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PERFORMANCE AND ANALYSIS OF DIFFERENTIAL MODE NOISE SEPERATION FOR POWER SUPPLIES

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ABSTRACT

In switching power circuits, due to the rapid switching of high current and high voltage, interference emission is created a serious problem. With the increase in switching frequency, possibility of interference also increases. When the interference is strong enough, then it can affect the normal working of associated circuits also. Electric and magnetic fields exist in any operating electric circuit. The current flowing in the circuit generates a magnetic field. For such a current to flow, there must be a potential difference, which produces an electric field. These fields can exist in any substance, including a vacuum. If they are strong enough, they make it possible for one electrical device to affect another. When this occurs unintentionally, it is known as electromagnetic interference, commonly abbreviated as EMI and often simply called as 'noise'.

Keywords: *Differential mode noise, Common mode noise, LISN, switch mode power supply, EUT,EMC*

1. INTRODUCTION

EMC is the ability of an electrical installation to work properly in an electro magnetically polluted environment without disturbing other electrical devices due to the emission of EMI. It means that the electrical devices don't influence themselves and one another, e.g. via the common ground of control and power circuits.EMC is defined as "the capability of components (of electronic system) to function together". EMC refers to the capability of two or more electrical devices to operate simultaneously without mutual interference. EMC is the ability of a system to function reliably even in the presence of a noise generating source, at the same time limits its own internally generated EMI to avoid any further interference at a higher system level. In order to achieve this goal, intentionally regulatory bodies have recommended acceptable emission levels. Commonly referred EMI standards include the International Special Committee on Radio Interference (CISRP), the U.S Federal Communications Commission (FCC) and German Verband Deutscher Elektroniker (VDE) specifications. FCC and CISPR standards have been organized for controlling the quantity of EMI emission that is generated from electric equipments. Electromagnetic energy generates both electric and magnetic fields, which can propagate into the environment in one of the two types of emissions and they are namely Radiated emissions and Conducted emissions

Electronic equipments are highly sophisticated, and hence more susceptible to EMI, power line filters will be called upon to perform the larger role. Brute force and off the shelf filters will not always satisfy the special requirements. The largest interest in power line filters is an economic one. An on board filter may be built in routine for roughly half the cost of a vendors enclosed filter. This cost savings is due to several factors. First, when building the power supply board, the filter components may be added for a very small cost. Next, having the filter on board saves the cost of a separate safety certification since the filter and the power supply are certified as one unit. Finally, the user saves the cost of the overhead and profit of the filter manufacturer. The largest drawback of an on board filter is the problems often experienced with radiated coupling to the filter resulting in degradation of performance.

Unlike communication filters, power line filters are terminated with varying source and load impedances. In addition the power handling requirements drive many of the parts parameters, such as breakdown voltage, wire size and core size. In power line filters, ideal elements are not accurate models of the real elements used. The real strength of the graphical attenuation calculation

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methodology is to simplify the calculations and the intuitive insight gained into the operation and optimization of filter.

1.1 Radiated EMI noise

Switching power supplies generate radiated EMI emissions. Radiated EMI appears in the form of electromagnetic waves that radiate into the immediate atmosphere directly from the circuitry and its interface leads. The circuitry and its interface leads can be connected together to a transmitting antenna for eliminating this radiated EMI. Radiated EMI emissions are generally measured at much higher frequencies beyond 30 MHz upto several GHz. Radiated interference is normally minimized, as a result of layout and wiring.

1.2 Conducted EMI noise

Switching power supplies generate conducted EMI emissions. The conducted EMI noises are separated by CM noise and DM noise. Conducted EMI emissions are measured at frequencies from 150 KHz to 30 MHz. To minimize this noise, a filter is inserted between the power lines and the power supply. The design of a power line filter for a power supply is also done with CM and DM parts.

2. CM AND DM SEPARATION

Diagnosis of power supply conducted EMI using a noise separator. It has been modified by a power combiner who is physically the same as a power splitter but used in reverse. A power splitter is a commonly used Radio Frequency (RF) device for splitting an input signal into two signals with equal amplitudes and a specified phase angle. 0^o power combiner is called Differential Mode Rejecter (DMR). 180^o power combiner is called Common Mode Rejecter (CMR). To measure the total noise; the input signal bypasses both DMR and CMR. The performance of the noise separator has been evaluated by measuring the rejection attenuation of both modes of noise going through the CMR or the DMR.

