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MPPT algorithm based on Multiple Linear Regression model for Solar PV systems

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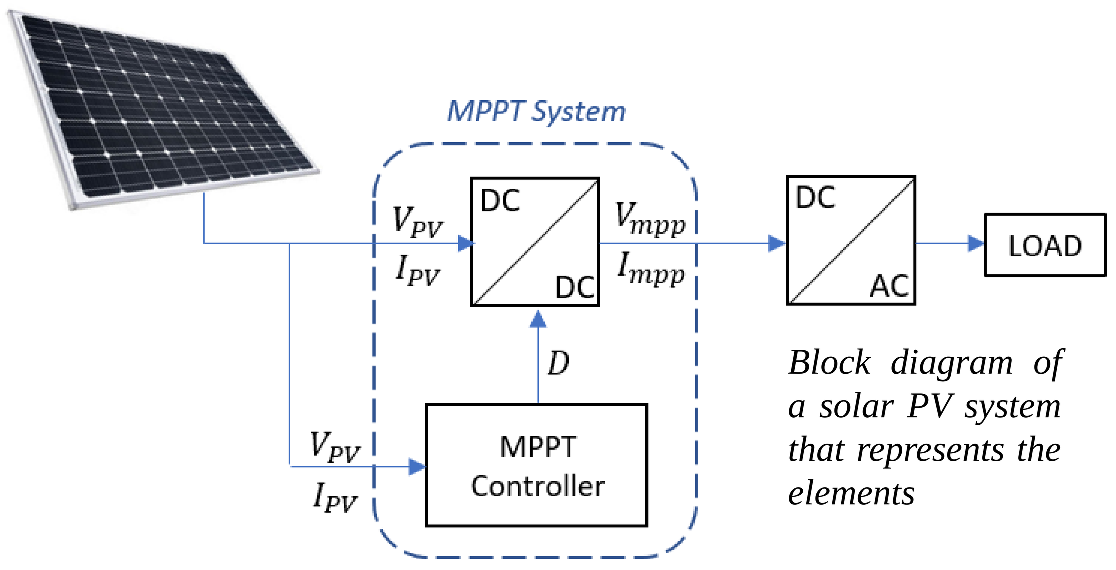
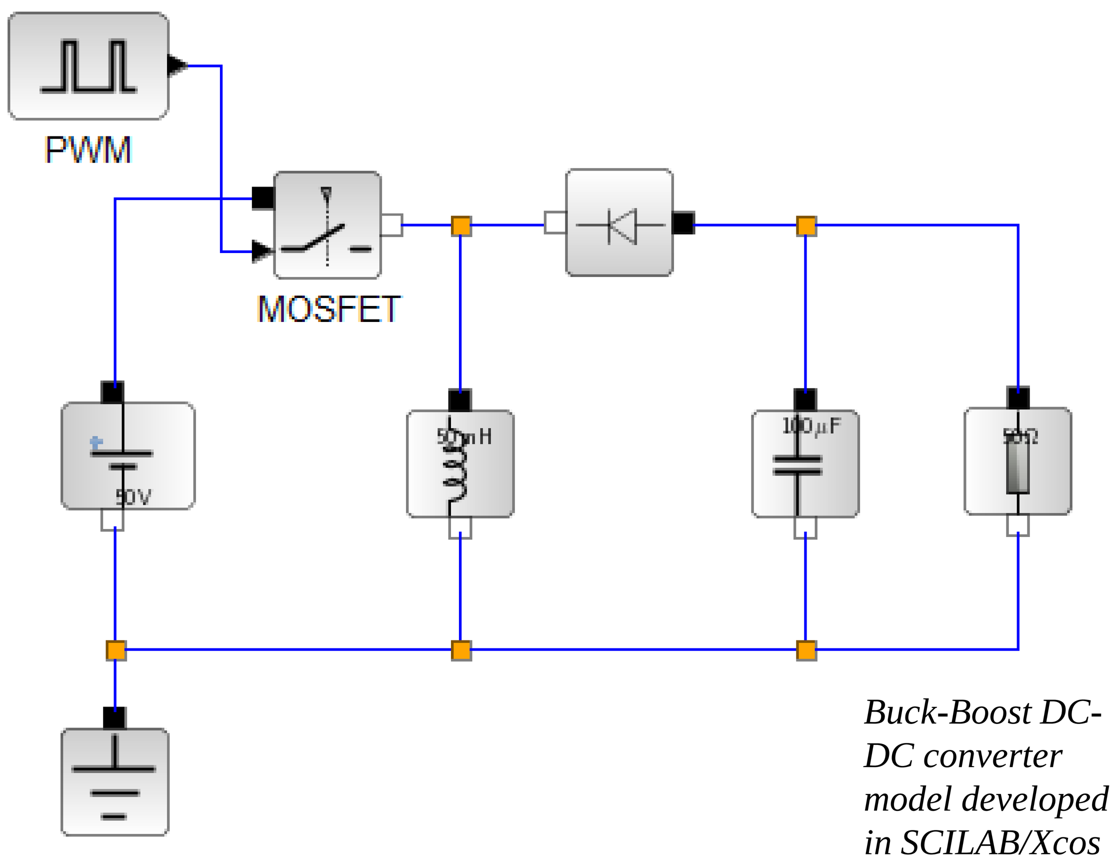
SUMMARY

