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# 3 LEVEL SVPWM SOLAR INVERTER USING DSP CONTROLLER

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**Abstract-** *These schemes improve quality of output waveform of voltage source inverter as they increase waveform steps and cut the voltage stress across switches by using multiple switches. As there is low voltage stress produced, the dv/dt ratio is also become less, which causes reduced EMI problems. Among these methods, three level scheme with neutral-point clamped is broadly used for these applications. As one of most capable modulation technologies in three phase systems, space vector PWM (SVPWM) for three-level converter has an advantage over sinusoidal PWM in voltage utility, for modulation range of SVPWM is 15% higher than that of sinusoidal PWM. Although three-level SVPWM technique is derived from two level SVPWM, three-level SVPWM is considerably more complex than that of two-level converter because of large number of balancing[3]. Due to its complexity in computation, three-level SVPWM algorithm is almost implemented using software based on DSP or MCU according to reported literatures.*

***Keyword-*** **Renewable energy, Digital Controllers, Inverter, DSP, eZdsp™LF2407**

## 1. INTRODUCTION

Every project dealing with renewable energy is in need of renewable energy conversion in form of multilevel power electronics. A power electronics device which converts DC power to AC power at required output voltage and frequency level is known as an inverter. This thesis approaches three level inverters in a wave power conversion point of view and covers the calculation and implementation of a pulse width modulation system using a modulation strategy that uses a space vector as a reference in order to achieve a desired three level waveform. This system specially adapted for three phase system that requires high power and high voltage and is therefore suitable for all types of renewable energy sources.

## 2.SOLAR POWER INVERTER

A solar inverter, or PV inverter, converts the variable direct current (DC) output of a photovoltaic (PV) solar panel into a utility frequency alternating current (AC) which can be fed into a profitable electrical grid or used by a local, off-grid electrical network. It is a serious component in a photovoltaic system, allowing the use of common place AC-powered equipment. Solar inverters have extraordinary functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection. (6)

Inverters take DC power and convert it to AC power so it can be fed into the electric utility company grid. The grid tied inverter must coordinate its frequency with that of the grid (e.g. 50 or 60 Hz) using a local oscillator and bound the voltage to no higher than the grid voltage. A high-quality modern GTI has a fixed unity power factor that means its output voltage and current are entirely lined up, and its phase angle is within 1 degree of the AC power grid. The inverter has an on-board computer which will sense the current AC grid waveform, and output 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. Otherwise, in a grid segment with considerable power from renewable sources voltage levels might rise too much at times of high production, i.e. around noon.(6

## 3. SVPWM TOPOLOGY

For finding appropriate modulation scheme it is essential to consider following factors:

- less load current harmonics and switching frequency
- switching frequency of all switches should be uniformly provided and capacitor DC voltage should be balanced.

Different PWM - techniques have the main purpose is reducing the Total Harmonic Distortion of the current. As we increase the switching frequency, lower-harmonics are going to reduced, which gives to a lesser Total Harmonic Distortion, to determine a voltage output waveform with the desired RMS values and frequency and a sinusoidal waveform resemblance.

Space Vector Pulse width Modulation generates the suitable gate drive signal for each PWM cycle. The inverter is considered as one single unit and can combine different switching states (number of switching states depends on levels). The SVPWM provides unique switching time calculations for each of these states. This technique can easily be changed to higher levels and works with all kinds of multilevel inverters (cascaded, capacitor clamped, diode clamped). The three vectors that form one triangle will provide duty cycle time for each, giving the required voltage vector (Vref).

The concept of space vectors is derived from the rotating field of AC machine which is used for modulating the inverter output voltage. In this modulation technique the three phase quantities can be transformed to their equivalent 2-phase quantity either in synchronously rotating frame or stationary frame. From this 2-phase component the reference vector magnitude can be found and used for modulating the inverter output. The process for obtaining the rotating space vector is explained in the following section, considering the stationary reference frame. The active and zero switching states can be represented by active and zero space vectors, respectively

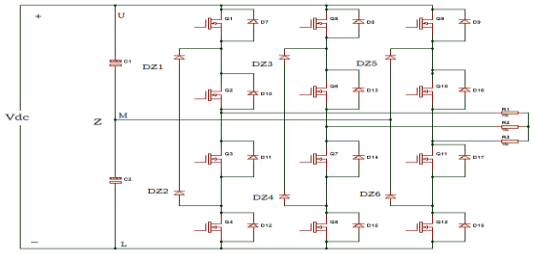


Figure.1Three Level NPC Inverter (10)

