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Single Phase Inverter Techniques a Review

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Abstract - *In many applications Alternating Current is preferred over Direct Current but as we see that we cannot store energy in the form of Alternating current. It is always stored in the form of Direct Current. To use this stored energy a device is required to convert DC energy into AC energy. The device which does this is called an inverter. Single phase inverter or three phase inverter are two types of inverters. Single phase inverter has again classified as half bridge inverter and full bridge inverter. In this paper we studied different types of the inverters and there harmonics contains. Square wave, modified sine wave and pure sine wave are single phase inverter techniques and are mainly discussed in this paper and compared for their suitable use. Square wave or modified-sine wave are generally used types of inverters. For low and medium power applications square wave or modified sine wave inverter can be used. Pure sine wave inverter has less harmonic distortion and more accurate.*

***Key Words*: AC, DC, harmonics, inverter techniques, pure sine wave, single phase inverters.**

1. INTRODUCTION

An inverter or power inverter is a device which converts direct current (DC) to alternating current (AC). There are three types of inverters based on type of output waveform as: square wave, modified-sine wave and pure sine wave.
A square wave is non sinusoidal waveform, most typically seen in electronics and signal processing. Square wave have two levels (positive and negative) and alternates regularly between these two levels. The output of a modified sine wave inverter is more like a square wave output except that it has one more level i. e, before switching positive or negative the output goes to zero volts. Though it is simple and low cost, most AC motors work on this power source or inverter reduces efficiency and the motors may also produce hissing sound while operating and due to which the life of equipment will reduce. A pure or true sine wave inverter changes or converts the DC supply into a near perfect sine wave. The sine wave has very little harmonic distortion which results in a very clean supply and makes it suitable for working electronic systems such as computers, motors and microwave ovens and other sensitive equipment without causing problems like noise. Things like mains battery chargers also run better on pure sine wave converters.
Ideally the output waveforms of an inverter should be sinusoidal. However, the waveforms of practical inverters are non sinusoidal and contains certain harmonics. Due to the availability of high speed power semiconductor devices, the harmonic contents present in the output voltage can be minimized significantly by using switching technique. BJTs, MOSFETs or IGBTs can be used as ideal switches. But IGBT is more popular as it combines the advantages of BJTs and MOSFETs. An IGBT has features like high input impedance such as MOSFETs and low on state conduction losses such as BJTs. The IGBT is a minority-carrier device and having large bipolar current-carrying capability. The IGBT is suitable for many applications in power electronics such Pulse Width Modulated (PWM) servo and three-phase drives requiring high dynamic range control and low noise.
An integral multiple of the frequency of some reference signal or wave is called as harmonic. The ratio of the frequency of such a signal to the frequency of the reference signal can also be referred as harmonic. Let the main or fundamental frequency of an alternating current signal is represent as f. This frequency f is expressed in hertz and most of the energy is contained at this frequency or the signal is defined to occur at this frequency. If harmonic signal is displayed on an oscilloscope the waveform will appear to repeat at a rate corresponding to f Hz.

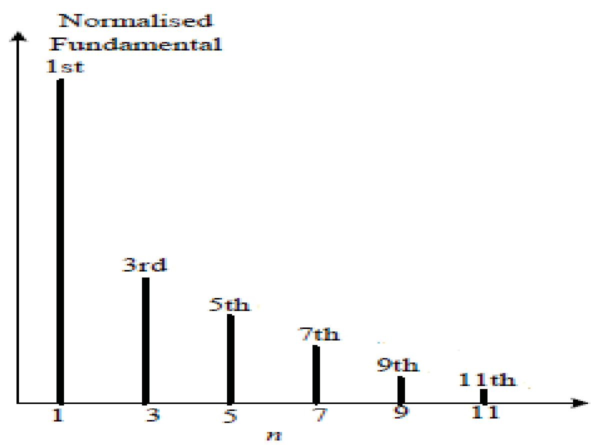

Fig -1: Harmonic Spectra of an Inverter

As observed in above fig. 1.1, harmonic decreases as n increases with a factor of (1/n). Odd harmonics are presents; the nearest harmonic is the 3rd harmonic while even harmonics are absent. If fundamental frequency is 50Hz, then the nearest harmonic is 150Hz as it is 3rd harmonic. Output low-pass filter design can be quite difficult as there is small separation between the fundamental and harmonics.

The unpleasant effects like unbalance and excessive neutral currents are cause because of harmonics. Harmonics give rise to different problems some of them are rise in interference in nearby communication networks and disturbance to other consumers, torque pulsations and cogging in electric motor drives etc.
If the non linear loads are introduced into the system, the non sinusoidal voltage and current are drawn across network and hence harmonics are generated. The presence of harmonics causes problems such as poor power factor, failure of operation, poor efficiency, shortens equipment life, overheating of lines etc. Because of these problems, the delivered energy is a concern object to the end user and solving these harmonic problems is challenging for power engineer.

