EMI Virtual Lab

Zheng Luo – MPS

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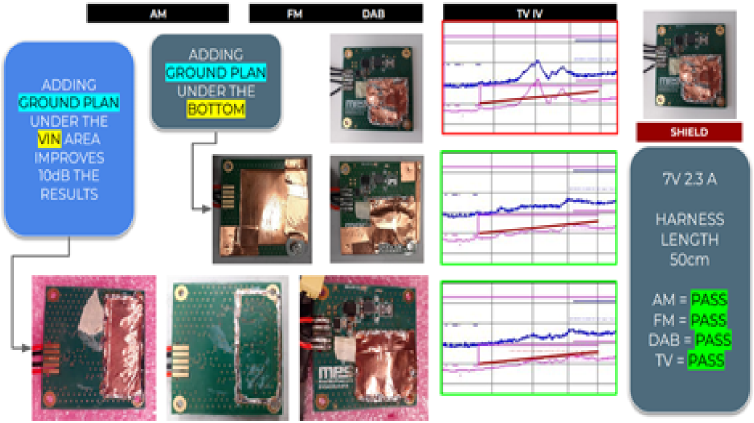
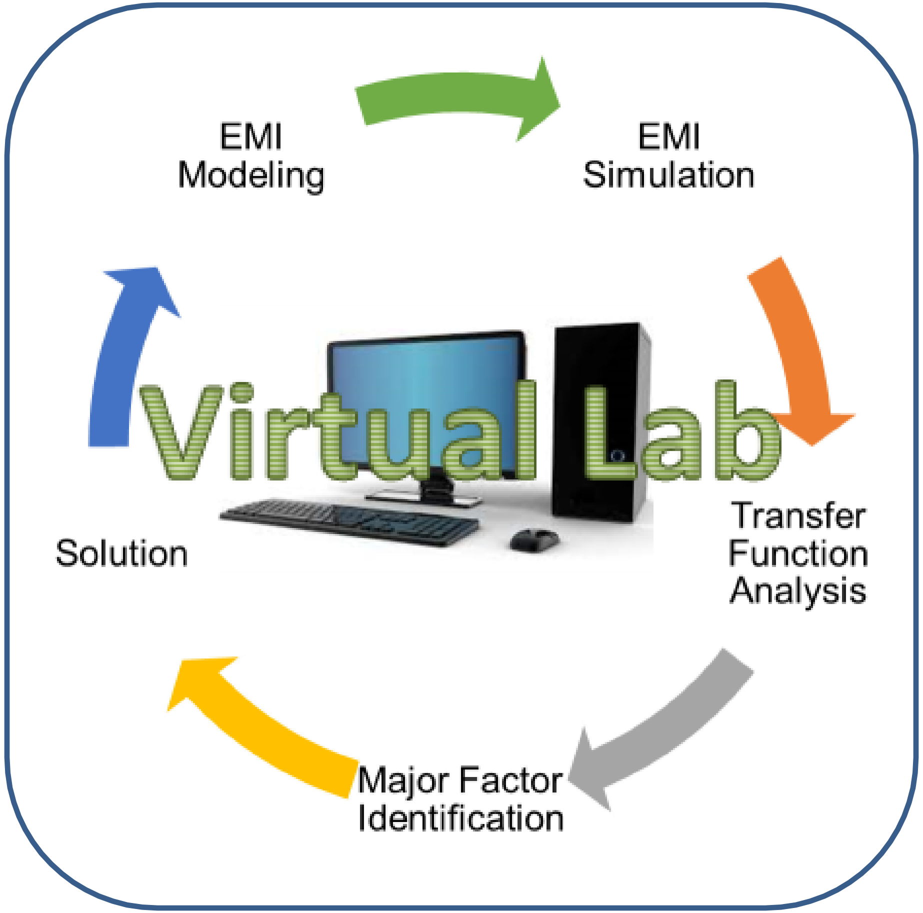
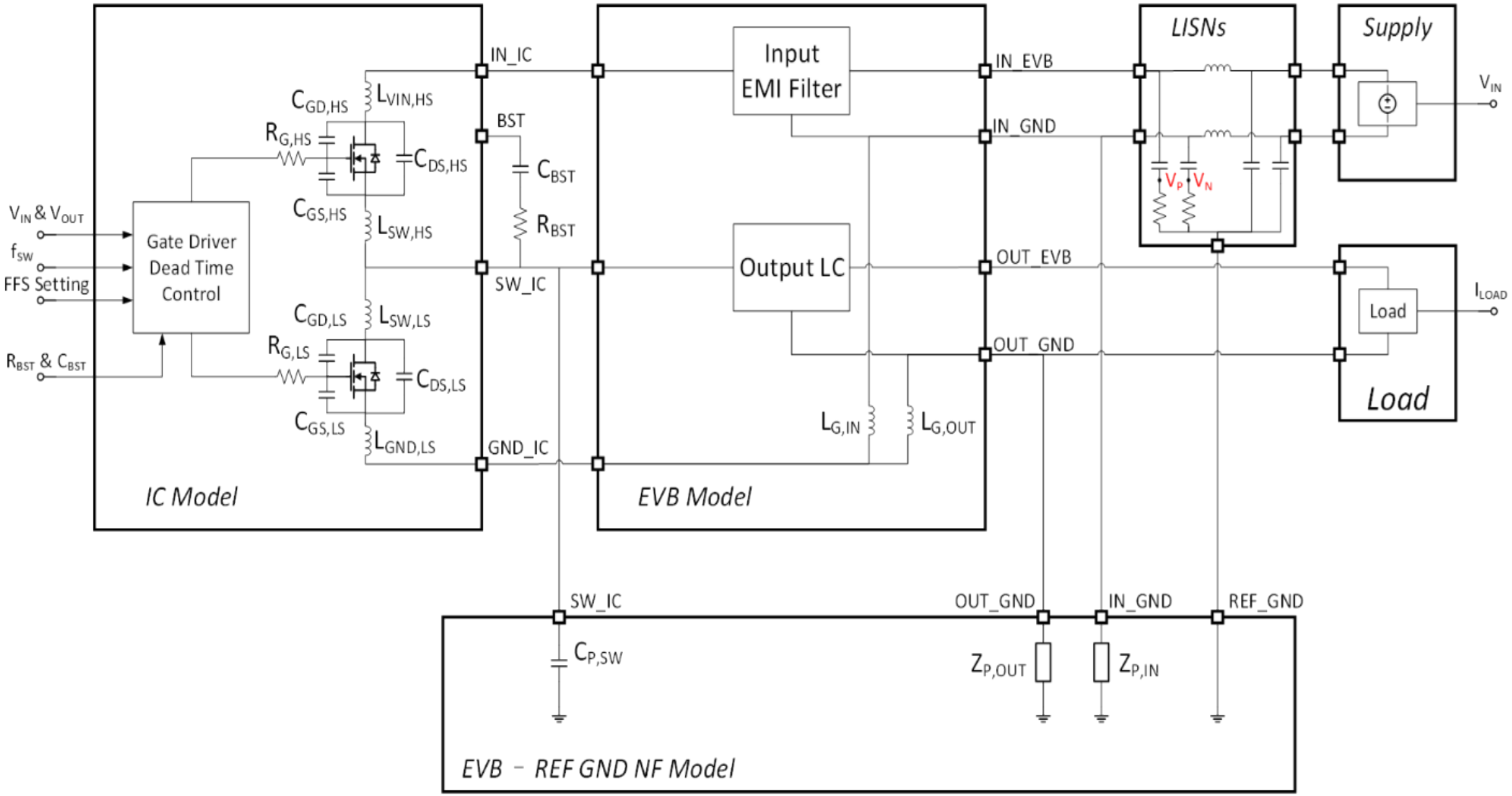
Traditional EMI Debug and Diagnostic Vs. Virtual Lab





