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INNOVACIÓN PARA LA EXCELENCIA

UNIVERSIDAD DE LAS FUERZAS ARMADAS ESPE

DEPARTAMENTO DE ELÉCTRICA Y ELECTRÓNICA

CARRERA DE INGENIERÍA EN ELECTRÓNICA E INSTRUMENTACIÓN

Artículo Académico Previo a la Obtención del Título de Ingeniero en Electrónica e Instrumentación

COMPARISON OF CONTROL STRATEGIES FOR MONITORING THE MAXIMUM POWER POINT TRACKING OF A PHOTOVOLTAIC PLANT.

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ACEPPTANCE

ETCM 2022 <etcm2022@easychair.org> 11 de agosto de 2022, 14:28
Para: Jacqueline Llanos <jdllanos1@espe.edu.ec>

Dear Jacqueline Llanos,

We are pleased to inform you that your paper No. 111, title "Comparison of control strategies for monitoring the maximum power point tracking of a photovoltaic plant" has been accepted by the Reviewers Committee Systems and Control & Industrial Electronics of the ETCM 2022. The Committee informs you that before 31 August 2022, you should make the changes suggested by the reviewers.

In a few days, we will send Camera-Ready instructions: how to use the PDF-Express tool, where you have to upload the approved version, and how to transfer copyright to IEEE.

