Sudan University of Science Technology
College of Graduate Studies

The Effect Of Magnetic Fieldon the operation of a Solar Cell,Illuminated with monochromatic light

تأثيرالمجال المغنطيسي علي تشغيل خلية شمسية مضاءة بضوء أحادي اللون

A thesis submitted for fulfillments partial of the requirement of the degree of Science master in physics

Prepared by

Mohammed RabihKelaHamad

Supervised by

Dr. RawiaAbdelganiElobaid Mohammed

November 2020

الايـــــة

قالتعالى:

بِسْـمِاللَّهِالرَّحْمَنِالرَّحِيمِ (1) الْحَمْـدُلِلَّهِرَبِّالْعَالَمِينَ (2) الرَّحْمَنِـالرَّحِيمِ (3) مَالِكِيَوْمِالـدِّينِ (4) إِيَّاكَنَعْبُدُوَإِيَّاكَنَسْـتَعِينُ (5) اهْدِنَاالصِّرَاطَالْمُسْـتَقِيمَ (6) صِرَاطَالَّذِينَأَنْعَمْتَعَلَيْهِمْغَيْرِالْمَغْضُوبِعَلَيْهِمْوَلَاالضَّالِّينَ((7)

صدقاللهالعظيم

سورةالفاتحة

Dedication

To the wonderful past, present & future my family

To the guiding stars in our sky my teachers

To the inspiring brothers in the garden were we live my friends

To the mountain of knowledge who fix my basis

Dr. RawiaAbdelgani

To my university

To all who help me

Acknowledgement

First thanks for Allah who always with us, and I would like to forward my deepest gratitude to my supervisor Dr. RawiaAbdelgani who helps me throughout this study and allow as a source of precious advice .

I would like to thank all staff of faculty Sudan University of Science Technology, College of Graduate Studies, who helped me in one way or another either directly or indirectly in contributing to the smooth progress of my research activities.

Abstract

In this study, an magnetic field was shed on the solar cell to study the effects of different wavelengths on the solar cell using three filters (yellow - green - purple), and also study the properties of both voltages and current by recording the reading of voltages and current, before and after the effect of induced magnetic field.

The results showed the value of I_{after} is greater than I_{before} and also the value of V_{after} is greater than V_{before}.

The yellow filter with wavelength 570 λnm recorded the heights value in the voltages and current of the cell, then the green filter with the wavelength 490 λnm followed by violet with wavelength 400 λnm.

المستخلص

تم في هذه الدراسة تسليط موجة كهرومغنطيسية على الخلية الشمسية لدراسة تأثير الأطوال الموجية المختلفة على الخلية الشمسية بإستخدام ثلاث مرشحات (أصفر - أخضر - بنفسجي) و أيضاً دراسة خصائص كل من الفولتية و التيار، من خلال تسجيل قراءات الفولتية و التيار قبل و بعد تأثير المجال المغنطيسي المستحث. أظهرت النتائج أن قيمة I_{before} أكبر من قيمة I_{after} و أيضاً قيمة V_{before} أكبر من قيمة V_{after}.

Table of Contents

List of Tables

List of Figures

Chapter One

Introduction

1.1 Preface

The Earth receives an incredible supply of solar energy. The sun, an average star, is a fusion reactor that has been burning over 4 billion years. It provides enough energy in one minute to supply the world's energy needs for one year.

In one day, it provides more energy than our current population would consume in 27 years. In fact, "The amount of solar radiation striking the earth over a three-day period is equivalent to the energy stored in all fossil energy sources."

Solar energy is a free, inexhaustible resource, yet harnessingit is a relatively new idea. Considering that "the first practical solar cells were made less than 30 years ago," we have come a long way. The prolongation of solar professional companies designing unique and specific solar power systems forindividual homes means there is no longer an excuse not to consider solar power for your home. The biggest jumps in efficiency came “with the advent of the transistor and accompanying semiconductor technology. There are several advantages of photovoltaic solar power that make it "one of the most promising renewable energy sources in the world." It is non-polluting, has no moving parts that could break down, requires little maintenance and no supervision, and has a life of 20-30 years with low running costs. It is especially unique because no large-scale installation is required [6].

Remote areas can easily produce their own supply of electricity by constructing as small or as large of a system as needed. Solar power generators are simply distributed to homes, schools, or businesses, where their assembly requires no extra development or land area and their function is safe and quiet. As communities grow, more solar energy capacity can be added. Solar energy is most sought today in developing countries, the fastest growing segment of the photovoltaic's market. People go without electricity as the sun beats down on the land, making solar power the obvious energy choice. "Governments are finding modular, decentralized character ideal for filling the electric needs of the thousands of remote villages in their countries." It is much more practical than the extension of expensive power lines into remote areas, where people do not have the money to pay for conventional electricity. There are only two primary disadvantages to using solar power: amount of sunlight and cost of equipment. The amount of sunlight a location receives "varies greatly depending on geographical location, time of day, season and clouds. Considering the importance of the use of solar cells and efficient use of solar energy, in this article we will examine the different types of solar cells.

A solar cell, or photovoltaic cell, is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect, which is a physical and chemical phenomenon. It is a form of photoelectric cell, defined as a device whose electrical characteristics, such as current, voltage, or resistance, vary when exposed to light. Solar cells[6].

1.2 Research Problem

Magnetic field affect the production of photovoltaic panels

1.3 Research Objectives

Improve cell performance by studying the effect of magnetic field on Silicon solar cells.

1.4 Research Importance

The importance of this research to improve the capacity of the solar cell in decreasing the amount of the electrical current

1.5 Research Review

1.5.1M. El-Aasser, 2014, Magnetic Field Effect on the Electrical Characteristics of a Monocrystallinen+pp+ Silicon Solar Cell.

The effect of magnetic field on I-V characteristics of a silicon solar cell of n+pp+ structure is studied in dark and illumination modes. In dark, both the current and the voltage decrease with increasing the magnetic field in forward bias. However in reverse bias, the behavior is different. Under illumination, the effect of magnetic field on I-V characteristics of the silicon solar cell is studied experimentally and simulated using Neural Network Algorithm (NNA). Both short circuit current (Isc) and open circuit voltage (Voc) are measured under the influence of magnetic field. The solar cell efficiency and the fill factor (FF) are calculated without and with the magnetic field. This performance testing of the solar cell under magnetic field can be considered as one of the non-destructive reliability tools.

