I-V Characteristics Measuring System for PV Generator based on PDM Inverter

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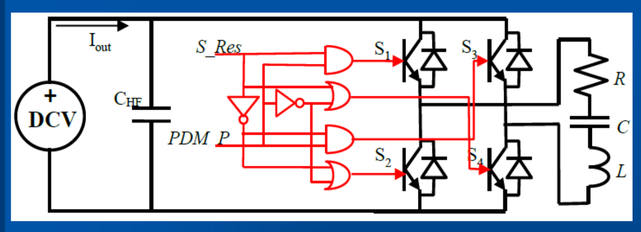
ABSTRACT

This paper presents a new method to characterize photovoltaic panels. The power electronic converter used is a Pulse Density Modulation (PDM) inverter. In this method, the inverter plays two roles: First, it is a DC inductor emulator. Second, it allows assembly between inductive and capacitive load methods. The PDM inverter is adapted to operate at very high switching frequency. In this application, it avoids the difficulties of making DC inductors with high DC current and its control remains very simple. This is an asset for increasing the power, power density and rapidity of tracers based on this method. The main disadvantage of this method, compared to methods based on DC-DC converter, is the use of twice as many semiconductor components. But this disadvantage can be compensated by a gain on reactive components. The simulations and experimental results of the proposed system are shown.

PDM Inverter: Topology, Control and model



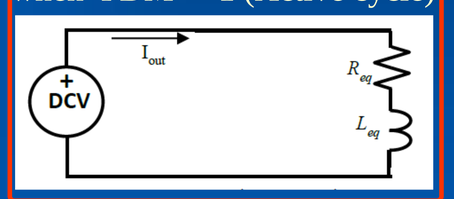
✓ **PDMP = 1 : Active Cycle**
Load voltage = ± DCV
Switching freq. = Resonance freq.

✓ **PDMP = 0 : Inactive Cycle**
Load voltage = 0
DC-supply current = 0

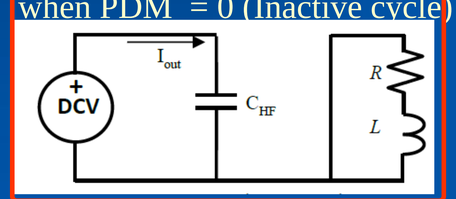
PDMP period = k x Switching Period PDMP duty cycle = Number of active cycle / k

- **Switching freq. = Resonance freq.**
  - ➡ **Switching loss = 0**
    - ➡ **Adapt for high switching frequency operation**
      - ➡ **Good Efficiency & Good size**
- **C_{HF} : High Frequency decoupling Capacitor**
  - *Absobs the high frequency ripple current*
  - ➡ **Low cost smooting of DCV's Current**
- **DCV sees inductive load or capacitive load that charge**

when PDM = 1 (Active cycle)



when PDM = 0 (Inactive cycle)



➡ **DC inductor emulation**

PV Tracer: Conventionnal Methods

Capacitive Load

Principle: PV charge Capacitor
Adv : Simple
Adv: Rapidity
Adv: Cheap
Disadv : Continuity of service

DC DC Load

Emulation of variable resistor
Disadv : Simple
Disadv: Rapidity
Disadv: Reactive components / DC inductor
Adv : Continuity of service

PV Tracer: Our Method

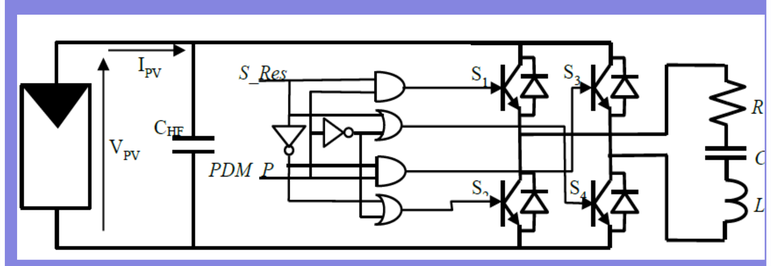
Goal

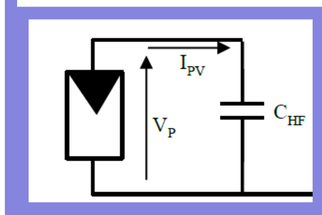
Keep the most advantages
Avoid the most disadvantages

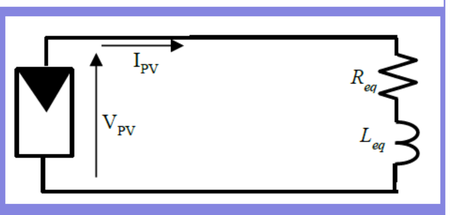
Contributions Expected

- **The command is invariable ie no BF sweep**
  - ➡ **Adv : Simple**
  - ➡ **Adv: Rapidity**
- **The process switches between capactive and inductive loads**
  - ➡ **Adv : Continuity**
- **HF and Lossless Switching**
  - ➡ **Adv : Reactive components small size and low value**
- **DC inductor emulation**
  - ➡ **Adv : High power field**

Methodology: Take a PV panel as DCV







Running as:

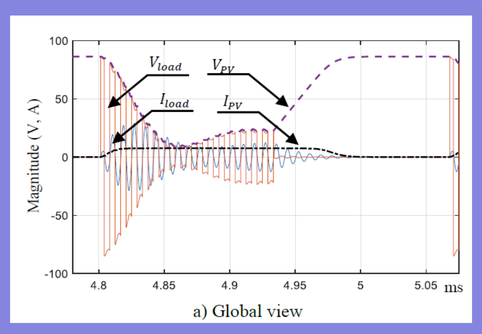
Capacitive load during inactive cycles
Inductive load during active cycles

