Implementation of a New Electro Magnetic Interference Filters Design to Diminish CM Noise

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ABSTRACT: This paper mainly deals with the Electro Magnetic Interference (EMI) in switching power supplies. The EMI consists of two sources of noise namely common mode and differential mode noises. Due to interference, the efficiency of the equipment reduces and sometimes the equipment may be damaged. To avoid this effect EMI filters are designed like Active and passive filters. Passive Electromagnetic Interference (EMI) filters are replaced by active EMI filters to deal with high-frequency noise interference. Based on the measurement of noise EMI filter is designed to avoid interference. Peak current mode control is mostly used for power factor correction. The constant output voltage is also maintained. The EMI filter together with the boost inductor has to attenuate the high frequency (HF) voltage component to the mains side of the converter. With it, the optimum switching frequency and ratio of the ripple and fundamental current amplitude with respect to volume and losses are found. Procedure for designing ac line EMI filters is presented. This procedure is based on the analysis of conducted EM1 problems and the use of a noise separator. Design of active EMI filters leads to optimal component values and eliminates CM noise over a wider frequency range.

KEYWORDS: EMI, EMC, Active EMI filter, PFC

I. INTRODUCTION

   Electromagnetic interference (EMI) is everywhere and unavoidable. It exists in nature and is also manmade. EMI is the unwanted electromagnetic energy which causes disturbances in electronic devices Natural sources can come from lightning and electrostatic discharges; while man-made sources can originate from motors, power lines, fluorescent bulbs etc. All electronic devices have the potential to be sources of EMI by generating conducted or radiating emissions, along with being victims by accepting EMI from other sources. The amount of EMI a device contributes is referred to as conducted or radiated EMI, and the amount of EMI a device which is able to withstand is referred to as EMI susceptibility. In an ideal world the perfect device would not conduct or radiate any EMI and would be entirely immune to EMI susceptibility, however due to the way electronics work this is an impossible task to achieve.

        With consumer electronics continuously on the rise, the effects of EMI on these devices must be taken into consideration._ It would be disturbing to get an audio device interfered by some other device. The effects of EMI can be heard from mobile phones coupling with television speakers, and can be seen by static noise on analog televisions [4]. If the magnitude of the electromagnetic field is large enough it can destroy sensitive electronic equipment. The vulnerability of electronic equipment must be hardened to increase the immunity, along with appropriate design techniques used to avoid conducted and radiated emissions. There are two types of emission namely conducted and radiated. Conducted EMI is defined

as energy which has coupled to a power or signal bus, and is propagating through the system. Radiated EMI is interference which is no longer restricted to a wire, but is an EM wave propagating away from the source. A receptor for EMI is the type device being affected by the interference. The amount of unwanted EMI is referred to as susceptibility. Diminishing the device susceptibility to EMI is also referred to as EMI hardening.

There are three types of EMIs are there which are explained below.

1. Conducted EMI:

When one considers the vast magnitude of interconnected equipment via power lines, telephone lines, or networking cables, the potential problems from conducted EMI is very huge. For example the conducted EMI is given here [5]. The two currents namely I_A and I_B two circuits flows through common source impedance ZS, and also returns through common ground impedance ZG is shown in fig 1. The supply voltage B is modified instantly by the current drawn by the circuit.

2. Internal EMI:

The example TV Attention must be given to module-to-module interference within the system because failure to do so may result in the system failing to perform its intended function. As another Example, take a oscilloscope, the magnetic flux of power transformer can couple high voltage CRT or amplifier circuit. To control the internal EMI the proper shielding, cable and proper layouts are must. With the rising complexity of present systems and with concurrent engineering development becoming trendier to decrease development cycle period to meet market demands; forecast and supervision of internal EMI is a very challenging aspect of electronics design.
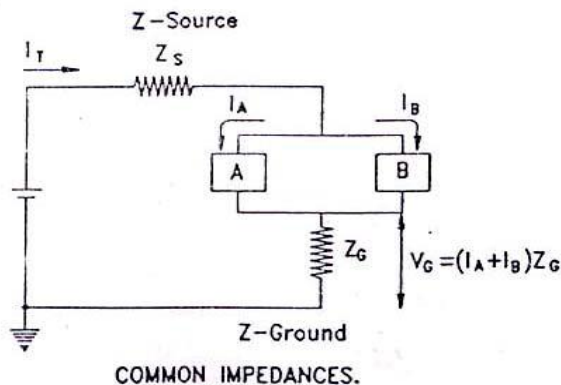

