Influence of Magnetic Field on Electrical Model and Electrical Parameters of a Solar Cell Under Intense Multispectral Illumination

By F. Toure, M. Zoungrana, B. Zouma, S. Mbojdi, S. Gueye, A. Diao & G. Sissoko

Université Cheikh Anta Diop, Senegal

Abstract - In this work we present a 3D modeling of the magnetic field influence on electrical model and electrical parameters ($J_{ph}$, $V_{ph}$, $R_s$, $R_{sh}$, $C$) of a polycrystalline silicon solar cell under intense multispectral illumination. For intense light, the electric field in the base of the solar cell has to be considered; taking into account this electric field and the applied magnetic field in our model lead to two major things: Firstly, new analytical expressions of the continuity equation, the photocurrent and the photovoltage are proposed; secondly an equivalent electrical model of the solar cell under constant magnetic field is proposed and the influence of the magnetic field is pointed out on electrical parameters such as shunt and series resistances and space charge capacitance.

Keywords : 1-Magnetic field, 2- Shunt Resistance, 3- Series Resistance, 4- SCR capacitance.

GJSFR-A Classification : FOR Code: 020302
Influence of Magnetic Field on Electrical Model and Electrical Parameters of a Solar Cell Under Intense Multispectral Illumination

F. Toure*, M. Zougrana*, B. Zouma*, S. Mbojii*, S. Gueyex, A. Diao§ & G. Sissoko§

Abstract - In this work we present a 3D modeling of the magnetic field influence on electrical model and electrical parameters ($J_{ph}$, $V_{ph}$, $R_s$, $R_{sh}$, $C$) of a polycrystalline silicon solar cell under intense multispectral illumination. For intense light, the electric field in the base of the solar cell has to be considered; taking into account this electric field and the applied magnetic field in our model lead to two major things: Firstly, new analytical expressions of the continuity equation; the photocurrent and the photovoltage are proposed; secondly an equivalent electrical model of the solar cell under constant magnetic field is proposed and the influence of the magnetic field is pointed out on electrical parameters such as shunt and series resistances and space charge capacitance.

Keywords : 1-Magnetic field, 2- Shunt Resistance, 3- Series Résistance, 4- SCR capacitance.

1. Introduction

The decrease of oil reserves in the world, the raise cost of hydrocarbons, the consequences of oil derivative garbage on health, environment and climate obliges everybody to move toward new sources of energy more proper and less polluting. In this sense, one of the possible alternatives for electric energy production is photovoltaic solar energy, that is clean silent shape of energy and whose source is available. However, although this shape of energy is advantageous, it is confronted to a crucial problem that is the weakness of solar cells energy efficiency. Thus, the numerous research tracks nowadays solar cells have for object to find good quality materials, news manufacture technologies or solar cells operating conditions that minimize solar cells performances factors limiting factors: minority carrier recombination photocurrent and photovoltage losses, shadiness effects and resistive losses [3],…

Whatever is solar cell quality, it is necessary at its installation moment to take into account an outside factor susceptible to lower efficiency: the magnetic field. Indeed, whatever is their installation place, the solar cells by their operating principle (electrons movement) can be influenced by magnetic field [4] that can be of various origin: terrestrial magnetic field ($5.10^{-5}$ T), magnetic component of electromagnetic wave coming from the radio emitters, television emitters and telecommunication emitter [5]: AM antenna, power of radiance: 50W-5kW, magnetic field values: $B \leq 1.29 \times 10^7$ T; FM antenna, power of radiance: 500W - 2MW, magnetic field values $4.10^6 \leq B \leq 2.58 \times 10^6$ T.

Since the electrical parameters ($J_{ph}$, $V_{ph}$, $P_{el}$, $R_{s}$, $R_{sh}$, $C$) and electronic parameters ($S_m$, $S_e$, $S_{iso}$, $L$, $D$) of the solar cell are closely dependent carrier distribution in the cell, the magnetic field will perturb these parameters. In this work we present a 3D study of the influence of magnetic field on the electrical parameters of a silicon solar cell under multispectral intense light [6] (more than 50 suns). For this intense light our model takes into account the electric field due to concentration gradient in the bulk of the base.

