Phase-Locked Loops based on the Elementary structure, the ideal In-quadrature Signal, the Park and the Inverse Park Transformation

The objective of this report is to present and to supply the simulation files, made in PSIM, of some PLLs presented on the book "Grid Converters for Photovoltaic and Wind Power Systems" by Teodorescu, R.; Liserre, M.; Rodríguez, P. Wiley-IEEE Press, 2011. All the details, such as math analysis and principle of operation, are found in the book. The simulation file is available here https://sites.google.com/site/busarellosmartgrid/material-didatico-didactic-material/PLLs%20-%20Elementary%20-%20%20Park%20-%20Inverse%20Park%20-%20In%20Quadrature.psimsch?attredirects=0&d=1

i. PLL based on the Elementary structure

The Figure 1 presents the PLL based on the Elementary structure.

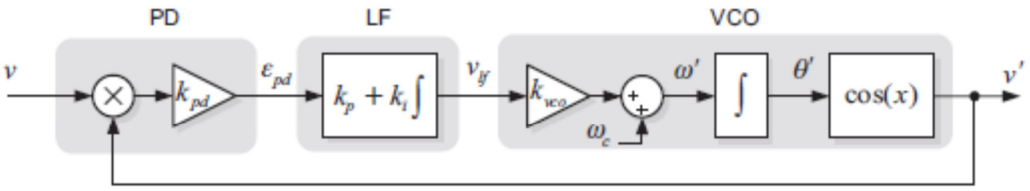

Figure 1: PLL based on the Elementary Structure. Figure Source: "Grid Converters for Photovoltaic and Wind Power Systems" by Teodorescu, R.; Liserre, M.; Rodríguez, P. Wiley-IEEE Press, 2011.

The Figure 2 present the simulation circuit for the PLL based on the Elementary structure

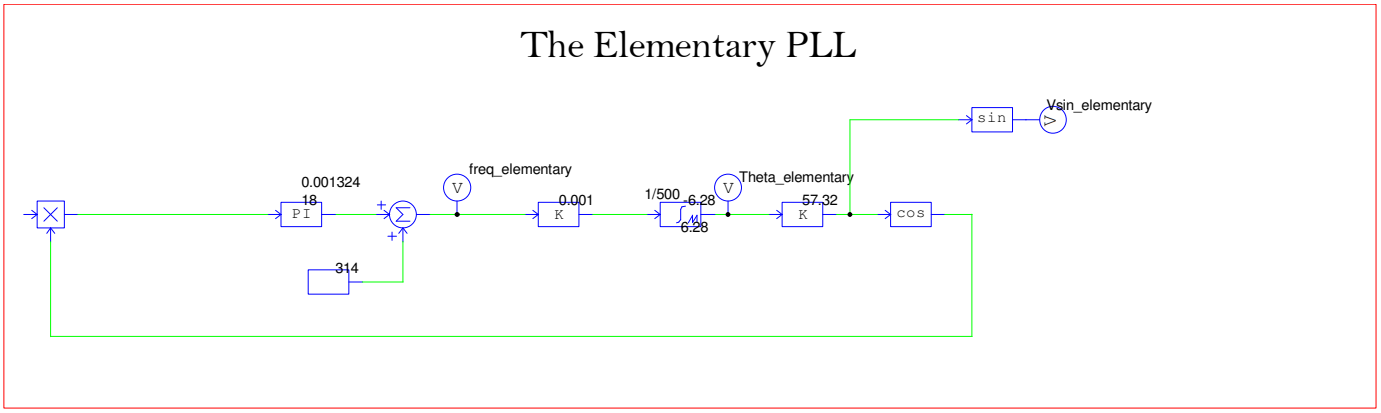

Figure 2: Simulation circuit for the PLL based on the Elementary structure.

ii. PLL based on the Ideal In-Quadrature Signal

The Figure 3 present the PLL based on the ideal in-quadrature signal.

