Sliding Mode Control of a Photovoltaic Water Pumping System

Ali BERBOUCHA
Laboratoire de Maitrise des Energies Renouvelables, Faculté de Technologie, Université de Bejaia, 06000 Bejaia, Algérie
Ali.berboucha@univ-bejaia.dz

Kamel DJERMOUNI
Laboratoire de Maitrise des Energies Renouvelables, Faculté de Technologie, Université de Bejaia, 06000 Bejaia, Algérie
Kamel.djermouni@univ-bejaia.dz

Kaci GHEDAMSI
Laboratoire de Maitrise des Energies Renouvelables, Faculté de Technologie, Université de Bejaia, 06000 Bejaia, Algérie
Kaci.ghedamsi@univ-bejaia.dz

Elyazid AMIROUCHE
Laboratoire de Maitrise des Energies Renouvelables, Faculté de Technologie, Université de Bejaia, 06000 Bejaia, Algérie
Elyazid.amirouche@univ-bejaia.dz

Said AISSOU
Laboratoire de Maitrise des Energies Renouvelables, Faculté de Technologie, Université de Bejaia, 06000 Bejaia, Algérie
Said.aissou@univ-bejaia.dz

Djamal AOUZELLAG
Laboratoire de Maitrise des Energies Renouvelables, Faculté de Technologie, Université de Bejaia, 06000 Bejaia, Algérie
Djamal.aouzellag@univ-bejaia.dz

Session: Energy Systems

MOTIVATION

Burning fossil fuels

Photovoltaic water pumping system

Greenhouse gas emissions

Solar energy

Climate change
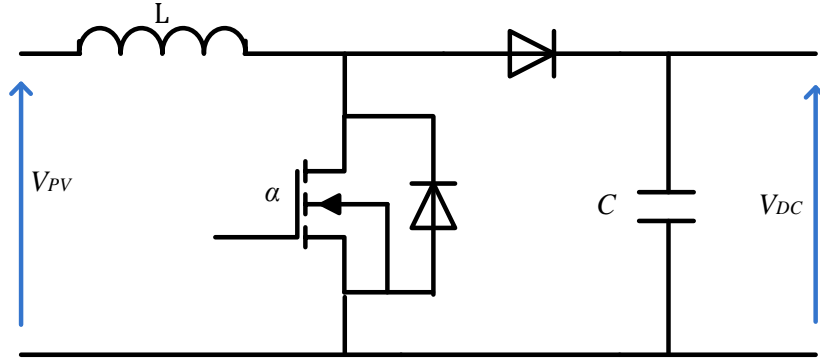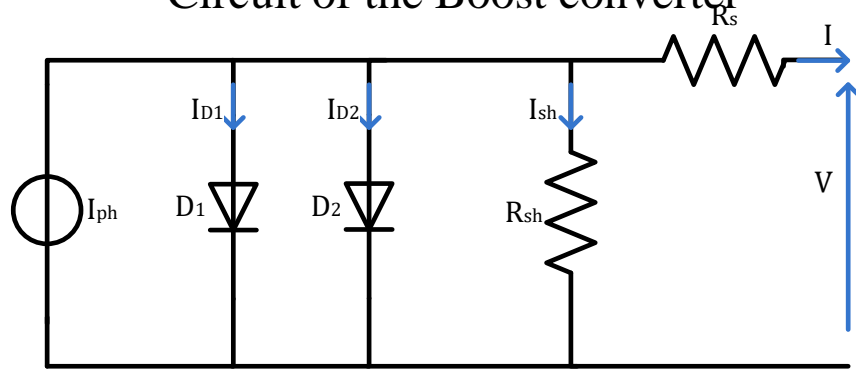
Use of renewable energies

OBJECTIVES

⊚ **To present a three-phase double-stage photovoltaic water pumping system based on three levels Neutral Point Clamped inverter.**

⊚ **To use the Sliding Mode controller instead the classical Proportional–Integral controller**

