Square Wave Inverters –A performance Comparison with Pure Sine wave Inverters

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Abstract- This paper presents operation and performance comparison analysis between square wave inverters and pure sine wave inverters. The paper also gives a review of various inverter topologies adapted for square wave conversion and subsequent filtering of the same.

Keywords- Square Wave Inverters, AC Inverters, Sine wave Inverters, AC filtering

I. INVERTERS: PRINCIPLE OF OPERATION AND PARAMETERS

Inverter is a key system element that is used for power conditioning [1]. Almost any solar systems of any scale include inverter of some type to allow the power to be used on site for AC-powered appliances or on grid. Different types of inverters are shown in Figure1 as examples. The available inverter models are now very efficient (over 95% power conversion efficiency), reliable, and economical. On the utility scale, the main challenges are related to system configuration in order to achieve safe operation and to reduce conversion losses to a minimum.

Fig.1: Inverters: small-scale inverter box for residential use (left) and Satcon utility-scale inverters (right)[2]

The three most common types of inverters made for powering AC loads include: (1) pure sine wave inverter (for general applications), (2) modified square wave inverter (for resistive, capacitive, and inductive loads), and (3) square wave inverter (for some resistive loads) (MPP Solar, 2015)[3]. Here, we will take a closer look at the physical principles used by inverters to produce those signals figure2.

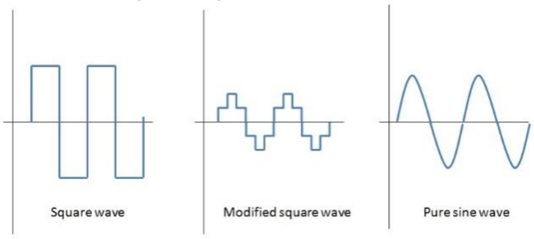

Fig.2: Different types of AC signal produced by inverters.

The process of conversion of the DC current into AC current is based on the phenomenon of electromagnetic induction. Electromagnetic induction is the generation of electric potential difference in a conductor when it is exposed to varying magnetic field. For example, if you place a coil (spool of wire) near a rotating magnet, electric current will be induced in the coil (Figure3)[4].

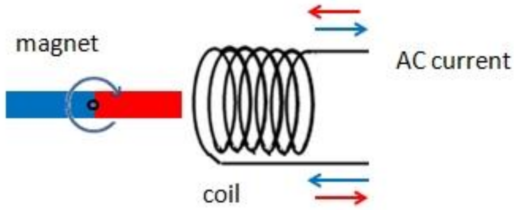

Fig.3: Schematic illustration of electromagnetic induction

Next, if we consider a system with two coils (Figure 4) and pass DC current through one of them (primary coil), that coil with DC current can act analogously to the magnet (since electric current produces magnetic field). If the direction of the current is reversed frequently (e.g., via a switch device), the alternating magnetic field will induce AC current in the secondary coil.

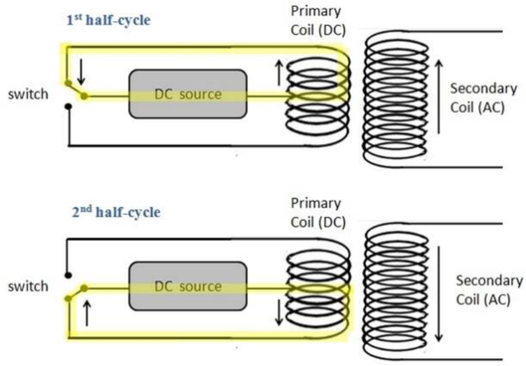

Fig.4: Inverter cycles. During the 1st half cycle (top), DC current from a DC source - solar module or battery - is switched on through the top part of the primary coil. During the 2nd half cycle (bottom), the DC current is switched on through the bottom part of the coil.

The simple two-cycle scheme shown in Figure 4 produces a square wave AC signal. This is the simplest case, and if the inverter performs only this step, it is a square-wave inverter. This type of output is not very efficient and can be even detrimental to some loads. So, the square wave can be modified further using more sophisticated inverters to produce a modified square wave or sine wave [5].

To produce a modified square wave output, such as one shown in the centre of Figure 2, low frequency waveform control can be used in the inverter. This feature allows adjusting the duration of the alternating square pulses. Also, transformers are used here to vary the output voltage. Combination of pulses of different length and voltage results in multi-stepped modified square wave, which closely matches the sine wave shape. The low frequency inverters typically operate at ~60 Hz frequency.

To produce a sine wave output, high-frequency inverters are used. These inverters use the pulse-width modification method: switching currents at high frequency, and for variable periods of time. For example, very narrow (short) pulses simulate a low voltage situation, and wide (long pulses) simulate high voltage. Also, this method allows spacing the pulses to be varied: spacing narrow pulses farther apart models low voltage (Figure 5).

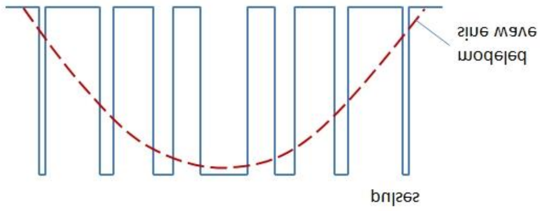

Fig.5: Pulse-width modulation to approximate the true sine wave by high frequency inverter.

In the image above, the blue line shows the square wave varied by the length of the pulse and timing between pulses; the red curve shows how those alternating signals are modelled by a sine wave. Using very high frequency helps create very gradual changes in pulse width and thus models a true sine signal. The pulse-width modulation method and novel digital controllers have resulted in very efficient inverters [4].

