A REVIEW ON POWER CONTROL SYSTEM INVERTERS WITH VARIATION POWER SYSTEM

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ABSTRACT

This paper presents the design and analysis of both the active and reactive power control of a single-phase voltage source inverter (VSI) for grid-connected photovoltaic (PV) system. The proposed method is based on vector control of power by decoupling control of the active and reactive current components to feed the active and reactive power to the grid. The aim of this research is to control power factor at grid, to improve overall efficiency of transferring power of PV to alternate current power conversion into the grid, and to decrease phase current distortion of VSI. In this work, mathematical model of system has presented in details. This review focuses on updating grid standard codes and regulations, in addition overview of recent control strategies and direct power control. The structure of the phase locked loop (PLL) with grid synchronization techniques for single phase and three phase is discussed in brief. Investigations are performed for a fault ride through capabilities with detailed analysis of islanding detection methods with its types. The PV- STATCOM control functionality for the enhancement is discussed in detail. The demand for electrical energy is increasing in Vietnam in recent decades; which has motivated the use of renewable energy sources (RES). Among them, Photovoltaic (PV) energy is becoming a promising energy sources because of their advantages. The connection and use of PV in distribution grid in Vietnam should be in line with the framework of sustainable energy development worldwide.

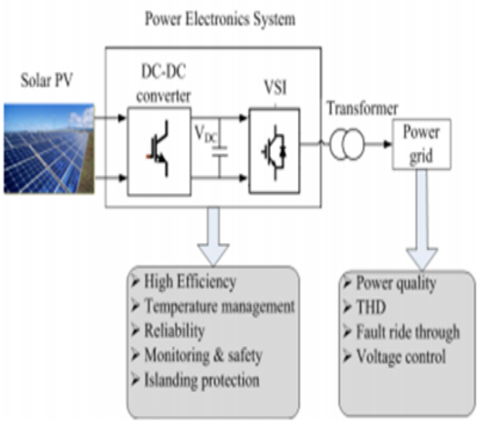
Keywords: *PV inverter, current control, PV-battery energy management.*

Introduction

The output voltage quality is the basic advantage of voltage source inverters (VSI) for UPS systems. The sinusoidal PWM is typical for single- or three-phase UPS systems while space vector modulation is the standard in three-phase induction motor control systems. In grid connected inverter, the power generated by PV plant is directly given to the transmission line and it is distributed. Henceforth, the use of batteries and other energy storage devices is not required that makes the arrangement less space, reduced investment cost and maintenance than stand alone system. The main purpose for PV grid-connected system is to control the power flow between the primary renewable energy source and the grid, as well as the power factor of PV inverter-grid connection with high power quality. shows the simulation results demonstrating the validity and performance of the control strategy. Conclusions are finally drawn in the last section. We focus only on the interconnection and use of PV in low-voltage grid for household's application. The voltage output of the PV grid-connected inverter must be obeys the standards given by the power company in general, such as safety conditions, grid's specification, and synchronization conditions.

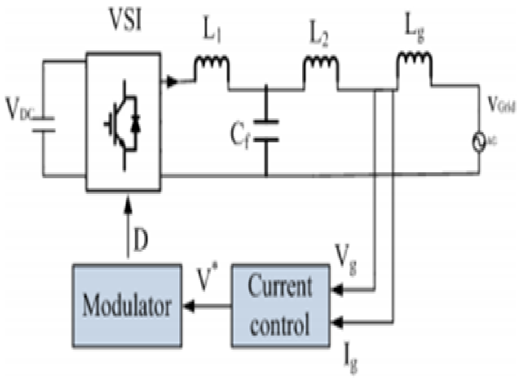
Standard codes and regulation of grid PV inverters

Since grid connected PV applications are becoming more significant, a series of standard requirements and codes are regularly maintained by international and national committee to assure security and smooth transmission of electric power into the grid. The most relevant international bodies developing standard grid demand are IEEE (Institute of Electrical and Electronic Engineers) in the US, IEC (International electro technical commission) in switzerland and DKE (german commission for electrical, electronic and information technologies of DIN and VDE) in the germany leading in the PV market.



Generic structure of grid connected PV system

The fundamental types of control can be classified into two types: voltage control and current control. Voltage amplitude and frequency of inverter gets synchronized with each other, when it is connected to the grid. The classical current control is classified as active power and reactive power control method. The grid frequency is tracked by a phase locked loop (PLL). The inverter assembly circuit with control strategy is shown in Fig. 2. The voltage and current of the grid is taken as reference and it is transformed to mathematical equation with current control structure and given as duty cycle to the inverter.

