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A Study to Determine the Intensity of Electromagnetic Fields of Low Frequencies Resulting From Power Transmission Lines and Switching Stations with Voltages (400-220-30-11)KV

Thesis submitted as a partial fulfillment of the requirement for the degree of Master of Science in Electrical Engneering

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Dedications

To my mother, my family.

Acknowledgment

My grateful thanks to Allah the almighty first for blessing me to finish this work, which would never be completed without his willingness.

I would like to express my gratitude to my research supervisor Prof. Rajab Alarabi Ibsaim, for his unlimited support, guidance, and continuous advice during my research activities.

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To my mother, my wife, my family as well deserve a special mention for their continued prayers to success and for their role of keeping my motivation strong to finish my project.

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Abstract

The electromagnetic field is considered to be one of the physical factors in the environment that surrounding us which has an undesirable effects on humans and living organisms. It has a special physical form, which is the combination of the electrical and magnetic properties of the sources of radiation. The most important factors of the mentioned field are frequency, wavelength and speed of propagation of electromagnetic waves. Members of the known sense cannot sense electromagnetic radiation, however; its effect is through the absorption of tissue to the radiation, which consequently results in the formation of static waves in the body. These static waves will concentrate the thermal energy in the body, which leads to an increase in the body temperature and local heating of tissues and cells. This heating is considered very dangerous to non-protected tissue such as the brain, eyes, intestines........ etc.

The electromagnetic field changes the behavior of the cells as it weakens the activity of the molecules and leads to the blackening of the eye crystal and skin diseases. Also, It leads to chronic changes in the functions of the nerves and blood vessels, which are characterized by the following symptoms: persistent fatigue, insomnia, high blood pressure and some cases of hysteria. The full protection from this radiation and its effect may not possible, however; there are some methods that can reduce the effect of this radiation.

This work concentrates on measuring the intensity of electromagnetic field associated with high and medium voltage lines, switching stations and electric home appliances in different places in Libya. The measured values of the electric and magnetic fields are the checked against the exposure limits set by some of the international organizations such as ICNIRP and IEEE. The obtained results from this work shows that most of the measured values are well below the set safety limits.

المستخلص

المجال الكهرومغناطيسي يعتبر من احد العوامل الفيزيائية في الوسط البيئي المحيط بنا والذي له تأثير غير مرغوب فيه على الإنسان والكائنات الحية ، وله خواص مادية حيث يتمثل في الجمع ما بين الخواص الكهربية والمغناطيسية لمصادر الإشعاع واهم عوامله هي التردد وطول وسرعة الانتشار ، الإشعاع الكهرومغناطيسي لا يمكن تحسسه بأعضاء الحس المعروفة ولكن تأثيره يتم عبر امتصاص الأنسجة للأشعة والذي ينتج عنه تكون موجات ساكنة في الجسم تتركز منها الطاقة الحرارية مما يؤدي إلى ارتفاع في درجة حرارة الجسم وتسخين موضعي للأنسجة والخلايا ويكون هذا التسخين خطرا جدا على الأنسجة غير المحمية من الأشعة بشكل جيد مثل الدماغ والعين والأمعاء ....الخ .

والمجال الكهرومغناطيسي يغير من سلوك الخلايا حيث يضعف نشاط الجزيئات ويؤدي إلى تعتيم كريستال العين والإمراض الجلدية، كما انه يؤدي إلى التغير المزمن لوظائف الأعصاب والأوعية الدموية والتي من أعراضها الشعور بالإرهاق المستمر والأرق وارتفاع ضغط الدم وبعض حالات الهستيريا والحماية الكاملة من هذه الإشعاعات وتأثيرها قد لا تتوفر ولكن هناك بعض الأساليب التي تقلل من حدة تأثير هذه الإشعاعات.

يرتكز هذا العمل عل قياس شدة المجال الكهرومغناطيسي المرتبطة بخطوط الجهد العالي والمتوسط ومحطات التحويل والأجهزة الكهربية المنزلية في أماكن مختلفة في ليبيا ثم التحقق من القيم المقاسة للمجال الكهربي والمجال المغناطيسي مقابل لمستويات التعرض المسموح بها التي وضعتها المنظمات الدولية مثل(IEEE، ICNIRP).

أظهرت النتائج التي تم الحصول عليها من هذا العمل أن معظم القيم المقاسة اقل بكثير من مستويات السلامة المحددة.

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List of abbreviation and symbol

Hz	Hertz
ELF	Extremely Low Frequency
HV	High Voltage
EMF	Electro Magnetic Field
ICNIRP	International Commission on Non-Ionizing Radiation Protection
NRPA	National Radiation Protection Association
FCC	The Federal Communications Commission
ANSI	American National Standards Institute
IEEE	The Society of Electrical and Electronics Engineers
ACGI	American Conference on Government Industries
PCSS	Personal Communication Service System
T	Tesla
μT	Micro Tesla
G	Gauss
mG	mille Gauss
E	Electric field
H	Magnetic field
P	Active power
Q	Reactive power

Chapter One: Introduction

1.1 Introduction

The Human logic, high-level income per person and technical industrial revolutions have led to the continuous and rapid increase in the use of electrical equipment in all aspects of modern life in houses, factories, facilities and modern means of transportation. This requires an increase in the consumption of electricity therefore more need of generated energy and the spread of networks of transmission and distribution of electricity all over the world has increased.

Power transmission lines, distribution networks, and electrical equipment are the main source of electric fields and low-frequency electromagnetic fields (50-60 Hz) to which the general public, some engineers and technicians working in electrical field are exposed .

Sources of electric fields and magnetic fields are considered pollutants to the environment. These pollutants, like other pollutants, can have serious effects on the human body, leading to serious health problems if it exceeds certain limits. These are classified according to frequencies, for example, electric power frequencies (50 - 60 Hz), which is known as Extremely Low Frequency (ELF) in the frequency range (0 - 3000 Hz) while the frequencies of the mobile phone (900 - 1800 MHz) are located in the band (300 MHz - 3 GHz), known as the Ultra High Frequency.

1.2 Literature Review

Electromagnetic waves are a factor of environmental pollution, and several studies have shown the impact of waves on humans and animals on a global and regional scale. Over the past three decades, researchers have been able to obtain some non-benign information of electromagnetic waves coming from electric power transmission lines, different communications devices, radio, video, broadcast stations and others.

As it has been found by H.Ahmadi et. al. The warning is for individuals who are under the High Voltage (HV) lines for long times like workers in HV who may get some harmful effects . They pointed out that alignment of the wires affects the resulted electric field of transmission lines (TL). This study also looked at the best 230kV structure that reduces the electric and magnetic fields effects and found that the circular structure has the least effect. The authors have refered to some other studies that looked at methods to decrease the field intensity, many designs have been proposed, one method is to compact the former towers which also has been discussed in other literature. Conductor bundling will mitigate the electric field by 25% to 30%. Placing the wires close to each other will decrease the electric field, but the safety of system would decline[1].

According to the reference (EMF JUNE 2002) American Medical Association In 1995, the American Medical Association advised physicians that no scientifically documented health risk had been associated with “usually occurring” EMF, based on a review of EMF epidemiological, laboratory studies, and major literature reviews[2].

It has been mentioned that there is an effect on a person when he is exposed to electromagnetic fields that may cause cancer. Some of them have noticed that some of the children have died of cancer diseases when exposed to the waves of the electromagnetic fields and their percentage has hit two of every three children in areas near electric power lines in [3].

Regarding the effect of the electromagnetic field at intermediate frequencies, the report stated that more studies must be done to find out the effect of the electromagnetic field at these frequencies. As for the infinitesimal frequencies, the report indicated that there may be a relationship between exposure to the electromagnetic fields resulting from these frequencies and leukemia in children. As for the relationship with breast cancer and cardiovascular diseases, it is not possible, with regard to neurological diseases and brain cancer. This matter is under study and research. The biological effects of electromagnetic radiation and their classification have been clarified in[4].

Visual devices and computers have been studied and this study concluded that the household electrical equipment cause a good amount of radiation from the electromagnetic field and is within the permissible limits for humans, although these devices that operate at low frequencies do not cause any harm to humans, as they constitute electronic waste and the research indicated that mobile phones affect largely on the health of people indirectly through incorrect use [5].

The author warned of several dangers of electromagnetic radiation to children's health, as it stipulated that absorption of electromagnetic energy through the head for children is greater than adults, living cells of children are more sensitive to the electromagnetic field as the brain of children is more sensitive The negative cumulative effect in cases of chronic exposure to the electromagnetic field [6].

The effects of low-frequency electromagnetic waves up to the visible light frequency are limited to cells and ordinary materials by heat and heating and thus depend on the strength of radiation [7]

The damage of the electromagnetic waves is usually a result of cumulative doses affecting human health, after some time has passed, and also the electromagnetic fields are produced in homes when operating electrical appliances and equipment. When the individual is close to this machine or device, he will be vulnerable to electromagnetic waves that penetrate his body and may expose him to danger, as well as the presence of houses very close to the transmission lines of electrical energy. Early clinical and many clinical types of research agree that no proven health damage was demonstrated as a result of exposure to electromagnetic radiation at levels less than 0.5 mm / cm^2, but exposure to levels higher than this and with cumulative doses may cause it to appear. Many of the symptoms, including (general symptoms such as fatigue, headache, and tension, organic symptoms appear in the cerebral nervous system and cause lower rates of fatty focus, behavioral changes, frustration and the desire to commit suicide, and organic symptoms appear in the visual system, the cardiovascular system, and the immune system) [8].

Stewart's report states that brain cancer has not been scientifically proven as a result of exposure to electromagnetic waves, but it must be taken into account that these waves have a thermal and biological effect in the form of (insomnia, headache and temporary loss of memory) and these effects depend on the frequency of the waves and the ability of the energy to be within the body’s tissues in addition to the length of exposure to these waves [9].

Dr. Omar Muhammad Abdullah stated that electromagnetic waves can enter the human body and interact with its cells and cause biological changes in it in a way that may result in imbalance and strike in the performance of various body systems, especially the circulatory system, reproductive system, brain, and nerves [10].

1.3 Purpose of The Study

This study aims to measure and determine the intensity of the electromagnetic fields resulting from the transmission lines of the electrical energy as well as the distribution networks and to determine the intensity of the radio magnetic from the transfer stations at different levels of their voltages, and compare them to international standards and to know their impact on humans and the environment.

1.4 The Importance of Studying

The importance of this study is due to controversy in most of the developed and developing countries on the negative impact of electromagnetic fields on human health, and doubts that the main cause of some diseases and if Allah Almighty to reach the end of this study will express an important reference to the electric engineers about electromagnetic pollution, and knowledge of the current global situation about its impact on humans.

1.5 Expected Results

After taking the field measurements and data analysis, we expect to obtain the following results:

1-knowledge of the intensity of electric fields and magnetism resulting from transmission lines of electric power.

2- Determine the severity of the magnetic leakage from the transfer stations according to their levels of voltage.

3- To know the extent of the impact of these areas on human health as well as environmental impact.

4- Determine whether the measured values are consistent with international standards.

5- The use of Libyan standards and safe limits compared to international safe limits (distance).

6-Field measurement of the intensity of electric fields and magnetism to some 400KV high voltage power transmission lines as well as 220 Kv high voltage and low voltage 30KV will be done for power transmission lines, for transfer stations will measure transfer station from 400 kV to 220 kV, and transfer station 220kv to 30 kV and transfer station 30kv to 11kv and transfer station 11kv to 0.4 kV.

1.6 Scope of Thesis

This thesis is classified into five chapters as follows :

Chapter one: " Introduction." literature review, the purpose of the study, the importance of the study, expected results, are explained in this chapter.

Chapter Two: "Electromagnetic Field" An overview of Electromagnetic Field and its impact on humans and international standards for electromagnetic fields.

Chapter three: " Introducing High Voltage TransmissionTowers Fields ", An overview of transmission lines and the device used to measure .

Chapter four: Selected locations field measurements and results.

Chapter five: Conclusion and recommendations.

Chapter Two:Electromagnetic Field

2.1Electromagnetic Radiation

In the year 1820 [11], the scientist Orested discovered that if a current passes through a wire, it creates a magnetic effect represented by the deviation of a magnetic needle placed next to the wire. This discovery linked a relationship between electrical science and magnetic science, magnetic spectrum, electromagnetic radiation or waves. All electromagnetics have the same physical meaning, that visible light, microwave radiation, X-rays, gamma rays, television waves, and radio waves are all rays known as Electromagnetic Radiation, and they all have the same characteristics, but they differ in Wavelength and Frequency. In Figure (1.2), note that the longer the wavelength increases, the less the frequency and the opposite is true. For us to understand these interactions, it is important learn about the physical properties of the waves that make up the magnetic spectrum.

2.2Physical Properties of Electromagnetic Radiation

Electromagnetic radiation are waves that travel at a speed of 300 thousand kilometers per second and carry energy called photons. These fields consist of two fields that spread in two perpendicular directions, the electric field and the magnetic field. The photon is launched in the direction perpendicular to both directions. The three factors have relations with each other, and each of them plays a certain role in the effect of the electromagnetic field on the biological system. The frequency of the electromagnetic wave is defined as the number of vibrations that pass through a fixed point in a unit of time.The average working frequency of an AM radio broadcast station is million Hertz and the wavelength is about 300 meters.Microwave ovens are using frequency of 2.45 GHz and the wavelength here is equal to 12 cm [11].

The energy of the photon is directly proportional to the frequency of the wave. The higher the frequency of the wave, the more energy the photon carries. The energy of the photon is estimated according to the frequency of the wave and is calculated by the relationship [12].

F (2.1) Energy = Planck constant × frequency

If the frequency is (Hertz) and Planck's constant is (Joule - sec), the energy will be in (Joule), the electromagnetic radiation has a wavelength and frequency that determines its properties and the speed of the electromagnetic radiation is related to the frequency and wavelength through the equation [12].

