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CONTROL OF CHAOS IN BOOST CONVERTER

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***Abstract*: Chaos is a kind of quasi-stochastic behaviours of determinate nonlinear system. Chaos in boost typical topology power electronic converters with a close loop controller is studied in this project. Recently, how to apply chaos has become the researching focus, chaos control is the basic problem of the application of chaos. To deal with this problem, some existing methods are reviewed and their features are analyzed, and then, this paper places emphasis on chaos control.**

I INTRODUCTION

Power electronic technology is widely used Power electronic technology is widely used in the industrial, commercial, household and outer space, this subject is related to the conversion of power solved urgently in the production practice. In power electronic subject, It is noticed that how to design the circuits to meet the needs of actual production. So, people usually find a particular circuit or system has already been put into a wide range of applications before it is analyzed thoroughly . At present people are still widely and deeply studying the characteristics and model of converters. Nonlinear is a general phenomenon in the power electronics; however, it has not been fully pay attention in previous analysis and design process. In the 1990s, the nonlinear power electronics and chaos phenomena have begun to notice. Chaotic motion occurs frequently in the DC-DC converters[1], for the performance of the harsh electromagnetic noise, the control system of the intermittent unstable and critical operation of the collapse, and so on. Chaos movement studies have identified in the DC-DC converters, most of them because of bifurcation and chaos caused in the system.

II CHAOS CONTROL OF EMI

In recent years there is wide expansion in the field of electronics , many applications in the field of electronics are been invented ,example electric vehicles ,smart phones and many others. All these applications use DC .The current we obtain from the grid is the AC current so it is necessary to convert AC current into DC current .To convert AC current into DC current the DC-DC converters are been used and they play a major in the conversion. DC-DC converters play a major role in portable electronics devices. The devices are supplied by the power through batteries rather from the external sources. “EMI is an unwanted disturbance that effects electrical circuits due to either electromagnetic induction or-electromagnetic radiation[4] emitted by an external source.” In terms of frequency band EMI is differentiated into two types electromagnetic induction with lower frequencies and electromagnetic radiation with higher frequencies. The conducted EMI with frequency ranging between 10KHZ to 30MHZ are of two types, Common mode (CM) noise and differential mode(DM) noise.

Common Mode noise:“Is conducted through all lines in the same direction and exists between power line and ground”.

Differential Mode noise:“Is conducted through all lines in the inverse direction and exists between power lines”.

The three power quality terms ie power factor, THD and EMI are related to each other. When there is high rate of change in voltage or current the EMI increases rapidly due to this THD increases and the power factor decreases.

So it is necessary to decrease the EMI,EMI may be in the form of Radiated EMI or Conducted EMI .Conducted EMI (low freq) and Radiated freq(high freq) are controlled using the chaos effect. When EMI is reduced the THD decreases[2] and Power factor increases (near to unity),so the loss of power is controlled using chaos.

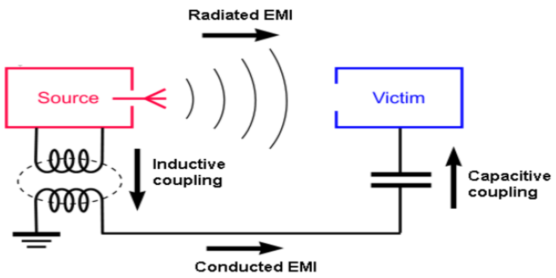

Figure 1.3 EMI Coupling modes

EMI is estimated by measuring the power spectral density (PSD),which tell the power of a signal or time series is distributed with frequency.

Conventional Techniques to suppress EMI:

Many methods are presented to suppress the EMI, the first one is the EMI filtering ,second is the EMI shielding[3].

EMI filtering: In EMI filtering only the lower frequency bands are been suppressed .So to suppress wide bind frequencies multiple filters are been used .Using multiple filters the wide band frequencies can be suppressed but the cost and weight will be increased and causes portability problem and design complexity.