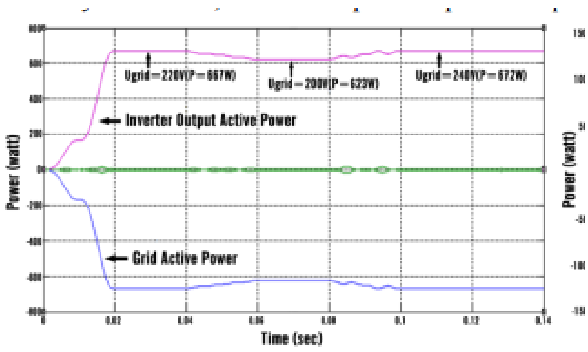


Block diagram of conventional three phase distributed inverter

Control structure of PV inverter defined in detail with active power and direct power control The growth of power electronics technology has made transformer less PV inverter well suited in kilowatt (kW) range by placing standards such as DIN VDE 01261-1. However, elimination of transformer creates leakage current and complication in the grid side controller. This paper gives the overview of recent advances in controllers in grid connected PV system. PV inverter followed by performance requirement.

Variation of grid voltage

The behavior of output power of inverter corresponding to grid voltage. The grid voltage is kept at 220 volt until 0.04 sec, inverter inject active power to grid is 667 watt as shows on red curve. At 0.04 sec the grid voltage is reduced to 200 volt, the corresponding inverter power output is reduced to 623 watt. At 0.08 sec, the grid voltage is increase to 240 volt, the inverter power output is increase to 672 watt. The grid receives active power is represented by blue curve, amounts of power equal to output power of inverter at correspond time.



(a)

Inverter output power and grid power respond to variation of grid voltage (a), and respond to variation shift angle δ (b)

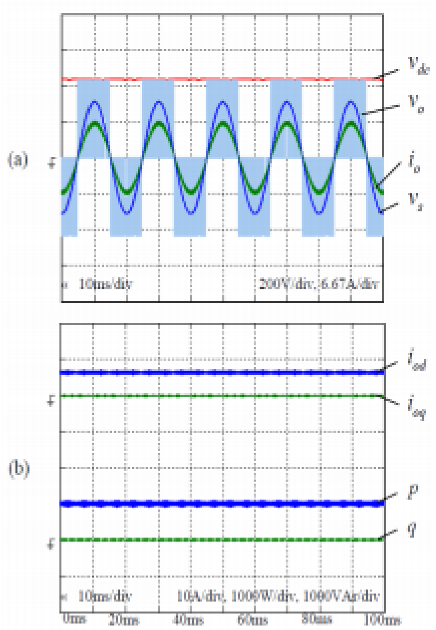
The Characteristics of Photovoltaic Panel

Mistubishi PV-MF 120EA 1000W/m^3,AM 1.5,25^{0}c	
Maximum power(P_{max})	120W
Open circuit voltage (V_{oc})	23V
Short circuit current(I_{sc})	6.89A
Maximum power voltage (V_{mp})	19V
Maximum power curent	6.30A

Finally, the strategy for the decoupled single-phase vector control of the inverter for grid-connected photovoltaic system is shown in Fig. This control scheme has three control loops. The output power and power factor of the grid can be controlled via changing the current components. In , DC reference voltages (* , * od oq v v) is converted to) form, which ® ⟨the AC reference voltages (* , * o o v v) is ⟨-axis (* o v ⟨the output voltage of the controller in used to generate the PWM signals for switching the devices in the single-phase inverter.

Steady state operation

In Fig. 7, the voltage and the current waveforms are represented in steady-state conditions. The objective is extracting the maximum power of PV and feeding 1,000 W active power to the grid-connected. Fig. 7 (a) shows the steady-state waveforms of the DC-link voltage dc v , the output voltage o v , the supply voltage s v , and the output current s i . As expected. The output current injected into the grid is exactly in phase agreement with the supply voltage. Fig. 7 (b) shows the steady-state waveforms of output current components , ds qs i i and active and reactive power p, q . As it is shown, active and reactive powers are independently controllable which powers were 1000 W and 0 VAr, respectively. There are consistence with current command of od i and oq i which are 6.43 A and 0 A, respectively. As seen from simulation results, the proposed decoupled vector control can control power feeding into the grid with stability. In Fig. 8, the frequency spectrum of outpu voltage and current of inverter are shown, where the supply voltage and output current are in phase and at unity power factor. Total harmonic distortions (THD) of current and voltage are 4.80% and 86.89%, respectively. The power factor is improved to DPF/ 1 THD2 0.998 i + = .



Voltage current, active and reactive owers during steady state operation

Literature review

Guguloth Mohanbabu et al [1] presents the design and analysis of both the active and reactive power control of a single-phase voltage source inverter (VSI) for grid-connected photovoltaic (PV) system. The proposed method is based on vector control of power by decoupling control of the active and reactive current components to feed the active and reactive power to the grid. The aim of this research is to control power factor at grid, to improve overall efficiency of transferring power of PV to alternate current power conversion into the grid, and to decrease phase current distortion of VSI.

Wang, F et al [2] Distributed power generation systems are expected to deliver active power into the grid and support it without interruption during unbalanced grid faults. Aiming to provide grid-interfacing inverters the flexibility to adapt to the coming change of grid requirements, an optimized active power control strategy is proposed to operate under grid faults.

