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THREE-PHASEGRID-TIEDPHOTOVOLTAIC SYSTEMS WITH ANTI-ISLANDING SCHEME MODELING AND ANALYSIS

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Abstract
The market acceptability of distributed energy resource (DER) technologies, as well as the gradual and consistent development in their penetration depth, have piqued interest in recent years. There has been a large increase in distributed photovoltaic (PV) generation that is interfaced with power distribution systems, and this trend is projected to continue. As a result, the integration, control, and optimal functioning of DER units has become a major priority in distribution system design and operation. Grid-connected distributed PV systems come in a variety of power levels, from modest single-phase residential roof-top systems to big three-phase multi-megawatt systems. The focus of this research is on analysing big, three-phase systems that include a power distribution system. A power electronic inverter is used to connect PV systems to the grid in all cases. Many of the critical aspects of PV generation are controlled by the inverter's design and performance, hence adequate inverter models are required to analyse PV systems. This Paper has labelled several distributed generation (DG) models, including switching and average models, that are suitable for various study purposes, as well as distinct inverter control modes. Detecting and eliminating unintended islands during grid breakdown is a vital function of the inverters. Many active anti-islanding strategies with voltage and frequency positive feedback have been investigated in this Paper. The effectiveness of these strategies for integrating distributed resources with electric power systems has been evaluated in terms of the tripping times stipulated in IEEE Std. 1547 Using power systems analysis tools such as CYMDIST and POWERWORLD, the influence of distributed PV on the voltage profile of a distribution system was investigated using ASU as the test bed. The current IEEE 1547 compliant inverters do not regulate the system voltage. The system is also analysed, and the impact of distributed PV on fault current magnitude, both with and without reactive power injection, investigated.

Keywords: Distributed energy resource (DER), Power world.

INTRODUCTION

With growing concern about global environmental protection, the necessity for pollution-free renewable energy sources such as solar energy has piqued interest. Solar energy is a clean, pollution-free, and unlimited alternative source of energy for the future. Solar PVs are one of the world's fastest-growing energy sources.Off-grid applications including as rural electrification, water pumping, and telecommunications were the dominant market for PV near the end of the previous millennium. The majority of the international market, however, is now for grid-connected claims, where the power is channelled into the electrical grid. Furthermore, the majority of the new PV capacity has been deployed as dispersed generation in the distribution grid. Concerns regarding the possible influence of solar PV on grid stability and operation have grown as the industry expands.Changes are being considered by utilities and power system operators to better integrate and manage this renewable energy source in their networks.

2.DISTRIBUTED GENERATION

On-site generating, also known as distributed generation, produces electricity from a variety of modest energy sources. DG refers to relatively modest generating units of 30MW or fewer that are installed at or near client locations to suit specific customer needs, assist the efficient operation of the current distribution system, or both. The proximity of the consumer improves the service's reliability and power quality. While central power networks are still vital to the nation's energy supply, they are limited in their flexibility. Large power plants are capital-intensive projects that necessitate a massive transmission and distribution grid to move the electricity. DG augments central power by offering a low-cost response to incremental increases in power demand. DG units are significantly and conceptually very different from conventional power system in terms of load characteristics, power quality constraints, market participation strategies and the control and operational strategies. The main reasons are as follows [11]

Steady-state and dynamic characteristics of DG units are different from those of the conventional large turbine-generator units.Presence of single-phase loads and DG units adds significantly to the imbalance of the microgrid. Wind-based units which are non-controllable sources of energy form a noticeable portion of supply within a micro-grid.Control and operation of a micro-grid may be dependent on energy storage units.Economic considerations generally dictate connection and disconnection of DG units and loads during its operation. Power quality levels of certain loads might be pre-determined. The micro-grid might have to strictly abide by this.

3.ISLANDING

The problem of islanding is one of the technical challenges caused by DG connectivity. Islanding occurs when a component of the utility system that includes both load and generation is isolated from the rest of the system and continues to run independently.To maintain utility grid reliability and the safety of the PV system installer, technical requirements must be met. Although grid-connected micro-grids can be built to operate in an isolated mode, the transition from grid-parallel to independent mode can be difficult. In some instances, if the main grid is cut-off, the DG unit will be expected to shut down and then restart in order to continue to provide local loads.

4.PV INVERTERS WITH THREE PHASE GRID CONNECTION

Large solar systems ranging from 20kW to 1MW are becoming more popular, highlighting the relevance of three-phase grid-connected inverters in the photovoltaic industry. The grid-tied inverter is different from a stand-alone inverter in that it can only work when it is connected to the utility grid. In fact, it acts as a link between the photovoltaic array and the utility company. The photovoltaic array's power output is conditioned by the grid-tied inverter. It also acts as a control mechanism for the system and as a conduit for site-generated electricity to reach the utility wires .The key design aspects to be studied are circuit topology, conversion efficiency, maximum power point tracking, power quality, anti-islanding, and cost.