Electromagnetic Shielding:"Electromagnetic shielding is the process of limiting the penetration of electromagnetic fields into a space by blocking them with a barrier mode of conductive material". It is effective method but it is very expensive.

Soft switching: The technique of soft switching was proposed in the year 1990 and is developed tremendously in recent years. The main aim of switching is to reduce the switching loss when converters function in high frequencies by switching on and off at zero current or zero voltage and thus reduces EMI. It has its own drawback, it focuses only on the frequency range 150KHZ to 30MHZ but fails to operate in the range of 10khz to 150khz.It requires more components hence expensive and difficult to design.

Random modulation: It is the new method introduced in the recent years to reduce EMI. It means the frequency switch is varied according to the given random signal, thus the overall energy is spread over a wide frequency band. The two limitations of random modulation is its very difficult to get real random signals and the design becomes complex.

With all the above limitations the two control techniques is been proposed:

1 Chaotic Peak current mode control

2 Chaotic Pulse width modulation control

In this project we are using Chaotic Pulse width modulation control.PWM is the most widely used and implemented technique to control EMI in DC – DC converters. This can be mainly differentiated into three sub parts, sampling and error amplifying, PWM carrier and PWM signal output.

III BOOST CONVERTER

A conventional boost converter is shown in Fig. 1, with a feedback path comprising a comparator and a flip- flop. The comparator compares the inductor current with a reference value (I_{ref}), to control the state of switch *S*.

The circuit has two states, depending on whether the controlled switch *S* is open or closed. When *S* is closed, diode *D* is reverse biased and is non-conducting. Neglecting the resistance of inductor *L*, i_L rises linearly and energy is stored in the magnetic field of the inductor. *S* is opened when $i_L = I_{ref}$ at which instant, a voltage $\frac{L di_L}{dt}$ is induced in the inductor, to try to maintain the current flow. This voltage forward biases the diode and the current decays linearly, accompanied by a transferral of energy from the inductor to capacitor *C*. The switch closes each time a pulse arrives from the clock with the period *T*. Increasing I_{ref} increases the energy transfer and consequently the output voltage of the converter.[5]

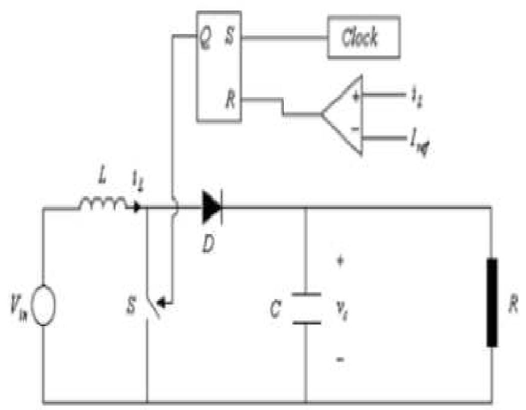

Figure 1 Boost Converter

IV CHOAS CIRCUIT OPERATION

Pyragas [8] has suggested that chaotic behaviour may be eliminated from the system if one applies the delayed feedback control scheme shown in Fig. 2.The feedback control force F(t), applied to the system is the difference between the current value of some system variable y(t), and its value τ seconds previously, multiplied by a constant K, where K is the feedback strength. The idea behind the scheme relies on the fact that a skeleton of a chaotic attractor is formed by an infinite (countable) set of unstable periodic orbits with different periods. If the value of time delay τ is exactly equal to the period T of one of the orbits, then at the appropriate values of K the orbit can become stable, and chaos will thus be eliminated. Once control is achieved, i.e. the phase trajectory reaches the periodic orbit, the control force F(t) is zero at any instant. This is called non-invasive control and implies that virtually no power is spent in the control loop to support the desired behaviour of the system.[15]

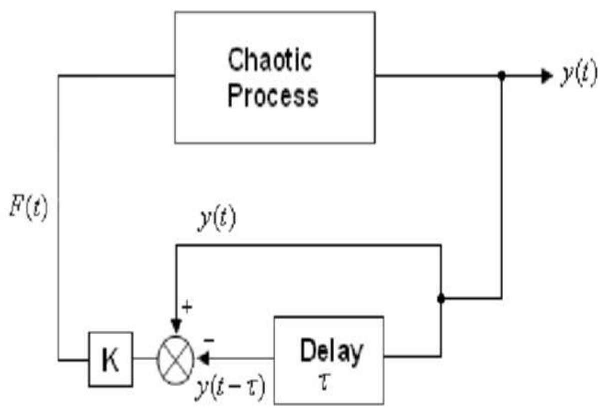

Figure 2 Delayed-current feedback control system.

