

Development of Three Step Charging H-Bridge based Sine wave Inverter

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ABSTRACT

The power electronics device which converts DC power to AC power at required output voltage and frequency level is known as inverter. Inverters can be broadly classified into single level inverter and multi-level inverter. Multilevel inverter as compared to single level inverters have advantages like minimum harmonic distortion, reduced EMI/RFI generation and can operate on several voltage levels. A multi-stage inverter is being utilized for multipurpose applications, such as active power filters, static VAR compensators and machine drives for sinusoidal and trapezoidal current applications. The drawbacks are the isolated power supplies required for each one of the stages of the multiconverter and it's also lot harder to build, more expensive, harder to control in software. This aims at development of the three step charging H-bridge based sinewave inverter. This inverter overcomes the drawback of the existing push pull based square wave inverter like poor efficiency, production of noise, generation of heat and very low switching frequency. The features of the proposed inverter are high switching frequency, generation of pure sinewave by using sine weighed pulse width modulated, and three step charging which are boost, absorb, floating. By using three step charging the gravity level of the battery is maintained for entire period of time.

1. INTRODUCTION

This paper focuses on DC to AC power inverters, which aim to efficiently transform a DC power source to a high voltage AC source, similar to power that would be available at an electrical wall outlet. Inverters are used for many applications, like solar panels or fuel cells where low voltage DC sources must be converted to AC power. another example of such a situation would be converting electrical power from a car battery to run a laptop, TV or cell phone.

The method in which the low voltage DC power is inverted is completed in two steps. The first being the conversion of the low voltage DC power to a high voltage DC source, and the second step being the conversion of the high DC source to an AC waveform using pulse width modulation. Another method to complete the desired outcome would be to first convert the low voltage DC power to AC, and then use a transformer to boost the voltage to 120 volts. This paper focused on the first method described and specifically the transformation of a high voltage DC source into an AC output.

Of the different DC-AC inverters on the market today there are essentially two different forms of AC output

generated: modified sine wave, and pure sine wave. A modified sine wave can be seen as more of a square wave than a sine wave; it passes the high DC voltage for specified amounts of time so that the average power and rms voltage are the same as if it were a sine wave. These types of inverters are much cheaper than pure sine wave inverters and therefore are attractive alternatives.

Pure sine wave inverters, on the other hand, produce a sine wave output identical to the power coming out of an electrical outlet. These devices are able to run more sensitive devices that a modified sine wave may cause damage to such as: laser printers, laptop computers, power tools, digital clocks and medical equipment. This form of AC power also reduces audible noise in devices such as fluorescent lights and runs inductive loads, like motors, faster and quieter due to the low harmonic distortion

1.1. OBJECTIVE

The objective of this paper is to generate a pure sine wave with three step charging namely boost, absorb and floating. In boost mode, the charging current for the battery is fixed at its rated value till fifty percent capacity of the battery. In the absorb mode, the charging current is reduced to a value for the range of eighty percent of the battery capacity. Similarly, in floating mode, the charging current is even more reduced for hundred percent of the battery capacity. By using three steps charging the gravity level of the battery is maintained for entire period of time.

1.2. FEATURES

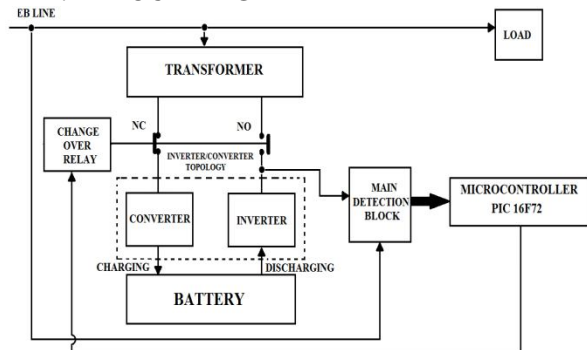
- Pure sine wave output (THD < 3%)
- Input & output fully isolation design
- Low power "Power Saving Mode" to conserve energy
- High efficiency 89~94%
- Advanced microprocessor
- Loading controlled cooling fan
- Protection circuit
- Main detection circuit
- Overload load detection circuit
- Charging current control circuit
- Temperature sensing circuit
- Buzzer circuit
- UPS circuit

1.3. APPLICATIONS

- Power tools – circular saws, drills, grinders, sanders, buffers, weed and hedge trimmers, air compressors.
- Office equipment – computers, printers, monitors, facsimile machines, scanner.