Figur.1 shows a three-level neutral point clamped inverter. It contains 12 controllable power switching components and also supplied with two capacitors (split capacitors) connected in series. Both are charged with $V_{DC}$. The point between these capacitors is the DC-voltage neutral point. Each phase leg is having four series-connected switching devices (IGBT's) and two clamping diodes. Their function is to clamp the six middle switches potential to the DC-link point at zero. Appropriate combinations of the twelve switches gives the five level neutral to phase and three level line to line output voltage. [4] The U,M and L. This means four switches in one phase leg can only be turned on two at a time and so be connected to the DC-link points that the three level voltage can be obtained by using O as reference. Here U= Upper two switches are ON, M=Middle two switches are ON and L= Lower two switches are ON.

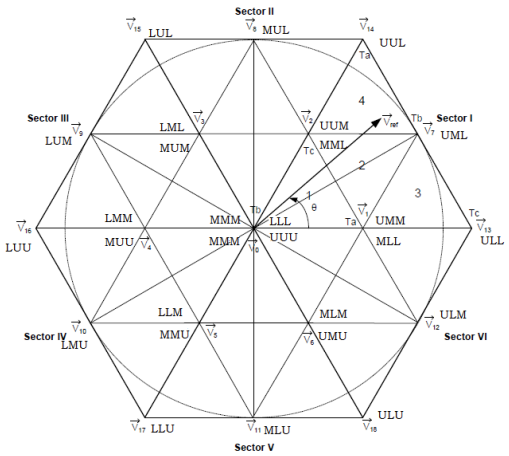


Figure.2 Space Vector Diagram of 3 Level Inverter

$\theta$ is calculated and from that the sector in which the reference voltage vector is determined as follows:

if $\theta$ is between 0≦<θ<60 then, the ref. vector is in sector 1

if $\theta$ is between 60≦<θ<120 then, the ref. vector is in sector 2

if $\theta$ is between 120≦<θ<180 then, the ref. vector is in sector 3

if $\theta$ is between 180≦<θ<240 then, the ref. vector is in sector 4

if $\theta$ is between 240≦<θ<300 then, the ref. vector is in sector 5

if $\theta$ is between 300≦<θ<360 then, the ref. vector is in sector 6

## 4.DSP CONTROLLER

The eZdsp TMS320 LF2407 is a stand-alone card--allowing evaluators to examine the TMS320LF2407 digital signal processor (DSP) to determine if it meets their application requirements. Furthermore, the module is an excellent platform to develop and run software for the TMS320LF2407 processor. The eZdspTMS LF2407 is shipped with a TMS320LF2407. The eZdspTMS LF2407 allows full speed verification of LF2407 code. With 64K words of onboard program/data RAM the eZdsp can solve a variety of problems as shipped. Three expansion connectors are provided for any necessary evaluation circuitry not provided on the as shipped configuration. To simplify code development and shorten debugging time, a C2000 Tools Code Composer driver is provided. In addition, an onboard JTAG connector provides interface to emulators, operating with other debuggers to provide assembly language and 'C' high level language debug.

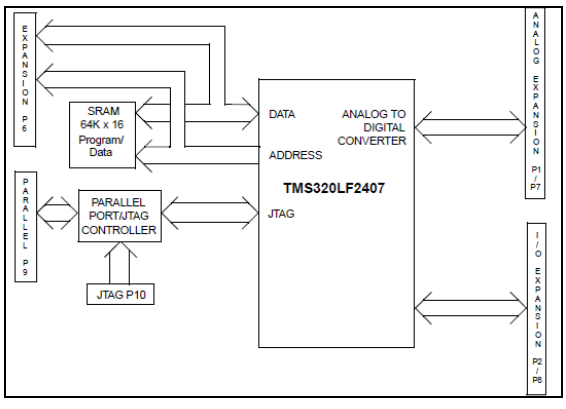


Figure.3 Block diagram OF eZdsp™LF2407

The eZdsp TM LF2407 consists of six major blocks of logic:

- External program and data memory
- Analog Interface
- I/O Interface
- Expansion interface
- JTAG Interface
- Parallel Port JTAG Controller Interface

**DRIVER**

In power electronic circuits , generally drivers are used to regulate current flowing through a circuit or used to control other components in the circuit. Here, TLP 250 driver is used for driving the MOSFETs of 3 level SVPWM inverter because of its characteristics.