The overall circuit is given by the figure[6] ,It consists of mainly two operations ,one the boost converter operation and the other control circuit operation. The boost converter operation is already discussed above.

The below figure 3 is the complete circuit diagram of the proposed system. The operation of the system is explained in this section. The operation of the circuit when switch is ON and the operation of the circuit when the switch is OFF is explained below. Also each component proposed in this system is explained.

The components used in the circuit to control chaos are Inverting amplifier ,A/D converter, D/A converter, summing amplifier, Differential amplifier, comparator, Dual mountable multi vibrator, RS flip flop ,level shifter and a driving circuit.

The circuit has two states depending on whether the controlled switch S is open or closed. The sample of the inductor current from the boost converter circuit is given to the feedback inverting Amplifier. The inverting amplifier amplifies the current and the output is inverted and is given to the ADC. The ADC converts the analog signal to the discrete signal. The output discrete signal is given to the delay τ .The signal along with the delay signal i.e $i_L(t-\tau)$ is given to the DAC. The DAC converts discrete signal to analog signal. This signal is given to the summing amplifier as one of the input $i_L(t-\tau)$. The other input $i_L(t)$ to the summing circuit is the output of the inverting amplifier without delay. The output of the summing amplifier is K[$i_L(t-\tau)$ -$i_L(t)$].If both $i_L(t)$ and $i_L(t-\tau)$ are equal then the output of the summing amplifier will be zero. This output is given to the differential amplifier the input. The differential amplifier which acts as a PI controller converts the current in the form of voltage. This is compared with the reference voltage with the help of the comparator . The output of the comparator is given to the mono stable multivibrator.If both the reference voltage and the reference current which is in the form voltage are equal then the pulse is not generated by the monostable multivibrator .Only the clock pulse will be passing which operates the switch to ON and OFF. It means there is no chaos effect and circuit operates in the normal way without loss in the power.

If the comparator of the voltage is not equal to zero it means the reference voltage and the reference current which is in the form of voltage are not equal. This output is given to the monostable multivibrator.The monostable multivibrator generates the pulse because of the non zero input .Along with the clock the pulse generated by the monostabe multivibrator is given to the RS flip flop .The RS flip flop resets in this condition. Due to this the pulse is not generated and make the switch to OFF or ON for that duration of pulse to get the required voltage.