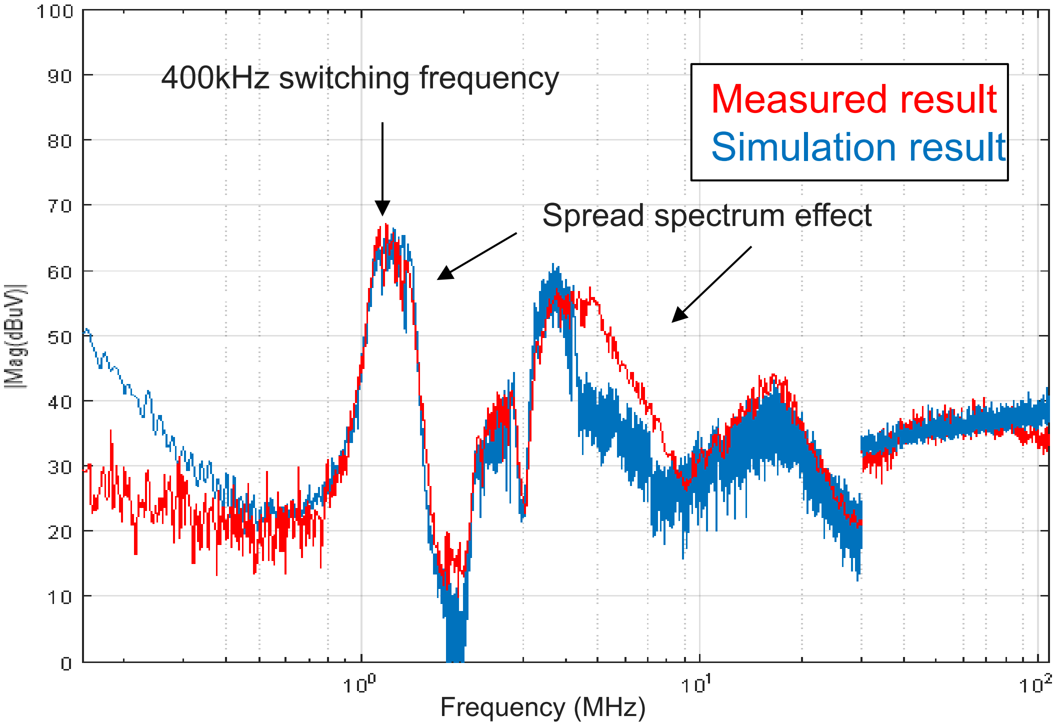
Conducted EMI Modeling



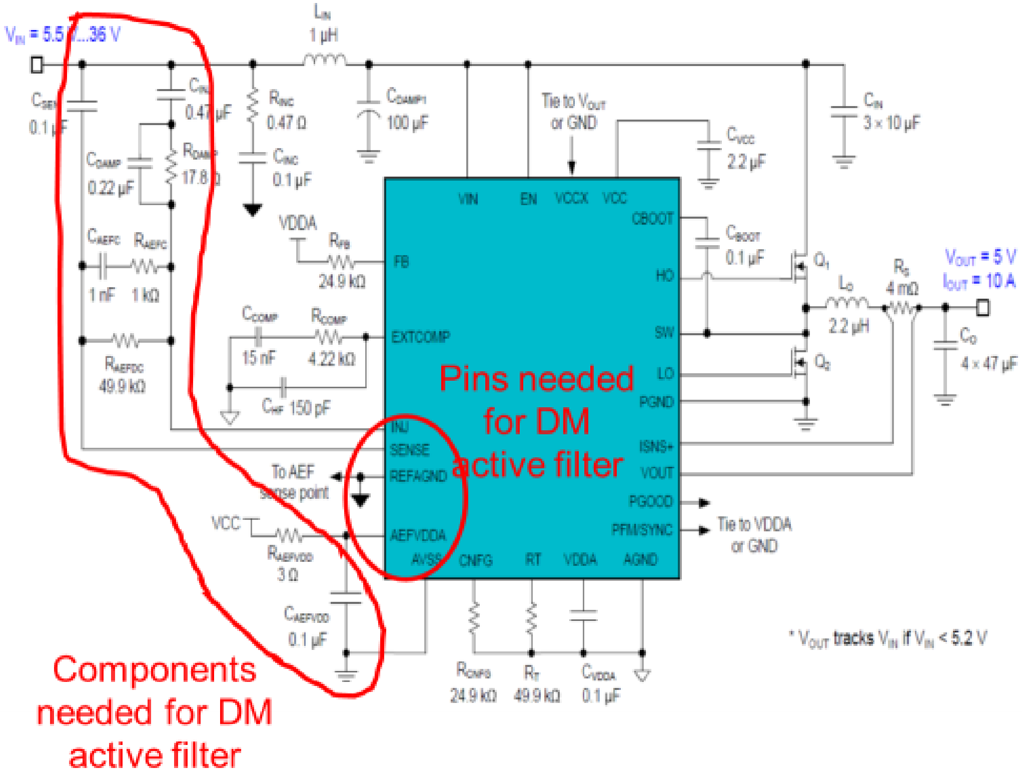
Virtual Lab Result vs. Measurement

Test Condition: 12Vin, 5Vout, 3A Load current w/o filter, with spread spectrum

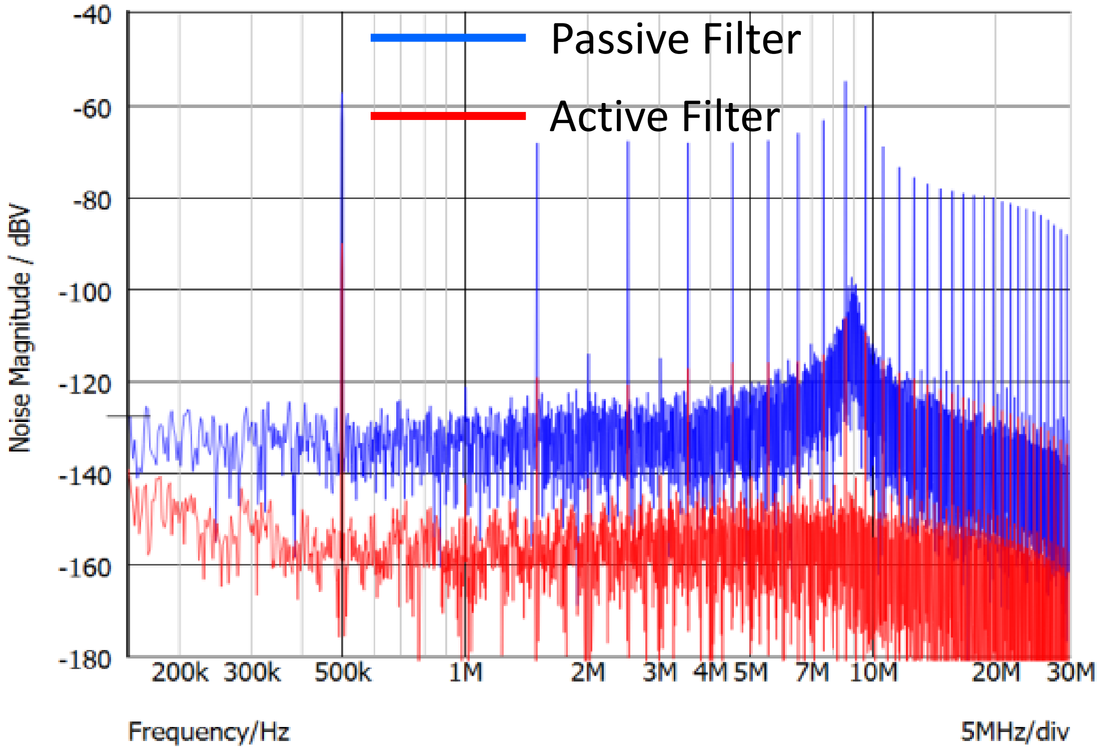
DUT: 40V Buck

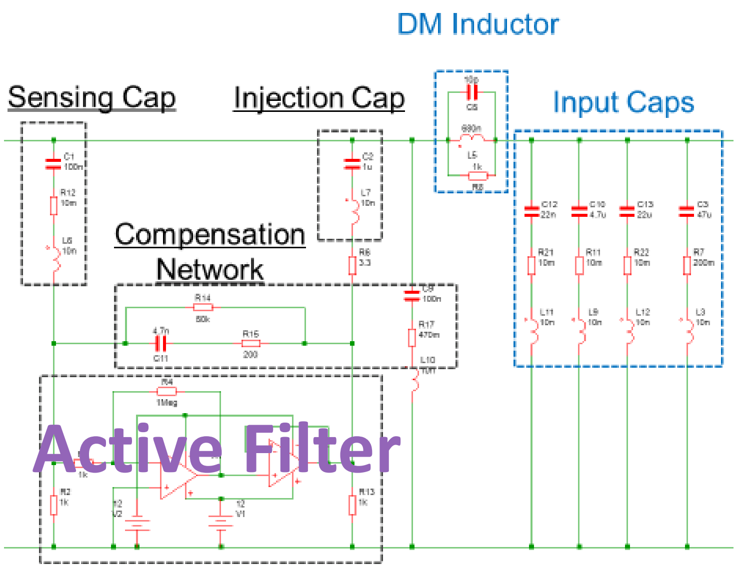


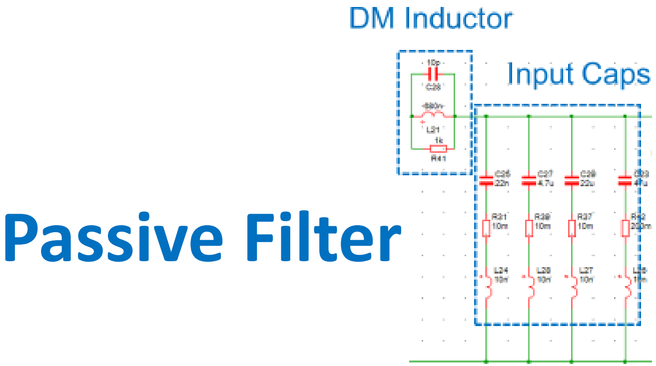
Case Study – Do We Need Active EMI Filter?