Fig.1 Conducted EMI

3. External EMI:

Consider a TV receiver is operated by using   proximity of a fluorescent tube. It can be observed that when the tube light is "ON", we can the lines or spots temporarily superimposed on the TV picture. These   effects are caused by the EMI from the contact noise of broadcasting which is selected by the TV antenna. The problem can often be seen even if the TV is operated via a cable connection. In that case travels as induced noise on the mains power line.

II. BACKGROUND AND RELATED WORK

Electromagnetic interference produces different types of noises in switching power supplies namely Common Mode Noise, Differential Mode Noise, and Non-Intrinsic Differential Mode Noise etc. These noises can be predictable by Spectrum Analyzer and this filtered by using noise separator. In this chapter Common Mode Noise and Differential Mode noises are considered.

A. Common Mode (CM) noise:
　　This noise is appearing between Phase and neutral side of the power supply of the converter.

B. Differential Mode (DM) noise:
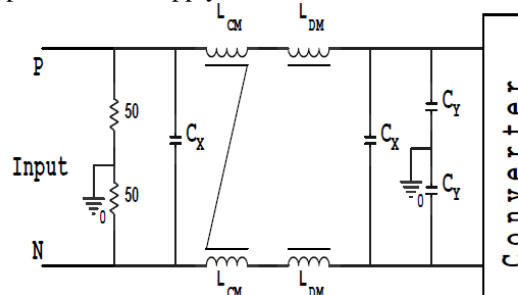　　It is the noise between two phases at the supply side of the converter.

Fig.2 EMI Filter

Fig.2 shows the structure of EMI filter. Here the parameters L_{CM} and C_Y are mainly used to suppress the common mode noise likewise L_{DM} and C_X are used to suppress differential mode noise. The two 50 ohms resistors are called as Line Impedance Source Network (LISN). The EMI Filter with LISN is connected to Spectrum analyser through noise separator to split   CM noise and DM noise to observe the spectrum of the total noise. The common mode current is flowing in all signal leads by using the ground as a return path. The differential mode current is flowing in two complementary leads; it flows in the same path as the functional current. The common mode voltage Vcm is the voltage between the ground and the geometric centre of the leads. The non symmetric voltage is the one between one lead and the ground. The differential mode voltage is the voltage between two leads.

III. TYPES OF NOISE FILTER

There are two types of noise filters are available namely passive and active noise filter.

A. Passive Noise Filter:
　　For inverter equipment, noise filters are virtually crucial in view of the EMI standards. Passive filters are commonly designed by common mode coils, capacitors are connected to ground also placed across the phases. The amount of filter attenuation is   determined by the components characteristics. The filters are in design stage still, its normal to theoretically secure the preferred amount of attenuation. However, this is not the sufficient and it is necessary to pay the attention to the followings (1) installation positions, (2) magnetic saturation of coil cores, (3) leakage current.
　　When a common-mode coil is made by using a large number windings of turns onto a small core, is used the core can go into magnetic saturation. To avoid saturation we have carefully design the core size and number of windings. Besides, since such a noise filters are designed by using LC circuitry, it has a resonant frequency. If this resonant frequency corresponds with a carrier frequency, a high common-mode current will be produced, so care is required. Moreover, regarding the magnetic

fluxes produced by coil cores, often only those fluxes that are generated by common-mode current are considered. The magnetic flux is also generated by using a normal mode current However, magnetic flux is also generated by normal-mode current on account of leakage inductance [9]. But the normal mode has a huge current value, for the flux that will develop in the coil core, it is necessary to calculate the saturation strength based on the flux amount determined by combining common-mode-induced flux and normal- mode-induced flux.

