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DESIGN AND ANALYSIS OF WAVELET TRANSFORM TECHNIQUE BASED INTERLEAVED BOOST CONVERTER

[1]P. Krishna Murthy, [2]A.K.Srikanth, [3]S. Neelina
[1]Department of EEE, Khammam Institute of Technology & Sciences, Khammam, India.
[2]Department of EEE, Government Polytechnic, Kothadugem, India.
[3]Dept. of CSE, Priyadarshini Institute of Science and Technology For Women, Khammam, India.

ABSTRACT: This paper utilizes the discrete wavelet method to display an in-depth study of three standard and two level convolved DC to DC converters. DC to DC adapters are becoming more and more important in a variety of application areas, including biomedicine, manufacturing, and household. owing to their incredible talent to magnify the voltage level to meet the demands of the preferred load voltage. However, ability to handle an elevated input signal when trying to design an output power inverters for high voltage applications is a significant challenge. The overlapping converter is the best power converter topology for small photovoltaic modules because of its higher efficiency, compact size, present sharing between levels, low input power ripple, and higher reliability. Using the discrete wavelet method, the achievement of the three - stage proposed converter is especially in comparison to that of the two level interleaved boost source inverterThe results of the simulation study, which was conducted in the MATLAB SIMULINK environment, are in good agreement with previously published research.

Keywords: *Interleaved Boost Converter, wavelet transforms*

1.0 INTRODUCTION

Green energy generation has become more vital source of electrical energy keeping in view of its merits such as availability, efficiency and also distributed generation capability. The best non conventional energy sources of electrical power are the solar photovoltaic power generation. With the improvements in power electronic devices and their reliability high power photo Voltaic power generation systems connected to grid are gaining momentum [1]. With the improved reliability and less conversion losses Boost converters are having wide range of applications viz., Hybrid electric vehicles, biomedical applications in specific adopters for various electronic pathology equipment and domestic applications also.

2.0 INTERLEAVED BOOST CONVERTER

The major challenges in the design of boost converters for high power applications is to handle the input currents and also high output voltages. In addition with the increased number of controlled devices used in high power boost converters the control network complexity increases [2].

The interleaved boost converter (IBC) topology presented in this paper is a parallel connected boost converters to accommodate the high input currents uniformly distributed among the parallel paths allowing a reduced stress of high current and also allowing smooth continuous output current. The interleaved boost converters mainly identified for high power applications has a number of boost converters with same frequency but with a phase Shift connected parallel configuration.

2.1 Operation principle of Interleaved Boost Converter:

Interleaved boost converter is different from conventional boost converter. This has three modes of operation such as critical operation mode, discontinuous conduction mode and continuous conduction mode [3]. The devices are triggered to turn ON when the current flowing through the boost converter is zero. Complex design of boost converter is observed when the boost converter is operated in critical conduction mode as the critical point shifts with the Load.

Interleaved boost converter in discontinuous conduction mode has some specific merits and demerits compared to continuous conduction mode [6]. The interleaved boost converter in discontinuous conduction mode is addressed the problems related to reverse recovery effects but due to high input current and conduction losses this mode of operation is not suitable for high power applications [8]. The demerits of discontinuous conduction mode of operation are well addressed in continuous conduction mode.

For high power applications, for better efficiency output current is divided into number of parallel currents leading to reduced I^2R losses and magnetization losses in the inductor [5]. As the current through the switching devices is reduced the reliability of circuit configuration is improved [7].

3.0 INTERLEAVED BOOST CONVERTER MATHEMATICAL MODELING

Three level boost converter simulation diagram is shown in figure 1.

