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Voltage-Controlled and Current-Controlled Low Voltage STATCOM: A Comparison

L. Ribeiro[1], D. Simonetti[1]

[1] Department of Electrical Engineering
Power Electronics and Drives Laboratory, Federal University of Espírito Santo
Campus of Goiabeiras, Vitória (Brazil)
Phone/Fax number: +55 27 4009-2644, e-mail: laila.sindra@gmail.com, d.simonetti@ele.ufes.br

Abstract. Inverter-based converters interconnecting DC-microgrids and AC-microgrids/grids are in a strong expansion. Besides power exchange, the inverter can be requested to furnish ancillary services and, among them, power factor compensation. This work presents a comparison between voltage control and current control in a low voltage inverter in a STATCOM operation. Both strategies use P&O controllers to control power factor, but in voltage-control the P&O adjust modulation index while in current-control P&O adjusts the current reference. HIL simulations show that both controllers can efficiently increase power factor; however, voltage control requires additional overcurrent protection. Current control can easily limit the devices current, but requires an extra current measurement when compared to the voltage controller, therefore has increased cost.

Key words. STATCOM, multilevel inverter, PLL, LCL filter, Hardware in the loop.

1. Introduction

Inverter-based converters interconnecting DC-microgrids and AC-microgrids/grids are in a strong expansion as renewable electrical resources are more and more tied to the electrical system, mainly due to the increase in energy demand as well as climate concerns. Rated power of such power sources, mainly wind and solar, ranges from a few kW to MW.

Also, interconnections at low-and-medium voltage distribution systems are increasing worldwide. As an example, from 2017 (end) to 2021 (end), residential solar farms in Brazil (below 75 kW) have jumped from 16,967 units to 614,680 units, leading to 3.8 GW of installed power [1].

It is expected that, in a near future, the total power furnished by prosumers below 75 kW will participate significantly in the power offer. It will be necessary to incorporate them, as a single unit or in a virtual power plant configuration, in the power system rules.

Along with the expansion of photovoltaic installations, DC microgrids are gaining increased interest, predicting the materialization of hybrid microgrids or DC/AC power system (Fig. 1).

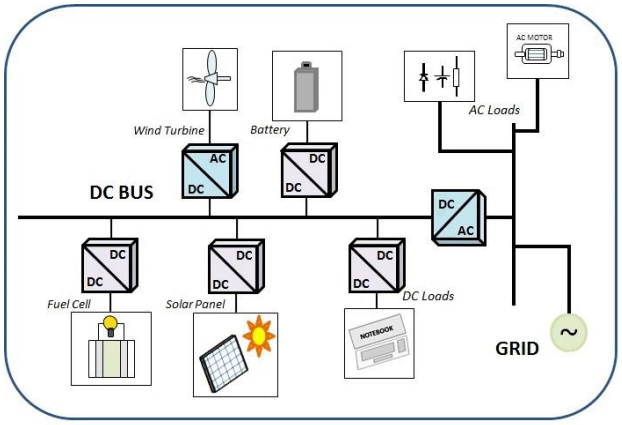

Fig.1. A basic AC/DC power system or hybrid microgrid.

In an integrated DC-microgrid and AC grid, the DC-AC converter connecting both systems is by default bidirectional. In the moments that an active power exchange is not required, the inverter can be requested to furnish ancillary services. Among them, power factor compensation arises.

In an electrical system, the amount of reactive power flow is relevant to maintain system reliability and power quality. The reduction of reactive power flowing in the system diminishes utility losses (lines, transformers, circuit breakers) improve voltage regulation, and liberates system capacity to deliver active power. As majority of electrical consumers present inductive behaviour, capacitors are a widespread solution to solve the problem, supplying reactive power. Meanwhile, this solution presents some negative aspects, as capacitors are not able to consume reactive power, and produces electrical transients during connection.

One solution to solve these constraints is the use of continuous-controlled power electronic converters operating as a reactive element. Such device can be controlled to be seen by the utility as a variable capacitor or inductor, being continuously adjusted to achieve a high power factor. The device is so-called STACOM and, applied to distribution levels, D-STACOM (STAtic COMpensator connected to the distribution system).