Sizing (PDM parameters)

$$k \geq \frac{(I_{sc})_{max}}{(V_{oc})_{min}} L_{eq} F_{res} + \frac{(V_{oc})_{max}}{(I_{sc})_{min}} C_{HF} F_{res}$$

$$\frac{(I_{sc})_{max}}{(V_{oc})_{min}} \frac{L_{eq} F_{res}}{k} \leq d \leq 1 - \frac{(V_{oc})_{max}}{(I_{sc})_{min}} \frac{C_{HF} F_{res}}{k}$$

Simulation results



a) Global view

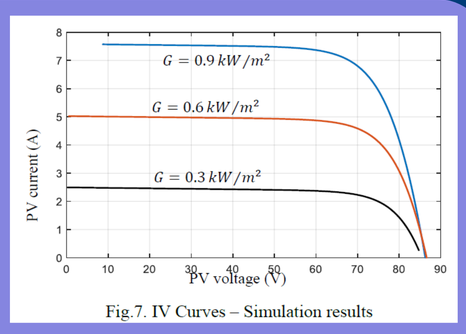
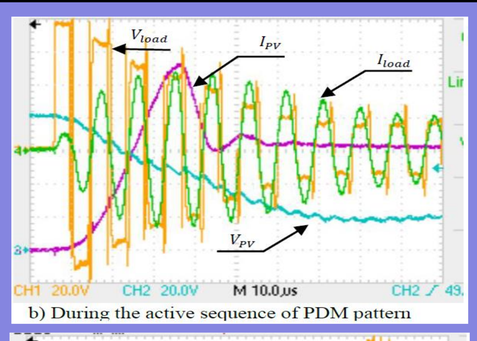


Fig.7. IV Curves – Simulation results

Experimental results



b) During the active sequence of PDM pattern

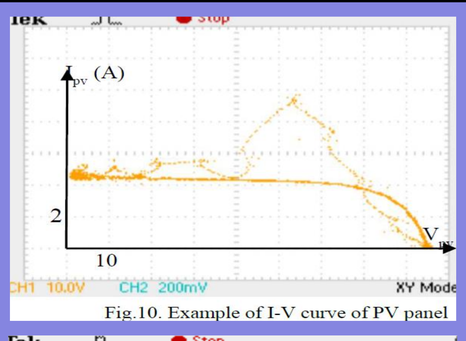
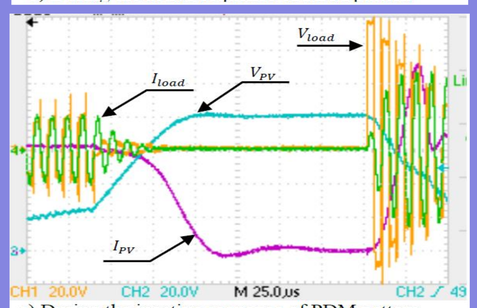


Fig.10. Example of I-V curve of PV panel



c) During the inactive sequence of PDM pattern

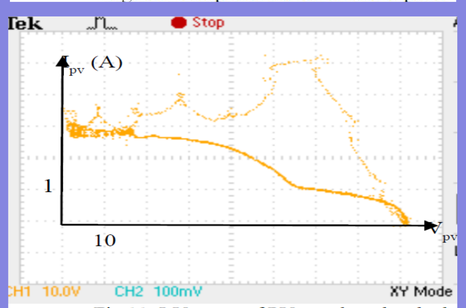
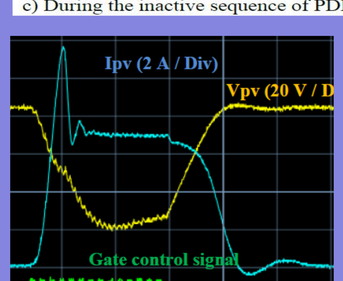
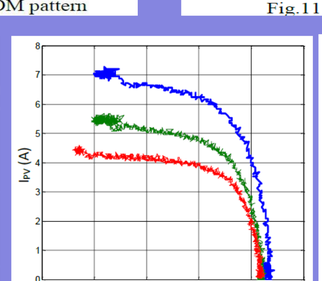
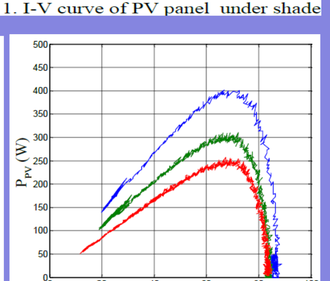


Fig.11. I-V curve of PV panel under shade







Conclusion and Perspectives

- ❑ Proposed solution is based on Series-Resonant-Inverter
- ❑ Compared to Capacitive and Inductive loads, it's both in the same device
- ❑ Compared to DC-DC load, it requires twice as many semiconductor components

… a disadvantage, but at the origin of several advantages:

- ✓ **Soft-Switching** ➡ **High Power, high efficiency, low size, …**
- ✓ **DC Inductor Emulation** ➡ **High DC Current, Low DC resistance**
- ✓ **Rapidity**

- ❑ When the inductive load mode is in operation, the shape of the *IV* curve obtained is different from the usual shape. This is not due to a malfunction of the prototype, but it is the reality of the PV generator in fast characterization
- ❑ This aspect is not taken into account neither by the simulation nor by the Solar PV emulators. Future work: Adaptation of simulation models to fast characterization cases

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