F (2.2) Speed = frequency × wavelength

As shown in Figure (2.1), the electromagnetic spectrum starts from radio waves of long wavelength and low frequency, then the microwave and infrared regions, then the visible radiation area, then the ultraviolet radiation area, then the X-ray region, then the gamma-ray region

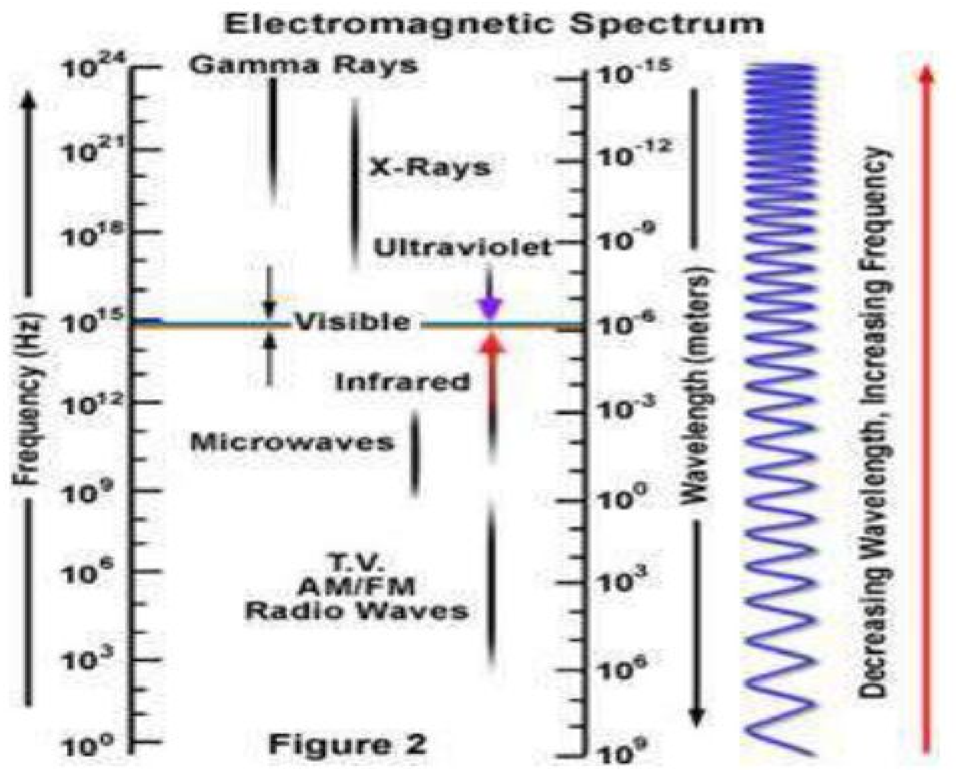


Figure (2-1)The relationship between the speed of the electromagnetic radiation with wavelength

This sequence is depending on the increase in the frequency of these waves, and each region of the electromagnetic spectrum has characteristics that distinguish them from each other. Accordingly, different applications have been produced for this radiation.

Electromagnetic waves on biological systems on the one hand have strong fields and on the other hand the photon energy [13].

2.3.1Types of Electromagnetic Waves

Electromagnetic waves are classified according to their frequencies and energy into ionizing radiation and non-ionizing radiation.

Ionizing rays are electromagnetic waves that have very high frequencies such as (X-rays and gamma rays) and their energy is very high enough to induce the process of the ion (meaning the formation of atoms or parts of molecules charged with negative or positive charges). Non-ionizing radiation is a general term,where part of the electromagnetic spectrum has a weak photon energy to the point where it is not able to break atomic bonds, and this part of the spectrum includes (ultraviolet, visible light, and infrared, Radiofrequency or Wireless, microwave fields, fields with very weak frequencies, as well as static electrical and magnetic fields), non-ionizing radiation even if their intensity is high cannot cause ionizing events in the biological system, yet they cause other biological effects, for example by raising the temperature or changing a stream chemical reactions in tissues and cells [14].

2.3.2The Difference Between Ionizing Radiation and Non-Ionizing Radiation

The interaction of the biological material with the electromagnetic waves produced by a source depends on the frequency of this source, so we find the X-ray waves and the waves resulting from the high-voltage lines that represent parts of the electromagnetic spectrum. Figure (2.2) shows this spectrum and the frequency range used in different applications, at the X-ray frequencies and they operate Space 1017 - 1019 Hz, the electromagnetic quantities have sufficient energy (40EV-40MEV) for the difference of the atoms or molecules of the medium that are exposed to these rays, as well as for breaking the chemical bonds of the molecules of the material. The appearance of genetic abnormalities and such radiation is defined as ionizing radiation, but at low frequencies, an electromagnetic radiation cannot break the chemical bonds and therefore it is said that they are not ionized and there is no similarity between them and the ionizing radiation from a biological point of view.

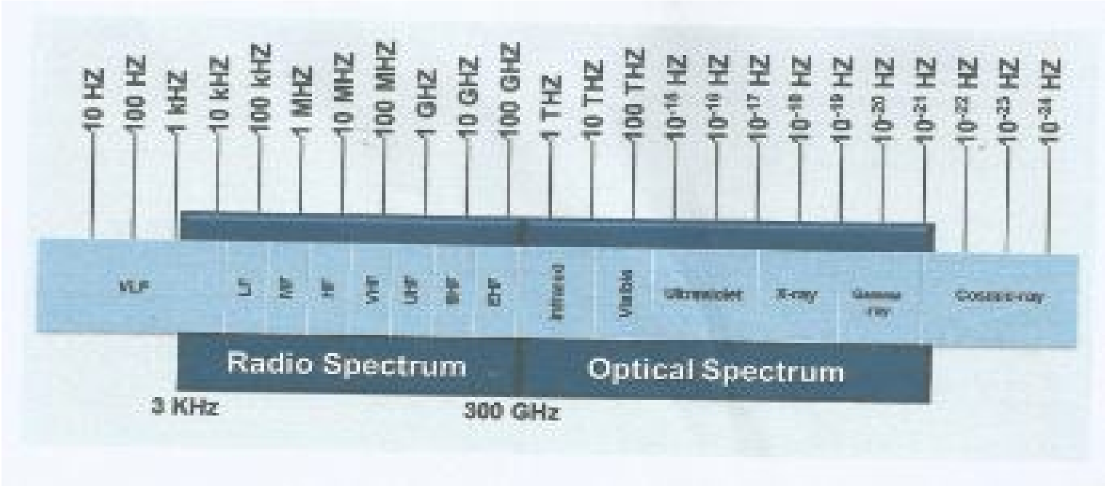


Figure (2-2) It shows the electromagnetic spectrum

2.4The Biological Effect of Electromagnetic Radiation

The level of biological impact depends on the frequency, and intensity, as well as the generation system, and the length of the influence of the electromagnetic field and the effect intensity varies with different frequency ranges. The lower the wavelength, the greater its energy. The high-frequency radiation is the tension of the atoms or molecules in the cells and thus it disturbs the current processes inside these cells. Electromagnetic oscillations of long waves can provide molecules with kinetic energy, and therefore the primary effect of electromagnetic radiation is heating that leads to alteration or damage to tissues and devices most sensitive to this radiation such as the nervous, immune, hormonal, and reproductive systems.

2.4.1 The effect of electromagnetic radiation onthe nervous system

A large number of studies have confirmed that the nervous system is one of the most sensitive devices to electromagnetic radiation in the human body. When a low-density field is affected, this leads to the emergence of perceptible diffraction in which to send nerve impulses, weakness in memory, and an imbalance in the formation of the capillary barrier of the brain, which leads with time to Chronic brain diseases and in a special condition,the fetal nervous system is more sensitive to electromagnetic radiation, especially in the last period of pregnancy.

2. 4.2 The effect ofelectromagnetic radiation on the immune system

Many facts are indicating the negative effect of electromagnetic radiation on the immune system as it suppresses the thymus gland (thymus), which produces the cells of the immune system, which leads to a change like the infection-resistance process.

2.4.3 The effect of electromagnetic radiation on the hormonal system

Studies on the effect of radiation on the hormonal showed that radiation creates stimulation and stimulation of the pituitary gland accompanied by an increase in the hormone adrenaline in the blood and the activation of blood clotting processes inside the blood vessels. A change in the cerebral membrane and cerebellum structure was also observed.

2.4.4 The effect of electromagnetic radiation on the reproductive system

Sexual dysfunction is associated with a change in its control in terms of the nervous system and hormonal system, as well as the sudden decrease in the activity of the reproductive cells. It has been proven that the female genital organs are more sensitive than the male genital organs and the sensitivity of the fetus to this radiation is greater than the mother's sensitivity to it and it has also been proven that the exposure of a pregnant woman to radiation has led to an affects on the normal rate of development of the fetus and that the percent female when exposed to radiation may cause them to drop the fetus by 1.5% and the fetus may generate distorted by 2.5%.

2.4.5 The effect of electromagnetic radiation onhuman health

The results of many studies have shown that long-term exposure to electromagnetic radiation in a very high-frequency range can lead to a disease called radio wave disease and this disease is characterized by the functional change of the nervous system as people who are located for a long time in the radiation area crossed by complaining about their sense of weakness and alienation continuous fatigue, poor memory, and sleep disturbance. As for the effect on the circulatory system, it is summarized in high blood pressure, pain in the heart, and instability of the pulse. This radiation leads to the appearance of opacity in the crystal’s eye. As for the medium-frequency radiation, it causes a change in alum,the cautery of the eye also leads to a change in the bone marrow of some individuals who are exposed to radiation for long periods and without interruptions of 1-3 years, while others appear to have a sense of tension and internal emotion and lack of complete control of their behavior, as well asa disturbance of attention, focus and weakness in memory and there are also many complain Of the inability to sleep deeply and comfortably and severe fatigue, and data are available on the emergence of mad cases in some people who have been exposed to radiation of intensity exceeding the level allowed for at least five years.

The issue of the effect of electromagnetic waves in the frequency range (3 kHz - 300 GHz) on humans is of the utmost importance in this era in which mobile communication networks are widely spread and this requires the establishment of large networks of transmitting and receiving stations within populated areas, and it is worth mentioning here that there are many among the recommendations and guidelines issued by many international organizations in this regard, which set safety limits that must be observed, especially the intensity, density and capacity of electromagnetic fields, and the most important foundations and bodies that took care of this issue: -

-International Commission on Non-Ionizing Radiation Protection (ICNIRP).

-National Radiation Protection Association (NRPA).

-The Federal Communications Commission (FCC).

-American National Standards Institute (ANSI).

-The Society of Electrical and Electronics Engineers (IEEE).

-American Conference on Government Industries (ACGI).

2.5 Safety levels of radio wave exposure

Table (2.1) shows the reference levels of the fields and the permitted electromagnetic power according to the specifications (IEEE2002 and ICNIRP 2010).

Table (2.1) Reference magnetic field levels at 50 Hz (IEEE 2002, ICIRP 2010) [15]

	IEEE 2002	ICNIRP 2010
GENERAL PUBLIC		
Exposure general	Not specified	200 µT*
Exposure to head and torso	904 µT	Not specified
Exposure to arms and legs	75,800 µT	Not specified
OCCUPATIONAL		
Exposure general	Not specified	1,000 uT*
Exposure to head and torso	2,710 µT	Not specified
Exposure to arms and legs	75,800 µT	Not specified

Table (2.2) Maximum exposure values of the electromagnetic field in multiple environments [16].

Table 1. EM exposure in various environments.

Source	Typical maximum public exposure	
	Electric field (V/m)	Magnetic flux density (μT)
Natural fields	200	70 (Earth's magnetic field)
Power transmission lines (beneath the lines)	10,000	20
TV and computer screens (at operator position)	10	0.7
	Typical maximum public exposure (W/m²)	
TV and radio transmitters	0.1	
Mobile phone base stations	0.1	
Microwave ovens	0.5	

Source: http://www.who.int/peh-emf/about/WhatisEMF/en/index4.html

Table (2.3) values of the wave absorption rate for some mobile devices [16].

Table 2. SAR values of some common mobile phones.

Model	SAR Value (W/kg)
Motorola	
C359	0.90
E360	0.482
V60i	0.71
Nokia	
2100	0.55
5100	0.48
6100	0.60
7650	0.35
8910i	0.43
Samsung	
C100	0.253
V200	0.685
S300	1.14
A800	0.961

Whereas Table (2.2) shows the maximum exposure values for the magnetic field in multiple environments, and Table (3.2) shows the absorption rate of electromagnetic waves for the most used mobile phones.

The values shown depend on the frequency, where laboratory results showed that the absorption of electromagnetic radiation at the radio frequency depends on the frequency and that the frequency range (30 MHz - 300 MHz) is the range in which the human body begins to be more likely to absorb radio energy when exposed to the far-field of the transmitter source and the boundaries are determined Safe in terms of the intensity of the electric field, the magnetic field, and the energy density. At low frequencies, the intensity of the electromagnetic field is the most appropriate criterion, but at high frequencies, given the short wavelength, the field is usually the far-field of the source and it is sufficient in this case, the energy density is specified.

The mobile phone frequency range is (800-900 MHz), so the maximum permissible power density value for this system is (0.53 -0.6 mW / cm^2) on average, the frequency range for the Personal Communication Service System (PCSS) is (1850-1950). MHz). Therefore, the average permissible power density for this system is (1.26 mW / cm^2), and the cordless phone ranges between (45 - 2200 MHz) and the permissible power density ranges from (0.2 - 1.7 mm) W / cm ^{2}).

There are also safety limits when exposure to what are known as radio pulse fields in the frequency range (100 kHz - 300 GHz) The maximum permissible value to exposure in terms of the electric field 100 kV / m. For the same frequency range if the time of the pulse duration is less than 100 milliseconds, then the maximum permissible power density exposed to one pulse has the equivalent value of the power density of the electric field shown in the fourth column of Tables (2.2) and Table (3.2) using the relationship:

Maximum value of field exposure ={ power density x mean time per second } / {5 x amplitude per second}

The number of pulses during a period equal to the meantime should not exceed 5 pulses, and the period of the pulse repetition should not be less than 100 milliseconds. It is that during any time of 100 milliseconds, the power density is determined from the relationship shown above.

2.6 International Standards for ElectromagneticFields

Initially, we must address the permissible values of exposure to electromagnetic fields according to international organizations:

The magnetic field is measured in (Gauss, Tesla, or amps/meters) as 1 Gauss may cause a current whose density is about(100 NanoAmper / cm^2) in the subject to it and also an electric field with a density of 1 kilovolt/meter causes a current whose density is about (30 NanoAmper / cm^2). Many researchers pointed out that it is difficult to say there is a value that can be taken as a safe value for the electromagnetic field for human exposure due to the difference of reference values from country to country or city to city, where in the United States of America most states did not set specific values allowed for magnetic fields. The American Conference on Government Industries has set exposure limit for workers to 25KV/m for electric field, and 10 G for magnetic field , while the states of New York and Florida put the values of (1.6 kV / m) and 200 gausses for both electrical and magnetic field respectively. California considered that the safety limit in the tread is (1.2×10^{-7}Tesla) and in other cities the safety limitof(4×10^{-7}Tesla) as the maximum permissible value. As for some cities, set(2×10^{-7} Tesla), while others went down to (1×10^{-7} Tesla), and the average recommended occupational exposure limit is (20×10^{-3} Tesla) per workday, and determining (40×10^{-3} Tesla) as a marginal value for continuous exposure to the general public, while in Switzerland the value was(2.5×10^{-7}Tesla) is the reference value for weak and mean electromagnetic fields Plan, while in Japan, the electric field value that was allowed for exposure is (3 kV / m). Russia allowed its values associated with a time of exposure where it is set to less than(5 kV / m), not there any particular period, but when exposed to an electric field between(5- 15 kV / m) must not be more than 3 hours per day, either if the value has increased from (10 to 15 kV / m) must not increase exposure for an hour per a period of a day and not to exceed the exposure period daily to 10 minutes if the field value of the electric field is between (15-20 kV / m) and it is not allowed to expose the body to an electric field of (20-25 kV / m) for more than 5 minutes per day [3,11].