2.1 Differential Mode (DM) noise

DM mode currents are opposite in phase on the hot line and the return as shown in Figure 1. The parasitic capacitance will introduce DM noises. DM noise may also be referred to as normal mode or longitudinal mode. It is also characterized by the currents flowing in the phase and neutral lines being 180° out of phase. The DM noise is dominant at frequency range less than 2 MHz. DM noise can also be caused by pulsating transistor current. DM noise follows the same path as the input power. DM currents flow in and out of the switching power supply via the power leads and its source (or load), and are totally independent of any grounding or earthing arrangement. Consequently, no differential mode current flows through the earth connection. Types of Differential Mode Noises

- Intrinsic DM (IDM) noise
- Non-Intrinsic DM (NIDM) noise

Intrinsic DM (IDM) noise

A pulsating or harmonic rich input current causes IDM noise. It exists even when there is absolutely no ground.

Non-Intrinsic DM (NIDM) noise

NIDM caused by ground current is a phenomenon existing in every power supply. The mechanism of NIDM noise is similar to common mode noise; both depend heavily on parasitic capacitances. The term “non-intrinsic” is used to distinguish the DM emission mechanism from the “intrinsic” DM that exists when there is absolutely no ground. NIDM is also termed as MM noise. NIDM noise occurs due to current imbalance in the LISN branches.

3. RESULTS

Simulation circuit for DM noise without filter is shown in Figure 2 and the simulation result as shown in figure 3. Simulation circuit for DM noise with filter is given in Figure 4 and simulation result waveform is shown in Figure 5. Experimental results with and without DM filter is shown in Figures 6 and 7.

4. CONCLUSION

In this paper, the differential mode noise can be measured by means of the simulation and hardware setup. Once the values are verified with commonly referred EMI standards include the International Special Committee on Radio Interference (CISRP), the U.S Federal Communications Commission (FCC) and German Verband Deutscher Elektroniker (VDE) specifications. From the above results, it is observed that the dm noise reduction at 0.750 MHZ is 16.4 dBµV in hardware and it is the highest noise

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reduction. The total noise reduction is very much below the limit of the FCC class A and class B standard.

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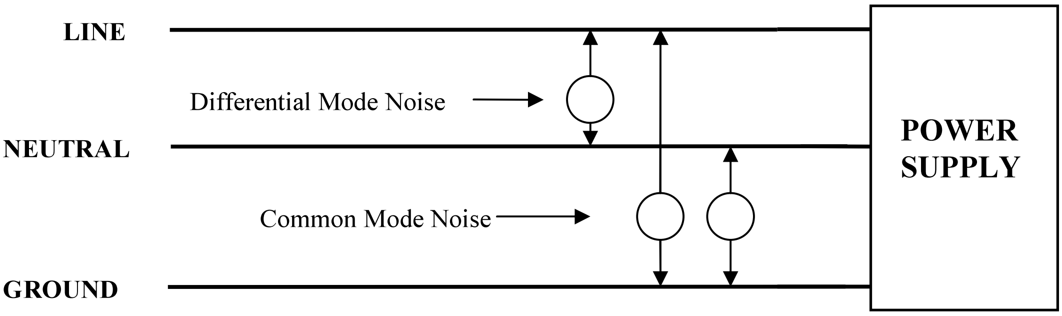

