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Title

EXERCISE 9: MPPT & DC LINK VOLTAGE CONTROL

Course Name

EE-465 Industrial Electronics I

1 INTRODUCTION

The maximum power point of PV panels depends on variations in temperature and cloud cover factors as well as seasons. In PLECS, the PV panels are modeled as controlled current sources driven by a solar irradiance signal, mimicking the weather conditions. The PV characteristics is stored in the file named `PVLookupData_BP365_single.mat` that should be placed in the same folder as the model using it.

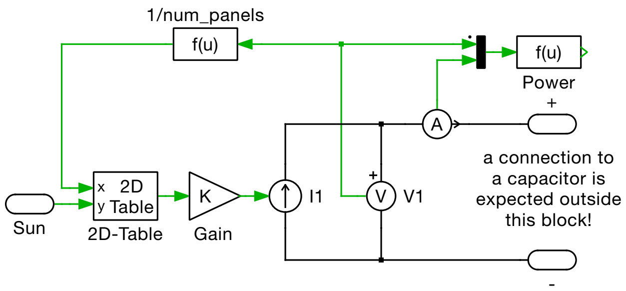

Fig. 1 PV panel model in PLECS.

The DC link voltage control ensures the correct power flow transfer from the input stage to the grid by setting the inverter active power (or current) reference.
The system parameters are summarized in Table 1. The parameters of the boost converter are close to what you were supposed to find in Exercise 1, it should not be necessary to re-tune your controller for this exercise.

C_{PV}	47 µF	L_B	2 mH	R_B	$2m\Omega$
C_{DC}	400 µF	R_{load}	28Ω	$f_{sw,B}$	10 kHz
V_{DC}	750 V	V_g	400 $V_{\text{l-l,rms}}$	f_g	50 Hz
$f_{sw,I}$	10 kHz	L_g	10 mH	R_g	$20m\Omega$

Table 1 System parameters.

2 TASKS DESCRIPTION

2.1 MPPT

1. Why are MPPT algorithm used? What are the PV panel characterized with?

2. Use the first PLECS skeleton provided for this point. Implement the perturb & observe MPPT algorithm on top of your discrete-time control of the Boost converter. If your discrete time control does not work properly, you can use your continuous time implementation instead.
   Hint: You can use the "C-Script" block, write your MPPT algorithm in the "Output function code". Make sure to update the sampling times for the PV voltage control `Ts_V`, and for the MPPT algorithm `Ts_MPPT` with your own values. What sampling time did you choose for the MPPT algorithm ? Justify this, taking into account that it provides a voltage reference for your boost controller. Show a scope capture of the PV voltage and its references over a few cycles of the MPPT algorithm to verify that your control can follow references provided by the MPPT algorithm.

3. What voltage step size are you using in your MPPT algorithm ? Justify this choice.

4. The MPPT sets the input capacitor voltage reference $V_{PV}^{\star}$. Verify that the maximum power point is reached by plotting the voltage and power in XY plot. Show that plot in the report.

2.2 Grid connected converter DC link control

1. Use the second PLECS skeleton provided for this point. The goal is here to control the Boost converter and the inverter to extract as much power as possible from the PV panel and inject it into the grid. Here are the recommended steps to get your model ready before implementing the last missing parts:
   (a) Leaving the control of the boost empty, import your PLL from exercise 8 and verify that it can properly estimate the grid frequency and angle in this PLECS model.
   (b) Import your current control in the DQ frame from exercise 7. Make sure to use the estimated grid frequency and phase angle obtained with your PLL. The voltage of the inverter's DC link is not controlled yet. To test your current control here, you can set $i_d* = 0$ and do a step of i_q*. (Keep $i_d* = 0$ otherwise you will affect the DC link voltage too much).

   For the report, show a capture of the "PLL verification" scope to verify that your PLL is still working properly with the grid conditions of this new PLECS file.

2. Now, implement the inverter DC-link voltage control using a PI controller. For this exercise session, only the active power is controlled (set $i_q^{\star}$ to 0). Using the provided "Control verification" scope, show that you can follow the DC-link voltage and inverter current references correctly, also provide a capture of your voltage control implementation.

3. Now import the control of the boost converter with MPPT that you developed in the first part of this exercise. Show again the "Control verification" scope as well as the time domain plot from the Boost control subsystem.

4. Verify if your power transferred from the PV panels is roughly equal to the AC power. What is the efficiency of your system (A good estimate can be obtained at the end of the simulation using the provided measurements) ? Where are the losses in the system, is it an accurate representation of a real system? Briefly discuss this in the report.