X SICEL 2021

Transición energética en la 4ta revolución industrial

Universidad Tecnológica de Pereira

UNIVERSIDAD NACIONAL DE COLOMBIA

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Comparative Analysis of MPPT Algorithms for PV Systems Under Partial Shading Conditions

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Institutions: Universidad Industrial de Santander (UIS)

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CONSTRUIMOS FUTURO

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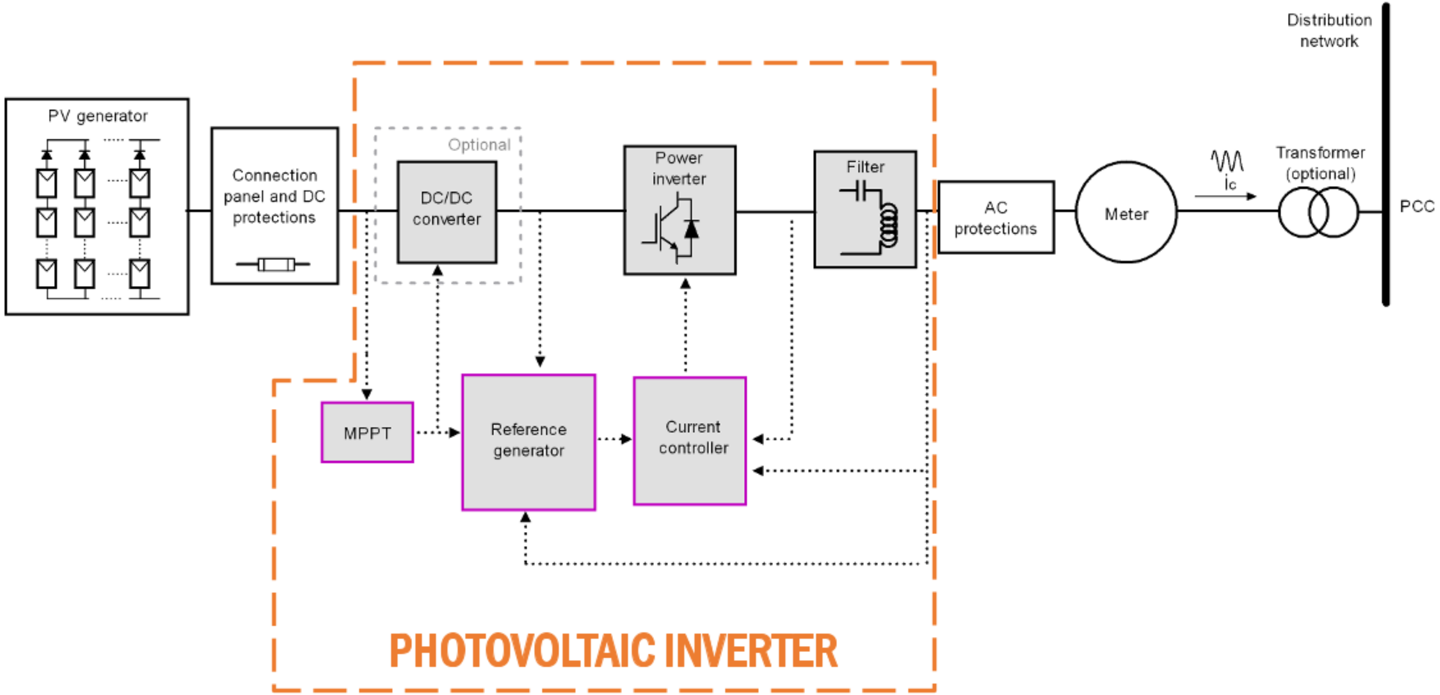
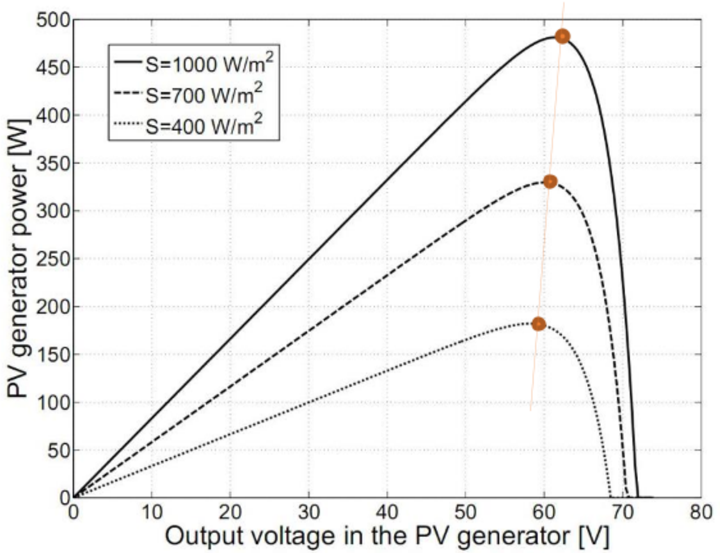
I. Introduction

