeutic use started in the 1700s. One can identify four different historical periods of electromagnetic stimulation, each based on a specific type or origin of electricity. These periods are named after Benjamin Franklin (American; 1706-1790), Luigi Galvani (Italian; 1737-1798), Michael Faraday (British; 1791-1867), and Jacques Arsène d'Arsonval (French; 1851-1940), as explained in Table 1.5. These men were the discoverers or promoters of different kinds of electricity: static electricity, direct current, induction coil shocks, and radiofrequency current, respectively (Geddes, 1984a). The essential invention necessary for the application of a stimulating electric current was the Leyden jar. It was invented on the 11th of October, in 1745 by German inventor Ewald Georg von Kleist (c. 1700-1748) (Krueger, 1746). It was also invented independently by a Dutch scientist, Pieter van Musschenbroek (1692-1761) of the University of Leyden in The Netherlands in 1746, whose university affiliation explains the origin of the name. The Leyden jar is a capacitor formed by a glass bottle covered with metal foil on the inner and outer surfaces, as illustrated in Figure 1.8. The first practical electrostatic generator was invented by Jesse Ramsden (British; 1735-1800) in 1768 (Mottelay, 1975). Benjamin Franklin deduced the concept of positive and negative electricity in 1747 during his experiments with the Leyden jar. Franklin also studied atmospheric electricity with his famous kite experiment in 1752. Soon after the Leyden jar was invented, it was applied to muscular stimulation and treatment of paralysis. As early as 1747, Jean Jallabert (Italian; 1712-1768), professor of mathematics in Genova, applied electric stimulation to a patient whose hand was paralyzed. The treatment lasted three months and was successful. This experiment,which was carefully documented (Jallabert, 1748), represents the beginning of therapeutic stimulation of muscles by electricity.

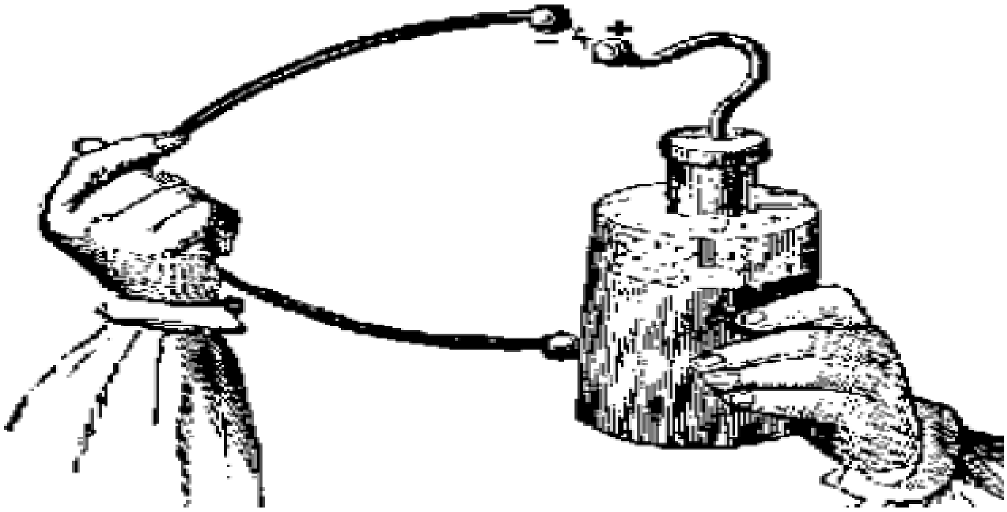


Figure 1.5 Glass bottle

The Leyden Jar, invented in 1745, was the first storage of electricity. It is formed by a glass bottle covered with metal foil on the inner and outer surfaces. (Krueger, 1746). The most famous experiments in neuromuscular stimulation were performed by Luigi Galvani, professor of anatomy at the University of Bologna. His first important finding is dated January 26, 1781. A dissected and prepared frog was lying on the same table as an electric machine. When his assistant touched with a scalpel the femoral nerve of the frog sparks were simultaneously discharged in the nearby electric machine, and violent muscular contractions occurred (Galvani, 1791; Rowbottom and Susskind, 1984, p. 35). (It has been suggested that the assistant was Galvani's wife Lucia, who is known to have helped him with his experiments.) This is cited as the first documented experiment in neuromuscular electric stimulation. Galvani continued the stimulation studies with atmospheric electricity on a prepared frog leg. He connected an electric conductor between the side of the house and the nerve of the frog leg. Then he grounded the muscle with another conductor in an adjacent well. Contractions were obtained when lightning flashed. In September 1786, Galvani was trying to obtain contractions from atmospheric electricity during calm weather. He suspended frog preparations from an iron railing in his garden by brass hooks inserted through the spinal cord. Galvani happened to press the hook against the railing when the leg was also in contact with it. Observing frequent contractions, he repeated the experiment in a closed room. He placed the frog leg on an iron plate and pressed the brass hook against the plate, and muscular contractions occurred. Continuing these experiments systematically, Galvani found that when the nerve and the muscle of a frog were simultaneously touched with a bimetallic arch of copper and zinc, a contraction of the muscle was produced. This is illustrated in Figure 1.9 (Galvani, 1791). This experiment is often cited as the classic study to demonstrate the existence of bioelectricity (Rowbottom and Susskind, 1984 p. 39), although, as mentioned previously, it is possible that Jan Swammerdam had already conducted similar experiments in 1664. It is well known that Galvani did not understand the mechanism of the stimulation with the bimetallic arch. His explanation for this phenomenon was that the bimetallic arch was discharging the "animal electricity" existing in the body. Alessandro Volta (Italian; 1745-1827), professor of physics in Pavia, continued the experiments on galvanic stimulation. He understood better the mechanism by which electricity is produced from two dissimilar metals and an electrolyte. His work led in 1800 to the invention of the Voltaic pile, a battery that could produce continuous electric current (Volta, 1800). Giovanni (Joannis) Aldini (Italian; 1762-1834), a nephew of Galvani, applied stimulating current from Voltaic piles to patients (Aldini, 1804). For electrodes he used water-filled vessels in which the patient's hands were placed. He also used this method in an attempt to resuscitate people who were almost dead.

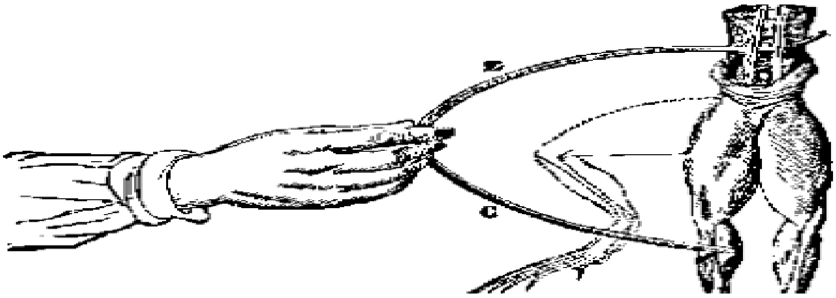


Figure 1.6 Frog Muscle

-Stimulation experiment of Luigi Galvani. The electrochemical behavior of two

dissimilar metals [(zinc (Z) and copper (C)] in a bimetallic arch, in contact with the electrolytes of tissue, produces an electric stimulating current that elicits muscular contraction. In 1872, T. Green described cardiorespiratory resuscitation, a method used to resuscitate surgical patients who were anesthetized with chloroform, an anesthetic with the side effect of depressing respiration and the cardiac pulse. Using a battery of up to 200 cells generating about 300 volts, he applied this voltage to the patient between the neck and the lower ribs on the left side. It is documented that T. Green used this method successfully on five or seven patients who suffered sudden respiratory arrest and were without a pulse (Green, 1872). Michael Faraday's invention of the induction coil in 1831 initiated the faradic era ofelectromedicine (Faraday, 1834). However, it was Emil Heinrich du Bois-Reymond (German; 1818-96), who in 1846 introduced the induction coil to medical applications (du Bois-Reymond, 1849). This was called the Faraday stimulation. An induction coil with hammer break is shown in Figure 1.10. An early experiment of Faraday stimulation of the cerebral cortex was made in 1874 by Dr. Robert Bartholow, a professor of medicine in Cincinnati (Bartholow, 1881). Robert Bartholow stimulated the exposed cerebral cortex with faradic currents and observed that they would elicit movements of the limbs of the opposite side and also the turning of the head to that side (York, 1987).In the late 1800s, Jacques Arsène d'Arsonval heated living tissue by applying high-frequency electric current either with an electrode or with a large coil (see Figure 1.11) (d'Arsonval, 1893). This was the beginning of diathermy. Jacques d'Arsonval

(1896) reported on a flickering visual sensation perceived when an individual's head was placed within a strong time-varying magnetic field. This was generated with a large coil carrying 32 A at 42 Hz. He called this phenomenon "magnetophosphenes." was caused by the stimulating effect of the magnetic field to the retina, which is known to be very sensitive to it. This was the first experiment on magnetic stimulation of the nervous system. The first transcranial magnetic stimulation of the motor cortex was achieved in 1985 (Barker, Jalinous, and Freeston, 1985).

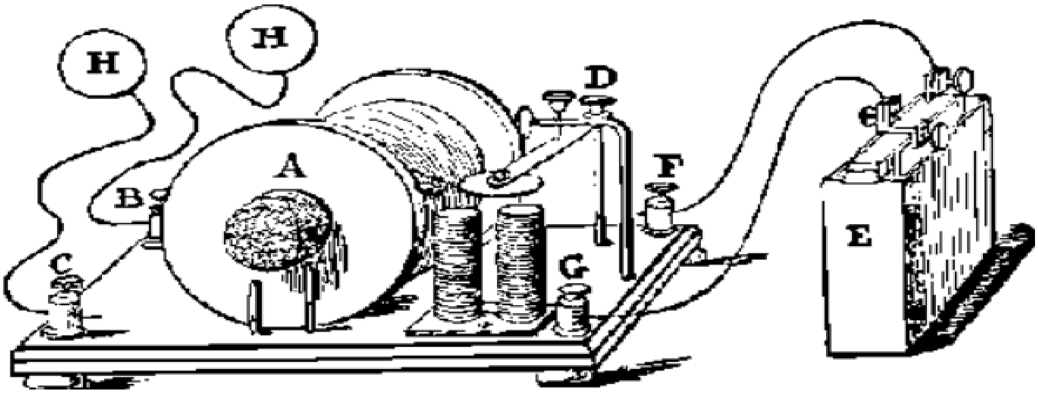


Figure 1.7 Induction coil

Induction coil with hammer break. Electric current from the battery (E) is fed to the primary circuit of the induction coil (A). This current pulls the hammer with the magnetic field of the solenoid (close to G) and breaks the circuit with the contactor (D). Through the vibration of the hammer this breaking is continuous and it induces a high voltage alternating current in the secondary circuit in (A). This current is applied to the patient with electrodes (H).