From the above, it can be noted the difference between one country and another. It is worth noting that these limits must coincide with the distance from the sources of the electromagnetic waves. Some field measurements will be performed and the obtained results will be recorded and then compared with these values.These values will be checked against the international standard set safety limit values.

Chapter Three: Introducing High Voltage TransmissionTowers

3.1 High Voltage Transmission Towers

Electrical power lines are distinguished by the electric and magnetic fields around them. The intensity of the electric field depends on the intensity of the voltage while the strength of the magnetic field depends on the intensity of the current and the intensity of the elctomagnetic field also depends on the distance from the line.

Several factors affect the design of electrical towers, the most important of which are:

- Electrical voltage used
- The number of circuits the tower holds
- The distance between the towers
- Climatic factors to which the line is exposed (winds - snow - the intensity of heat, etc.) and also the nature of the land (mountains of desert plateaux, etc.).
- The diameter of conductors and the distance between them

Most of the towers have a height of 50 meters, but there are special cases, where in China there is a tower at a height of 370 meters and also in Egypt, there are two towers at a height of 221 meters located in the Suez Canal .

3.2 Towers charcterstics

High voltage towers installation consists of the following:

1. towers

2. Insulators

3. Conductors

4. Ground line

5. Vibration dampers

6. Wire breaks and metal grommets

The height of the towers often ranges from 15 to 55 meters[16]. The minimum distance between the conductors and the ground is as follows:

33kV, 5.1 meters and 66 kV, 5.49 m 132 kV, 6.1 m 220 kV, 7.015 m 400 kV, 8.840 meters. The distance depends on the voltage value first and also the gap allowed so that the conductors do not come into contact at the time of the wind blowing. The optimal distance between the high voltage towers , wind is the distance that gives less cost to the line with the provision of the limits of safety required and performed calculations per kilometer after determining whether the line is single or double, will it be placed in a normal flat land or on the land of trees with its rock. Then identify some of the data such as the strength of the intensity of conductors at the lowest temperature that have made these conductors at the highest temperature. They have taken also into account the height of the towers and the length of isolators comment strings pale. In addition to the size and costs of the force counting concrete towers and earthing are usually carried out calculations at the distance of 100 meters between the towers and then gradually increase up to 500 meters. Then choose the distance that gives the least cost and ,calculate these accounts by special programs to get results quickly and must also take into account the existence of appropriate spacing distance of buildings and trees for lines path so that if trees fell for any reasons they are not to fall on the lines and the need to estimate the maximum length up to the length of the tree.

The installation and construction of the tower body are one of the most difficult because it requires high skill in installing the pieces to each other and there are three ways to install the towers:

- Manual installation, whereby in this way the manpower is relied upon, where the parts of the tower are assembled stage by stage with each other according to the design of the tower.
- Installation by the crane in lifting the parts, a method that is done by using the crane machines to raise the parts to the place specified for installation, as in this way it depends on the place in terms of moving freely for the lifting machines.
- Installation by helicopter to raise the parts of the tower, as this method is used when the place where the tower is to be installed in small or insufficient to

assemble the parts of the tower in it where the tower parts are assembled in a place and then transferred by helicopter to be installed at the desired location

3.3 Types of Constellations

The towers consist of three main towers .

3.3.1 Suspension Towers

The caustic towers of high-voltage lines are usually made of galvanized steel, and the type of tower is determined by the method of installing the insulator installed on it or the function performed by it. Because if the insulator was suspended, it is a suspension tower, and if the insulator is tight, it is a tension tower, and the tower that crosses a water block is called a transit tower and these towers forms about 80% of the total number of towers in the line and these towers that are employed to carry the connector only does not fall under any tensile strength horizontal for example, suspension towers form, figure (3 - 1) depends on stability on the presence of two forces to flatten equal on both sides of the tower. The conductors will be affected in all adjacent suspension towers, this type of tower can be distinguished by the presence of one chain of isolators for each conductor at each point of suspension. To avoid the extension of this problem, a tension tower is used after every ten suspension towers.

Figure (3-1) Suspension Towers

3.3.2 Tightening Towers

Whereas, the turret carries mechanical tensile forces independently of the ones that precede it or that follow it, where this tower can be characterized by the presence of two series of insulators at each fixation point so that the conductor between it and the tower that precedes it is linked to the insulators and the link between it and the tower that follows it is attached to the insulator. The second as shown in figure (3-2) tightening to avoid the fall of the wire on all the towers in the event of a cut in it because if all the towers on the line path are suspension towers and a cut occurred in the conductor it will fall on all the towers and thus this will need a great time and effort and a high cost of repair.

Figure (3-2) Tightening towers

3.3.3 Switch Towers

It is through the switch tower figure (3 - 3) switch vases equal distances along the line to balance the inductance and capacitance on the three-phases. For the three gloves along the line, the arrangement of the vases at the beginning of the line must have the same arrangement at the end of it after the exchange process, and the exchange tower must be a tension tower.

Figure(3-3) Switch Towers

3.4 Distribution of the electricity network in Libya

General Electric Company established in the year 1984 and undertake the implementation of projects in the field of operation and maintenance of power grids, power plants, production, and related distribution stations and switching lines power transmission and distribution centers and electrical control, management, operation and maintenance of water desalination plants in our beloved country. The Libyan electricity grid is made up from high voltage lines 400, 220, 30 and 11 KV distributed in vast areas to cover all parts of the country. Figure (3-4) shows the transfer stations (220-66-30 kV) and a network of 220 kV lines and also the figure (3-5) Shows the high voltage electrical transmission system, 400 kV.

Where the 220 kV lines run from the city of Al-Uwaynat in the far southwest, and also distributed to Ruwais and Abu Kamash in the far west of Libya and passes on all coastal cities to Kufra, Tazirbu, and Al- Sirir in the southeast, and extends to Tobruk and the far east of Libya and connects to the Egyptian network. The 400 kV line is distributed from Ghadames in the far southwestern borders of Algeria and is distributed to the Mellitah complex in the far northwest of Libya, passing through all coastal cities. It extends to the bed in the southeast, was Tobruk to, the far north-eastern Libyan[28].

Figure (3-4) The transfer stations (220/66/30 kV) and the 220 kV distribution network in Libya

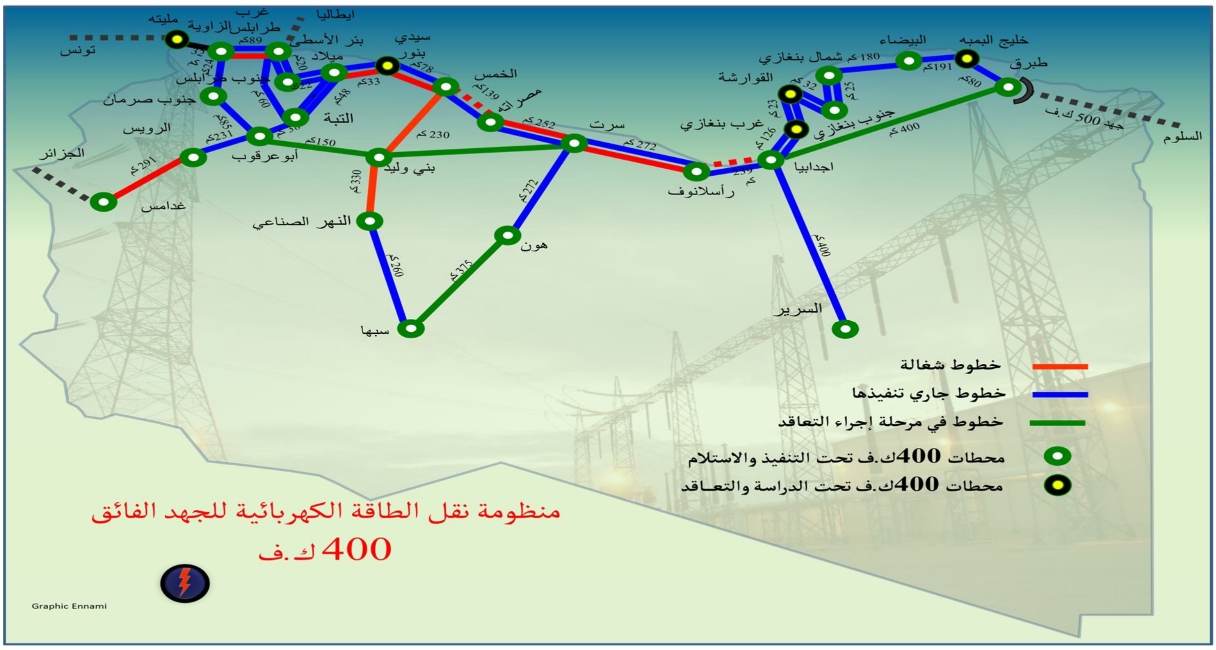


Figure (3-5) The 400 kV voltage transmission system in Libya

3.5 Device used for Measurement

It is a device used to measure low-frequency electromagnetic waves called (HI-3604) shown in figure (3-6). The measurement is made using the waves from the electric power transmission lines in the frequency range from (50 - 60) Hertz.

The electric field can be measured in units of measurement v / m, The magnetic field is measured in units of measure (Tesla-Gauss - Am / m) Where there is a mathematical relationship between them to convert from one unit to another as required:

F (3.1) 0.1µ T(MicroTesla) = 1mG (mili Gauss) = 80 (mA / m).

Note:

In the global unit system, the Tesla unit is used to measure the magnetic field

Strength. Specifications of the device:

- Frequency response from (30-2000)Hz.
- field sensitivity of the electric (1v/m – 200kv/m)
- field sensitivity magnetic (0.2mG – 20G)

3.5.1 Method of operation and measurement

1. Click the on button, then the device will operate automatically to measure the intensity of the magnetic field

2. The change was done to measure the electric field strength or vice versa Mode Select where we notice the unit of measurement appear on the screen

3. When Mode select button is pressed this gives option of selecting 3 positions on the display and thus the field allows us each time 3 options for the buttons on the left, meaning that it allows us to operate the device on 9 patterns of measurement modes as well as the button Mode Select is also used to determine the unit of measurement of the magnetic field.

4. When Mode Select is pressed and by choosing the first column and then pressing the top button on the left to choose the scale, which in turn, will move from auto

setting into position fix. This will give a constant value when measuring and to return to the automatic mode, hold down the right scale a little until it returns to auto on the screen.

5. When using the device at the measurement site, the processor will take the highest value and store it. To show this value, press the button max, the word max will appear on the screen, it shows the highest measured value and when the button max is dissabled it will stop reading.

6. It also uses a button max modify units H-Field and that when operating the device as follows:

When starting up, press and hold Mode Select until Setup Mode is enabled. That is, until it appears on the screen F- # and units H-field. Click on Max to choose the right unit for H- Field. When selecting the appropriate unit, press Mode Select to store this unit in Setup Mode, then leave Setup Mode and start taking measurements with the new unit chosen.

7.When the button E / H is prssed, it will switch the measurement system from the electric field to the magnetic field and the unit of measurement will be visible on the screen, as well as when entering Setup Mode and Mode Select have to be pressed immediately after playback to display F- # and when E / H is pressed, this gives the choice of selecting the operating modes F1, meF2, meF3, meF4, where F1 has the slowest time response so that the difference is from stage to stage, and through experience and practice, any best stage of response is appropriate to for the required measurements, and then exit from Setup Mode and go to the analogy directly.

8. The device comes from a factory in place-2 Stored in memory and when changed to F-3 or F-4, it is automatically stored in the memory.

9. When pressing the button BATT, it shows the battery sign and its value on the screen and the battery sign will appear on the screen also if the battery voltage drops to 7.5V and when the battery reaches 7.25 the screen becomes black and therefore it must be replaced with a new battery.

10. When pressing the button DISP3 / 4 moved on from Digit4 to Digit3 and can return in the same way, in the case of rounding the number because in some cases Digit3 might be easier and better.

11. When pressing the button Clear Data, it will erase all data inside Logging Memory. When the word clr appears keep pressing until the value 000 is displayed, which means memory scanning

12. When pressing LOG, the current reading will be stored inside Logging Memory so the numbers 1-112 appear.

To store in one of these numbers, and so on for each reading it is stored and when the memory is filled, the number 112 will be stored in memory.

13. When pressing the button PREV, it will display another stored reading and remains displayed on the screen until the same button is press again and afterabout 25 seconds will return the current reading. The correct operation of the button will move the screen down towards memory Value identification # 1 Way of the buttonPREV It works when Value # 1 is shown. The value will wrap around the highest recorded value for the number.

14. When pressing the button NEXT the next value will appear on the screen because it is stored in the memory and if the same button is run on the last stored value then the value will wrap around the first value for memory.

15. To use the device to measure the magnetic field, hold it vertically as shown in figure (3- 7a) and press the button MAX to get the most value.

16. The device is adjusted to measure the electric field and place it in a horizontal plane on an insulating surface at a height from the ground as shown in Figure (3-7b) and leave it for 30 seconds and press a button MAX To take the highest value.

Figure (3.6) The device used for measurement (HI-3604)

(a) (b)

Figure (3-7) (a) How to measure the magnetic field (b) How to measure the electric field

Chapter Five: Conclusion and Recommendations

5.1 Conclusions

1. There are some unplanned areas, which are usually named as rondo areas. Many of the building either houses, shops or other facilities are constructed very close to high voltage lines. Since there was no pre-planning for the ses area, high power transmission lines paths crosses over many of these buildings. This of course exposes the residents of theses buildings to electromagnetic field for long periods. Although, according to many studies done worldwide, there is no evidence that these field can cause any chronic despises but causion must be taken in case.

2. Due to lack of planning of the electric power transmission linestracks, where there are some pathways of these transmission lines are close to or cross overresidential buildings , which increases the chance of exposure toelectromagnetic fields , which might icrease health hazards.

3. The obtained field mesurements valuesgive an indication to the General Electric Company on how to setup high voltage lines paths through higly populated areas.

4. The obtained results also indicate that exposure to these fields for short periods is not harmfull since nearly all the measured values of these field were well below the expouser safety limits set by the international organizations such ICNIRP, which are 5 KV/m for electric field and 200 µT for maganetic field for general public and 10 KV/m and 1000µTfor professionals.

