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A Review of Current Control Strategies for Single Phase Grid Integrated Inverters Used in Photovoltaic Applications

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Abstract

The current focus is shifting toward the integration of small and medium-scale power plants based on renewable energy sources into the power distribution system. Solar energy is the fastest growing renewable energy source, and a single phase voltage source inverter is used to connect photovoltaic plants to the distribution system. The control requirements for the grid integrated inverter are stringent. A current controller is used to reduce harmonics in the injected current into the grid and to regulate the power exchange between the plant and the grid. This paper provides an overview of the current control strategies used for a single phase grid-connected photovoltaic inverter. Through simulation and experimental results, a comparative performance evaluation of current control techniques is also presented.

Keywords: Photovoltaic • Phase • Current • Inverter

Introduction

The power generation sectors rely heavily on non-renewable fossil fuels, which contribute to environmental pollution. Coal reserves are depleting at an alarming rate. Given the current situation, the emphasis is shifting toward the integration of small and medium-scale power plants based on renewable energy sources (RES) into the power distribution system. These are known as distributed generation (DG) plants [1].

According to the International Energy Outlook (IEO) 2016 report, renewable energy consumption will rise by an average of 2.9% per year from 2012 to 2040. It is expected that by 2040, the net power generation from renewables will equal the power generation from coal, with wind and solar accounting for nearly half of this renewable power generation. Rapid development has resulted in lower renewable energy generation costs. Solar photovoltaic (PV) costs are expected to fall by 40-70% by 2040, while on-shore wind costs are expected to fall by 10-20%. According to Fig. 2, solar is the fastest growing form of renewable energy, with a net increase in solar power generation of 8.3% per year [2].

Solar photovoltaic (SPV) power plants, residential PV, PV lighting systems, and building integrated PV are common applications for solar energy systems. Residential PV systems can be operated as either stand-alone or grid-connected systems. Stand-alone systems are mostly used in remote areas where the grid does not exist. Instead of connecting to the grid, the output of the power converter, which can be either a DC/DC converter or a DC/AC converter, is fed directly to the load. In grid connected mode, the DC/AC converter's power output is injected into the grid [3,4].

Grid integration of DG plants and storage systems aims to inject power into the grid. Power exchange between the DG and the grid must be done in a controlled manner. This can be accomplished in two ways: one is to directly control the injected current, and the other is to control the voltage difference between the inverter output voltage and the grid voltage. Voltage control strategies are challenging to implement. Although the current control technique is simple to implement, inverters that use current controllers do not regulate the power system frequency and voltage, which may cause stability issues when more power is fed into the grid.

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Literature Review

Harmonics in voltage across the local load and harmonics in current injected into the grid by the DG inverter are the main power quality issues associated with renewable grid integration. Harmonics are signals present in the original signal with frequencies that are integral multiples of the original signal's fundamental frequency. Harmonics are generated by the VSI connecting the DG to the grid or by non-linear loads in the system. The total harmonic distortion (THD) is a power quality index that indicates the harmonic content of a distorted waveform [5].

The output of RES is not consistent. It varies with temperature and atmospheric conditions such as solar irradiance and wind speed. As a result, it is critical to ensure that the RES-based DG delivers maximum power for its capacity regardless of environmental conditions. A maximum power point tracking (MPPT) algorithm must be integrated with the DG plant to accomplish this task. This task is carried out by a power electronic converter (PEC). Depending on the system configuration, the PEC is either a DC/DC or a DC/AC converter.

Discussion

Islanding occurs when the DG plant or energy storage systems continue to inject power into the grid after the grid has failed. This could endanger the workers on the job site. As a result, detection of islanding is required in order to disconnect the DG from the grid in the event that the grid loses power. Anti-islanding is the process of detecting islanding. When the grid is disconnected, detection of islanding is also required to power the local loads connected to the DG plant.After the fault has been cleared, an effective grid synchronisation technique can complete the task of anti-islanding and grid reconnection [6].

The MPC strategy is used to control the current of a neutral point clamped (NPC) inverter. With a lower switching frequency, the proposed control strategy achieved good sinusoidal reference current tracking. To reduce the common mode voltages (CMVs) from matrix converters feeding an induction motor load in, a predictive control strategy is used. The CMV is reduced by 70% while the THD of line side currents is not increased. In, a model-based predictive control scheme is used to control the active and reactive power of an active front end rectifier. The proposed control strategy generates sinusoidal input current while operating at unity power factor. The authors concluded that the MPC strategy is simple and straightforward to implement on a digital signal processor (DSP), and that it demonstrated good dynamic response by controlling the input power [7].

Conclusion

A model-based predictive control strategy for controlling the output voltage of a three-phase inverter with an LC output filter is presented. Under linear and nonlinear loads, the proposed predictive control method outperforms hysteresis and PWM control. With both linear and nonlinear loads, the proposed MPC strategy achieved good voltage regulation. Furthermore, the control scheme is simpler to design because it does not require parameter tuning or cascaded control structures.The inverter output current is plotted using FFT analysis. The magnitude of the controllers' THD is compared in. When compared to other control schemes, the THD value of output current is 1.48% in the case of the MPCC scheme. CHC, PICC, PRCC, and DBCC strategies have THD values of 5.35%, 4.28%, 3.30%, and 1.86%, respectively. The improvb performance of the MPCC scheme is due to its cost function optimization, which minimises the current error.

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Conflict of Interest

There are no conflicts of interest by author.

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