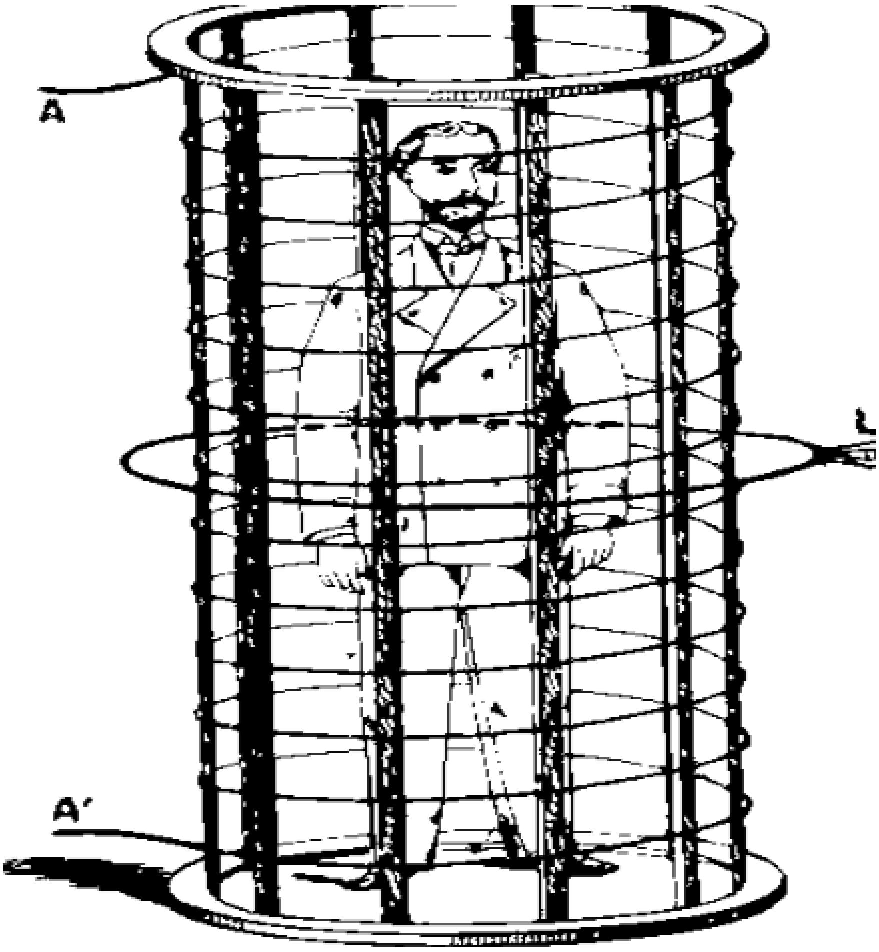


Figure 1.8 Field direction

1.3 Detection of Bioelectric Activity

The connection between electricity and magnetism was discovered in 1819 by Hans Christian Örsted (Danish; 1777-1851). Örsted conducted his first experiment during his lecture at the University of Copenhagen. Passing an electric current through a wire above a magnetic needle, he forced the needle to move to the direction normal to the wire (Örsted, 1820a,b,c). By reversing the direction of the electric current, he reversed the direction of the needle deflection. (The magnetic needle, i.e. the compass, was invented in China about A.D. 100 and is the first detector of magnetic field.)After this discovery, it was possible to devise a galvanometer, an instrument detecting weak electric currents. Invented by Johann Salemo Christopf Schweigger (German; 1779-1875) in 1821, it is based on the deflection of a magnetized needle in the magnetic field inside a coil, into which the current to be measured is introduced. Because he increased the magnetic field by using multiple loops of wire forming the coil, Schweigger called his instrument multiplikator (Schweigger, 1821). In 1825, Leopold Nobili (Italian; 1784-1835), a professor of physics in Florence, invented the astatic galvanometer (Nobili, 1825). In its construction, Nobili employed a double coil of 72 turns wound in a figure eight . One magnetic needle was located in each of the two openings. The needles were connected on the same suspension. They were parallel, but of opposite polarity. Since the current flowed in opposite direction in the two coils, both needles moved in the same direction. Because of their opposite direction, the needles did not respond to Earth's magnetic field. Another version of the astatic galvanometer is illustrated . This construction includes only one coil around one of the two magnetic needles. The other needle (identical but opposite in direction), provided with a scale, serves also as an indicator.

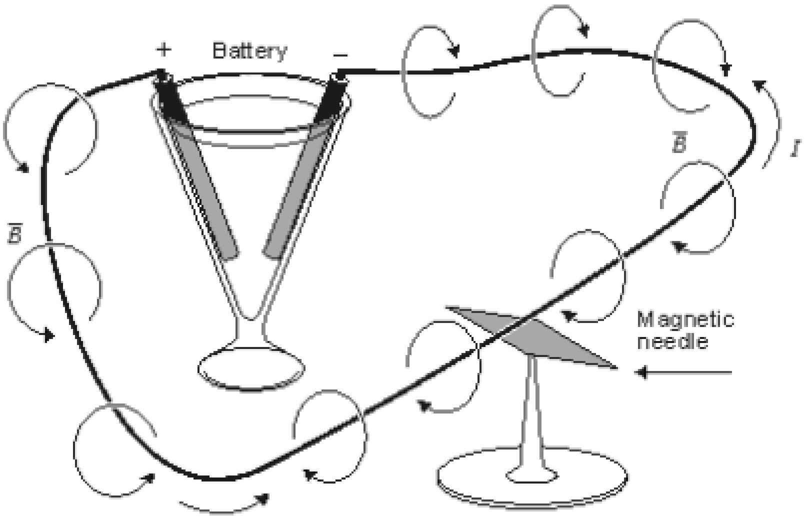


Figure 1.9 Magnetic needle

Reconstruction of the first demonstration of the electromagnetic connection by Hans Christian Örsted in 1819. The battery generates an electric current I to flow in the circuit formed by a metal wire. This current induces a magnetic induction around the wire. The magnetic needle under the wire turns parallel to the direction of the magnetic induction demonstrating its existence. (Örsted, 1820a,b,c).

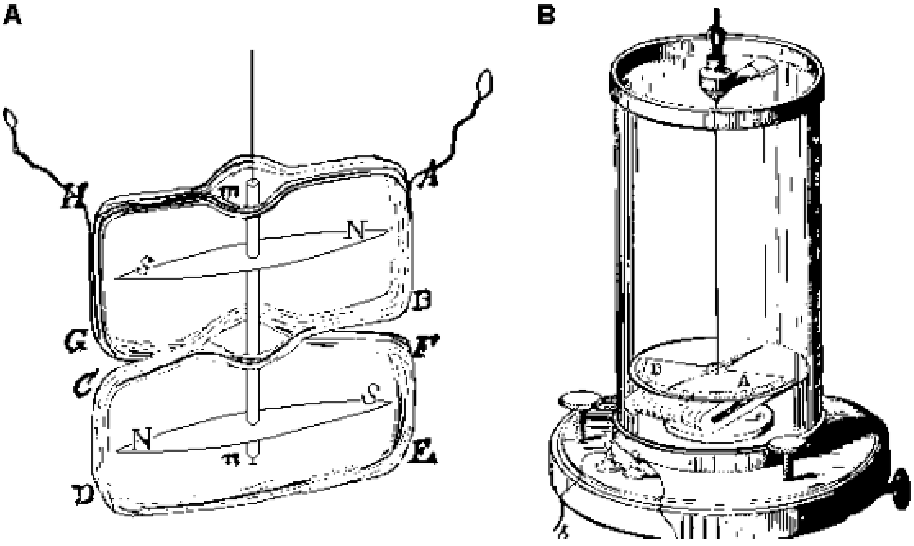


Figure 1.10 Astatic galvanometer

(A) Astatic galvanometer invented by Nobili in 1825. He compensated for the effect of the Earth's magnetic field by placing two identical magnetic needles connected on the same suspension in opposite directions in the openings of a coil wound in the form of figure eight.(Nobili, 1825.) (B) A technically more advanced version of the astatic galvanometer. Only one of the two identical (but opposite) needles is surrounded by a coil. The other needle serves as an indicator.Carlo Matteucci (Italian; 1811-65) was the first to measure a bioelectric current. Using the astatic galvanometer, he made his first measurement of muscle impulse in frog muscle in 1838 (Matteucci, 1838), although the report did not appear in print until 1842. In 1841, the German physiologist Emil du Bois-Reymond had received a copy of Matteucci's short essay on animal electricity, and thus was aware of the experiments of Matteucci. He repeated the studies with improved instrumentation. Besides detecting the bioelectric current from frog muscle, du Bois-Reymond, in 1842 (shortly before Matteucci's paper was published), measured the current arising from a frog nerve impulse (du Bois-Reymond, 1843). One of his experiments is shown in Figure 1.14. The English school of neurophysiology began when Richard Caton (British; 1842-1926) became interested in the recording technique of du Bois-Reymond and applied it to the measurement of the electric activity of the brains of rabbits and monkeys. The first report of his experiments, published in 1875 (Caton, 1875), is believed to constitute the discovery of the electroencephalogram (EEG). In 1888, a young Polish scientist Adolf Beck (1863- 1942), working for the great physiologist Napoleon Nicodemus Cybulski (1854-1919) at the University of Krakow, succeeded in demonstrating that the electric impulse propagated along a nerve fiber without attenuation (Beck, 1888). Without knowledge of the work of Caton, Beck studied the electric activity of the brain in animal experiments and independently arrived at many of Caton's conclusions (Beck, 1891). The German psychiatrist Hans Berger (1873-1941), made the first recording of the EEG on a human in 1924, and identified the two major rhythms, and (Berger,1929). Berger's recordings on EEG are illustrated .

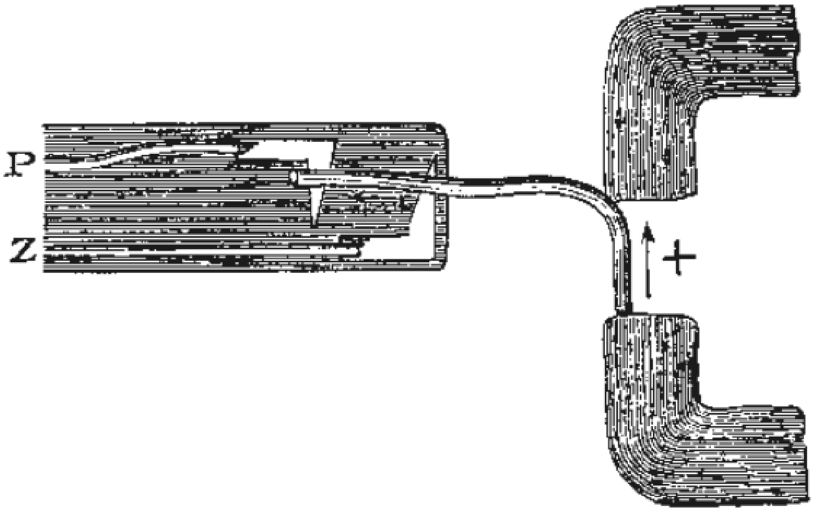


Figure 1.11 Berger's recordings on EEG

Du Bois-Reymond's apparatus for studying effect of continuous current on nerve.

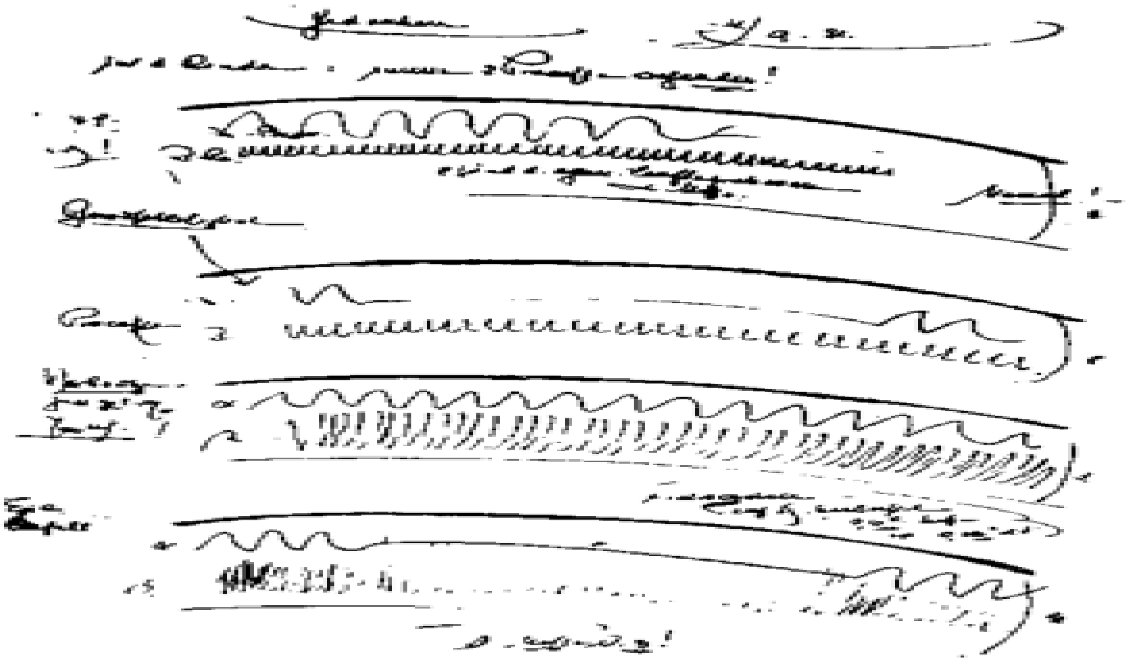


Figure 1.12 Records for Berger's EEG

A page from Berger's notebook illustrating early recordings of the human EEG.The tracings of the electric activity of the human heart, the electrocardiogram (ECG), was first measured in 1887 by Augustus Waller (British; 1856-1922) using capillary electrometer (Waller, 1887). In a capillary electrometer a moving photographic film is exposed along a glass capillary tube filled with sulphuric acid and mercury. Their interface moves in response to an electric field. The sensitivity of the capillary electrometer is about 1 mV, but its time response is very poor. The capillary electrometer was invented in 1873 by Gabriel Lippman (1873), and the photographic technique by which the signal was recorded by E. J. Marey and G. J. Lippman (1876). Waller found that the cardiac electric generator has a dipolar nature and suggested that the ECG should be measured between the five measurement points formed by the hands, legs, and mouth (a total of 10 bipolar leads). He was also the first to record a set of three nearly orthogonal leads, including mouth-to-left arm, mouth-to-left leg, and back-to-front. A pioneer in modern electrocardiography was Willem Einthoven (Dutch; 1860-1927) who, at the beginning of this century, developed the first high-quality ECG recorder based on the string galvanometer (Einthoven, 1908). Though Einthoven is often credited with inventing the string galvanometer, that honor actually belongs to Clément Ader (1897). However, Einthoven undoubtedly made important improvements in this device such that it was possible to apply it to clinical electrocardiography. Einthoven summarized his fundamental results in ECG research in 1908 and 1913 (Einthoven, 1908; Einthoven et al., 1913), and received the Nobel Prize for his work in 1924. Horatio Williams, who was the first to construct a sequence of instantaneous vectors (Williams, 1914), is usually considered to be the inventor of vectorcardiography. Hubert Mann made further studies in vectorcardiography to develop it as a clinical tool. He published his first two-dimensional vectorcardiogram based on Einthoven's triangle in 1916 and called this construction the "monocardiogram" (Mann, 1920). After J. B. Johnson (1921) of the Western Electric Company invented the low-voltage cathode ray tube, it became possible to display bioelectric signals in vector form in real time. This invention allowed vectorcardiography to be used as a clinical tool. The invention of the electron tube by Lee de Forest (American: 1873-1961) in 1906 allowed bioelectric signals to be amplified, revolutionizing measurement technology. Finally, the invention of the transistor by John Bardeen and Walter Brattain in 1948 marked the beginning of the semiconductor era. It also allowed the instrumentation of bioelectromagnetism to be miniaturized, made portable and implantable, and more reliable.