- Household items – vacuum cleaners, fans, fluorescent and Incandescent lights, shavers, sewing machines.
- Kitchen appliances – coffee makers, blenders, ice markers, toasters.
- Industrial equipment – metal halide lamp, high – pressure sodium lamp.
- Home entertainment electronics – television, VCRs, video games, stereos, musical instruments, satellite equipment.

2. BLOCK DIAGRAM



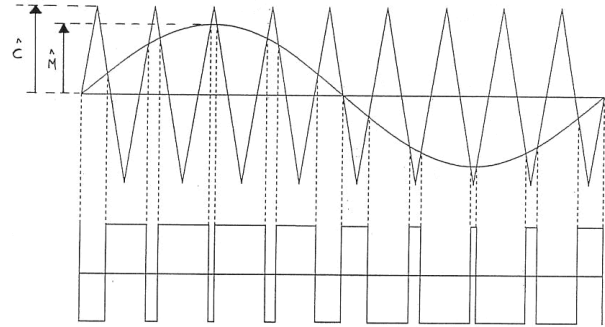
2.1. DESCRIPTION

In normal condition EB single phase supply performs two operation. One, it is directly connected to drive the load and second is to charge the battery. The charging of battery is done in three steps. It is split in to boost, absorb and floating. In case of EB supply failure the energy stored in the battery is connected to the load .so the backup energy now starts discharging. This was made possible by the changeover relay which was normally open (NO) in the inverter side and normally closed in the converter side (NC), for the above condition the inverter side relay is NC and the converter side relay is NO. So inverter circuit get connected to the load when the EB supply interrupted. We are giving both EB supply and inverter tapping voltage to the main detection circuit, it sends the error signal to microcontroller which one of them in live condition. If the main power is not available microcontroller send signal to relay. Relay here act change over action. So converter contact get open and inverter contact corresponding closed. Now load get supply through inverter.

3. METHODOLOGY

3.1. PULSE WIDTH MODULATION

In electronic power converters and motors, PWM is used extensively as a means of powering alternating current (AC) devices with an available direct current (DC) source or for advanced DC/AC conversion. Variation of duty cycle in the PWM signal to provide a DC voltage across the load in a specific pattern will appear to the load as an AC signal, or can control the speed of motors that would otherwise run only at full speed or off. This is further explained in this section. The pattern at which the duty cycle of a PWM signal varies can be created through simple analog components, a digital microcontroller, or specific PWM integrated circuits.

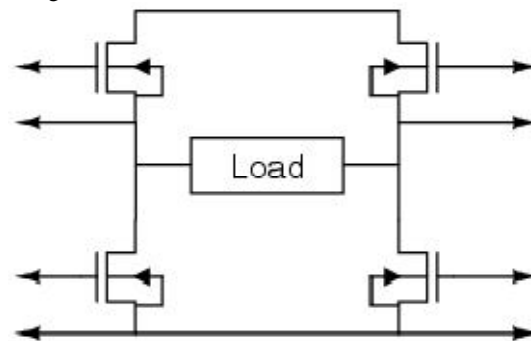


Analog PWM control requires the generation of both reference and carrier signals that feed into a comparator which creates output signals based on the difference between the signals¹⁰. The reference signal is sinusoidal and at the frequency of the desired output signal, while the carrier signal is often either a saw tooth or triangular wave at a frequency significantly greater than the reference. When the carrier signal exceeds the reference, the comparator output signal is at one state, and when the reference is at a higher voltage, the output is at its second state. This process is shown in Figure 3 with the triangular carrier wave in red, sinusoidal reference wave in blue and modulated and un modulated sine pulses.

