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A RESEARCH VISION

Duty cycle and radiation estimates using maximum load transfer point for optimization of a 100KVA photovoltaic system

Estimaciones de ciclo de trabajo y radiación utilizando máximo punto de transferencia de carga para la optimización de un sistema fotovoltaico de 100KVA

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PRELIMINARY PUBLICATION

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PUBLICACIÓN PRELIMINAR

Este artículo cumplió con las fases editoriales de envío, recepción y aceptación para su publicación en el Volumen 14, Número 2 de la Revista Visión Electrónica, algo más que un estado sólido de la Facultad Tecnológica de la Universidad Distrital Francisco José de Caldas. La versión evidencia las modificaciones realizadas por los autores a partir de los conceptos emanados de los evaluadores. En consecuencia, la versión preliminar del artículo es visible para consulta y cita; sin embargo, debe aclararse que este documento es provisional ya que no ha completado las etapas de corrección de estilo, traducción, diseño, así como detalles de forma correspondientes a la finalización del proceso editorial del artículo. Esta versión se puede consultar, descargar y citar como se indica a continuación. Tenga en cuenta que el documento final en formato PDF, o sus metadatos, puede ser diferente.

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Abstract

In this document, the variation of temperature and radiation in a 100 kW photovoltaic assembly is connected to a 25 kV network through a DC-DC booster converter and a three-phase three-phase voltage source converter (VSC). Maximum power point tracking (MPPT) is implemented in the elevator converter using a Simulink® model that uses the technique of 'Incremental Conductance + Integral Regulator'.

The switching duty cycle is optimized by an MPPT controller that uses the technique of 'Incremental Conductance + Integral Regulator'. This MPPT system automatically modifies the duty cycle to generate the voltage required to extract the maximum power.

Keywords: Duty cycle, MPPT, Photovoltaic, Power, Radiation, Temperature.

Resumen

En este documento, se describen la variación de la temperatura y radiación en un conjunto fotovoltaico de 100 kW está conectado a una red de 25 kV a través de un convertidor de refuerzo CC-CC y un convertidor de fuente de voltaje trifásico de tres niveles (VSC). El seguimiento del punto de máxima potencia (MPPT) se implementa en el convertidor elevador mediante un modelo Simulink® que utiliza la técnica de 'Conductancia incremental + Regulador integral'.

El ciclo de trabajo de conmutación está optimizado por un controlador MPPT que utiliza la técnica de 'Conductancia incremental + Regulador integral'. Este sistema MPPT varía automáticamente el ciclo de trabajo para generar el voltaje requerido para extraer la potencia máxima.

Palabras clave: Duty cycle, MPPT, Fotovoltaico, Potencia, Radiación, Temperatura.