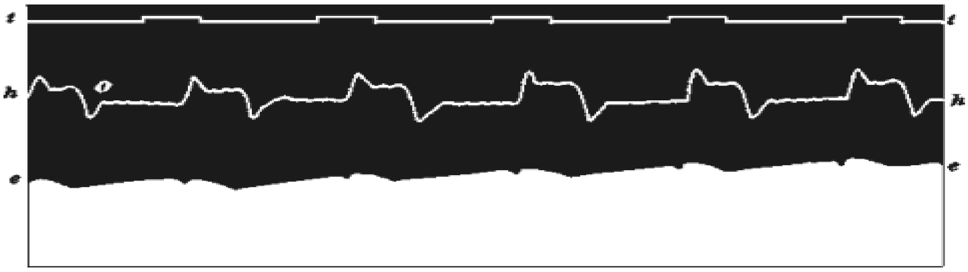


Figure 1.13 Monocardiogram

The first recording of the human electrocardiogram by Augustus Waller (1887). The recording was made with a capillary electrometer. The ECG recording (e) is the borderline between the black and white areas. The other curve (h) is the apex cardiogram, a recording of the mechanical movement of the apex of the heart.

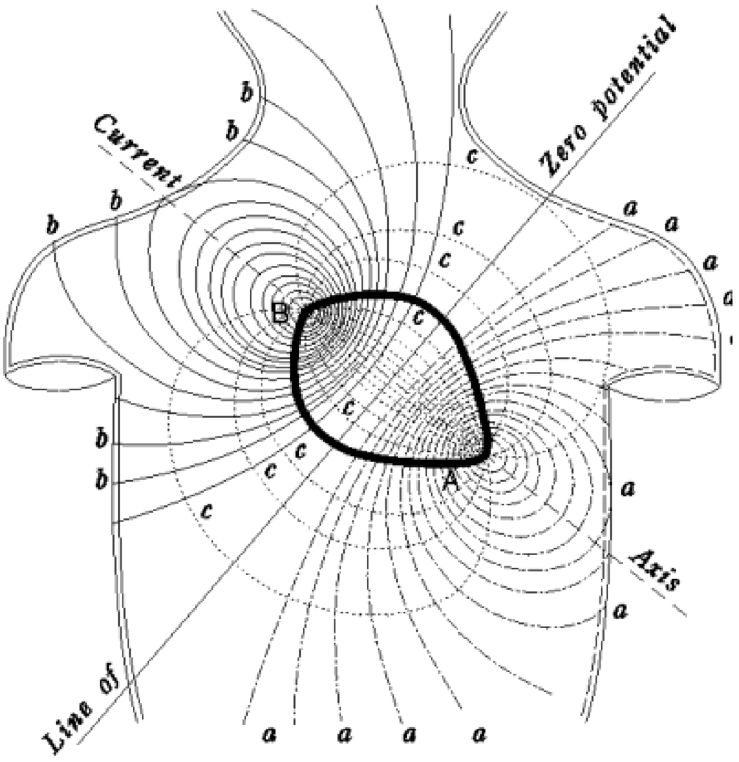


Figure 1.14 Electric field of the heart

Electric field of the heart on the surface of the thorax, recorded by Augustus Waller(1887). The curves (a) and (b) represent the recorded positive and negative isopotential lines,respectively. These indicate that the heart is a dipolar source having the positive and negative poles at (A) and (B), respectively. The curves (c) represent the assumed current flow lines.

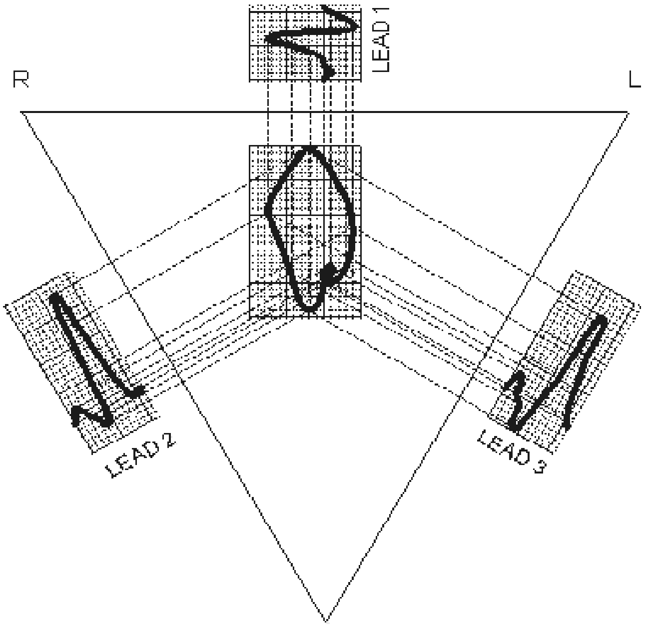


Figure 1.15 Current flow lines

1.4 Modern Electrophysiological Studies of Neural Cells

The term neuron was first applied to the neural cell in 1891 by Heinrich Wilhelm Gottfried Waldeyer (German; 1837-1921). Basic research into the study of neurons was undertaken at the end of the nineteenth century by August Forel (Swiss; 1848-1931), Wilhelm His, Sr. (Swiss; 1831-1904), and Santiago Ramón y Cajal (Spanish; 1852-1934). According to their theory, it is the neural cell that is the functional unit in the nervous system. (In 1871, Santiago Ramón y Cajal also discovered that neurons could be selectively stained with a special silver preparation.)Sir Charles Scott Sherrington (British; 1856-1952) introduced the concept of the synapse (Sherrington, 1897). He also contributed the concept of the reflex arc. Lord Edgar Douglas Adrian (British; 1889-1977) formulated the all-or-nothing law of the neural cell in 1912 (Adrian and Lucas, 1912; Adrian, 1914) and measured the electric impulse of a single nerve 1926. Adrian and Sherrington won the Nobel Prize in 1932. The founder of membrane theory was Julius Bernstein (German; 1839-1917), a pupil of Hermann von Helmholtz. Bernstein stated that the potential difference across the membrane was maintained by the difference in concentration of potassium ions on opposite sides of the membrane. The membrane, which is selectively permeable to all ions, has a particularly high permeability to potassium. This formed the basis for an evaluation of the transmembrane voltage as proportional to the logarithm of the concentration ratio of the potassium ions, as expressed by the Nernst equation. Herbert Spencer Gasser (American; 1888-1963) and Joseph Erlanger (American; 1874-1965) studied nerve impulses with the aid of a cathode ray tube. Because they could not get a cathode-ray oscilloscope from the Western Electric Company, which had recently invented it, they built such a device themselves from a distillation flask. Linking the device to an amplifier, they could record the time course of nerve impulses for the first time (Gasser and Erlanger, 1922). With their experiments they were also able to confirm the hypothesis that axons of large diameter within a nerve bundle transmit nerve impulses more quickly than do thin axons. For their studies Gasser and Erlanger received the Nobel Prize in 1944. Sir Alan Lloyd Hodgkin (English; 1914-) and Sir Andrew Fielding Huxley (English; 1914-) investigated the behavior of the cell membrane in great detail and developed a very accurate mathematical model of the activation process (Hodgkin and Huxley, 1952). Sir John Eccles (Australian; 1903-) investigated synaptic transmission in Canberra, Australia, in the 1950s. Eccles, Hodgkin, and Huxley won the Nobel Prize in 1963. Ragnar Arthur Granit (Finnish; 1900-1991) undertook fundamental research in the bioelectric phenomena of the retina and the nervous system in the 1930s and 1940s. In 1935, he could show experimentally that inhibitory synapses are found in the retina. Hermann von Helmholtz had proposed that the human ability to discriminate a spectrum of colors could be explained if it could be proven that the eye contains receptors sensitive to different wavelengths of light. Granit's first experiments in color vision, performed in 1937, employed the electroretinogram (ERG) to confirm the extent of spectral differentiation. In 1939, Granit developed a microelectrode, a device that permits the measurement of electric potentials inside a cell. With this technique Granit further studied the color vision and established the spectral sensitivities of the three types of cone cells - blue, green, and red. Ragnar Granit shared the 1967 Nobel Prize with H. Keffer Hartline and George Wald "for their discoveries concerning the primary physiological and chemical visual processes in the eye." (Granit, 1955) The behavior of ion channels in the biological membrane has been described in greater detail through the invention of the patch clamp technique by Erwin Neher (German; 1944-) and Bert Sakmann (German; 1942-) (Neher and Sakmann, 1976). With the patch clamp method it is possible to measure the electric current from a single ionic channel. This extends the origins of bioelectromagnetism to molecular biology so that this technique can also be used, for instance, in developing new pharmaceuticals. Neher and Sakmann won the Nobel Prize in 1991.

1.5 Bioelectromagnetism

As mentioned in Section 1.4.3, the connection between electricity and magnetism was experimentally discovered in 1819 by Hans Christian Örsted. French scientists Jean Baptiste Biot (1774- 1862) and Félix Savart (1791-1841) proved that the force between a current-carrying helical wire and a magnet pole is inversely proportional to the distance between them (Biot, 1820). André Marie Ampère (French; 1775-1836) showed that a current-carrying helical wire, which he called the solenoid, behaved magnetically as a permanent magnet (Ampère, 1820) hence linking the electric current to the production of a magnetic field. Ampère also developed the mathematical theory of electrodynamics (Ampère, 1827). The electromagnetic connection was theoretically formulated in 1864 by James Clerk Maxwell (British; 1831-79), who developed equations that link time-varying electricity and magnetism

