Multidimensional Maximum Power Point Tracking Control for Converters Connected to Photovoltaic Arrays with Particle Swarm Optimization Technique

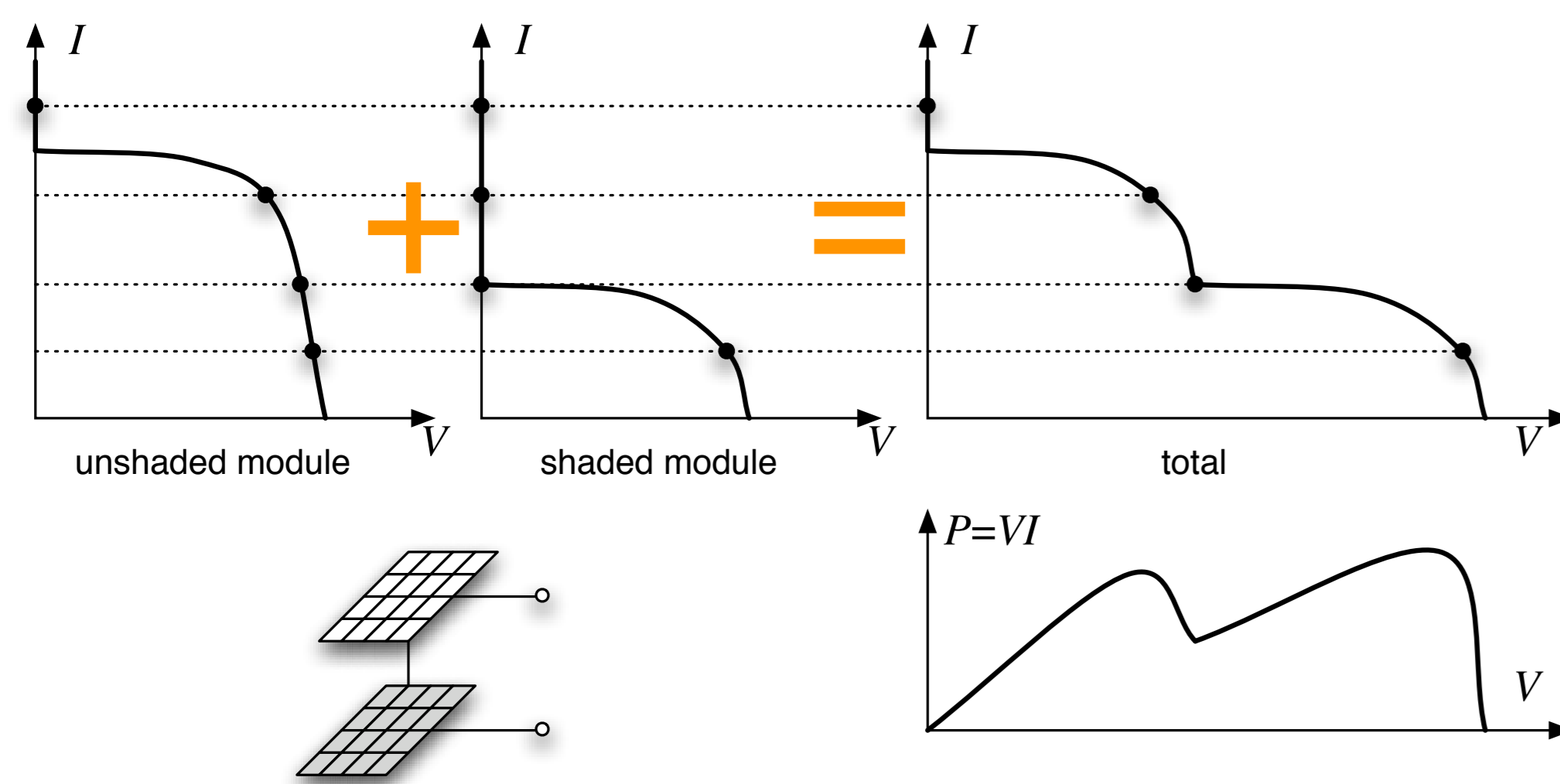**Masafumi Miyatake*, Mummadi Veerachary† , Nobuhiko Fujii*, Fuhito Toriumi* and Nabil A. Ahmed***
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1. Introduction