II. Theoretical Model

This study is based on a 3D modeling of a polycrystalline silicon solar cell; we made the following assumptions:

a) A columnar model is considered [3] with the grains having square cross section ($g_s = g_b$) so that their electrical properties are homogeneous; we can then use the cartesian coordinates; the base depth is H.

b) The grain boundaries are perpendicular to the junction and their recombination velocities independent of generation rate under AM1.5 illumination. So the boundary conditions of continuity equation are linear;

c) The illumination is uniform. We then have a generation rate depending only on the depth in the base z;

d) The contribution of the emitter and space charge region is neglected [3], so this analysis is only developed in the base region.
Theoretical model of square grain with an external magnetic field and internal electric field.

The solar cell is front side illuminated with more than 50 suns; the external magnetic field is parallel to the junction and the electric field due to concentration gradient along the z axis in the base region can be expressed as [6, 8]:

$$E(z) = \frac{D_p - D_n}{\mu_p + \mu_n} \frac{1}{\delta(x, y, z)} \frac{\partial \delta(x, y, z)}{\partial z}$$  \hspace{1cm} (1)

$$D_n$$ et $$\mu_n$$ are respectively electrons diffusion constant and mobility, $$\delta(x, y, z)$$ is the minority carrier’s density in the base of the solar cell, $$\tau_n$$ is the electrons lifetime and $$C$$ indicates the concentration factor (in suns).

We supposed also that carrier distribution along x and y axes are uniform for a given z plane so that there is no conduction current along these axis; we can write:

$$E(x) = E(y) = 0$$  \hspace{1cm} (2)

Taking into account the electric field given by Equation 1, the continuity equation can be written as:

$$\frac{\partial \delta(x, y, z)}{\partial t} = \frac{1}{e} \mathbf{V} \cdot \mathbf{J}_n + G(z) - R(z)$$  \hspace{1cm} (3)

$$G(z)$$ is the carrier generation rate at the depth z in the base: $$G(z) = C \cdot \Sigma a_i \cdot e^{-b z}$$

Parameters $$a_i$$ and $$b$$ are coefficients deduced from modeling of the generation rate considered for overall the solar radiation spectrum when AM = 1.5 [9].

$$R(z)$$ is the recombination rate at depth z given by:

$$R(z) = \frac{\delta(x, y, z)}{\tau_n}$$

$$\mathbf{J}_n$$ can be written as the sum of [10]:

1. the drift current: $$\mathbf{J}_c = e \cdot \mu_n \cdot \delta_n(x, y, z) \cdot E$$
2. the current induced by the magnetic field: $$\mathbf{J}_m = -\mu_n \cdot \mathbf{J}_n \wedge \mathbf{B}$$ and
3. the diffusion current: $$\mathbf{J}_d = e D_n \cdot \nabla \delta_n(x, y, z)$$

We then have:

$$\mathbf{J}_n = \mathbf{J}_c - \mathbf{J}_m + \mathbf{J}_d = e D_n \cdot \nabla \delta_n(x, y, z)$$  \hspace{1cm} (4)

with $$\mathbf{B} = B \mathbf{j}$$, $$B(x) = B(z) = 0$$.

The drift current is zero along x and y axes, that is:

$$\frac{\partial \mathbf{J}_c}{\partial x} = \frac{\partial \mathbf{J}_c}{\partial y} = 0$$

Using the components of the scalar product $$\mathbf{V} \cdot \mathbf{J}_n$$ and inserting them in equation 3 in static regime

$$\frac{\partial \delta(x, y, z)}{\partial t} = 0$$, we obtain the following differential equation:

$$C \frac{\partial^2 \delta(x, y, z)}{\partial x^2} + C \frac{\partial^2 \delta(x, y, z)}{\partial y^2} + \frac{\partial^2 \delta(x, y, z)}{\partial z^2} + \frac{G(z)}{D^*} \delta(x, y, z) = 0$$  \hspace{1cm} (5)

and

$$D^* = \frac{(D_n - \mu_n A)}{1 + \mu_n B^2}, \quad L^2 = \tau_n \cdot D^* \quad \text{with} \quad A = \frac{D_p - D_n}{\mu_p + \mu_n}$$