II. SQUARE WAVE INVERTER WORKING

A switching circuit is used in the conversion of DC voltage to an alternating (or bipolar) square wave voltage. One method is the use of the inverter bridge (also known as an H-bridge), which is illustrated in Figure 6.

The switch symbols are used to represent switching transistors (IGBTs or MOSFETs) or other types of electronic switching devices. In Figure 6a, switches S2 and S3 are on for a specified time and S1 and S4 are off.

As you can see, the direct current is through the load, which creates a positive output voltage. In Figure 6b, opposite switches are on and off. The current is in the opposite direction through the load, and the output voltage is negative. The complete on/off cycle of the switches produces an alternating square wave.

The transistors are switched by a timing control circuit, which is not shown for simplicity. The harmonic distortion of a typical square wave output is in the range of 45%, which can be reduced somewhat by filtering out some of the harmonics.

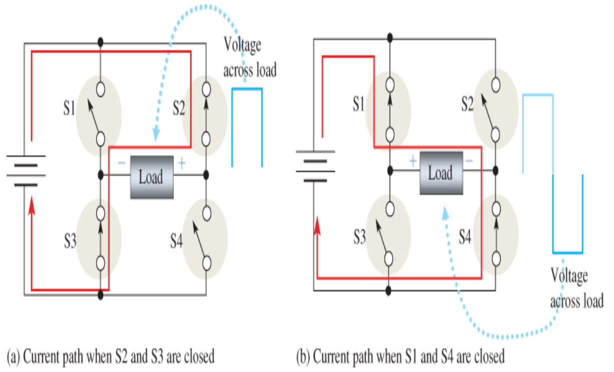

Fig.6: Inverter Bridge. The inverter bridge (H-bridge) is a method of producing a square wave from a DC voltage.

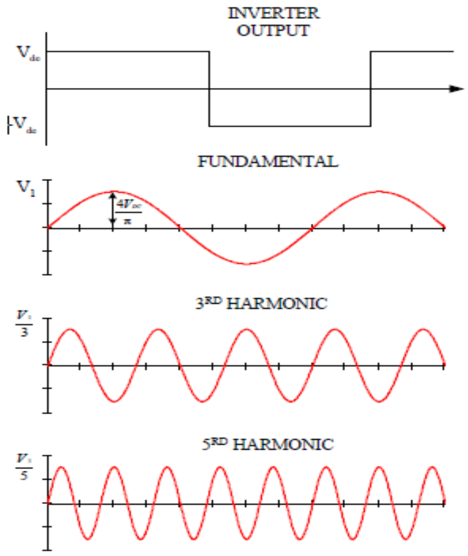

Fig.7: Waveforms and harmonics of square-wave inverter

Feature	Square wave inverter	Sine wave inverter
Supported appliances	Motors	Computers, laptops, refrigerators, ovens
Noise level	High, creates humming noise in inverter as well as in appliances	Normal
Safety of appliances	Less	High
Price	Economical	High

III. NEED FOR FILTERING IN SQUARE WAVE INVERTERS

Output of the inverter is "chopped AC voltage with zero DC component". In some applications such as UPS, "high purity" sine wave output is required. An LC section low-pass filter is normally fitted at the inverter output to reduce the high frequency harmonics. In some applications such as AC motor drive, filtering is not required.

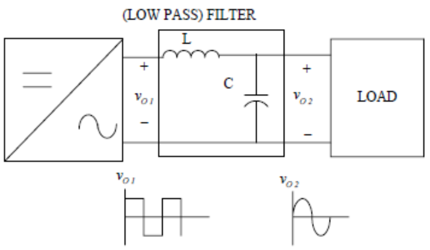

Fig.8: LP Filter for Square Wave Inverters

IV. SQUARE WAVE VS SINE WAVE INVERTERS

a) Output voltage wave form of the true wave inverter is a pure sine wave which we get through utility usage in our home for the electric loads. IN pure wave of sine distortion is approximately zero just like electricity obtain from supplied by company. But in square wave harmonics produces distortion which can destroy or damage our equipment while running on square wave. So pure sine wave is better than square wave.

b) Most of the time we used inductive loads in our homes while we are using such loads we have to use pure sine wave. Because it run faster with pure sine wave than square wave. Inductive load can be micro wave oven, Motors, Cooler and etc. so again proved that pure sine wave inverter must be used for more efficiency.

c) Sine wave reduces audio able and noise pollution while running electric machines. Even when we use square wave audio and noise pollution are in very large quantity.

V. CONCLUSION

Sine wave inverter output is very close to the AC current. It is very pure form compared to square wave output. Many devices gets heated up if you use on Square wave inverter and make humming noise too. Because of this reason square wave inverters in few European countries is banned.

VI. REFERENCES

[1]. https://www.theengineeringprojects.com/2016/10/introduction-inverters.html
[2]. ZeeshanAleem ;MoinHanif "Single-phase transformer based Z-source AC-AC converters"2016 IEEE 2nd Annual Southern Power Electronics Conference (SPEC) Year: 2016 Page s: 1 – 6
[3]. TeuvoSuntio ; JariLeppäaho ; JuhaHuusari ; LariNousiainen "Issues on Solar-Generator Interfacing With Current-Fed MPP-Tracking Converters" IEEE Transactions on Power Electronics Year: 2010 , Volume: 25 , Issue: 9 Page s: 2409 – 2419
[4]. Djuro G. Zrilic "Alternative Approach to Use of Pulse Width Modulation" 2006 World Automation Congress Year: 2006 Page s: 1 – 5
[5]. Ankit Kamani, JaideepSatapara "Study of Modified Sine Wave Inverter"International Research Journal of Engineering and Technology (IRJET)Volume: 05 Issue: 01 | Jan-2018

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