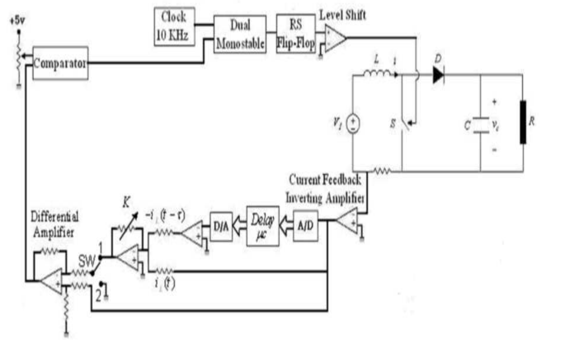

Figure 3.Chaos control circuit

V SIMULATIONS

The waveform of the input AC side waveform is as shown below

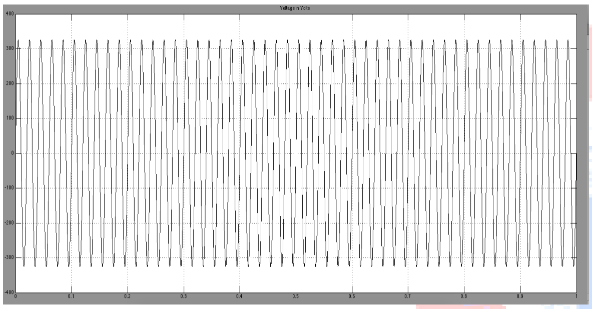

Figure 4. Voltage vs Time Input AC side

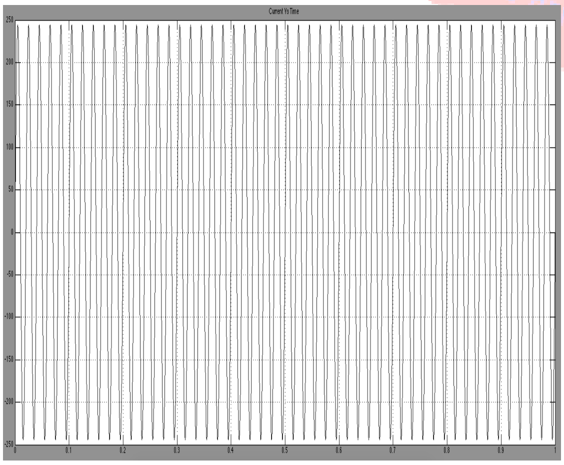

Figure 5.Current Vs Time Input AC side

The input side current waveform, which is in phase with the AC voltage with unity power factor, is shown in the figure 5.

RMS voltage for the input voltage is as shown in the figure 6 The amplitude of the instantaneous voltage is given in the figure which is shown in figure 2 is 300 V and the rms voltage in the figure 3 shows the 230 V. The RMS input current is given as 172 amps.

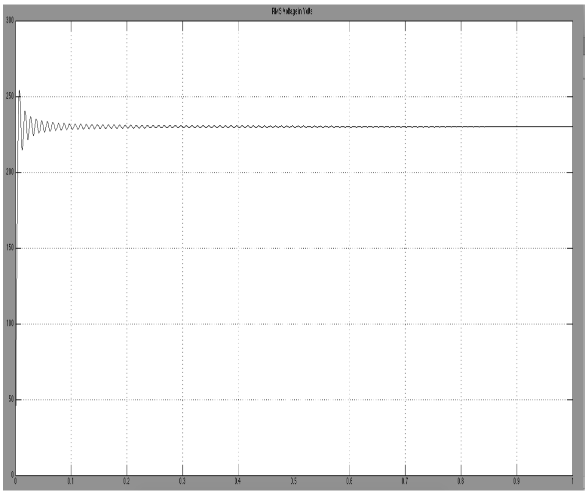

Figure 6. RMS Voltage Input Side

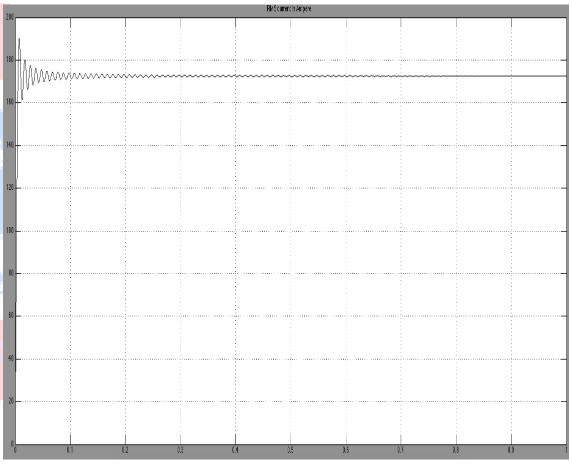

Figure 7 . RMS Current input side

The boost converter DC output is given in the following figures .

The figure 8. Shows the DC current output of the DC boost converter.

