

EMI Virtual Lab

Zheng Luo – MPS

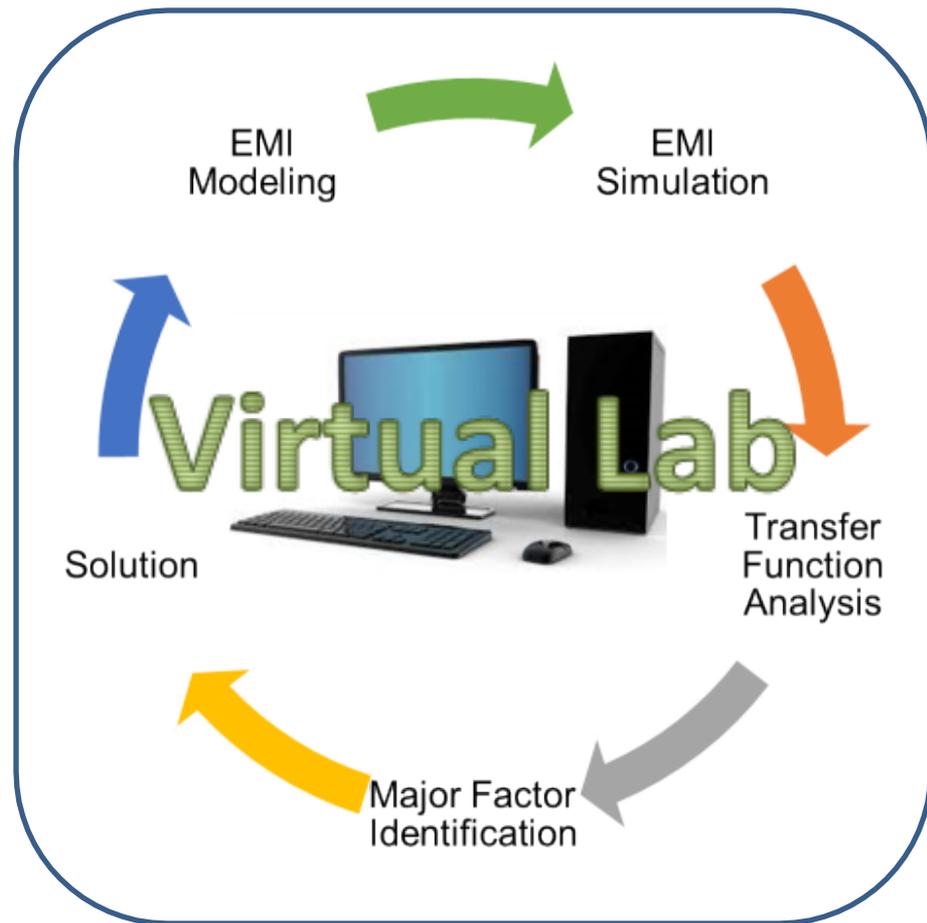
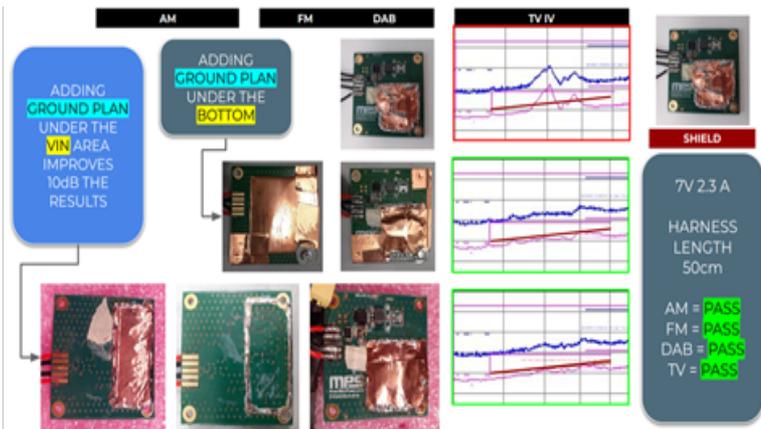
Table of Contents