With Warmest Regards

Fernando Carrera - Soraya Sinche

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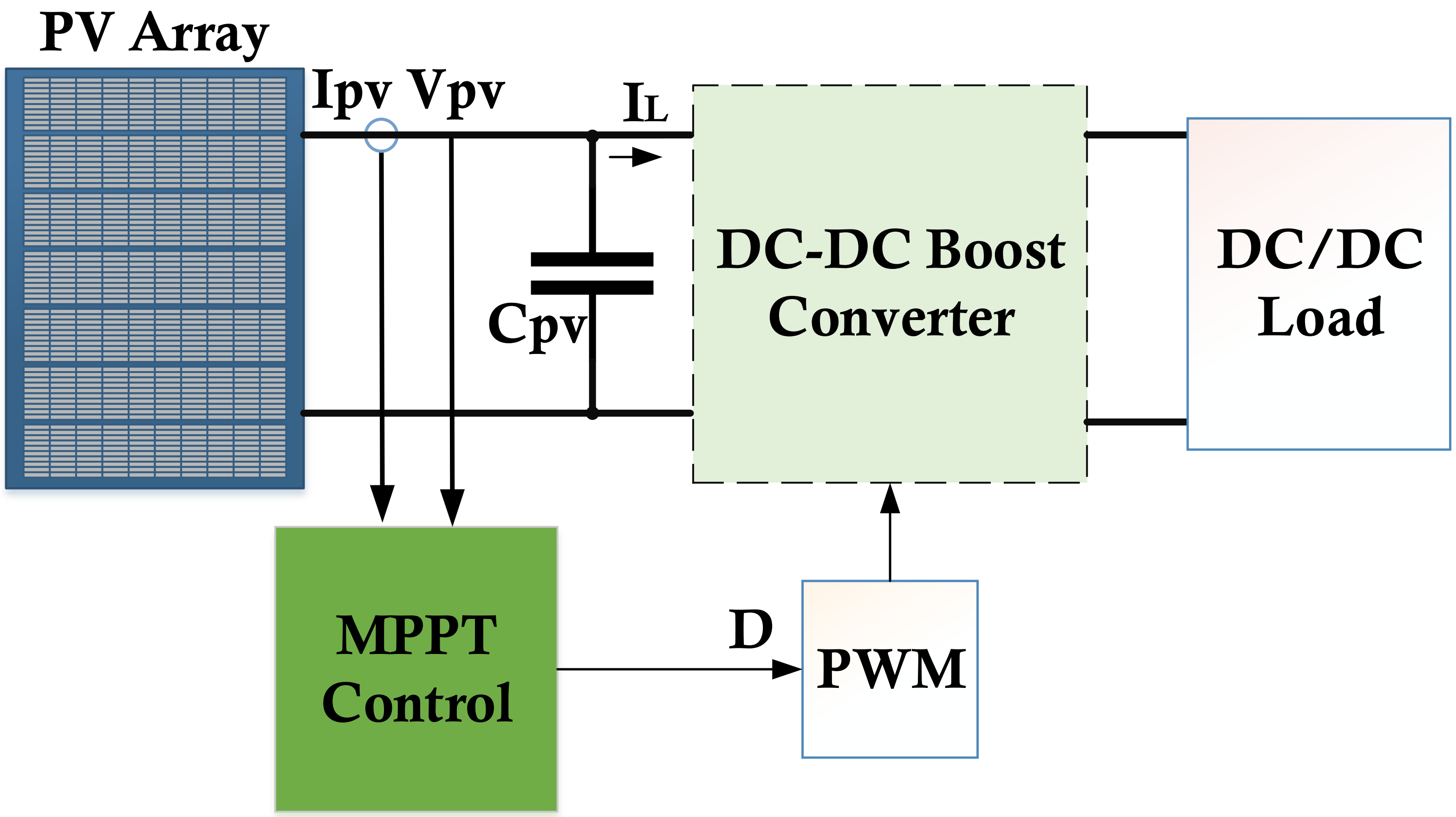
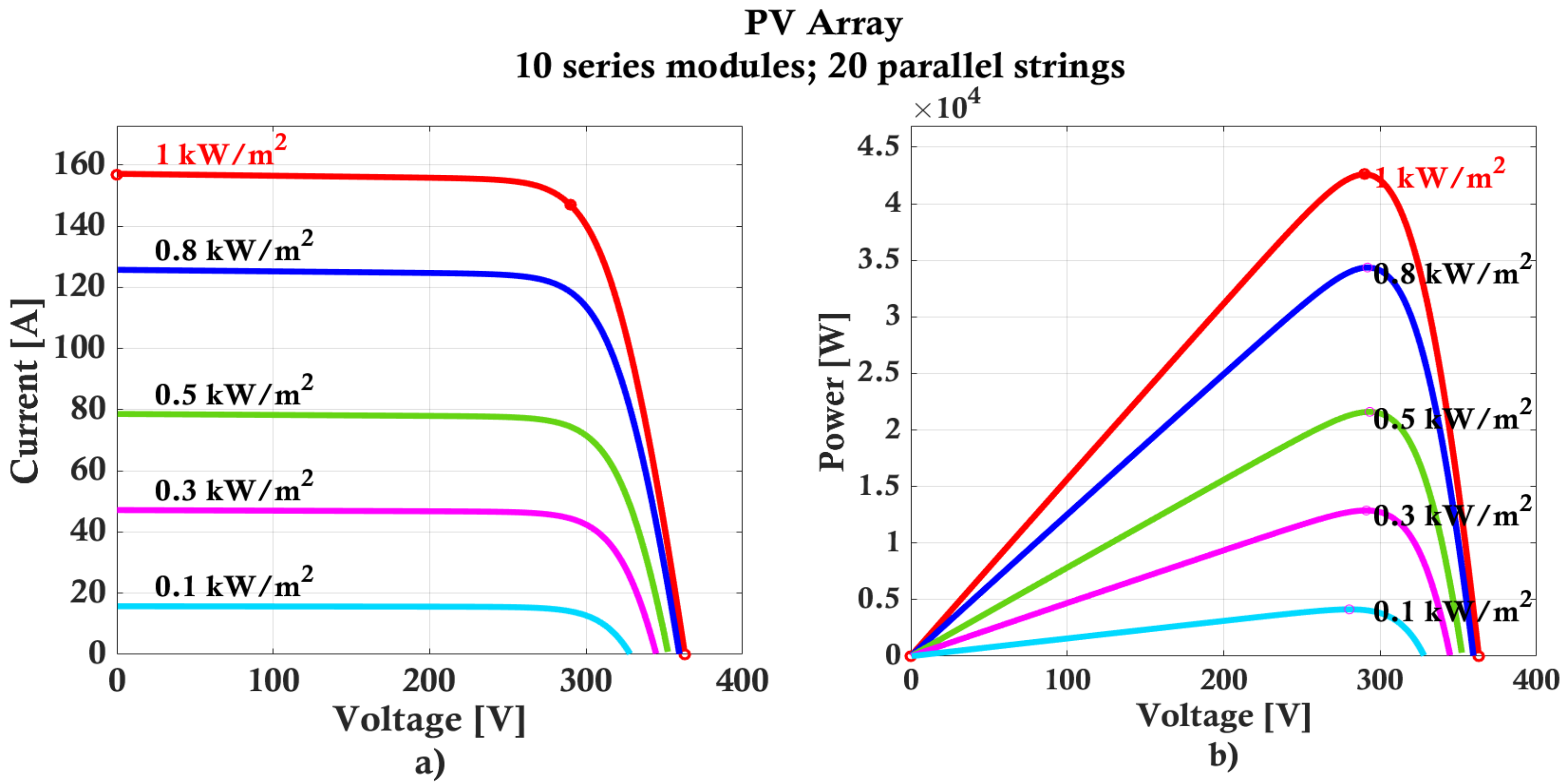
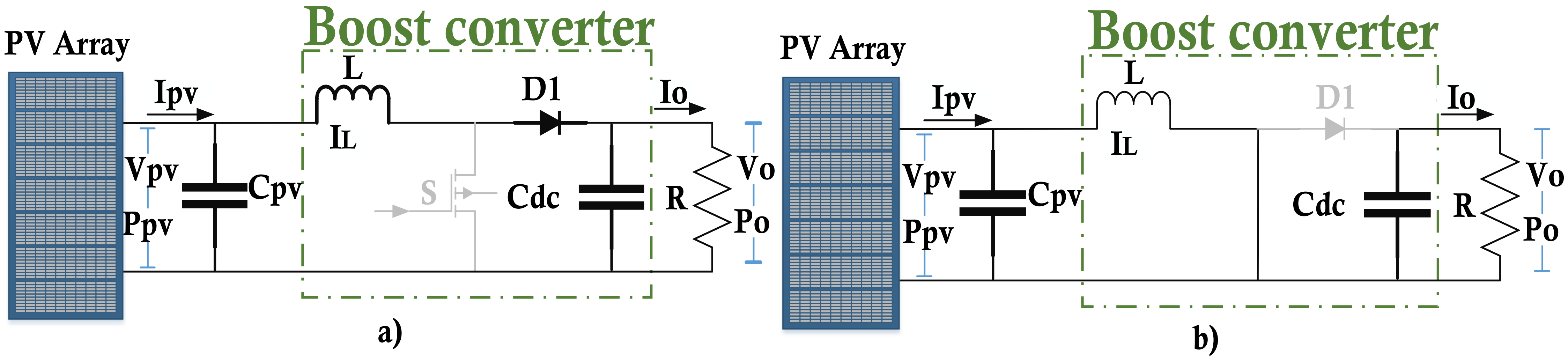


