



Cairo University

# **PERFORMANCE ANALYSIS OF A PHOTOVOLTAIC CELL PLACED NEARBY POWER TRANSMISSION LINES**

By

**Mohamed Sayed Abdelkhalek Afifi**

A Thesis Submitted to the  
Faculty of Engineering at Cairo University  
In Partial Fulfillment of the  
Requirements for the Degree of  
**MASTER OF SCIENCE**  
**In**  
**Electrical Power and Machines Engineering**

FACULTY OF ENGINEERING, CAIRO UNIVERSITY  
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**Key Words:**

Overhead Transmission Line; Electric Field; Photovoltaic; Performance; COMSOL

**Summary:**

The thesis studies the effect of the electric fields resulted from over-head transmission lines on the photovoltaic cells. The thesis research comprises modeling of Photovoltaic using finite element method on COMSOL Multiphysics software. The effect of light wave and electric field waves has been introduced to the model to study their effect on Photovoltaic model. The study is built on comparing the electrical performance parameters of the Photovoltaic module like voltage, current and power-voltage curve in the existences and absence of the transmission line fields. The study has been supported with practical measurements for photovoltaic module placed under the transmission line subjected to electric field of 2.1 kV/m, also laboratory verification carried out on higher values of electric field and using high voltage AC up to 25 kV to generate electric field up to 21.55 kV/m in the experimental case. The study shows that the performance of the photovoltaic module is not affected by the fields under the transmission lines which opens the door for further studies leading to better use of lands under their right of way.

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## **List of Abbreviations**

CSM	Charge Simulation Method.
DNA	Deoxyribonucleic Acid.
ELF	Extremely Low Frequency Fields.
EMC	Electromagnetic Compatibility.
EMF	Electromagnetic Fields.
FDM	Finite Difference Method.
FEM	Finite Element Method.
OHTL	Overhead Transmission Line.
PV	Photovoltaic.

## List of Symbols

$\nabla$	Mathematical Curl operator
A	Closed surface area in divergence equation
c	Speed of light in free space and air $2.998 \times 10^8$ m/s
D	Electric flux density
E	East known potential point of point P in finite difference method
$E_f$	Electric Field
$E_g$	Bandgap energy needed to cross the band in semiconductor
$E_{ph}$	Energy of the photons
FF	the fill factor of the photovoltaic cell
h	Planks constant ( $6.625 \times 10^{-34}$ joules.s)
$h_E$	distance between P and E in finite difference method
$h_N$	distance between P and N in finite difference method
$h_S$	distance between P and S in finite difference method
$h_W$	distance between P and W in finite difference method
I	the total current for photovoltaic cell
$I_0$	Diode current
$I_L$	light generated current of photovoltaic cell
$I_{MP}$	Maximum Current of the photovoltaic cell
$I_{SC}$	the short-circuit current of the Photovoltaic cell
j	complex number operator equals $= \sqrt{-1}$
k	Boltzmann's constant
n	Ideality factor of the diode
N	North known potential point of point P in finite difference method
P	Unknown potential point in finite difference method

$P_{MP}$	Maximum power of the photovoltaic cell
$q$	Electron charge constant
$Q_1$	Point charge 1
$Q_2$	Point charge 2
$R_{CH}$	Characteristic Resistance of photovoltaic cell
$R_S$	Series Resistance of photovoltaic cell
$S$	South known potential point of point P in finite difference method
$T$	Absolute Temperature
$V$	The total voltage for photovoltaic cell
$V_{MP}$	Maximum voltage of the photovoltaic cell
$V_{OC}$	the open circuit voltage of the Photovoltaic cell
$W$	West known potential point of point P in finite difference method
$W_{FE}$	Energy stored in the volume in finite element method
$\epsilon$	The isotropic permittivity of the material
$\epsilon_x$	The anisotropic permittivity of the material in x-direction
$\epsilon_y$	The anisotropic permittivity of the material in y-direction
$\epsilon_z$	The anisotropic permittivity of the material in z-direction
$\eta$	the efficiency of the Photovoltaic cell
$\sigma$	Electrical conductivity
$\lambda$	Wavelength of light wave
$\Phi$	The potential symbol for numerical techniques
$\Phi(E)$	Potential value of point E in finite difference method
$\Phi(N)$	Potential value of point N in finite difference method
$\Phi(S)$	Potential value of point S in finite difference method
$\Phi(W)$	Potential value of point W in finite difference method

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# Abstract

The Electromagnetic Fields and Electromagnetic Compatibility (EMC) are key sciences; they are used to ensure the proper performance of the electrical and electronic devices. These sciences should be utilized to study the effect of the equipment on each other and expect the performance when parameters change.

Many unplanned performances for electric equipment has been noticed, especially due to the effect of the electric fields surrounding the transmission line. There is a need to know about the performance of many devices when subjected to abnormal conditions especially electric fields.

The selected device to be tested is the photovoltaic module (PV). The analysis needed to be done is to study the change in performance that may result if the module is placed nearby a transmission line.

Many studies have been done to numerically calculate the electric fields nearby transmission lines, also many studies have been made to model the PV cells to calculate its performance parameters. The most common studies simulated the PV cells using finite element method.

This research uses a simulation using finite element package. A blending of two physics in COMSOL® Software has been done to simulate such environment, which are the “Electromagnetic Waves” and the “Semiconductors”.

The study has been supported with practical measurements for photovoltaic module placed under the transmission line subjected to electric field of 2.1 kV/m, also laboratory verification carried out on higher values of electric field and using high voltage AC up to 25 kV to generate electric field up to 21.55 kV/m in the experimental case.

The main results obtained shows that there is no change noticed in the performance of the PV cell, which opens the door for better utilizing the huge areas under the transmission lines in PV farming.