D: Duty Cycle

$$D = 1 - \frac{(V_{in\_min} * n)}{V_{out}}$$

d_i: input current ripple

$$d_i = I_{ripple} * I_{out} * \frac{V_{out}}{V_{in}}$$ I_{out}

Generally I_{ripple} can be taken as 20% to 40% of

$$I_{out} = \frac{P_{out}}{V_{out}}$$

$$L = \frac{(V_{in} * (V_{out} - V_{in}))}{(d_i * f_s * V_{out})}$$

d_V : Output voltage ripple

$$d_V = V_{out} * \frac{d_{V\%}}{100}$$

Capacitor C:

$$C = \frac{(I * D)}{(f_s * d_V)}$$

Based on the previous mathematical modelling, the IBC is simulated using the Matlab Simulation environment. Both the performance of the Boost converter at three levels and at two levels is evaluated. The three level boost converter and the two level boost converter are compared in this study. In order to present the results of the frequency domain analysis, high frequency interference [11] and sensitive biomedical applications [12] were taken into consideration.

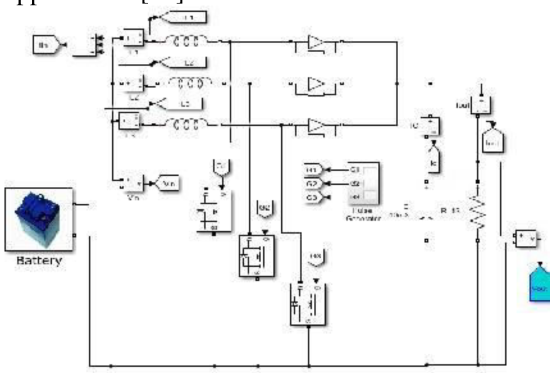

Fig.1 Simulation diagram of three level interleaved Boost converter

3.1 Wavelet transforms:

A single function known as the mother wavelet or analysing wavelet is scaled and translated to produce a family of functions called wavelets [9].

The ability of the wavelet transform to localise both time and frequency allows for the simultaneous identification of the sharp transitions of signals and the place where they occurred. A set of wavelet functions are chosen for the wavelet transform, much like how sinusoidal functions are the foundation for the Fourier transform. By shifting and distorting a mother wavelet prototype on various levels, the basic operations are produced. The wavelet coefficients are the original function's projections onto the basis. The wavelet analysis quantifies how much the fundamental functions (wavelets) resemble the original function, as stated in the definition of the wavelet transform. The calculated coefficients demonstrate how it was similar to articular scale and the function is to the daughter wavelet. There will have been computed a comparatively large number of coefficients by this point in the time scale. Popular wavelets used in signal processing, power system transient studies, etc. include the Meyer wavelet, Daubechies wavelet, Morlet wavelet, and Mexican Hat wavelet.

4.0 RESULTS AND DISCUSSION

The interleaved boost converter is designed to step-up the DC voltage from 25V to 50 V. while doing so the higher order harmonics are being injected into the output due to the continuous switching. Hence a thorough analysis of the output signals is carried out by using Power Density Spectrum. This is very vital in view of some specific applications of these boost converters for some sensitive high power applications.

Correlation is the best concept to estimate the noise present in the signal in time domain (if a periodic signal is mixed with the noise then correlation is used to extract original data.) To implement this in frequency domain we go for Weiner-Khinchine relation. According to this the PDS is equivalent to the Fourier Transform of correlation function. Here we have PDS of V_{in} and V_{out}. By applying this relation on this wave forms one can estimate the noise present in that signals.

Generally PDS is the best tool to estimate the strength of the signal. The PDS gives the oscillatory signal information in time domain and it also indicates which frequency rage variations are strong.

In three level boost converter the total harmonic distortion in the initial stages is identified around 49% with respect to the DC component around 76.91% however after the first second of time period as the time progresses the total distortion is falling from around 49% to 7% and it is coming to 2% within a fraction of not more than 15 cycles of time period however the total time taken to reduce the total harmonic distortion from 49% to 0.23% is around 3 seconds.

Once steady state is attained the input and output currents are maintaining stability with very less total harmonic distortion. Therefore V_{in}, V_{out}, I_{in}, I_{out} are observed to have steady state once the boost converter gains its momentum and reaching to stability or the current voltage components are almost balanced. The input voltage is observed to be around 25 V and the lithium ion battery is charged up to 80% of its capacity. Therefore the fall of potential is also observed to be marginal the impact of the sudden switching of boost converter is not reflected on the performance of the battery. And as per the wavelet Coefficient analysis the 10^{th} harmonic is observed to be predominant from the signal spectrum.