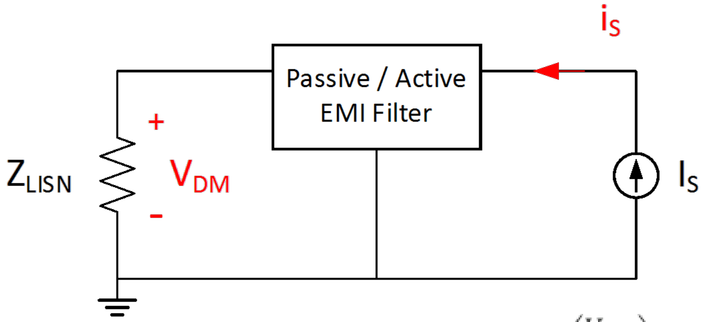
Conducted EMI Comparison



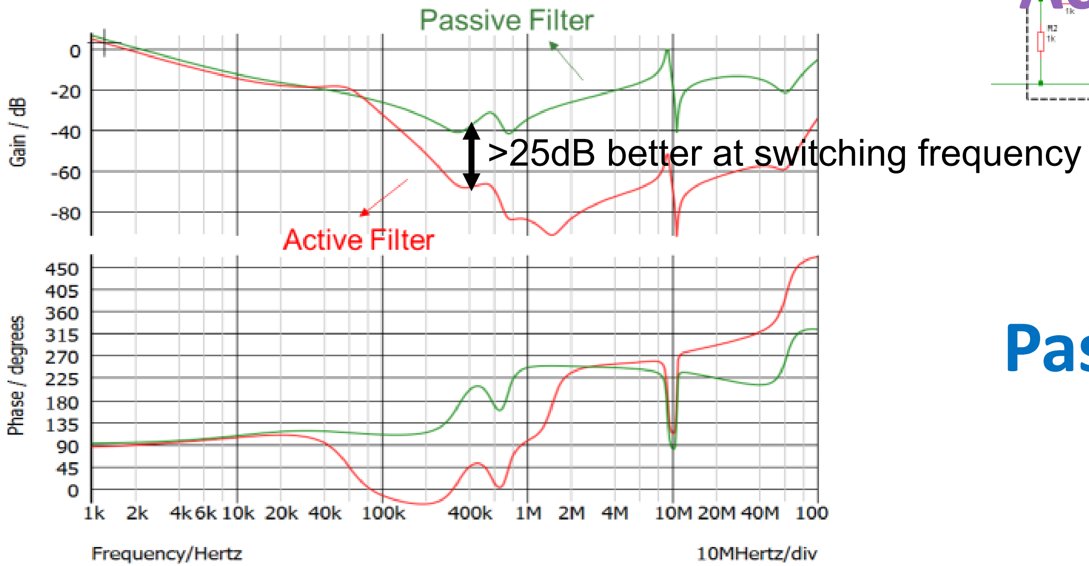


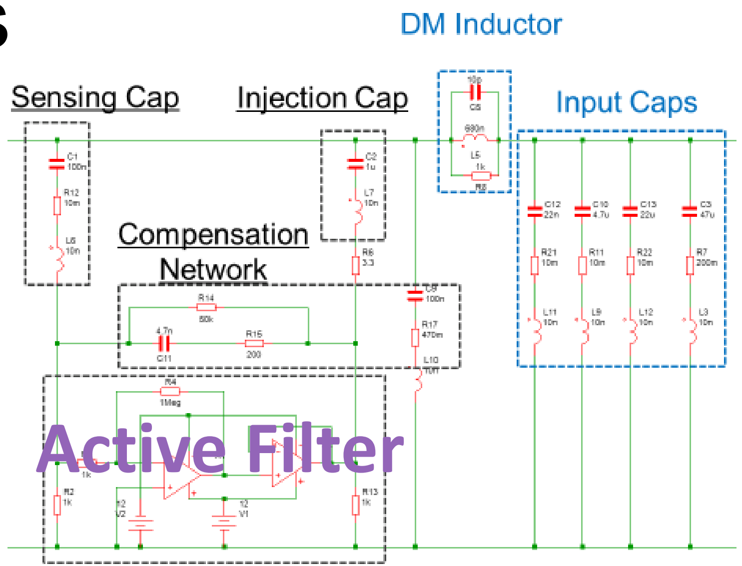


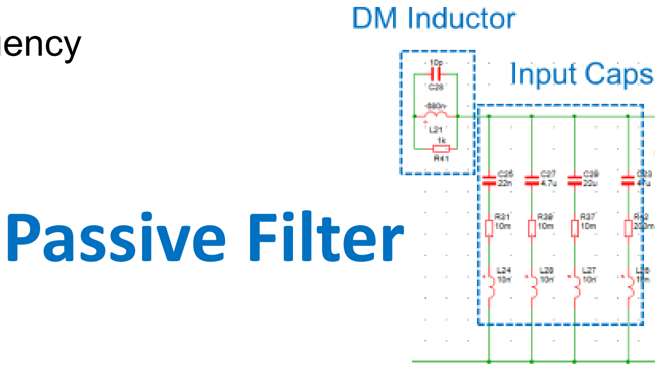
Noise Transfer Gain Analysis



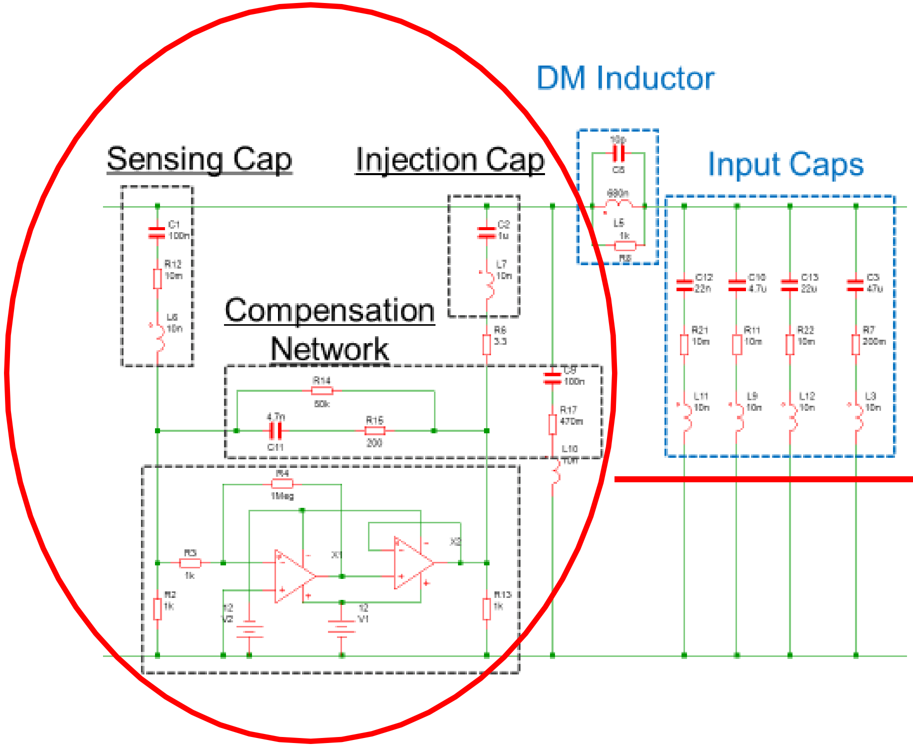
$$Noise\,Transfer\,Gain = 20\log_{10}\left(\frac{V_{DM}}{I_S}\right)$$