1.5.2I. Zerbo, 2012, Silicon Solar Cell Under Electromagnetic Waves InSteady State: Electrical Parameters DeterminationUsing The I-V And P-V Characteristics.

The principal effect that limits solar cell efficiency is the recombination of the

photo generated charge carriers before they participate to energy current. Theserecombination are characterized by electronic (recombination) and electric interdependentparameters that influence the solar cell quality and conversion efficiency.In previous works, we have studied the influence of telecommunication (AM radio antenna ora FM radio antenna) source’s power of radiation on a silicon solar cell illuminated by a whitelight in steady state. We analyzed the effects of electromagnetic field on photo-currentdensity, back surface recombination velocity, intrinsic junction recombination velocity,photo-voltage, maximum electric power and conversion efficiency by making vary theantenna power of radiation.

1.5.3 Pooja Singh, 2021, P-V and I-V Characteristics of Solar Cell.

A PV cell is a semi-conductor specialized diode, which transforms visible light into direct current (DC). Any PV cells can also transform radiation from infrared to ultraviolet (UV) to control DC. Photovoltaic cells are a feature of solar power systems. This paper explores the successful deployment of photovoltaic, with an emphasis on PV characteristics and photovoltaic systems as a whole. The photovoltaic cell's power-voltage characteristic is non-linear. The maximum power point (MPP) must be constantly monitored to achieve the maximum performance power from the photovoltaic device. Solar cell implementations have been challenging in recent years. More focus is placed on updating the technology in order to optimize module performance. In this paper the simple current equations are applied to construct a MATLAB/Simulink model of a solar cell. Different parameters are addressed and their influence is traced in the shape of I-V and P-V curves on solar cells.

1.5.4 Martial Zoungrana1, IssaZerbo and others, 2017, (The Effect Of MagneticField On The Efficiency Of A Silicon Solar Cell Under An Intense LightConcentration).

This work put in evidence, magnetic field effect the electrical parameters of asilicon solar cell illuminated by an intense light concentration: external loadelectric power, conversion efficiency, fill factor, external optimal charge load.

Due to the high photogeneration of a carrier in intense light illumination mode,in addition of magnetic field, we took into account the carrier gradient electricfield in the base of the solar cell.

Finally, we used simultaneously the J-V characteristics and equipower curves todetermine the optimal external load resistance. The results of this study haveshowed that the maximum electric power and the conversion efficiency arehigher than those of monofacial and bifacial silicon solar cells illuminated byconventional light but they decreased with the increase of magnetic field.

1.6Thesis layout

The following is general layout of this research Chapter one contain introduction, problem, objective, and thesis layout, Chapter two in an introduction, definition of solar cell, operations of solar cell, some types and applications of the solar cell, Chapter three introduction, The Effect Of Electromagnetic Field On Solar, The Effect of Incidence Angle of Magnetic Field on the Performance of a Polycrystalline Silicon Solar Cell, andDiffusion Coefficient in Silicon Solar Cell with Applied Magnetic Field and under Frequency, Chapter four introduction, material, method, discussion, conclusion, reference.

Chapter Two

Effect of Magnetic field on Solar Cell

2.1 Operation of Solar Cells:

This process requires firstly, a material in which the absorption of light raises an electron to a higher energy state, and secondly, the movement of this higher energy electron from the solar cell into an external circuit. The electron then dissipates its energy in the external circuit and returns to the solar cell. A variety of materials and processes can potentially satisfy the requirements for photovoltaic energy conversion, but in practice nearly all photovoltaic energy conversion uses semiconductor materials in the form of a p-n junction[5].

2.2 P-V and I-V Characteristics of Solar Cell

2.2.1 A PV cell is a semi-conductor specialized diode.

2.2.2 A PV Transforms visible light into direct current (DC).

2.2.3 PV cells transform radiation from infrared to ultraviolet (UV) to control DC[3].

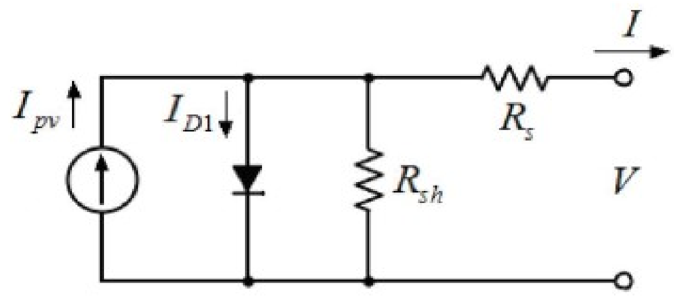
2.3 Equation of the Solar Cell

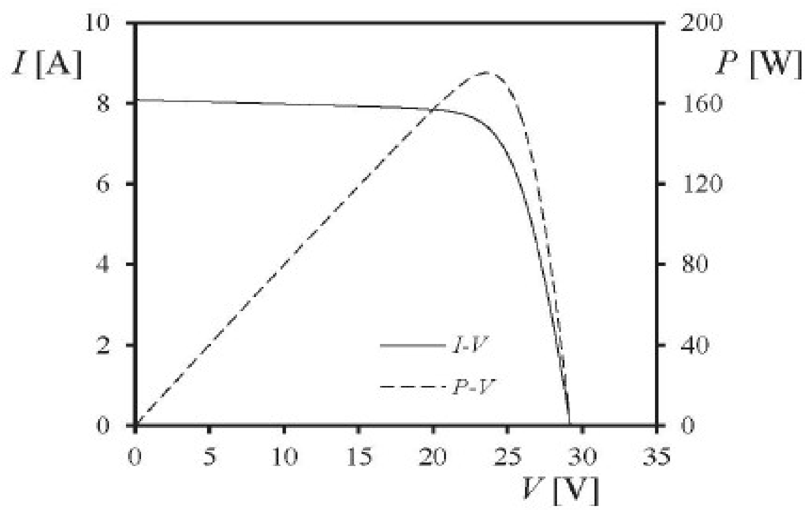
Within the last decades, the use of photovoltaic devices (solar cells/panels) has been greatly increased as a clean way to obtain energy, or due to its obvious advantages in autonomous systems such as the ones designed for space operations (i.e., satellites, spacecraft).