**TLP250**

TLP 250 is used for gate driving circuits of IGBTs or power MOSFETs. The TOSHIBA TLP250 consists of a GaAlAs light emitting diode and a integrated photo detector. This unit is 8–lead DIP package.TLP 250 is used for following devices:

Transistor Inverter, Inverter For Air Conditioner, IGBT Gate Drive, Power MOS FET Gate Drive

## 5. SIMULATION AND RESULTS

- Part I –Alpha Beta Transformation
- Part II – Reference voltage vector , angle , modulation index
- Part III – Sector Selection
- Part IV – Switching Times Calculation
- Part V – Inverter Output

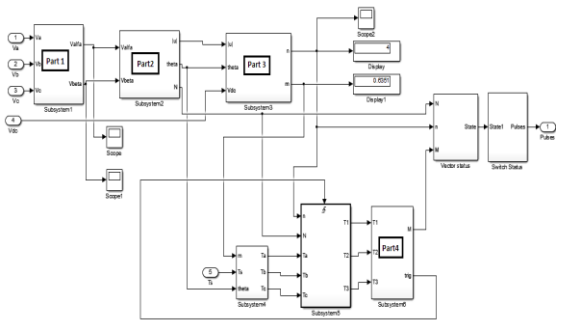

Figure.4 Overview Of Three Phase Three Level SVPWM Inverter Made In Simulink And Different Calculating Part

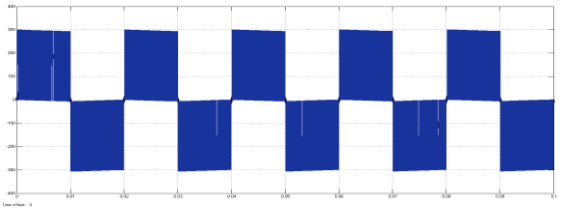

Figure.5 Waveform Of Phase Voltage

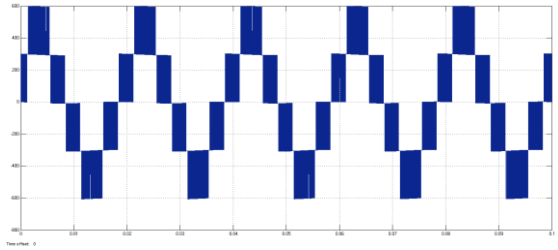

Figure.6 Waveform Of Line Voltage

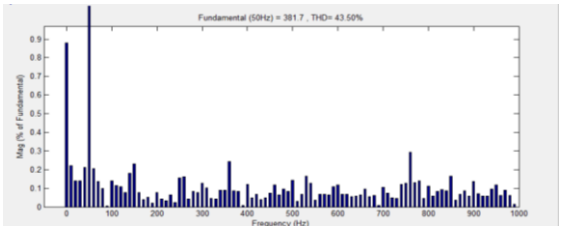


Figure.7 FET Analysis OF SVPWM

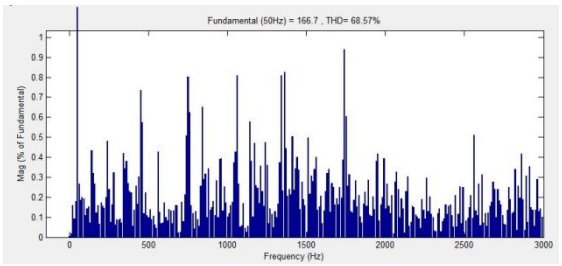


Figure.8 FET Analysis of SPWM

## 6. CONCLUSION

Higher level means lower distortion, but at the same time the problem with the neutral point unbalance is attending. SVPWM has good utilization of the DC link voltage, low current ripple and is relative easy to implement in the hardware Suitable for high-voltage high-power applications, such as renewable power generation. Increasing the voltage levels decreases the harmonic distortion, because it resembles the desired sinusoidal output more having less harmonic content. But since the number of devices is more, the losses will be more compared to normal inverters.

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