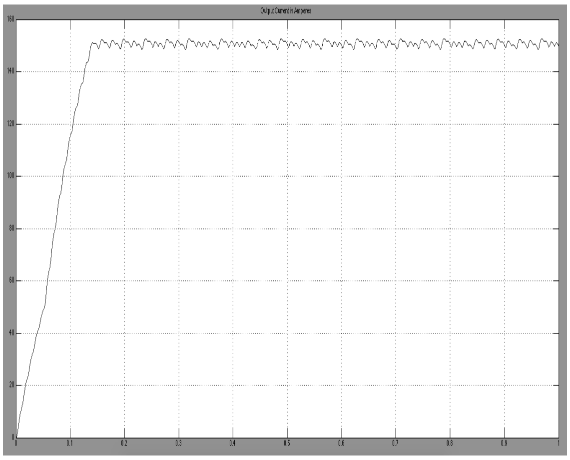

Figure8. Current waveform DC Boost converter Output .

The current waveform has a little ripple in the output which is less than the 1% of the current amplitude which is within the allowable limit.

The ouput voltage waveform of the Boost converter is as shown in figure 9.

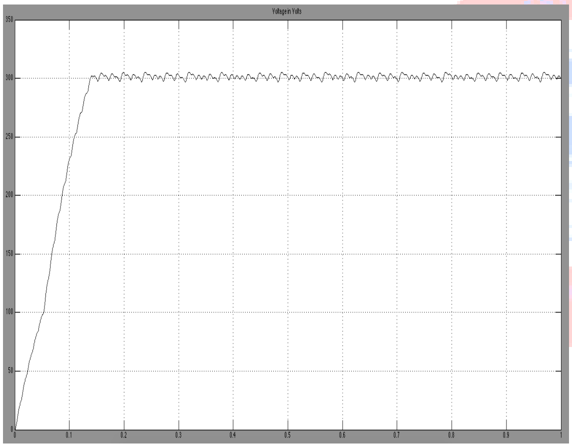

Figure 9. Output Voltage Waveform of the DC Boost converter

The allowable limit of voltage ripple was observed in the above figure.

The power factor of this boost converter working with the chaos control has been observed to be unity which is inferred from the figure 10. Figure 10. depicts that the voltage and the current are in phase with each other.

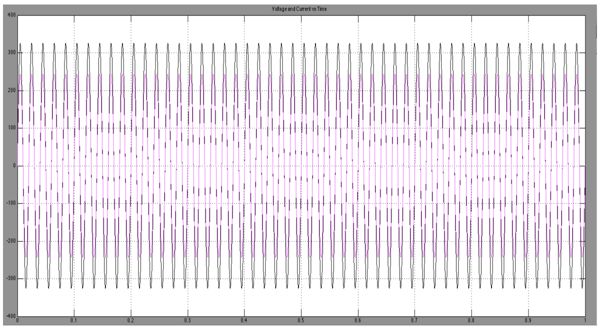

Figure 10. Voltage and Current Vs Time Input AC side

The THD observed in this chaos controlled boost controller in the source side is 0% as shown in figure 11

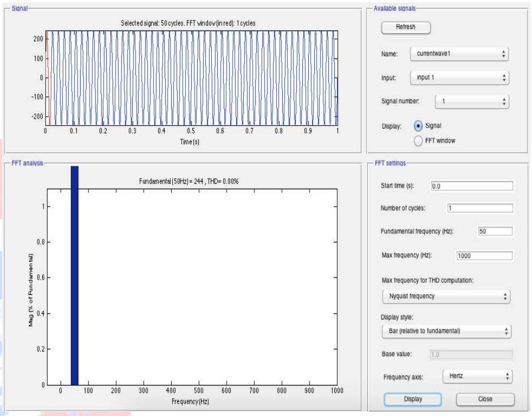

Figure 11. Total Harmonic Distortion

VI CONCLUSION:

The rapid development and wide deployment of electrical and electronic products have caused severe problems to be faced by scientists and engineers. The project surveys the EMI suppression techniques for DC-DC converters, since DC-DC converters have become increasingly important with the rapid development of electronic engineering .The pros and cones of traditional EMI filters and electromagnetic shielding are discussed , and the very promising chaos control methods for EMI reduction are pointed out, which have many merits.

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