General scheme of a grid-connected PV system



I. Introduction

Maximum Power Point Tracking (MPPT) under uniform irradiance and temperature conditions

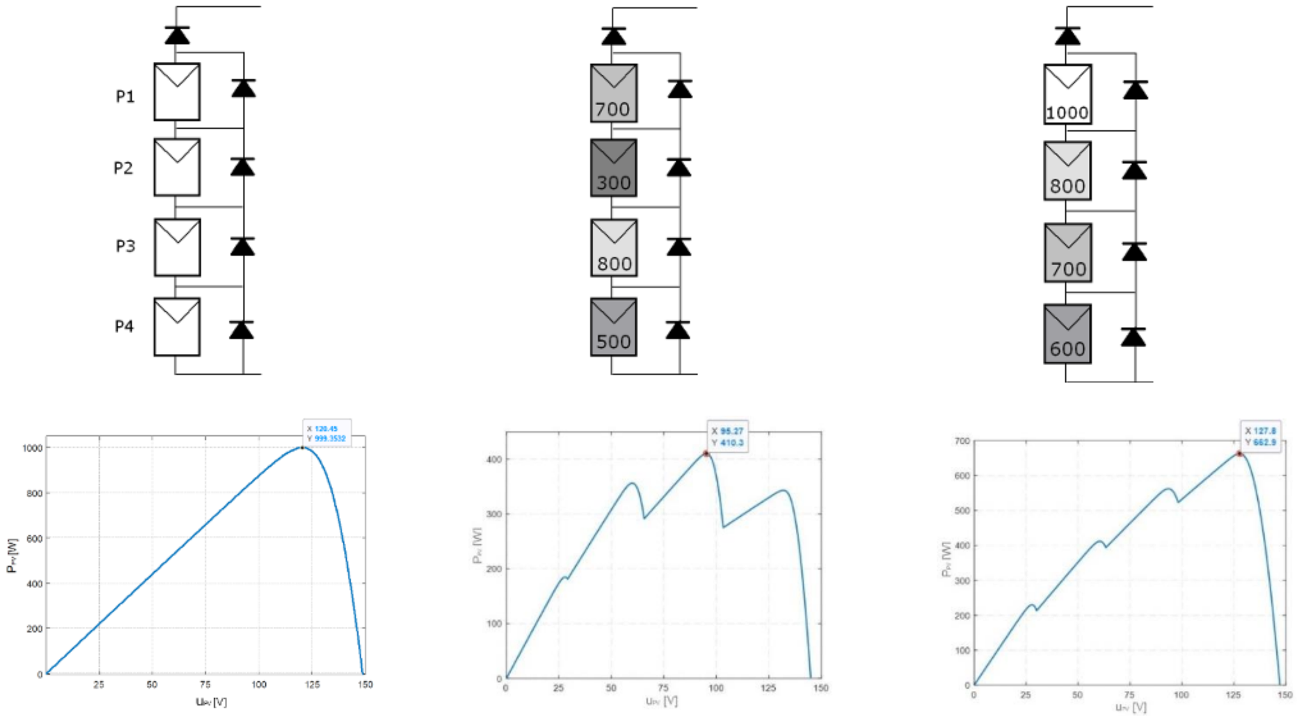


MPPT algorithms:

- Perturb and Observe (P&O) technique
- Incremental Conductance (IC) technique
- Constant Voltage (CV) method
- Adaptive P&O technique
- Adaptive IC technique
- P&O with compensation network
- Fuzzy logic
- Artificial Neuron Network

I. Introduction

Characteristic curves under different irradiance and partial shading conditions



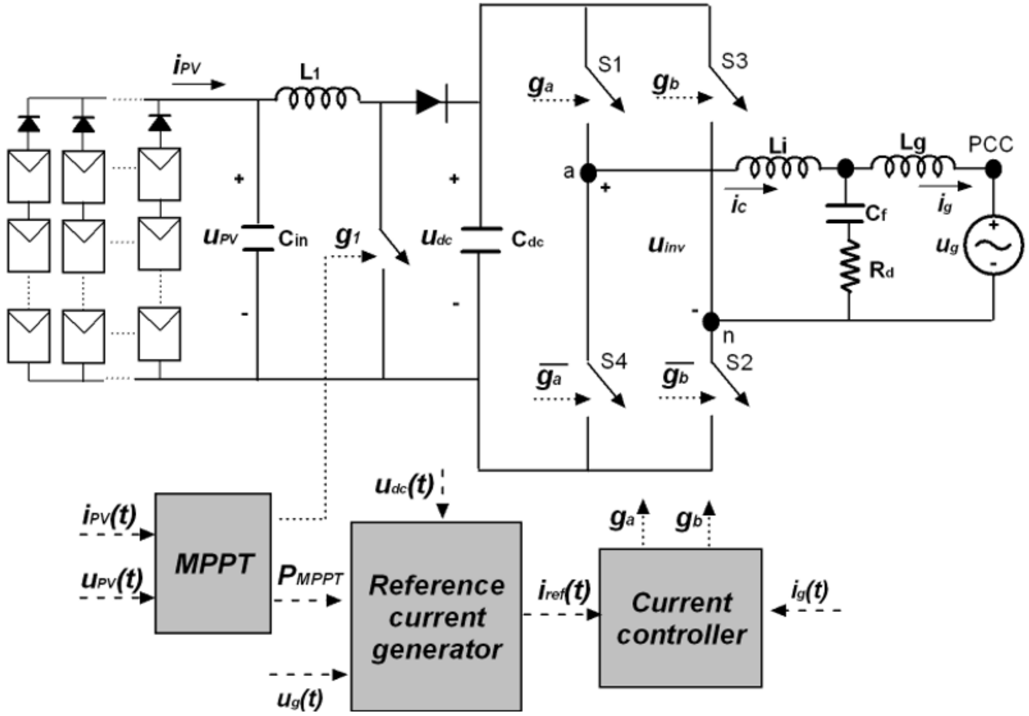
I. Introduction

This work presents a performance comparison between different kind of MPPT techniques for grid-connected PV systems under partial shading conditions.

Traditional methods	Algorithm based on modifications of traditional methods	Algorithm based on artificial intelligence
• P&O technique	• Observe, Compare and Perturbed (OC&P) technique	• Fuzzy logic controller

II. Grid-connected PV system

Scheme of the grid-connected PV system



II. Grid-connected PV system

Reference signal generation:

- Algorithm based on Fryze power theory

$$i_{ref} = \frac{P^* u_g}{U_{gRMS}^2}$$

$$P^* = P_{PV} - P_{dc}$$

where:

$$P_{dc} = k_p e + \frac{k_p}{T_i} \int e dt$$

$$e = U_{dc}^* - u_{dc}$$

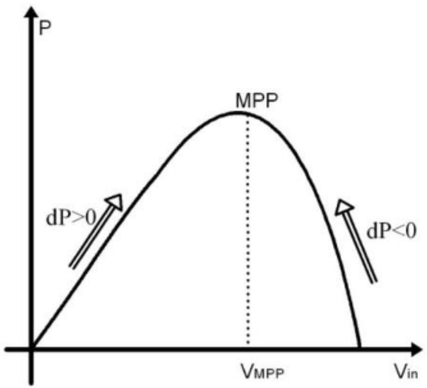
Current controller:

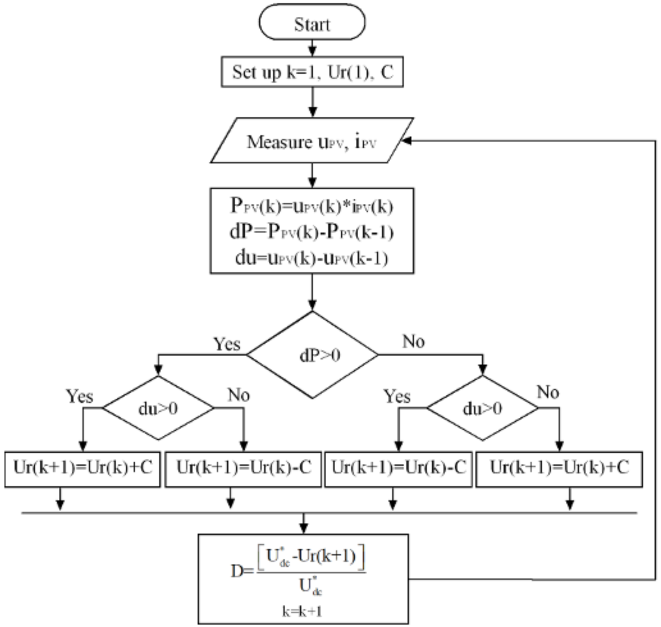
- Proportional resonant (PR) damped controller with PWM technique