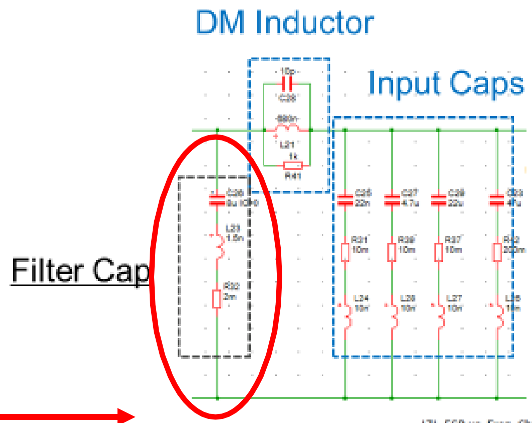




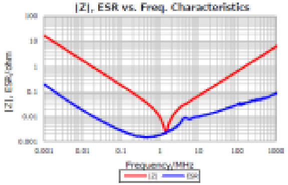


How about replace the Active Filter with a capacitor?

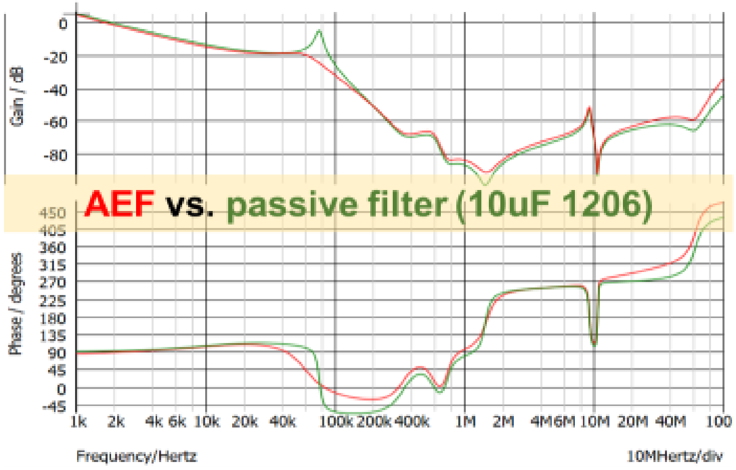


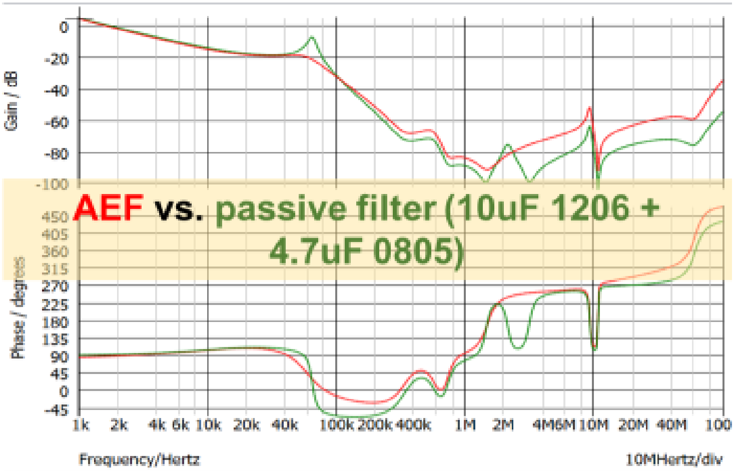


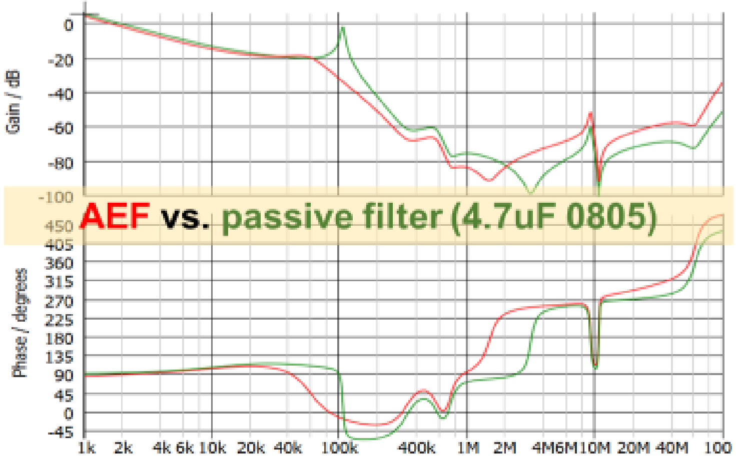
TDK 50V, 10uF, size 1206
Effective capacitance $8\mu F$,
ESL 1.5nH, ESR $2m\Omega$