Conducted EMI modeling
and Case Study

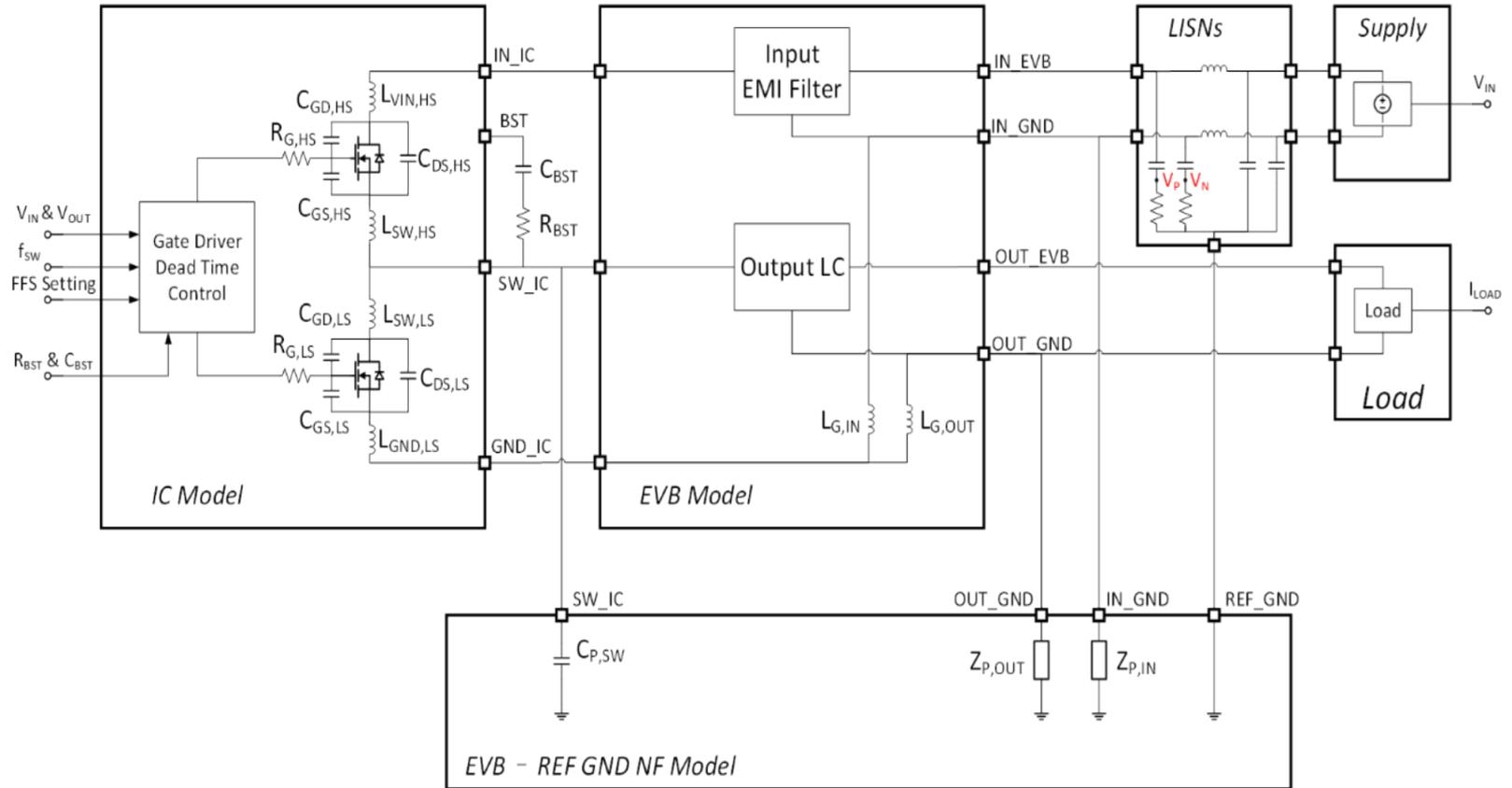


Radiated EMI Modeling
and Case Study

Traditional EMI Debug and Diagnostic Vs. Virtual Lab

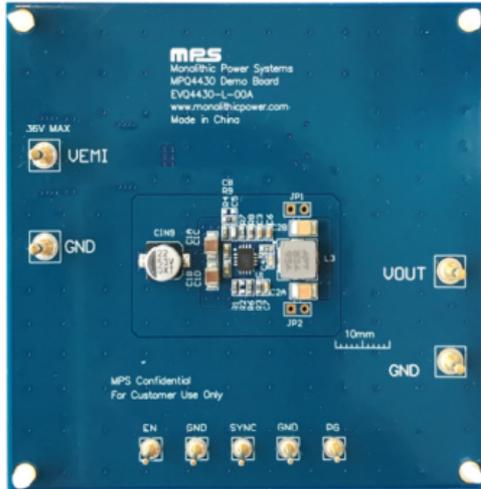