Afshin Samadia et al [3] Accommodating more and more PV systems in grids has raised new challenges that formerly had not been considered and addressed in standards. According to recently under-discussed standards, each PV unit is allowed to participate in reactive power contributions to the grid to assist voltage control. There are some PV models in the literature however those models mostly assumed unity power factor operation for PV systems owing to the contemporary standards.

Aida Fazliana Abdul Kadir et al [4] overview of some of the main issues in photovoltaic based distributed generation (PVDG). A discussion of the harmonic distortion produced by PVDG units is presented. The maximum permissible penetration level of PVDG in distribution system is also considered. The general procedures of optimal planning for PVDG placement and sizing are also explained in this paper. The result of this review shows that there are different challenges for integrating PVDG in the power systems.

Arulkumar, K et al [5] focuses on updating grid standard codes and regulations, in addition overview of recent control strategies and direct power control. The structure of the phase locked loop (PLL) with grid synchronization techniques for single phase and three phases is discussed in brief. Investigations are performed for a fault ride through capabilities with detailed analysis of islanding detection methods with its types.

Aurobinda Panda et al [6] presents a control scheme for single phase grid connected photovoltaic (PV) system operating under both grid connected and isolated grid mode.The control techniques include voltage and current control of grid-tie PV inverter. During grid connected mode, grid controls the amplitude and frequency of the PV inverter output voltage, and the inverter operates in a current controlled mode.

Adrian Timbus [7] discusses the evaluation of different current controllers employed for grid-connected distributed power generation systems having variable input power, such as wind turbines and photovoltaic systems. The focus is mainly set on linear controllers such as proportional–integral, proportional–resonant, and deadbeat (DB) controllers. Additionally, an improved DB controller robust against grid impedance variation is also presented.

Variation of shift angle between inverter voltage and grid voltage

The relation between inverter output power and shifting angle δ are represented by red curve in Figure 3(b). Inverter is controlled to inject power into grid at 0.08 sec, it take a 0.1 sec to reach stable and keep constant around 900 watt correspond at δ=9° until 0.2 sec. At that time we control the δ reduce from 9° to δ = 8°, result is output inject in to grid is fluctuated and stable at lower value around 500 watt. At 0.3 sec, we increase δ to 10°, the output power increase back and stability around 1300 watt. On the other hand, the blue curve show the grid absorb power, and this value as same as output power of inverter. This work presented the power control shifting phase technique for controlling a power of the single phase grid-connected PV system, which controls inverter output power by control the phase angle δ between PV inverter output voltage and grid voltage. This control strategy does not require complicated device, it is foundation for promotes low cost grid-connected PV system.

Power control method for a single phase grid-connected PV generation system

Grid-connected inverter control description

The PV system shows a non linear current-voltage characteristics varying with the irradiance and temperature which affects its power output. It is normally used a maximum power point tracking (MPPT) technique to continuously deliver highest possible power in different conditions. The MPPT control is critical for the success of a PV generation system . The main purpose for PV grid-connected system is to control the power flow between the primary renewable energy source and the grid, as well as the power factor of PV inverter-grid connection with high power quality. The filter LfCf is designed to reduce high-order harmonics introduced by the sinusoidal pulse generator of the DC/AC inverter. Moreover, the control of the power flow to the grid, according to the European standards (EN 61727), is based on the control of active and reactive power. The renewable energy sources such as solar, wind etc. has accelerated the transition towards greener energy sources. The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power-supply reliability and quality. The cost effective solutions of custom power devices and FACTS devices are highlighted to give an insight to the scope of research in low and medium level voltage networks and for 1Ø and 3Ø grids technologies.

The increasing number of renewable energy sources and distributed generators requires new strategies for the operation and management of the electricity grid in order to maintain or even to improve the power-supply reliability and quality.

The current methodologies for optimizing of generation power of PV system are not completely efficient. Therefore many researches are required for overall configuration of the grid connected PV system, the Maximum Power Point Tracking algorithm, the synchronization of the inverter. This paper presents a control technique of the PV generation power by shift of phase angle of the inverter output voltage and grid voltage. In order to synchronize an alternative current output of the PV system's inverter into grid, the proposed method has been described, simulated in MATLAB/Simulink. The work helps to give a study results about interconnection standard, power generation optimization method of PV system into power grid.

Conclusion

The objective of the grid connected inverter control is to maintain the DC-link voltage and independent active and reactive power flow. The outlook of recent standard grid codes and regulation of interconnecting PV inverter to the grid have covered in detail, which focuses on the performance requirement and power quality. The advanced material of SiC and GaN based power converter shows enhanced future performance in PV inverter technology. To minimize the fluctuations and intermittent problems power electronics devices are the viable options. Further, energy storage and use of dump load and MPPT could be used for reducing the power fluctuations in PV systems. In addition to the aforesaid, the up gradation in balance of systems by incorporating the new materials and storage elements could reduce the problems associated with grid integration. PV system was carried. The simulation results express quite clear the behavior of inverter output how influence by variation of grid voltage, the phase angle δ between the inverter output voltage respect to the grid voltage and loader. The results are explainable by theory and also it help to give a study about interconnection standard of PV system into power grid.

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