$$G_{PR}(s) = k_{pr} + \frac{2 k_i \omega_c s}{s^2 + 2\omega_c s + \omega_o^2}$$

III. Maximum Power Point tracking (MPPT) algorithms

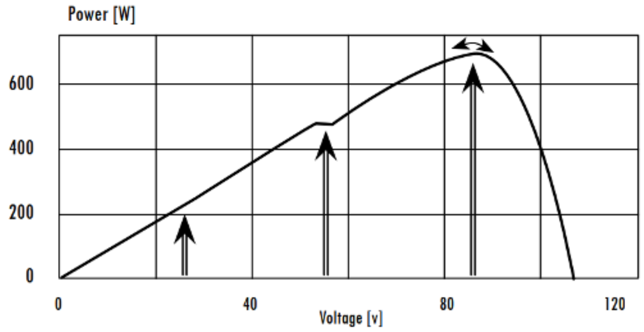
I. Perturb and Observe (P&O) technique

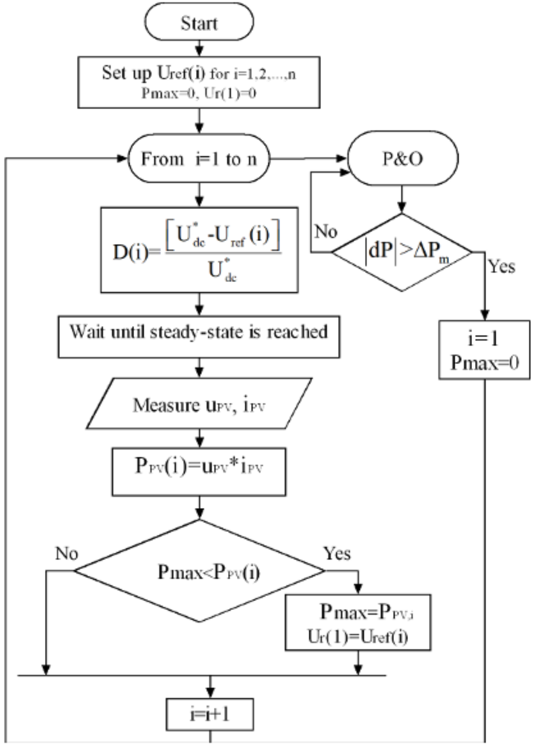




III. Maximum Power Point tracking (MPPT) algorithms

II. Observe, Compare and Perturb (OC&P) technique

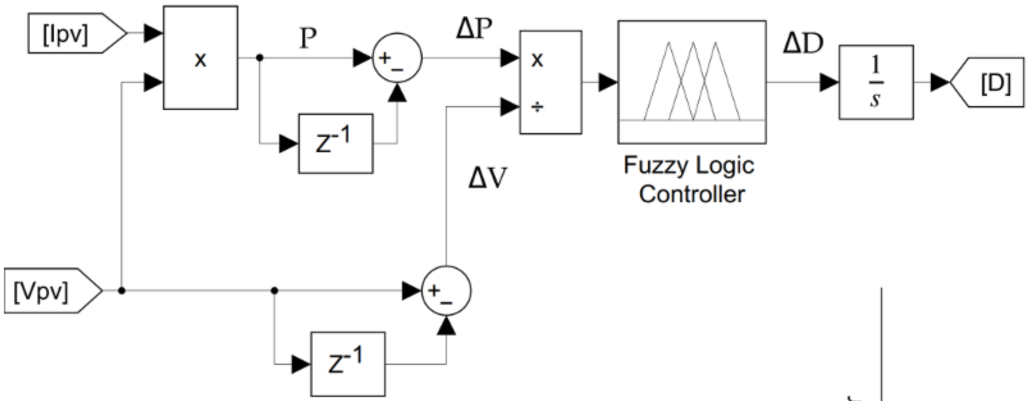


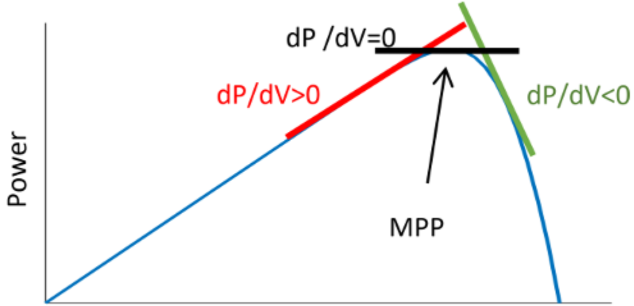


Reference: J. Archila-Valderrama, M. Mantilla-Villalobos, J. Barrero Perez, J. Petit-Suárez, and G. Ordóñez-Plata, "A maximum power point tracking algorithm for photovoltaic systems under partially shaded conditions," Ingeniería y Universidad, vol. 20, no. 2, pp. 391–410, Jun. 2016. [Online]. Available: https://revistas.javeriana.edu.co/index.php/iyu/article/view/12635

III. Maximum Power Point tracking (MPPT) algorithms

III. Fuzzy logic controller

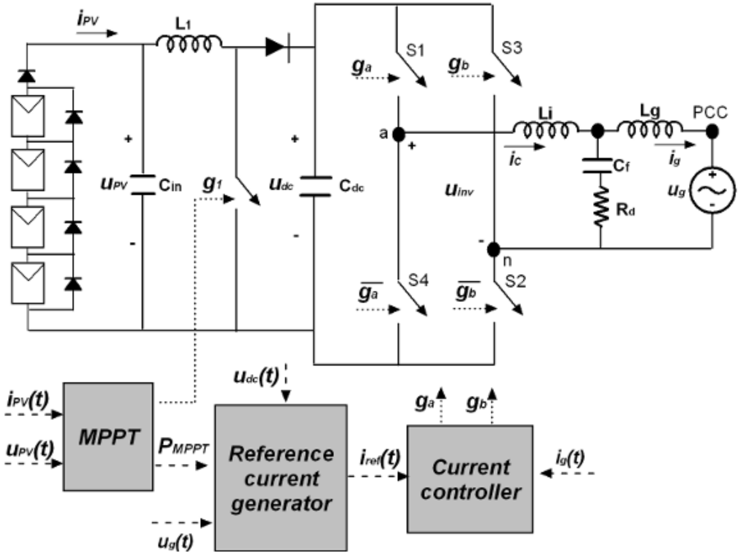




Reference: B. Benlahbib, N. Bouarroudj, S. Mekhilef, T. Abdelkrim, A. Lakhdari, and F. Bouchafaa, "A fuzzy logic controller based on maximum power point tracking algorithm for partially shaded pv array-experimental validation," Elektronika ir Elektrotechnika, vol. 24, no. 4, pp. 38–44, Aug. 2018. [Online]. Available: https://eejournal.ktu.lt/index.php/elt/article/view/21476