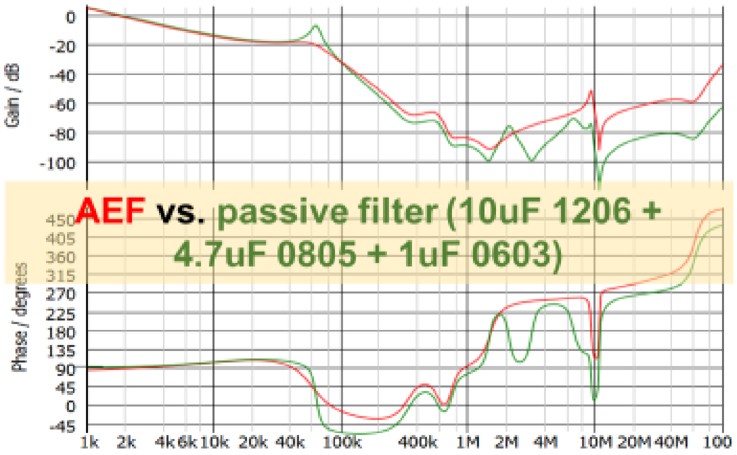


Noise Transfer Function: Active Filter vs. Just Cap

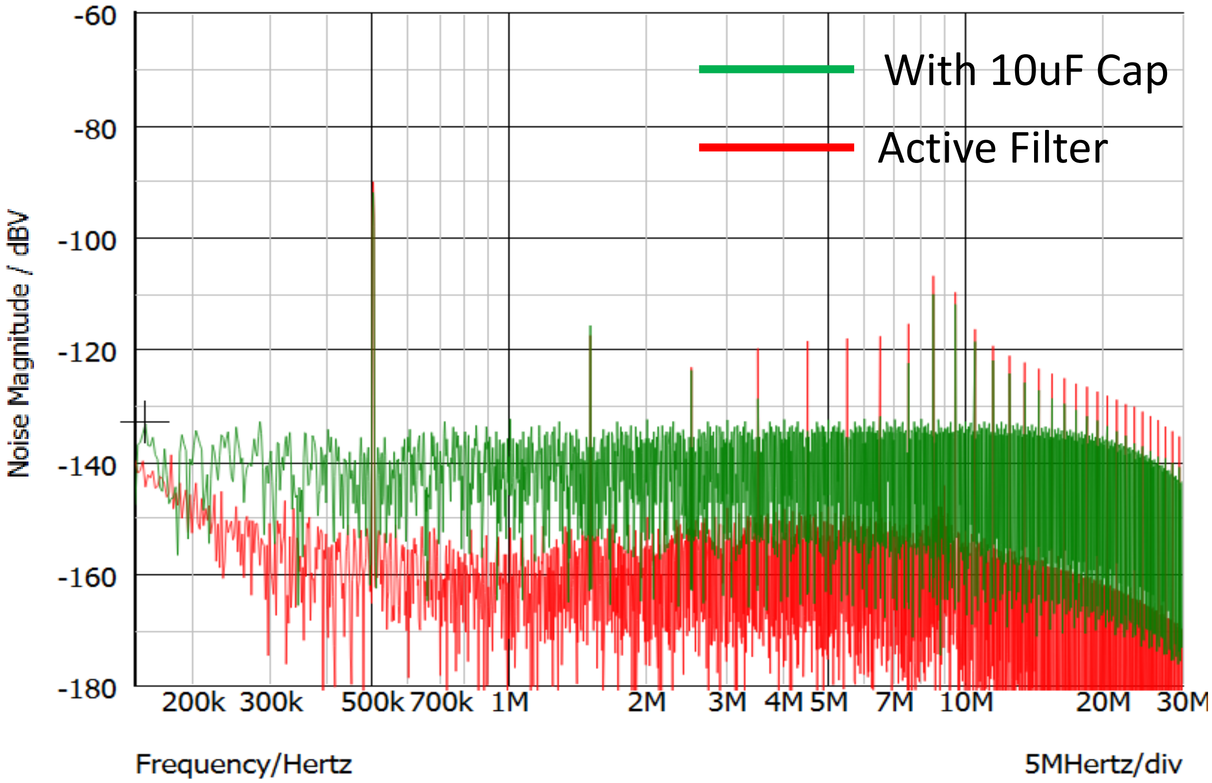






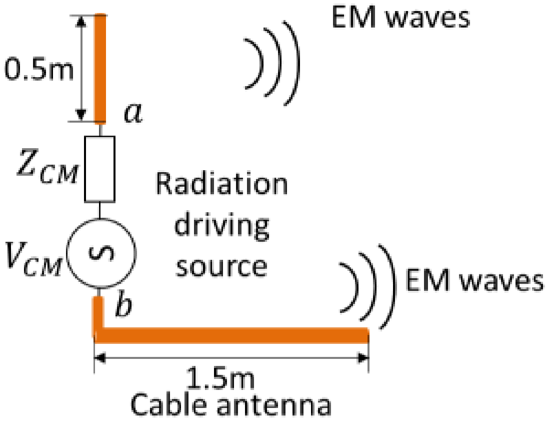


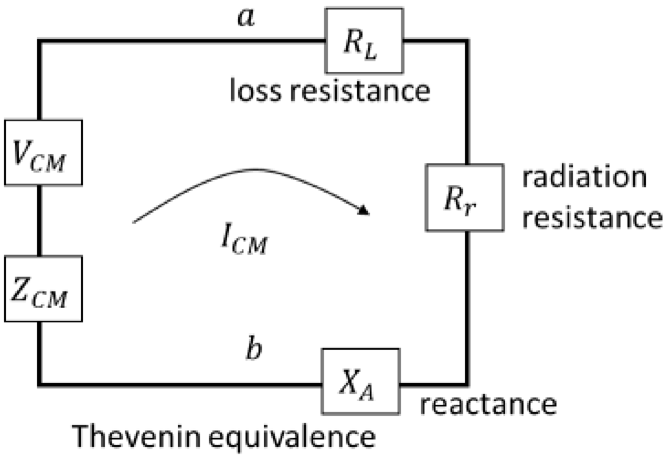
Conducted EMI Result: Active Filter Vs. 10uF Cap

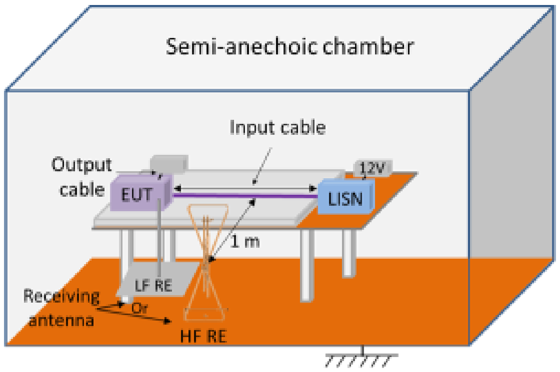


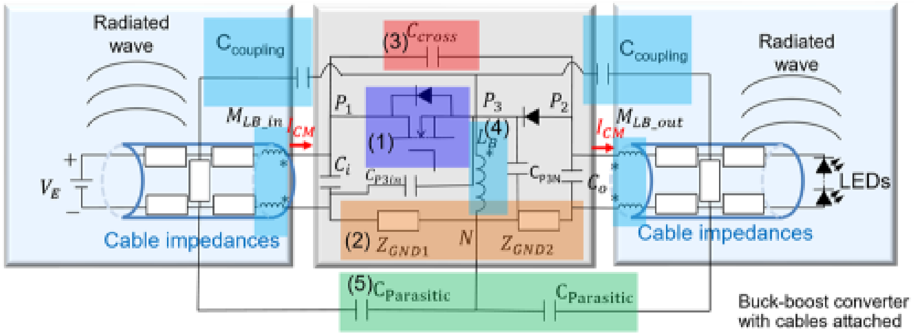
As expected, 10uF cap is slightly better