5. The obtained results regarding the magnetic leakage intensity levels from tranformers in switching stations also show that care must be taken to be at a safe distance from these transformers, although most of the obtained results are well below the internationally set exposure limits

6. Profeesionals in the field of electricity must take an extra care when working on high voltage lines and in switching stations, although as it is already referred to most of the measured results are well below safety limits, but the exposure to high doses of these radiations might cause some health problems.

7. For home aplliancesstanding directly in front of a microwave, electric oven, and TV screens for a long time may cause some health damage.

5.2 Recommendations

1. We recommend the need to think seriously in the case of determining the paths of high voltage lines or changing these paths through densilypopulatedareas and population expansion in the future so as not to expose the population to health hazards.

2. The necessity of conducting a health survey and conducting periodic health studies and checks on the residents of the homes located below and near the power transmission lines and assessing whether they are suitable for housing or not.

3. Not to establish any homes, sports fields, andparks below or near high voltage transmission lines

4. Relocating the electrical transmission lines that are located in crowded places, if possible

5. Coordination with the competent authorities and the Public Safety Authority in terms of granting legal licenses to build homes located near transmission lines, except after ensuring the degree of safety and security

6. The necessity of wearing insulating clothes for workers in places of magnetic leakage and observing safety standards and not being exposed to electromagnetic fields more than the time designated for that

7. It is preferable to change work sites for workers exposed to magnetic fields generated by high-voltage transmission lines as well as switching stations because of the harmful effects of exposure to these areas may be expected to preserve their health

8. It is preferable for workers exposed to magnetic fields to do comprehensive periodic examinations and to make their health care, the results of which are recorded and followed upon.

9. Not to stand directly in front of microwave, electric oven, washing machine, and TV screens when they are on and take a distance of at least two meters to avoid exposure to the electromagnetic waves coming from them and avoid excessive and frequent use of a hairdryer.

Chapter Four: Field Measurements

4.1 Introduction

At first, it should be clear that results vary depending on time and circumstances were measuring the temperature, humidity, light, and the length of the line and the value of the line load all these factors affect the value of the results and measurements where the field value of the electromagnetic lines of high pressure in the summer is not the same value in the winter and not like in the spring and autumn semester.A number of high voltage lines (400-220-30-11) KV electromagnetic fields were measured in different regions in Libya in order to ensure that the study is as comprehensive and accurate as possible as we measured in the city of Zawia, Tripoli, Alkoms and Sabratha , and we also measured the electromagnetic leakage in switching stations for various levels of voltages and have also done measurementsinside and around 11 KVswitching stations within highly populated areas, and also within the Faculty of Engineering building at Al-Zawiya University. The measurements and results were as follows:

Al- Khomscity - Beer AlostaMilad region in Tripoli, Libya

The measurements were taken from the high-voltage lines connecting the Al-Khoms city with BeerAlostaMiladin Tripoli, as shown in figure (4-1), and they were as follows:

4.2 Line 400 KVAl-Khoms – BerAlostaMilad

This line at time of measurement was loaded with 60MW. Measurement was taken at different distances from centre of tower starting with center of tower then at each 10 m distance from the center upto a distance of 70 meters. The measure ments were taken for both the electrical field and the magnetic field. The obtained were for this line can be seen in table 4.1 and figure 4.2.

Table (4.1) the values of the electric and magnetic field in the 400 KV line

Distances measured in meters(m)	Center of the tower	10	30	50	60	70
Electric field (KV/m)	3.050	1.472	0.99	0.64	0.34	0.17
Magnetic field (A/m)	1.062	0.382	0.047	0.032	0.023	0.014
Magnetic field (μT)	1.33	0.479	0.059	0.040	0.029	0.018

Figure (4-1) The measurement of the electric field and the magnetic field for the Al-Khoms - Beer AlostaMilad

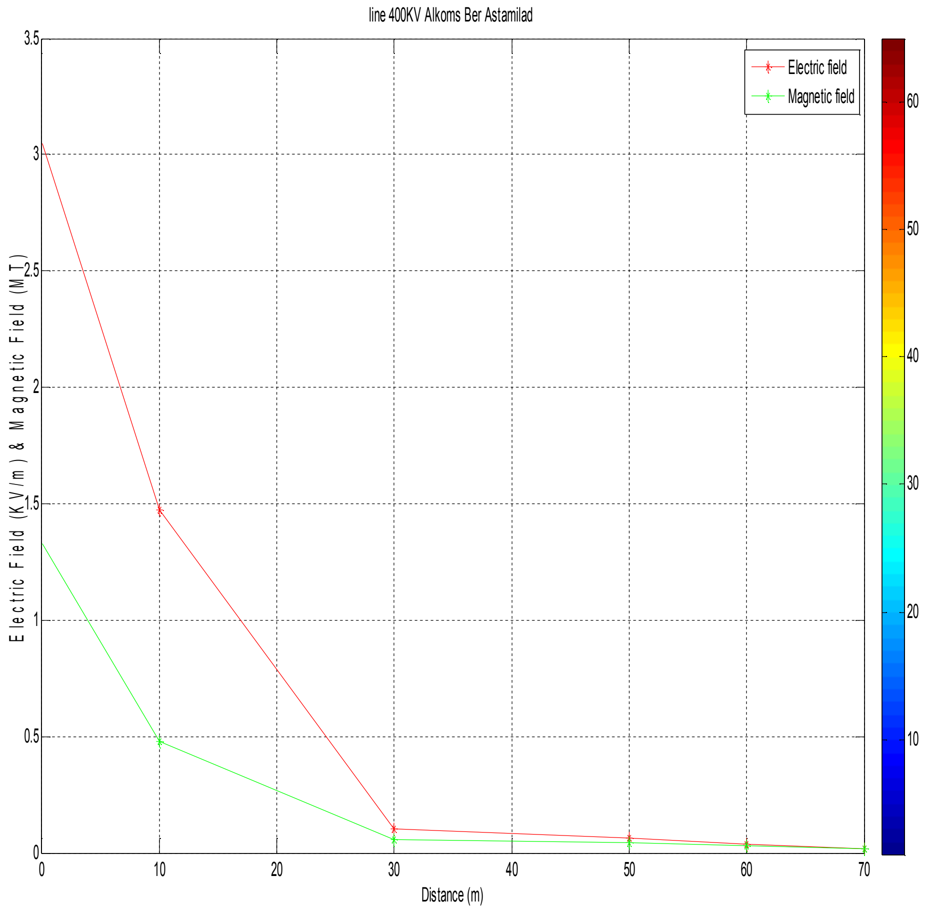


Figure (4-2) The electric field and magnetic field of line400KV Al-Khoms - Beer AlostaMilad

Note:

1. The measurement at the center of the tower was 2 meters near the base of the tower.
2. The measurement at a temperature of approximately 14 degrees .

The measurement was done from the center of the tower, 10 meters from the center, 30 meters, 50, 60, and 70 meters away. The results show that the farther the distance away from the center of the tower, the lower the field value for both electric and magnetic fields. From the table it can be seen that the maximum measured value for the electric field is 3.05 KV/m at the center of tower and the maximum measured value for the magnetic field is 1.33µT at the center of the tower. These values are well below the international saftyornaiztion set limits, which means was per these measured results there is hazards on the general public near this high voltage line.

4.3Line 220KV Al-Khoms – BeerAlostaMilad

The value of the loaded energy of the measurement for this line is (50MW). The measurements were taken of the magnetic field and the electric field from the center of the tower and at different distances as shown in Table (4-2).

Table (4-2) The measurements of the line 220 KV Al-Khums Beer Asta Milad:

Distances measured in meters(m)	Center of the tower	10	20	30	40
Electric field (KV/m)	2.750	1.274	0.373	0.328	0.145
Magnetic field (A/m)	0.419	0.326	0.435	0.036	0.026
Magnetic field (μT)	0.5250	0.4088	0.5450	0.0451	0.0325

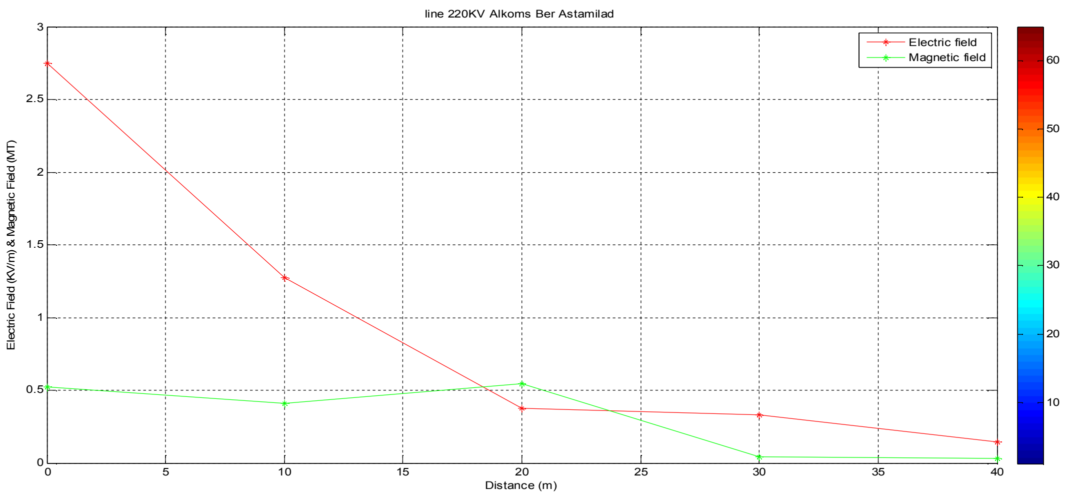


Figure (4-3) shows the electrical and magnetic field line220KVAlkhums Beer Asta Mila

The electric field and the magnetic field have been measured as shown in the figure (4-3) from the center of the tower, 10 meters away, 20 meters away, 30 meters and 40 meters away. The highest value of the magnetic field was measured at the center of the tower, and then it gets weaker as the distance gets further from the center of the tower.

Note: There are two 220KV lines and 4 circles, one of the lines was measured and the two lines were loaded (50MW), according to the control center station Alkhoms BeerAlostaMmiladInformation center.

4.4 Transmission Line 30KV Passing by a farm in the city of Zawia

A 30 KV line running through a farm in the city of Zawia (in Salah al-Deen) was measured. The value of the energy loaded to the line was (17MW) and the results were as shown in Table (4-3):

Table (4-3) The measured electric and magnetic fields values for line 30KVin a farm in Zawia city

Distances measured in meters(m)	Center of the tower	3	6	10	15
Electric field (KV/m)	0.387	0.320	0.263	0.137	0.067
Magnetic field (A/m)	0.698	0.627	0.594	0.454	0.363
Magnetic field (μT)	0.872	0.783	0.742	0.567	0.453

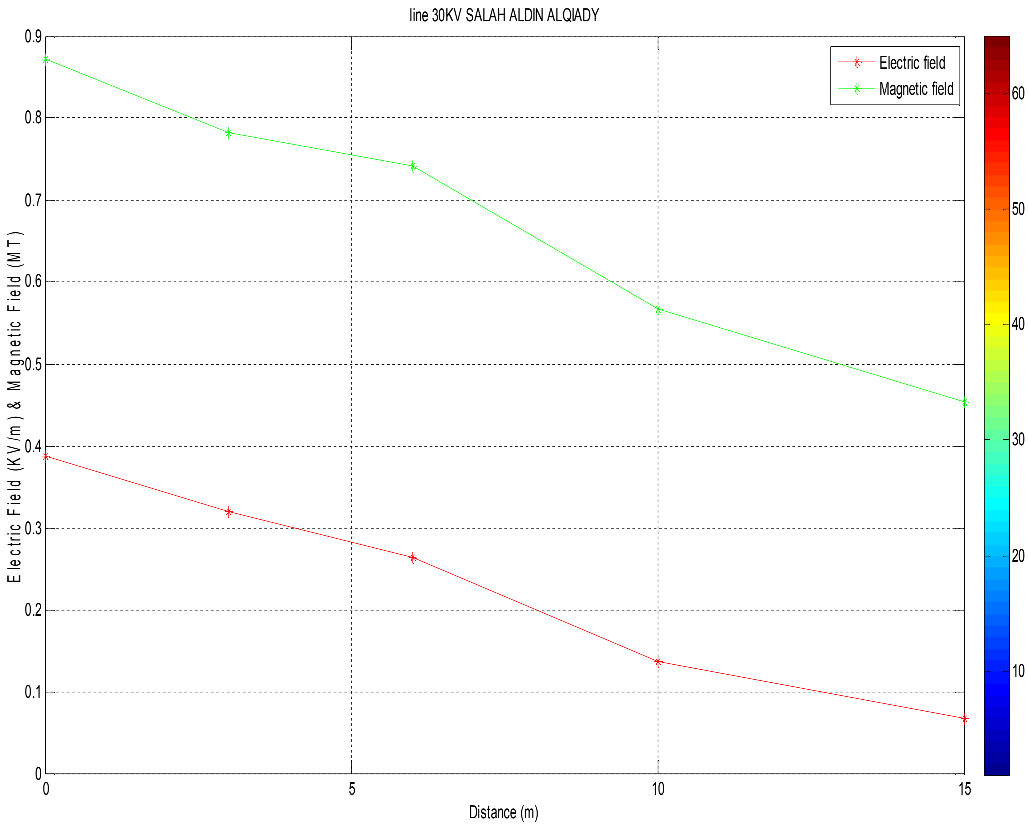


Figure (4-4) The electrical and magnetic field line 30KV of Salah ad Din

The measurements and results are taken at different distances, as shown in the figure (4-4).The electrical field and magnetic field of this line were measured from its center and at distance of 3 meters, 6 meters, 10 meters and 15 meters from the center. The intensity of both fields get weak as distance increased away fro center of tower and this is expected. The highest measured value for the electric field as well as the mangnetic field was at the center of tower. The measured electric field value was 0.387 KV/m and for the maganetic field was 0.872μT.It can be noted that these values are less than the measured values for the 400 KV line since the 30 KV line has lower voltage as well as lower loading, hence the higher the voltage the higher the field intensity. Once again these measured value are well below the unternational standards set safe limits.

4.5 Transmission line 220KVpassing by a farm in the city of Zawia

The measurements were takenon a 220 KV voltage line that passes by a farm in the city of Zawia, Al- Barnawi area, as explained below and shown in Figure (4-5)

- Line (1) 220 KV,Al-Zahra –Al-Harsha, length of 25 km.
- Line (2) 220KV, Al-Zahraa - Al-Ajilat, length 70 km.
- Both lines are load with 70MW.
- Measurement date 23/12/2018.

Firstly a measurement was taken at the mid point btween these two lines, which was about 100 m, since these line run in parallel through the location of measurement at a separating distance of 200 m. The obtained results were 50810 KV/m for electric field and 0.0223 µ for magnetic field .