IV. Simulation test

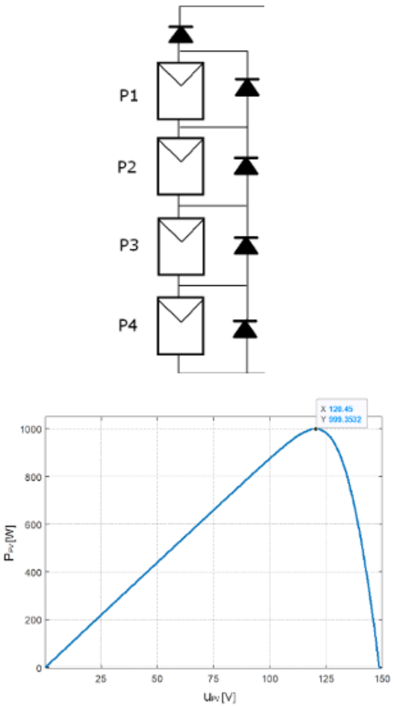
Grid-connected PV system



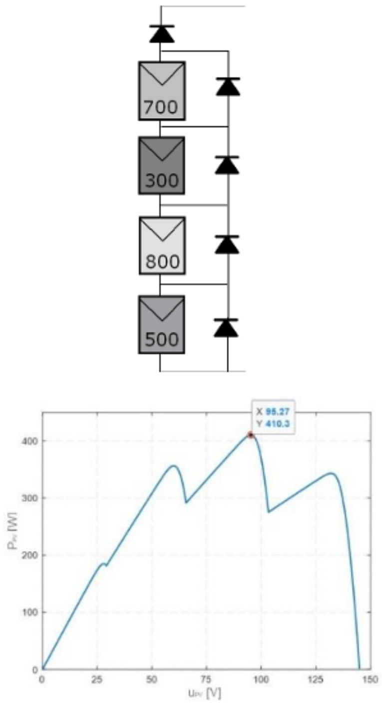
Parameter	Value
Power at the MPP under STC	1000 W
Voltage at the MPP under STC	120.4 V
Current at the MPP under STC	8.3 A
Input capacitor (C_{in})	10 μF
DC-link capacitor (C_{dc})	2200 μF
Filter capacitor (C_f)	9.2 μF
Filter damping resistor (R_d)	1.5 Ω
Boost converter inductor (L_1)	10 mH
Inverter side inductor (L_i)	3.7 mH
Grid side inductor (L_g)	180 μH
Grid voltage (u_g)	120 V_{rms} / 60 Hz
Switching frequency (f_s)	20 kHz
DC-link reference voltage (U_{dc}^*)	300 V

IV. Simulation test

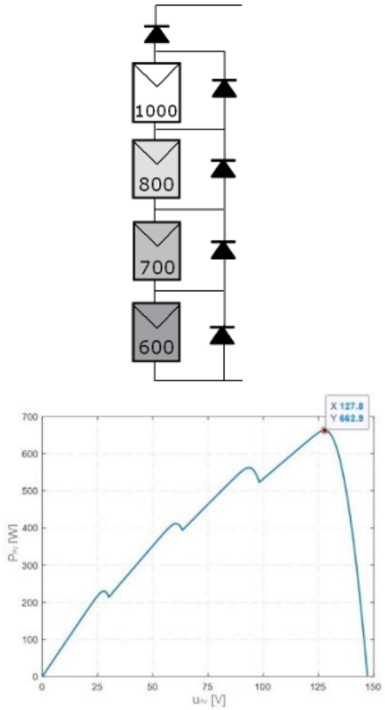
PV generator and shading conditions



0 ≤ t ≤ 4 [s]



4 < t ≤ 6 [s]



6 < t ≤ 8 [s]

IV. Simulation test

Comparison criteria:

- Convergence time: time required to reach the 95% of the final value of the power at the global MPP after the occurrence of a disturbance.