METHODOLOGY

Global diagram of the studied system

Control diagram of the studied system

METHODOLOGY

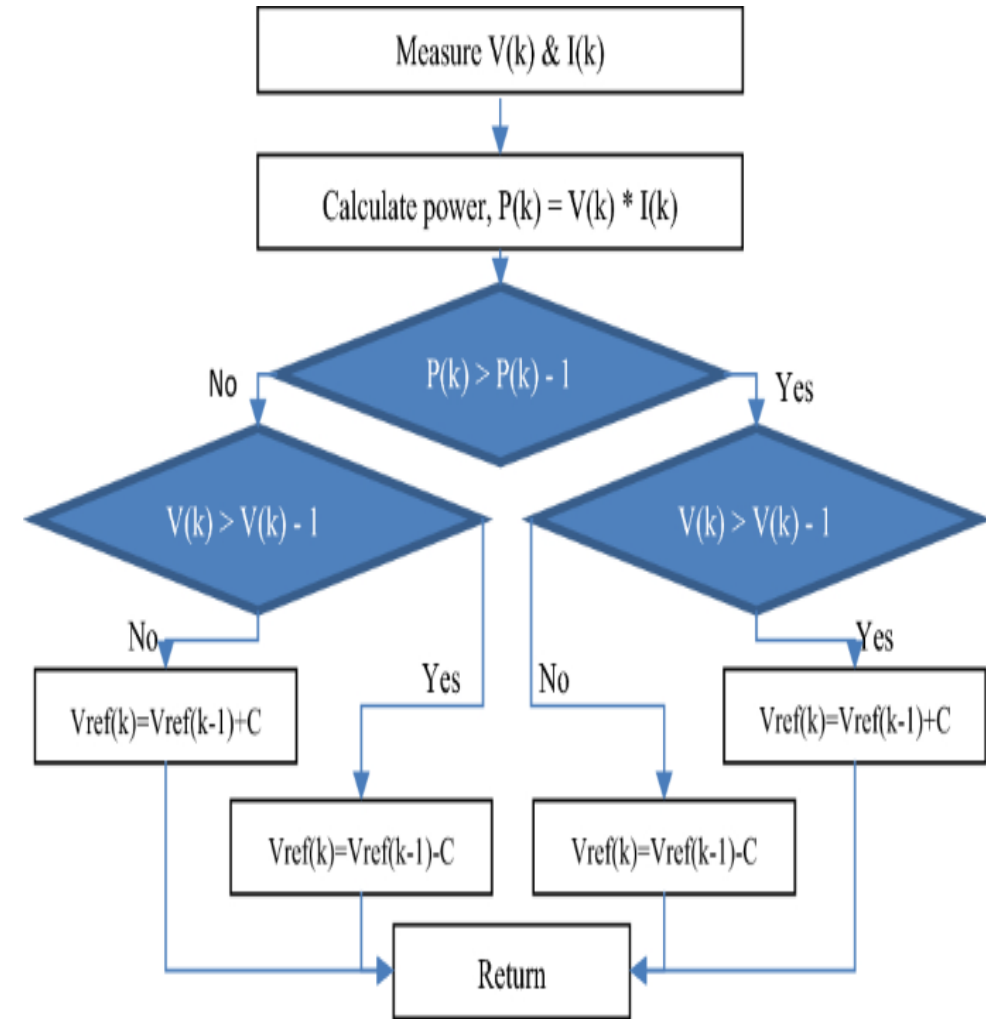Circuit of the Boost converter

$$V_{dc} = \frac{V_{PV}}{1-\alpha}$$

Photovoltaic cell electrical model

$$I = I_{ph} - (I_{D1} + I_{D2}) - I_{sh}$$

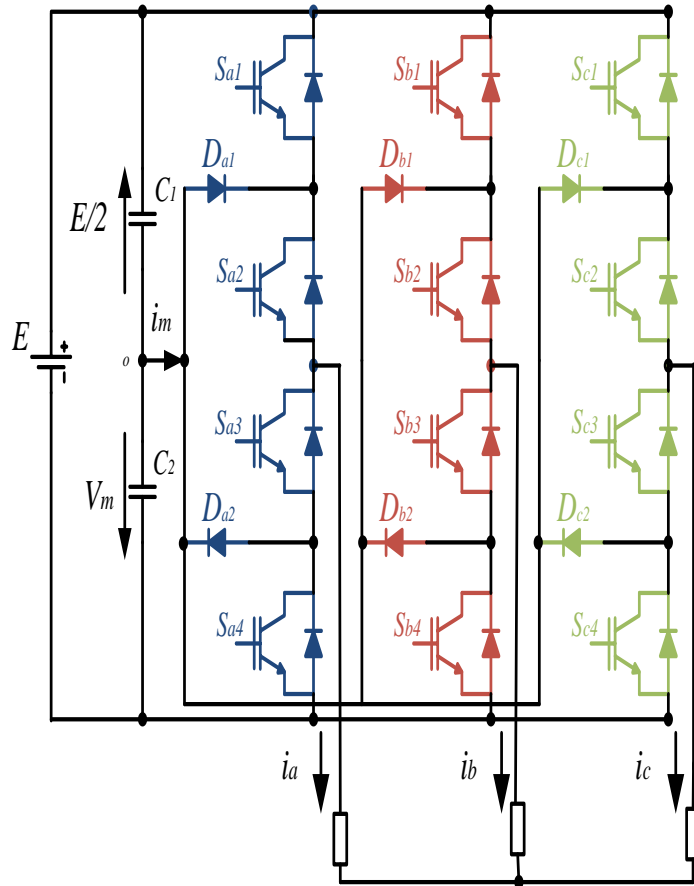With:

$$I_{D1} = I_1 \times \left[e^{\frac{q*(v+Rs*I)}{A*K*T}} - 1 \right] \quad \text{and} \quad I_{D2} = I_2 \times \left[e^{\frac{q*(v+Rs*I)}{A*K*T}} - 1 \right]$$