### III. Solution of the Continuity Equation

Equation 6 is a partial differential equation with general solution in the form:

$$\delta(x, y, z) = \sum_j \sum_k Z_{j,k}(z) \cdot \cos(C_{jx} x) \cdot \cos(C_{yk} y)$$  \hspace{1cm} (7)

with $$C_{jx} = \frac{C_j}{C_x}$$, $$C_{yk} = \frac{C_k}{C_y}$$

Coefficients $$C_{jx}$$ et $$C_{yk}$$ are determined by mean of boundary conditions at the grain boundaries $$x = \pm \frac{g_x}{2}$$ et $$y = \pm \frac{g_y}{2}$$ given respectively by:

$$\left[ \frac{\partial \delta(x, y, z)}{\partial x} \right]_{x=\pm \frac{g_x}{2}} = \pm \frac{Sgb}{D^*} \cdot \delta(\pm \frac{g_x}{2}, y, z)$$

and

$$\left[ \frac{\partial \delta(x, y, z)}{\partial y} \right]_{y=\pm \frac{g_y}{2}} = \pm \frac{Sgb}{D^*} \cdot \delta(x, \pm \frac{g_y}{2}, z)$$  \hspace{1cm} (8)
Coefficients $C_{xj}$ and $C_{yk}$ are solution of the following transcendental equations:

$$C_{xj} \tan(C_{xj} \cdot \frac{g_x}{2}) = \frac{Sgb}{D^*} \tag{9.1}$$

and

$$C_{yk} \tan(C_{yk} \cdot \frac{g_y}{2}) = \frac{Sgb}{D^*} \tag{9.2}$$

Taking into account the orthogonality of the cosine functions, $Z_{jk}(z)$ can be written in the form [11]:

$$Z_{jk}(z) = A_{jk} \cos\left(\frac{z}{L_{j,k}}\right) + B_{jk} \sinh\left(\frac{z}{L_{j,k}}\right) - \sum_{\nu=1}^{3} K_{\nu} e^{-\nu z} \tag{10}$$

With

$$K_{\nu} = C \cdot \frac{a_{\nu} \cdot L_{\nu j,k}}{D_{j,k} \cdot \left[b_{\nu}^* \cdot L_{j,k}^* - 1\right]}$$

and

$$\frac{1}{L_{j,k}} = \left[C_j^2 + C_k^2 + \frac{1}{L_n^2}\right]$$

$$1 = \frac{16 \cdot \sin(C_{xj} \cdot \frac{g_x}{2}) \cdot \sin(C_{yk} \cdot \frac{g_y}{2})}{D_{j,k} \cdot \sin(C_{xj} \cdot g_x) + C_{xj} \cdot g_x \cdot [\sin(C_{yk} \cdot g_y) + C_{yk} \cdot g_y]}$$

Coefficients $A_{jk}$ and $B_{jk}$ are obtained by inserting equation 7 and boundary conditions into equation 6 [11]:

$$A_{jk} = \sum_{\nu=1}^{3} K_{\nu} \cdot \frac{S_{\nu} \cdot D_{\nu}^*}{D_{\nu}} \exp(-\nu z \cdot H) + B_{jk} \left[\frac{S_{L} \cdot D_{L}^* + bi}{D_{L}^*} \right] \tag{11.1}$$

and

$$B_{jk} = \sum_{\nu=1}^{3} K_{\nu} \cdot \frac{S_{\nu} \cdot D_{\nu}^*}{D_{\nu}} \exp(-\nu z \cdot H) \cdot \alpha_{jk} \left[\frac{S_{L} \cdot D_{L}^* + bi}{D_{L}^*}\right] \tag{11.2}$$

with:

$$\alpha_{jk} = \frac{1}{L_{j,k}} \cdot \sinh\left(\frac{H}{L_{j,k}}\right) + \frac{S_{b}}{D^*} \cdot \cosh\left(\frac{H}{L_{j,k}}\right)$$

$$\beta_{jk} = \frac{1}{L_{j,k}} \cdot \cosh\left(\frac{H}{L_{j,k}}\right) + \frac{S_{b}}{D^*} \cdot \sinh\left(\frac{H}{L_{j,k}}\right)$$

With these coefficients $A_{jk}$ and $B_{jk}$, the final solution of the continuity equation is well known.

### IV. Determination of the Equivalent Electrical Model of the Solar Cell Under Magnetic Field

We present on figure 2 the equivalent electrical one diode model of the solar cell without magnetic field.

![Figure 2: One diode equivalent electrical model of the solar cell without magnetic field.](image)

In this model, the diode characterizes not only the diffusion saturation current in the base and the emitter but also the generation-recombination saturation current in the space charge region $[1, 12]$. It appears also in this model two parasitic resistances $[13]$:

- The shunt resistance $R_{sh}$ characterizes current losses at the junction. These losses are induced by intrinsic recombination ($S_{0b}$) at the junction. Then a part of the photocurrent is derived into this resistance and could not be used by the external load.
- The series resistance characterizes the contacts resistance, the resistivity of the base material and the dynamic resistance of the junction $[3]$. The presence of this resistance leads to a decrease of the voltage across the external load.