Conducted EMI Modeling

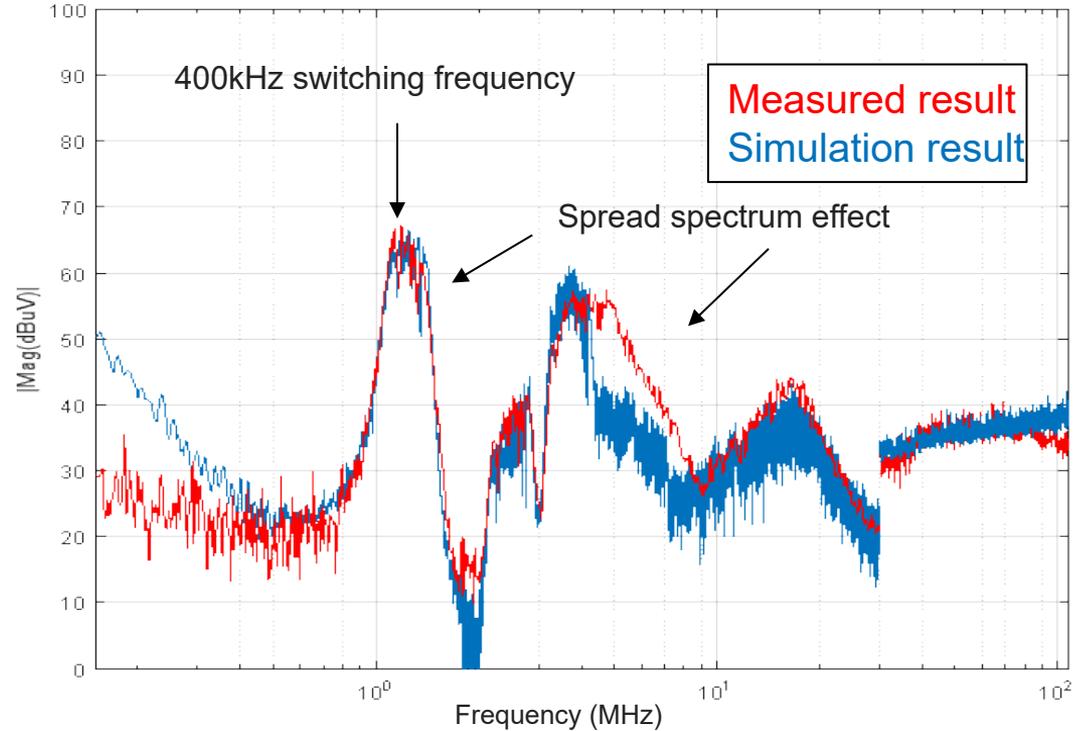


Virtual Lab Result vs. Measurement

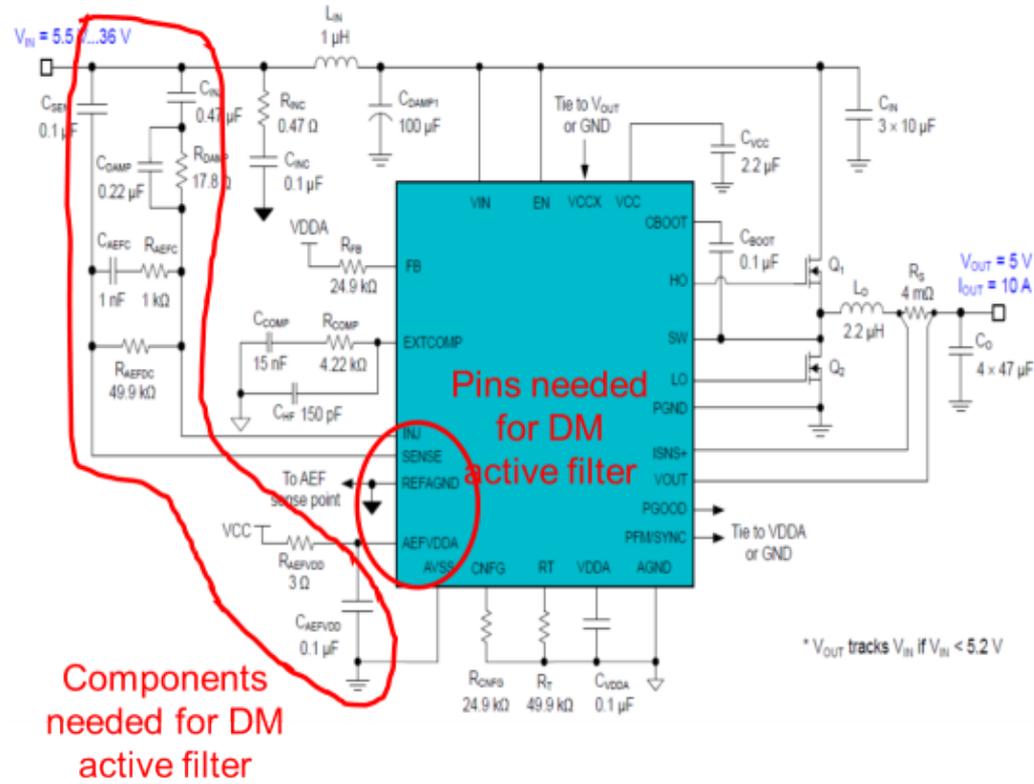
Test Condition: 12Vin, 5Vout, 3A Load current w/o filter, with spread spectrum