Performance Curve



Description of the system

DC/DC Boost Converter circuit modes



$$\frac{I_o}{I_L} = (1 - D)$$

$$\frac{dI_L}{dt} = -\frac{1}{L}\cdot Vo + \frac{1}{L}\cdot Vpv$$

$$\frac{dVo}{dt} = -\frac{1}{R\cdot Cdc}\cdot Vo$$

$$L > R\cdot D\cdot(1-D)^2\cdot\frac{T}{2}$$

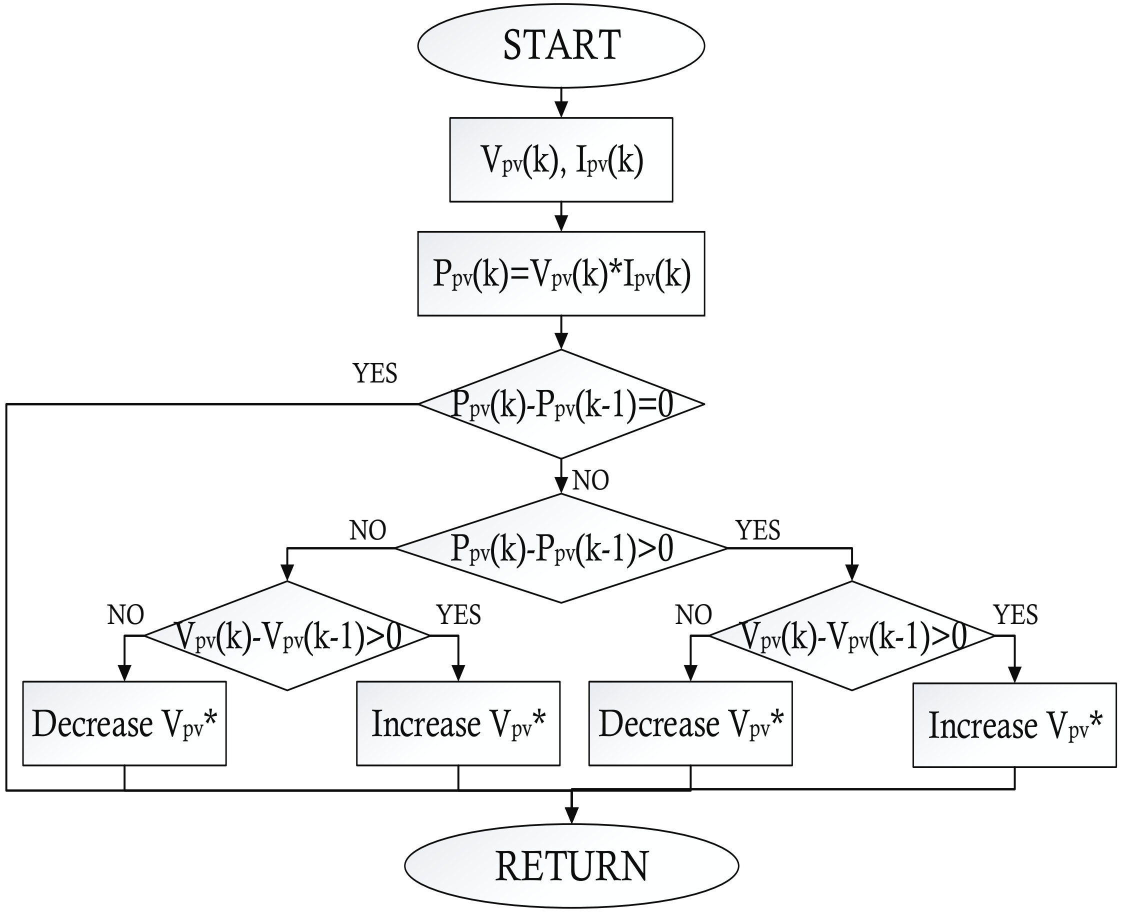
$$\frac{dVo}{dt} = -\frac{1}{Cdc} I_L - \frac{1}{R\cdot Cdc}\cdot Vo$$