(Maxwell, 1865). Since Örsted's discovery, electromagnetic interdependence has been widely utilized in a large variety of devices. Examples of these include those used for the measurement of electric current (galvanometers and ammeters), electric generators, electric motors, and various radiofrequency devices. However, biomagnetic signals were not detected for a long time because of their extremely low amplitude. The first biomagnetic signal, the magnetocardiogram (MCG), was detected by Gerhard M. Baule and Richard McFee in 1963 with an induction coil magnetometer (Baule and McFee, 1963). The magnetometer was made by winding two million turns of copper wire around a ferrite core. In addition to the detector coil, which was placed in front of the heart, another identical coil was connected in series and placed alongside. The two coils had opposite senses and thereby canceled the distributing common magnetic fields arising from distant external sources (see Figure 1.19). A remarkable increase in the sensitivity of biomagnetic measurements was obtained with the introduction of the Superconducting QUantum Interference Device (SQUID), working at the temperature of liquid helium (-269 C) (Zimmerman, Thiene, and Hardings, 1970; Cohen, 1972). Although David Cohen succeeded to measure the magnetic alpha rhythm with an induction coil magnetometer (Cohen, 1968), the magnetic signal generated by the electric activity of the brain, measured in the magnetoencephalogram (MEG), is so low that in practice its detection is possible only by using the SQUID. With such a device the MEG was first detected by DavidCohen in 1970 (Cohen, 1972). John Wikswo and his co-workers were first to measure the magnetic field of a frog nerve bundle in 1980 (Wikswo, Barach, and Freeman, 1980). In this connection we want to draw the readers' attention to the fact that the difference between the measurement principles in the first measurements of the bioelectric and biomagnetic signals is surprisingly small: In the first measurement of the bioelectric signal, Matteucci (1838) used a magnetized needle as the detector. (The bioelectric field is, of course, far too low to deflect the needle of an electroscope.) The biomagnetic field, produced by the bioelectric currents flowing in the frog leg, was too small to deflect the magnetic needle directly. It was therefore multiplied by feeding the bioelectric current to a coil of multiple turns and with placement of the needle inside the coil, an application of the invention of Schweigger (1821). The effect of the Earth's magnetic field was compensated by winding the coil in the form of a figure eight, placing two identical magnetic needles on the same suspension and oriented in opposite directions in the two openings of the coil. This formed an astatic galvanometer, as described earlier. In the first measurement of a biomagnetic signal (the magnetocardiogram), the magnetic field produced by the bioelectric currents circulating in the human body was measured with a coil (Baule and McFee, 1963). Because of the low amplitude of this biomagnetic field, multiple turns of wire had to be wound around the core of the coil. To compensate for the effect of the magnetic field of the Earth and other sources of "noise", two identical coils wound in opposite directions were used Thus, in terms of measurement technology, the first measurements of bioelectric and biomagnetic signals can be discriminated on the basis of whether the primary loop of the conversion of the bioelectric current to a magnetic field takes place outside or within the body, respectively. Since the invention of the capillary electrometer by G. J. Lippman (1873) and especially after the invention of electronic amplifiers, electric measurements have not directly utilized induced magnetic fields, and therefore the techniques of bioelectric and biomagnetic measurements have been driven apart. In terms of measurement theory, the first measurements of bioelectric signals were measurements of the flow source, and thus truly electric. The first measurement of the biomagnetic signal by Richard McFee was the measurement of the vortex source, and thus truly magnetic. It will be shown later that with magnetic detectors it is possible to make a measurement which resembles the detection of the flow source. However, such a measurement does not give new information about the source compared to the electric measurement. This example should draw our readers' attention to the fact that from a theoretical point of view, the essential difference between the bioelectric and biomagnetic measurements lies in the sensitivity distributions of these methods. Another difference stems from the diverse technical properties of these instrumentations, which impart to either method specific advantages in certain applications..

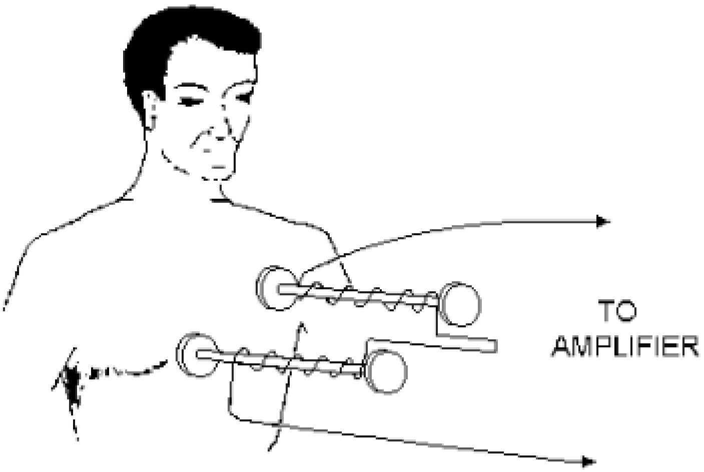


Figure 1.16 External conductors

1.6 Theoretical Contributions to Bioelectromagnetism

The German scientist and philosopher Hermann Ludwig Ferdinand von Helmholtz (1821-1894) made the earliest significant contributions of the theory of bioelectromagnetism. A physician by education and, in 1849, appointed professor of physiology at Königsberg, he moved to the chair of physiology at Bonn in 1855. In 1871 he was awarded the chair of physics at the University of Berlin, and in 1888 was also appointed the first director of Physikalisch-Technische Bundesanstalt in Berlin. Helmholtz's fundamental experimental and theoretical scientific contributions in the field of bioelectromagnetism include the following topics:

1. The demonstration that axons are processes of nerve cell bodies (1842)
2. The establishment of the law of conservation of energy (the First Law of Thermodynamics) (1847)

3. The invention of the myograph and the first measurement of the conduction velocity of a motor nerve axon (1850)
4. The concept of double layer source (1853)
5. The solid angle theorem for electric potentials
6. The principle of superposition (1853)
7. The reciprocity theorem (1853)
8. The insolvability of the inverse problem (1853)
9. Helmholtz's theorem concerning the independence of flow and vortex sources
10. The Helmholtz coils (applied in biomagnetic instrumentation)

Besides these, the contributions of Helmholtz to other fields of science include fundamental works in physiology, acoustics, optics, electrodynamics, thermodynamics, and meteorology. He is the author of the theory of hearing (1863) from which all modern theories of resonance are derived. He also invented, in 1851, the ophthalmoscope, which is used to investigate the retina of a living eye. Until the end of the nineteenth century, the physics of electricity was not fully understood. It was known, however, that neither pure water nor dry salts could by themselves transmit an electric current, whereas in aqueous solution salts could. Svante August Arrhenius (Swedish; 1859-1927) hypothesized in his (1884) doctoral thesis that molecules of some substances dissociate, or split, into two or more particles (ions) when they are dissolved in a liquid. Although each intact molecule is electrically balanced, the particles carry an electric charge, either positive or negative depending on the nature of the particle. These charged bodies form only in solution and permit the passage of electricity. This theory is fundamental for understanding the nature of the bioelectric current, because it flows in solutions and is carried by ions. Svante Arrhenius won the Nobel Prize in Chemistry in 1903. At the end of the nineteenth century, Walther Hermann Nernst (German; 1864-1941) did fundamental work in thermochemistry, investigating the behavior of electrolytes in the presence of electric currents. In 1889, he developed a fundamental law, known as the Nernst equation. Nernst also developed many other fundamental laws, including the Third Law of hermodynamics. He was awarded the Nobel Prize in Chemistry in 1920. Dutch scientists Hermann Carel Burger (1893-1965) and Johan Bernhard van Milaan (1886-1965) introduced the concept of the lead vector in 1946 (Burger and van Milaan, 1946). They also extended this to the concept of the image surface. In 1953, Richard McFee and Franklin D. Johnston introduced the important concept of the lead field, which is based on the reciprocity theorem of Helmholtz (McFee and Johnston, 1953, 1954ab). The invention of the electromagnetic connection in 1819 by Örsted tied bioelectric and biomagnetic fields together. The invention of the reciprocity theorem in 1853 by Helmholtz showed that the sensitivity distribution of a lead for measuring bioelectric sources is the same as the distribution of stimulation current introduced into the same lead. Furthermore, this is the same as the sensitivity distribution of a tissue impedance measurement with the same lead. All this is true for corresponding magnetic methods as well. These principles are easily illustrated with the concept of lead field. Dennis Gabor (British; 1900-1979) and Clifford V. Nelson published the Gabor-Nelson theorem in 1954 (Gabor and Nelson, 1954). This theorem explains how an equivalent dipole of a volume source and its location may be calculated from measurements on the surface of a homogeneous volume conductor.

Chapter 2

Definition of ECG

2.1 ECG definition

The electrocardiogram (ECG) is a graphic recording of electric potentials generated by the heart. The signals are detected by means of metal electrodes attached to the extremities and chest wall and are then amplified and recorded by the electrocardiograph. ECG leads actually display the instantaneous differences in potential between these electrodes .The clinical utility of the ECG derives from its immediate availability as a noninvasive, inexpensive, and highly versatile test. In addition to its use in detecting arrhythmias, conduction disturbances, and myocardial ischemia, electrocardiography may reveal other findings related to life-threatening metabolic disturbances or increased susceptibility to sudden cardiac death (e.g., QT prolongation syndromes). The widespread use of coronary fibrinolysis and acute percutaneous coronary interventions in the early therapy of acute myocardial infarction has refocused attention on the sensitivity and specificity of ECG signs of myocardial ischemia

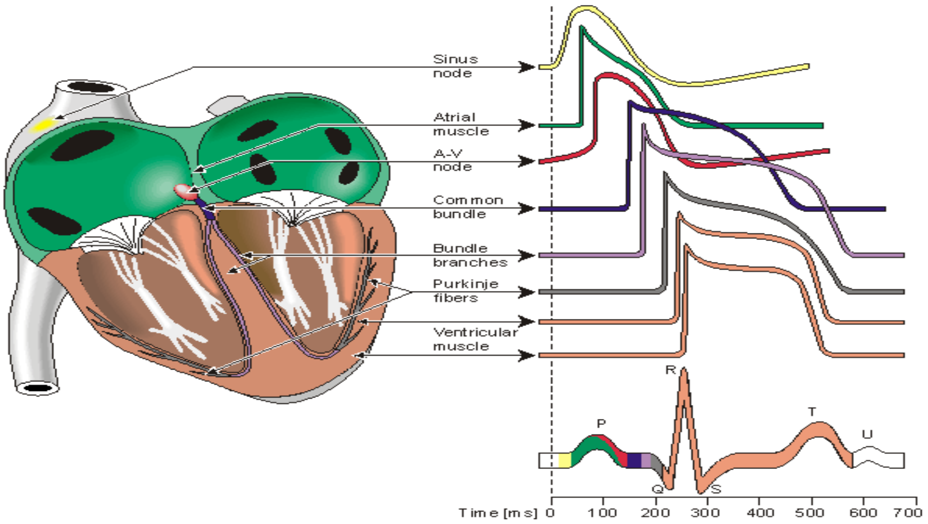


Figure 2.1 Electric potentials generated by the heart

2.2 ECG Tracing

As cardiac cells depolarize and repolarize, electrical currents spread throughout the body because the tissues surrounding the heart are able to conduct electrical currents generated by the heart. When these electrical currents are measured by an array of electrodes placed at specific locations on the body surface the recorded tracing is called an ECG. The repeating waves of the ECG represent the sequence of depolarization and repolarization of the atria and ventricles. The ECG does not measure absolute voltages, but voltage changes from a baseline (isoelectric) voltage. ECGs are generally recorded on pa- per at a speed of 25 mm/sec and with a vertical calibration of 1 mV/cm. By convention, the first wave of the ECG is the P wave. It represents the wave of depolarization that spreads from the SA node through- out the atria; it is usually 0.08 to 0.1 seconds period after the P wave represents the time in which the atrial cells are depolarized and the impulse is traveling within the AV node, where conduction velocity is greatly reduced. The period of time from the onset of the P wave to the beginning of the QRS complex, the P-R interval, normally ranges from 0.12 to 0.20 seconds. This interval represents the time between the onset of atrial depolarization and the onset of ventricular depolarization. If the P-R interval is greater than 0.2 seconds, a conduction defect (usually within the AV node) is present (e.g., first-degree heart block).The QRS complex represents ventricular depolarization. The duration of the QRS complex is normally 0.06 to 0.1 seconds, indicating that ventricular depolarization occurs rapidly. If the QRS complex is prolonged (greater than 0.1 seconds), conduction is impaired within the ventricles. Impairment can occur with de- fects (e.g., bundle branch blocks) or aberrant conduction, or it can occur when an ectopic ventricular pacemaker drives ventricular de- polarization. Such ectopic foci nearly always cause impulses to be conducted over slower pathways within the heart, thereby increasing the time for depolarization and the duration of the QRS complex .The isoelectric period (ST segment) fol- lowing the QRS is the period at which the en- tire ventricle is depolarized and roughly cor-responds to the plateau phase of the ventricular action potential. The ST segment is important in the diagnosis of ventricular

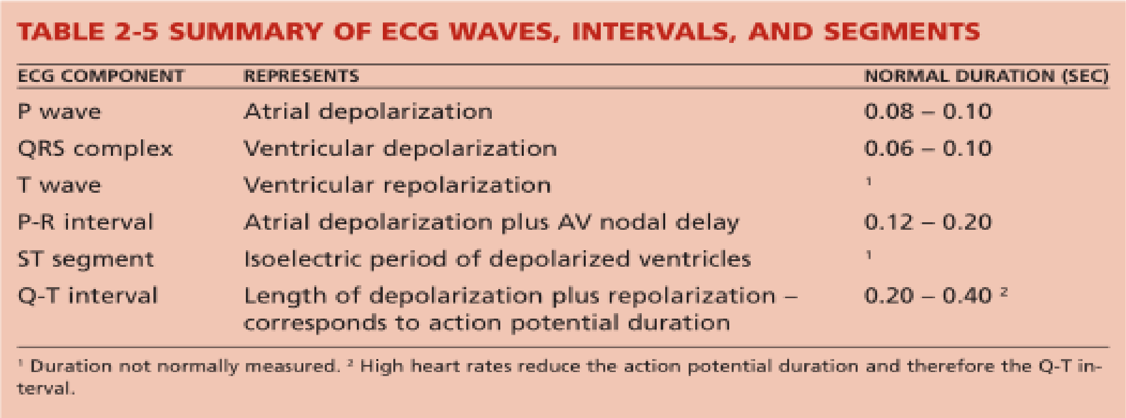


TABLE 2-5 SUMMARY OF ECG WAVES, INTERVALS, AND SEGMENTS

ECG COMPONENT	REPRESENTS	NORMAL DURATION (SEC)
P wave	Atrial depolarization	0.08 – 0.10
QRS complex	Ventricular depolarization	0.06 – 0.10
T wave	Ventricular repolarization	[1]
P-R interval	Atrial depolarization plus AV nodal delay	0.12 – 0.20
ST segment	Isoelectric period of depolarized ventricles	[1]
Q-T interval	Length of depolarization plus repolarization – corresponds to action potential duration	0.20 – 0.40 [2]

[1] Duration not normally measured. [2] High heart rates reduce the action potential duration and therefore the Q-T interval.