Fig 2,3,4 is the graphical representation of the input and output voltage current waveforms along with the approximated signal respectively .It is observed from the wavelet coefficients that other than the DC component specific higher order harmonics are predominant in the voltage and current signal where as the order of the harmonics present in the output voltage and current waveform is directly dependent on the switching frequency hence a tuned capacitor filter may be incorporated to minimise the impact of the harmonics on the sensitive loads with a marginal drop in efficiency of the boost converter.

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The wavelet coefficients are plotted as shown in fig 2 to 5 and the performance of the boost converter is analyzed by using wavelet transform technique.

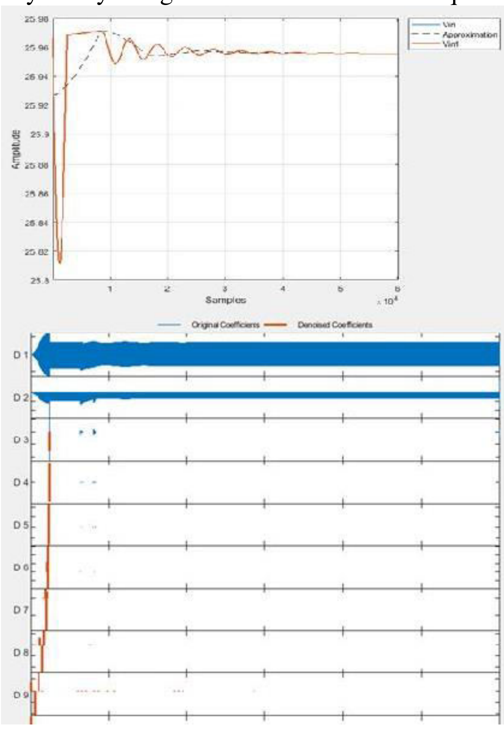

Fig 2. Three level V_{in} Wavelet Signal Deionizer

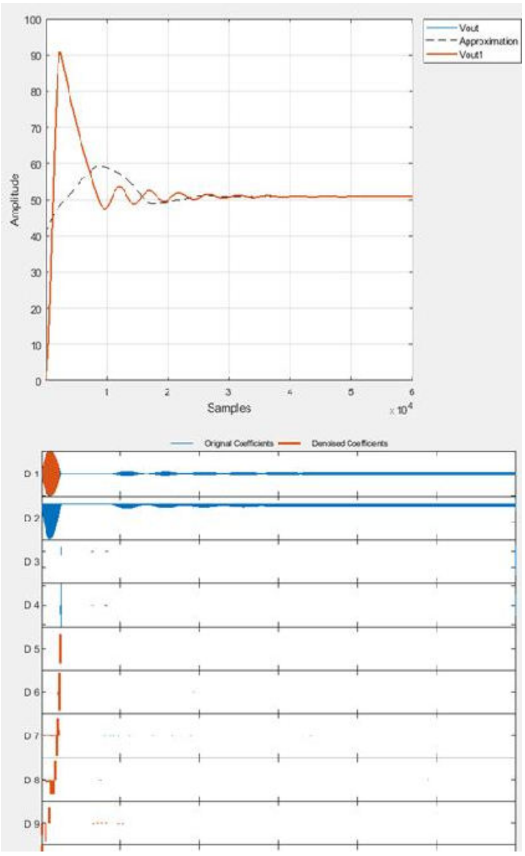

Fig 3. Three level Vout Wavelet Signal Deionizer

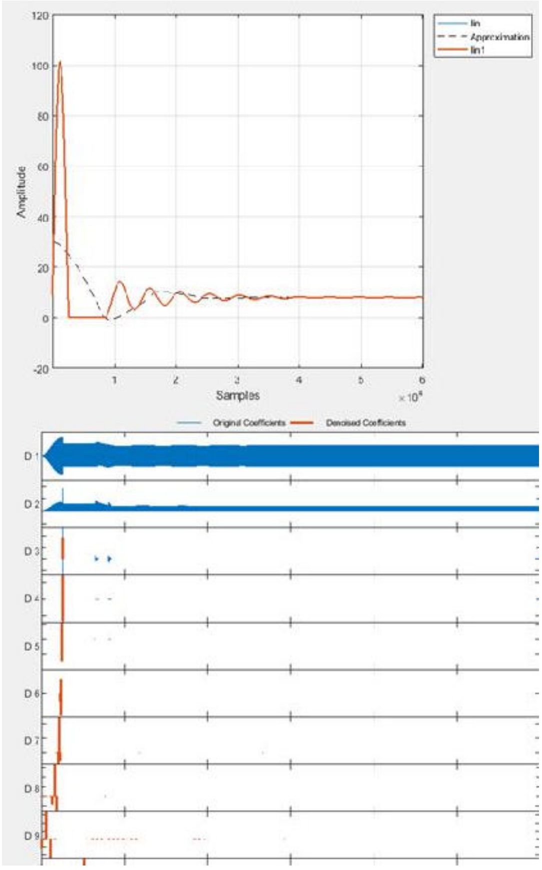

Fig 4. Three level I_{in} Wavelet Signal Deionizer

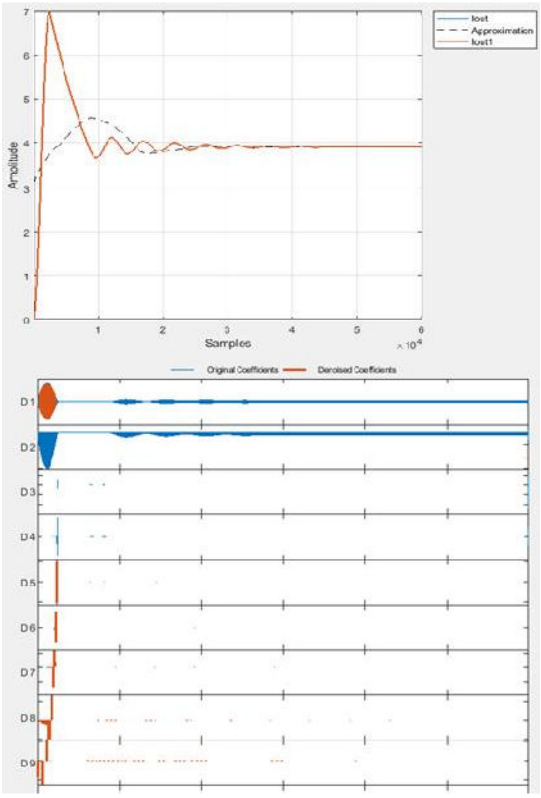

Fig 5. Three level I_{out} Wavelet Signal Deionizer

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Figure 6 and 8 shows the input voltage and current waveform of three level interleaved boost converter. The lithium ion battery is connected as a source and the battery is charged up to 80 % of its total capacity and once the battery is connected to boost converter the voltage drop down marginally and regain its value around 24 volts and it is almost maintaining stability after 10 cycles of its operation for a switching frequency of 20000 kilohertz. Interleaved boost converter for the given load conditions the output voltage and output current are drawn in figure 7 and 9 respectively and it is observed that the output voltage is shooting up to a value of maximum and it is coming back to normal at about 1 to 1.5 seconds of time around 20 cycles of its operation and the total harmonic distortion of the three phase interleaved boost converter is observed to be about 105.42 % and after few cycles of operation it is dropped down to a value of 0.13 % which is exponentially falling down and it is observed that in steady state the total harmonic distortion in the output voltage is almost observed to be zero that is 0.05% Where as similar performance is observed even in output current also. Output current total harmonic distortion switching state at time t = 0 is around 105 % and it is dropped down to 1.62 % and finally at steady state it is almost equal to 0. In case of output voltage and the output current of two phase interleaved boost converter total harmonic distortion is bit high that is equal to 110 % when compared to that of a 3 phase interleaved boost converter where harmonic distortion is around 105 % where as the harmonic distortion is dropping down to around 0.21 % by the time it reaches steady state stability which is comparatively higher when compared to three phase interleaved boost converter.