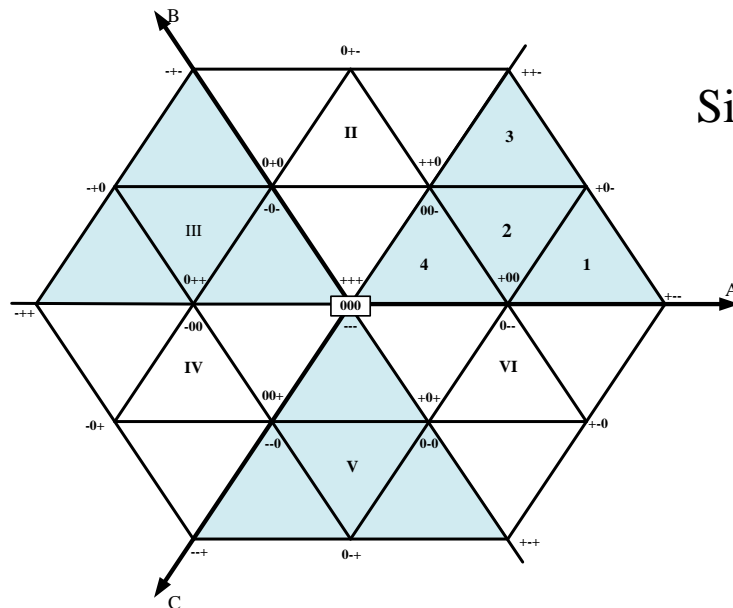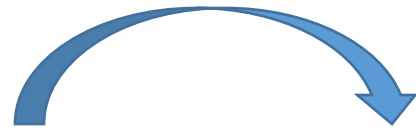$$I_{sh} = \left(\frac{V+R_S*I}{R_{sh}} \right)$$
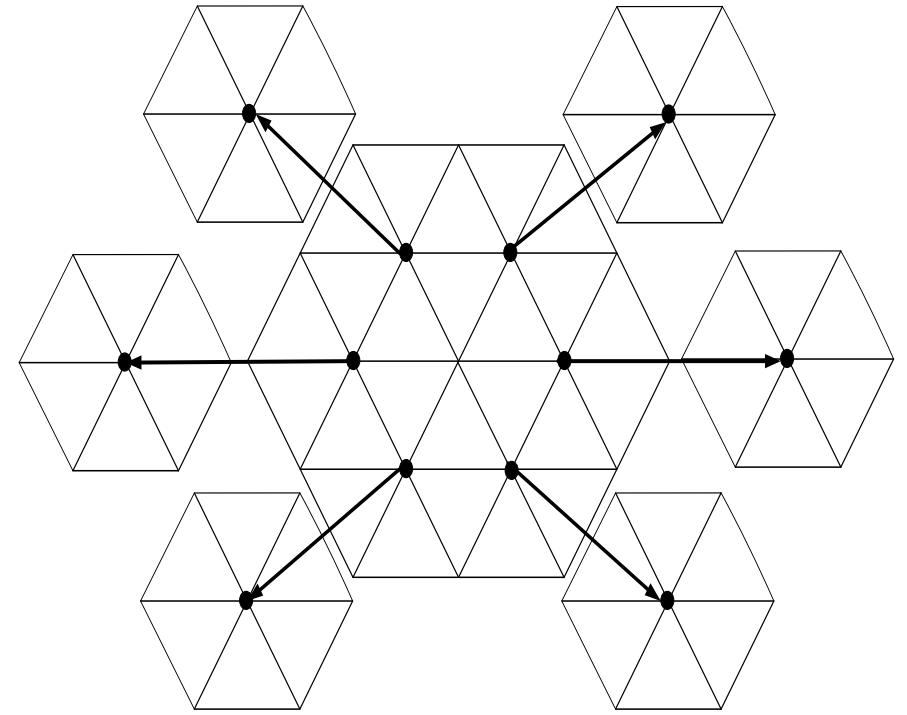