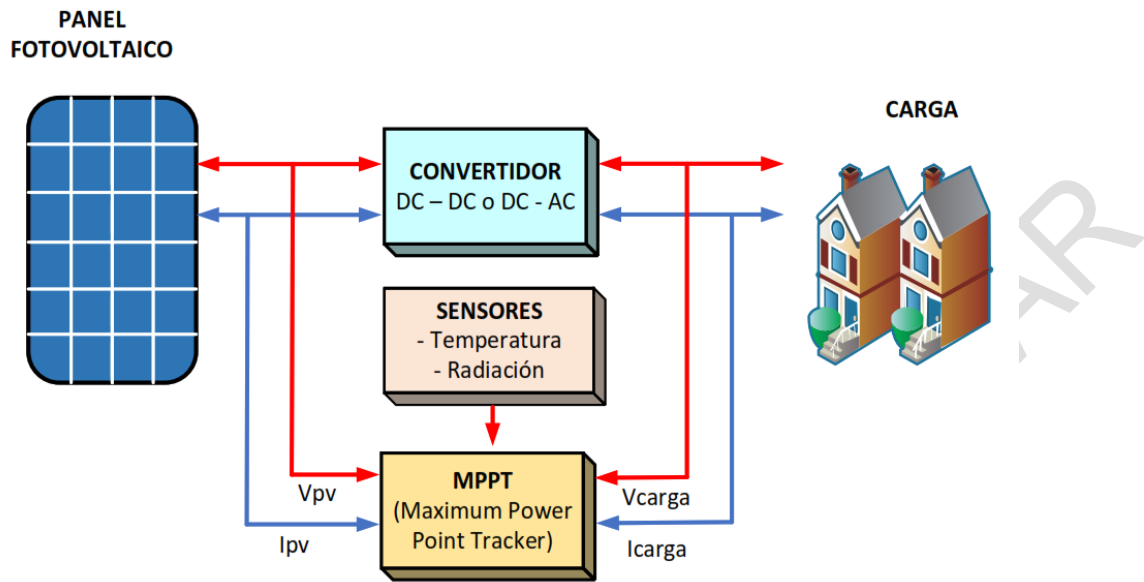
1. Introduction

The solar power generation system has advanced and been investigated in several countries around the world as a new high-tech energy species that is highly promising [1]. This type of energy will occupy a very important position in the energy system in the coming years.

The output characteristic of the photovoltaic matrix is not linear due to the conditions with which this type of energy is acquired and that it changes through the different light conditions and temperature of the environment in which it is found. Therefore, the output power will be greatly affected by this factor. To ensure and guarantee that this output power value in the photovoltaic array is the maximum, the maximum power point must be tracked and found in real time.

There are some methods which can track the maximum power point among which are: constant voltage monitoring method, disturbance and observation method, the incremental conductance method, etc. [2-3] Although the constant voltage monitoring method can be easily controlled, it does not take into account the influence of temperature on the open circuit voltage, that is, when the temperature changes in great magnitude, it will produce large deviations in the final value. On the other hand, the efficiency of the disturbance and observation method and the incremental conductance method are relatively high compared to the previous one, but in this case the step of the variation of the working relationship in the MPPT circuit of the two methods is a constant and this is a big problem, because it is difficult to choose the variation step of the working ratio. The purpose of this article is to find and determine the maximum point of disturbance through a relationship in the variables that appear in each case, in turn, it is also intended to find a mathematical model that allows finding new relationships depending on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power

point again, that is, it uses very small steps near the maximum power point. The purpose of this article is to find and determine the maximum point of disturbance through a relationship in the variables that appear in each case, in turn, it is also intended to find a mathematical model that allows finding new relationships depending on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power point again, that is, it uses very small steps near the maximum power point. The purpose of this article is to find and determine the maximum point of disturbance through a relationship in the variables that appear in each case, in turn, it is also intended to find a mathematical model that allows finding new relationships depending on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power point again, that is, it uses very small steps near the maximum power point. It is also intended to find a mathematical model that allows finding new relationships based on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power point again, that is, it uses very small steps near the maximum power point. It is also intended to find a mathematical model that allows finding new relationships based on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power point again, that is, it uses very small steps near the maximum power point. It is also intended to find a mathematical model that allows finding new relationships based on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power point again, that is, it uses very small steps near the maximum power point. It is also intended to find a mathematical model that allows finding new relationships based on radiation and temperature in the same sector. The step of the variation of the working ratio for this case is variable since with it the maximum power point can be detected. When the output power is having large variations in its magnitude, it quickly seeks to track the maximum power point again, that is, it uses very small steps near the maximum power point.

Figure 1. Representation of the model implementation.

Source: own.

The idea of the constant voltage monitoring method is as follows: the voltage of the photovoltaic array at the point of maximum power is almost the same under a different lighting intensity according to the output characteristics of the photovoltaic array, when the temperature remains constant. Therefore, it can be thought that the maximum power points of a given photovoltaic array correspond to approximately the same voltage. If the output voltage is controlled with this voltage, the PV array is working at the point of maximum power [4-5].