$$Cdc = \frac{Po\cdot D\cdot T}{Vo\cdot \Delta Vo}$$

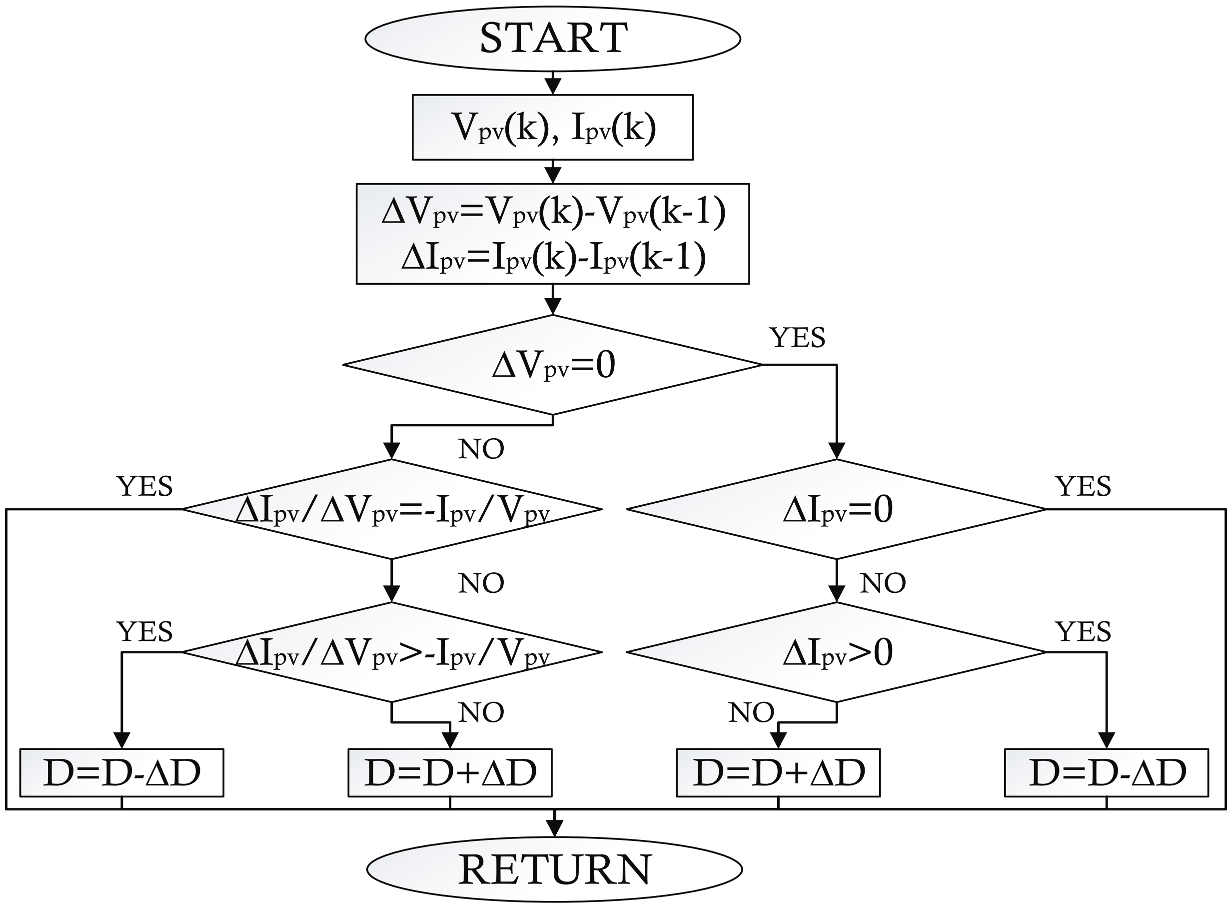
$$\frac{dI_L}{dt} = \frac{1}{L}\cdot Vpv$$