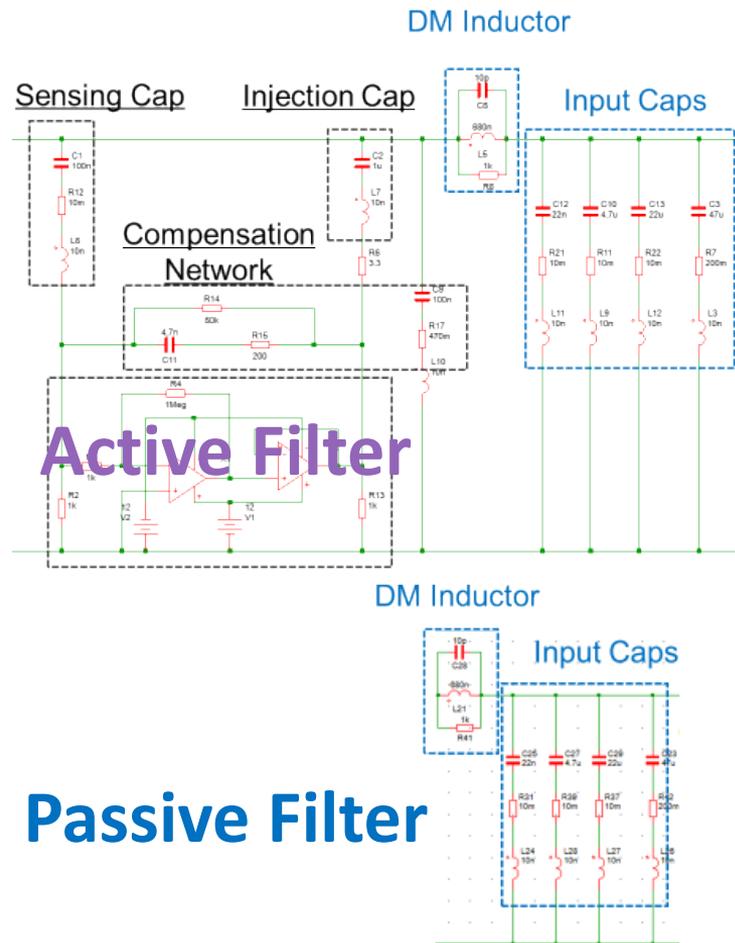
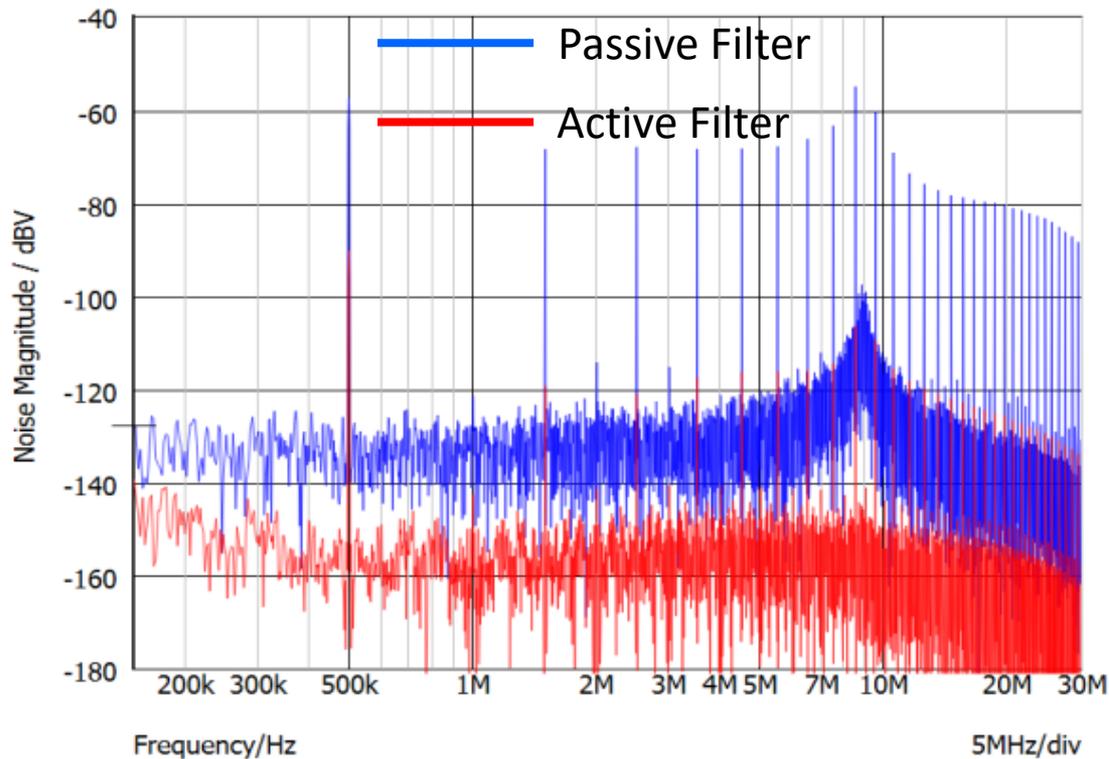
DUT: 40V Buck



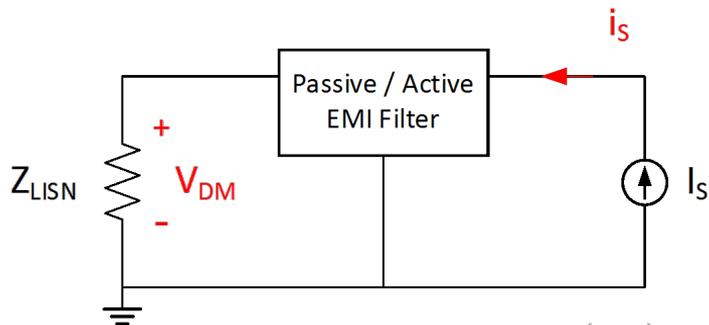
Case Study – Do We Need Active EMI Filter?