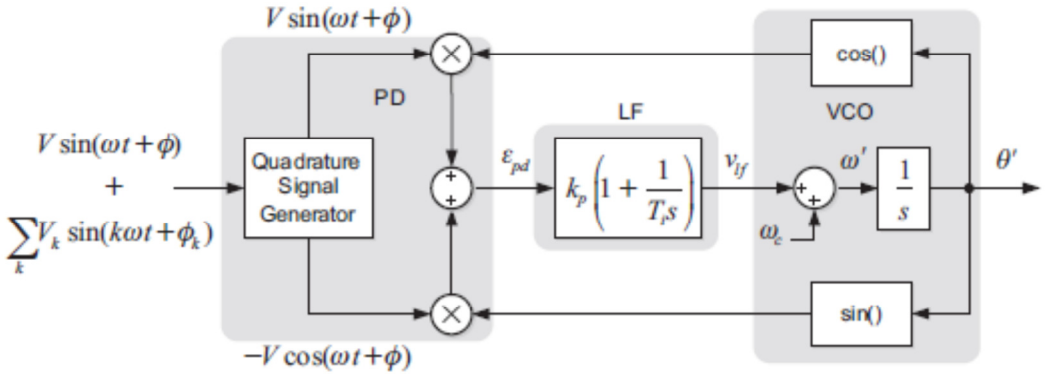

Figure 3: PLL based on the Ideal In-Quadrature Signal. Figure Source: "Grid Converters for Photovoltaic and Wind Power Systems" by Teodorescu, R.; Liserre, M.; Rodríguez, P. Wiley-IEEE Press, 2011.

The Figure 4 presents the simulation circuit for PLL based on the ideal in-quadrature signal.

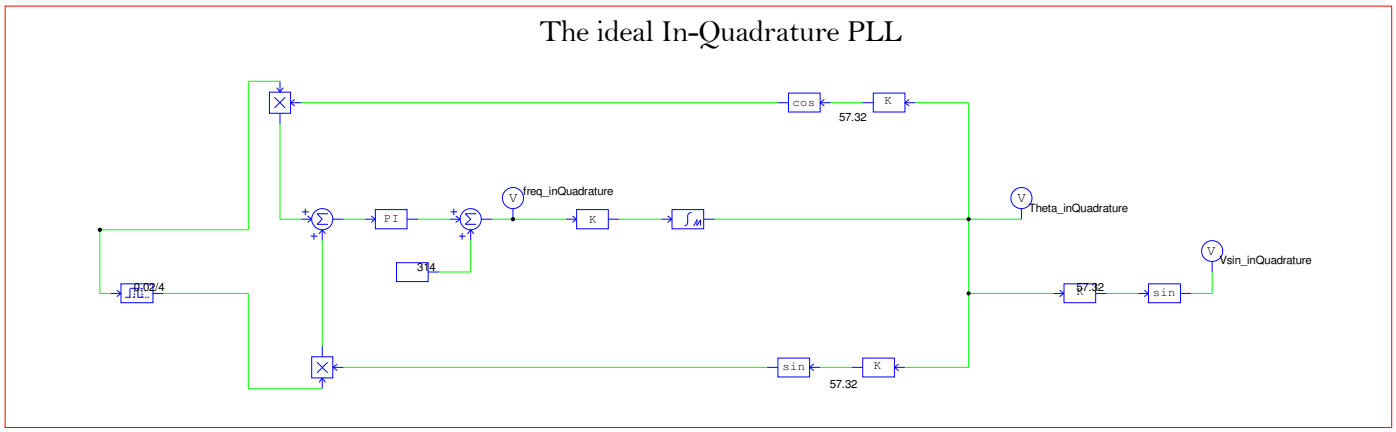

Figure 4: simulation circuit for PLL based on the ideal in-quadrature signal.

iii. PLL based on the Park Transformation

The Figure 5 presents the PLL based on the Park Transformation.

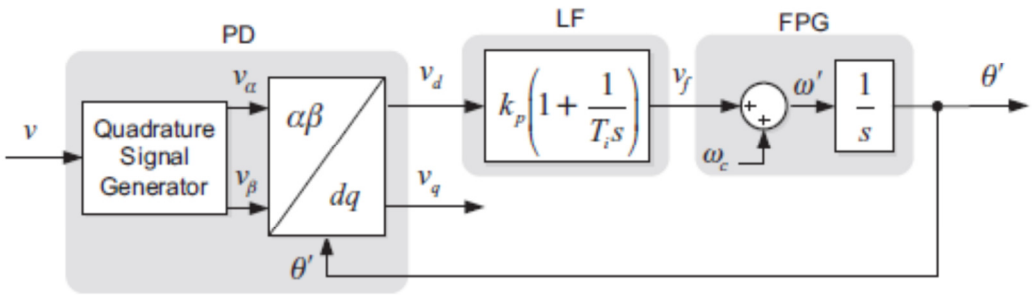

Figure 5: PLL based on the Park Transformation. Figure Source: "Grid Converters for Photovoltaic and Wind Power Systems" by Teodorescu, R.; Liserre, M.; Rodríguez, P. Wiley-IEEE Press, 2011.