Control Design of MPPT

Perturb and Observe

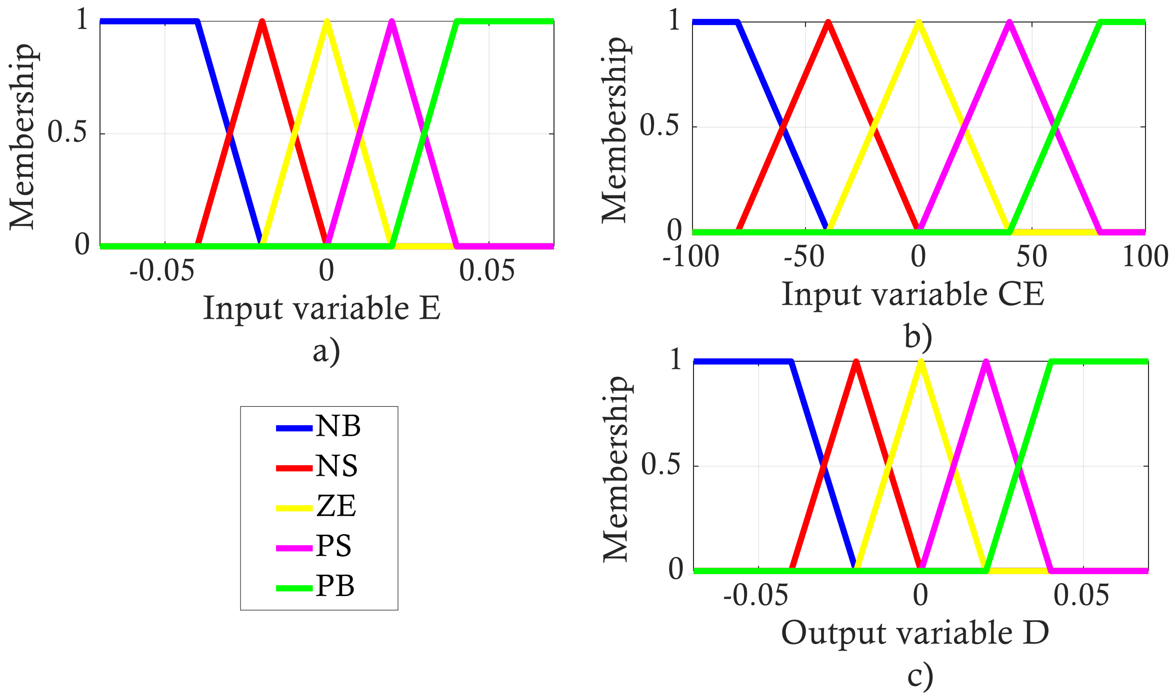


Incremental Conductance



Control Design of MPPT

Fuzzy Logic

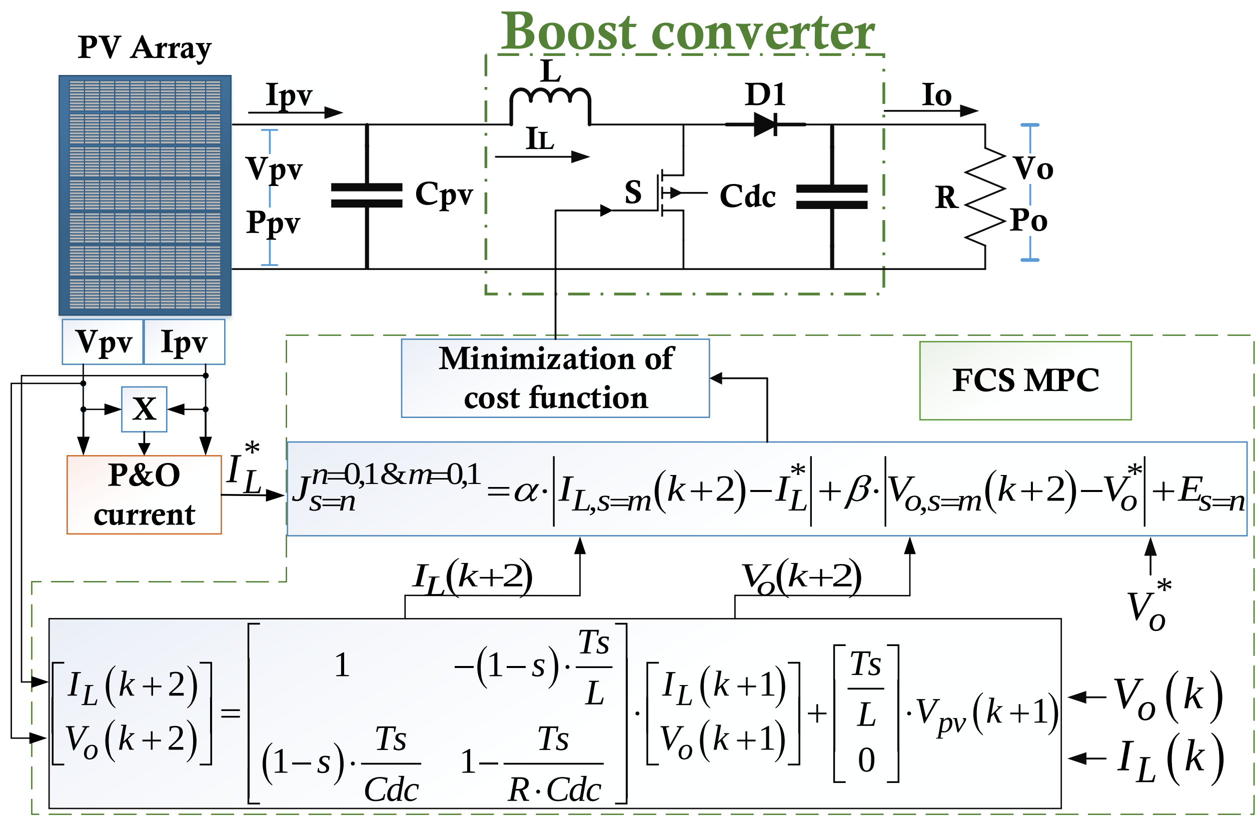


CE/E	NB	NS	ZE	PS	PB
NB	NB	NB	NB	NS	ZE
NS	NB	NB	NS	ZE	PS
ZE	NB	NS	ZE	PS	PB
PS	NS	ZE	PS	PB	PB
PB	ZE	PS	PB	PB	PB

Controller rules based on fuzzy logic

Control Design of MPPT

FCS-MPC for MPPT



$$I_{L,s} = I_L(k+n-1) - (1-s)\frac{Ts}{L}\cdot Vo(k+n-1) + \frac{Ts}{L}\cdot Vpv(k+n-1)$$