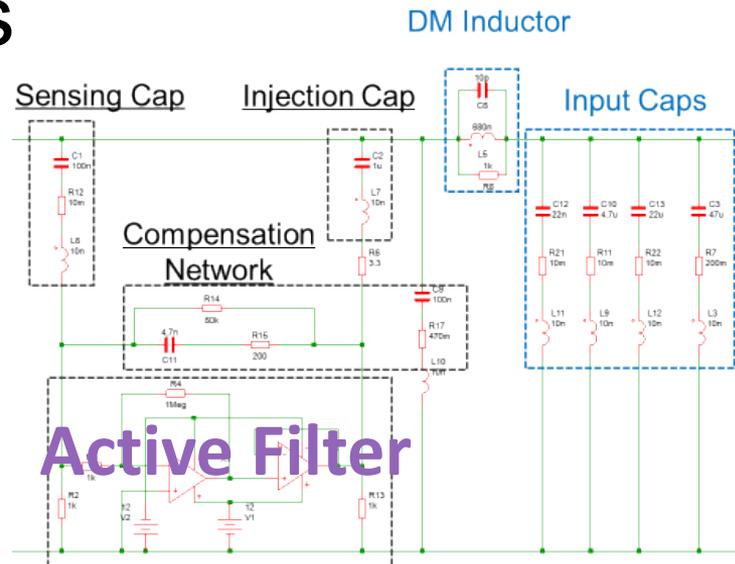
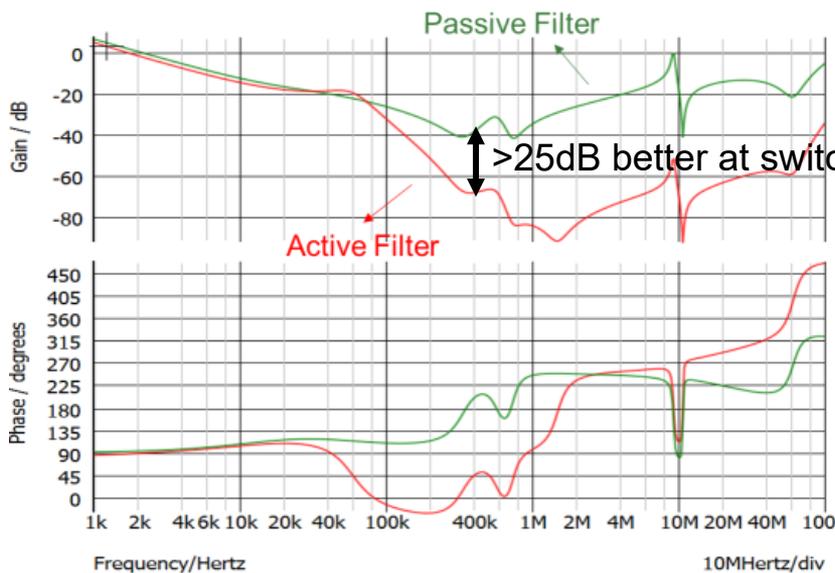
Conducted EMI Comparison