1.1 Partial shade problem of PV system

Finding maximum power condition with operating :
Maximum Power Point Tracking (MPPT) control

Effect of partial shade

- difficult to search global MPP
  ➡ large power loss

1.2 Possible improvements

- intelligent controller to find the global MPP
- dividing an array into several parts not to have multiple MPPs
  - controlling the voltages independently
    ➡ multidimensional control
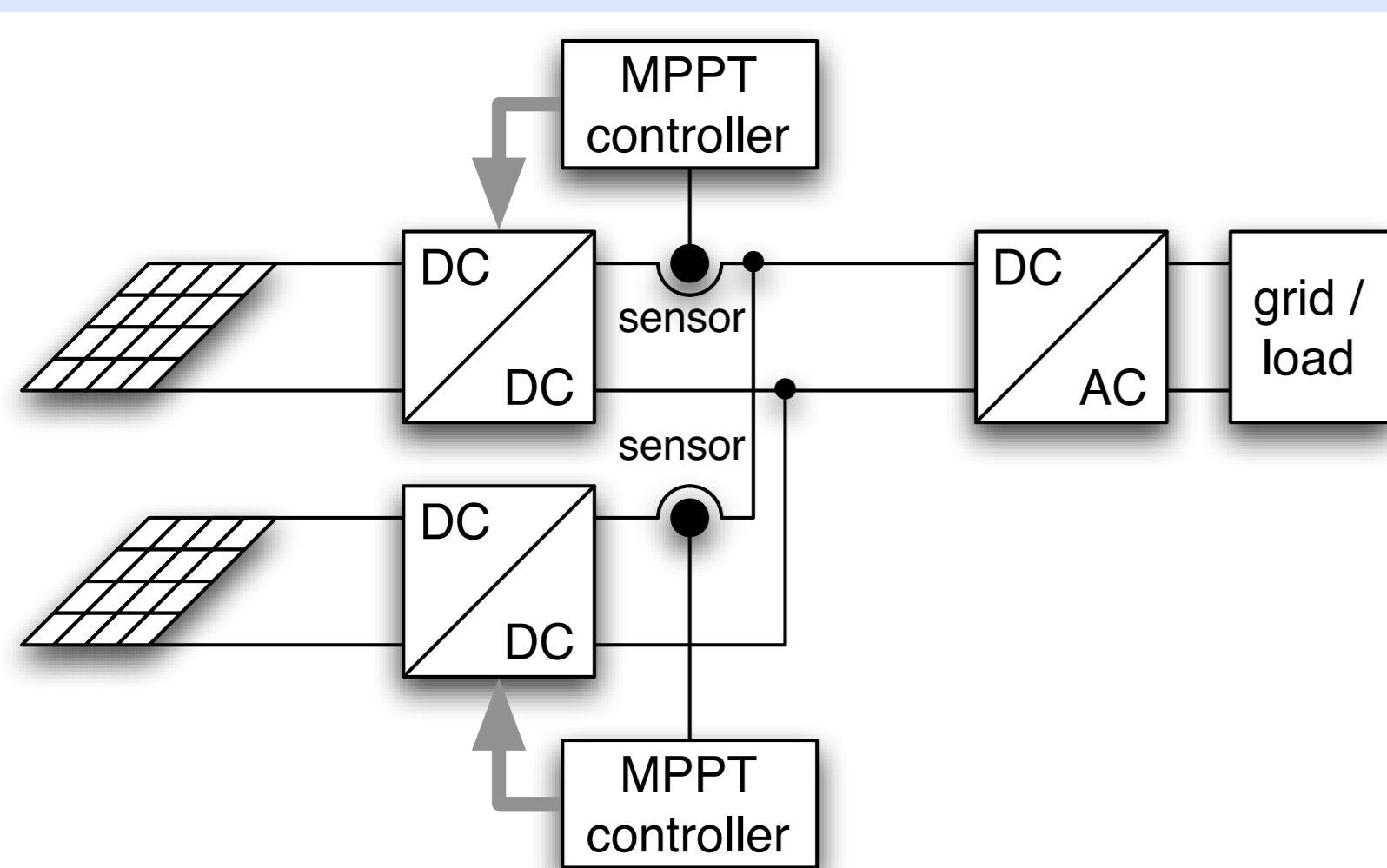
However, many complicated controllers and sensors
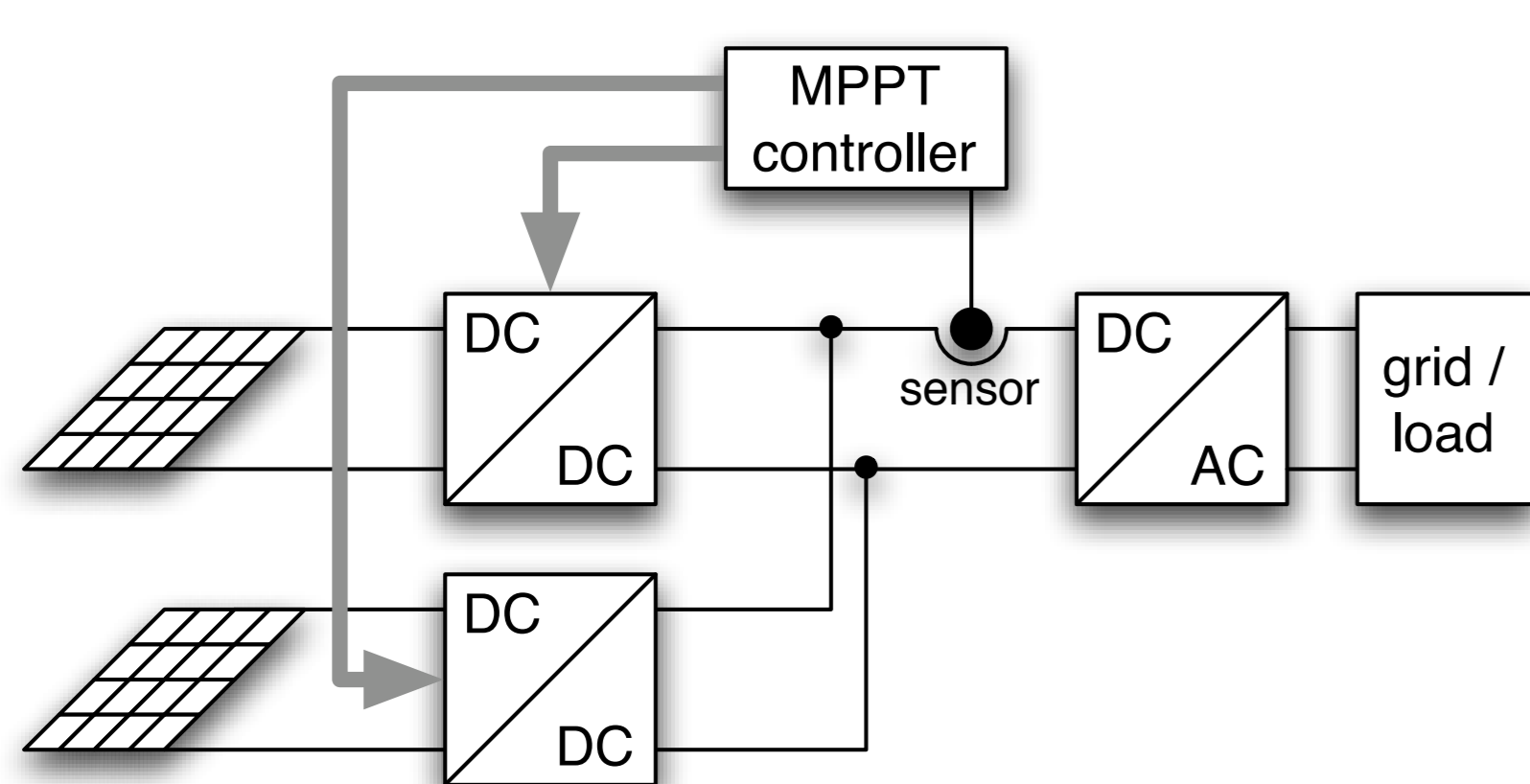 ➡ higher cost