2. LITERATURE REVIEW

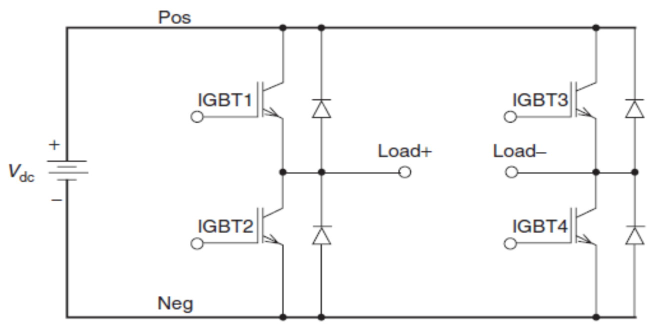

Fig -2: Single Phase full bridge inverter [9]

There are two types of single phase inverters i.e. full bridge inverter and half bridge inverter.
1) Half Bridge Inverter
The half bridge inverter is the basic building block of a full bridge inverter. It contains two switches and each of its capacitors has an output voltage equal to Vdc/2. In addition, the switches complement each other i. e. if one is switched ON the other one goes OFF.

2) Full Bridge Inverter
This inverter circuit converts DC to AC. It is obtained by turning ON and OFF the switches in the right sequence. It has four different operating states which are based on which switches are closed.

A low cost, microcontroller-based sinusoidal power source with variable voltage variable frequency (VVVF) is developed. MOSFET H-bridge inverter is used in power source with a standalone LCD as a display system. Sinusoidal pulse width modulation signals are generated for the driver circuit of the inverter. In sinusoidal pulse width modulation (SPWM), pulses are generated with constant amplitude but having different duty cycles for each period. The developed system has been properly worked for an ac voltage range of 30–80 V rms and a frequency range of 40–70 Hz. The power source is having an incorporated ROM-based LUT which provides desired performance and additional robustness for achieving proposed system capability. The system uses two microcontrollers where one of them microcontroller is used to generate the proposed variable frequency sine wave PWM drive and the other one microcontroller is used for controlling the stand alone LCD display of the developed power source [1].
A single phase inverter is design and implemented by using IGBT as switch and the output responses are studied. The inverter consists of the control circuit and the power circuit where the control circuit is used to generate the gate pulses to trigger the IGBTs and the power circuit consists of IGBTs and according to the duty cycle of the gate pulses these IGBT's can be turn on and off. The pulse width modulation i. e. PWM technique has been used. A microcontroller is used to obtained Pulse width modulated (PWM) pulses and to achieve the controlled AC output voltage, these PWM pulses are being used as triggering pulses for the inverter circuit. A sine-wave should be the desired output waveform with very low harmonic distortion. The advantages of pure sine wave inverters are such as inductive loads like motors and microwaves run faster, cooler and quieter. It reduces electrical and audible noise in fans, audio amplifiers, TV, fax, fluorescent lights and answering machines. It prevents glitches in monitors and crashes in computers [2].
A single phase inverter control circuit is developed which produces a pure sine wave. The output voltage magnitude and frequency is same as of grid voltage. To operate electrical and electronic appliances smoothly power rating inverter is required. The example of square wave inverter or quasi sine wave inverter is most of the available commercially uninterruptible power supplies (UPSs). Due to the harmonic contents, the electronic device managed by these inverters gets damaged. The available pure sine wave inverters neither cheaper nor generates pure sinusoidal output while the sine wave generation is extremely important in power electronics. The sinusoidal pulse width modulation (SPWM) switching technique is used for getting a pure sine wave. This involves a certain switching pattern used in the inverter bridges. The SPWM is widely used in power electronics applications such as the renewable energy system, the motor driver and UPS. The peripheral interface controller (PIC) microcontroller is used which is capable of storing commands to generate the necessary pulse width modulation waveform using built in PWM module. The applied voltage on the gate drive can be controlled by using variable frequency pulse width modulation signal which is provided by the microcontroller. The features of used microcontroller are it is simpler, flexible to change control algorithms in a real time, low cost and reduces the complexity of the control circuit. The stand-alone or grid connection from a direct supply of photovoltaic cells uses this type of inverter [3].
In standalone mode or grid connected application, the DC voltage from the PV array is converted into line frequency AC voltage for which an inverter is needed. To make a cost

effective inverter which provide pure sine wave AC voltage is an objective. This inverter reduces the total harmonic distortion (THD) and maximizes efficiency. When solar cells are interconnected in series and parallel then PV array is formed. The sunlight energy is directly converted into electricity by solar cell. A solar cell is having very low efficiency. To match the source and load properly different methods are to be undertaken in order to increase the efficiency. Maximum Power Point Tracking (MPPT) is one of such methods. In this method the maximum possible power is obtained from a varying source. If I-V curve is non linear in photovoltaic system, it is difficult to power a certain load. This is obtained by using a boost converter and MPPT algorithm is used to vary a duty cycle of this boost converter. This is most common method. Very less number of sensors are utilize in this method. The operating voltage is changes in the required direction by the algorithm but before that it should be sampled. Pure sine wave inverter with MPPT technique is designed and simulated. Various advantages exist like low small size, switching losses, cost less. This can be mainly used in residential purpose [4].