Today, the most common way to simúlate the behavior of such photovoltaic devices is through equivalent circuits. See in Fig. 1 the l-diode/2-resistor equivalent circuit model of a solar cell/panel whose behavior (that is, the relationship between the output current, /, and the output voltage, V), is defined by the following im-plicit equation:

$$I = I_{pv} - I_{D1} - \frac{V + IR_s}{R_{sh}} = I_{pv} - I_0\left[\exp\left(\frac{V + IR_s}{naV_T}\right) - 1\right] - \frac{V + IR_s}{R_{sh}}, \quad (1)$$

where's and Rsf¡ are the series and shunt resistors, lm is the current through the diode, lpv is the photocurrent delivered by the current





source, ¡o is the saturation current of that diode, Vj is the thermal voltage (defined as a function of the temperature, the charge of the electrón, and the Boltzmann constant), a is ideality factor of the diode, and n is the number of series-connected cells in the device. More information on this model can be found at. The main problem when using the equivalent circuit consists in the parameter extraction, that is, all of the above parameters need to be correctly estimated in order to obtain a good fitting to the current -voltage l-V curve of the solar cell/panel (an example of this curve is shown in Fig. 1).

There are múltiple procedures (analytical, computational) to extract the equivalent circuit parameters depending on the information available in relation to the photovoltaic device. This information can be the l-V curve measured experimentally or, in most cases, the current and voltage levéis at the characteristic points which can be found in the manufacturera datasheets (short circuit current, lsc, máximum power current and voltage, Imp and Vmp, and open circuit voltage, Voc). In Refs.a thorough review of the different methods for fitting the equivalent circuit to the solar cell/ panel behavior can be found. The equivalent circuit parameter extraction process is not an immediate task, and even doing it by analytical methods it requires a quite large number of calculations. Some efforts have been made in order to ease the parameter extraction procedure, the use of a reduced number of points of the

Fig. 1. Top: l-diode/2-resistor equivalent circuit model of a solar cell/panel. Bottom: I-V and P-V curves of a Kyocera KC175GHT-2 solar panel at constant solar irradiance (1000 W/m2) and T = 25 °C. This results were calculated using Equation (1) with na = 48.548, Ipv = 8.11 A, /0 = 4.8610-10 A, Rs = 0.262 ü, and Rsh = 90.85 Q.

I-V curve being an interesting methodology, together with the use of expressions based on the fill factor, In the present paper, a new simple mathematical method to approach the behavior of a photovoltaic device is proposed as an alternative to the equivalent circuit models. In some applications a very quick and easy approach to a solar cell/panel behavior is required. We have detected this need when programming the power subsystem module of the Concurrent Design Facility (CDF) for space missions at the IDR/UPM Institute. Within this module, the solar panels behavior has to be calculated in a quite large number of different situations, including sometimes real-time programing on spreadsheets. In this specific case, once a proper level of accuracy is guaranteed, the simpler methodology is preferred. This work is part of a larger research framework carried out at the IDR/UPM Institute to analyze photovoltaic systems behavior, in order to produce models to be involved in more complex simulations developed to study space systems, Furthermore, some professionals from the photovoltaic sector may not have the resources (human or technical), to program equivalent circuit models in order to optimize their energy systems. Based in our experience, this could happen at the first steps of a project (that is, the pre-design for engineering tenders/proposals), which are normally characterized by a strict limitation on time and expenses.

Some examples oí I-V curve explicit expressions can be found in the literature. For instance, Akbaba and Alattawi suggested a model for the solar cell/panel behavior based on the following equation:

$$I = \frac{V_{oc} - V}{A + BV^2 - CV}, \quad (2)$$

A + BV2 - CV' where A, B and C, are constants that depend on the short circuit

current, the open circuit voltage, and two additional points of the I-V curve. A model based on a similar equation has been recently proposed by Miceli et al. [20]. El-Tayyan proposed a simpler equation, only dependent on two coefficients, Q and C-¿:

$$I = I_{sc} - C_1 \exp\left(-\frac{V_{oc}}{C_2}\right)\left[\exp\left(\frac{V}{C_2}\right) - 1\right], \quad (3)$$

that can be either estimated or calculated based on the character-istic points of the I-V curve [22]. Besides, polynomials fitted to the/-V curve have been also proposed to describe the solar cell/panel performances [23,24]. An even simpler model is the power law model suggested by Karmalkar and Haneefa:

$$\frac{I}{I_{sc}} = 1 - (1-\gamma)\frac{V}{V_{oc}} - \gamma\left(\frac{V}{V_{oc}}\right)^m, \quad (4)$$

where constants y and m are calculated with the current and voltage levéis at points V\V0C = 0.6 and I\ISC = 0.6, respectively. Another power law relation between solar cell/panel current and voltage output levéis were independently proposed by Das [27] and Saetreetal.:

$$\frac{I}{I_{sc}} = \left[1 - \left(\frac{V}{V_{oc}}\right)^{f}\right]^{\frac{1}{g}}, \quad (5)$$

where coefficients / and g are estimated with output current measurements at V\V0C = 0.8 and V\V0C = 0.9. Finally, Das also proposed the equation:

$$\frac{I}{I_{sc}} = \frac{1 - \left(\frac{V}{V_{oc}}\right)^{k}}{1 + h\left(\frac{V}{V_{oc}}\right)}, \quad (6)$$

as a suitable model to describe solar cell/panel performance, h and k being calculated with the slope of the I-V curve at short circuit and open circuit points.

The model proposed in this paper is based on the shape of the power curve (i.e., output power in relation to the output voltage) of the solar/cell panel (see in the graph of Fig. 1 an example of this power curve). This P-V curve has been modelled sometimes through a third-degree polynomial, in order to obtain the voltage level of máximum power point in photovoltaic systems [30]. In the present work, the P-V curve is modelled with two different simple mathematical equations, one for voltage levéis lower than the máximum power voltage, Vmp (that is, within the bracket [0, Vmp[), and another one for voltage levéis above that máximum power voltage (within the bracket [Vmp, Voc\). Once the equations for the output power are defined, the output current can be easily derived by dividing by the output voltage. As a result, an easy and explicit expression of the output current as a function of the output voltage is derived.

The present work is organized as follows. In Section 2 the proposed model is described, whereas in Section 3 the model valida-tion is carried out by its application to different solar cells/panels and comparison to the l-diode/2-resistor equivalent circuit model. Finally, the conclusions are summarized in Section 4[9-8].