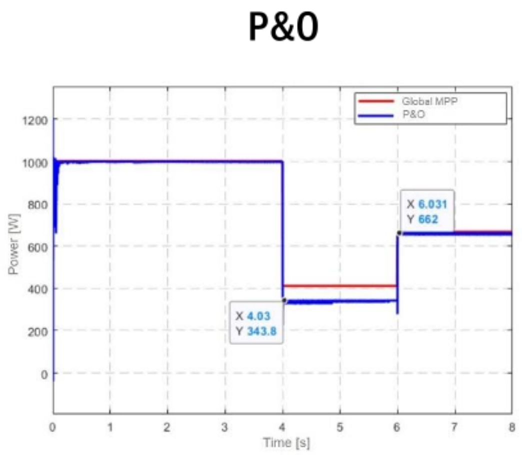
- Maximum relative error in steady-state between the power delivered by the PV generator (P_{PV}) and the power at the global MPP (P_{MPP}):

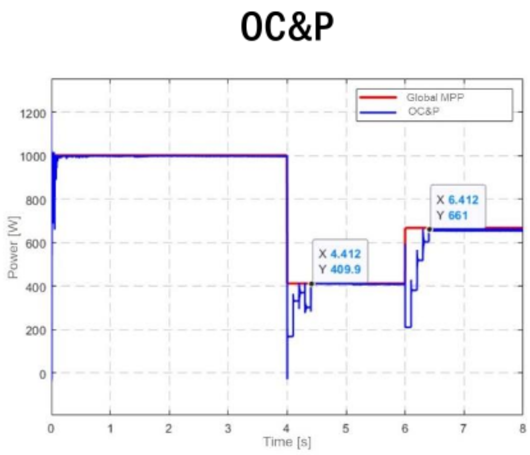
$$\varepsilon = max\left(\frac{|P_{PV} - P_{MPP}|}{P_{MPP}}\right)$$

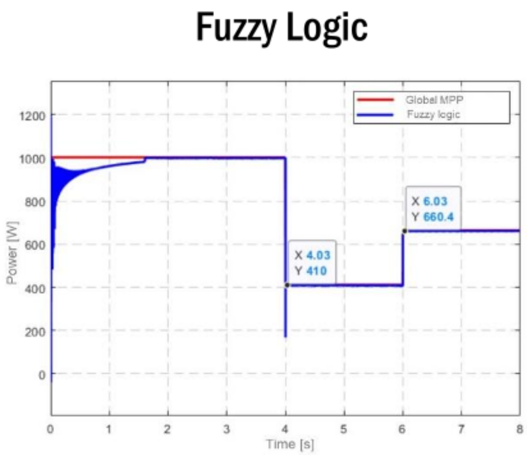
- The efficiency of the algorithm in steady-state according to:

$$\eta(t) = \frac{\int_{t_1}^{t} P_{PV}(\tau)d\tau}{\int_{t_1}^{t} P_{MPP}(\tau)d\tau}$$

V. Results







Technique	Convergence time [s]	Relative error [%]	Efficiency [%]
OC&P	0,412	0,509	above 95
Fuzzy logic	0,03	0,178	above 95

VI. Conclusions

- The traditional P&O technique may converge to non-global maximums under partial shading conditions, which depends on the initial reference voltage value and the location of the global maximum.

- The OC&P method and fuzzy logic controller presented an outstanding performance on the tracking of the global maximum under different cases of partial shading conditions with an efficiency above the 95% in steady-state. Between these two algorithms, the fuzzy logic controller presented a faster respond to the global maximum power and smaller relative errors than the OC&P technique once the system has already been initialized.

VI. Conclusions

- The fuzzy logic controller requires a previous algorithm that provides the most suitable ranges for the membership functions, otherwise it could lead to local maximums.

- Regarding the OC&P method, it presented a convergence time less to 0.5 [s], which is feasible for this application. However, this algorithm requires prior knowledge of the number of PV panels in series connection in the PV generator and the number of sub-modules per panel with bypass diodes.

VII. Questions

¡THANK YOU!

¡GRACIAS!