Figure(4-5) 220 KV voltage line that passes by a farm in the city of Zawia, Al- Barnawi area

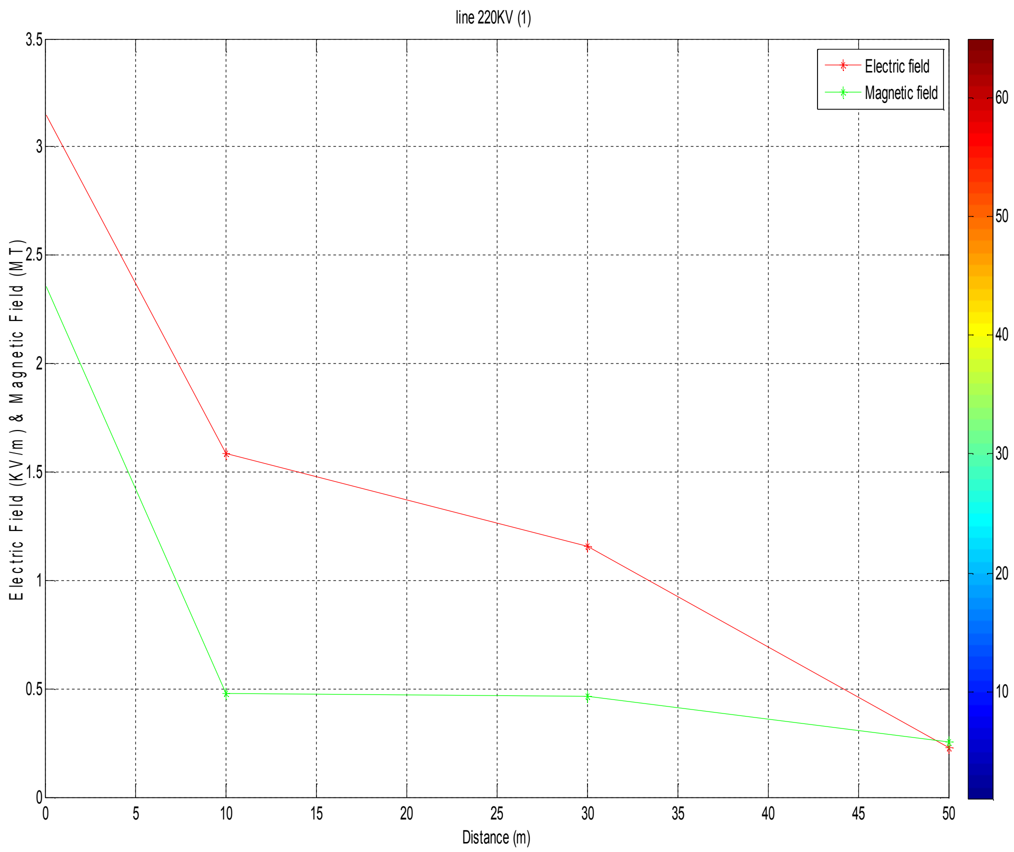
The two fields for the two lines were measured. Details of these measurments are as follows:

4.5.1 Transmission Line 220KV(Al - Zahra - Al – Harsha)

Table (4-4) The electric and magnetic field measured values and distances for the line (220KVAl-Zahra / Al- Harsha).

Table (4-4) measured values for the electric and magnetic field for the line (220KV) (Al-Zahra / Al- Harsha)

Distances measured in meters(m)	Center of the tower	10	30	50
Electric field (KV/m)	3.15	1.584	1.159	0.227
Magnetic field (A/m)	1.887	0.382	0.373	0.206
Magnetic field (μT)	2.358	0.477	0.466	0.257



Figure(4- 6) The electric field and magnetic field of Line 220 KV (Al-Zahra / Al- Harsha)

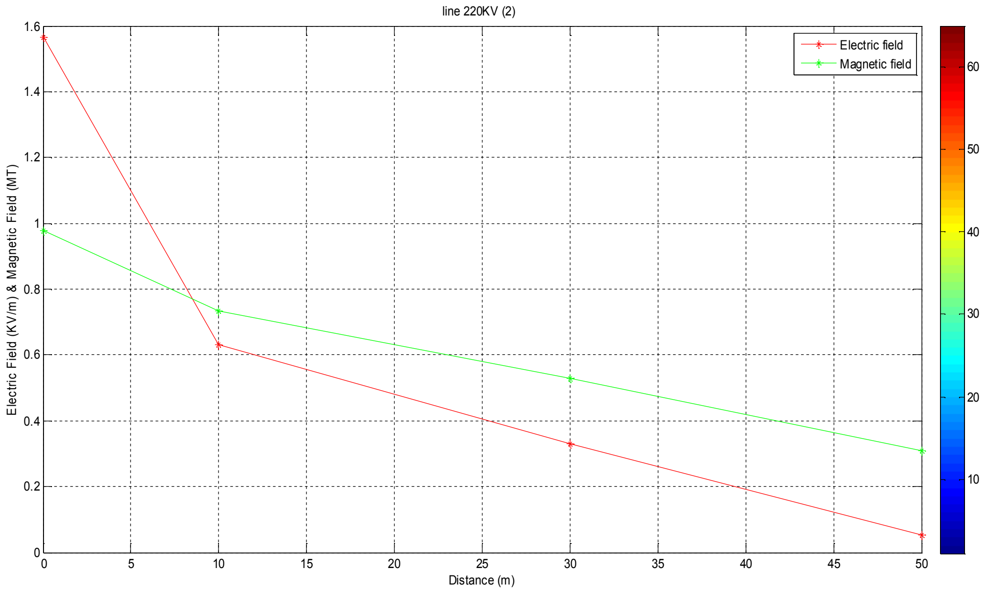
The measurements and results are taken at different distances, as shown in the figure (4-6), The measurements were taken from the center of the tower, at a distance of 10 meters, then a distance of 30meters, and at a distance of 50 meters. The intensity of both fields gets weaker as distance increased away from the center of tower as it is the cas with other measured sites. The highest measured values for bothe electric and magnetic field were 3.15 KV/m and 2.358 µT respectively. These results also indicate that the values for both fields are well below allowable safety limits.

4.5.2. Transmission Line 220KV(Al - Zahra - Al –Ajailat)

Table (4-5) shows the electric and magnetic field values measured for line (220 KV Al-Zahra / Al-Ejailat).

Table (4-5) Measured values for the electric and magnetic field for the line (220KVAl-Zahra / Al-Ejailat)

Distances measured in meters(m)	Center of the tower	10	30	50
Electric field (KV/m)	1.564	0.630	0.330	0.053
Magnetic field (A/m)	0.782	0.587	0.423	0.247
Magnetic field (µT)	0.977	0.733	0.528	0.308



Figure(4-7) The Line 220 KV(Al-Zahra / Al Ajailat)

The measurements and results are taken at different distances, as shown in the figure (4-7). The measurements were taken from the center of the tower, 10 meters away, 30 meters, and 50 meters away. The highest measured values were eat the center of the tower, where the electric field value was 1.564 KV/m and the magnetic field value was 0.977µT.It can be noted that these values are much less than the values for the 220 KV line between Al-zahar and Al-Harsha although they have the sam voltage and same loading but what makes this variance in results is the difference in distances covered by the two lines and hence the distance is an effecting factor for the intensity of the electromagnetic fields.

4.6 ALkhomsMafateh Station

This is 400KV / 220KVswitching station.The purpose of the visit was to measure the magnetic leakage from the power transformers in the station, as well as the distribution bars and also assessing the effect of incoming and outgoing loaded voltage lines into the transformer. The measurements were taken insid the switching station taken into account the following loading on the distribution lines going out of the sataion:

1. The Alkhomsline - Energy measured at line 250 MW.
2. .TheAlkhomsline–Misurata Energy measured at Line 300MW.

3. The Alkhoms line - berastamiladEnergy measured at line 80 MW.

The results were as follows:

4.6.1Transformer No. (1) 400KV / 220KV

Table (4-6) shows the magnetic field measured from the transformer (1)KV (400/220KV:

Table (4-6) The magnetic field measured from the transformer (1)KV (400/220KV)

Distances measured in meters(cm)	30	60	90	120
Electric field (KV/m)	1.564	0.630	0.330	0.053
Magnetic field (A/m)	10.503	9.00	6.860	4.490
Magnetic field (μT)	13.128	11.25	8.575	5.612

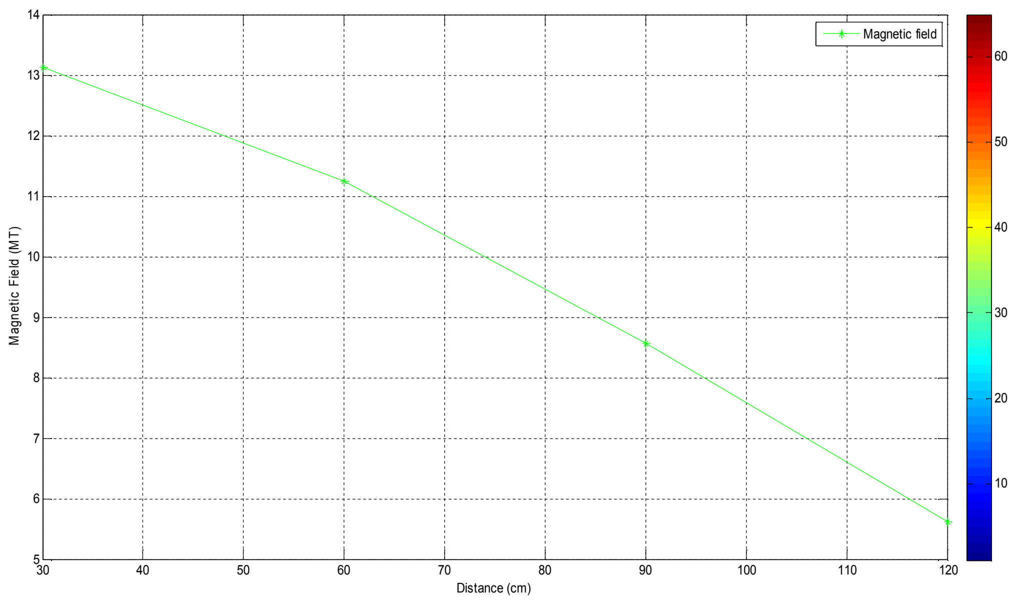


Figure (4-8) The magnetic field of the transformer (1) 400KV/ 220KV

The measurements and results are taken at different distances, as shown in the figure (4-8), The magnetic leakage from 400 KV/ 220KVtransformer No. (1) was measured at distances 30 cm and then 60, 90 and 120 cm. The magnetic leakage as it is expected , its value gets weaker as the distance is increased away from the transformer and the value of the leakage magnetic less as we move away from the transformer. The highest magnetic leagage value that was measured is 13.128μT. Hence this measured value is much less than the permissible magnetic field intensity limit of 200 μT set by the international standards.   ang to international standards,

4.6.2 400KV/ 220KVTransformer No. (2)

Table (4-7) shows the measured magnetic leakage values from the transformer (2) 400KV/ 220KV:

Table (4-7) the measured magnetic leakage values from the transformer 2, 400/ 220

Distances measured in meters(cm)	30	60	90	120
Magnetic field (A/m)	8.180	7.792	5.950	2.300
Magnetic field (μT)	10.225	9.740	7.437	2.875

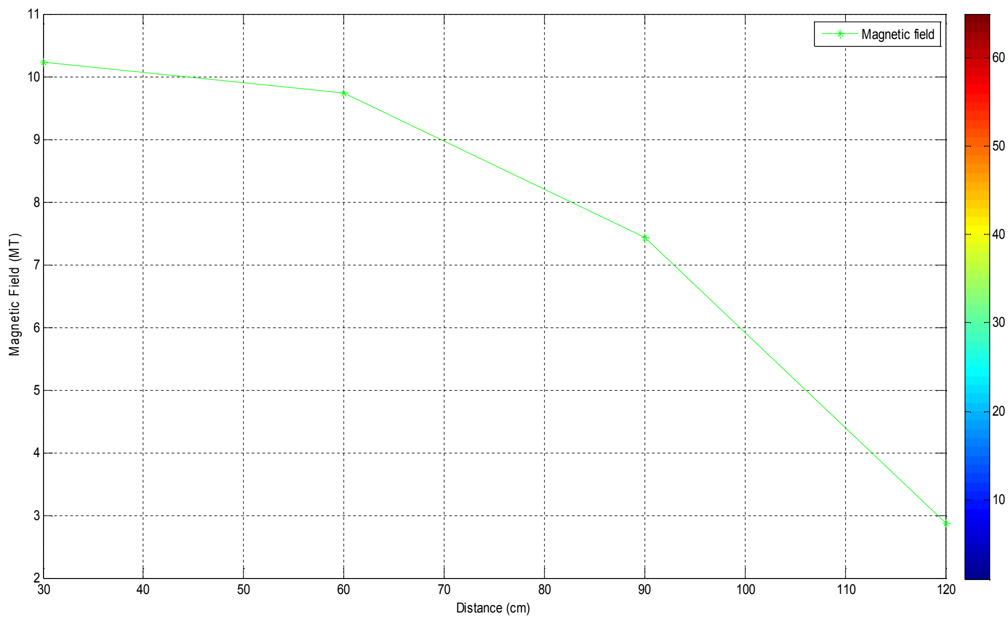


Figure (4-9) The magnetic field of the transformer (2) 400KV/ 220KV

The measurements and results are taken at different distances. as shown in the figure (4-9).The same measurements were taken as for transformer 1 . The highest measured value for this transformer is 10.225µT.