2.4 Magnetic Field Effect on the Electrical Characteristics of a Monocrystalline n+ pp + Silicon Solar Cell

the effect of magnetic field on I-V characteristics of a silicon solar cell of n+pp+ structure is studied in dark and illumination modes. In dark, both the current and the voltage decrease with increasing the magnetic field in forward bias. However in reverse bias, the behavior is different. Under illumination, the effect of magnetic field on I-V characteristics of the silicon solar cell is studied experimentally and simulated using Neural Network Algorithm (NNA). Both short circuit current (Isc) and open circuit voltage (Voc) are measured under the influence of magnetic field. The solar cell efficiency and the fill factor (FF) are calculated without and with the magnetic field. This performance testing of the solar cell under magnetic field can be considered as one of the non-destructive reliability tools[10,11-1].

2.5The effect electric magnetic field on I-V and P-V Characteristics of the Solar Cell

The effect of a magnetic field and an electricfield on silicon solar cell [1-6]. It was evident from these studies that magnetic field valueslower than 0,1 mT don't have any effect on silicon solar cell, on the other hand the magneticfield values superior to 0,1 mT have an ominous effect on silicon solar cell recombinationparameters (carrier’s diffusion length and lifetime). As for the electric field, according to itsorientation it can have beneficial or ominous effects on silicon solar cell recombinationparameters. The magnetic field can have various origins: terrestrial magnetic field, magneticcomponent of the electromagnetic wave coming from radio transmitters, televisiontransmitters and telecommunication transmitters, magnetic field coming from the electricenergy corporation distributor stations of transformers … Also, we were interested in theelectromagnetic wave influence coming from radio transmitters and other telecommunicationsources on silicon solar cell because whatever is their installation place, the silicon solar cellofphotovoltaic systems by their principle of working (movement of electrons) can beinfluenced as well by the magnetic field and the electric field of the electromagnetic waves ofthe different telecommunication sources that exist close to their installation place. It is in thisoptics that first we studied the effects of electromagnetic waves on silicon solar cellrecombination parameters by changing the distance between the 2 MW power of radiationAM antenna and the solar cell. Secondly, we studied the influence of telecommunication(AM radio antenna or a FM radio antenna) source's power of radiation on a silicon solar cellilluminated by a white light in steady state. We analyzed the effects of electromagnetic fieldon photo-current density, back surface recombination velocity, intrinsic junctionrecombination velocity, photo-voltage, maximum electric power and conversion efficiency bymaking vary the antenna power of radiation. In this present article we study the influenceof telecommunication source's power of radiation on silicon solar cell electric parameters (Rs,Rsh, Jp, Vp, Pp, FF, Rpp) using the I-V and P-V .characteristics. This telecommunication

antenna can be either a radio antenna functioning in frequency modulation M or a radioantenna functioning in amplitude modulation AM. This radio station antenna is the source ofproduction of progressive monochromatic plane electromagnetic waves linearly polarizedwhose electric field intensity measured at a distance r from the source is dependant on thepower radiated by the source and the distance r. Therefore we will study the influence ofelectromagnetic field on shunt and series resistance, peak photo-current density, peak photovoltage, peak electric power, fill factor and peak power point's load resistance by varying theantenna power of radiation. We will relate the peak power point’s load resistance to thejunction recombination velocity calculated in the previous article[12 - 13].

2.6 External magnetic field effect on bifacial silicon solar cell's electric power and conversion efficiency

The efficiency of a solar cell depends on the electric power delivered to an external circuit but some externalfactors such as magnetic field, external electric field, and electromagnetic field can inuence this electricpower and so the solar cell quality.

Many studies on electronic and electrical parameters of solar cells under constant magnetic field have beenproposed with a one- or three-dimensional approach. Many authors proposed experimental methods to study themagnetic field's effect on solar cell properties. Betser et al. proposed an experimental method to determineInP/GaInAsheterojunction bipolar transistor's photocurrent and minority carriers' mobility under constant

magnetic field, while Vardanyan et al. proposed another method for measurement of all recombinationparameters (diffusion length, diffusion coefficient, carriers mobility, back surface recombination velocity) in thebase region of bifacial solar cells. Erel studied the effect of electric and magnetic fields on the operation of aCdS/CuInSe2 photovoltaic cell. The experience showed that the open circuit voltage and the electron effectivemass increase while the magnetic field intensity increases. Other authors proposed studying the modelling of themagnetic field's effect on solar cell properties. Madougou et al. showed that photocurrent density decreaseswith the magnetic field for each illumination mode of the bifacial solar cell, while the photovoltage increases withthe magnetic field for front side and simultaneous front and back side illumination. I{V characteristics of thebifacial silicon solar cell also decrease with the magnetic field. Zoungrana et al. with a three-dimensional[14-15].

2.7 The Effect Of Electromagnetic Field On Solar:

The magnetic field effect the electrical parameters of a silicon solar cellilluminated by an intense light concentration: external load electric power,conversion efficiency, fill factor, external optimal charge load. Due to the highphotogeneration of a carrier in intense light illumination mode, in addition ofmagnetic field, we took into account the carrier gradient electric field in the baseof the solar cell. Taking into account this electric field and the applied magneticfield in our model led to new analytical expressions of the continuity equation,the photocurrent and the photovoltage.

The effect of electric and magnetic fields on the operation of three different typesof solar cells (i.e. mono, poly, and amorphous Si solar cells).

The increase of magnetic field, the maximum electric power produced by thesolar decrease and moves to the small values of junction dynamic velocity andthis behavior means a reduction of the quantity of carriers which cross thejunction to participate to the photocurrent with magnetic field increase. We havealso put in evidence that the maximum electric power leads to the solar cellexternal load and its conversion efficiency decreases with the increase ofexternal magnetic field. This result confirmed the reduction of the quantity ofcarriers that cross the junction with magnetic field increase.

The magnetic field effect on the solar cell also led to the carrier storage near thesolar cell's junction and had as consequence the increase of the fill factor and theopen circuit voltage. We noted that the optimal load resistance increase with themagnetic field increase. That means for a given load resistance, the increase ofmagnetic field induced a decrease of the maximum electric power and theconversion efficiency, and therefore the magnetic field causes a deterioration ofthe solar cell efficiency [4].

