Inverter Control Design for the optimal management of electrical Micro-grids

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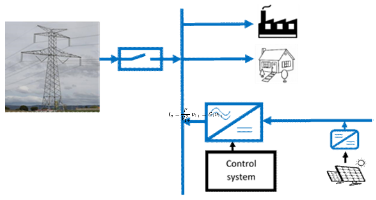
Abstract: Nowadays, the promotion of renewable energy sources is a necessity. Technically, the increase of the renewable penetration in the power system is a challenge. One solution for this problem is the use of self-controlled micro-grids (smart grid, SG). In this work, the design of an algorithm to optimal manage the SG energy through the power inverter control in the SG is presented. In general, a SG consists of renewable energy sources, electrical loads and storage systems. In an isolated SG (no connected to the power system), a DC/AC converter (power inverter, PInv) is necessary to provide an alternating voltage to supply the loads. If the SG is connected to the PS, the PInv is used to inject the active power from the renewable energy sources.

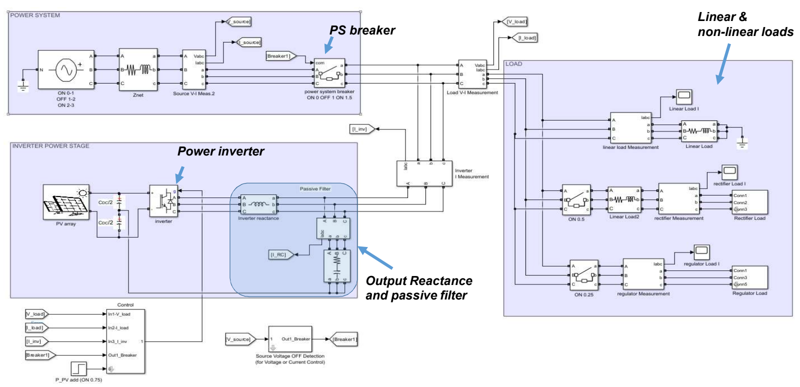
Micro-grid scheme



The renewable energy sources are connected to DC side. The power inverter (Pinv) is controlled to supply the AC loads and to inject the resting energy to the power system (PS).

In the grid-connected mode, the PInv could be also used as a shunt active power filter and an adequate current control would allow the improvement of the power quality in the PCC.

MATLAB/Simulink simulation



Grid-connected and isolated mode

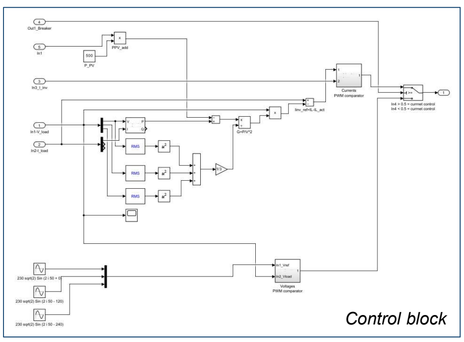
Current control (grid-connected)

$$i_a = \frac{P}{V_{1+}^2} v_{1+} = G_1 v_{1+} \Rightarrow i_C = i_L - G_1 v_{1+}$$

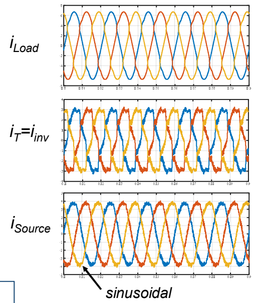
$$i_{RS} = \frac{P_{RS}}{v_{1+}^2} v_{1+} = G_2 v_{1+}$$

$$\Rightarrow i_T = i_{RS} + i_C = i_L - (G_1 - G_2) v_{1+} = i_L - G_T v_{1+}$$

$$i_T = i_L - (G_T \pm \rho) v_{1+} = i_L - K v_{1+}$$

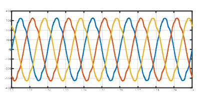


Control block



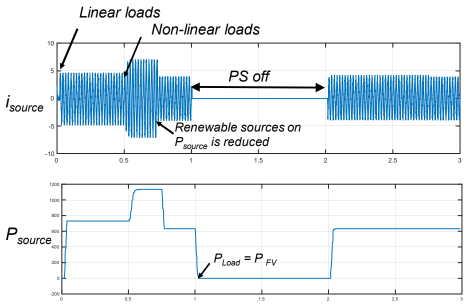
Voltage control (isolated mode)

$$v_T^* = v_{1+}$$



Power system active power

To analyze the transit performance, the non-linear loads were connected in second 0.5 and the renewable source in second 0.75. The harmonics are still compensated and the source currents are still sinusoidal. From this time on, the PS active power is reduced because of the renewable energy source connection.



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Conclusions

In this paper, a complete control algorithm for a power inverter in a smart grid has been proposed, to make that the inverter acts as a source current or as a voltage source depending on the SG connection to the power system. In the case that the SG works in isolated mode, the control algorithm makes that the inverter produce a direct, symmetric sinusoidal three-phase 400 V voltage system to supply the smart grid AC loads. In the case of grid-connected mode, the control algorithm makes that the inverter work as a current source and the current provided contains two components: the first one injects the active power produced by the SG renewable sources to the power system and the second one compensates the harmonic and asymmetric components introduced by the SG loads into the system.

The control algorithm has been tested in a simulation platform designed within Matlab/Simulink and the results have been presented in this paper. These results show the good performance of the control proposed.