This work presents a model to establish the optimal working point of photovoltaic panels to be used in installations sensitive to changes in environmental conditions, such as solar pumping, to obtain maximum power in any temperature and irradiance condition of the panels. The model reduces the response time of the system because it also has a control system implemented whose setpoint value is the one provided by the algorithm itself. This is possible with the help of external temperature and solar radiation sensors that provide these values in real time. The setpoint is the working voltage target for the panels (Vmpp), for which the system does not become unstable despite the oscillations allowed by the control system. The algorithm is based on a model that consists of a Multiple Linear Regression through which the entire P-V curve of any photovoltaic panel can be represented for any temperature and radiation.

SOLAR PV SYSTEM DESCRIPTION

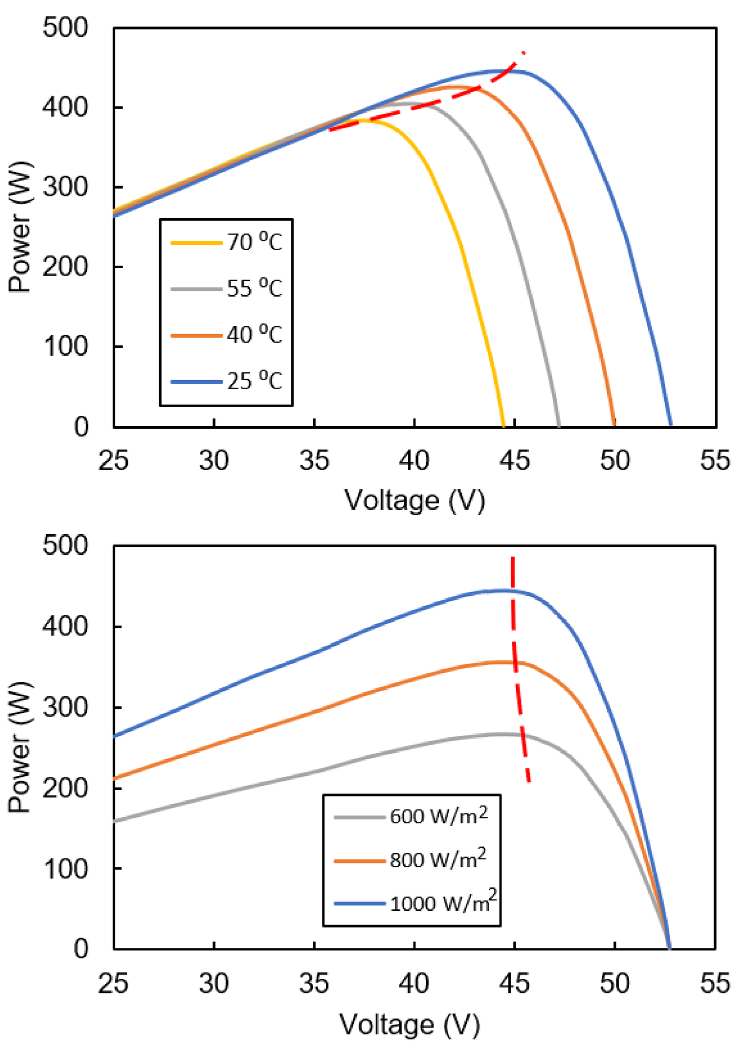


Block diagram of a solar PV system that represents the elements



Buck-Boost DC-DC converter model developed in SCILAB/Xcos

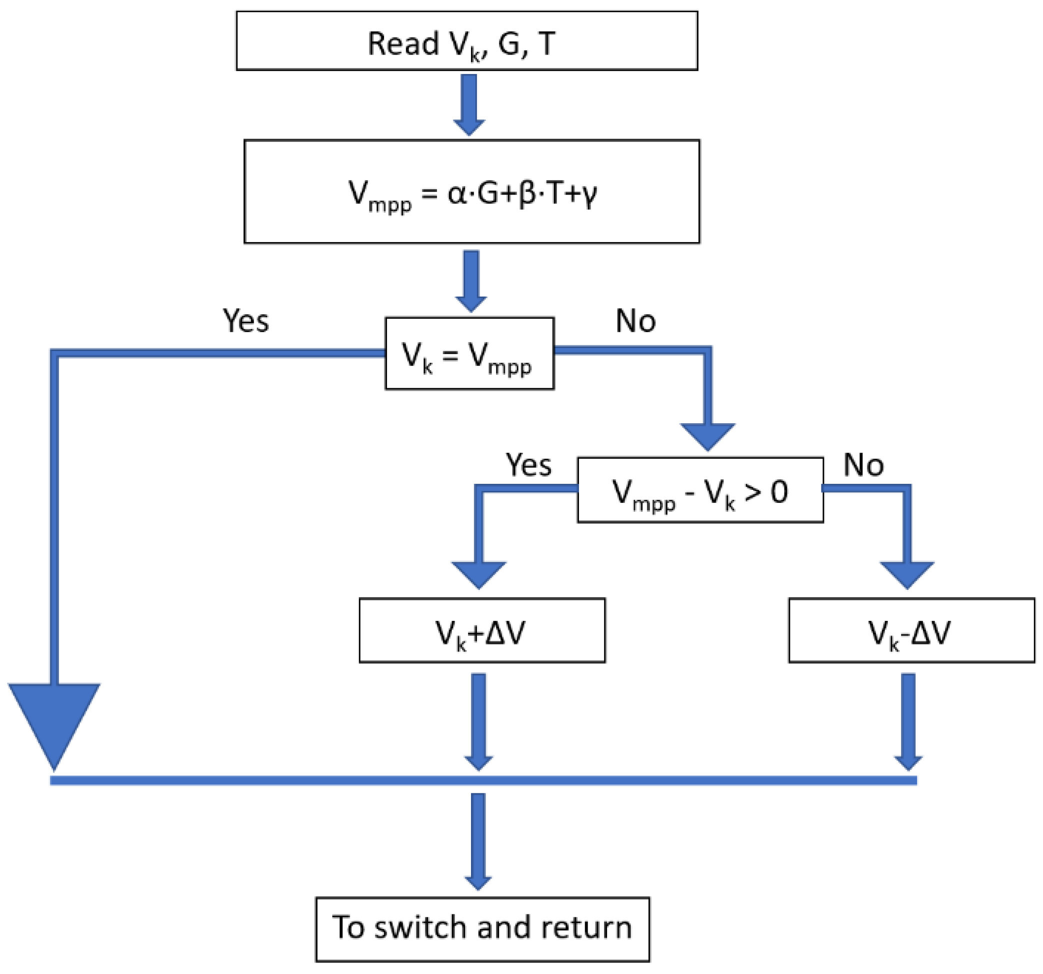
MULTIPLE LINEAL REGRESSION MODEL



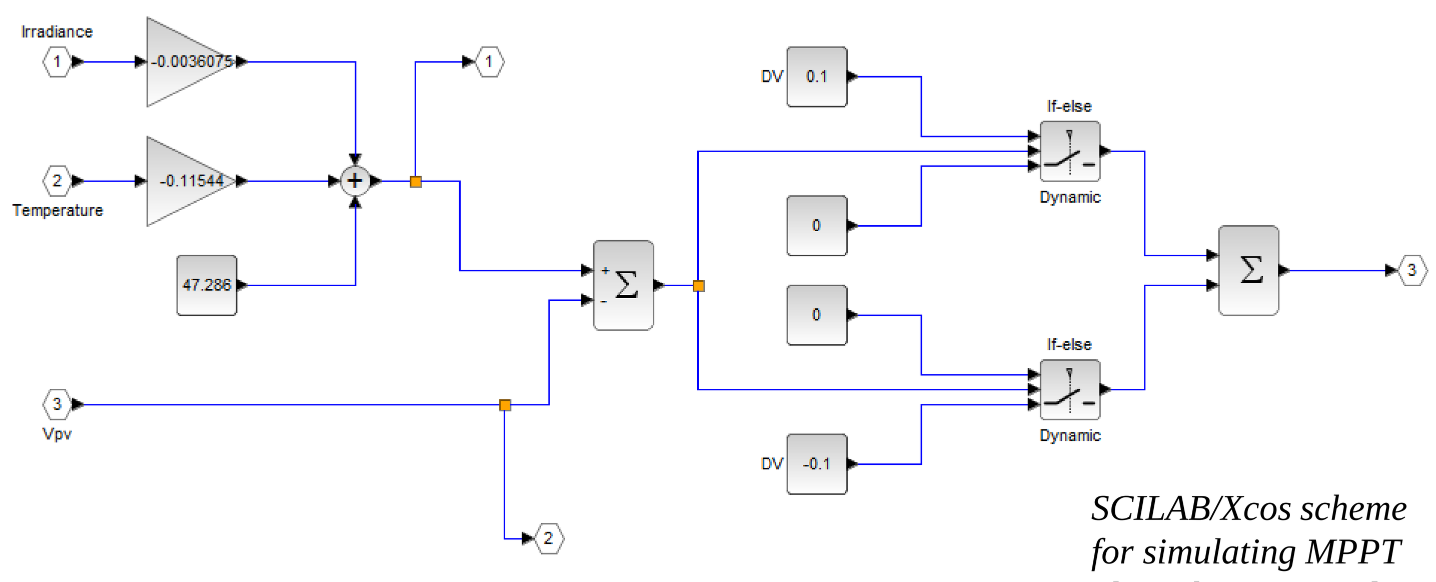
P-V characteristics of the module at different temperature (up) and irradiance levels (down). The red dashed line represents the place of the maximum powers of all PV curves.