The signal analysis is presented in figures 6 to 11 waveforms where the spectrum analyser output waveform clearly indicating that higher order predominant frequencies are observed and which are vanished within fraction of seconds from the time of switching of interleaved boost converter .Better filtering of these higher order harmonics can be achieved as the desirable output voltage is only DC. Dominant frequencies can be filtered by using appropriate filters so as to give less impact on voltage source.

The figure 6 to 11 shows the input, output voltage and current waveforms and along with their power spectrum. from the power spectrum it is evident that the magnitude of higher order frequencies is high at three level compared to that of the two level leading to easy filtering solutions. It is observed that the magnitude of the higher order frequency for a three level is approximately 60 db where as for a two level it is approximately equal to 52 db.

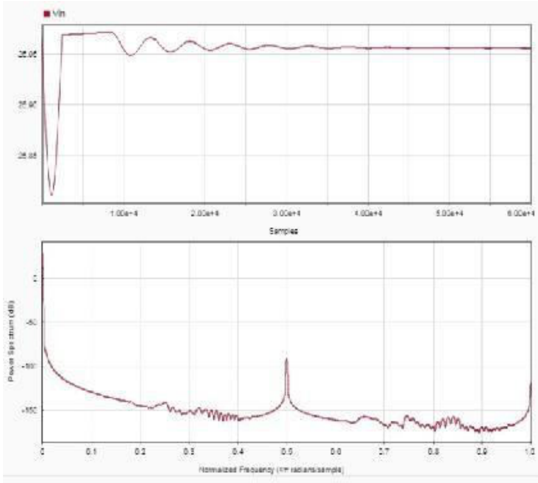

Fig.6 Signal analyzer waveforms for V_{in} of Three level interleaved boost converter

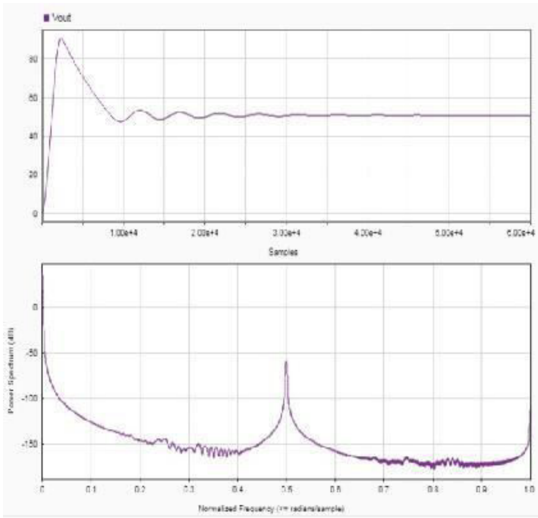

Fig.7 Signal analyzer waveforms for V_{out} of Three level interleaved boost converter

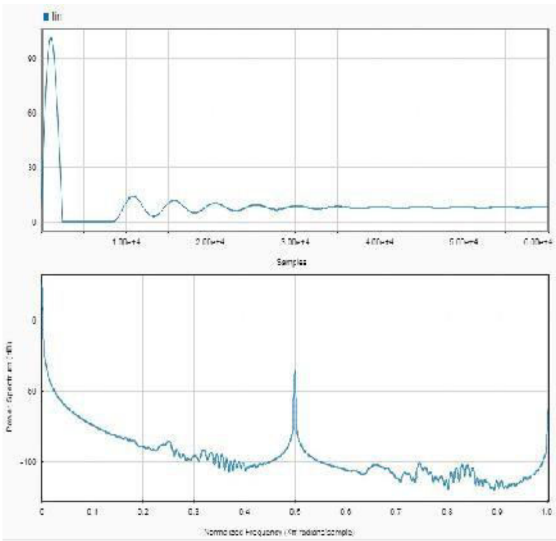

Fig.8 Signal analyzer waveforms for I_{in} of Three level interleaved boost converter