The Figure 6 presents the simulation circuit for the PLL based on the Park Transformation.

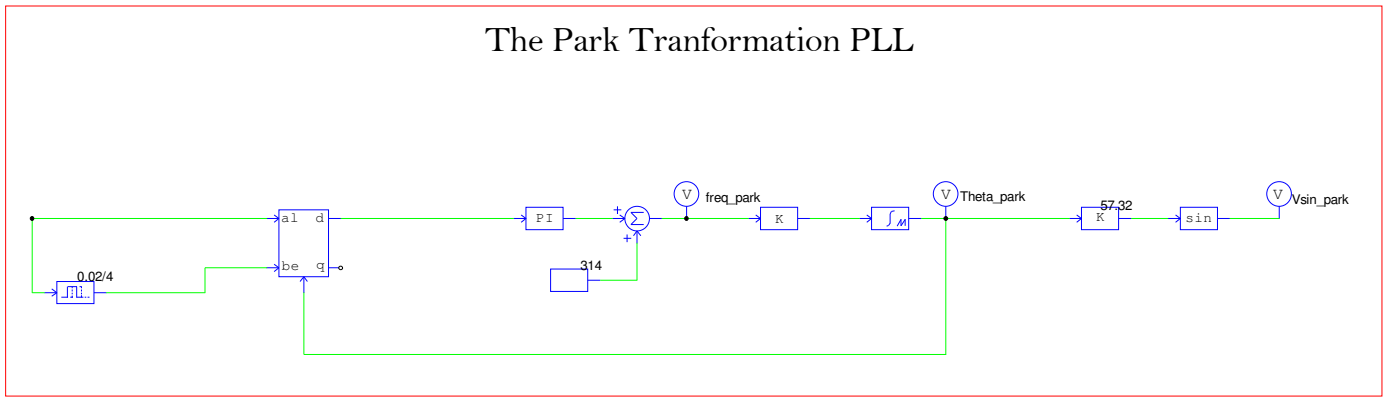

Figure 6: simulation circuit for the PLL based on the Park Transformation.

iv. PLL based on the Inverse Park Transformation

The Figure 7 presents the PLL based on the Inverse Park Transformation.

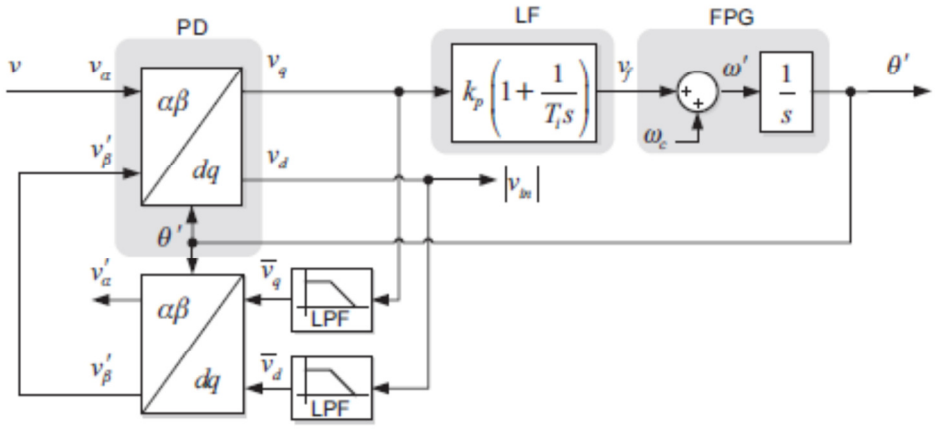

Figure 7: PLL based on the Inverse Park Transformation. Figure Source: "Grid Converters for Photovoltaic and Wind Power Systems" by Teodorescu, R.; Liserre, M.; Rodríguez, P. Wiley-IEEE Press, 2011.