4.6.3 Distribution Bar 400KV

Table (4-8) The electric and magnetic fields of the distribution bar 400KV:

Electric field	9.4 v / m
Magnetic field	3.751 µT

4.6.4 220/30KV Transformer No. (1)

Table (4-9) shows the measured magnetic leakage values for transformer (1) 220KV/ 30KV:

Table (4-9) The measured magnetic leakage values for transformer (1) 220KV/ 30KV

Distances measured in (cm)	30	60	90	120
Magnetic field (A/m)	2.860	2.480	2.430	1.480
Magnetic field (µT)	3.575	3.100	3.037	1.850

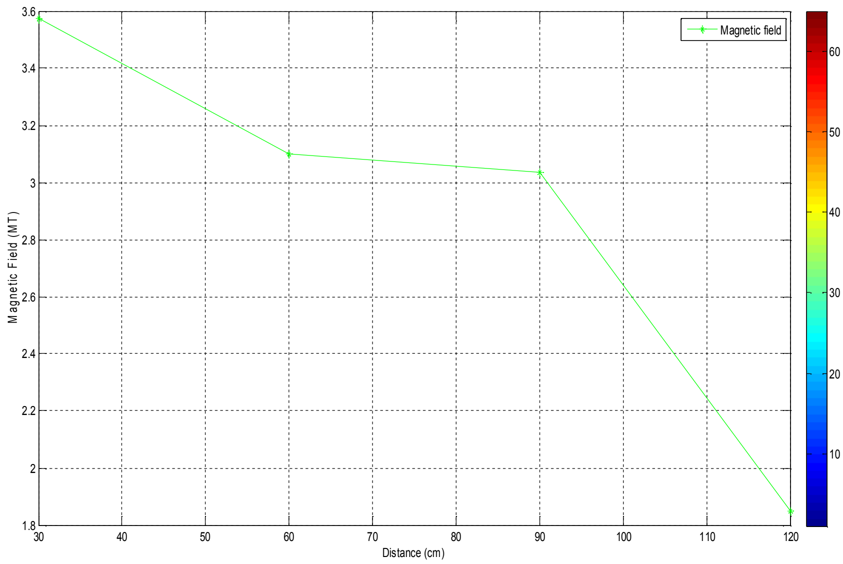


Figure (4-10) The magnetic field of the transformer (1) 220/30KV

The measurements and results are taken at different distances, as shown in the figure(4-10). The magnetic leakage from 220 KV/ 30 KVtransformer No. (1) was measured staring with a distance of 30 cm from the transformer and then three other measurement were taken at distances 60, 90 and 120 cm respectively. From table 10 it can be noted that the highest measured magnetic leakage intensity was 3.575µT at a distance of 30 cm. Other values at the other distantace get weaker as the distance from the transformer increases. Also It can be noted that the leakage value here is less than the 400/220 KV transformer and that clear since with dealing with a lower voltage level. The highest obtained value is still within the safety limits set be the international safety organizations.

4.6.5 Transformer No. (2) 220/30KV

Table (4-10) shows the measured magnetic leakage values for transformer No. (2) 220KV/ 30KV:

Table (4-10) The measured magnetic leakage values for transformer No. (2) (220KV/ 30KV)

Distances measured in meters(cm)	30	60	90	120
Magnetic field (A/m)	1.355	0.794	0.641	0.449
Magnetic field (µT)	1.693	0.992	0.801	0.561

The same measurements were done on this transformer and the obtained measurement results are shown in table (4.10) and displayed in figure(4-11). From the obtained results it can be obsereved that again the highstmeasured magnetic leakage intensity 1.693µT at a distance of 30 cm from transformer. Figure (4.11) shows the plot magnetic field intensity against distance of measurement. From the figure it is quite clear the field intensity is inversally proportional with distance.

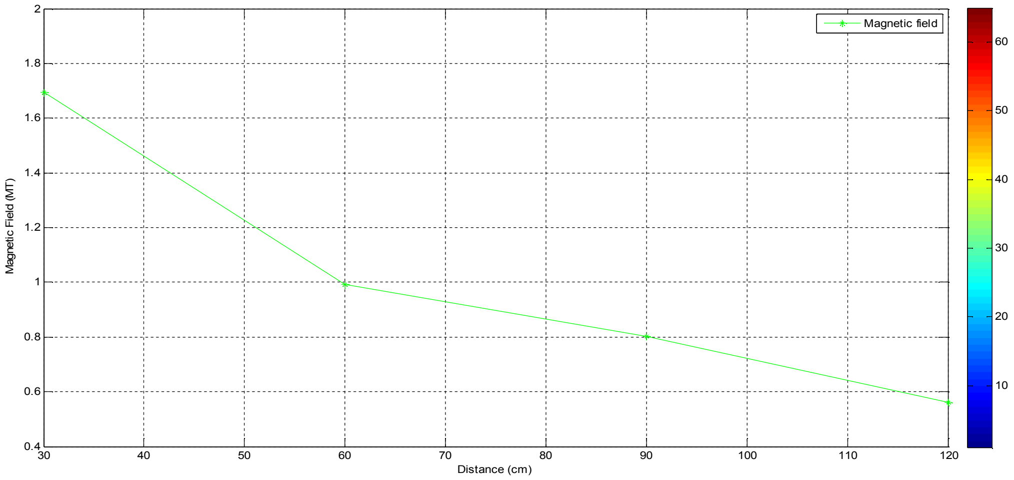


Figure (4-11) The magnetic field of the transformer (2)220/30KV

4.7 Transmission Line400 KV (Al-Khattaba / Al- Harsha)

Figure (4-11 a) shows a picture during measurement process of the 400 KV Al-Khattaba / Al- Harsha line and these mesurments were don onFriday 18/1/2019.This line was loaded with 80 MW.

Table (4-11) shows the measured electric and magnetic fields values for line 400KV Al-Khattaba / Al- Harsha:

Table (4-11) The measured electric and magnetic field values for line 400KV Al-Khattaba / Al- Harsha

Distances measured in meters	Tower center	10	20	30	40	50	60	70
Electic field KV/m	1.100	0.221	5.250	6.090	4.940	3.360	0.420	0.180
Magnetic field (A/m)	0.430	0.207	0.735	1.039	0.726	0.460	0.080	0.009
Magnetic field (μT)	0.538	0.258	0.918	1.298	0.907	0.575	0.100	0.011

Figure (4-11a) Line400KV al Khattabah / Al- Harsha

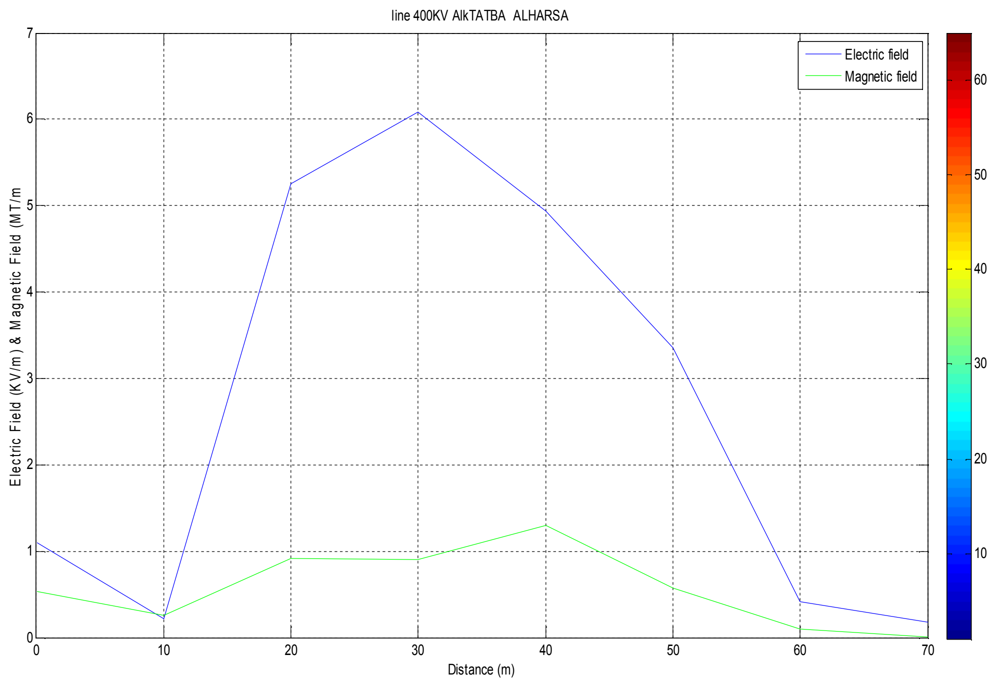


Figure (4-11 b) The electric field and magnetic field of Khattaba / Harsha 400KV

The measurements and results are taken at different distances, as shown in the figure(4-11b) and The importance of measuring this line comes at the request of citizens whomthe line crossesover their farms in the area of Dahman, and since the safe distance of the 400KVlineaccording to international specifications is approximately within (50) meters from the center of the tower that houses two circles, the measurement was extended to (70) meters from the center of the tower to increase the assurance of the safe distance because there are some houses near the tower.

It was noted that the readings at the distances of 20-30-40 meters look higher compared to the distances at the center of the tower as well as at 10 meters due to the presence of the 0.4KVline that intersects with the 400 KV line near the distances 20-30-40 meters.But as distance is increased beyond 40 meters the intensity of both field decreases . So the higest measured values were at distance of 30 meters, which was 6.090 KV/m for the electric field and 1.298µT for the magantic field.

4.8 Measuring Magnetic Leakage of engineering college transformers at Zawia University (25KVA -50KVA)

The magnetic leakage of the two transformers of the College of Engineering, the internal transformer, and its capacity, was measured at 25KVA. The external transformer has a capacity of 50KVA. The measurement was done on Sunday, 20/1/2019, the measurement was carried out from the front of the transformer about two meters away and also from the side about two meters away.

4.8.1 Internal Transformer

- The electromagnetic field strength was 0..406 µTat a distance of 2 meters from transformer fron side.
- The electromagnetic field strength was 0..303µT from the side of the transformer at a distance of 2 meters.

4.8.2 The External Converter

- The electromagnetic field strength was 0.861 µT at a distance of 2 meters from transformer fron side .
- The electromagnetic field strength was 0.604µT from the side of the transformer at a distance of 2 meters.

Whereas these values compared to the value determined by the American Industry Organization, Gauss is considered safe.

4.9 Measuring transformers electromagnetic leakage within densely populatedareas

Measurement of magnetic leakage from some transformers located in densely populated areas in the city of Zawiya on 27/1/2019, and these transformers were measured from 4 sides (in front of the transformer - the right side of the transformer - the left side of the transformer - behind the transformer). These transformers are located in the middle of some homes adjacent to the houses on three sides. The purpose of these measurements is to determine the intensity of the magnetic leakage caused by these transformes, as follows:

4.9.1 District ofAlmktei transformer(1)11KV/ 0.4KV, Switch Capacity (1000KVA)

Table (4-12) shows the measured magnetic leakage values for the locality transformer section 11KV/ 0.4KV:

Table(4-12) The measured data for theDistrictofalmktei transformer
(11KV/ 0.4KV)

Measurement of magnetic leakage in µT	Measurement distances in meters
1.026	In front of the transformer ,1 m
1.033	Behind the adapter ,1 m
0.834	Right side ,3m
0.535	The left side, 3 m

4.9.2 The village mosque transformer (2) 11KV / 0.4KV, Switch Capacity (1000KVA)

Table (4-13) shows the measured magnetic leakage values for the village mosque transformer 11KV / 0.4KV:

Table(4-13) The measured data for the village mosque transformer(11KV / 0.4KV)

Measurement of magnetic leakage in µT	Measurement distances in meters
3.434	In front of the transformer, 1 m
3.263	Behind the adapter, 1 m
1.248	Right side, 3 m
0.405	The left side, 3 m

It has been noted from this transformer measurements thatat 1 meter distance from front and back side the intensity of the magnetic field is relatively large compared to transformer number (1) and this because this transformer was fully loaded during measurement operation.

4.9.3 Al-Qamudimosque transformer (3)11KV/0.4KV, Capacity (1000KVA)

Table (4-14) shows the measured 11KV/0.4KV Al-Qamudi mosque transformermagnetic leakage intensity.

Table (4 -14) The magnetic leakage measured transformer locality collector Gammoudi values 11KV/0.4KV

Measurement of magnetic leakage in µT	Measurement distances in meters
0.724	In front of the transformer, 1 m
0.424	Behind the adapter, 1 m
0.851	Right side, 1 m
0.759	Left side, 1 m

4.9.4 Antenna transformer (4) (air station) 11KV / 0.4KV, Capacity (1000KVA)

Table (4-15) shows the magnetic leakage measured values for 11KV/0.4KVair station.

Table (4-15) The magnetic leakage measured adapter antenna values (air station) 11KV/0.4KV

Measurement of magnetic leakage in µT	Measurement distances in meters
11.976	Under transformer
6.270	In front of the transformer, 1 m
1.159	Right side, 5 m
1.994	Left side, 5 m

This air station feeds the surrounding area from four directions and this explains the high readings around the station. After taking the measurements and recording the results for the transformers (1), (2), (3), (4) as shown in tables (4-12), (4-13), (4-14), (4-15), and compare the magnetic leakage values with the previously set values according to international standards, which is 200 µT, the values were in the internationally permitted framework.

4.10Transformers Size(220/30 KV) and (30/11 KV) in Bin Yusuf Zawia Station

Magnetic Leakage of trsformers220/30 KVand 30/11 KVhavebeen measured at the Bin Youssef Substation in Zawia, on Thursday 7/2/2019.

The measurement results were as follows:

4.10.1.Transformer No.(1) (220/30 KV)

The transformer characteristicsare as follows:

capacity (100)MVA, current 1.1KA andenergy measured P = 58.5MW , Q = 12.8MVAR**.**

Table (4 -16) shows magnetic leakage measured values for the 220/30KV transformer No.1:

Table (4 -16) magnetic leakage measured values for the 220/30 KVtransformer No.1

Measurement of magnetic leakageµT	Measurement distances in meters
4.163	In front of the transformer, 1 m
202.40	Back side of transformer, 1 m
2.596	Right side, 2 m
4.376	The left side, 2 m
1.573	In front of the transformer, 10 m

The measured magnetic intensity at the back side of transformer was too high and this is due to 220 KV cables entries.The Reading on the left side is considered relatively high as compared to reading on the right side and this is because there is another transformer nearby on the left side.

4.10.2Transformer No. (2) (220/30KV)

The transformer characteristicsare as follows:

Capacity (100MVA) And the current 1.0KV, The measured energy P = 54MW , Q = 14MVAR.

Table (4 -17) shows magnetic leakage measured values of the 220/30KVtransformerr No2:

Table (4 -17) magnetic leakage measured values of the 220/30KV transformerr No2

Measurement of magnetic leakageµT	Measurement distances in meters
3.001	In front of the transformer1 m
3.273	the right side m1
155.496	Behind the adapter1 m
2.834	Left side1 m
0.917	In front of the transformer10 m

Since there are 220 KVcables entries at the back side of the transformer the magnetic leakage intensity is rather high.

4.10.3 Transformer No. (3) (220/30KV)

The transformer characteristicsare as follows:

Capacity (100MVA), Current 1.0KA , The measured energy = 9.3MW, Q = 2.9MVAR.

Table (4 -18) shows magnetic leakage measured values of the 220/30KVtransformerr No3.

Table (4 -18) magnetic leakage measured values of the 220/30KV transformerr No3

Measurement of magnetic leakageµT	Measurement distances in meters
3.612	In front of the transformer, 1 m
3.474	the right side, m1
186.971	Back side, 1 m
2.015	Left side, 1 m
0.642	In front of the transformer, 10 m

Once again because 220 KV enter the the transformer from the back side, the leakge intensity is a lot higher than other sides.

4.10.4Transformer No. (4) (30/11KV)

The transformer characteristicsare as follows:

Capacity 20MVA, Current 183A, The measured energy P = 9.3MW , Q = 2.9MVAR.