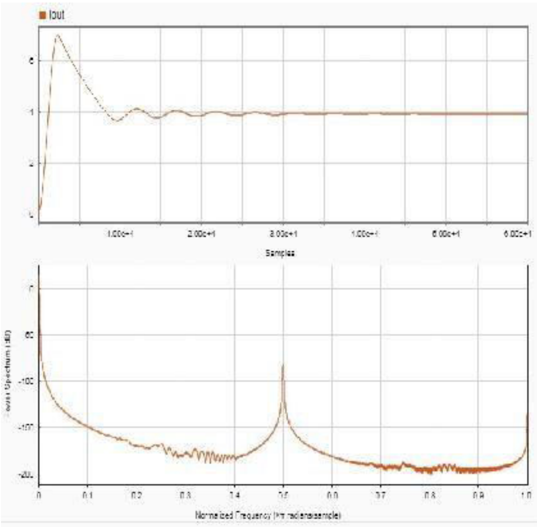

Fig 9. Signal analyzer waveforms for I_{out} of Three level interleaved boost converter

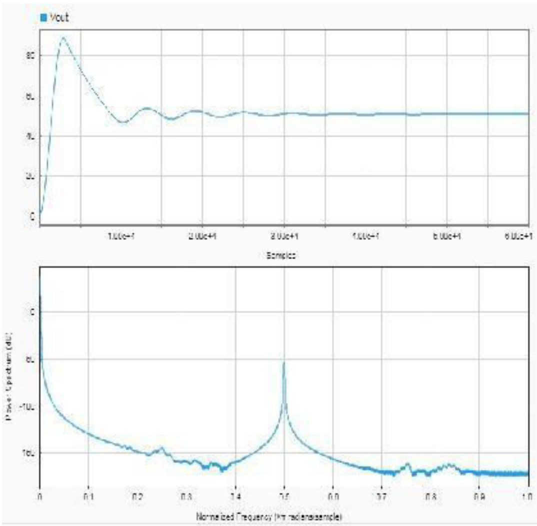

Fig 10. Signal analyzer waveforms for V_{out} of Two level interleaved boost converter

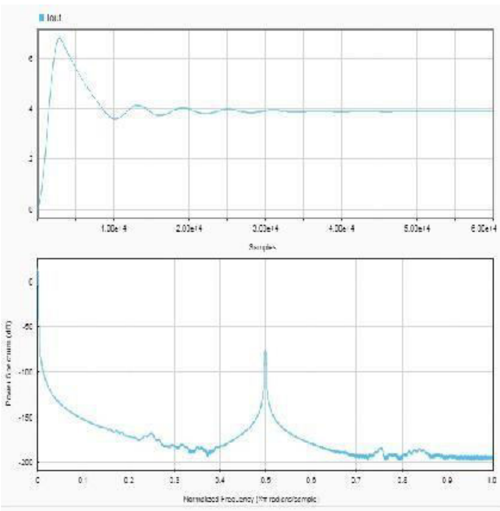

Fig 11. Signal analyzer waveforms for I_{out} of Two level interleaved boost converter

5.0 CONCLUSION

In the MATLAB SIMULINK environment is a three-level interleaved boost converter configuration which is used to create and simulate the mathematical model. Calculations are made for a number of variables, including output capacitance at the load and input inductance. A mathematical model is developed for both the three level and two level configurations to assess the performance of the interleaved boost converter. When the boost converter is operating at a duty cycle of 0.5, the input voltage, input current, output voltage, and output current are used as parameters for the analysis. A comparison of two and three level boost converters is given, along with a performance analysis of the boost converter. Three level boost converters are found to have more benefits than two level boost converters. When it comes to high power sensitive load applications, the three level boost converter will be more dependable and effective than the two level boost converter.

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