The Figure 8 presents the simulation circuit for the PLL based on the Inverse Park Transformation.

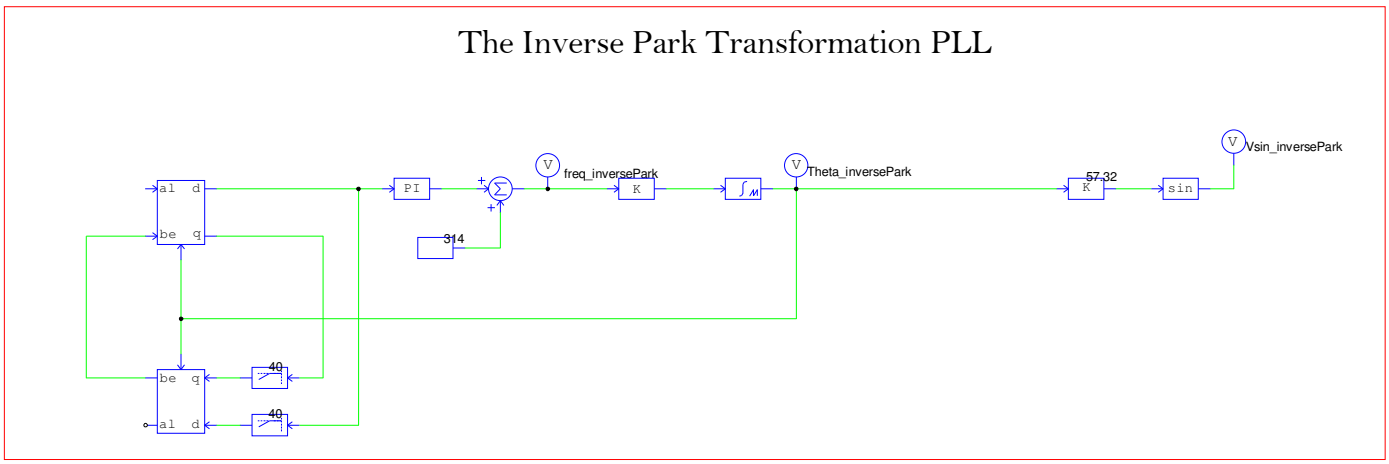

Figure 8: Simulation circuit for the PLL based on the Inverser Park Transformation.

The Figure 9 presents the frequency values for the four covered PLLs during the start-up and during a 45 reference degree step (at t=5s).