In order to source an output with a PWM signal, transistor or other switching technologies are used to connect the source to the load when the signal is high or low. Full or half bridge configurations are common switching schemes used in power electronics. Full bridge configurations require the use of four switching devices and are often referred to as H-Bridges due to their orientation with respect to a load.

3.2. H-BRIDGE CONFIGURATION

An H-Bridge or full bridge converter is a switching configuration composed of four switches in an arrangement that resembles an H. By controlling different switches in the bridge, a positive, negative, or zero potential voltage can be placed across a load. When this load is a motor, these states correspond to forward, reverse, and off. The use of an H-Bridge configuration to drive a motor is shown in Figure.



The H-Bridge circuit consists of four switches corresponding to high side left, high side right, low side left, and low side right. There are four possible switch positions that can be used to obtain voltages across the

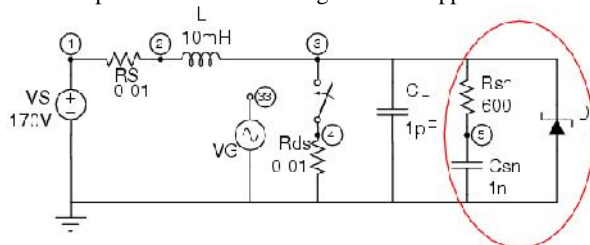
load. These positions are outlined in Table 1. Note that all other possibilities are omitted, as they would short circuit power to ground, potentially causing damage to the device or rapidly depleting the power supply.

High Side Left	High Side Right	Low Side Left	Low Side Right	Voltage Across Load
On	Off	Off	On	Positive
Off	On	On	Off	Negative
On	On	Off	Off	Zero Potential
Off	Off	On	On	Zero Potential

The switches used to implement an H-Bridge can be mechanical or built from solid state transistors. Selection of the proper switches varies greatly. The use of P-Channel MOSFETs on the high side and N-Channel MOSFETs on the low side is easier, but using all N-Channel MOSFETs and a FET driver, lower “on” resistance can be obtained resulting in reduced power loss. The use of all N-Channel MOSFETs requires a driver, since in order to turn on a high side N-Channel MOSFET; there must be a voltage higher than the switching voltage (in the case of a power inverter, 170V). This difficulty is often overcome by driver circuits capable of charging an external capacitor to create additional potential. MOSFET drivers and discussion of how they achieve this higher potential are discussed in the following section.

3.3. CIRCUIT PROTECTION AND SNUBBERS

One of the major factors in any electronic device is its ability to protect itself from surges that could damage the circuitry. In the case of the inverter, inductive loads can cause special problems because an inductor cannot instantly stop conducting current, it must be dampened or diverted so that the current does not try to flow through the open switch. If not dampened the surges can cause trouble in the MOSFETs used to produce the output sine wave; when a MOSFET is turned off the inductive load still wants to push current through the switch, as it has no where else to go. This action can cause the switch to be put under considerable stress, the high dV/dt , dI/dt , V and I associated with this problem can cause the MOSFETs to malfunction and break. To combat this problem snubber circuits can reduce or eliminate any severe voltages and currents. Composed of simply a resistor and capacitor placed across each switch it allows any current or voltage spikes to be suppressed by critically dampening the surge and protecting the switch from damage. The snubber can become more effective by the addition of a zener diode so that any large current surge the resistor capacitor snubber cannot handle gets passed through to ground by the zener diode. The diagram in Figure 9 shows a simple representation of an inductive load (L) over a switch representation, Figure 10 and Figure 11 show how snubbers can be implemented so that a surge will be suppressed.