$$Vmpp = \alpha \cdot G + \beta \cdot T_{amb} + \gamma$$

ALGORITHM



Flowchart of the MPPT algorithm proposed

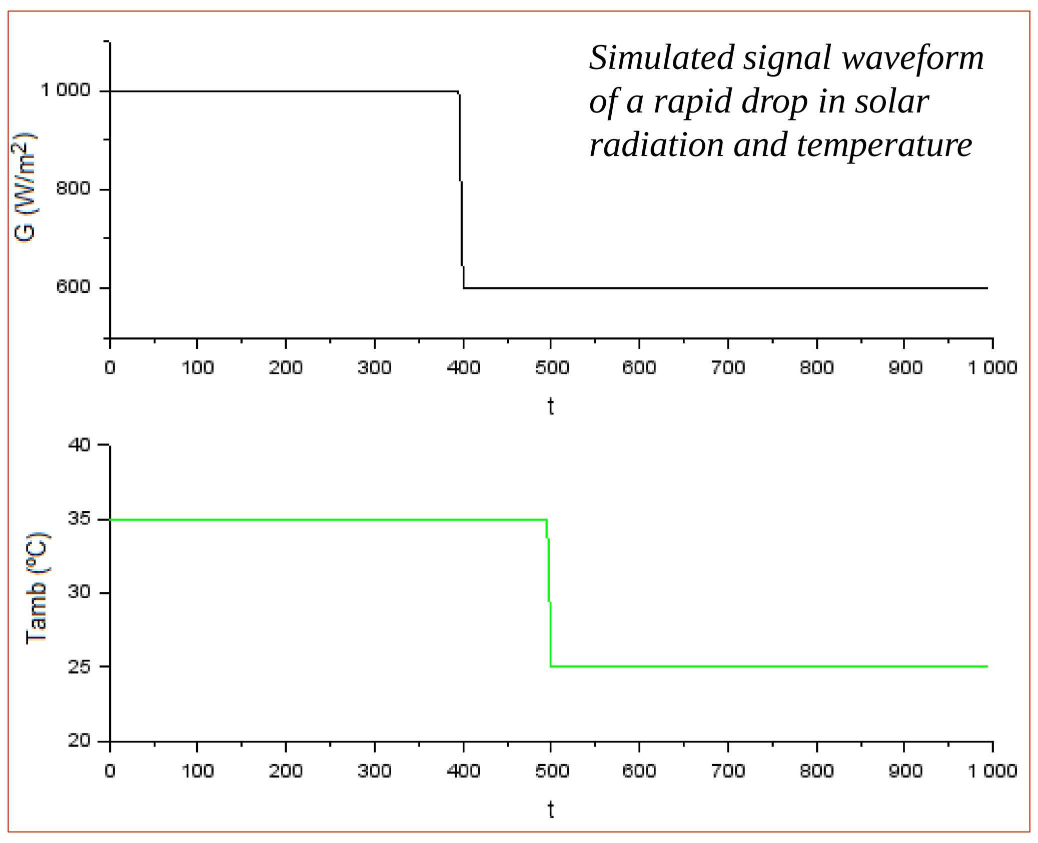


SCILAB/Xcos scheme for simulating MPPT algorithm proposed

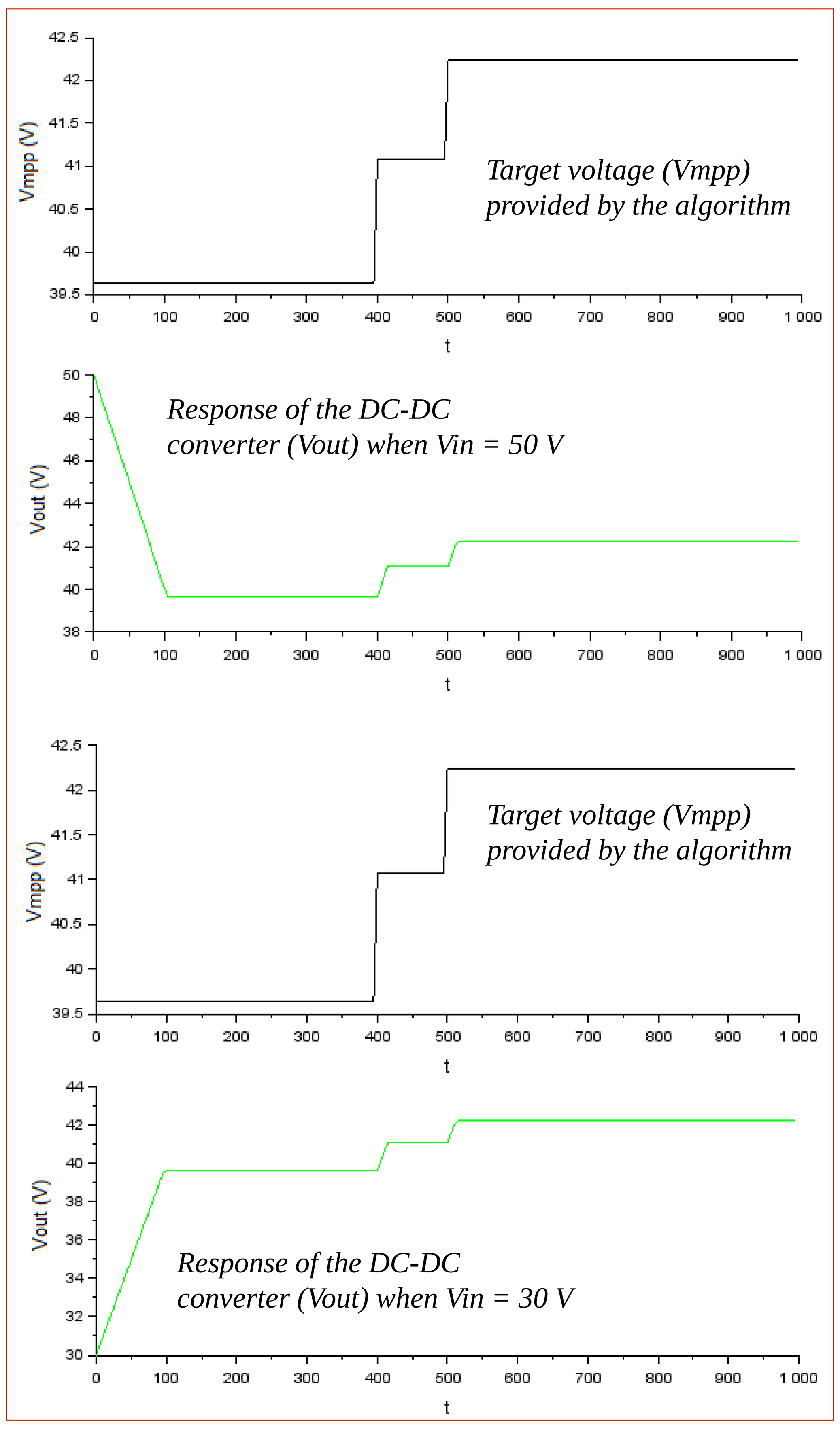
The equation that allows us obtaining the duty cycle ratio D of the *Buck-Boost* DC-DC converter as function of step size ΔV is:

$$V_{out} = \frac{D}{1-D} \cdot V_{in} \quad \Rightarrow \quad D = \frac{V_{in} \pm \Delta V}{2V_{in} \pm \Delta V}$$