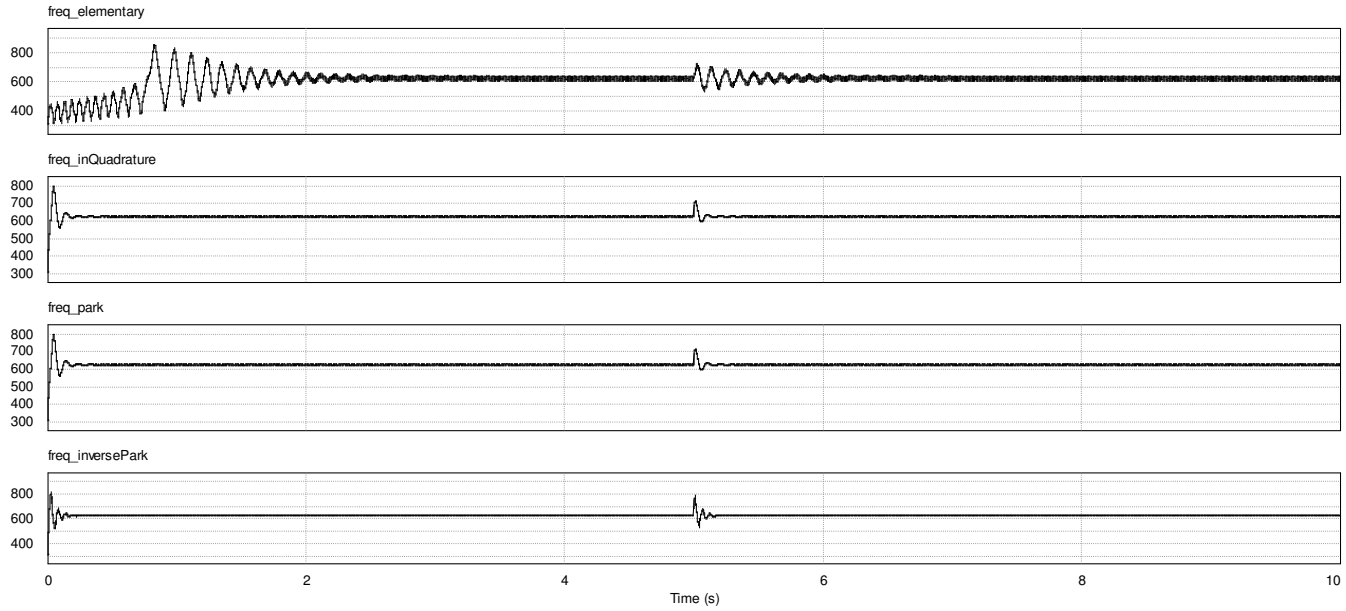

Figure 9: Frequency values (x2) for the four covered PLLs during the start-up and during a 45 reference degree step (at t=5s).

The Figure 10 presents input signal (Vref) and the output signal for the four covered PLLs. The elementary PLL reaches the steady-state (not shown) after approximately 1.5s.

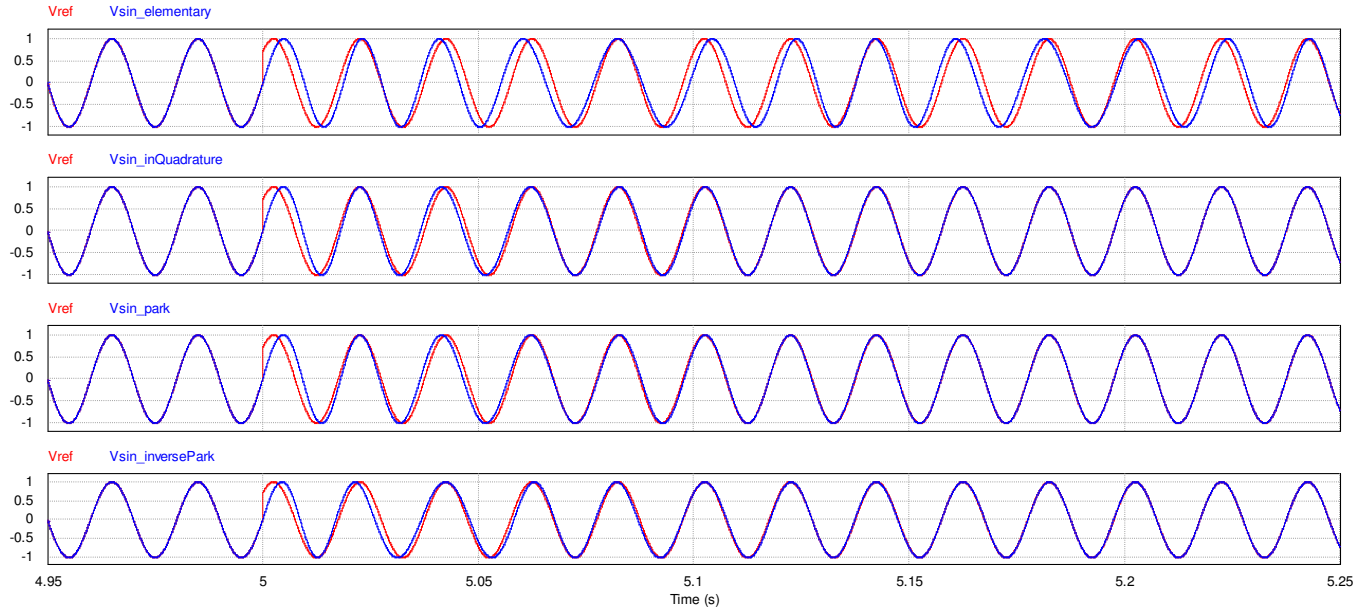

Figure 10: Input signal (Vref) and the output signal for the four covered PLLs.