Perturb and Observe MPPT flowchart
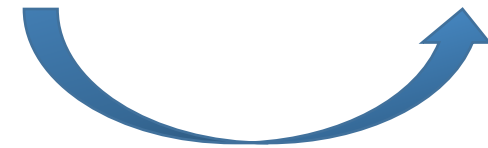
METHODOLOGY
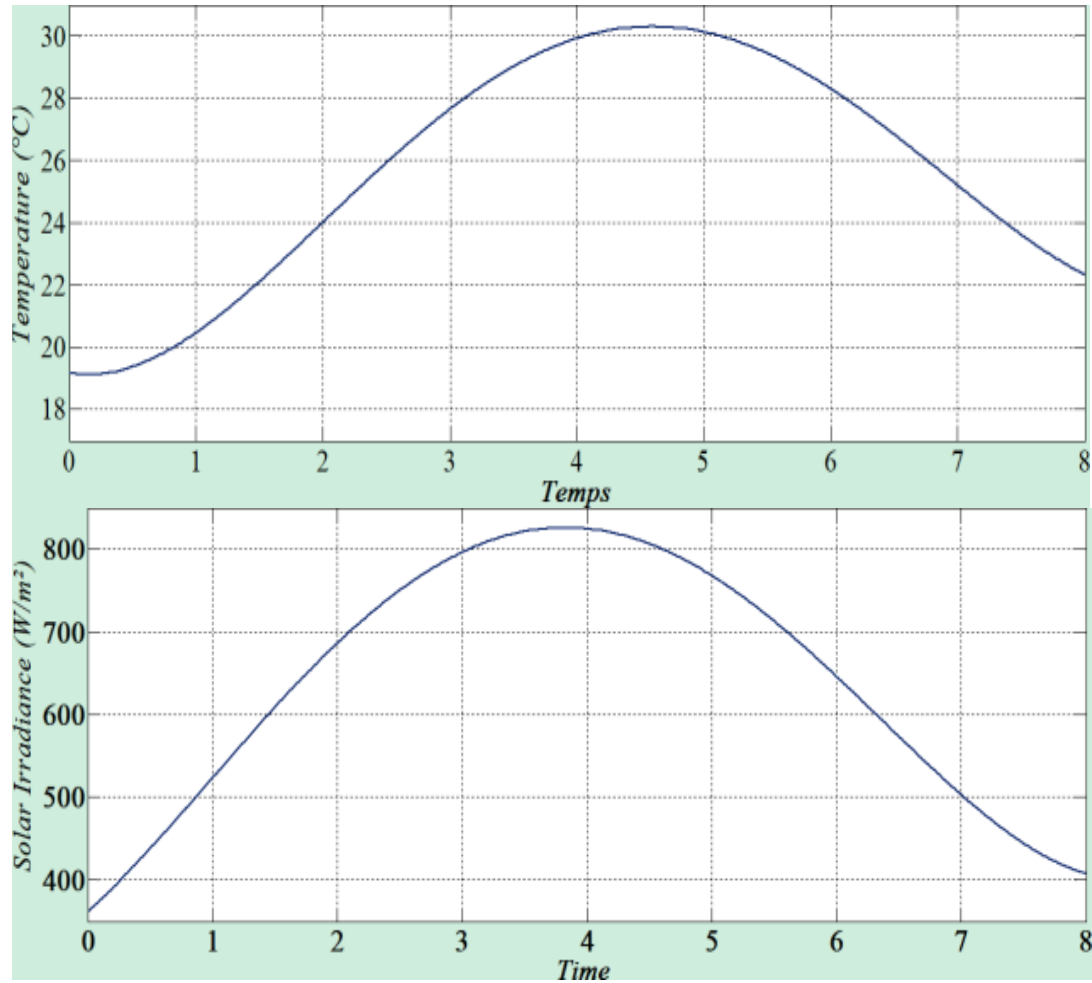