#### a) Space charge region capacitance variation with magnetic field

Figure 3 below show the dependence of the carriers’ density on the magnetic field and the depth in the base. In figure 4, we present a closer view (near the junction) of the influence of the magnetic field for various depths in the base.
Figure 3: Excess minority carriers profile in the base of a photoexcited cell versus base depth and magnetic field: C=200 suns; \( g_x = g_y = 3 \times 10^{-3} \) cm; \( S_b = 10^4 \) cm.s\(^{-1} \); \( S_{gb} = 10^3 \) cm.s\(^{-1} \); \( S_f = 10^4 \) cm.s\(^{-1} \).

Figure 4: Influence of magnetic field on the excess minority carriers density for various depths in the base: \( z = 0.01 \) cm, \( z = 0.005 \) cm, \( z = 0.0025 \) cm, \( z = 0.0005 \) cm.

Figures 3 and 4 show that for increasing magnetic field, the maximum of the excess minority carriers density increase also and are shifted left to the junction. This increasing of the maximum of the excess minority carriers density translates an increase of the carrier concentration near the junction. The displacement of the maximum of the excess minority carriers density shows that there is a decreasing carriers flow through the junction. These two consequences translate that there is an accumulation of carriers near the junction for increasing magnetic field.

These accumulated carriers enforce the space charge region leading to an extension of the space charge region [14].

To exhibit the capacitive effect of the space charge region, let us replace the diode by a capacitor with capacitance \( C \). The expression of \( C \) is inversely proportional to the space charge region width \( l \) :

\[
C = \frac{S \varepsilon}{l}.
\]

\( S \) is the junction surface and \( \varepsilon \) is the silicon permittivity. In these conditions, a space charge region extension corresponds to a decrease of the capacitance; the interpretation of this phenomenon leads us to add in series with \( C \) an extra capacitor with capacitance \( C_m \) depending on the applied magnetic field.

b) Shunt resistance variation under magnetic field

The photocurrent density \( J_{ph} \) is given by [11,15],

\[
J_{ph} = \frac{q \cdot D^*}{g_x \cdot g_y} \int_{0}^{\infty} \int_{z=0}^{\infty} \left( \frac{\partial \delta(x,y,z)}{\partial z} \right) dx dy
\]  

(12)

With

\[
\delta(x,y,z) = \sum_{j} \sum_{k} Z_{j,k}(z) \cdot \cos(C_{y,j} \cdot x) \cdot \cos(C_{y,k} \cdot y)
\]

Replacing \( \delta(x,y,z) \) and equations (8), (9.1) and (9.2) into equation (12) we obtain:

\[
J_{ph} = q \cdot D^* \cdot \sum_{j} \sum_{k} R_{jk} \cdot \left[ \frac{B_{jk}}{L_{jk}} + \sum_{i=1}^{3} K_{jk} b_i \right]
\]

(13)

with

\[
R_{jk} = \left( 1 + \mu_x^2 \cdot B^2 \right) \cdot 4 \sin \left( C_{y,j} \cdot \frac{g_x}{2} \right) \cdot \sin \left( C_{y,k} \cdot \frac{g_y}{2} \right)
\]

\[
R_{jk} = \frac{g_y \cdot g_x \cdot C_{y,j} \cdot C_{y,k}}{2}
\]

Figures 5 and 6 illustrate the effect of magnetic field [10,16] on the photocurrent density.

Figure 5: Effect of magnetic field and junction recombination velocity on photocurrent:

\( g_x = g_y = 3 \times 10^{-3} \) cm, \( S_{gb} = 10^2 \) cm.s\(^{-1} \), \( S_b = 104 \) cm.s\(^{-1} \).
We observe on figure 5 that near the open circuit \( (S_f \rightarrow 0) \), there is practically no influence of magnetic field on the photocurrent density, contrary to short circuit \( (S_f \rightarrow \infty) \) where the photocurrent density decreases drastically with increasing magnetic field (figures 5 and 6). This decrease of the photocurrent combined with the accumulation phenomenon depending on magnetic field mean that there is an increase of the leakage current (through the junction and the edges of the solar cell).