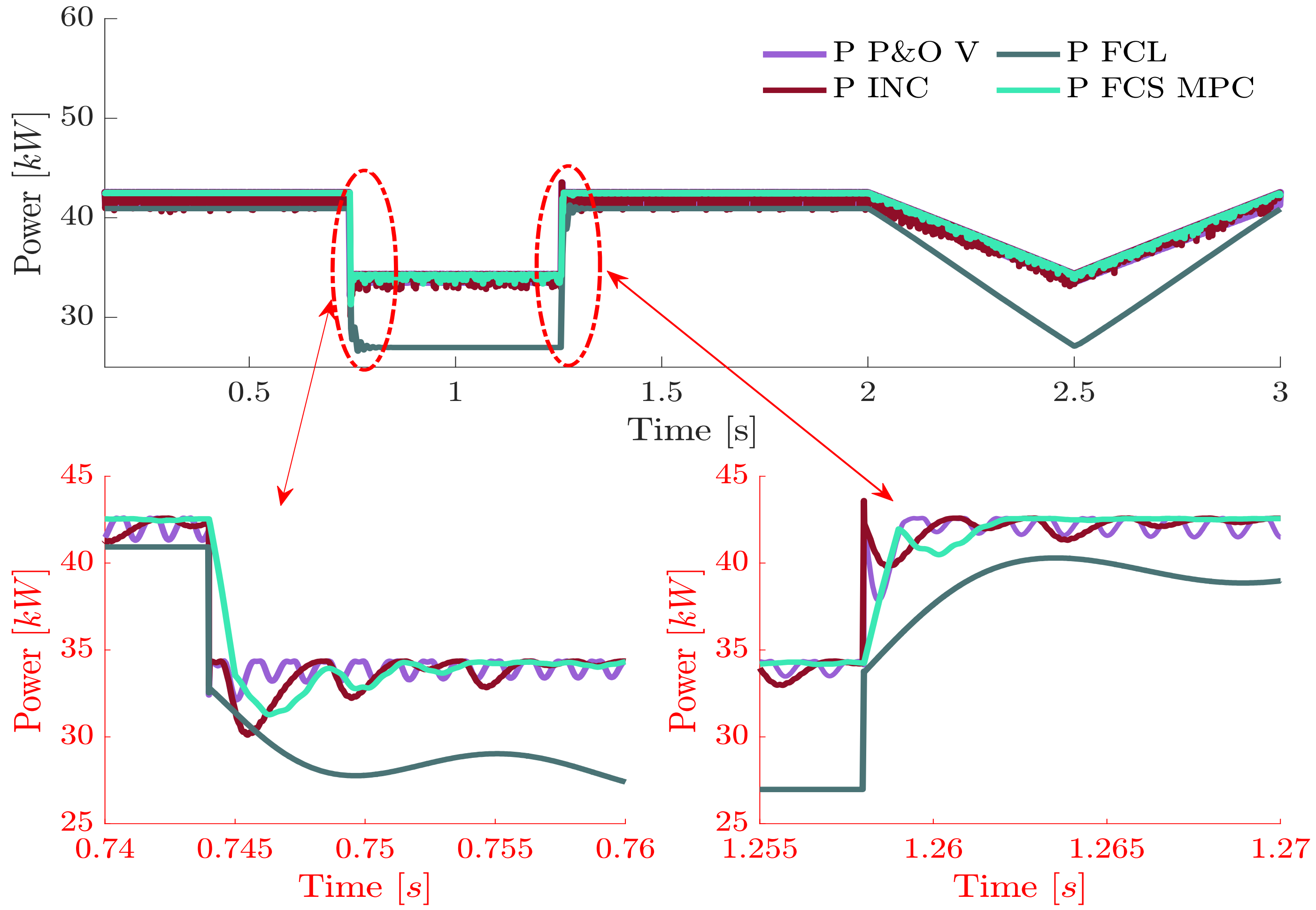
$$V_{O,s} = (1-s)\frac{Ts}{Cdc}\cdot I_L(k+n-1) + \left(1-\frac{Ts}{R\cdot Cdc}\right)\cdot Vo(k+n-1)$$

$$\begin{bmatrix} I_L(k+2) \\ V_o(k+2) \end{bmatrix} = \begin{bmatrix} 1 & -(1-s)\cdot\frac{Ts}{L} \\ (1-s)\cdot\frac{Ts}{Cdc} & 1-\frac{Ts}{R\cdot Cdc} \end{bmatrix} \cdot \begin{bmatrix} I_L(k+1) \\ V_o(k+1) \end{bmatrix} + \begin{bmatrix} \frac{Ts}{L} \\ 0 \end{bmatrix} \cdot V_{pv}(k+1)$$

$$J_{s=n}^{n=0,1\,\&\,m=0,1} = \alpha\cdot\left|I_{L,s=m}(k+2) - I_L^*\right| + \beta\cdot\left|V_{o,s=m}(k+2) - V_o^*\right| + E_{s=n}$$