Three-level NPC inverter circuit
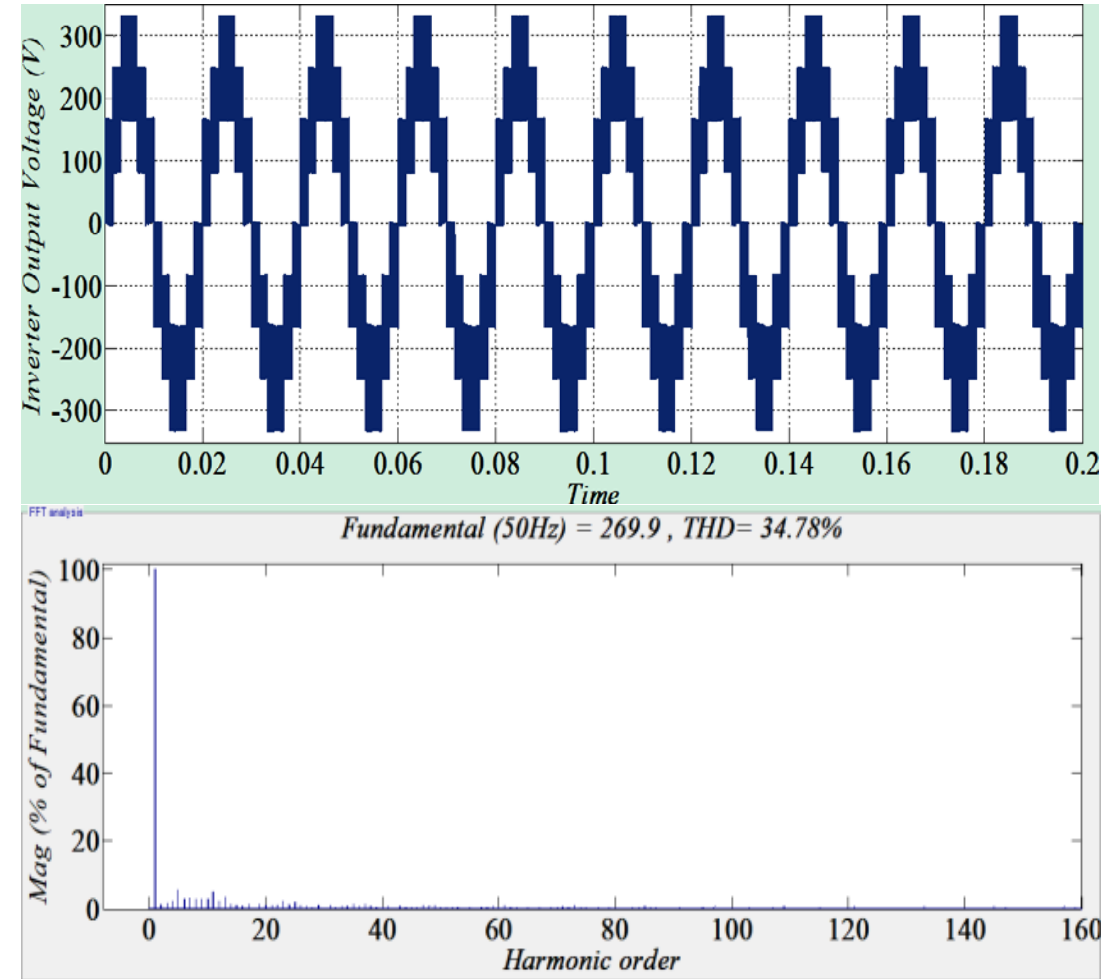

Three-level space vector diagram