4.1INVERTER MODELLING

In recent years, three-phase inverter technology has gained more practical value. Furthermore, the three-phase inverter technology can be used to single-phase inverters. Front-end conversion and regulation are generally included in the entire power-conditioning system. DC/DC conversion for prime movers with DC output, such as fuel cells, PV, and batteries, or AC/DC conversion for prime movers with AC output, such as micro-turbines and sterling engines, are examples. At the DC bus, they may have an energy-management device, such as a battery charger. In both of these circumstances, the inverter's input is a controlled DC source. The input to the inverter is modelled as a DC voltage source in the model.The inverter output filters are a simplification in the model, and they could have several variants in practical implementations; for example, the output filter could comprise L, LCL, or LC plus a transformer, with or without harmonic filters. An L only (inductor) filter is considered in the analysis. The modelling of a three-phase PV inverter was done using dq implementation and controller ideas.

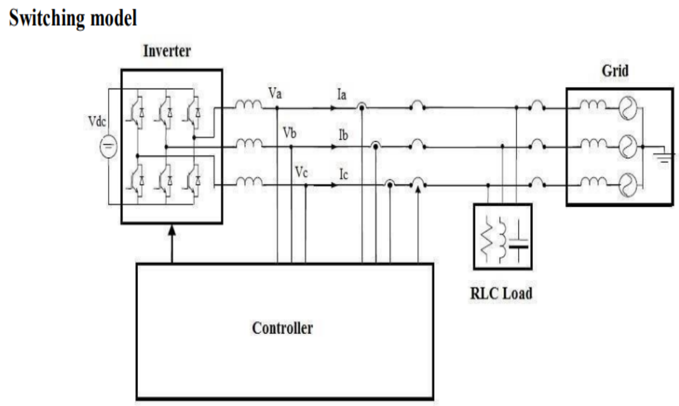

Fig. 2.1 Three-Phase Inverter Switching Model

The inverter-, load-, and grid-system diagrams are shown in Fig. 2.1, with the inverter modelled as a switching model. Isolated gate bipolar transistors are the most common switching devices used in inverters (IGBTs). IGBTs can be modelled as ideal on/off switches that represent the discrete switching behaviours of the inverter. The switching model incorporates not only voltage and current ripples, but also dead time and delays depending on IGBT device characteristics and gate-driver architecture in the actual hardware. Once the new algorithms have been programmed and simulated, the same code can easily be compiled and loaded onto the hardware for testing. Fig. 2.2 shows the inverter-, load- and grid-system diagram where the inverter is represented as an average model. The switching model is ideal for validating new algorithms. However, it has two limitations that motivate development of the average model: • The switching model takes a long time to simulate. • The process of development of new algorithms using the switching model would be inefficient. It is difficult to perform small-signal analysis directly on switching model due to its discrete behaviour

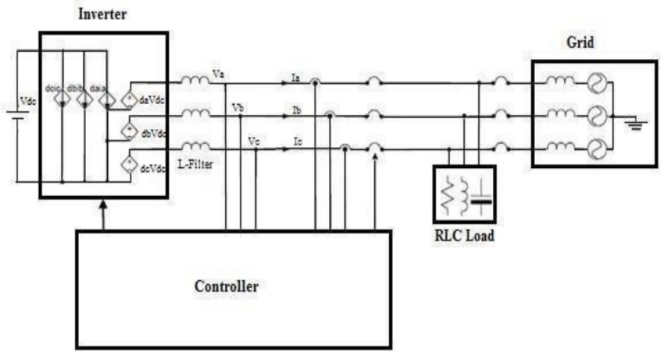

Fig. 2.2 Modeling an inverter with an RLC load and a grid

The average model overcomes both of these drawbacks. Averaging is a two-step procedure. The switching network is one thing, and the controller is another. Controlled voltage and current sources with averaged switching duty cycles can be used to depict the switching network. Instead of utilising discrete code, the controller represents control behaviour with corresponding continuous functions such as Proportional (P), Proportional-Integral (PI). The average model simulation speed is at least an order of magnitude faster than the switching model due to the averaging of the switching function and reduced controls.