Noise Transfer Gain Analysis

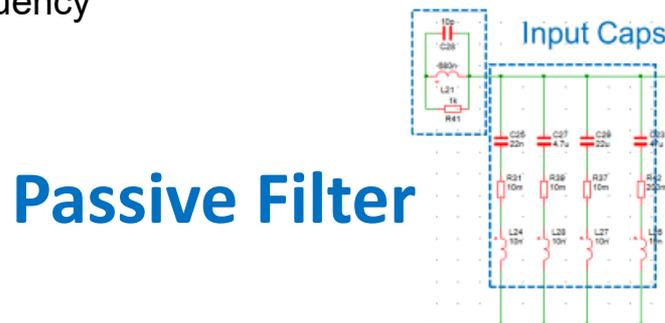


$$\text{Noise Transfer Gain} = 20 \log_{10} \left(\frac{V_{DM}}{I_S} \right)$$



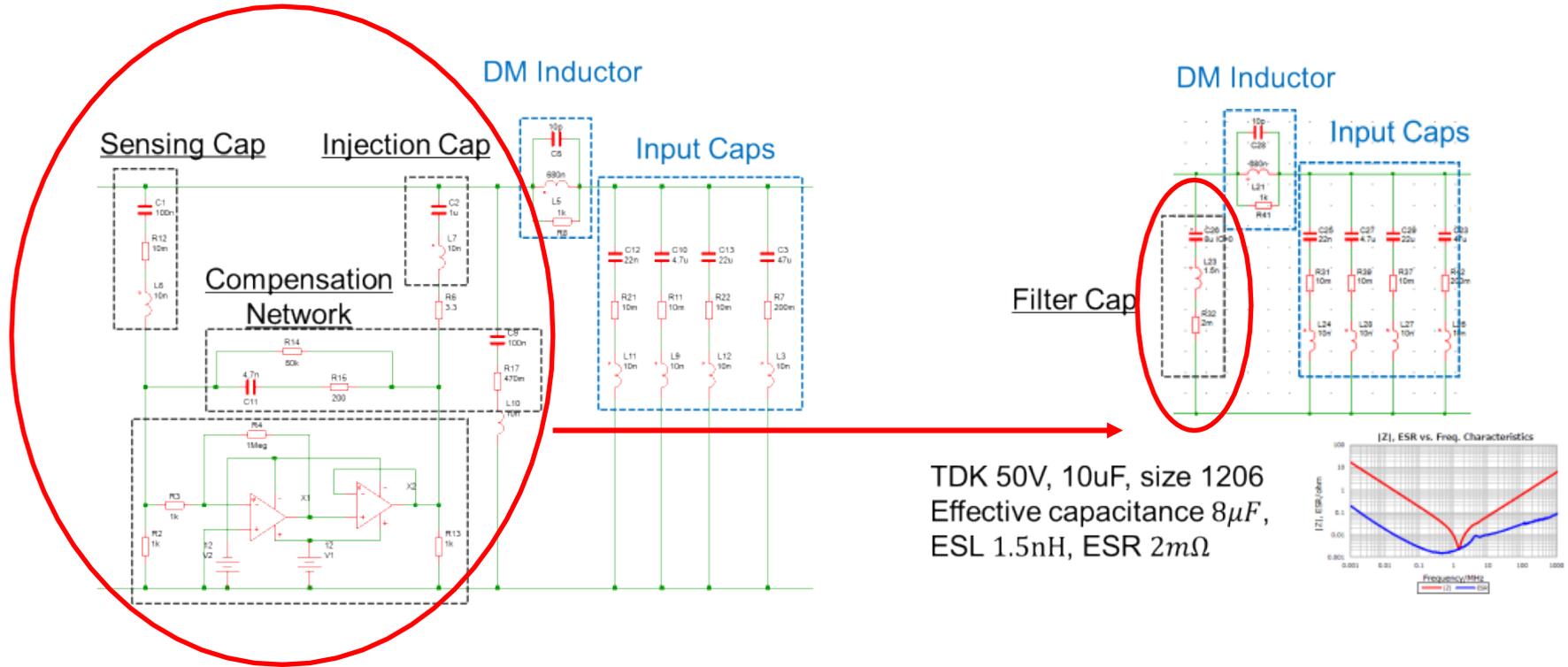
Active Filter

DM Inductor

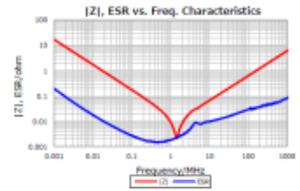


Passive Filter

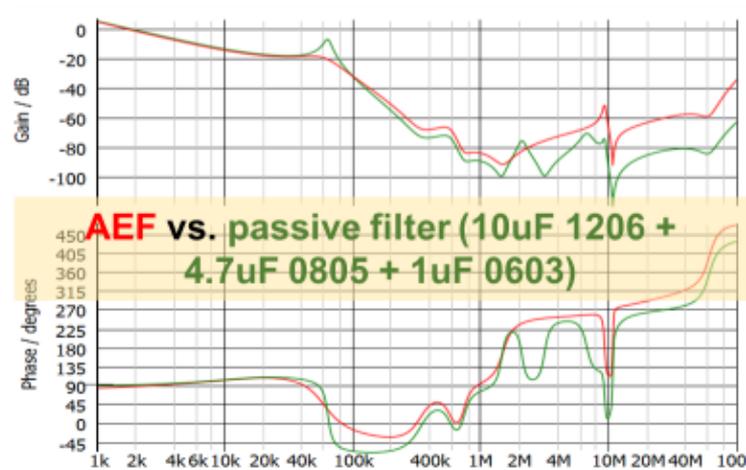
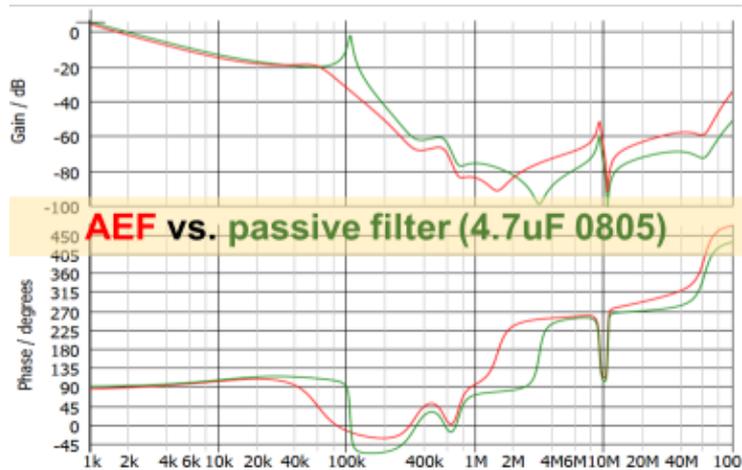
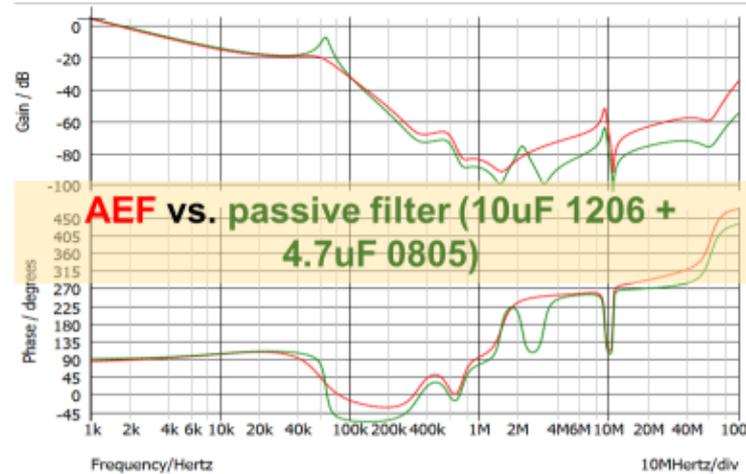
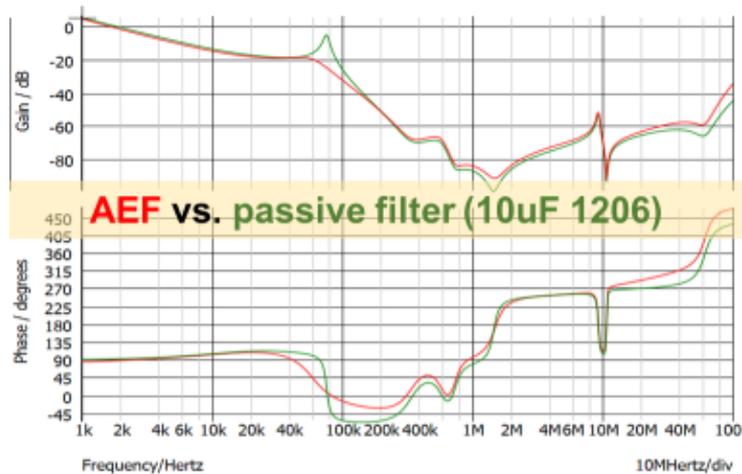
How about replace the Active Filter with a capacitor?