This leakage current can be represented by an extra resistance \( R_{th} \) depending on the magnetic field, in parallel with the shunt resistance \( R_{sh} \).

c) Series resistance variation under magnetic field

The photovoltage can be expressed by means of the Boltzmann law \([11, 15]\):

\[
V_{ph} = V_T \ln \left[ 1 + \frac{N_B}{n_i^2} \sum_j \frac{\delta_y}{2} \sum_k \frac{\delta_x}{2} \delta(x, y, 0) dx dy \right] \quad (14)
\]

In this expression, \( V_T \) is the thermal voltage given by: \( V_T = k_B T / q \). \( n_i \) is the carrier concentration at equilibrium: \( n_i = n_i^2 / N_B \) \( (n_i \) represents the intrinsic carrier concentration : \( n_i = 10^{10} \text{ cm}^{-3} \) for silicon, \( N_B \) is the base doping density : \( N_B = 10^{19} \text{ cm}^{-3} \) and \( k_B \) is the Boltzmann’s constant.

The resolution of the equation 14 leads to the following expression for \( V_{ph} \):

\[
V_{ph} = V_T \ln \left[ 1 + \frac{N_B}{n_i^2} \sum_j \sum_k R_{jk} \cdot \left[ A_{jk} - \sum_{i=1}^{3} K_i \right] \right] \quad (15)
\]

We show on figures 7 and 8 the effect of the magnetic field on the photovoltage.

We observe on these figures that the photovoltage which means an accumulation of charges across the junction present a maximum for very low \( S_f \) values (open circuit); this open circuit voltage increases with increasing magnetic field. This is a consequence of charge accumulation in the base and diminution of junction recombination with increasing magnetic field; this phenomenon is accompanied by an increase of recombination in the bulk and at the grain boundaries \([8, 15]\).
The behavior of the photovoltage under magnetic field characterizes an increase of resistive losses in the base (due to material structure and electrical grids); this increase of resistive losses leads to a decrease in the output voltage. We characterize this behavior by adding an extra resistance $R_{sem}(B)$ (depending on magnetic field) in series with $R_s$. 

From our previous results, we propose below an equivalent electrical model for the solar cell under intense light and external magnetic field.

\[
R_{sem}(B) = R_s + R_{sem}(B) \quad (16)
\]

\[
\frac{1}{R_{sem}(B)} = \frac{1}{R_{sh}} + \frac{1}{R_{sem}(B)} \quad (17)
\]

\[
\frac{1}{C_{sem}(B)} = \frac{1}{C_{sh}} + \frac{1}{C} \quad (18)
\]

$R_{sem}(B)$, $R_{sh}(B)$ and $C_{sem}(B)$ represent electrical parameters under magnetic field, $R_s$, $R_{sh}$ and $C$ correspond to the same electrical parameters without magnetic field.

V. MAGNETIC FIELD EFFECT ON ELECTRICAL PARAMETERS

a) Magnetic field effect on shunt resistance

When an external load (with non-zero or non-infinite resistance) is connected to a solar cell, the solar cell will operate at a given operating point between open circuit and short circuit. The current $I$ that flow through that load is given by [17]:

\[
I = I_{ph} - I_{d}(V) - I_{sh}(V) = I_{ph} - I_s \left[ \exp \left( \frac{q(V + I R_{sem})}{n k_B T} \right) - 1 \right] \quad (19)
\]

$I_s$ is the diode saturation current and $n$ is the ideality factor.

The $I(V)$ curve of the solar cell is then presented below based on the set of equations 10, 11, 13 and 19.

\[
J_{cc} = \lim_{S_f \to \infty} J_{ph} \quad (20)
\]

It appears on this $I-V$ curve that near the short circuit, the solar cell behaves like a non-ideal current generator, that is an ideal current generator associated with a shunt resistance [18,19]. We determine the shunt resistance through the equivalent electrical model of the solar cell in short circuit (figure 11). The short circuit is characterized by a maximum carrier flow through the junction, thus this situation exhibit very well the losses at the junction and then the shunt resistance.

\[
R_{she} = \frac{V(S_f)}{(J_{cc} - I(S_f))} \quad (21)
\]

$J_{cc}$ is the short circuit current density given by:

\[
J_{cc} = \lim_{S_f \to \infty} J_{ph}
\]
The load resistance \( R_{ch} \) is taken very low to keep the solar cell close to the short circuit, given that \( R_{ch} \) and \( S_f \) vary inversely. [20]

The figure 12 below shows the effect of the magnetic field on the shunt resistance.

![Figure 12](image)

**Figure 12:** Magnetic field effect on the shunt resistance.

We observe on this figure that the shunt resistance decreases with the increase of magnetic field [21]. This behavior means that intrinsic recombination in the solar cell increase and then the output current decrease. This phenomenon means that the shunt resistance derives a part of the generated photocurrent.