Figure 1. Conducted EMI noise

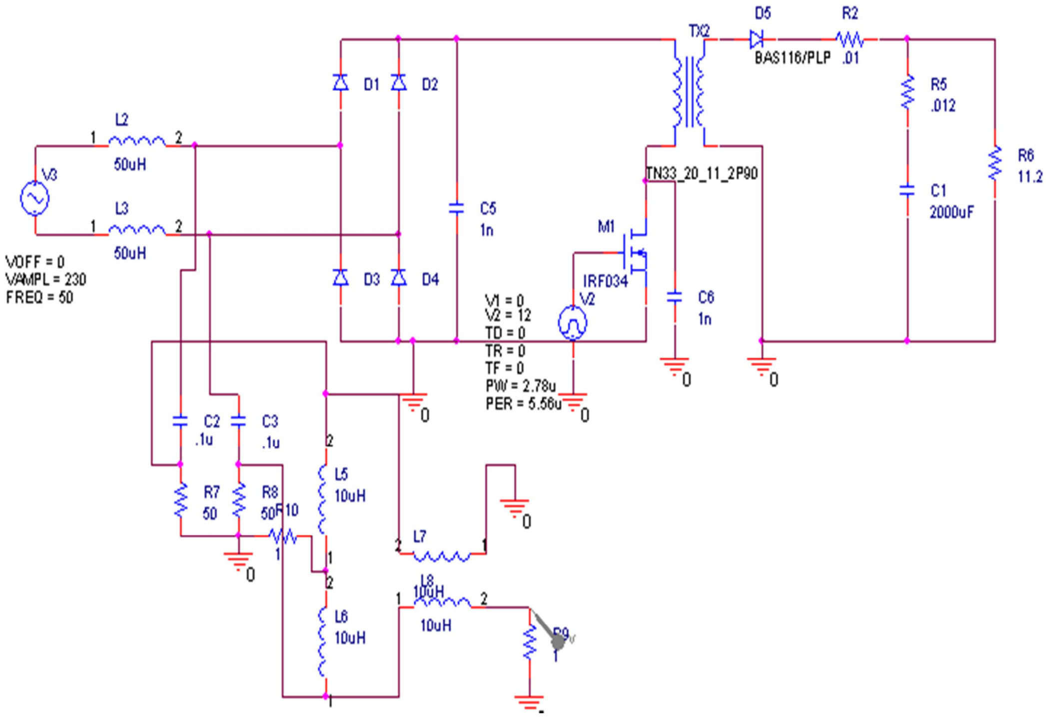

Figure 2 Simulation diagram for DM noise without filter

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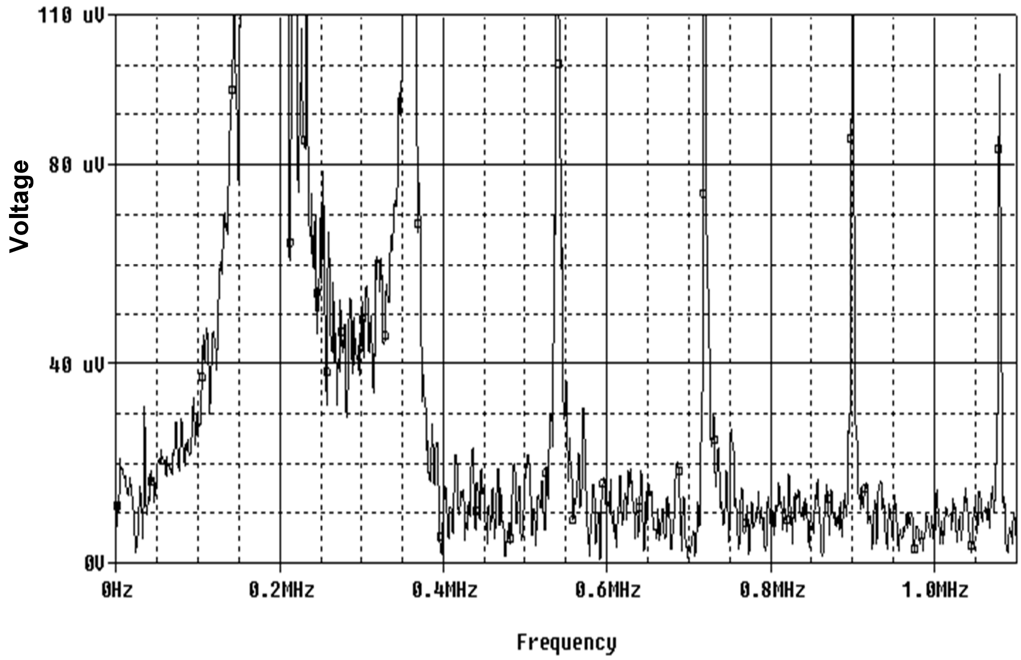

