

Implementation of Grid Tied Inverter in Solar Panel

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Abstract— Solar grid tied inverter system in an electricity generating system that is connected to the utility grid. This paper discuss the design of a grid tied inverter (GTI). This DC voltage is then converted into AC voltage using Full wave inverter topology. Then synchronised is achieved between grid and photovoltaic system. Finally power flow control mechanism controls the power flow from GTI system to grid and the house load. This paper gives an idea about Grid Tie Inverter, PV inverter topology to give an efficient power output to the grid system from the PV arrays.

Index Terms-Solar Grid Tied Inverter, full wave inverter topology, utility grid, PV inverter.

I. INTRODUCTION

Environmental concerns like global warming and climate change are driving the need for increased penetration of distributed renewable resources into the next generation of the electricity grid. Environmental friendly electricity generation and storage, along with energy policy and regulations are changing the characteristics of electricity networks and supply. As a result, microgrids provide a unique opportunity for integrating renewable resources into the distribution system. Microgrids are small-scale versions of centralized electricity systems where smaller scale distributed generators and renewable energy resources like wind turbines, solar panels, and energy storage, provide power closer to point of use. As well as providing an opportunity to reduce environmental impacts through increased use of renewable resources, microgrids have the capability to improve power quality, network efficiency, reliability and economics.

Conversion between AC and DC power is an important issue in a microgrid system. Renewable energy sources typically generate DC electricity, while the conventional electricity grid is based on AC power generation, transmission and distribution. Hence, the DC power must be converted to AC power in order to connect the renewable sources to the standard AC power system. Further in batteries for example, AC power in the grid must be converted to DC for energy storage. Conversion from DC power to AC is performed by an “inverter”, while the conversion from AC into DC power is done by a “rectifier”. An inverter is an electrical device that converts direct current (DC) to alternating current (AC); the AC signal can be at any required voltage and frequency with the use of appropriate transformers, switching, and control. Four switches (in two legs) are used to generate an AC

waveform at the output from the DC source. Any semiconductor switch like IGBT, MOSFET or BJT can be used. Diodes in parallel with switches are called feedback diodes. They feed energy back to the DC source in case of inductive loads when the main switch is turned off. The special kind of inverter used to connect a renewable resource to an AC network is called a grid-tie (synchronous) inverter which is described in the next section.



Fig.1 Grid Tied Inverter

II GRID TIED INVERTER

A grid-tie inverter (GTI) is a special type of inverter that converts DC power to AC power for connection to an existing electrical grid. GTIs are often used to convert DC power produced by renewable energy sources, such as solar arrays or wind turbines, into the AC power used to power homes and businesses. The GTI in this study is used to connect laboratory scale sources to an 18 V RMS AC network. Commercial GTI's were not used because they are typically designed for higher voltage systems (e.g. 120 V RMS AC), do not have the capability to control real/reactive power (four quadrant) output and are unable to directly interface with the PLCs in our system. We need a GTI capable of bidirectional control of active and reactive power flowing to and from the network, providing the ability to regulate power quality and dynamic and transient characteristics of power angle, frequency, and voltage. The overall block diagram of the GTI is shown in Fig. 2. The main part of the GTI is the full-bridge inverter that consists of four semiconductor switches. The inverter has a driver section that provides the switching pulses to the power switches. A controller section (typically an electronic

circuit) is used to generate the right commands/pulses to control the inverter in an appropriate way. Here, a microcontroller is used to control the GTI system as well as perform other tasks such as sampling the grid voltage and communicating with higher-level controllers in the network.

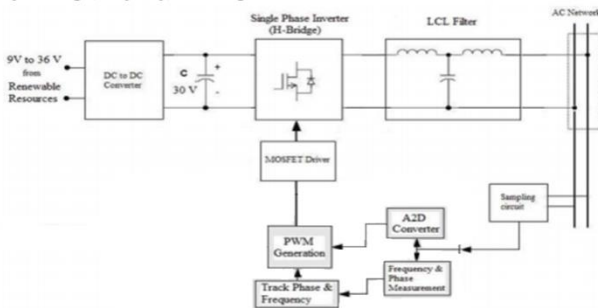


Figure.2 Block Diagram of GTI

III. CIRCUIT WORKING PRINCIPLE

Grid tie inverters convert DC electrical power into AC power suitable for injecting into the electric utility company grid. The grid tie inverter must match the phase of the grid and maintain the output voltage slightly higher than the grid voltage at any instant. A high quality modern grid tie inverter has a fixed unity power factor, which means its output voltage and current are perfectly lined up, and its phase angle is within 1 degree of the AC power grid. The inverter has an on board computer which senses the current AC grid waveform, and outputs a voltage to correspond with the grid. However, supplying reactive power to the grid might be necessary to keep the voltage in the local grid inside allowed limitations. Grid tie inverters are also designed to quickly disconnect from the grid if the utility grid goes down.