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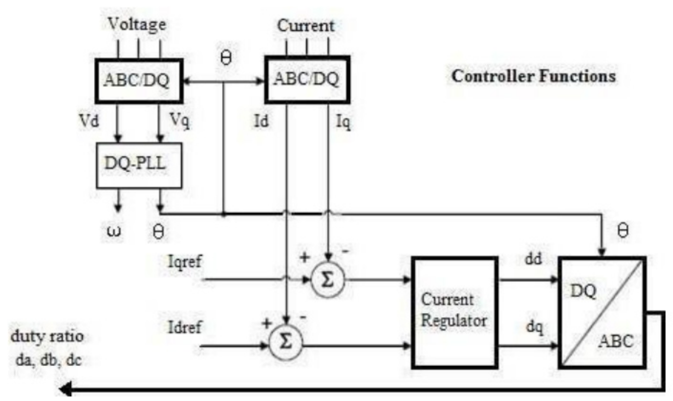

Fig. 2.3. Block diagram of constant-current-controlled inverter.

5. SIMULATION RESULTS

In the grid connected mode, the three phase voltages, currents, and real and reactive power waveforms are shown in Fig. 2.6. The inverter is capable of delivering 100kW of real power while generating no reactive electricity. As previously stated, a dq-based approach is used, making the controller implementation simple to use. The d- and q-axis voltages, as well as the frequency of operation, are shown in Fig. 2.7

6.CONCLUSION

Simulink was used to model an average grid-tied three phase inverter using the design criteria. The grid-connected inverter is based on a GE device. In this model, the DC link voltage was provided by a constant DC voltage source. The K-factor approach was used to model a type II constant current controller. In the analysis, an L-only filter was used. The ABC phase scheme was transformed to the dq frame, which reduced the three AC quantities to two DC. This simplifies inverter control calculations and aids in the development of the continuous feedback signal required for the positive feedback anti-islanding strategies outlined in the following chapter. The inverter model aids in the implementation of these methods.

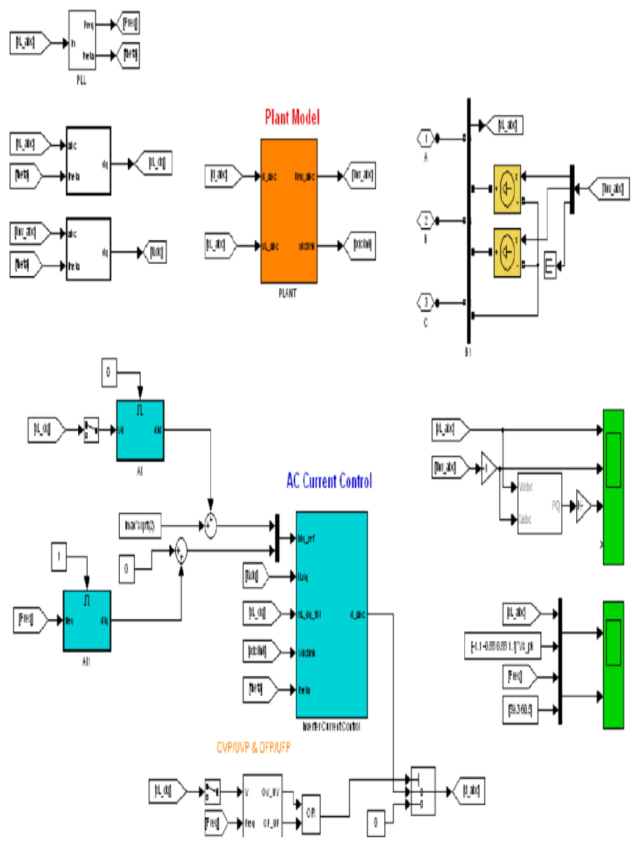

Fig. 2.4 MATLAB/Simulink model of a detailed inverter average.

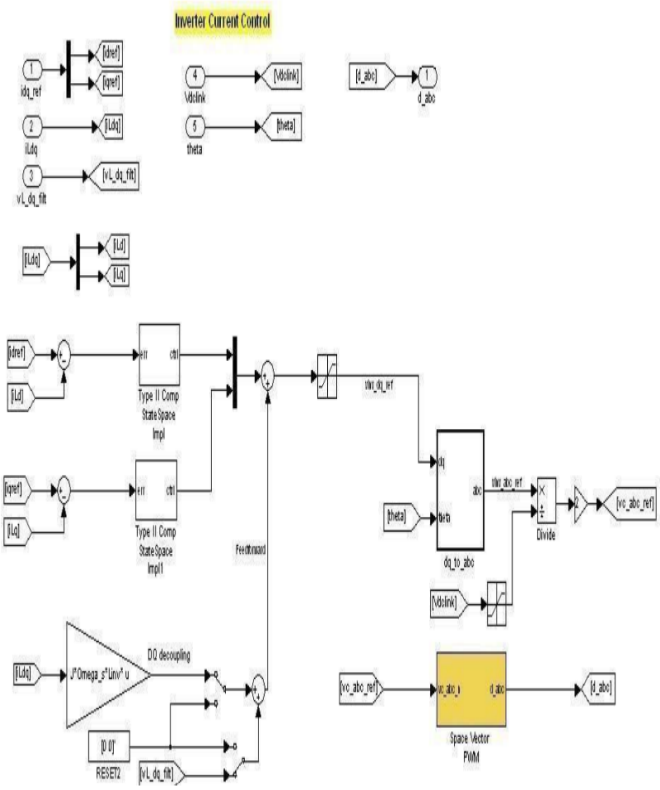

Fig. 2.5 Current controller block in MATLAB/Simulink.

