IIT MADRAS
Indian Institute of Technology Madras

Technology Transfer Office
TTO – IPM Cell

Industrial Consultancy & Sponsored Research (IC&SR)

PCB-incorporated based low cost differential mode filter for EMI/ EMC of power electronic converter

IITM Technology Available for Licensing

PROBLEM STATEMENT

- **Electromagnetic interference (EMI)** poses significant challenges for power electronic converters, necessitating emissions below international standards.
- The frequency range for **conducted emission noise in power electronics is 150 kHz to 30 MHz**, divided into high-frequency and low-frequency zones.
- Low-frequency zone primarily influences conducted emissions due to converter switching frequency.
- High-frequency zone includes emissions related to switching transients, especially in **Wide Band Gap devices like SiC MOSFETs.**
- Current passive filter designs typically maintain a corner frequency below 150 kHz.
- **PCB-level inductors** are utilized in series with X-capacitors, optimizing impedance at around 160 kHz.
- **Biela et al. (2009) present a passive hybrid integrated EMI filter**, combining integrated and discrete components.
- Despite advancements, reliance on bulky common mode chokes and differential mode **inductors remains a limitation, especially in achieving** inductors with high self-resonant frequency values.

TECHNOLOGY CATEGORY/ MARKET

Technology: Low cost differential mode filter for EMI/ EMC
Category: Electronics & Circuits
Industry: Electronic components industry
Application: Power Converters And Inverters
Market: The global market size was valued at **USD 56.44 Billion in 2021** and is projected to reach **USD 109.80 Billion by 2030,** growing at a **CAGR of 8.23% from 2023 to 2030.**

INTELLECTUAL PROPERTY

IITM IDF Ref. 2524,Patent No: IN 549282

TRL (Technology Readiness Level)

TRL-6, Technology validated in relevant environment (Industrially relevant enabling technologies)

Research Lab

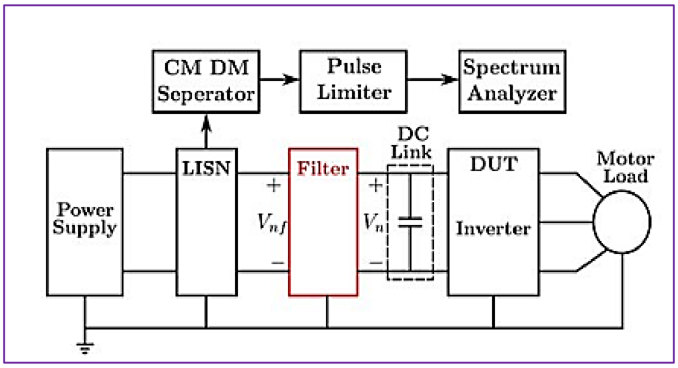
Prof. Kamalesh Hatua ,
Dept. of Electrical Engineering

TECHNOLOGY

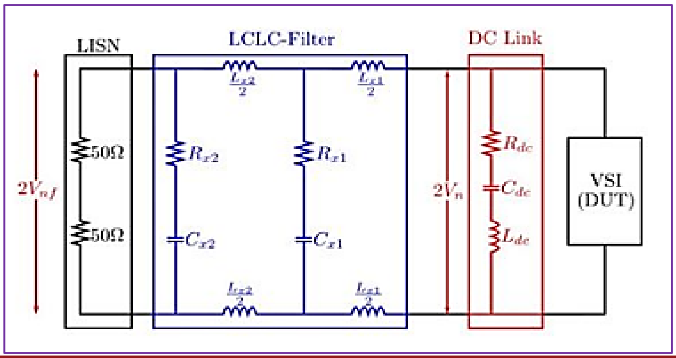
- A **filter reduces Differential Mode (DM) emission noise in power converters** with an inductance-capacitor circuit and damping resistance, ensuring attenuated noise **(Vnf) meets the equation.**

$$V_{nf} = \left[\frac{(1+sC_{x1}R_{x1})(1+sC_{x2}R_{x2})}{(1+sC_{x1}R_{x1}+s^2C_{x1}L_{x1})(1+sC_{x2}R_{x2}+s^2C_{x2}L_{x2})}\right] \times V_n$$