Table 2.1 EGC Waves

Chapter 3

Hardware

In this chapter we are GOING LLUSTRATE THE hardwre of the project including the components and their electric carateristics

Component of the project

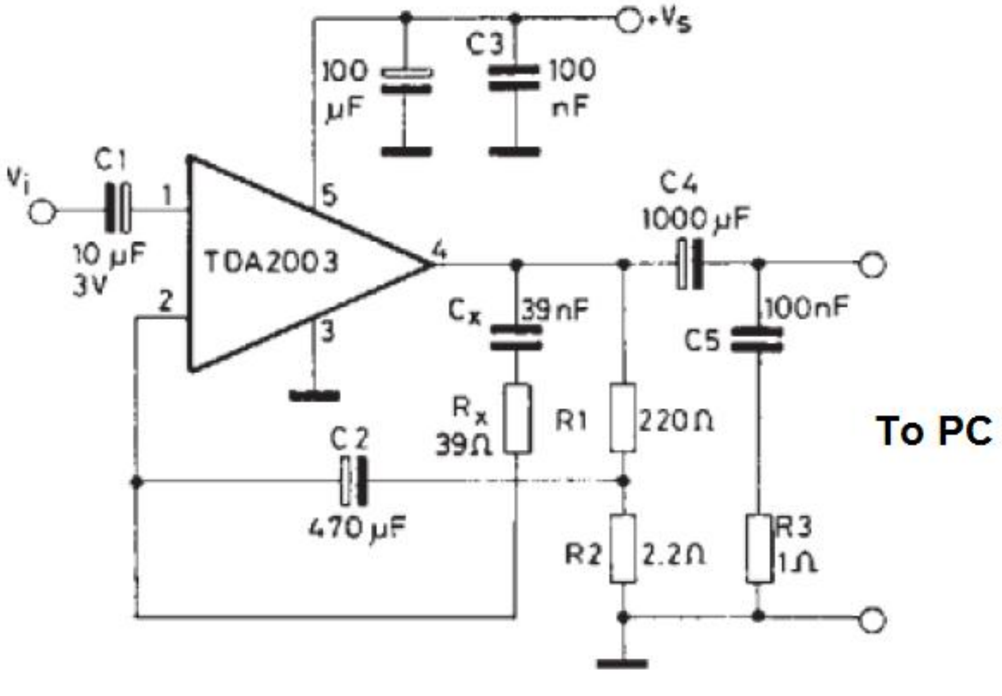


Figure 3.1 Project circuit

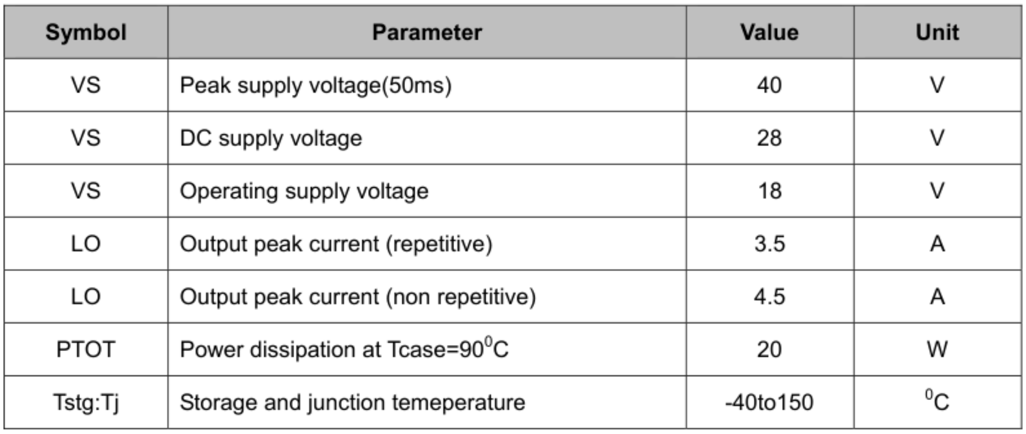
1- contain an element of the tda2003" Blaster operations "

The TDA 2003 has improved performance with the same pin configuration as the TDA 2002. The additional features of TDA 2002, very low number of external components, ease of assembly, space and cost saving, are maintained. The device provides a high output current capability. very low harmonic and cross-over distortion. Completely safe operation is guaranteed due to protection against DC and AC short circuit between all pins and ground thermal over-range ,load dump voltage surge up to 40V AND fortuitous open ground.

capability very low harmonic and cross-over distortion. Completely safe operation is guaranteed due to protection against DC and AC short circuit between all pins and ground thermal over-range ,load dump voltage surge up to 40V AND fortuitous open ground.

Figure 3.2 TDA 2003

ABSOLUTE MAXIMUM RATIONGS



Symbol	Parameter	Value	Unit
VS	Peak supply voltage(50ms)	40	V
VS	DC supply voltage	28	V
VS	Operating supply voltage	18	V
LO	Output peak current (repetitive)	3.5	A
LO	Output peak current (non repetitive)	4.5	A
PTOT	Power dissipation at Tcase=90^{0}C	20	W
Tstg:Tj	Storage and junction temeperature	-40to150	^{0}C

Table 3.1 Absolute Maximum Ratio

PIN CONNECTION(top view)

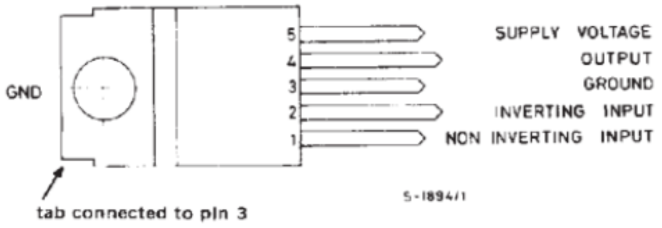


Figure 3.3 PIN Connection

SCHEMATIC DIAGRAM

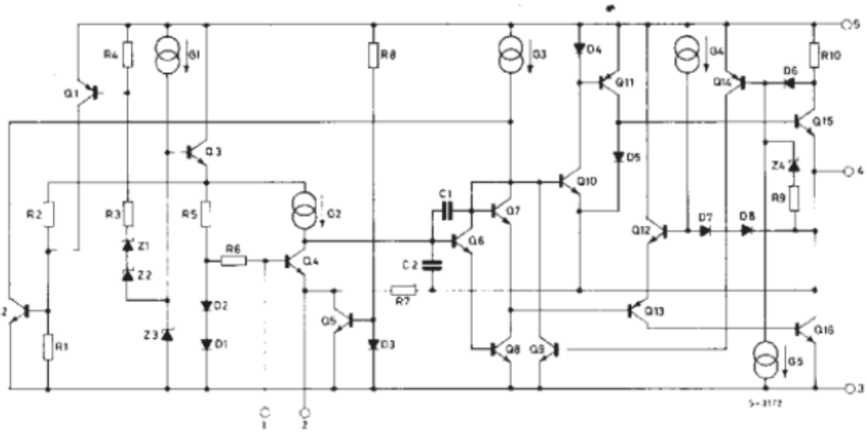


Figure 3.4 Schematic diagram

Of the most important uses

a-For dc circuit

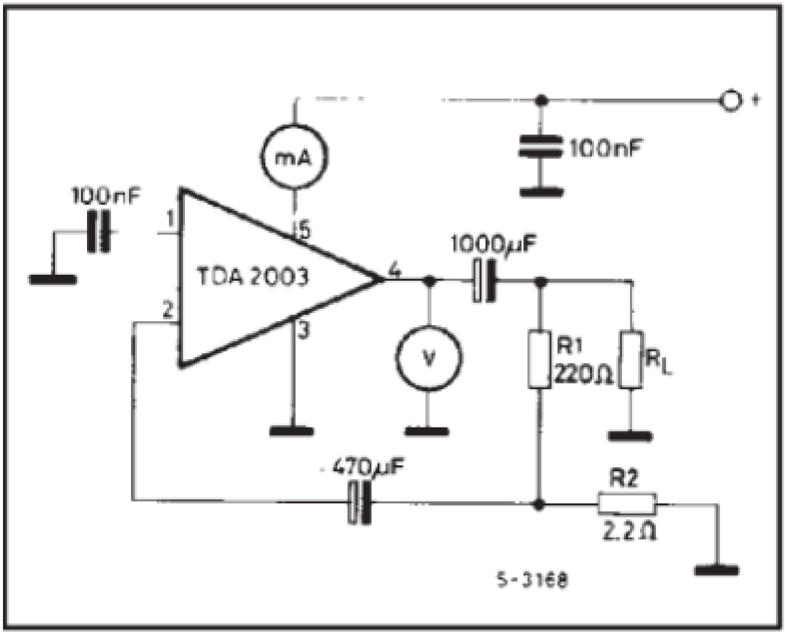


Figure 3.5 DC circuit

b- for ac circuit

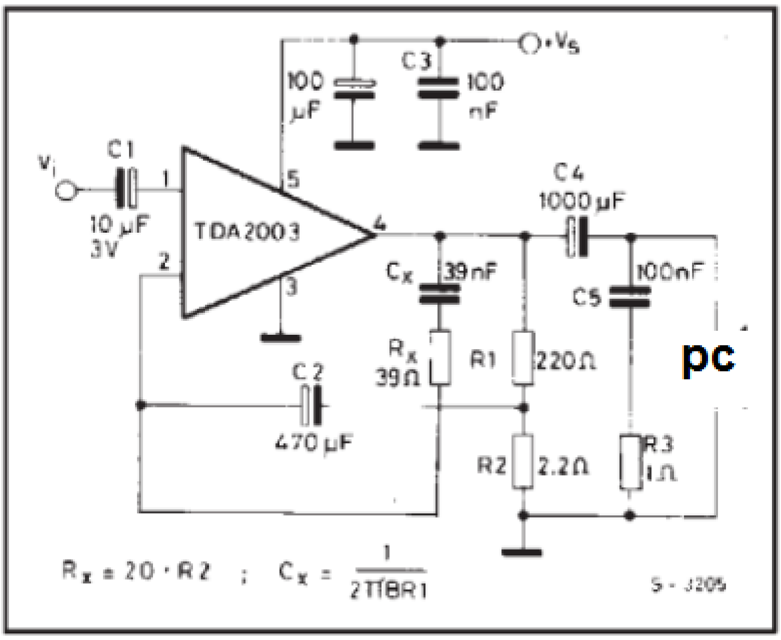
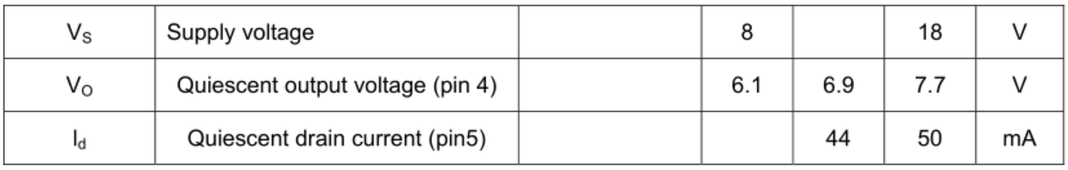


Figure 3.6 AC circuit

ELECTRICAL CHARACTERISTICS (VS=14.4V,Tamb=250C unless otherwise specified)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit