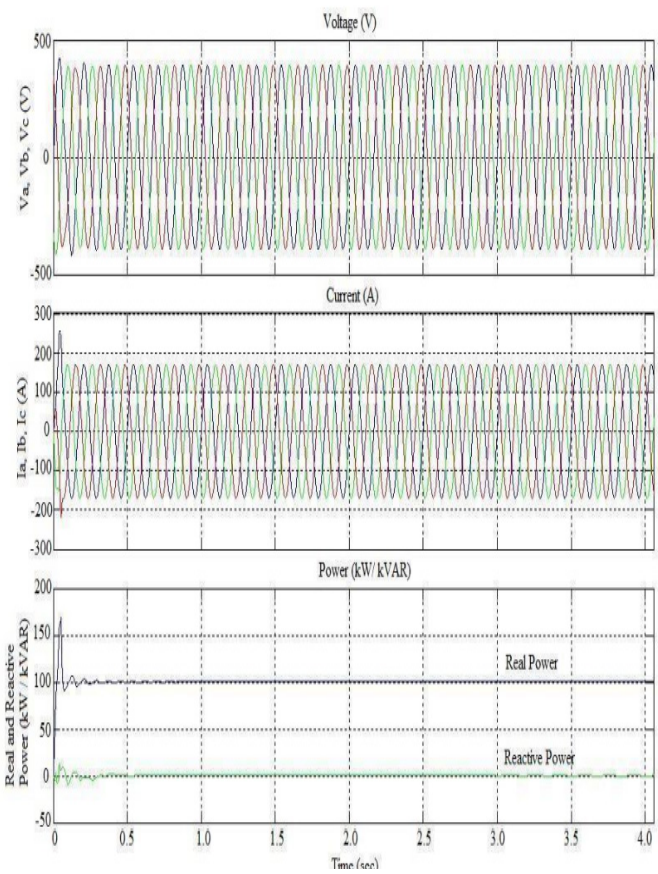

Fig.2.6 current and power waveforms for inverter in grid connected mode.

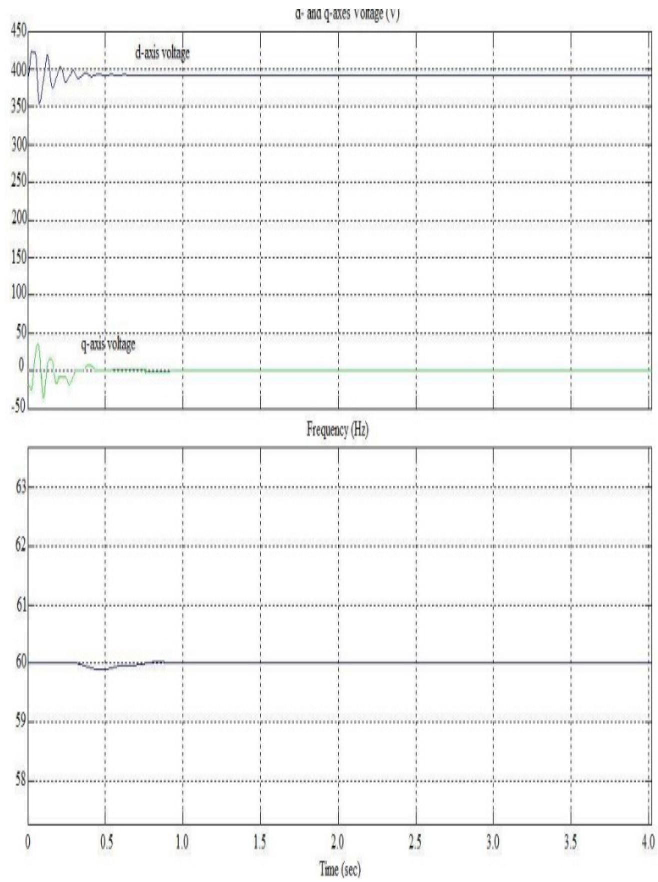

Fig. 2.7 Vd, Vq voltages and frequency waveform of inverter

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