Radiated EMI Modeling









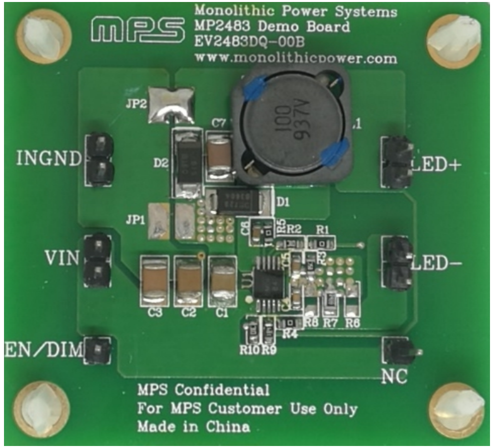
In the far field region, in the isotropic and uniform radiation case, electric field E is,

$$E = \sqrt{P_r \eta / 2\pi r^2}$$

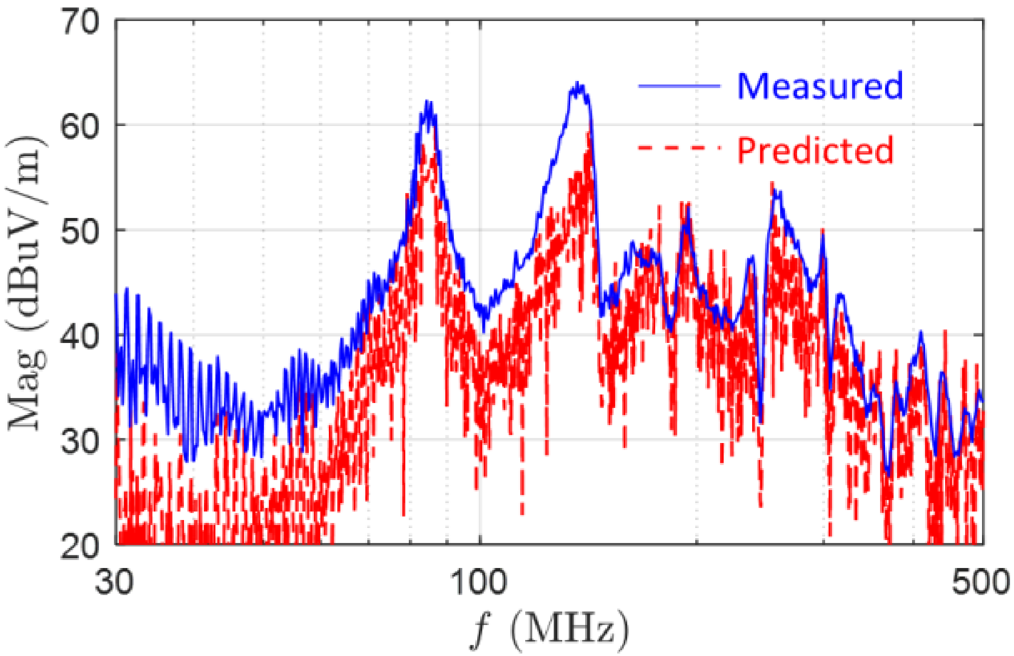
$$\text{Where, } P_r = \frac{1}{2}|I_{CM}|^2 R_r = \frac{|V_{CM}|^2}{2}\left[\frac{R_r}{|Z_{CM}+R_L+R_r+jX_A|^2}\right]$$

Virtual Lab Result vs. Measurement

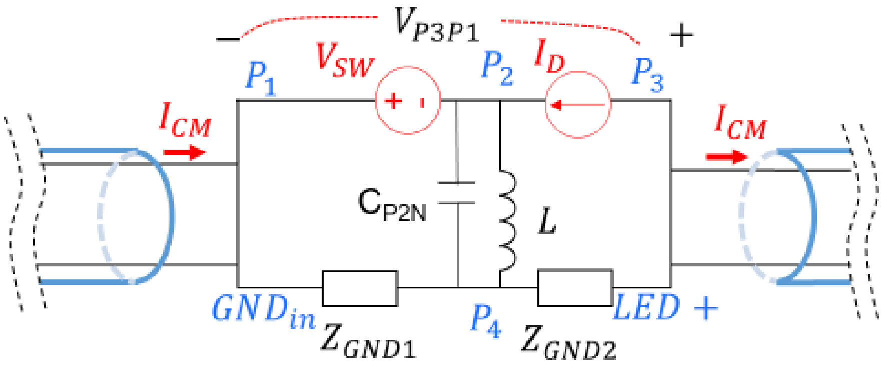
Test Condition: 12Vin, 10Vout, 350mA LED current w/o Filter

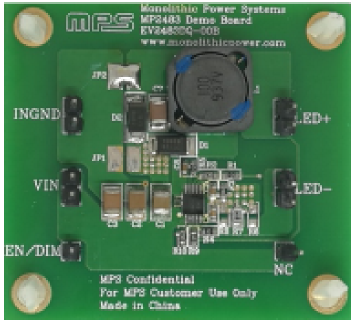


DUT: 40V Buck-Boost LED Driver

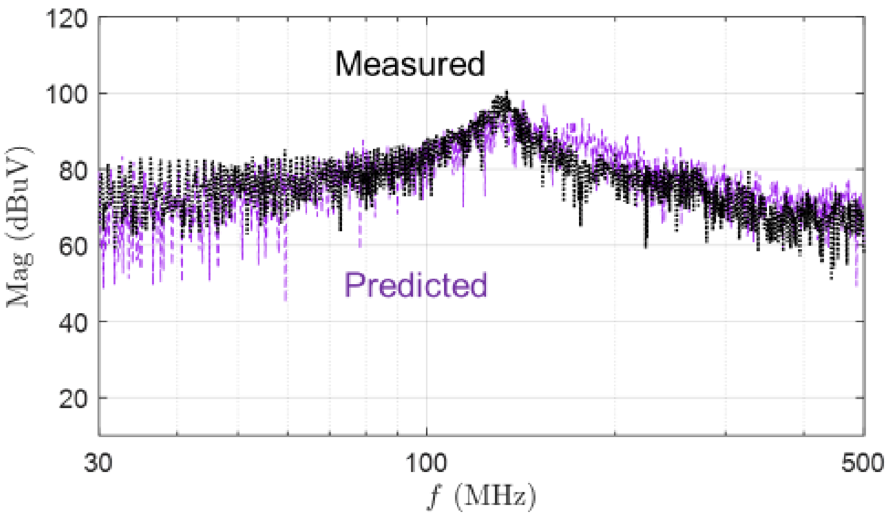


Case Study: Radiated EMI Analysis and Reduction



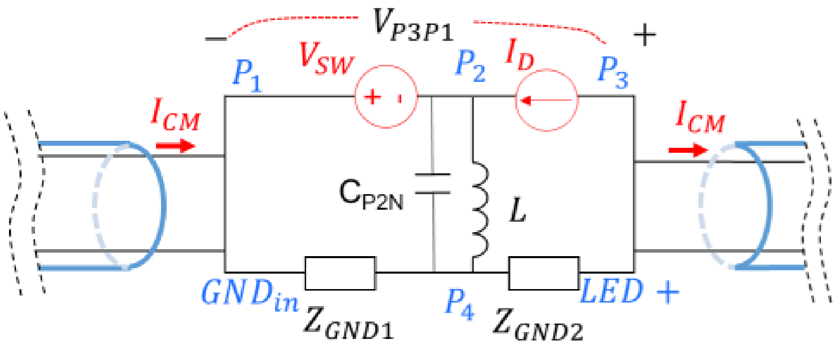


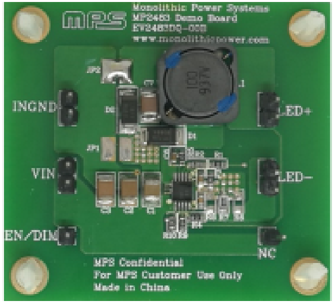
Measured vs. predicted CM terminal voltage V_{P3P1}

