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*Title*


# THIRD REPORT


*Course Name*
EE-465 Industrial Electronics I

*Keywords*
Grid current control, PLL, MPPT


## TABLE OF CONTENTS

# 1 CONTINUOUS-TIME GRID CURRENT CONTROL

1. Implement the PI controller in dq frame (subsystem) as the grid current controller. Perform the required coordinate transformations, knowing that the grid angle is provided from the 3ph grid block. Include reference limitation and anti-windup with back calculation. Show the PLECS implementation.

   …to be filled in…

2. Tune the controller according to the criterion of your choice (Magnitude Optimum or target Phase Margin for a given $\omega_c$). Consider double-update PWM (implying $T_d = 0.75/f_{sw}$).

   Test the closed-loop control response with the provided reference profile. Are you satisfied with the control performance? If not, compare it with another criterion of your choice, in case some performance improvement is achieved.

   Show a scope capture of the response in ABC domain and in the DQ frame (use the scopes of the template showing, P,Q, grid voltages, converter voltages, grid currents and their references).

   …to be filled in…

3. Implement the PR controller in αβ frame (subsystem) as the grid current controller. Perform the required coordinate transformations. Show the PLECS implementation.

   …to be filled in…

4. Tune the resonant controller. Consider double-update PWM (implying $T_d = 0.75/f_{sw}$). Test it in the same way as the PI controllers in DQ frame. Show a capture of the same scopes as before.

   …to be filled in…

5. Are there any major differences between a PI controller in dq frame and a PR controller in αβ frame in terms of controller response and performance, such as disturbance rejection?

   …to be filled in…

# 2 PHASE LOCKED LOOP - PLL

1. Implement a continuous-time PLL based on dq coordinate transformation, where the Park transformation acts as quadrature signal generator. Design your PLL for a settling time $t_s = 100\,\text{ms}$ and a damping factor $\xi = \sqrt{2}/2$. Is the PLL settling time impacted by the grid voltage magnitude? If yes, which measure has to be taken in order to ensure a constant settling time independently of the grid voltage magnitude? Implement that measure. Provide a schematic capture of the implementation and a capture of the scope provided in the template, and comment what happens if you tune your PLL for a smaller $t_s$.

   …to be filled in…

2. Set the parameter h to 3, 5 and 7 and discuss how this affects your PLL. In the report, provide a scope capture of the relevant waveforms. Consider the zero component of the voltages defined as $v_0 = (v_a + v_b + v_c)/3$.
   Again, comment on what happens if you tune your PLL targeting a different $t_s$.

   …to be filled in…

# 3 MPPT & DC LINK VOLTAGE CONTROL

## 3.1 MPPT

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

   …to be filled in…

2. 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.
   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. Verify that the maximum power point is reached by plotting the voltage and power in the XY plot.

   …to be filled in…

3. The MPPT sets the input capacitor voltage reference $V_{PV}^{\star}$. 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.
   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.

   …to be filled in…

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

   …to be filled in…

## 3.2 GRID CONNECTED CONVERTER DC LINK CONTROL

5. Implement the current control in the DQ frame (exercise 7) and verify that it works with the grid frequency and phase estimated by the PLL (developed in exercise 8). Show a capture of the ”PLL verification” scope to verify that your PLL is working properly with the grid conditions of the new PLECS file.

   …to be filled in…

6. Implement the inverter DC-link voltage control using a PI controller. Since only the active power is controlled, set $i_q^{\star}$ to 0. Using the provided ”Control verification” scope, show that the DC-link voltage and inverter current references can be followed correctly. Also, provide a capture of your voltage control implementation.

   …to be filled in…

7. Import the control of the boost converter with MPPT. Show again the ”Control verification” scope as well as the time domain plot from the Boost control subsystem.

   …to be filled in…

8. Verify that 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.

…to be filled in…