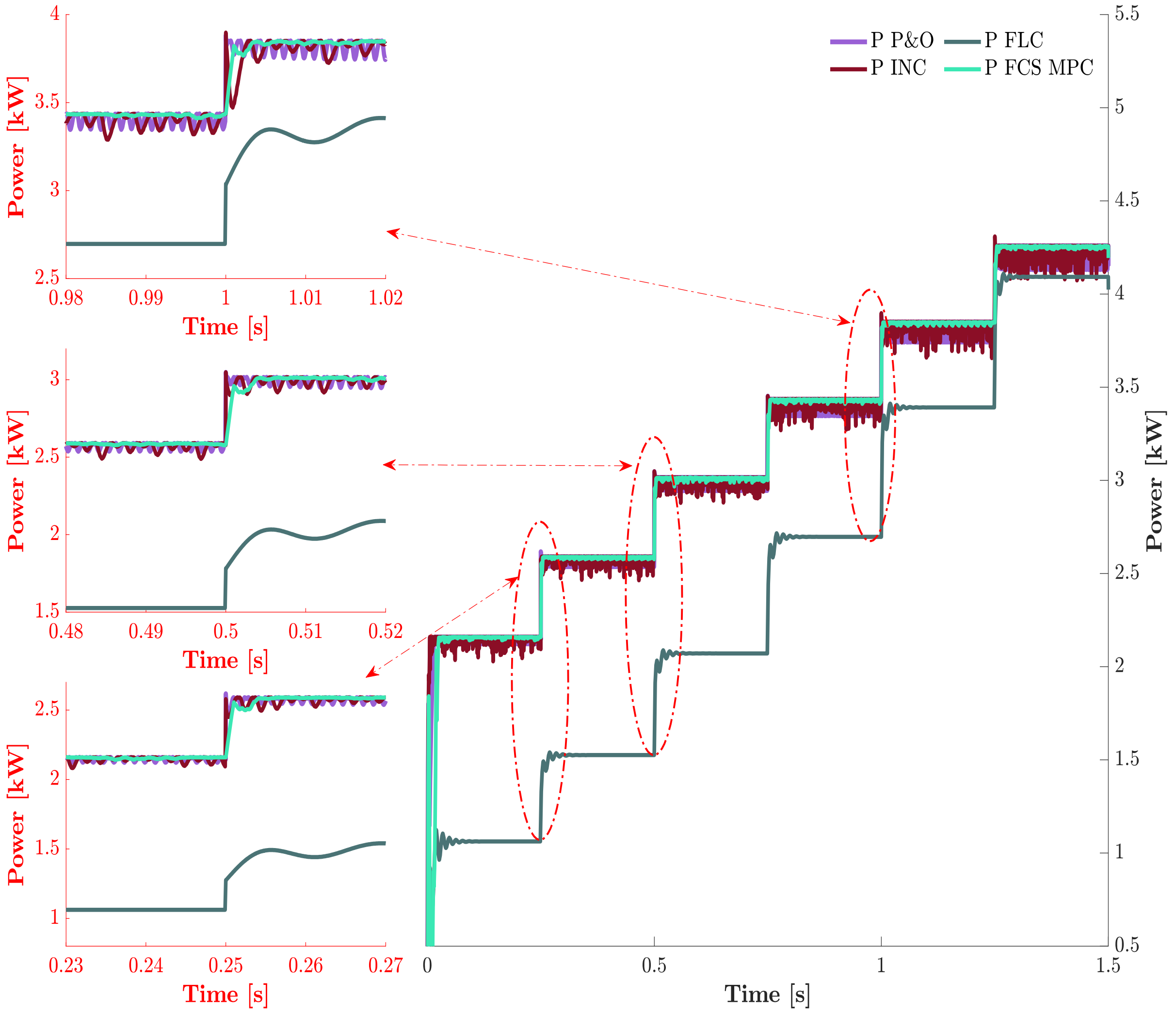
Model mathematic of FCS-MPC

Results



Irradiance [W/m2]		1000	800
Desired power [kW]		42,60	38,34
MPPT Power [kW]	P&O	41,76	33,77
	INC	41,52	33,89
	FLC	40,92	26,97
	FSC MPC	42,50	34,30
Deviation [%]	P&O	98,78	99,15
	INC	99,04	99,28
	FLC	96,07	79,3
	FSC MPC	99,68	99,46
Average efficiency [%]	P&O	99,07	
	INC	99,17	
	FLC	91	
	FSC MPC	99,76	
Average computational time [µs]	P&O	0,68	
	INC	0,46	
	FLC	0,83	
	FSC MPC	327,82	

Results



Irradiance [W/m2]		1000	900	800	700	600	500
Desired power [kW]		42,6	38,34	34,08	29,82	25,56	23,30
MPPT Power [kW]	P&O	41,83	37,89	33,87	20,15	25,22	21,54
	INC	41,84	38,37	34,1	30,2	25,39	21,17
	FLC	40,92	33,91	26,97	20,71	15,25	10,62
	FSC MPC	42,96	38,47	34,43	30,12	25,82	21,57
Deviation [%]	P&O	98,78	99,05	99,15	99,17	99,15	99,14
	INC	98,91	99,23	99,21	99,19	99,06	98,99
	FLC	96,07	88,45	79,13	69,46	59,00	49,86
	FSC MPC	99,77	99,73	99,41	99,18	98,93	98,9
Average efficiency [%]	P&O	99,85					
	INC	99,90					
	FLC	73,56					
	FSC MPC	99,99					
Average computational time [µs]	P&O	0,81					
	INC	0,46					
	FLC	1,07					
	FSC MPC	259,31					