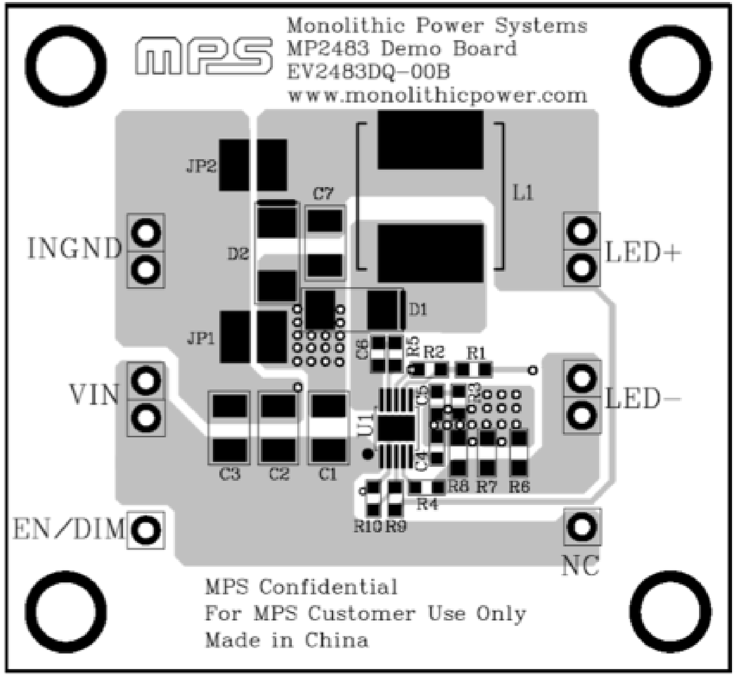


V_{SW}, I_D, Z_{GND1}, Z_{GND2} are most important for radiated EMI on this Board

Visualization the Key Elements for the Radiated EMI

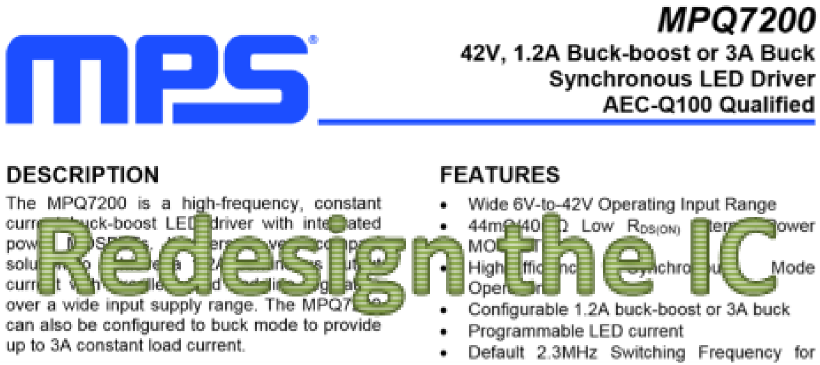


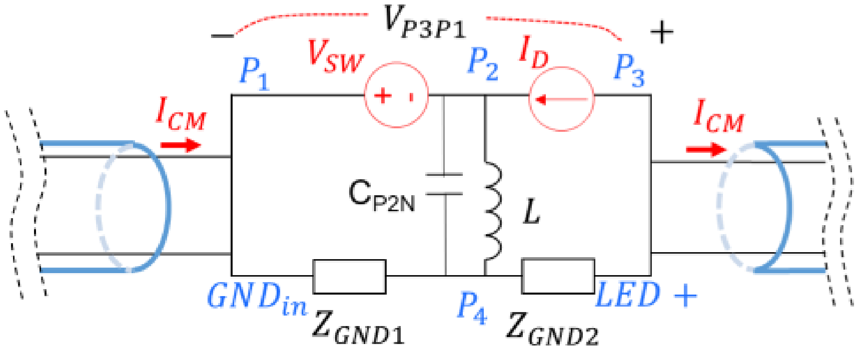


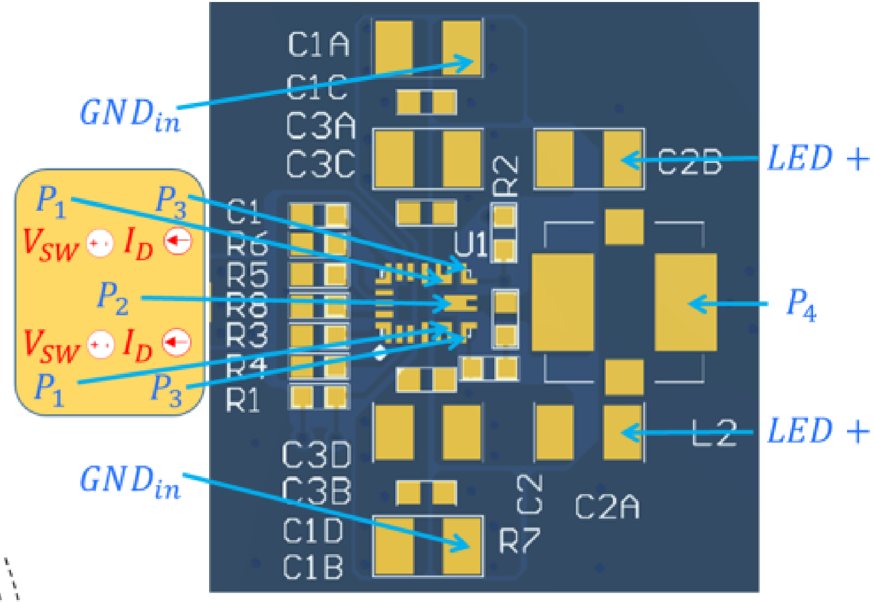


Z_{GND1} (nH)	Z_{GND2} (nH)
20.7	14

How to Reduce the Total GND Impedance?