B. Active noise filters

A typical way to reduce the electromagnetic noise is to connect a passive filter, but this way we can increase the overall volume and cost of a given inverter system. The resonant problem is occurs between reactors and capacitor by making up a passive filter and magnetic saturation in the cores of such reactors. Therefore, we introduce a "active noise filtering" that is characterized to reduce both normal-mode and common-mode conducted emissions, this eliminates the need of a common-mode transformer, and its makes possible to reduce the breakdown voltage of transistors that are used in active elements. An active noise filter is designed such that to detect conducted emissions and perform feedback control on output current for each individual phase with the help of transistor circuitry so as to reduce those conducted emissions to zero.

IV. ACTIVE EMI FILTER DESIGN

Passive EMI filters are found in almost all electronic equipment these days to comply with emission standards of commercial purposes.

1. LC Inductor filter

The choice of EMI filter depends on the noise source and load impedance. The CM noise source impedance is much greater than the CM noise load impedance which is approximately 50Ω. For such configurations, LC inductor filter is appropriate and to increase the attenuation and to understand a steep skirt response, several LC stages may be cascaded. Capacitors Cy is used to bypass the Common mode current to ground. When the load and source impedances are unequal, the largest insertion loss is usually achieved be achieved when the shunts capacitors has the higher impedance. The filter is placed between the LISN and EUT and the filter has two CM inductors L1 and L2 and two CM capacitors. The total capacitance, Ct is,

$$C_t = C_Y + C_Y \qquad (1)$$

So, 1pF value is chosen for each capacitors for the design and then we use these capacitor value for the CM inductors are tuned to the required value such that they could provide the CM filter insertion loss indicated in equation. The tuned values of CM inductors are, this filter gives the poor attenuation at high frequency and the resonance effects caused by lead inductance of the capacitors are of critical importance.

2. Choke Filter

Traditionally, the IL has been used to characterize power filters or their elements. Unfortunately, the IL alone is not enough tp provid information for full characterization. DM and CM modes are described in the following section which is used to show how the IL and the elements of the π-equivalent circuit of a CM choke can be obtained. The winding is done along with the minimum inter winding capacitances and the CM chokes executes well because the permeability to common-mode currents is much better [11, 12]. This is very similar to LC but it uses a single choke inductance. The CM capacitance is 1pF each and the tuned CM choke inductance is about 2mH that created almost negligible CM noise across the output of noise separator. But, choke filters have a poor compensation and they too operate well only over a narrow range of frequencies due to parasitic affect of the passive components and the limitations of the leakage inductance. By analyzing the several techniques and Keeping in view all these negative aspect of passive EMI filters, the design of a simple active EMI filter was considered a good substitute and the schematic employing an active EMI filter is shown in Fig.3

3. Active EMI filter:

The active EMI filter consists of a 741 op-amp along with some resistors and capacitors. A transformer coupled is used between EUT and LINS and the capacitors c1 and c2 should not be huge to meet the leakage current safety specification. Hence, the capacitances chosen were, =3300pf. This Coupled transformer was tuned to specific values such that it produced minimized to CM noise satisfying the condition. The designed internal parameter values of the CM coupled transformer are, c=0.01pf,G=100,L=0.1 R=0.5K ohms.
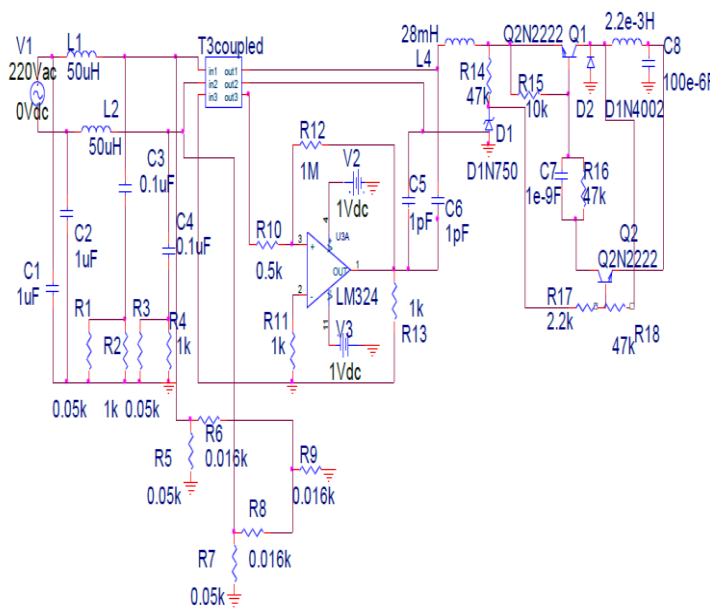

Fig.3 Active EMI Filter

Peak current Control

    Peak current mode control is a two loop control method which is inner loop and outer loop for power electronic converters. The main advantages of peak current mode control is to operate with a constant switching frequency, only the switch current is sensed and this can be proficient by a current transformer, this avoids the losses due to the sensing resistor and there is no use of current error amplifier and its compensation network and there is a possibility of a true switch current limiting.