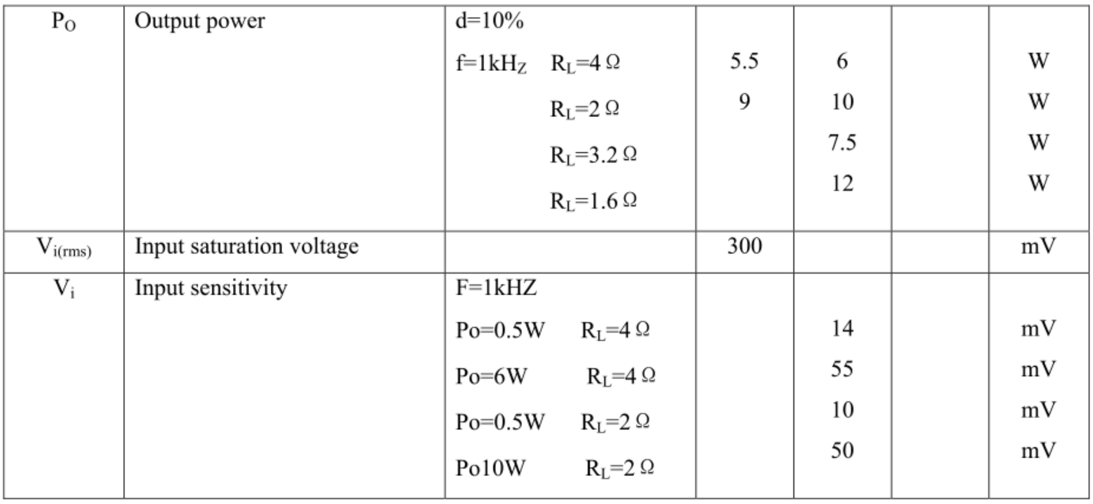
DC CHARAC TERISTICS (Refer to DC test circuit)



V_S	Supply voltage		8		18	V
V_O	Quiescent output voltage (pin 4)		6.1	6.9	7.7	V
I_d	Quiescent drain current (pin5)			44	50	mA

Table 3.2 DC characteristics

AC CHARACTERISTICS(Refer to AC test circuit, Gv=40dB)



P_O	Output power	d=10%				
		f=1kHz R_L=4 Ω	5.5	6		W
		R_L=2 Ω	9	10		W
		R_L=3.2 Ω		7.5		W
		R_L=1.6 Ω		12		W
$V_{i(rms)}$	Input saturation voltage		300			mV
V_i	Input sensitivity	F=1kHZ				
		Po=0.5W R_L=4 Ω		14		mV
		Po=6W R_L=4 Ω		55		mV
		Po=0.5W R_L=2 Ω		10		mV
		Po10W R_L=2 Ω		50		mV

Table 3.3 AC characteristics

ELECTRICAL CHARACTERISTICS(continued)

Symbol	Parameter	Test conditions	Min.	Typ.	Max.	Unit
B	Frequency response(-3dB)	Po=1W R_L=4 Ω	40to15,000			H_Z
d	Distortion	f=1kH_Z Po=0.05 to4.5W R_L=4 Ω Po=0.05to 7.5W R_L=2 Ω		0.15 0.15		% %
R_j	Input resistance(pin1)	f=1Khz	70	150		K
G_v	Voltage gain (open loop)	f=1kH_Z f=10kH_Z		80 60		dB dB
G_v	Voltage gain (closed loop)	f=1kH_Z R_L=4 Ω	39.3	40	40.3	dB
e_N	Input noise voltage (0)			1	5	
i_N	Input noise current (0)			60	200	pA
η	Efficiency	f=1HZ Po=6W R_L=4 Ω Po=10W R_L=2 Ω		69 65		% %
SVR	Supply voltage rejection	f=100HZ V_{ripple}=0.5V R_g=10K Ω R_L=4 Ω	30	36		dB

Table 3.4 Electrical characteristics

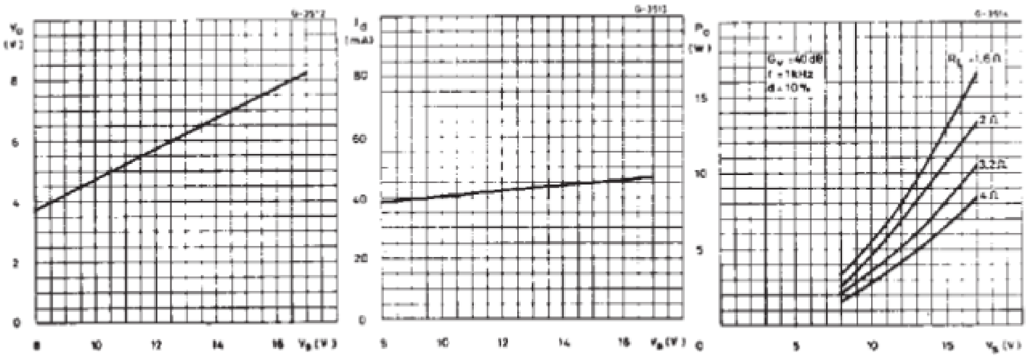


Figure 1.Quiescent output Voltage vs.supply voltage

Figure2. Quiescent drain current vs.supply voltage

Figute3. Output power vs. supply voltage

Figure 3.7 Electrical characteristics

Figure 4. Output power vs. Load resistance R_L

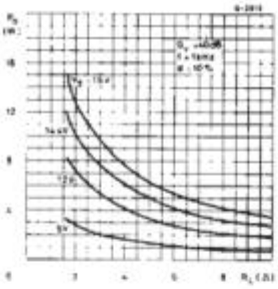


Figure 5. Gain vs. input sensivity

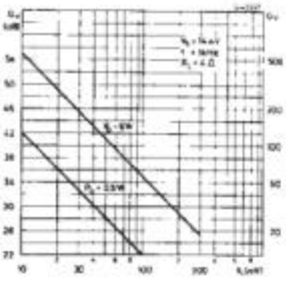


Figure 6.Gain vs.input sensivity

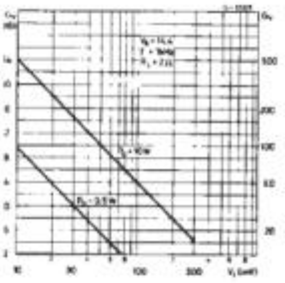


Figure 7.Distortion vs. output power

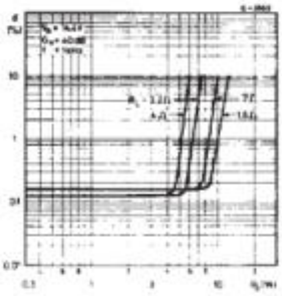


Figure 8.Distortion vs. frequency

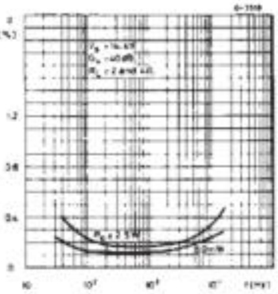


Figure 9. Supply voltage rejection vs.voltage gain

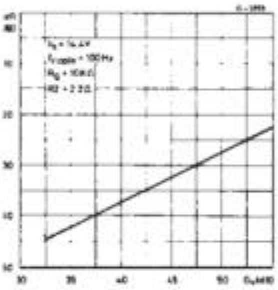


Figure 10.Supply voltage Rejection vs.frequency

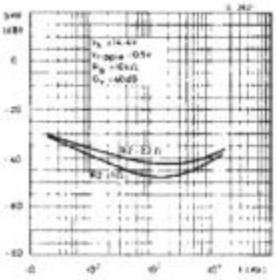


Figure 11.Power dissipation and efficien cy vs.output power(R_L=4 Ω)

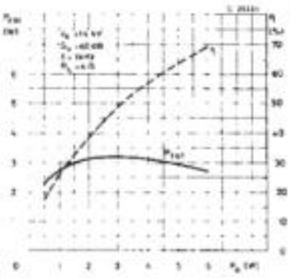


Figure 12.Power dissipation and efficiencyvs.output power(R_L=20 Ω)

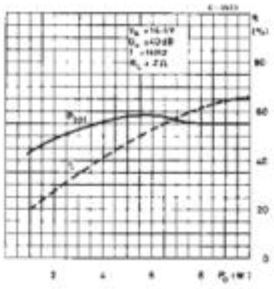


Figure 3.8 Electrical characteristics

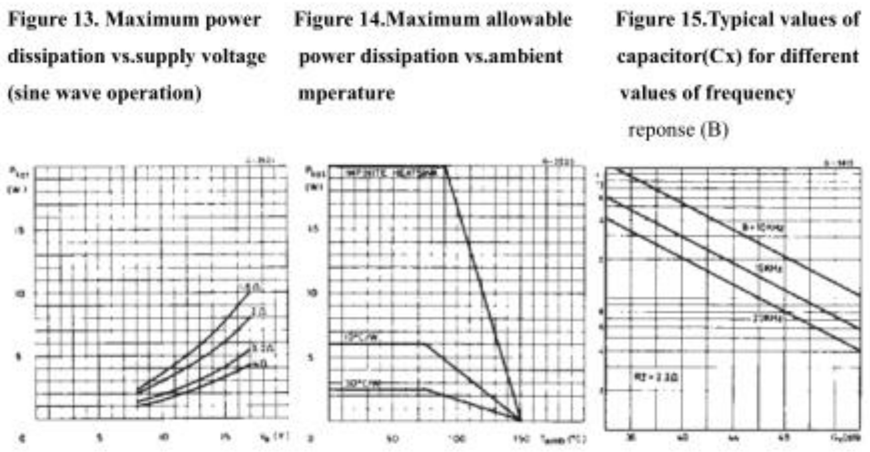


Figure 13. Maximum power dissipation vs.supply voltage (sine wave operation)

Figure 14.Maximum allowable power dissipation vs.ambient mperature

Figure 15.Typical values of capacitor(Cx) for different values of frequency reponse (B)

Figure 3.9 Electrical characteristics

APPLICATION INFORMATION

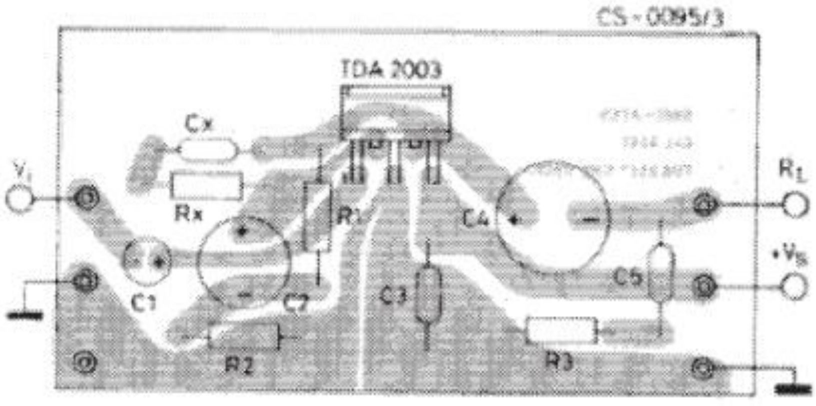


Figure 3.10 Application information

BUILT-IN PROTECTION SYSTEMS

Load dump voltage surge

The TDA 2003 has a circuit which enables it to withstand a voltage pulse train, on pin 5,of the type shown in fig.19. If the supply voltage peaks to more than 40V,then an LC filter must be inserted between the supply and pin 5,in order to assure that the pulses at pin 5 will be held within the limits shown in fig.18. A suggested LC network is shown in fig.19.With this network ,a train of pulses with amplitude up to 120V and width of 2 MS can be applied at point A. This type of protection is ON when the supply voltage(pulsed or DC) exceeds 18V.For this reason the maximum operating supply voltage is 18V.

Figure 18.

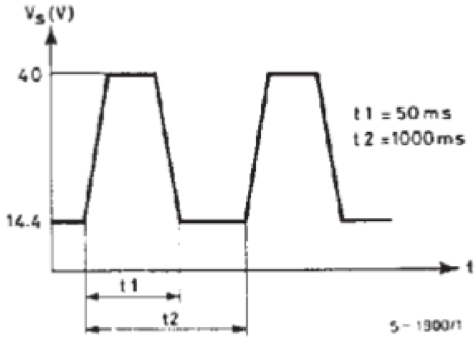


Figure 19.

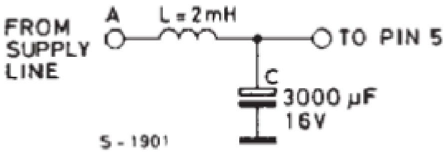


Figure 3.11 BUILT-IN protection systems

3.1 Short-circuit (AC and DC conditions)

The TDA 2003 can withstand a permanent short circuiton the output for a supply voltage up to 16V.

3.2 Polarity inversion

High current can be handled by the device with no damage for a longer period than the blowout time of a quick 1A fuse (normally connected in series with the supply).

This feature is added to avoid destruction if, during fitting to the car, a mistake on the connection of the supply is made.

3.3 Open ground

When the radio is in the ON condition and the ground is accidentally opened, a standard audio amplifier will be damaged. On the TDA 2003 protection diodes are included to avoid any damage.

3.4 Inductive load

A protection diode is provided between pin4 loads.

In particular, the TDA 2003 can drive a coupling transformer for audio modulation.

3.5 DC voltage

The maximum operating DC voltage on the TDA 2003 is 18V.

However the device can withstand a DC voltage up to 28V with no damage. This could occur during winter if two batteries were series connected to crank the engine.