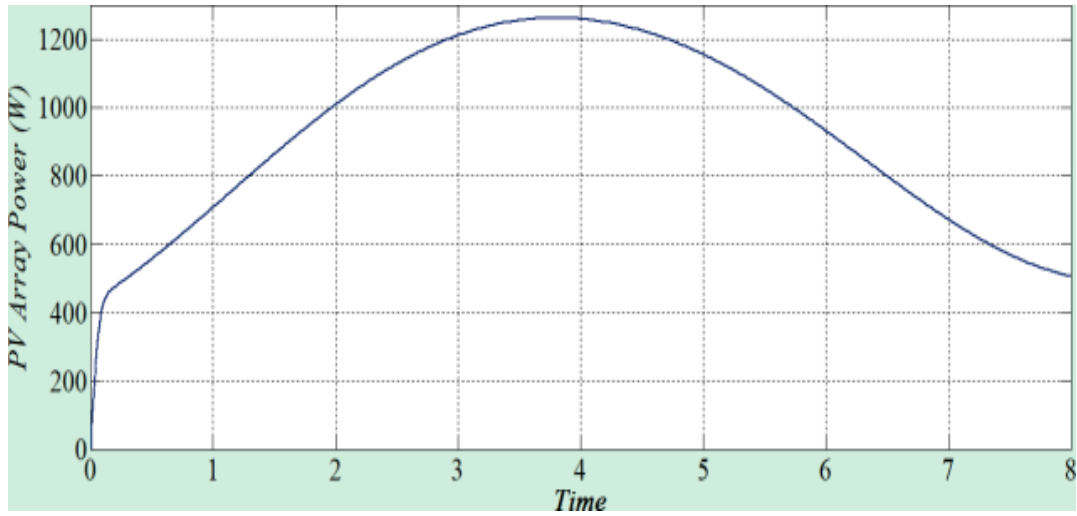Simplification three-level space vector diagram
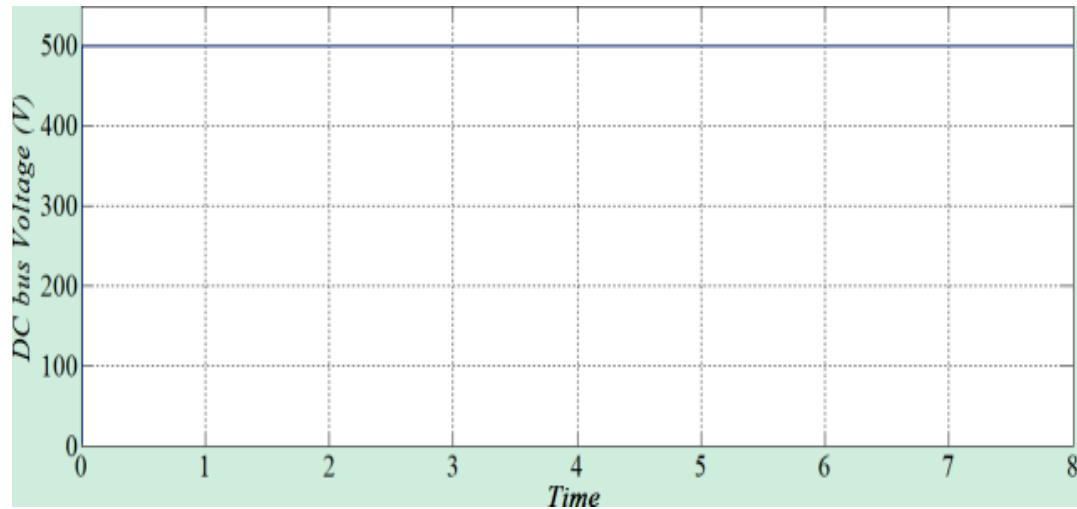
RESULTS