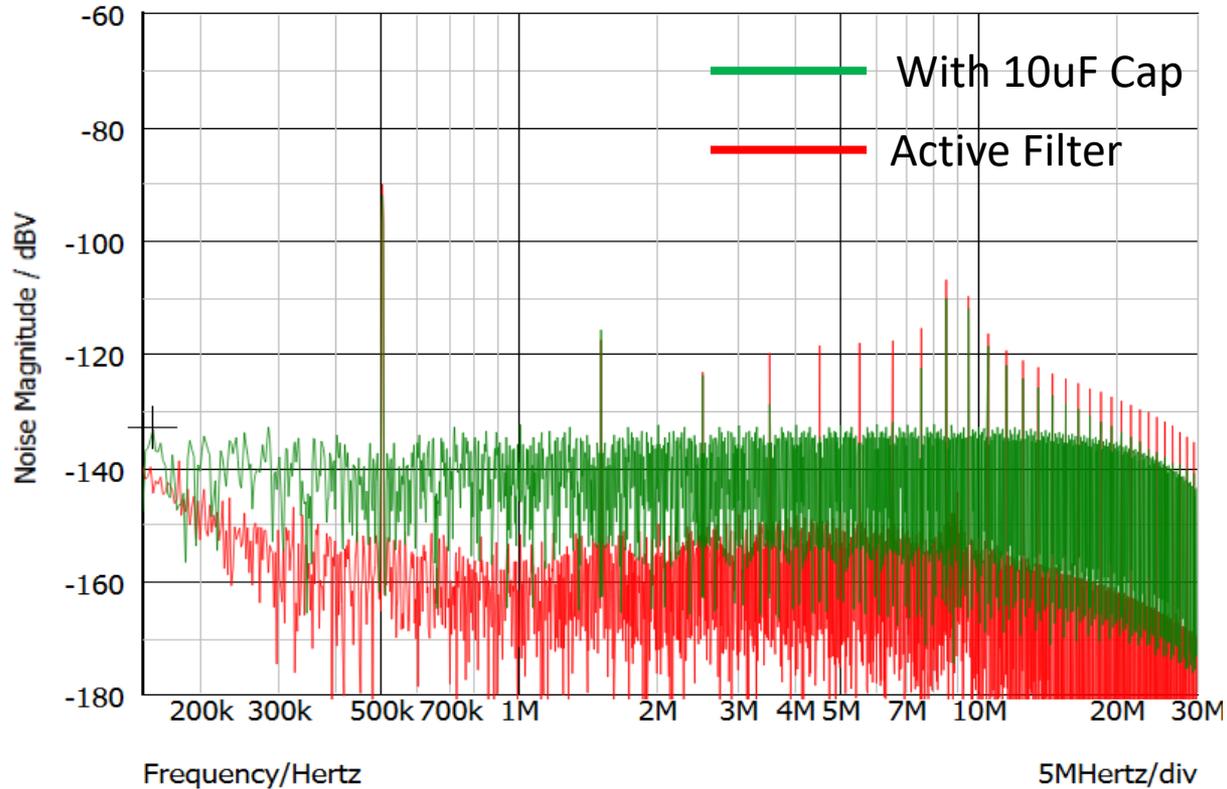
TDK 50V, 10uF, size 1206
Effective capacitance $8\mu\text{F}$,
ESL 1.5nH, ESR 2m Ω



Noise Transfer Function: Active Filter vs. Just Cap

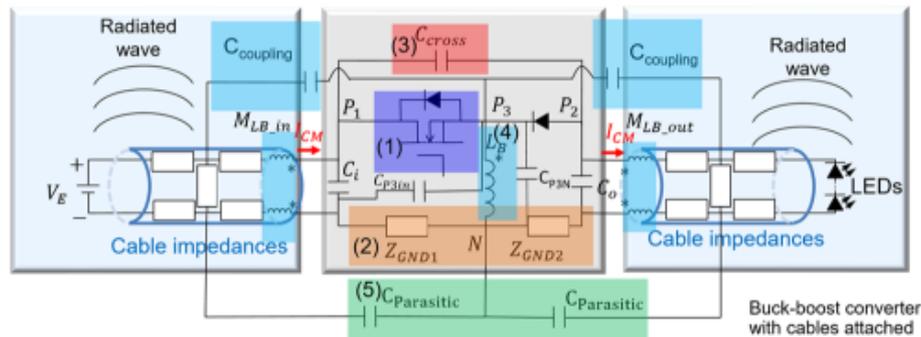
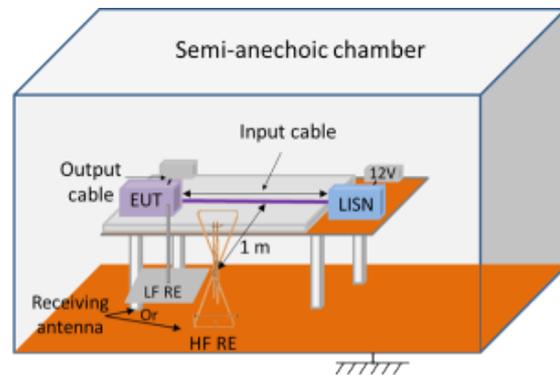
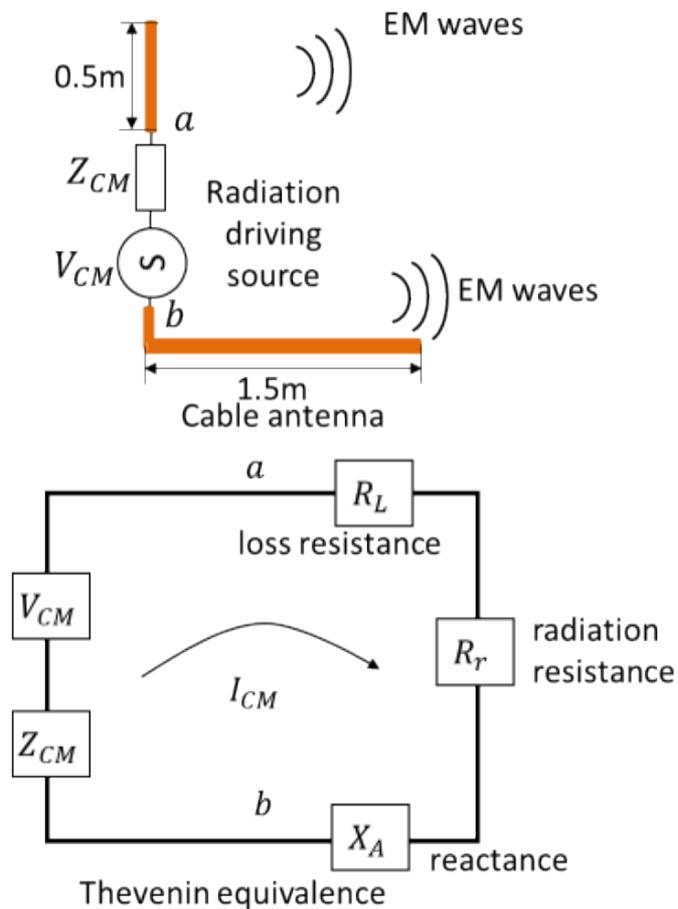