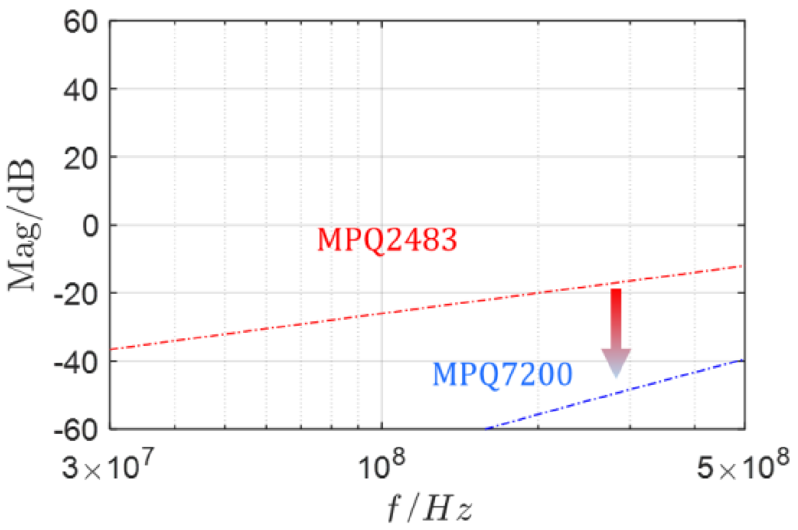




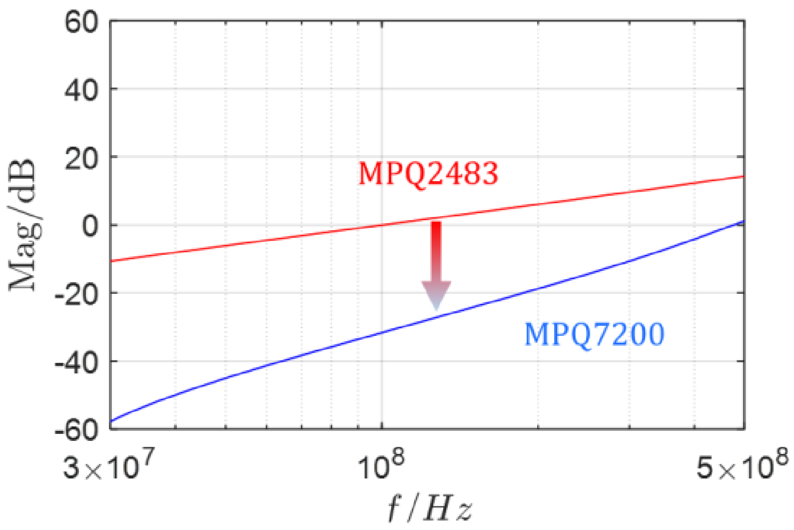
Z_{GND1} (nH)	Z_{GND2} (nH)
1.5	0.4

Reduced Noise Source to Terminal CM Voltage Transfer Gain

V_{sw} to Terminal CM voltage Transfer Gain



I_D to Terminal CM voltage Transfer Gain

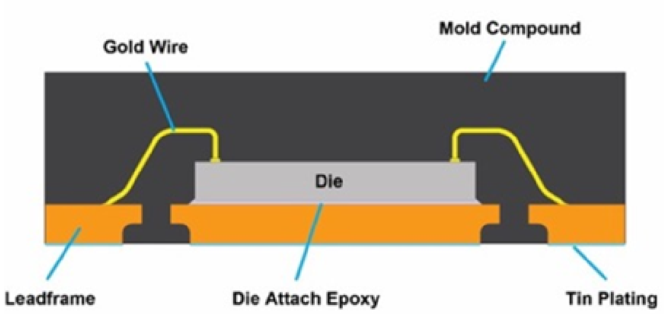


Noise Source to Terminal CM voltage Transfer Gain Reduced 30dB

Further Reduce the Impedance Inside the Package

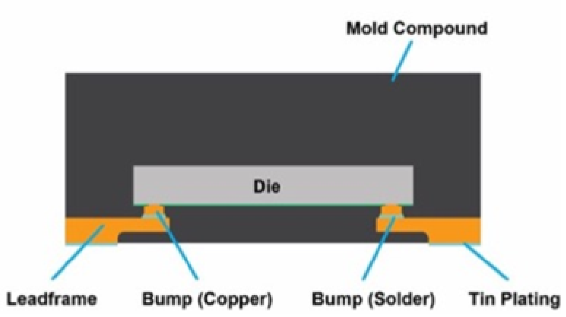
MPQ2483

Wire Bond



MPQ7200

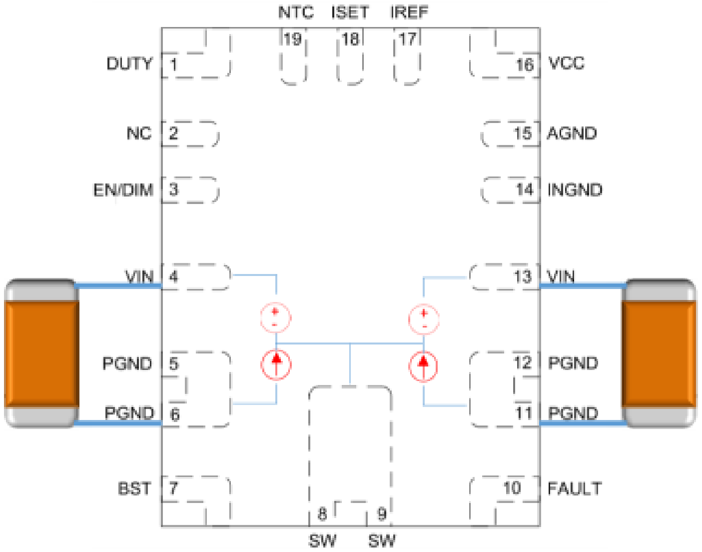
Mesh Connect™
(No Wire Bond)



Z_{wire} (nH)	Z_{bump} (nH)
1.9	0.007

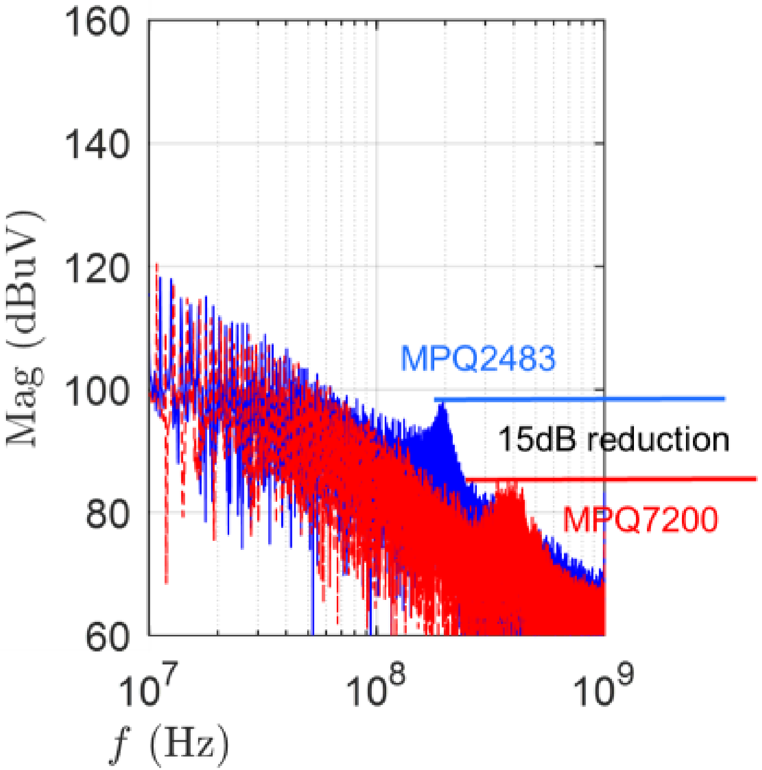
Reduce the Switching Noise

MPQ7200 (QFN3x4)

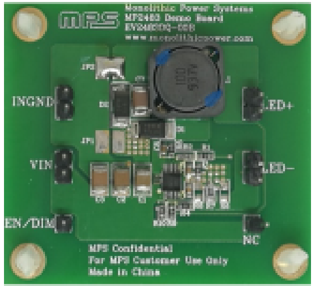


Splitted symmetric noise source

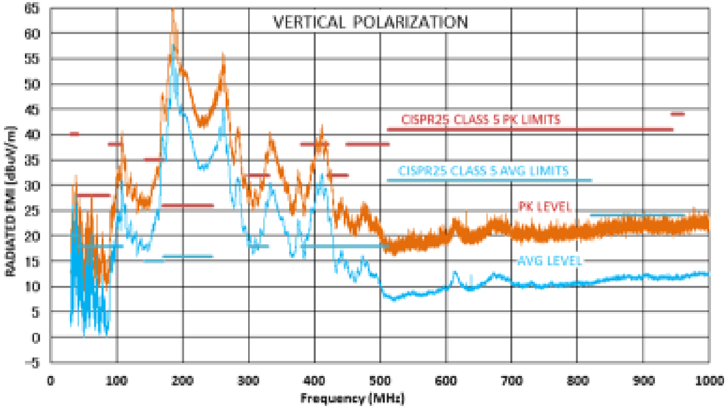
Switching Noise Spectrum Comparison



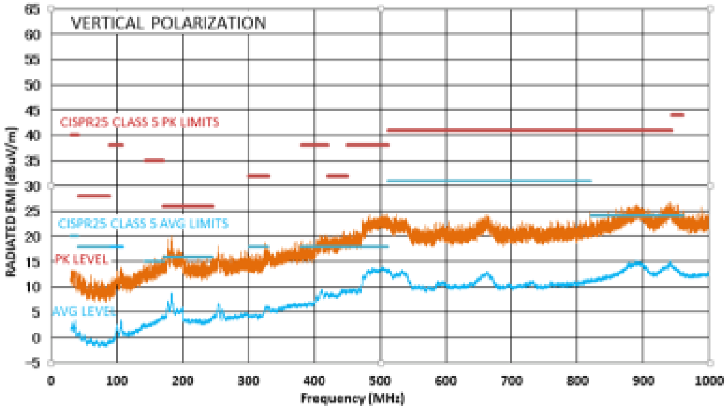
Buck-Boost EMI Comparison – 1st Gen vs. 2nd Gen



1st Gen, MPQ2483, not optimized for EMI



2nd Gen, MPQ7200 optimized for EMI



Max 45dB reduction after redesign the IC!