Variations of solar irradicance and temperature

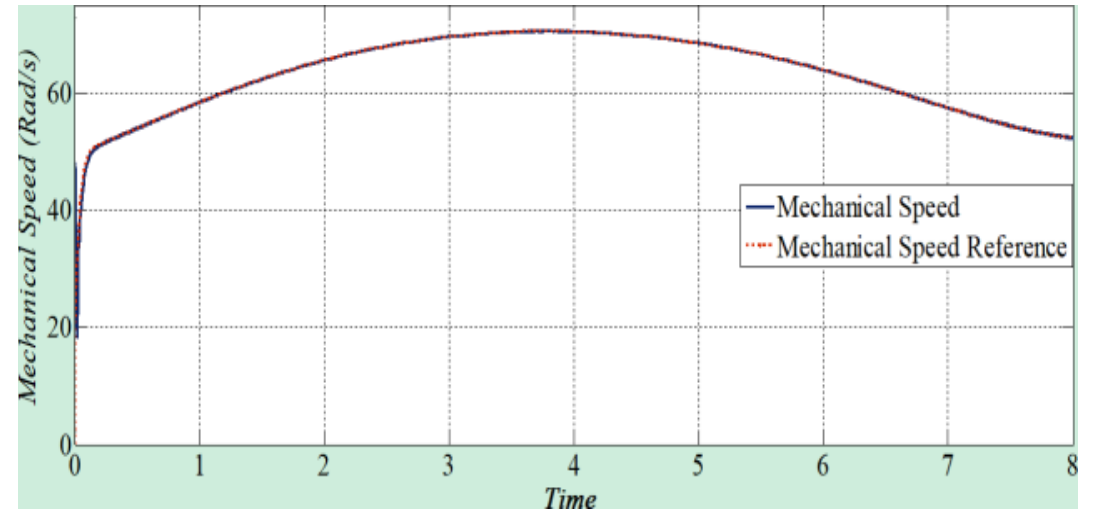Output voltage of the NPC inverter and its spectral analysis