Chapter Three
Material and Method

3.1 Introduction

A solar cell transform light energy in to electro current in this experiments we study effect electromagnetic field on the solar cell by using single solar cell, plug-in board , pair of board holders, potentiometer , set of ten bridging plugs, voltmeter, ammeter, halogen lamp housing, incandescent lamp, transformer, saddle base ,Connecting leads, Color filters

3.2 Material

1 solar cell, 2 V / 0.3 A, STE 4/100	578 63
1 plug-in board A4	576 764
1 pair of board holders	576 77
1 potentiometer 220 Ω, 3 W, STE 2/19	577 90
1 set of ten bridging plugs	501 48
1 voltmeter, DC, $U \leq 10$ V	e. g. 531 120
1 ammeter, DC, $I \leq 3$ A	e. g. 531 120
1 halogen lamp housing,12 V, 50/100 W	450 64
1 incandescent lamp 12 V, 100 W	450 63
1 transformer 2 to 12 V	521 25
1 saddle base	300 11
Connecting leads	
Color filters	

3.3 Method

- ❖ The experimental setup is illustrated in Fig. 4.1
- ❖ Plug the STE solar cell into the plug-in board, and connect
- ❖ The upper negative pole to the lower positive pole using
- ❖ Two bridging plugs (series connection of four solar cells).
- ❖ Plug in the STE potentiometer as a variable resistor, andconnect it to the solar battery using bridging plugs.

- ❖ Connect the ammeter in series with the solar battery andthe variable resistor. Select the measuring range 100 mA DC.
- ❖ Connect the voltmeter in parallel to the solar battery, andselect the measuring range 3 V DC.
- ❖ Connect the halogen lamp to the transformer, and align itso that the solar battery is uniformly irradiated.

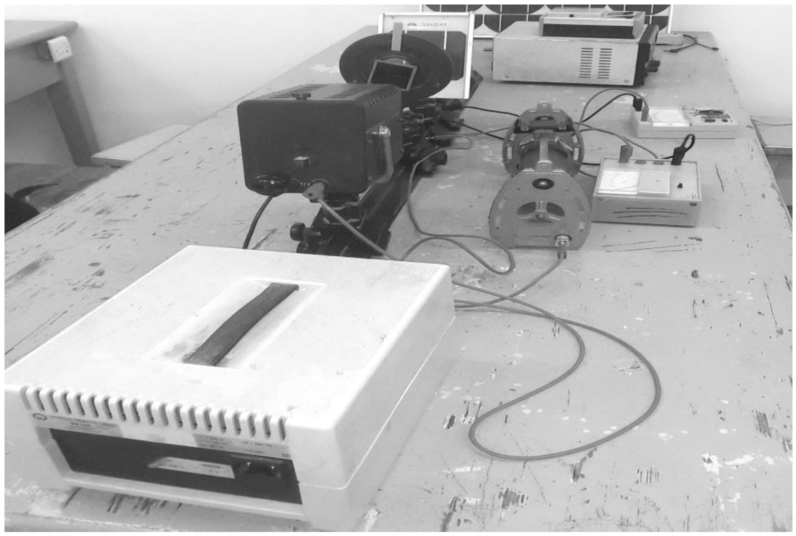


Figure 3.1 Experimental Setup for Recording the Current-Voltage Characteristics of a Solar Batteryas Functions of the irradiance

3.4 Carrying out the experiment

- ➢ Close the circuit, first shorting the variable resistor with an additional bridging plug between the points a and b, and choose the distance of the halogen lamp so that the short circuit current is approximately 100 mA.
- ➢ Remove the shorting bridging plug, and increase the terminalvoltage or decrease the current, respectively, step by step by changing the load resistance. For each step read the current and the voltage, and take them down.
- ➢ Then interrupt the circuit, and measure the open-circuit voltage.
- ➢ Adjust a short-circuit current of approximately 75 mA, after that 50 mA, 25 mA, by increasing the distance of the halogen lamp and repeat the series of measurements.

3.5 Result

Table (3.1) below explain measures of ammeter and voltmeter for single solar cell without magnetic field.

Tables (3.1) the color effect filter without magnetic field

Violet filter	
I/A mlA ±0.1	V/V ±0.01
18	1.5
16	2.5
15	3
14	3.5
4	4.5
Green filter	
I/A mlA ±0.1	V/V ±0.01
15	0.5
14	1.5
14	2
11	2.75
6	3

Yellow filter	
I/A mlA ±0.1	V/V ±0.01
12	0.75
10	1.5
8	2
6	2.25
4	2.5

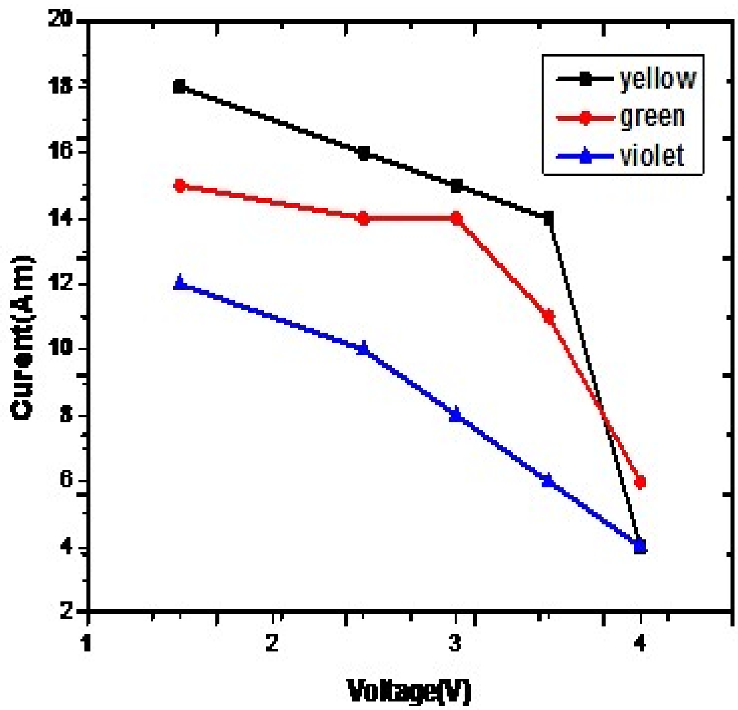


Figure 3.2Without Magnetic fields

The table below explain measures of ammeter and voltmeter for single solar cell with effect magnetic field.