1.3 Objectives

- Avoiding the problem of partial shade for achieving larger power
- Control of several converters connected to arrays with only one sensor and controller for lower cost

2. Multidimensional MPPT

One MPPT controller per each PV array (conventional)

One MPPT controller per several PV arrays (proposed)

3. Application of PSO method

3.1 Particle Swarm Optimization (PSO)

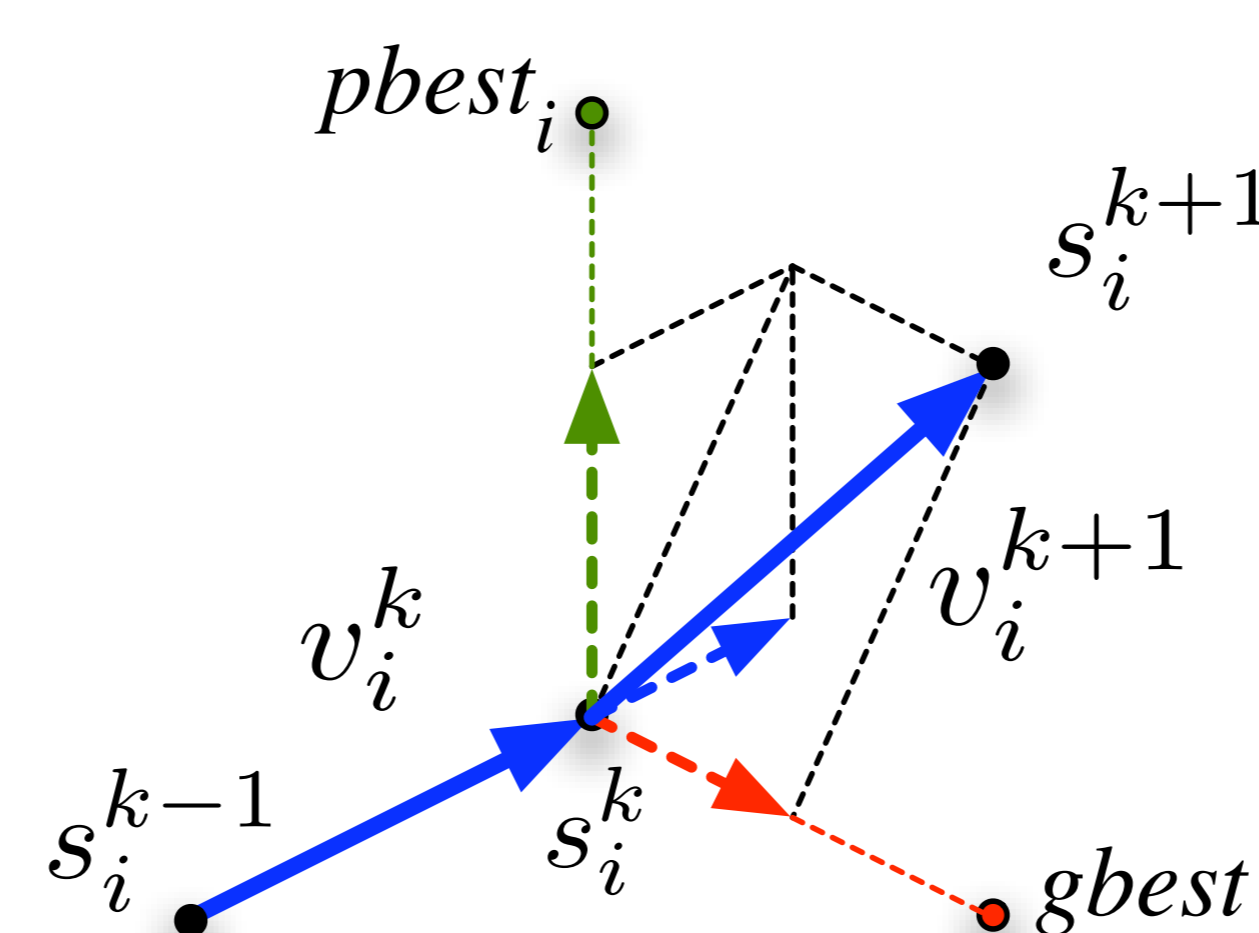- A meta-heuristic optimization method for multi-dimensional functions
- Using several agents
  - writing the best point already found to "pbest"
  - sharing information of pbests and choose the best "pbest" as "gbest"
  - controlled with random numbers r_1 & r_2