Table (4 -19) shows magnetic leakage measured values for the 30/11KVtransformer No4:

Table (4 -19) magnetic leakage measured values for the 30/11KVtransformerNo4

Measurement of magnetic leakageµT	Measurement distances in meters
4.050	In front of the transformer1 m
8.954	the right side, 1 m
5.994	Back side, 1 m
6.772	Left side, 1 m
0.0352	In front of the transformer, 10 m

It has been noticed that the two readings on the right side and the left side are relatively large due to the presence of 30KV cable entries On the right side as well as 11 KVcable entries On the left side.

4.10.5 Transformer No. (5)(30/11KV)

The transformer characteristicsare as follows:

capacity of 20MW the current 215A, The measured energy P = 10.8MW, Q = 3.6MVAR.

Table (4 -20) shows magnetic leakage measured values for the 30 / 11KV) transformer(No5:

Table (4 -20) magnetic leakage measured values for the(30 / 11KV)transformerNo5

Measurement of magnetic leakageμT	Measurement distances in meters
1.683	In front of the transformer1 m
12.452	the right side m1
1.001	Behind the adapter1 m
5.204	Left side1 m
0.364	In front of the transformer10 m

The high values on left and right sides are for the same reasons that was wasmensioned for transformer no. 4. above

After completing these measurements and comparing them with the values determined by the American Industry Organization, it was found that they are within the internationally permitted safetylimits.

The electrical and magnetic fields have been measured around two houses near the Bin Yusef substation. The first house is located about 25 meters from the 220 KVtransmission line next to the station and the second one, it is approximately 50 meters from the 220 KVtransmission line. Thesemeasurements were taken to assess the of impact of these high voltage lines on the the residents of the two homes.

4.11 1-A house located approximately 100 m from theswitching station 220/30 KV and 25 m from high voltage line 220KV

Table (4-21) The measured electric and magnetic field values for line 220KV:

Distances measured in meters(m)	5	15	25
Electric field (KV/m)	5.730	2.980	0.586
Magnetic field (A/m)	1.885	0.834	0.631
Magnetic field (µT)	2.3560	1.042	0.7887

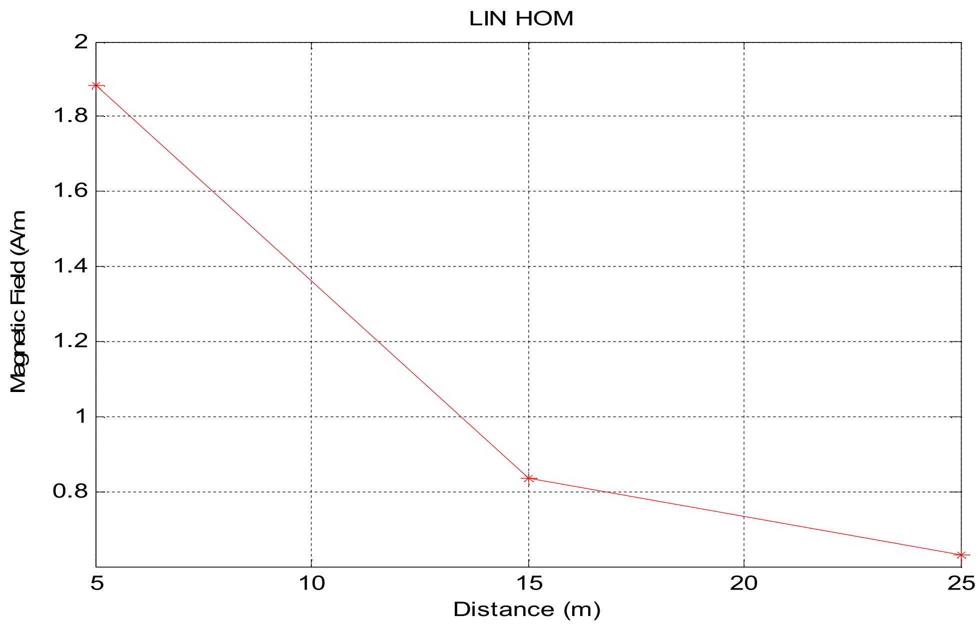


Figure (4-12) The magnetic field of line 220KV Close to home, 25 meters to 220/30transfer station KV

4.11.1 2 –A house approximately 100 m from the switchingStation220/30 KVand 50 m fromthe high voltage Line 220KV:

Table (4 -22) shows the electric field and magnetic field values of the measured line 220KV:

Table (4 -22) The electric field and magnetic field values of the measured line 220KV

Distances measured in meters(m)	5	15	25	50
Electric field (KV/m)	0.519	0.262	0.1473	0.1042
Magnetic field (A/m)	0.736	0.328	0.289	0.203
Magnetic field (μT)	0.920	0.411	0.3612	0.2537

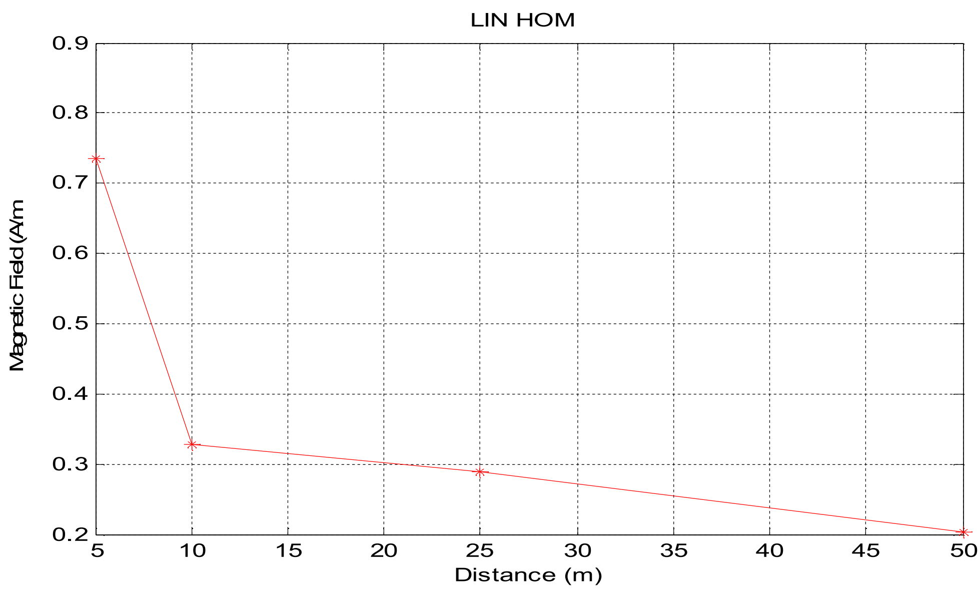


Figure (4-13) The magnetic field of the line 220KVclose to a home, 100 meters from 220/30 KV switching station

After completing the measurements and according to the distances shown in the figure(4-12) and figure(4-13), and compare the magnetic leakage values with the previously set value according to international standards, which is 200 µT, the values were within the internationally permitted framework

4.12 Home Tests

Given that some household electrical appliances emit electromagnetic waves, these devices are of course used daily for housewives and also near children and for the importance and to emphasize the safety of housewives and children and their residents and to test the safety and magnetic leakage of these devices.

The magnetic leakage of the microwave, household electric oven, hairdryer, washing machine and Samsung 40 inch SMART TV screen model UA40 K5300 Phil HD and Samsung 43 inch plasma screen Model 4000 F 43 PS were measured on Friday evening, corresponding to 25/10/2019, inside my house located in Zawia city, and it was as follows:

4.12.1 Microwave type Candy Model 2070INPUT1200W- output 700W

Radio waves heat water and fats in foods, as these waves cause vibrations of food particles that heat them in this way, so the primary use of the microwave is to reheat pre-cooked food or in most semi-cooked foods

The measurements were taken of the microwave inside the house and it was on several distances where the magnetic leakage was measured directly in front of it inside the kitchen of the house and then a meter and then 2 meters and then 3 meters, then the measurements were taken in the room near to the kitchen where a corridor separates it at about 3.5 meters and then 4 meters and then at the end of the room at 5 meters away.The values of magnetic leakage were as shown in the table (4-23):

Table (4-23) The measurement of microwave magnetic leakage

Distances measured in meters(m)	0	1	2	3	3.5	4	5
Magnetic field (A/m)	13.96	5.7	0.997	0.149	0.382	0.122	0.068
Magnetic field (μT)	17.45	7.12	1.24	0.18	0.47	0.15	0.08

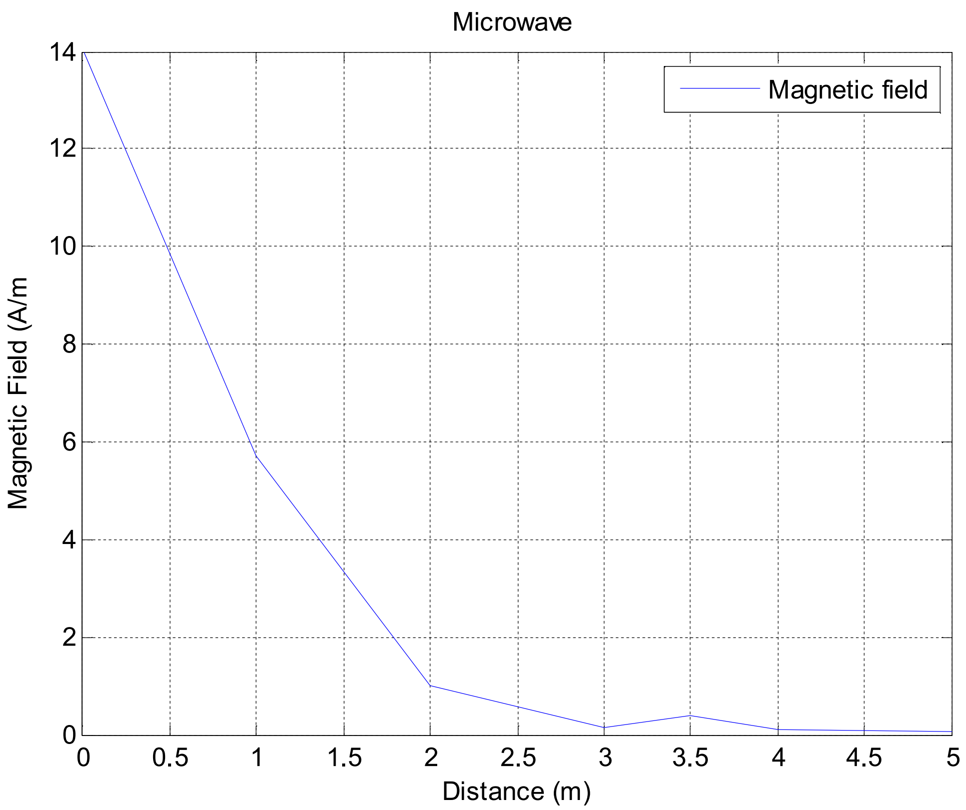


Figure (4-14) The magnetic field from the microwave

When drawing the curve measurements as shown the figure(4-14),It was noted that athe leagage intensity increased at the distance 3.5m in the gusst room, the possible reason for that there is a 40 W electric glow lamp of the type that emmites magnetic field, then intensity starts decreasing as distance increased away from the electric lamp.

4.12.2 Household electric oven type DAW 1600W

The magnetic leakage from the electric oven was measured, and the measurements were in front of it directly, one meter, two meters, three meters, five meters in the opposite room, 6 meters in the same room, and 7 meters in the same room and the results were as shown in the table (4-24):

Table (4-24 The measurement of magnetic leakage by the electric oven

Distances measured in meters(m)	0	1	2	3	5	6	7
Magnetic field (A/m)	0.711	0.415	0.096	0.062	0.037	0.029	0.018
Magnetic field (µT)	0.88	0.51	0.12	0.07	0.04	0.03	0.02

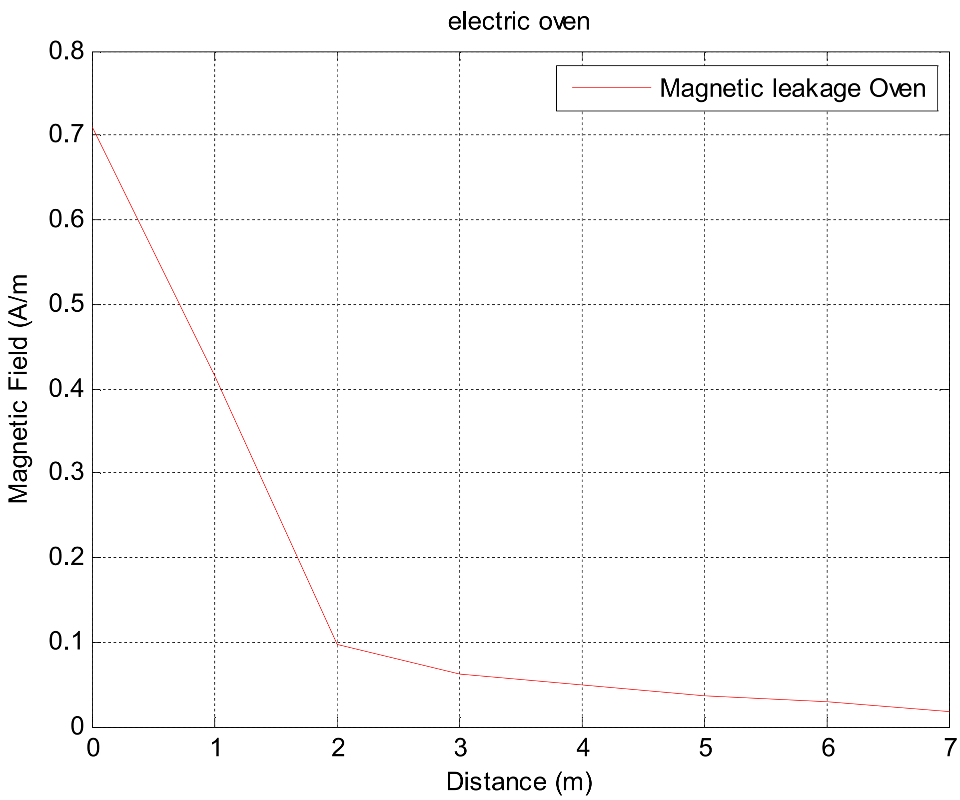


Figure (4-15) The magnetic field issued by the household electric oven

After taking the measurements and drawing the curve shown in the figure (4-15). It can be clearly noted that the value of the magnetic field directly in front of the oven at a distance of about zero m, was relatively high by comparing it with the values measured on the other distances where it was decreased and nearly approached zero with the distance increase.