**b) Magnetic field effect on series resistance**

To determine the series resistance, let us take a look on the I-V curve near the open circuit (figure 13) particularly the circled part of the figure.

![Figure 13](image)

**Figure 13:** Behavior of the solar cell near the short circuit

Near open circuit, the solar cell operates like a real voltage generator, that is an association of an ideal voltage generator and an internal series resistance \( R_{se} \) which causes a voltage drop and thus decreasing the output voltage. The determination of this series resistance is made near the open circuit. Near this operating point there is a charge accumulation in the cell so that any losses are due to the cell structure and electrical grids.

Near this open circuit, the solar cell can be represented by the following electrical model

![Diagram](image)

**Figure 14:** Electrical model of the solar cell near open circuit.

Based on the figure 14 above we obtain:

\[
V(S_f) = V_{co} - R_{se} I(S_f)
\]

We then deduce the series resistance as:

\[
R_{se} = \frac{V_{co} - V(S_f)}{I(S_f)}
\]

\( V_{co} \) is the open circuit voltage and can be obtained from the Boltzmann relation when \( S_f = S_{fo} \) [7,11].

\[
V_{co} = V_t \ln \left[ 1 + \left( \frac{N_A}{n_i} \right) \sum_j R_j \cdot \left( A_{jk} - \sum_i K_i \right) \right]
\]

with:

\[
A_{jk} = \frac{1}{L_{jk}} \left( S_{fo} \exp(-bi) + \beta_{j,k} \left( S_{fo} + bi \right) \right)
\]

\[
K_i = \frac{S_{fo}}{D^*} \beta_{j,k} + \frac{1}{L_{jk}} \cdot \alpha_{j,k}
\]

Figure 15 below presents the series resistance versus magnetic field:

![Figure 15](image)

**Figure 15:** Series resistance versus magnetic field.
It can be observed that for magnetic field values less than $7 \times 10^5$ Tesla there is no change on the series resistance; for values greater than $7 \times 10^5$ Tesla the series resistance increases with increasing magnetic field.

This series resistance must be kept as low as possible to minimize losses in the solar cell.

c) Magnetic field effect on the space charge region

The solar cell junction behaves like a capacitor with capacitance $C$ [3, 22] depending on the space charge region width.

Based on the carrier density in the base, one can evaluate the amount $Q$ of charge accumulated near the junction by: $Q=q\delta(0)$ [20,23]. The associated capacitance is given by [23]: $C=Q/V_j$, where $V_j$ is the voltage across the junction.

Figure 16 presents the effect of the magnetic field on the equivalent capacitance:

![Graph showing the effect of magnetic field on the equivalent capacitance](image)

Figure 16: Magnetic field effect on the equivalent capacitance.

As noted for the series resistance, the equivalent capacitance seems to not depend on magnetic field for values less than $B< 7 \times 10^5$ Tesla. But for more intense magnetic field the equivalent capacitance decrease very rapidly.

This behavior of the equivalent capacitance is directly related to the space charge region widening with magnetic field.

V. Conclusion

This study of magnetic field effect on solar cell lead us to put in evidence new analytical expressions of carrier density in the base of the solar cell and electrical parameters such as $J_{ph}$, $V_{ph}$, $P_{el}$, $R_{el}$, $R_{ph}$ and $C$. It was shown that magnetic field causes charge accumulation across the junction, increase the junction recombination and open circuit voltage but decrease in the same time the short circuit current density.

The analysis of the magnetic field effect on carrier density, photocurrent and photovoltage show that there is a variation of electrical parameters such as shunt resistance, series resistance and space charge capacitance; we then proposed an equivalent electrical model describing the behavior of the solar cell under magnetic field.

Based on this model, the expressions of the series and shunt resistances, space charge capacitance have been determined, and the effects of the magnetic field on these parameters have been shown. It seems that magnetic field less than $7 \times 10^5$ Tesla has no effect on electrical parameters; for magnetic field greater than $7 \times 10^5$ Tesla, the shunt resistance and the capacitance decrease contrary to the series resistance.

These results also show that the terrestrial magnetic field ($5 \times 10^5$ Tesla) and the electromagnetic waves (AM antenna, $B \leq 1.29 \times 10^{-7}$ T; FM antenna, $4 \times 10^{-7}$ T $\leq B \leq 2.58 \times 10^{-6}$ T) have no effects on solar cells.

References Références

5. U. Freyer Nachrichten-Uebertragungstechnik, 1994 Edition Carl Hanser ( Munich)