$$v_i^{k+1} = wv_i^k + c_1 r_1 \; p_{best_i} + c_2 r_2 \; g_{best}$$
$$s_i^{k+1} = s_i^k + v_i^{k+1}$$

Movement of an agent following PSO algorithm

3.2 Added functions for MPPT

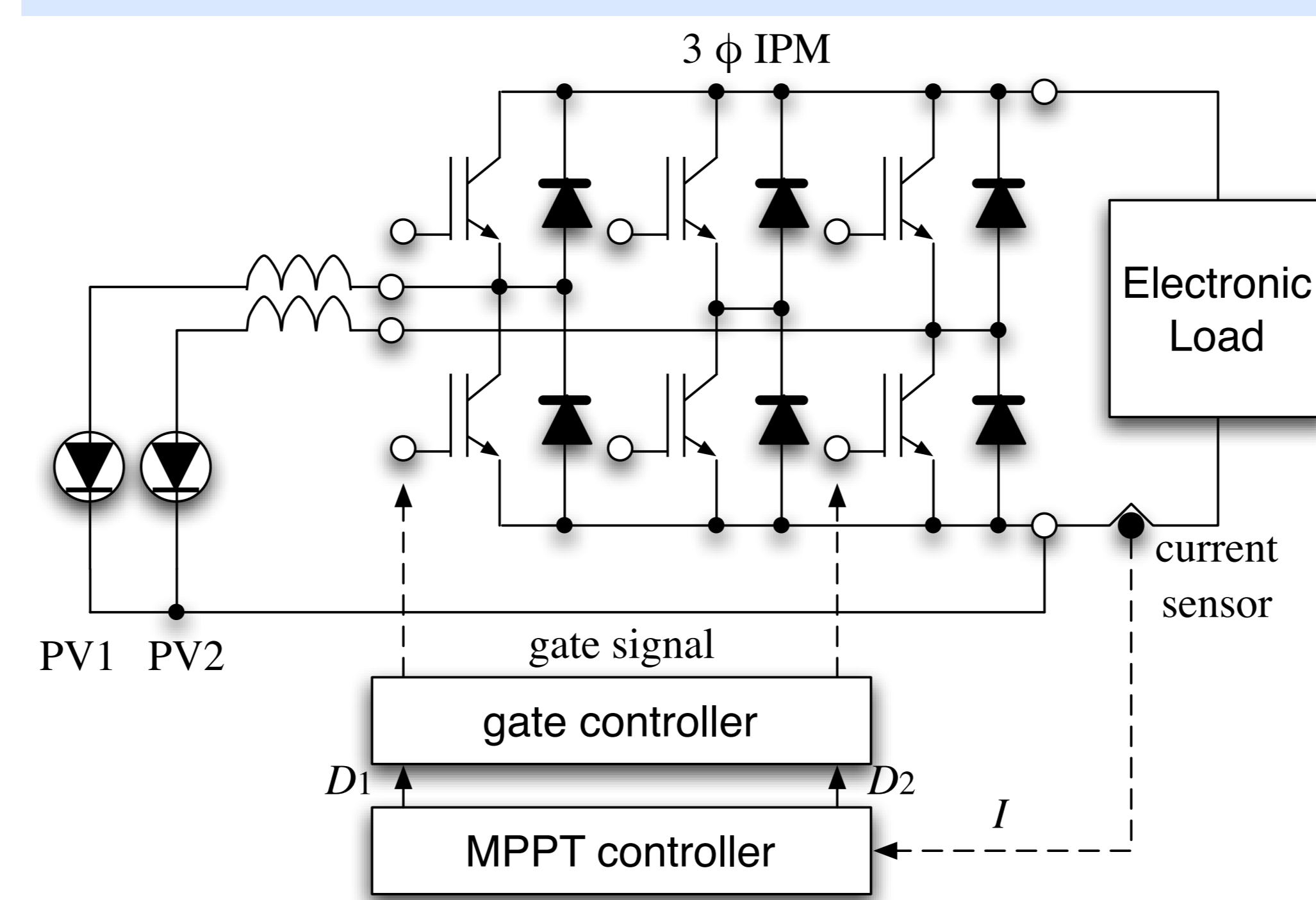Initialization when change of insolation is detected