4.12.3 Hair dryer type AQIANG a model YQ-1212 with a power rating of 1500W

The magnetic field strength was measured of ahome hair dryer having a power rating of 1500 watt and measurements directly close to the dryer and at one meter, two, three, four, five , and six meters in the gusst room and at seven and eight meters outside the gusstromm. The obtained measurements are as shown in table (4-25):

Table (4-25) The magnetic leakage values of a hair dryer

Distances measured in meters(m)	0	1	2	3	5	6	7	8
Magnetic field (A/m)	1.249	0.877	0.068	0.058	0.049	0.039	0.028	0.019
Magnetic field (μT)	1.561	1.096	0.085	0.072	0.061	0.048	0.035	0.023

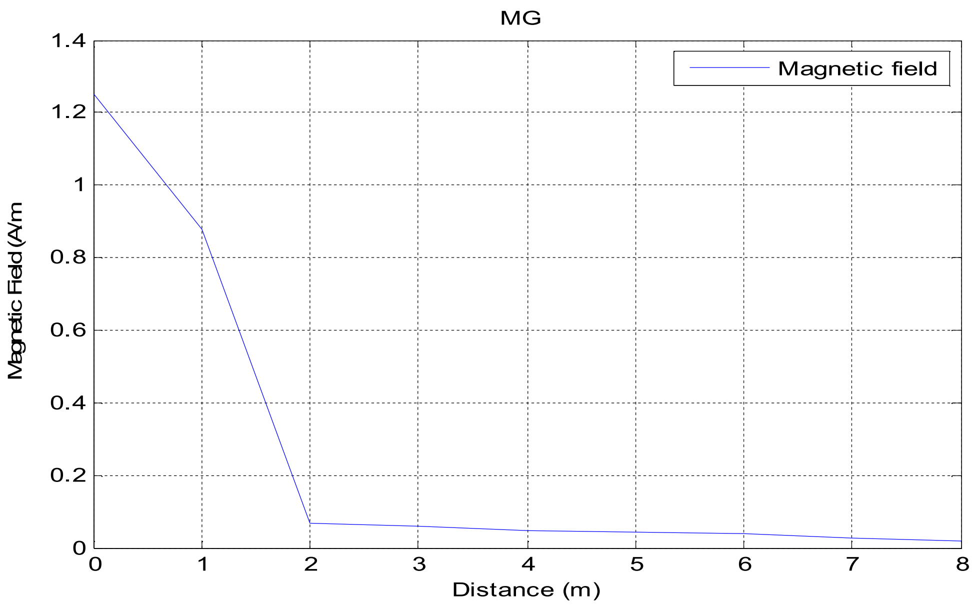


Figure (4-16) The magnetic field issued by the hairdryer

After taking the measurements and drawing the curve shown in the figure (4-16). It was noted that the value of the magnetic field generated by the electric hair dryer was relatively high at zero distance compared to the values measured on the other distances.

4.12.4 Automatic washing machineTypeDWD-F1013STS Capacity of 8 kg with a power output of 2200W

The magnetic field of the washing machine was measured directly in front of it, then at 1, 2, 3 and 4 meters away, then in the opposite room, 5 and then six meters away, and the results were as in the following table (4-26):

Table (4-26) The magnetic leakage values from the washing machine

Distances measured in meters(m)	0	1	2	3	4	5	6
Magnetic field (A/m)	0.359	0.227	0.125	0.062	0.051	0.040	0.032
Magnetic field (μT)	0.450	0.285	0.157	0.078	0.064	0.050	0.040

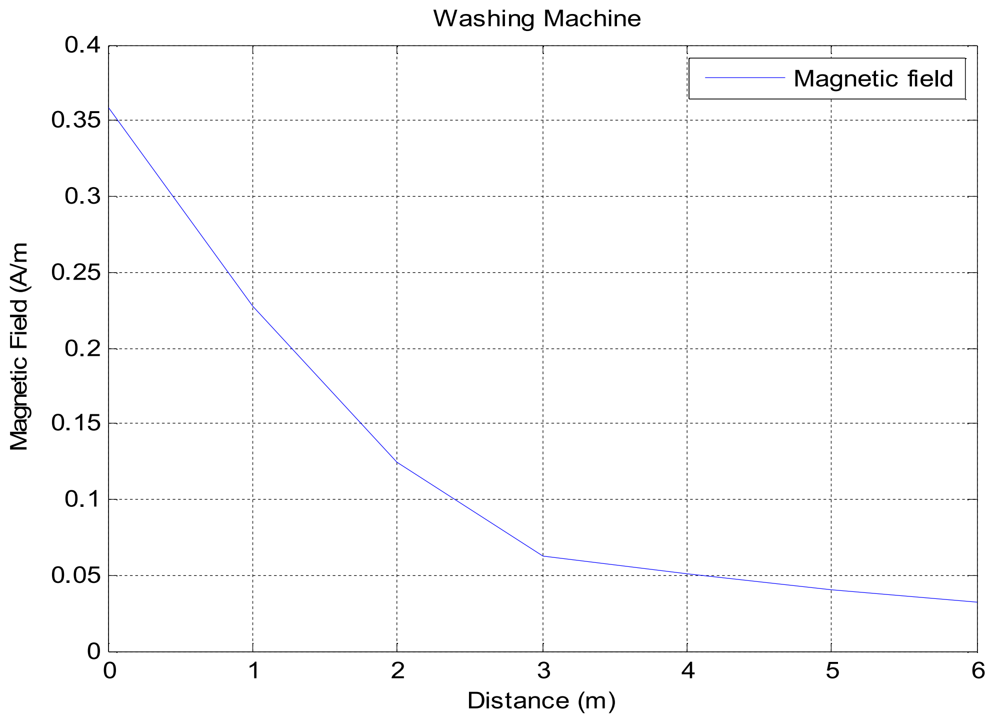


Figure (4-17) The intensity of the magnetic field by the washing machine

After taking the measurements and drawing the curve shown in the figure (4-17).It can be clearlyobserved that the value of the magnetic field directly in front of the machine at a distance of about zero m, was relatively high in comparison with the values measured on the other distances where it was decreased and nearly approached zero with the distance increase.

4.12.5 Plasma screen type samsungmodel 4000F 43 PS with anouput power of 170W

The measurements of the magnetic field strength of the screen were taken directly in front of it, one, two, three, and three and a half meters inside the TV room and in the opposite room, measurements were taken at four and a half and five meters away. The obtained results are shown in the table (4-27):

Table (4-27) The magnetic leakage values from the Samsung plasma screen

Distances measured in meters(m)	0	1	2	3	3.5	4.5	5
Magnetic field (A/m)	0.625	0.442	0.083	0.064	0.055	0.021	0.019
Magnetic field (μT)	0.781	0.552	0.103	0.08	0.068	0.026	0.023

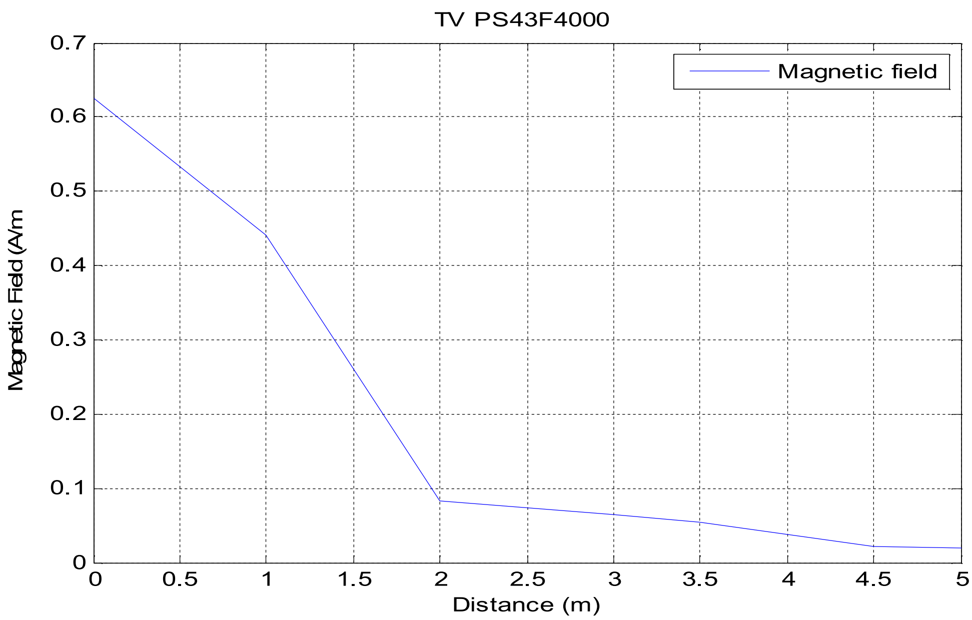


Figure (4-18) The intensity of the magnetic field by the Samsung screen PS43F400

After taking the measurements and results and drawing the curve shown in the figure (4-18). It has been noted that the value of the magnetic field emitted by the plasma screen is relatively high at a distance of 0 meters, compared to other distances, so it is recommended that not sitting directly in front of the screen but rather take a good distance so as not to be exposed to the magnetic field .

4.12.6 Samsung smart screen full HD model UA40 K5300, 100W power ratings.

The measurements for this screen have been taken and compared to the previous screen at the same distances. The value of the magnetic field generated by the plasma screen was relatively higher than the Samsung smart screen HD. The results were as in the table (4-28):

Table (4-28) The magnetic leakage values from the Samsung Smart screen

Distances measured in meters(m)	0	1	2	3
magnetic field of a Smart Screen (A/m)	0.137	0.126	0.053	0.050
Magnetic field (μT)	0.172	0.158	0.066	0.063

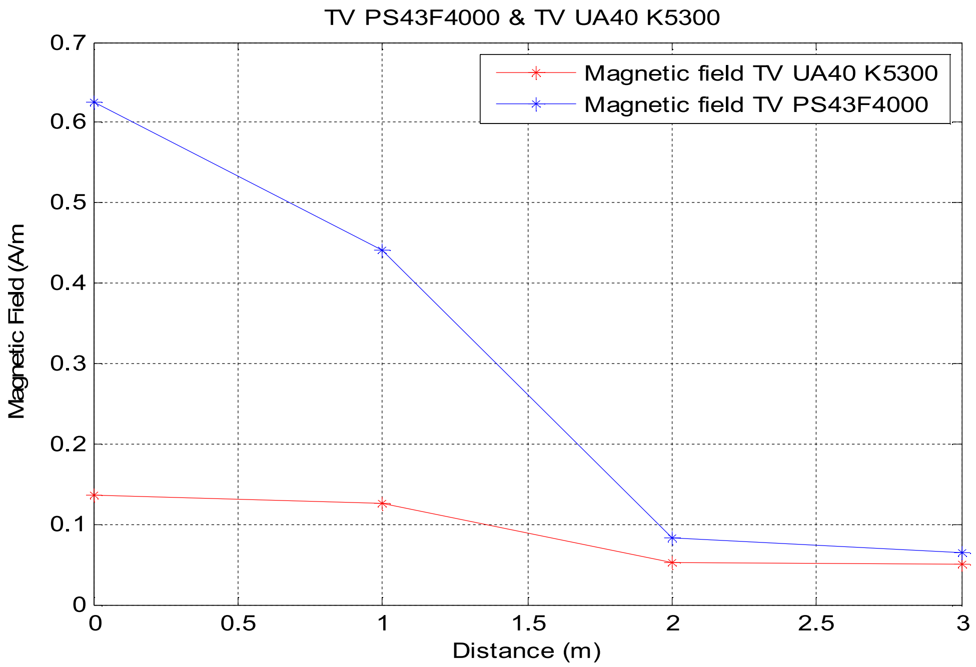


Figure (4-19) The magnetic field strength of the Samsung plasma screen and the Samsung smart screen

After taking the measurements and results and drawing the curve shown in the figure (4-19). Note that the value of the magnetic field by the plasmaSamsung screen typePS43F4000 are greater than the values of the magnetic field of the Samsung smart screenPhil HD ,model UA40 K5300. This is due to several reasons, including a difference in power ratings , a different load, a different model and manufacturing, where the Smart TV is newer.

After completing all the tests on the electrical appliances inside the house and comparing the values of magnetic leakage with the previously specified value set by international organizations, which is 200 µT.It was found that the values are considered safe and in the internationally permitted framework.

The sources of these fields, especially magnetic fields have been considered in this study. The usefulness of such measurements is evident in the absence of any local standards or recommendations in Libya and in light of the lack of interest of local authorities in such measurements, whether for public safety purposes or reference documentation. Figure (4-20) shows some of the electrical household appliances present in most homes in the Libyan community in particular and around the globe in general.

It is clearly noted from the figure (4-20), how the strength of the magnetic field is related to distance for all the test home appliance devices. The microwave has the greatest effect since the intensity of the field is strongest between o and 2 meters after which the intensity decays very fast. While the rest of the other devices do not have any strong effect and their effect comes with frequent use. The effect is cumulative, and the effect of fields in household electrical appliances depends on the capacity of the device.

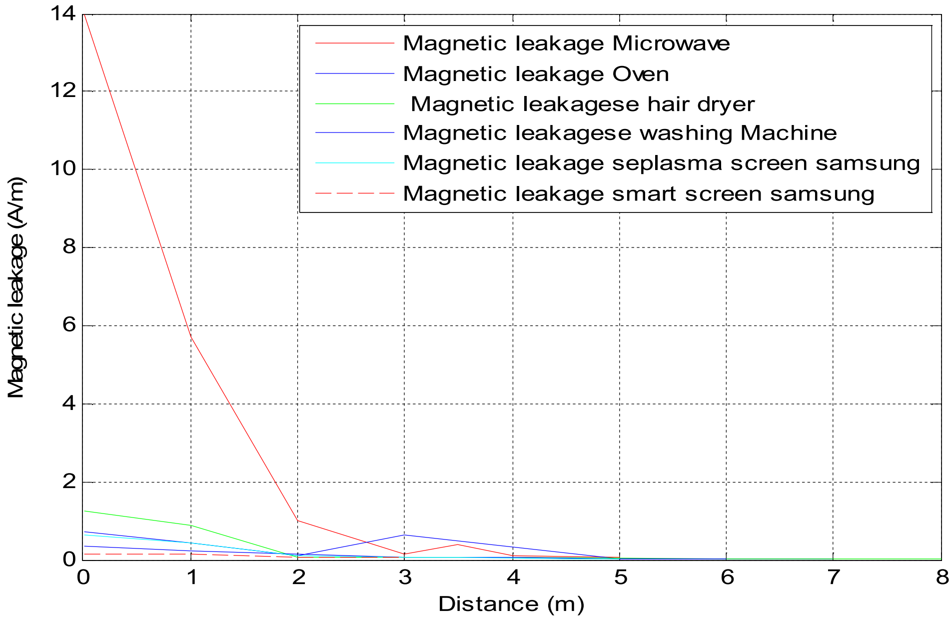


figure (4-20) All measured electrical appliances

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