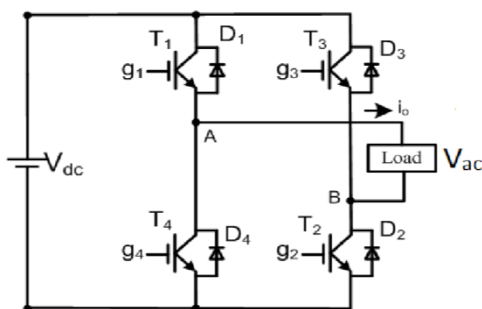


Figure3. Single Phase Inverter

IV. HARDWARE CONFIGURATION

A. H-Bridge

In this section the design of the hardware for the GTI is described. The diagram shows the full bridge inverter and driver circuits along including the low pass filter. The full H-bridge inverter consists of four IRF530 (N-channel,

enhancement) MOSFET switches rated for 100V and 17A, with fast switching time (22 n Second rise times and 25 n Second fall times). This switch also has ultra low resistance (90 mΩ), resulting in less power dissipation and higher efficiency. The MOSFET driver IR2110 is used to apply the switching pulses coming from the microcontroller to the MOSFET switches. The IR2110 is a high voltage half bridge gate driver designed to drive both the high side and the low side N-Channel MOSFETs in a synchronous buck or half bridge configuration. The rising edge of each output can be independently delayed with a programming resistor. Inductor L5 (and L6) with capacitor C14 make the LC(L) lowpass filter1.

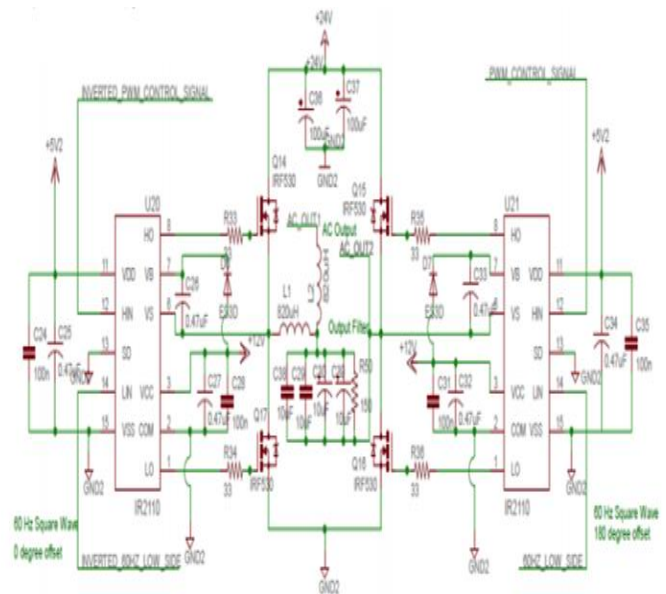


Fig4.H-Bridge and MOSFET Drives

B. Pulse Width Modulation

Signals Pulse Width Modulation (PWM) signals are produced by the microcontroller and used to drive the MOSFETs; the output from the H-bridge circuit is also a PWM signal. This PWM signal can be produced in different ways. The most basic technique is the 2-Level PWM method. A 2-Level PWM signal is obtained from reference sine wave by modulation with a carrier wave at a much higher frequency. This can be accomplished by running both signals through a comparator, which would then produce an output PWM signal with a duty cycle that is directly proportional to the amplitude of the reference sine wave. An alternative to this method is the 3-Level PWM signal. This is similar to the 2-Level method, in regards to the reference sine wave being modulated by a high frequency carrier wave, but the difference is that the carrier wave is half the amplitude of the sine wave and is switched between the upper and lower halves of the sine wave as shown.