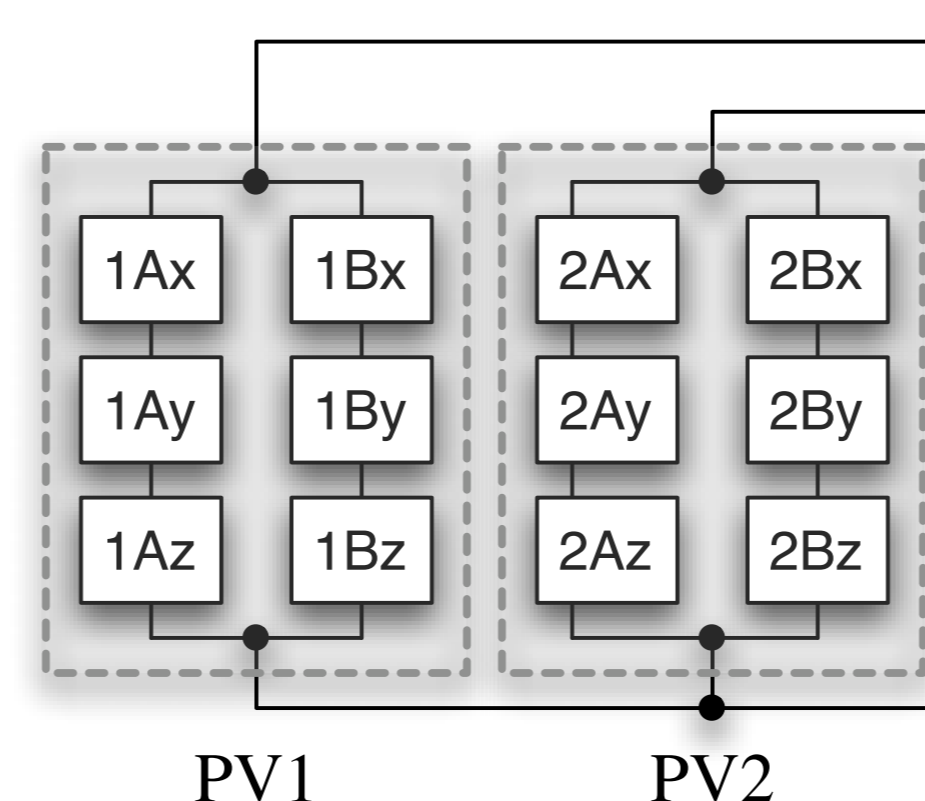Agent position s^k : vector of PV array voltages

$$s_i^k = [V_1^k, V_2^k]$$

Implement of agents :

$$\cdots \to s_1^k \to s_2^k \to s_3^k \to s_1^{k+1} \to s_2^{k+1} \to s_3^{k+1} \to \cdots$$