3.4. FILTERING

Filters come in many different packages, with many different advantages – and disadvantages. For example, a digital filter is easily reconfigurable and can have almost any frequency response desired. If the response is simply lowpass/high pass/bandpass behavior with a set frequency, an active filter can be made to have a very sharp edge at the cutoff, resulting in enormous reductions in noise and very little attenuation of the signal. These, however, require opamps. Opamps capable of filtering a 120V RMS sine wave exist, but are expensive and lossy, since the opamp must be able to source hundreds of watts, and must be very large to do so without burning. Digital filters have a similar drawback and, designed with TTL and CMOS technology, can only work with small signals. Lastly we come to a passive filter. Generally large in size and very resistive at low frequencies, these filters often seem to have more of a prototyping application, or perhaps use in a device where low cost is important, and efficiency is not. Given these choices, an application such as a high power sine inverter is left with only one viable option: the passive filter. This makes the design slightly more difficult to accomplish. Noting that passive filters introduce higher resistance at lower frequencies (due to the larger inductances, which require longer wires), the obvious choice is to switch at the highest possible frequency. The problem with this choice, however, is that the switching MOSFETs introduce more switching losses at higher frequencies. This would imply that we should switch slower to improve our switching efficiency, which contradicts the filter's need for a higher frequency.

3.5. TOTAL HARMONIC DISTORTION

The total harmonic distortion, or THD, of a signal is a measurement of the harmonic distortion present and is defined as the ratio of the sum of the powers of all harmonic components to the power of the fundamental frequency. THD is used to characterize the linearity of audio systems and the power quality of electric power systems. In audio systems, lower THD means the components in a loudspeaker, amplifier or microphone or other equipment produce a more accurate reproduction by reducing harmonics added by electronics and audio media.

To understand a system with an input and an output, such as an audio amplifier, we start with an ideal system where the transfer function is linear and time-invariant. When a signal passes through a non-ideal, non-linear device, additional content is added at the harmonics of the original frequencies. THD is a measurement of the extent of that distortion. When the input is a pure sine wave, the measurement is most commonly the ratio of the sum of the powers of all higher harmonic frequencies to the power at the first harmonic, or fundamental, frequency.

$$THD = \frac{P_2 + P_3 + P_4 + \dots + P_\infty}{P_1} = \frac{\sum_{i=2}^{\infty} P_i}{P_1}$$

which can equivalently be written as

$$THD = \frac{P_{total} - P_1}{P_1}$$

if there is no source of power other than the signal and its harmonics.

Measurements based on amplitudes (e.g. voltage or current) must be converted to powers to make addition of harmonics distortion meaningful. For a voltage signal, for example, the ratio of the squares of the RMS voltages is equivalent to the power ratio:

$$\text{THD} = \frac{V_2^2 + V_3^2 + V_4^2 + \dots + V_\infty^2}{V_1^2}$$

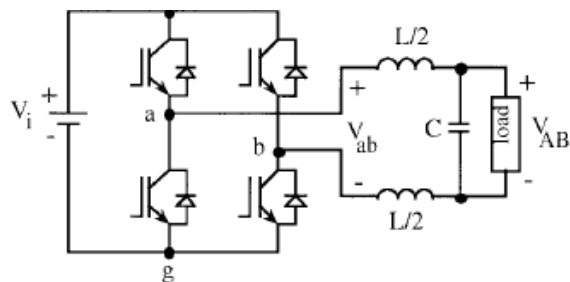
where V_i is the RMS voltage of i th harmonic and $i = 1$ is the fundamental frequency.

$$\text{THD} = \frac{\sqrt{V_2^2 + V_3^2 + V_4^2 + \dots + V_\infty^2}}{V_1}$$

This latter definition is commonly used in audio distortion (percentage THD) specifications. It is unfortunate that these two conflicting definitions of THD (one as a power ratio and the other as an amplitude ratio) are both in common usage.