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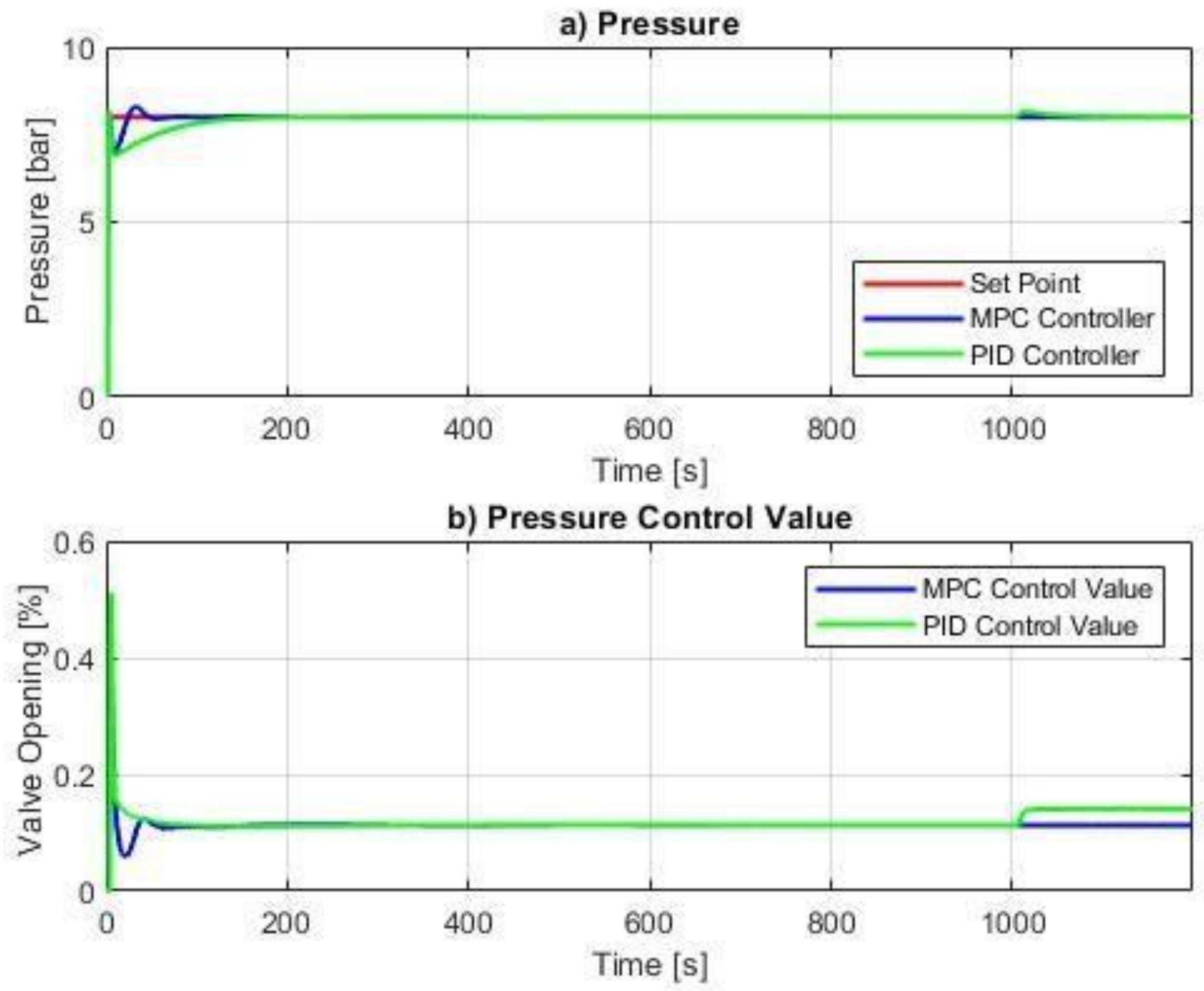
Results



Parameters	PID Controller	MPC Controller
	Pressure	Pressure
Overshoot [%]	*1.25*	*3.75*
Settling time [s]	*188*	*55*
Steady-state error [bar]	*3.1x10-3*	*5.92x10-5*

Conclusions

In this work, four MPPT-based control algorithms are compared with each other so that the PV array captures the greatest energy. The algorithms evaluated are Perturb and Observe, Incremental Conductance, Fuzzy Logic Control, And Predictive Control Based On Finite Control Set Model in different irradiance scenarios.

The FCS MPC control algorithm has shown better performance concerning a degree of similarity to the ideal value of 99.99%, which is higher than the other controllers. However, this controller presents a higher computational burden than other controllers; it is about 327.82µs and 259.31µs in both cases of the irradiance profile tested, P&O has 0.81µs, and the computational burden of INC is 0.46µs. Traditional algorithms like P&O have a degree of similarity to the ideal of 99,85%, and INC shows a degree of similarity to the ideal of 99,89%. FLC controller offers a lower efficiency than the different algorithms; however, it improves the photovoltaic system's stability and its time computational is not far from conventional algorithms.