Tables (3.2)the color filter with effect magnetic field

Yellow filter	
I/A mlA ±0.001	V/V ±0.001
0.035	0.002
0.035	0.003
0.033	0.005
0.032	0.006
0.03	0.007

Green filter	
I/A mlA ±0.001	V/V ±0.001
0.024	0.001
0.024	0.002
0.023	0.003
0.022	0.004
0.02	0.005

Violet filter	
I/A mlA ±0.001	V/V ±0.001
0.020	0.001
0.019	0.002
0.018	0.003
0.017	0.004
0.015	0.005

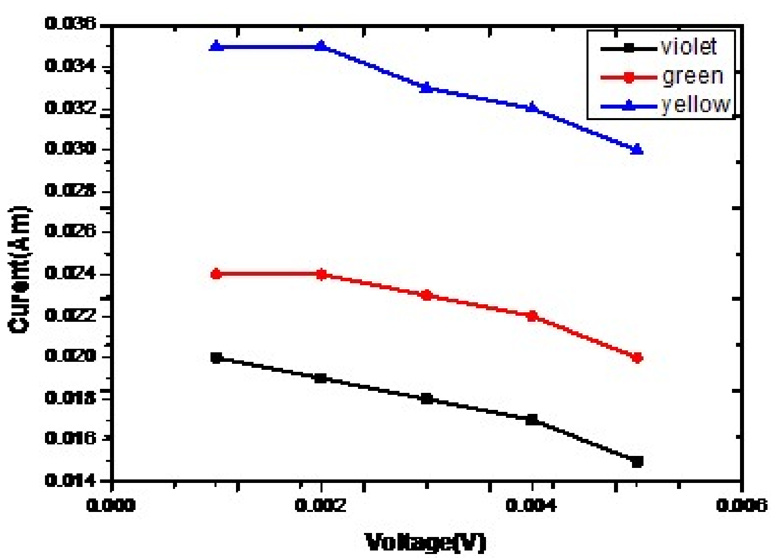


Figure3.3With magnetic fields

The tables explain comparison between effect of magnetic field and without magnetic field.

Table(3.3) Current result between without effect and with effect of magnetic field for violet filter

I_{before}/A	I_{after}/A	I_{before} / I_{after}
18	0.02	900
16	0.019	842.1
15	0.018	833.3
14	0.017	823.5
4	0.015	266.7

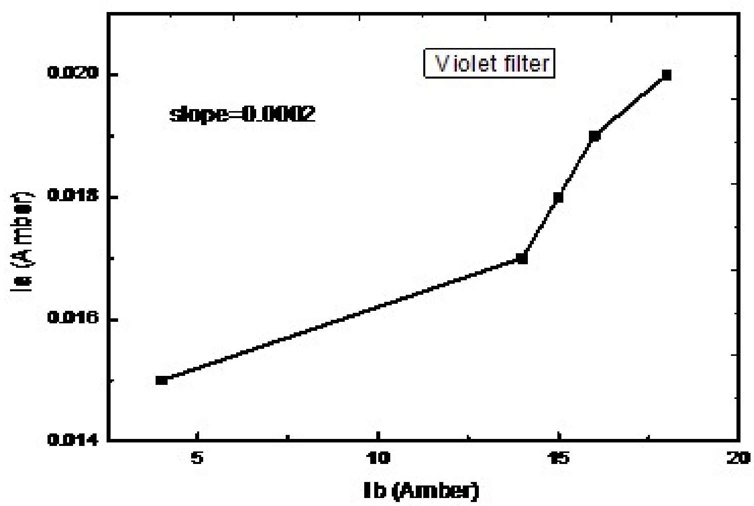


Figure3.4 Show Current Comparison Between Without Effect and With Effect of Magnetic field for Violet Filter

Table (3.4) Voltage Result Between Without Effect and With Effect of Magnetic field For Violet Filter

V_{before}/V	V_{after}/V	V_{before} / V_{after}
1.5	0.001	1500
2.5	0.002	1250
3.5	0.003	1000
3	0.004	875
4.5	0.005	900

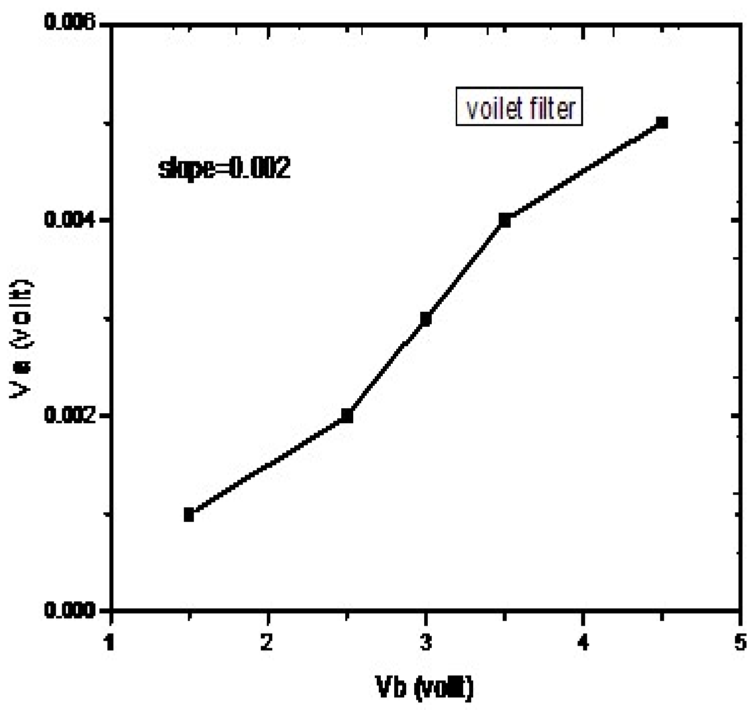


Figure3.5 Show Voltage comparison between without effect and with effect of magnetic field for violet filter

Table (3.5) Current result between without effect and with effect of magnetic field for Green filter

I_{before}/A	I_{after}/A	I_{before} / I_{after}
15	0.024	625
14	0.024	583.3
14	0.023	508.7
11	0.022	500
9	0.020	300