Figure 3 Simulation result of DM noise without filter

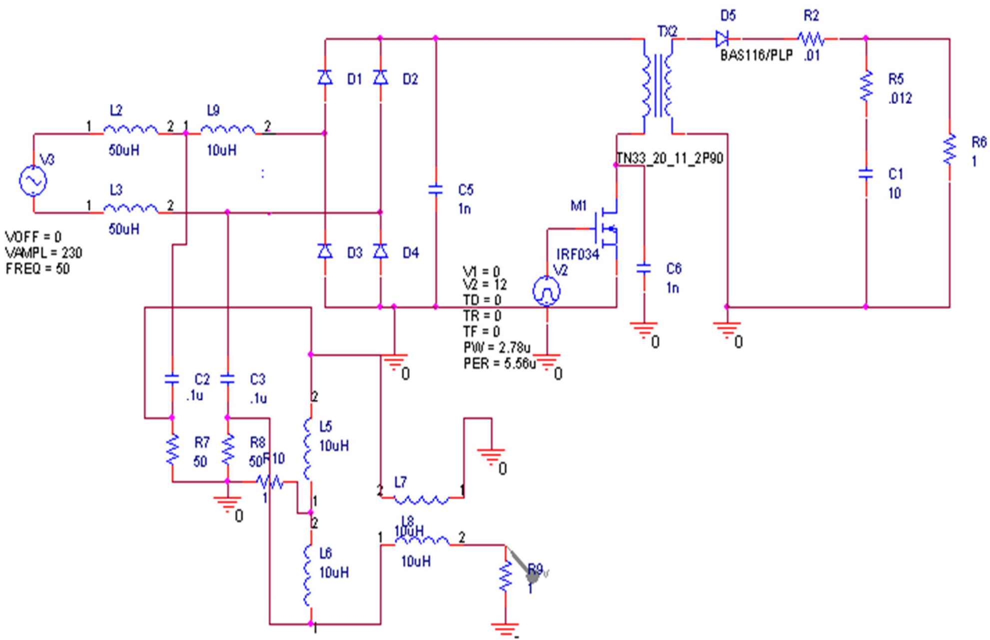

Figure 4 Simulation diagram for DM noise with filter

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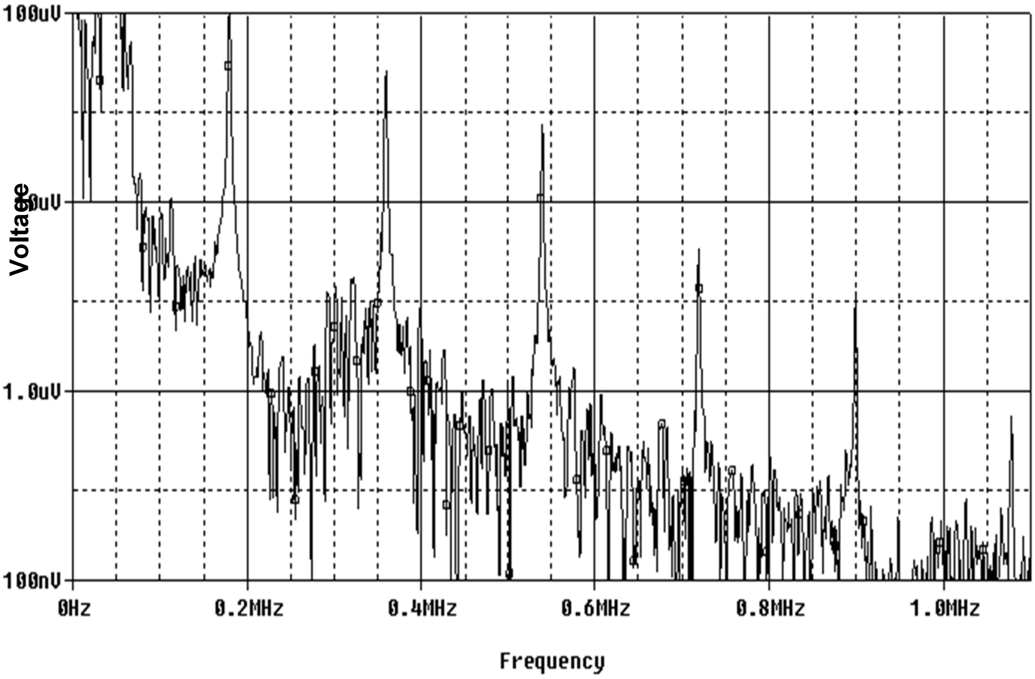