3.6 Thermal shut-down

The presence of a thermal limiting circuit offers the following advantages:

1) An overload on the output (even if it is permanent). or an excessive ambient temperature can be easily withstood.

2) The heat-sink can have a smaller factor compared with that of a conventional circuit.

There is no device damage in the case of excessive junction temperature: all that happens is that Po (and therefore Ptot) and ld are reduced.and 5(see the internal schematic diagram) to allow use of the TDA 2003 with inductive

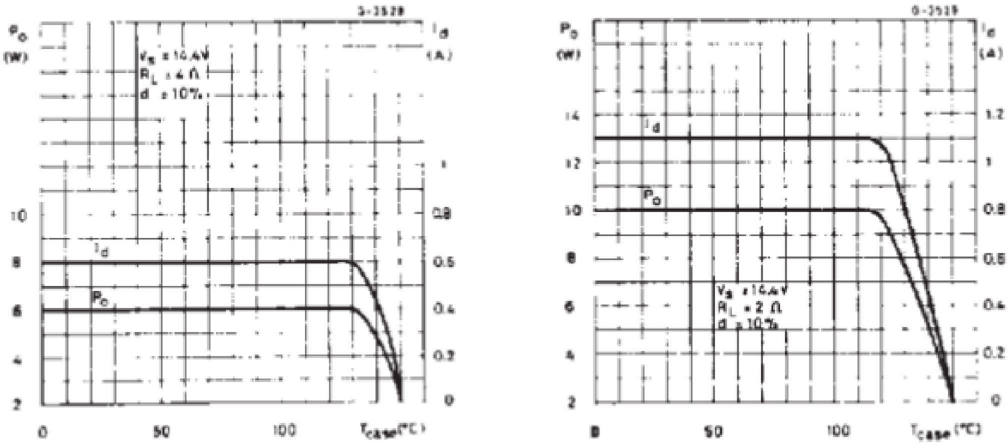


Figure 20. Output power and drain current vs. case temperature(R_L=4 Ω)

Figure 21. Output power and drain current vs. case temperature(R_L=2 Ω)

Figure 3.12 Thermal shut-down

3.7 -PRATICAL CONSIDERATION

-Printed circuit board

The layout shown in fig. 17 is recommended. If different layouts are used, the ground points of input 1 and input 2 must be well decoupled from the ground of the output through which a rather high current flows.

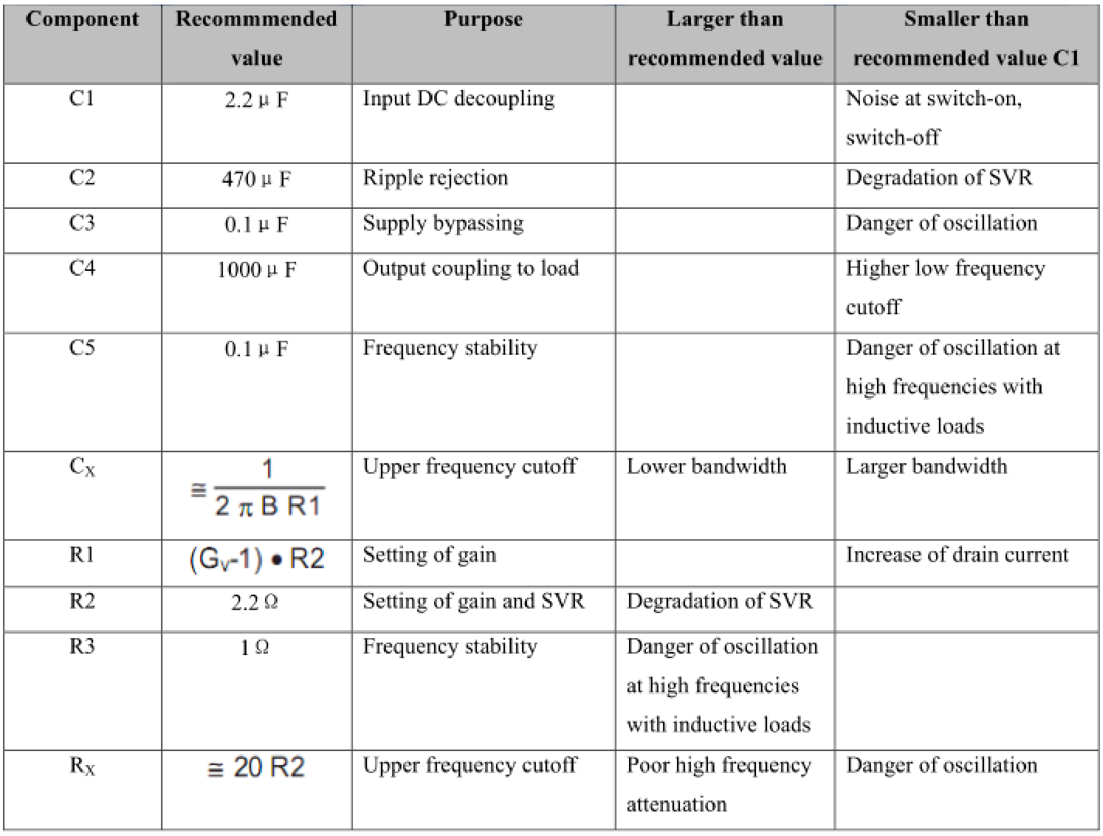
-Assembly suggestion

No electrical insulation is required between the package and the heat-sink. Pin length should be as short as possible. The soldering temperature must not exceed 2600C for 12 seconds.

-Application suggestions

The recommended component values are those shown in the application circuits of fig.16.

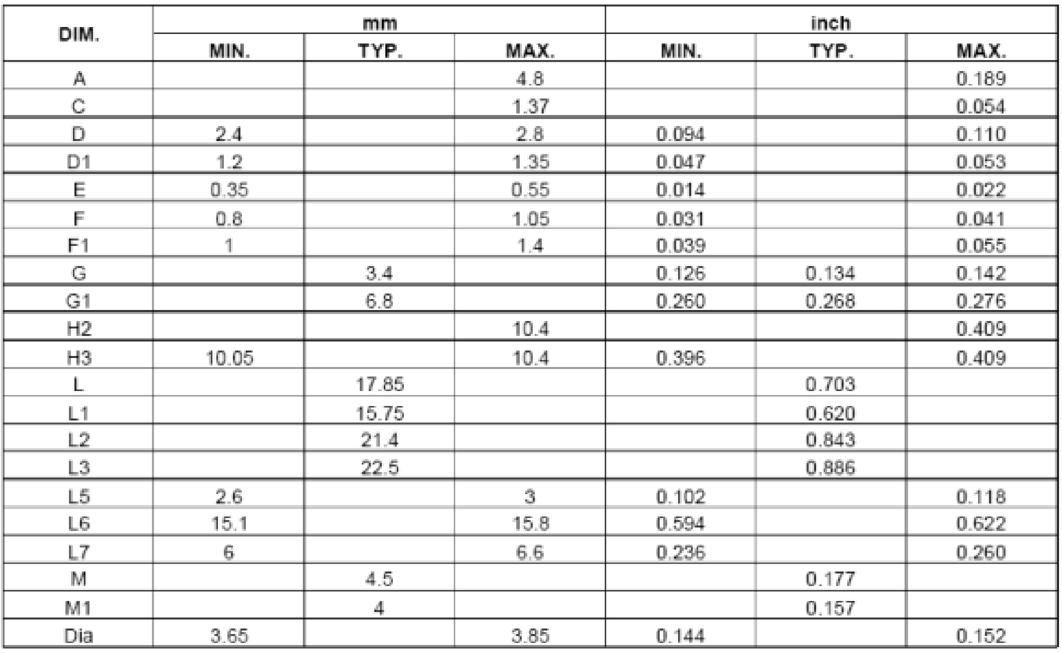
Different values can be used. The following table is intended to aid the car-radio designer



Component	Recommmended value	Purpose	Larger than recommended value	Smaller than recommended value C1
C1	2.2 μ F	Input DC decoupling		Noise at switch-on, switch-off
C2	470 μ F	Ripple rejection		Degradation of SVR
C3	0.1 μ F	Supply bypassing		Danger of oscillation
C4	1000 μ F	Output coupling to load		Higher low frequency cutoff
C5	0.1 μ F	Frequency stability		Danger of oscillation at high frequencies with inductive loads
C_X	$\cong \frac{1}{2 \pi B R1}$	Upper frequency cutoff	Lower bandwidth	Larger bandwidth
R1	$(G_V-1) \bullet R2$	Setting of gain		Increase of drain current
R2	2.2 Ω	Setting of gain and SVR	Degradation of SVR	
R3	1 Ω	Frequency stability	Danger of oscillation at high frequencies with inductive loads	
R_X	$\cong 20\ R2$	Upper frequency cutoff	Poor high frequency attenuation	Danger of oscillation

Table 3.5 Application suggestions

3.8 Pentawatt Package Mechanical Data



DIM.	mm			inch		
	MIN.	TYP.	MAX.	MIN.	TYP.	MAX.
A			4.8			0.189
C			1.37			0.054
D	2.4		2.8	0.094		0.110
D1	1.2		1.35	0.047		0.053
E	0.35		0.55	0.014		0.022
F	0.8		1.05	0.031		0.041
F1	1		1.4	0.039		0.055
G		3.4		0.126	0.134	0.142
G1		6.8		0.260	0.268	0.276
H2			10.4			0.409
H3	10.05		10.4	0.396		0.409
L		17.85			0.703	
L1		15.75			0.620	
L2		21.4			0.843	
L3		22.5			0.886	
L5	2.6		3	0.102		0.118
L6	15.1		15.8	0.594		0.622
L7	6		6.6	0.236		0.260
M		4.5			0.177	
M1		4			0.157	
Dia	3.65		3.85	0.144		0.152

Table 3.6 Pentawatt Package Mechanical Data

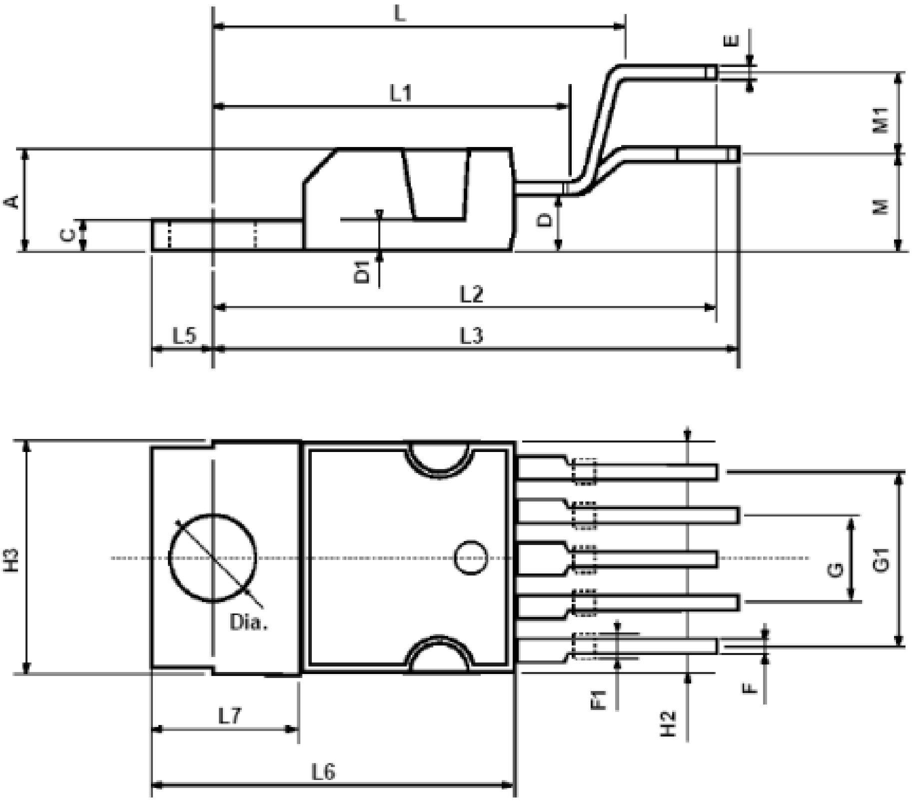


Figure 3.13 Pentawatt Package Mechanical Data

2- c1 capacitor value " 10 microfarad " is to withhold any continuous signal at the entrance of operational amplifier