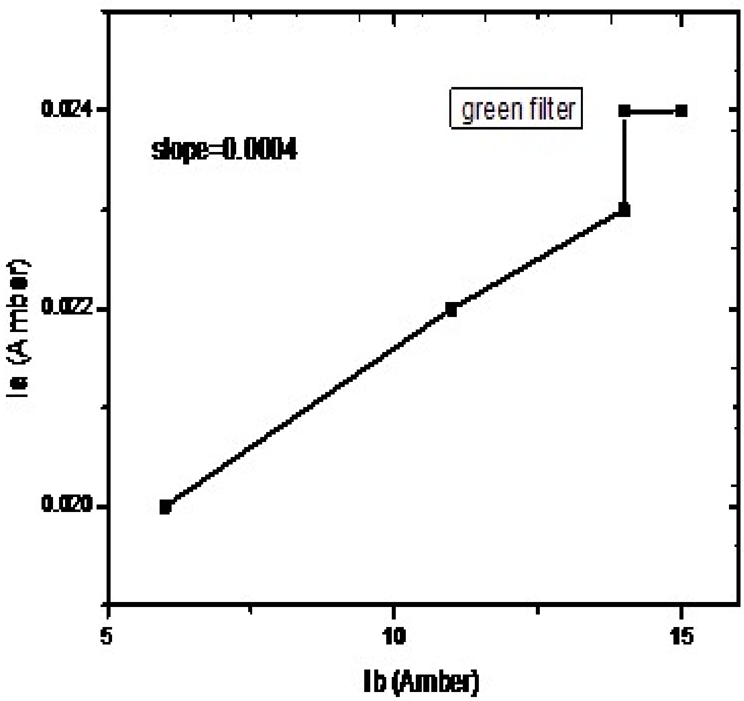


Figure3.6 Show Current comparison between without effect and with effect of magnetic field for Green filter

Table (3.6) Voltage result between without effect and with effect of magnetic field for Green filter

V_{before}/V	V_{after}/V	V_{before} / V_{after}
0.5	0.001	625
1.5	0.002	583.3
2	0.003	508.7
2.75	0.004	500
3	0.005	300

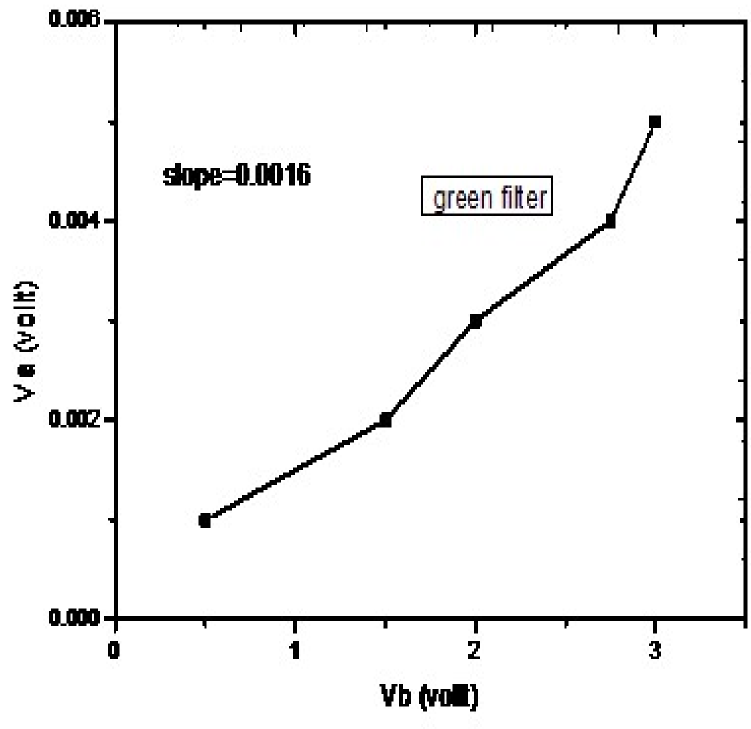


Figure3.7 Show Voltage comparison between without effect and with effect of magnetic field for Green filter

Table(3.7) Current result between without effect and with effect of magnetic field for Yellow filter

I_{before}/A	I_{after}/A	I_{before} / I_{after}
12	0.035	324.5
10	0.035	285.7
8	0.033	242.4
6	0.032	187.5
4	0.030	133.3

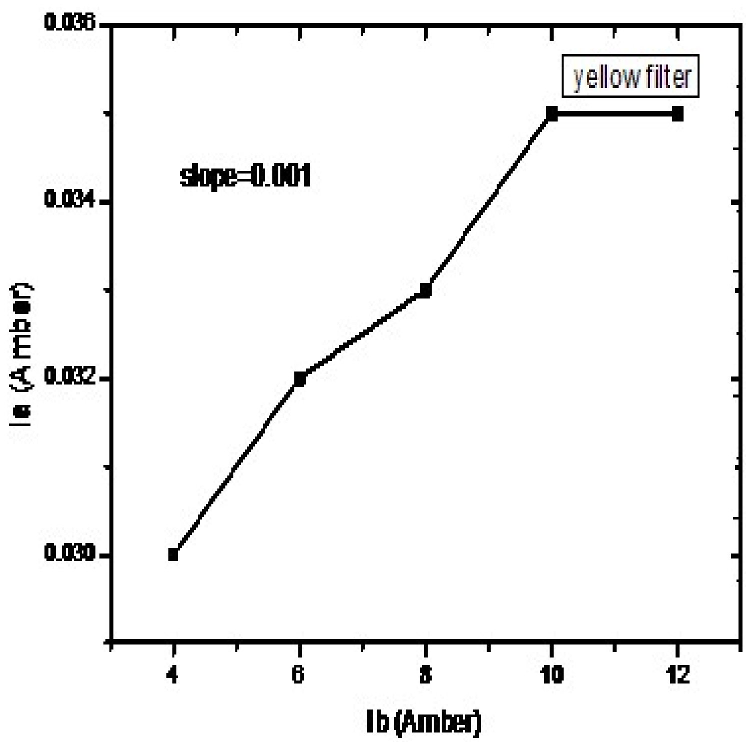


Figure3.8 Show Current Comparison Between Without Effect and With Effect of Magnetic field for Yellow Filter

Table (3.8) Voltage Result Between Without Effect and With Effect of Magnetic field for Yellow Filter

V_{before}/V	V_{after}/V	V_{before} / V_{after}
0.75	0.001	750
1.5	0.002	750
2	0.003	666.7
2.25	0.004	562.5
2.5	0.005	500