Power Factor Correction

    PFC is a measurement of the degree of the utilization of the power from grid. Mathematically its defined as proportion of the real power to the apparent power and is in the range of 0 to 1.

$$PFC = \frac{Real\ power}{Apparent\ power} \qquad (1)$$

    Real power is measured in the unit of watts and is the power necessary for real work done. Apparent power is measured in volt-amp and is the vector summation of active and reactive power. Consider the ideal sin input voltage source, PF

is defined as the product of displacement power to the distortion power as given in eq.2. The distortion power factor is the ratio of the root-mean-square (RMS) current Irms to the total RMS current Irms. The displacement power factor is defined as the cosine of the displacement angle between the fundamental input current and the input voltage (4).

$$PF = K_d\,K \qquad (2)$$

The distortion power factor is given by the following equation.

$$K_d = \frac{I_{rms(1)}}{I_{rms}} \qquad (3)$$

The displacement power factor K is given by the following equation

$$K = cos\theta \qquad (4)$$

Simulation of the proposed circuit that is bridgeless high power factor buck converter with peak current mode control is done simulation tool. Simulink model of the proposed circuit control is shown Fig.4 Simulation is done with an input voltage Vac =230V, fs=50 kHz, R=38 Ω , L1=L2 =100H,C1=C2=500μF, P =700W and Vout=180V.Bridgeless buck rectifier provides input power factor upto 0.9 and also constant output voltage is maintained.
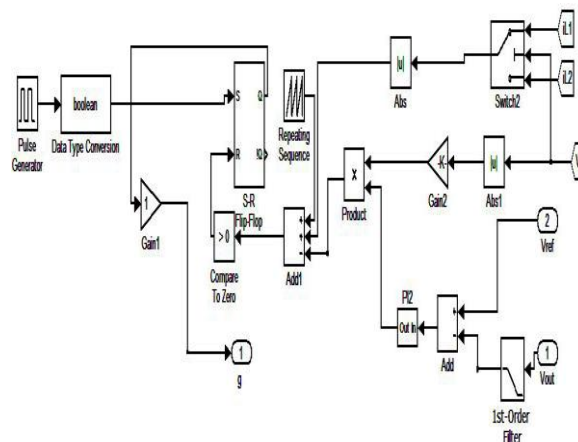
Fig.4 Bridgeless Buck Rectifier

The need of the power factor correction circuit understate are maintaining a pure dc output voltage of stable value and maintain input current waves form as pure sinusoidal at unity power factor. But PFC buck rectifier will not shape the line current during the time intervals when the line voltage is lower than output voltage.
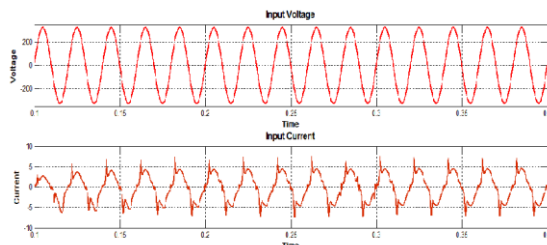
Fig. 6 Simulation graph

V. CONCLUSION

The measured and simulation of the process is done over the range of 150-2MHz frequency range, passive noise filters are not used to minimize the CM noise level below the narrow frequency range but frequency beyond the limit the parasitic components of the passive filters are increased and become heavy. On the other side active EMI filters are very compact and it could be used in wide range of frequencies in the range of 150khz to 3khz.so that active EMI filters are better alternative for passive EMI filters for reducing common mode noise. Peak current mode control is used to control the process of buck converter. The power factor is maintained high and the also the output voltage is maintained constant. The simulation of the bridgeless power factor buck converter is carried out Simulink.

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