Block diagram in a real-time application



Circuit diagram



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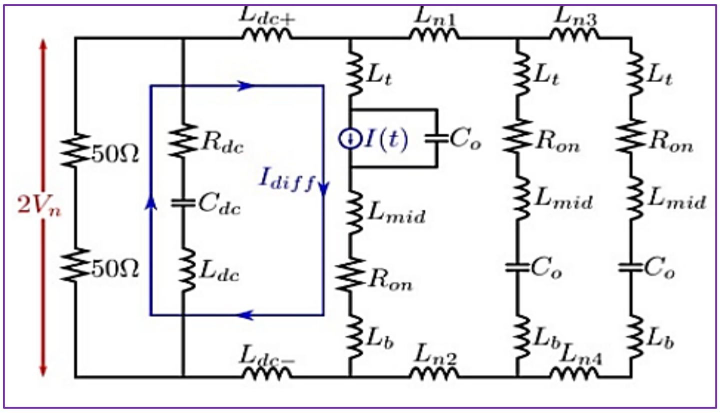
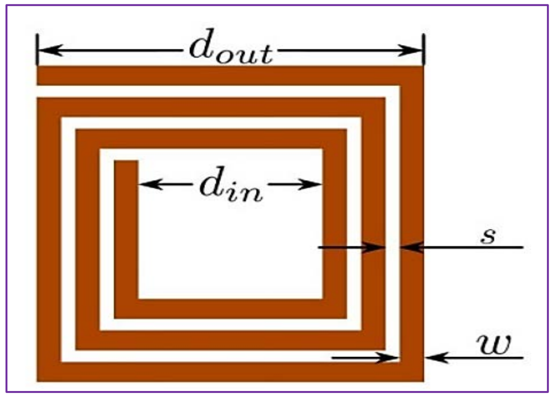
Circuit of an experimental set up



Copper trace on the PCB



Key Features / Value Proposition

Reducing Differential Mode Emission Noise in Power Converters

- **Utilizes printed circuit board filter.**
- **Implements inductance-capacitor circuit with damping resistance.**
- **Adjusts length, width, thickness, and distance between PCB traces.**
- **Multi-layer PCB for higher inductance and current rating.**
- **Device free from magnetic core.**
- **Estimates differential mode noise voltage for voltage source inverter.**

$$V_{nf} = \left[\frac{(1+sC_{x1}R_{x1})(1+sC_{x2}R_{x2})}{(1+sC_{x1}R_{x1}+s^2C_{x1}L_{x1})(1+sC_{x2}R_{x2}+s^2C_{x2}L_{x2})}\right] \text{x}\, V_n$$

$$V_n = \frac{I(s)[s^4A_1 + s^2B_1 + 1]Z}{sC_{dc}[As^6 + s^5B + s^4C + s^3D + s^2E + sF + 1]}$$

where $L_1 = L_t + L_b + L_{mid}$, $L_2 = L_1 + L_{n3} + L_{n4}$ and $L_3 = L_{dc} + L_{dc+} + L_{dc-}$;

Coefficient	Expression
A	$C_o^3[L_1L_2(L_2+L_3) + (L_2+L_1)((L_{n1}+L_{n2})L_3 + L_1(L_{n1}+L_{n2}+L_3))]$
B	$C_o^3R_{dc}[L_1(L_1+2L_2)+(L_{n2}+L_{n1})(L_2+2L_1)]$
C	$C_o^2[L_1(L_1+2L_2)+2L_3(L_2+2L_1) + (L_{n1}+L_{n2})(L_1+2L_3+3L_1)]$
D	$C_o^2R_{dc}[4L_1+2L_2+2(L_{n1}+L_{n2})]$

E	$C_0[2L_1+L_2+3L_3+2(L_{n1}+L_{n2})]$
F	$3C_0R_{dc}$
A_1	$C_0^2[L_1L_2+(L_2+L_1)(L_{n1}+L_{n2})]$
B_1	$C_0[L_2+L_1+2(L_{n1}+L_{n2})]$

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