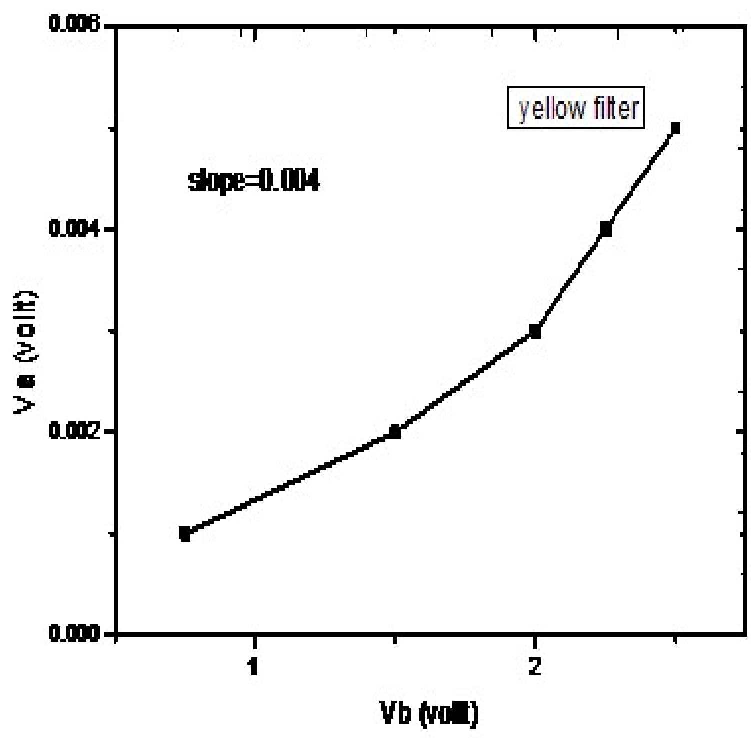


Figure3.9 Show Voltage Comparison Between Without Effect And With Effect Of Magnetic field For Yellow Filter

3.6 Discussion

From the table (4.1) and fig (4.1) show the spectrum in absence of magnetic field while table (4.2) and fig (4.2) show the spectrum in presence of magnetic field.

Fig (4.3), (4.4) show relation between and subject to magnetic field induction and potential difference and respectively from which one can calculate the slope in figure (4.3) is equal to 0.0002 while in fig (4.4) equal to 0.002.

Fig (4.5), (4.6) show relation between and subject to magnetic field induction and potential difference and respectively from which one can calculate the slope in fig (4.5) is equal to 0.0004 while in figure (4.6) equal to 0.0016.

Fig (4.7), (4.8) show relation between and subject to magnetic field induction and potential difference and respectively from which one can calculate the slope in fig (4.7) is equal to 0.001 while in fig (4.8) equal to 0.004.

3.7 Calculations

For different color filter used which reveals the relation to be

For violet filter				
0.0036	0.0032	0.003	0.0028	0.0008
0.003	0.005	0.006	0.007	0.009

For green filter				
0.006	0.0056	0.0056	0.0044	0.0024
0.0008	0.0024	0.0032	0.0044	0.0048

For yellow filter				
0.012	0.01	0.008	0.006	0.004
0.003	0.006	0.008	0.009	0.01

3.8 Conclusion

From the result obtained it was found slope for current before (I_{before})- current after (I_{after}) and slope for voltmeter (V_{before}) – and voltmeter (V_{after}) from the graph after that calculate the and from the relation to be and for difference color filters.

3.9 Recommendation

Research has been carried out in the effect of magnetic were on solar cell has produced some inter resting finding so its recommended that solar cell shout not be placed close up to the electromagnetic area.

References

[1] M. El-Aasser, 2014, Magnetic Field Effect on the Electrical Characteristics of a Monocrystallinen+pp+ Silicon Solar Cell, International Journal of Advances in Applied Sciences (IJAAS)Vol. 3, No. 4, December 2014, pp. 196~201ISSN: 2252-8814

[2] I. Zerbo, 2012, Silicon Solar Cell Under Electromagnetic Waves In Steady State: Electrical Parameters DeterminationUsing The I-V And P-V Characteristics, International Journal of Science, Environmentand Technology, Vol. 1, No 4, 2012, 230 – 246.

[3]Pooja Singh, 2021, P-V and I-V Characteristics of Solar Cell, ISSN: 0011-9342 | Year 2021 Issue: 6 | Pages: 520-528

[4] Martial Zoungrana1, IssaZerbo and others, (The Effect Of Magnetic Field On The Efficiency Of A Silicon Solar Cell Under An Intense Light Concentration), Advances in Science and Technology, Research Journal, Volume 11, Issue 2, 2017.

[5]Askari Mohammad Bagher, Mirzaei Mahmoud AbadiVahid, Mirhabibi Mohsen, 2015, Types of Solar Cells and Application, American Journal of Optics and Photonics. Vol. 3, No. 5pp. 94-113. doi: 10.11648/j.ajop.20150305.17

[6]Sergio Daher, JurgenSchmid and Fernando L.M Antunes, "Multilevel Inverter Topologies for Stand-Alone PV Systems" IEEE Transactions on Industrial Electronics.vol.55, July 2008.

[7]SoerenBaekhoegKjaer, John K.PedersenFredeBlaabjerg "A Review of Single –Phase Grid-Connected Inverters for Photovoltaic Modules," IEEE Trans. on Industry Appications, vol.5, 2005.

[8] J. Cubas, S. Pindado, C. de Manuel, Explicit expressions for solar panel equivalent circuit parameters based on analytical formulation and the lambert W-Function, Energies 7 (2014) 4098-4115.

[9] J. Cubas, S. Pindado, M. Victoria, On the analytical approach for modeling photovoltaic systems behavior, J.Power Sources 247(2014)467-474.

[10] Chopra K. L., et al,, “Thin-Film Solar Cells: An Overview," Prog. Photovolt: Res. Appl., 2004, Vol. 12, pp. 69–92.

[11] Handy R., “Theoretical Analysis of the Series Resistance of a Solar Cell,” Solid-State Electronics, 1967, Vol. 10, No. 8, pp. 765-775.

[12] M. Zoungrana, M. Thiame, A. Dioum, S. Raguilnaba, G. Sissoko; 3 D study of bifacialsilicon solar cell under intense light concentration and under external constant magnetic field:recombination and electric parameters determination; 22nd European Photovoltaic SolarEnergy Conference, 3-7 September 2007, Milan, Italy ,447-453.

[13] M. Zoungrana, I. Ly, B. Zouma, F. I. Barro, G. Sissoko; 3 D study of bifacial silicon solarcell under intense light concentration and under external constant magnetic field: effect ofmagnetic field and base depth on excess minority carrier generation, Journal des Sciences,Vol. 7, N°4 (2007) 73-81.

[14] Zerbo, I.; Zoungrana, M.; Ser_e, A. D.; Zougmor_e, F. IOP Conf. Ser.: Mater. Sci. Eng. 2012, 29, 012019.

[15] Zerbo, I.; Zoungrana, M.; Ouedraogo, A.; Korgo, B.; Zouma, B.; Bathiebo, D. J. Global Journal of Pure and AppliedSciences. 2014, 20, 139{148.