SIMULATIONS



Simulated signal waveform of a rapid drop in solar radiation and temperature



Target voltage (Vmpp) provided by the algorithm

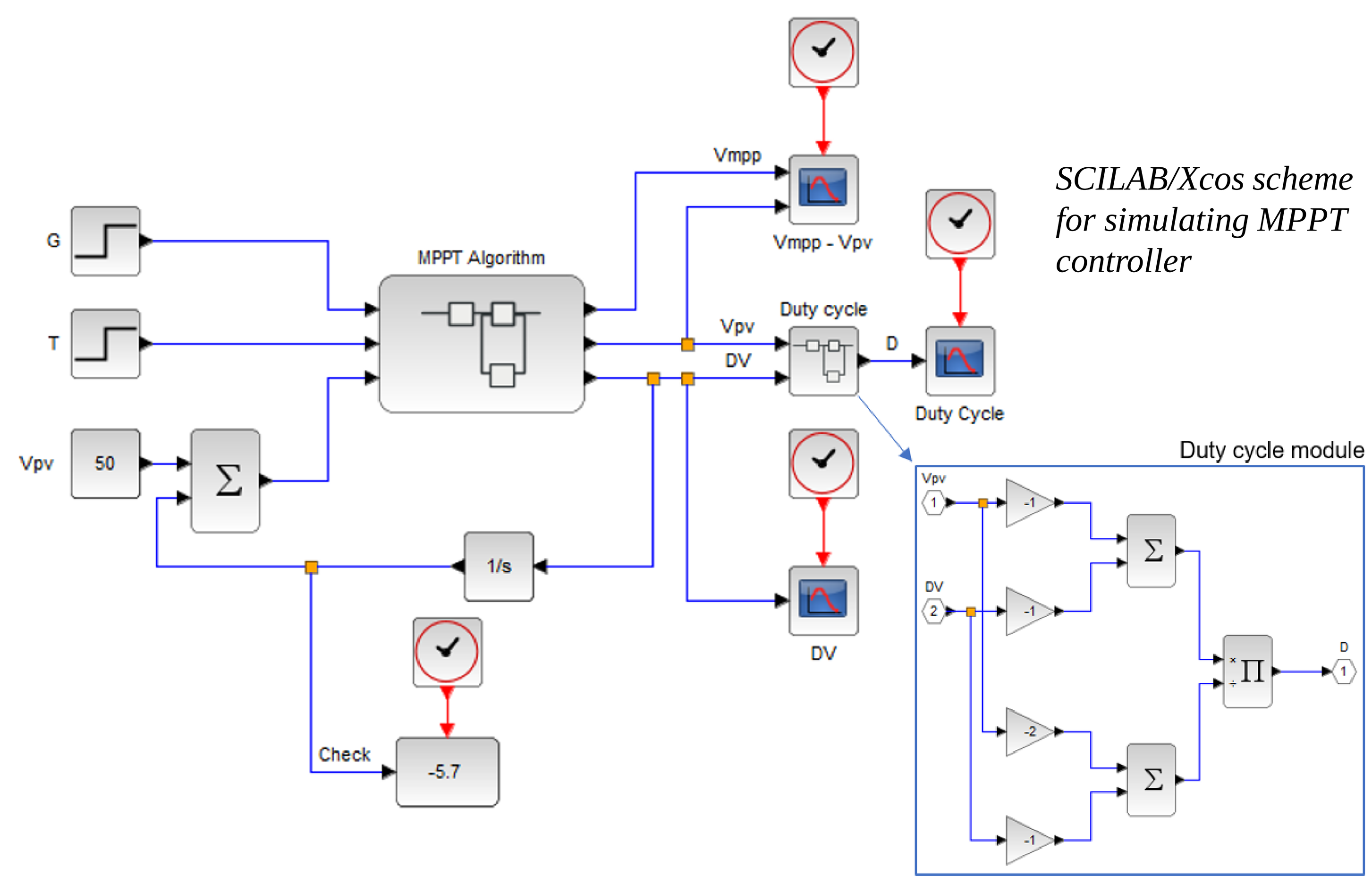
Response of the DC-DC converter (Vout) when Vin = 50 V

