EE 673, Power Electronics and Power System Laboratory

Indian Institute of Technology, Bombay

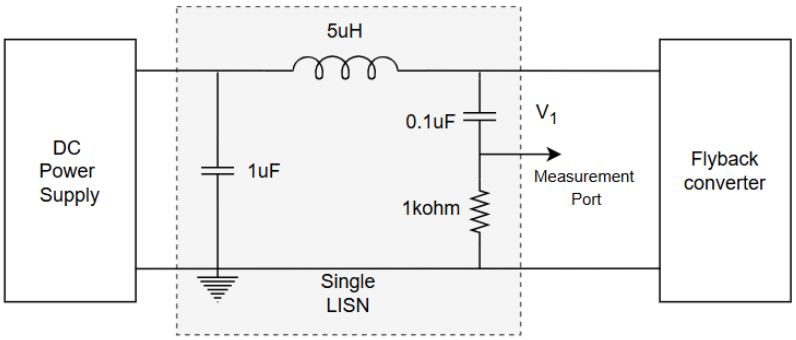
Experiment : Conducted EMI measurement

Date- 28/03/2025 ***Duration: 3 hours***

Software

Activity 1:

- Model the flyback converter with all the parasitics in LTspice in open-loop configuration.
- Connect a single LISN to measure complete EMI (CM + DM).



- Capture the waveform to observe both common-mode and differential-mode noise combined.

Steps to obtain EMI spectrum:

- Run the simulation.
- Open the plot window.
- Right click → View → FFT → Select measurement port
- TO convert into dBµV → right click to open expression editor → multiply by factor $5*10^5$

Activity 2 -

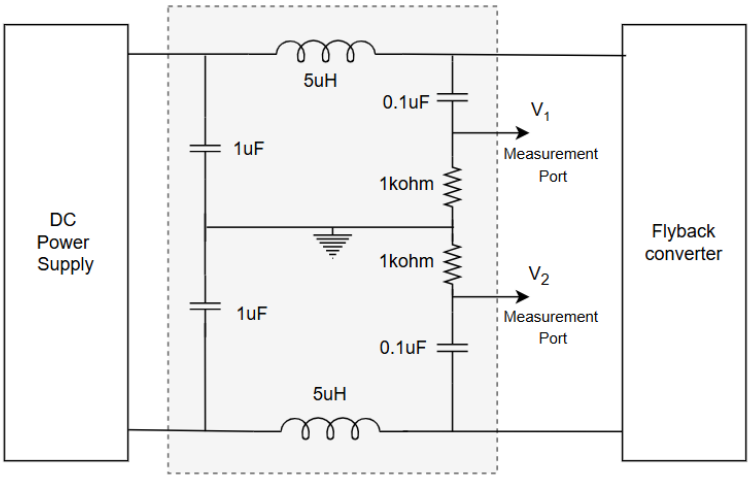
- ADD CISPR limit lines for acceptable EMI levels. The EMI plot (in dBµV) should be below the CISPR limit line across the entire frequency range. Table for Class B (Residential, commercial & light industrial, PC, notebook adapter) CISPR limits given below.

Frequency (MHz)	Quazi Peak (dBµV)
0.15 - 0.5	66 decreasing to 56
0.5 - 5	56
5 - 30	60

Steps to add CISPR line:

- Right click on FFT plot window →Notes & Annotation → lines → Draw lines according to CISPR standards
- Identify frequency components exceeding the limits and find maximum frequency components.
- Save the plot settings

Activity 3 – Connect two LISN to measure CM and DM noise separately.



- To get the EMI spectrum follow the steps in activity 1 and select both measurement ports → Alt & double click to get expression editor and write the below formulas
- CM → $(V_1 + V_2)*500000$
- DM → $(V_1 - V_2)*500000$
- ADD CISPR limit line to find the frequency components exceeding the limits find maximum frequency components for which filter need to be designed.

Activity 4 –

Change gate resistance and observe the effect on CM & DM noise.

Activity 05 –

- Change the switching frequency and observe the effect on CM & DM noise.

Hardware

Activity 1: Oscilloscope settings

- Channel 1 → Set probe impedance to 50Ω.
    - Spectrum view → Turn ON display → set unit in dBμV → Normal/max-Hold
- Spectrum plot → Center frequency = 15 MHz, Span = 30 MHz, RBW = 9 kHz / 10 kHz.
- Spectrum plot → view settings → Set X-axis as log
- Adjust trigger for stable spectrum

Activity 2: Connect a single LISN to observe complete EMI (CM + DM). Note down the maximum frequency component.

Activity 3: Connect two LISN to observe CM and DM noise separately. Note down the maximum frequency component for which filter need to be designed.

Activity5: Connect the EMI filter and observe the effect on CM & DM noise.

Activity 4: Change gate resistance and observe the effect on CM & DM noise.

Postlab Activities:

Activity 1 – Write all the observation during the lab in hardware and software.

Activity 2 – Design the EMI filter to limit the CM-DM noise under the CISPR standards for the flyback in LTspice.

$(\text{Attenuation required})_{DM}$ = Max value of DM noise – limit + 5dB(safety margin)

$(\text{Attenuation required})_{CM}$ = Max value of CM noise – limit + 5dB(safety margin)

Filter corner frequencies:

$$(\text{Attenuation required})_{DM} = 40 * \log_{10}\left(\frac{\text{Freq of max noise components } (f_{max})}{Corner\ frequency\ (f_{DM})}\right)$$

$$(\text{Attenuation required})_{CM} = 40 * \log_{10}\left(\frac{\text{Freq of max noise components } (f_{max})}{Corner\ frequency\ (f_{CM})}\right)$$

(Note: Youtube videos for filter design is given in the resource material for the reference.)

Activity 3 – Find the tradeoff between switching loss and EMI spectrum.