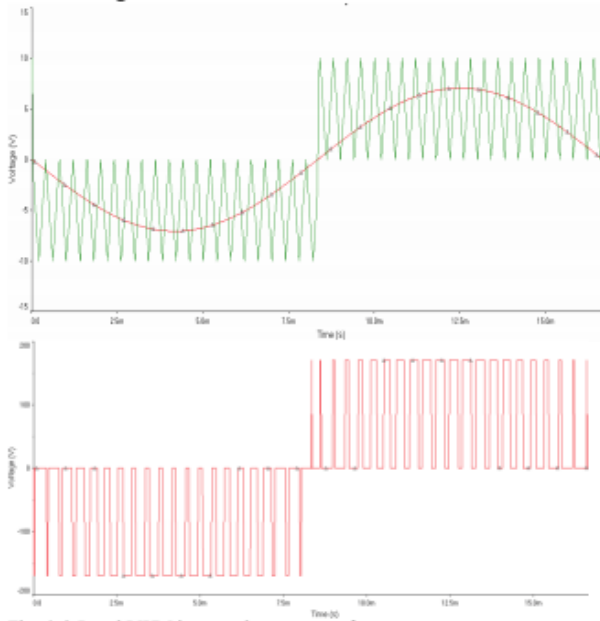


Fig5. 3-Level PWM input and output waveforms

V. SIMULATION AND OUTPUT

The inverter produces the output voltage of 230V is verified by using the simulator blocks in the matlab software.

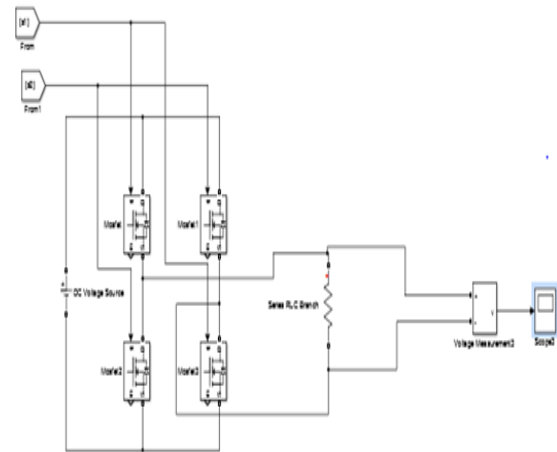


Fig7. Simulation block diagram of GTI

IV. EXPERIMENTAL SETUP

The GTI that includes two boards, transformers and connections. The board to the right consists of MOSFET switches and drivers, DC regulators, sampling circuit, opto couplers and other devices. The board on the left is the Atmel EVK1100 armed with an AVR32 UC3A0512 microcontroller, LCD display and other useful features. The two transformers in this picture are used to convert the 120V AC grid voltage to 18V AC and for isolating the electronic board from the 18V AC network voltage. Figure 8 shows the output sine waveform along with the grid sine waveform of the GTI. Although the LC filter applied to the output of the H-bridge removes most of the high frequency noise, a better filter structure maybe needed in the final design.

GTI board (right side) connected to the EVK11000 Atmel board (left side).



Fig6. Grid tied inverter setup

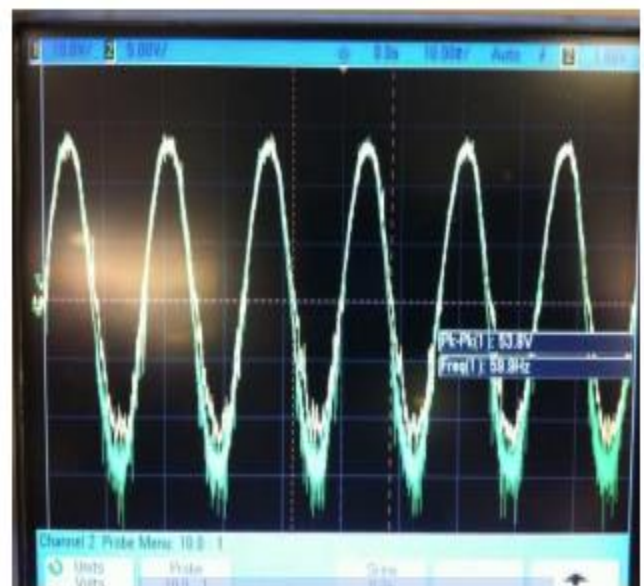


Figure8. Output waveform of Grid Tied Inverter

V. CONCLUSION

Design and implementation of a grid-tie inverter has been presented. The GTI has been designed to be used in a laboratory grid demonstration system. The frequency, amplitude and phase of the GTI output signal are synchronized with the voltage signal of the grid. The GTI is controlled by an Atmel microcontroller (EVK1100 with UC3A0512). Results confirm that the GTI is capable of producing an AC waveform that is synchronized with the grid. Future software modifications will add the capability to control real and reactive power output from the inverter, in addition to output frequency.

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