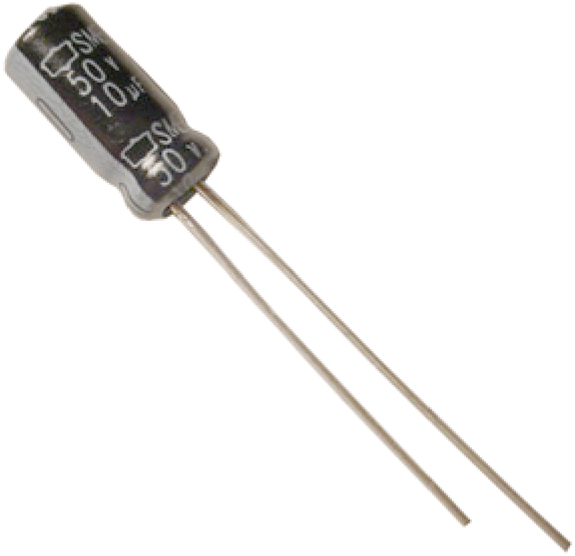


Figure 3.14 Capacitor value 10 microfarad

3- c4 capacitor value " 1000 microfarad" up signal emerging from the operational amplifier tda2003 entrance to the computer to display the signal

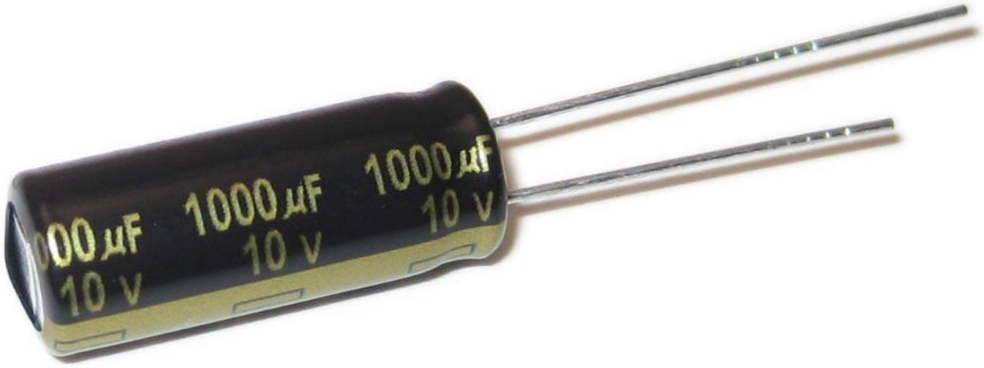


Figure 3.15 Capacitor value 1000 microfarad

4- the rest of the elements dealing with the internal tda2003 circuit due to the high value placed on a separate form through the legs ""

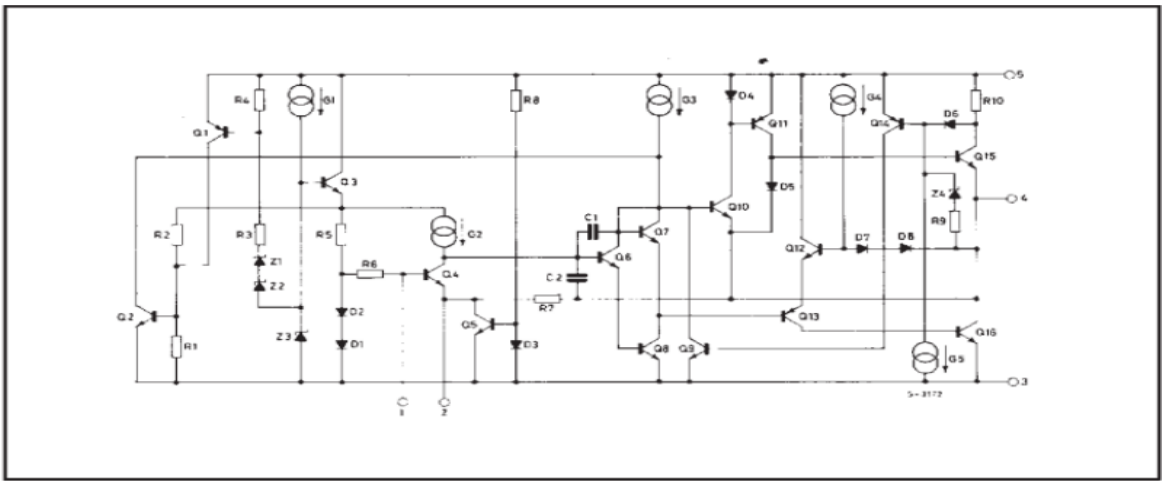


Figure 3.16 Rest of TDA 2003

5- resistance " variable " to adjust and to get the best amplitude of the signal " after the c4"

Figure 3.17 Variable Resistance

6- audio output of the blade to the computer

Figure 3.18 Audio output

7-power

Figure 3.19 Power supply

8- Adobe Audition for display the signal

Matlab Software

MATLAB provide DSP algorithm designers, system architects, and embedded hardware and software engineers with a comprehensive set of tools that address the challenges of shortened design cycles for systems with increasing complexity. With MATLAB , you can Develop digital signal processing (DSP) algorithms   Model and simulate systems Verify and validate your hardware and software implementations

3.9 Sound Processing in MATLAB

Part work in Matlab was used MATLAB to apply filters references analogue saluting We take the output signal of the audition which is about an audio file format wave "could be in any other format," and then we read and apply the filter appropriate, and then painted and thus we get the signal-free noise or other signals that affect the shape of the heart signal

3.10 What is digital sound data?

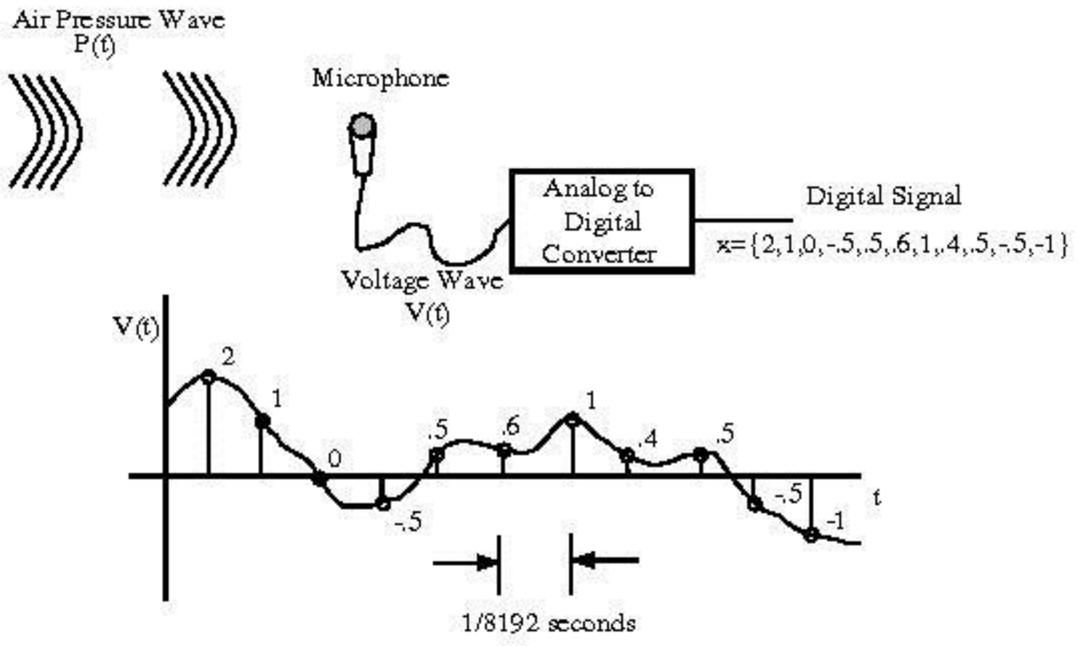


Figure 3.20 Digital sound data

Loading Sound files into MATLAB

We want to read the digital sound data from the .wav file into an array in our MATLAB workspace. We can then listen to it, plot it, manipulate, etc. Use the following command at the MATLAB prompt:

```
[heart, fs] = wavread('C:\Users\FARIS\Desktop\heart.wav');
```

The array heart now contains the stereo/mono sound data and fs is the sampling frequency. This data is sampled at the same rate as that on a music CD (fs=44,100 samples/second).

Or it can be in other rates as we configure the recorded file in Audition.
See the size of heart: Let’s plot the data versus time. Note that the plot will look solid because there are so many data points and the screen resolution can’t show them all. This picture shows you where the signal is strong and weak over time.

```
time = (1/fs) * length(heart);

t = linspace(0, time, length(heart));

plot(t, heart)

xlabel('time (sec)');

ylabel('relative signal strength')
```

Let’s plot a small portion so you can see some details

```
time = (1/fs) * 2000;

t = linspace(0, time, 2000);

plot(t, heart(1:2000))

xlabel('time (sec)');

ylabel('relative signal strength')
```

Let’s listen to the data (plug in your headphones). Click on the speaker icon in the lower right hand corner of your screen to adjust the volume. Enter these commands below one at a time. Wait until the sound stops from one command before you enter another sound command!

```
soundsc(heart ,fs)
```

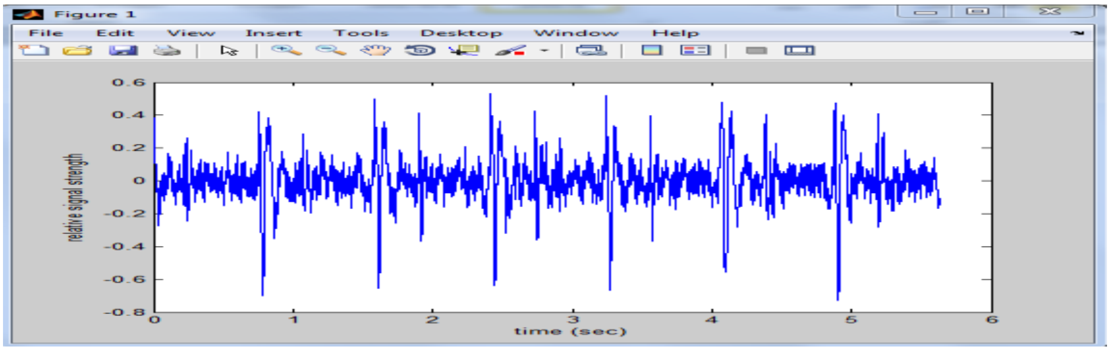


Figure 3.21 Sound in MATLAB

Adobe audition

We connect the circuit and record an audio clip of the heart rate and saved wave format and then submitting it to the window we have Adobe Audition 3.0 and we took a section of this signal

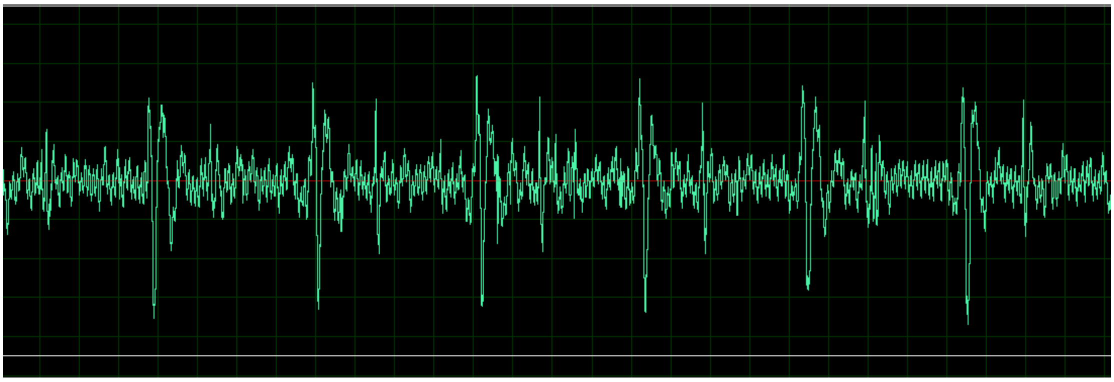


Figure 3.22 Adobe Audition

Chapter 4

Conclusion and future work

The measurement and recording of electrical activity of the heart is an important and essential tool in order to analyze and diagnose the medical problems associated with the heart.

the aim of this project is to record the audio signal generated by the heart using a microphone and then using MATLAB software to filter the recorded signal and its variables "P, QRS, T, PR, ST, QT" is tangible evidence or practical to explore problems after taking the signal and then enlarge through the amplifier and the problem in this reference it is sensitive to noise so answers measured in a quiet place, but through filtering reduce this problem

Possible in the future development of the circuit to display the heart rate through wireless instead of wire audio. It can add it to counter heart rate to be used in other areas such as sports machine field and walking machines as well as possible filters for signal and become clear over the old circuit

Figure 4.1 Future work

Reference

Books:

Bioelectromagnetism (Malmivuo & Plonsey)

Cardiovascular_Physiology_Concepts

Web site:

http://pdf.datasheetcatalog.com/datasheet/SGSThomsonMicroelectronics/mXutuqt.pdf

http://pdf.datasheetcatalog.com/datasheet/SGSThomsonMicroelectronics/mXutuqt.pdf

http://en.wikipedia.org/wiki/Heart_rate_monitor