4. Experimental system

Circuit configuration

Series-parallel connections of PV arrays

- A 3-phase Intelligent Power Module is used for composing two boost choppers.
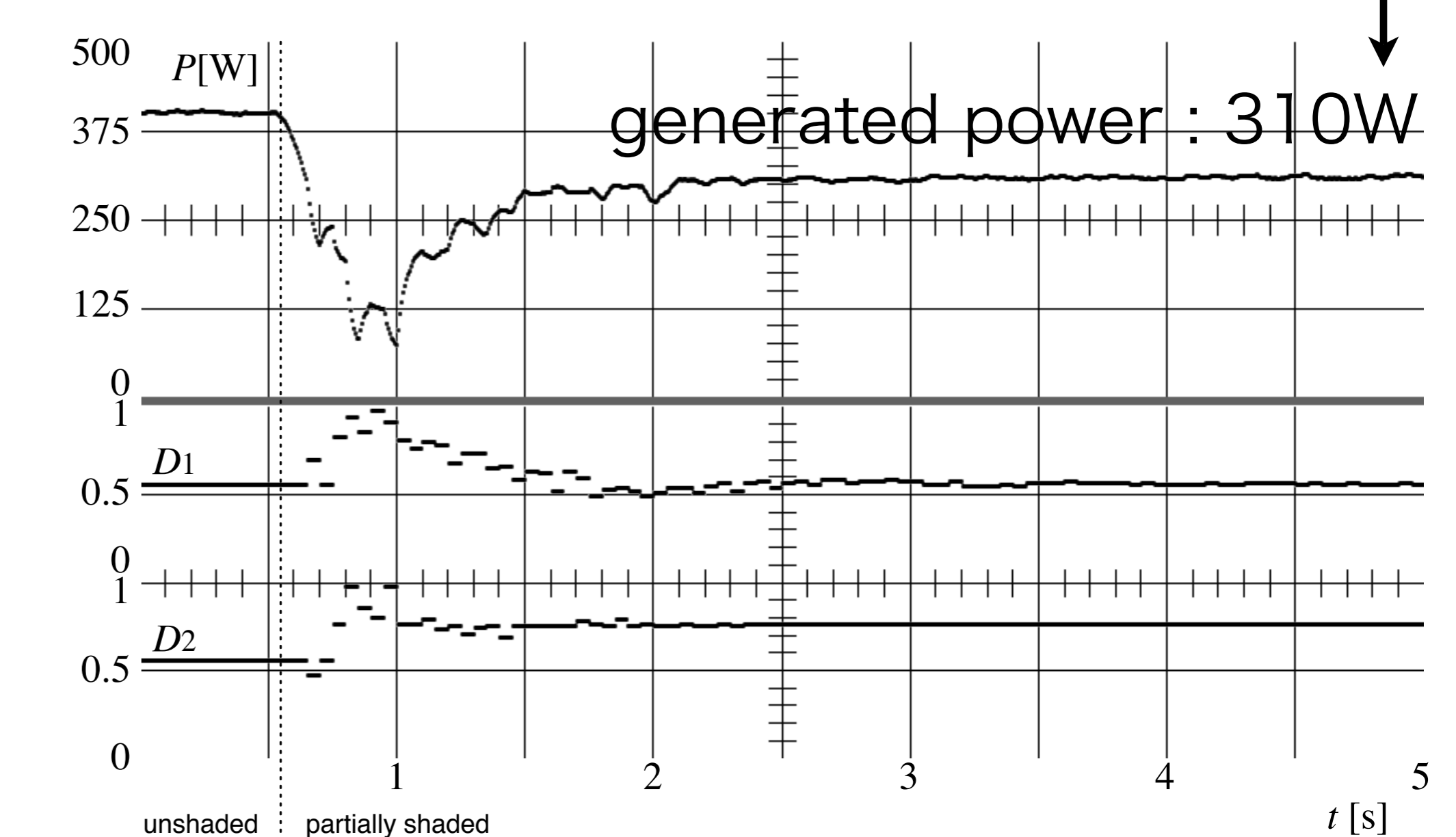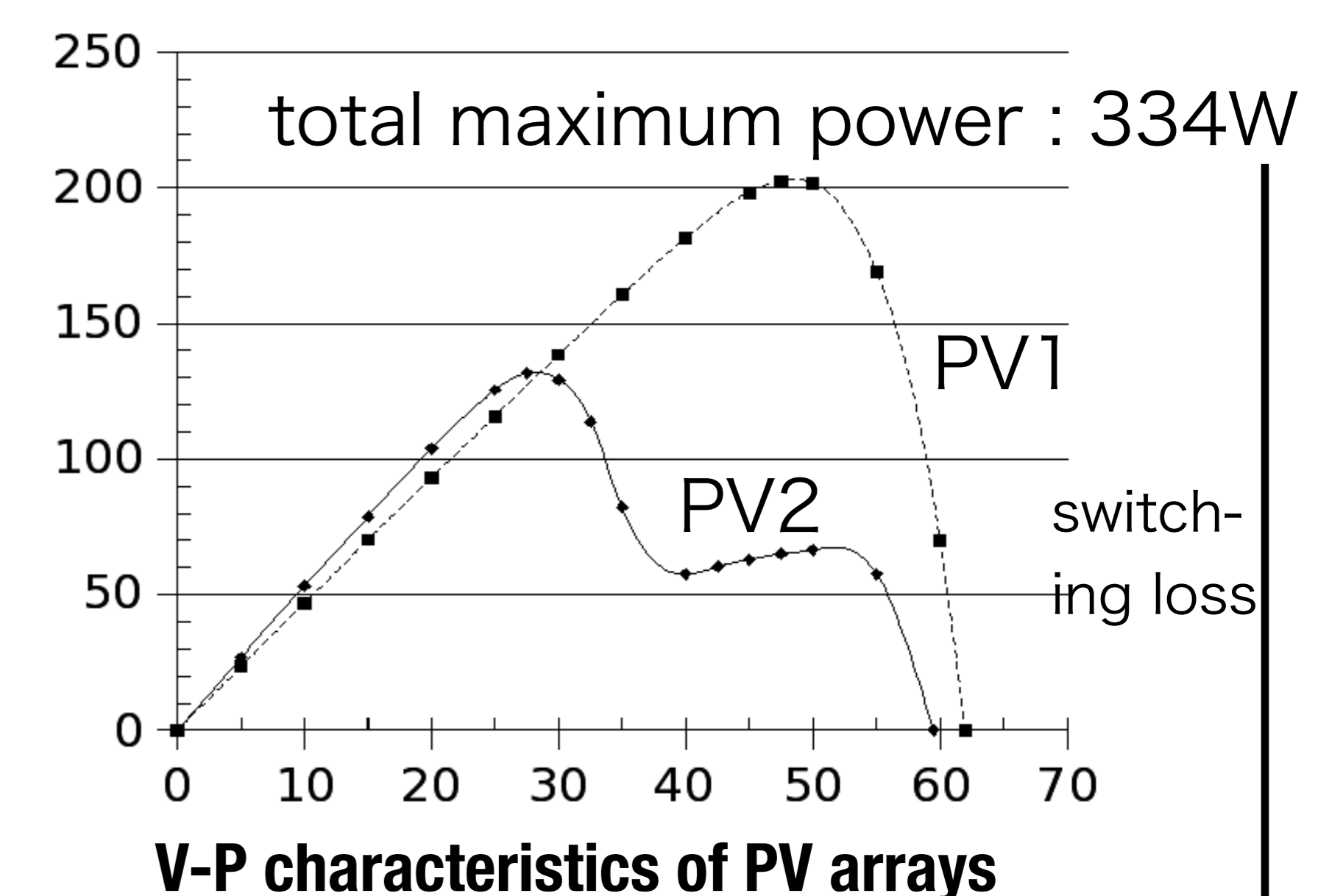- The electronic load keeps load voltage constant.
- A DSP control system is used for MPPT contoller.

How to make artificial shades

5. Experimental Results

A case study : modules of 2Az and 2Bz are shaded.

V-P characteristics of PV arrays

Result of MPPT control

- Response time is about 1[s].
- It can finds the MPP again after shaded although one PV module has local MPP.
- Good results are obtained on other shaded cases.

6. Conclusions

A novel PSO MPPT algorithm :

- control of several PV arrays with one pair of voltage and current sensors
- simple and low cost
- accurate tracking of MPP and fast response

The future developments :

- continuous change of insolation under cloud
- detailed evaluation and comparison
- experiments for 3 or more dimensional control