RESULTS

Power generated by photovoltaic panels

Rotation speed of the pump and its reference

DC bus voltage
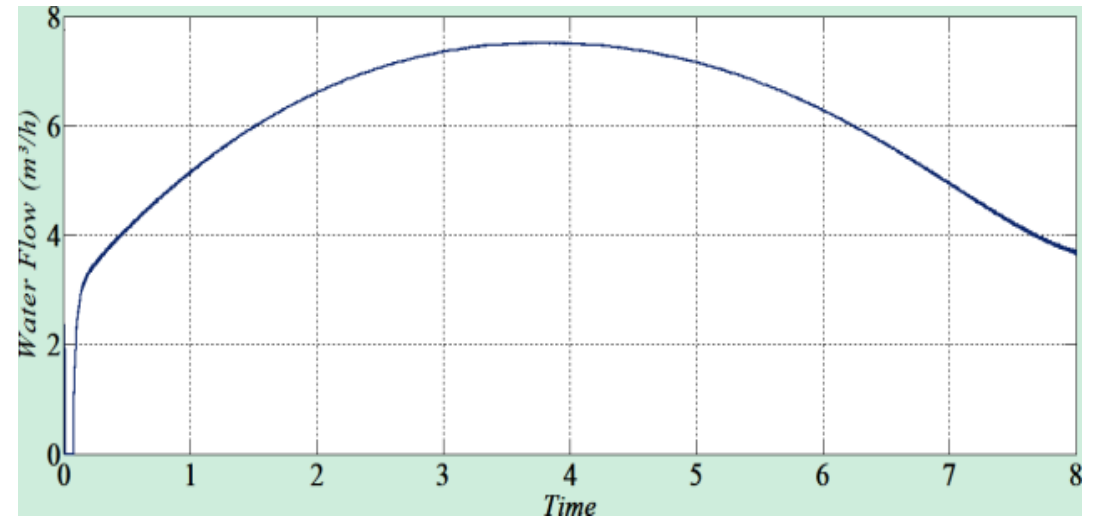
Flow of water pumped

CONCLUSIONS

❏ **The proposed control scheme features several advantages such as the generation of high-quality voltage, the capacity to operate at a lower switching frequency than a two-level.**

❏ **The proposed Sliding Mode Control of our system showed its effectiveness and robustness against variations in parameters influencing PV systems.**

❏ **The inverter can be easily expanded by increasing the levels. Thus, number of the output levels is increased and the inverter generates higher-quality output voltage.**

❏ **The proposed system produces less dv/dt stresses imposed on the switching devices and generates fewer harmonic in voltage and current.**

References

❖Key World Energy Statistics (2021).

❖K. Djermouni, A. Berboucha, K. Ghedamsi, D. Aouzellag, "Optimization of a photovoltaic field during faulty and normal operation", Solar Energy, Vol.113, pp. 171-180, 2015.

❖C. Szász, "Analysis of Photovoltaic Modules Energy Efficiency in LabView Simulation Environment", Journal of Electrical and Electronics Engineering, Vol. 11: 2, pp. 31-36, 2018.

❖N. Kumar, I. Hussain, B. Singh, B.K. Panigrahi, "Framework of maximum power extraction from solar PV panel using self predictive perturb and observe algorithm", IEEE Transactions on Sustainable Energy, Vol. 9, pp. 895-903, 2018.

❖A.Berboucha, K. Ghedams, "Control of Wind-Battery Energy Systems connected to Grid using Nine-Level-Inverter", *Electrotehnica, Electronica, Automatica*, vol. 66, no 1, p. 17-24. 2018.

❖J.H, Seo., C.H, Choi., D.S, Hyum. (2001). A new simplified space-vector PWM method for three-level inverters. *IEEE Transactions on Power Electronics*, vol.16, no. 4, pp. 545–550.

❖R. Rawat, S.C. Kaushik, R. Lamba, "A review on modeling, design methodology and size optimization of photovoltaic based water pumping, standalone and grid connected system", *Renewable and Sustainable Energy Reviews*, vol. 57, pp. 1506–1519. 2016.

❖Pablo Fernández-Bustamante, Isidro Calvo, Eneko Villar, Oscar Barambones. "Centralized MPPT based on Sliding Mode Control and XBee 900 MHz for PV systems", Electrical Power and Energy Systems 153 (2023) 109350

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Laboratoire de Maîtrise des Energies Renouvelables

Ali.berboucha@univ-bejaia.dz