Figure 5 Simulation result of DM noise with filter

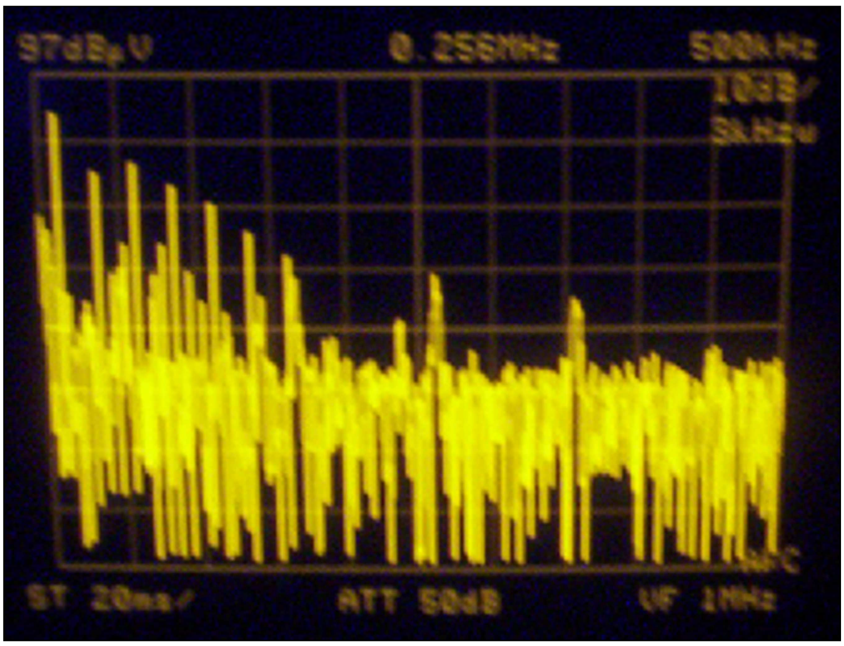

Figure 6 Hardware result of DM noise without filter

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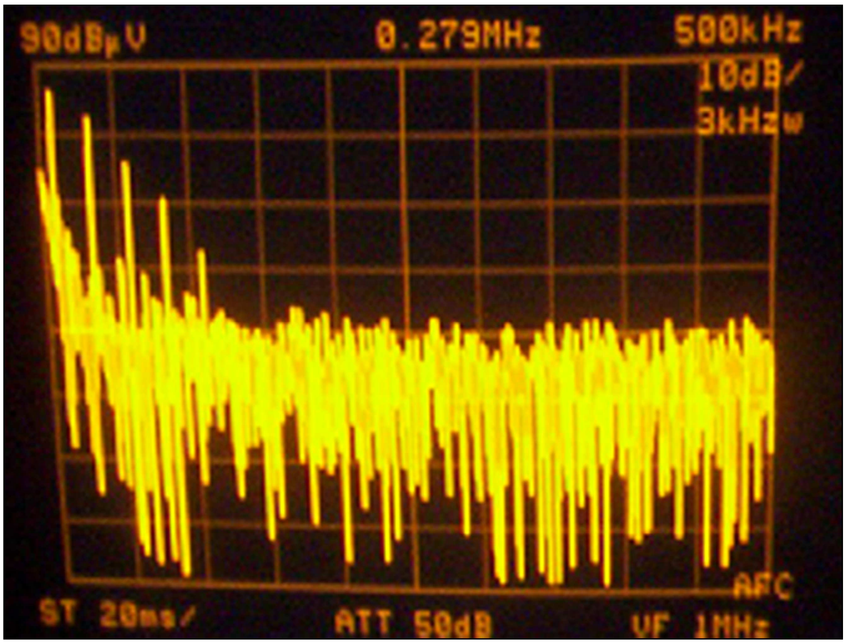

Figure 7 Hardware result of DM noise with filter