The constant voltage tracking method is easy to control and has high reliability and stability. But it does not take into account the influence of temperature on the photovoltaic matrix. In practice, the output voltage of the PV array will decrease with increasing temperature. Therefore, the constant voltage tracking method will produce big deviation and power loss, when the temperature change is big. Therefore, its control precision is poor and it does not have the ability to adapt itself.

2. Maximal power point tracking in isolated photovoltaic systems.

The observation and disturbance method is that the PV system controller changes the output power of the PV array using a minor disturbance in each control period to determine if the direction of the disturbance is correct. If the output power increases, the direction of the disturbance remains the same as in the last control period. But if the output power decreases, the disturbance direction must be changed to the opposite one. In this way, the actual working point of the photovoltaic array is gradually closing to the point of maximum power and is finally reaching the alternative steady state in a small range near it [6-8].

The disturbance and observation method can be easily performed and its sensor accuracy requirement is not high. But the pace of the disturbance is a constant. It will produce large fluctuations near the point of maximum power and will cause serious energy loss if the step size is large [9-14]. If the step size is small, the number of disturbances necessary to reach the point of maximum power will be greater and the time will be much longer. Therefore, we cannot consider tracking accuracy and response speed when selecting step size [15-26].

3. Formulation of the Problem

Table 1. The variables of the MPPT model.

Symbol	Quantity
D	Duty cycle
t	Weather
I	Stream
V	Voltage
P	Power
T	Temperature
PV	Matrix Voltage
MPPT	Maximum Power Point Tracking

Source. own.

Algorithm

Entry: Run the model provided by Simulink

Departure: Clustering

Step 1: From $t = 0$ [s] to $t = 0.05$ [s] the pulses to the Boost and VSC converters are blocked.

At $t = 0.05$ [s] Boost and VSC converters are unlocked.

The DC link voltage is regulated to $V_{cc} = 500$ [V] Calculate # zones = P

When the steady state reaches $t = 0.25$ [s] the resulting PV voltage is: $V_{dc} = 250$ [V] and the output power of the array is 96 [kW], while the irradiance power is approximately 100.7 [kW].

Step 2: At $t = 0.4$ [s] the MPPT is enabled, therefore the regulator begins to set the voltage by varying the duty cycle to extract the maximum power.

When $D = 0.454$, the maximum power of 100.4 [kW] is obtained.

At $t = 0.6$ [s] The matrix voltage PV = 274 [V] (As expected in the module specifications).

From $t = 0.6$ [s] to $t = 1.1$ [s] Solar irradiance decreases from 1000 to 250, while MPPT continues to track peak power.

Step 3: At $t = 1.2$ [s] when the irradiance has been reduced to 250, the Duty Cycle $D = 0.461$, the voltage $V_{mean} = 268$ [V] and $P_{mean} = 24.3$ [kW].

From $t = 1.2$ [s] to $t = 2.5$ [s] Solar irradiation is restored to 1000 [W] and the temperature increases to 50 °C, when the temperature rises from 25 °C to 50 °C the output power of the set decreases from 100.7 [kW] to 93 [kW].

3.1. Mathematical Model

Incremental Conductance Method

Objective Function:

$$P_{PV} = V_{PV} * I_{PV} \quad (1)$$

Subject to:

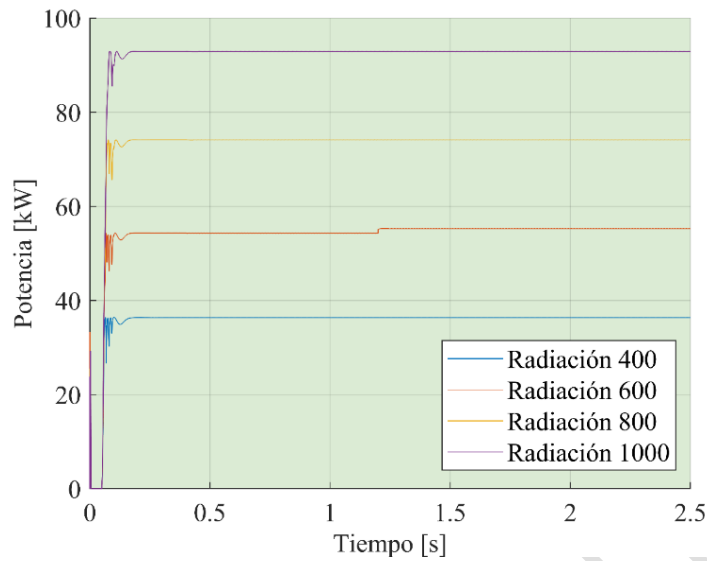
$$\frac{d P_{PV}}{d V_{PV}} = I_{PV} + V_{PV} \frac{d I_{PV}}{d V_{PV}} = 0 \quad (2)$$

$$\frac{d I_{PV}}{d V_{PV}} = -\frac{I_{PV}}{V_{PV}} \quad (3)$$

4. Analysis of Results

When the radiation values vary, the average power values vary, depending on the amount of radiation, the values used in the simulations are 400, 600, 800, 1000 giving a small disturbance at 0.1 seconds and then stabilizing at a value of 35, 55, 75, 95 on average as shown in the graph. [27]

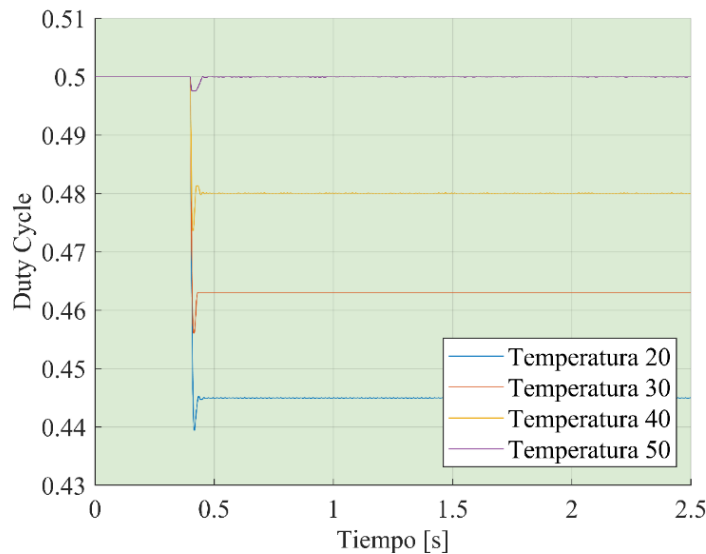
Figure 2. Detail of the Power-Radiation relationship.



Source: own.

The same experimentation was carried out when varying the temperature and variation in the Duty cycle was visualized due to its relationship, the values we gave at temperature for this simulation are 20, 30, 40, 50 the same ones that make the Duty Cycle vary which it begins with a value of 0.5 and at 0.4 seconds it falls depending on the value of the temperature 0.44, 0.455, 0.475, 0.498 and it proceeds to stabilize as shown in the graph.

Figure 3. Detail of the Duty Cycle -Temperature relationship.



Source: own.

5. Conclusions

We can estimate the value of the Power in KW knowing the radiation that the panel is receiving, in the graphs we can see that when we have a radiation of 400 the power is very close to the value of 40 KW, in the same way in the other experiments so that we can conclude that the expected power is the value of the Radiation divided by 10 and will give us an approximate value to the real thing.

The value of the Duty Cycle almost does not vary when the temperature varies as we have observed in the graph of Duty Cycle vs Time but it should be noted that having a value of 50 degrees the Duty Cycle has a small disturbance and remains at its value, at reducing the temperature value by 10 degrees the Duty Cycle value falls to 0.4 seconds and loses 2 hundredths of the value it was in, and this is similarly reproduced in the other simulations.

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