As a result, THD is a non-standardized specification and the results between manufacturers are not easily comparable. Since individual harmonic amplitudes are measured, it is required that the manufacturer disclose the test signal frequency range, level and gain conditions, and number of measurements taken. It is possible to measure the full 20–20 kHz range using a sweep. For all signal processing equipment, except microphone preamplifiers, the preferred gain setting is unity. For microphone preamplifiers, standard practice is to use maximum gain. Measurements for calculating the THD are made at the output of a device under specified conditions. The THD is usually expressed in percent as distortion factor or in dB relative to the fundamental as distortion attenuation.

3.6. GEOMETRIC APPROACH



This review focuses on the mathematical calculation of the proposed system it consist of two leg (one -phase, two-wire) inverter system. And also some of the information that is: The topologies are “full-bridge”

voltage-source inverters with LC filters suitable for producing sinusoidal output voltages. The switching states and corresponding output voltage vectors produced by each inverter are identified and presented along with an analysis of the geometric arrangement of these voltage vectors.

$$V_{ab} = V_{ag} - V_{bg}$$

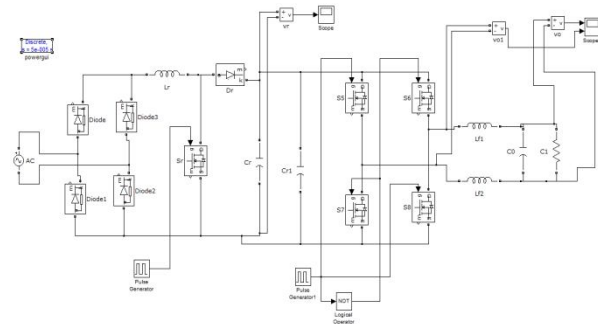
TWO-LEG INVERTER SWITCHING STATES AND VOLTAGE VECTORS

S_a	S_b	V_{ag}	V_{bg}	V_{ab}	Vector #
0	0	0	0	0	0
0	1	0	V_i	$-V_i$	2
1	0	V_i	0	$+V_i$	1
1	1	V_i	V_i	0	3

$$\begin{bmatrix} V_{ab} \\ V_o \end{bmatrix} = \begin{bmatrix} 1 & -1 \\ 1 & 1 \end{bmatrix} \begin{bmatrix} V_{ag} \\ V_{bg} \end{bmatrix}$$

4. SIMULATION RESULT

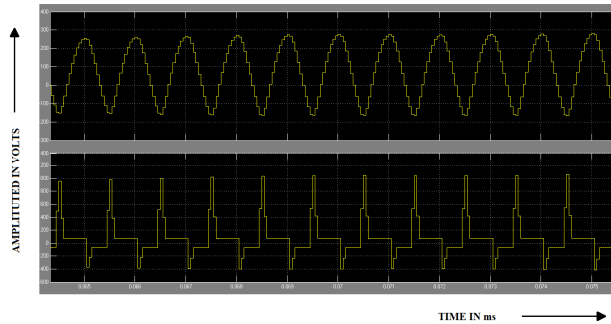
4.1. CIRCUIT DIAGRAM



4.2. DESCRIPTION

The input single phase AC supply is rectified by a single phase diode rectifier which converts alternating AC input to pulsating DC supply. It is allow to flow through LC filter circuit for the purpose of filtering harmonics and to get a nearly constant DC supply. Now the output of filter is given to boost converter, it boosts the input dc voltage to desired DC voltage. And we connect a diode in series to avoid reverse current to flow. We are preparing two driver circuits. Each driver circuit control two switches. Switch m1&m2 high gate pulse from driver circuit. Corresponding switch m3&m4 get low gate pulse from driver circuit.

4.3. OUTPUT WAVEFORM



5. CONCLUSION

In this paper a detail study of the problem were made and a circuit is proposed to overcome the above. A partial theoretical analysis of the proposed circuit was carried out and various results of the analysis were verified by MATLAB simulation. Further in upcoming phase the hardware of the proposed circuit would be constructed and the theoretical analysis and simulation results should be verified practically.

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