Target voltage (Vmpp) provided by the algorithm

Response of the DC-DC converter (Vout) when Vin = 30 V

Table I. – Simulations Conditions

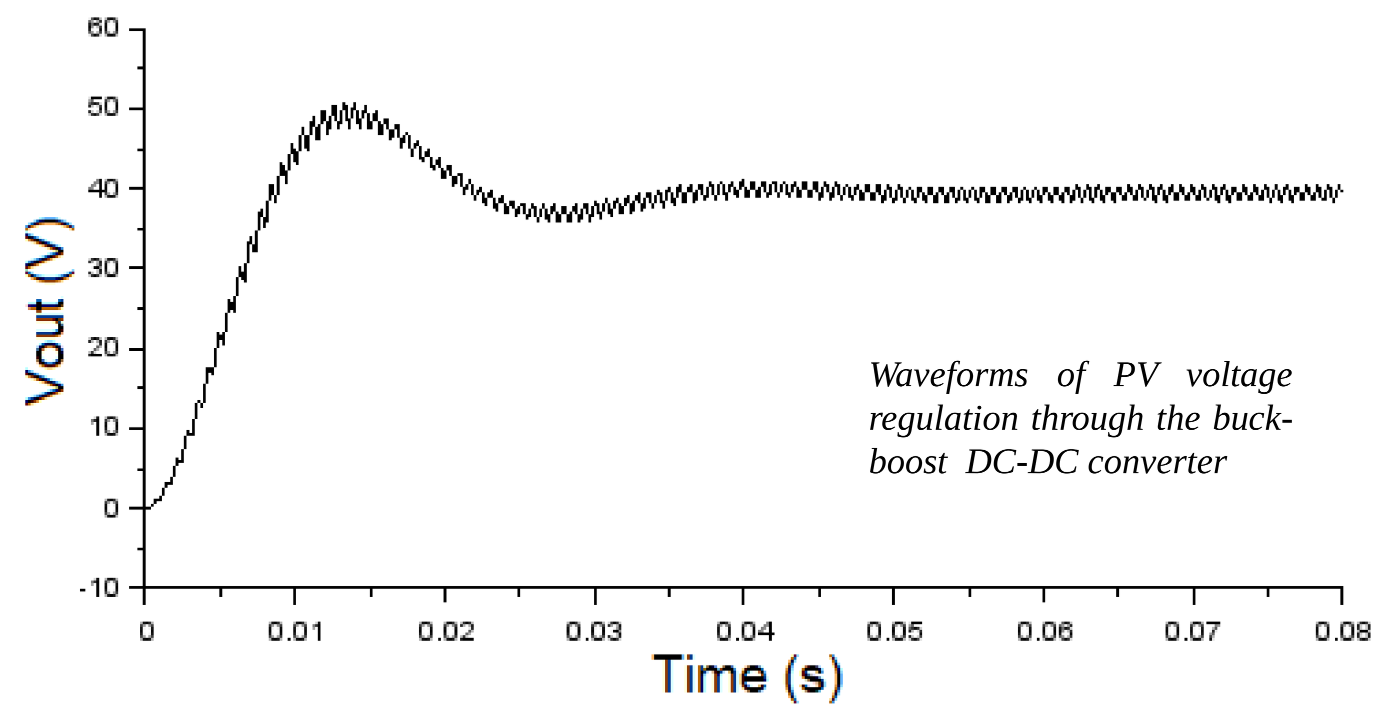
MAGNITUDE	RANGE
Ambient Temperature	25ºC-50ºC
Irradiation	600 – 1000 W/m²



SCILAB/Xcos scheme for simulating MPPT controller

The equation that allows us to obtain the step size ΔV as a function of the duty cycle ratio D is the following transfer function of the DC-DC converter. With this equation, a PID could easily be designed to reduce oscillations and reach the target voltage faster.

$$\frac{V_{out}}{V_{in}} = \frac{D(D-1)}{LCs^2 + \frac{L}{C}s + (1-D)^2}$$



Waveforms of PV voltage regulation through the buck-boost DC-DC converter