Pure sine wave output is produced by the sine wave inverter. The sine wave inverter has higher efficiency. To design an efficient cost effective system which provides pure sine wave AC voltage as an output is the main objective. The SPWM (Sinusoidal Pulse Width Modulation) technique is used to produce sine wave output by the system. In Pulse Width Modulation (PWM) the pulse width is varied to control the output voltage of inverter. The SPWM is a process of varying width of every pulse in pulse train in proportion of the sine wave amplitude evaluated at the centre of the same pulse. Simulation software used is PSIM. It is specially designed for friendly user interphase and fast simulation. To address our simulation needs the PSIM provides a powerful simulation environment. It also provides easy to use and an intuitive graphic user interphase for schematic editing [5].

Random Pulse Width Modulation is a new method for single phase variable voltage inverter. The output current and voltage waveforms have continuous frequency spectrum in Random Pulse Width Modulation based inverter. This is because of the devices which controlling the output voltages having the randomized switching function. The frequency spectrum can be controlled by keeping distributions of the random numbers within certain limit with respect to the peak value of reference sinusoidal waveform which are generated by the random source. The Pulse Width Modulation (PWM) is normally used to controlled variable output voltages. But the problem with PWM based converters is that it introduces higher frequency components which are discrete in nature. The periodic switching of the power electronics devices which controls the output voltages is responsible to originate this problem. Random Pulse Width Modulation (RPWM) is one solution to address the problems related to discrete frequency spectrum. The random PWM which produces switching functions that have a non-deterministic (random) component is the key property that differentiates random PWM from classic PWM is that. Because of non periodicity of the signal, the non-deterministic switching function will have continuous frequency spectrum. In both the cases, deterministic PWM and random PWM as the switching speed decreases the power quality of an inverter output will also reduces [6].

A microcontroller based power source is developed with variable voltage variable frequency. The H-bridge inverter is used by the power source which uses four MOSFETs for this purpose. Special kinds of signals are generated for the driver circuit. This special signal is nothing but a pulse width modulated signal which is applied as an input to the driver circuit. A table based memory is incorporated by the microcontroller. The Read Only Memory (ROM) that uses Look-Up-Table is used in this case. The AT89S52 microcontroller is used for controlling of an inverter. The design consideration is to obtain a perfect square wave but acceptable compromise is made with respect to the design parameters of inverter circuit components which has led us to a square wave with drop. In the current work, the square wave for different frequencies such as 19 Hz, 38 Hz, 50 Hz & 78 Hz is obtained with slight approximations. Thus one can conclude that an appropriate filter circuits is the field where further work can be carried out. These filters circuits converts the square wave to sine wave that can be used for different useful applications such as traction control , speed control of motors, iron loss measurement of magnetic specimens etc [7].

Table -1: Comparison of inverter techniques

Comparison of inverter techniques			
Parameter	Square wave inverter	Modified sine wave inverter	Pure sine wave inverter
Output waveform	Square wave.	Square except that the output goes to zero volts for a time before switching positive or negative wave.	Sine wave.
Harmonic distortion	More.	Moderate.	Less.
Power loss	More.	Moderate.	Less.
Heat generation	More.	Moderate.	Less.
Design complexity	Simpler.	Less complex design than pure sine wave inverter.	More.
Cost	Less expensive.	Moderate expensive.	More expensive.
Suitability	Not appropriate to delicate electronic devices	Not appropriate to delicate electronic devices	Appropriate to delicate electronic devices

3. SUMMARY

Single phase inverters are of three types i. e. square wave inverter, modified sine wave inverter and pure sine inverter. These types of inverters are studied in this paper. Off-the-shelf inverters are either square wave or modified sine wave. These two types of inverters are cheaper and are not suitable to delicate electronic devices. The output of pure sine wave inverter is near perfect sine wave. Pure sine wave inverters have less power loss and less heat generation. The sine wave has minor harmonic distortion resulting in a very clean supply and makes it most suitable for running electronic systems such as microwaves ovens, computers and motors and other sensitive equipment without causing problems or noise. Pulse Width Modulation (PWM) technique is best for sine wave generation.

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