Conducted EMI Result: Active Filter Vs. 10uF Cap



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,

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

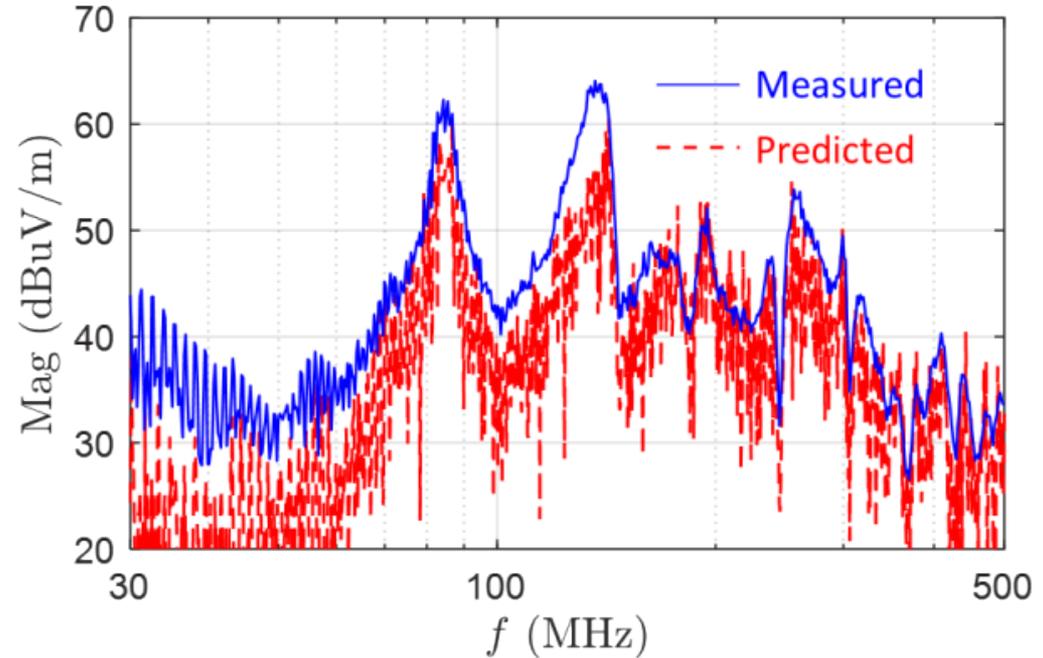
$$\text{Where, } P_r = \frac{1}{2} |I_{CM}|^2 R_r = \frac{|V_{CM}|^2}{2} \left[\frac{R_r}{|Z_{CM} + R_L + R_r + jX_A|^2} \right]$$

Virtual Lab Result vs. Measurement

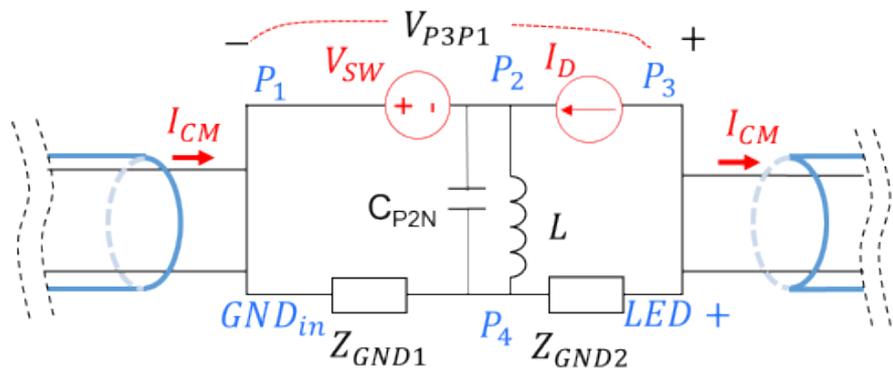
Test Condition: 12Vin, 10Vout, 350mA LED current w/o Filter



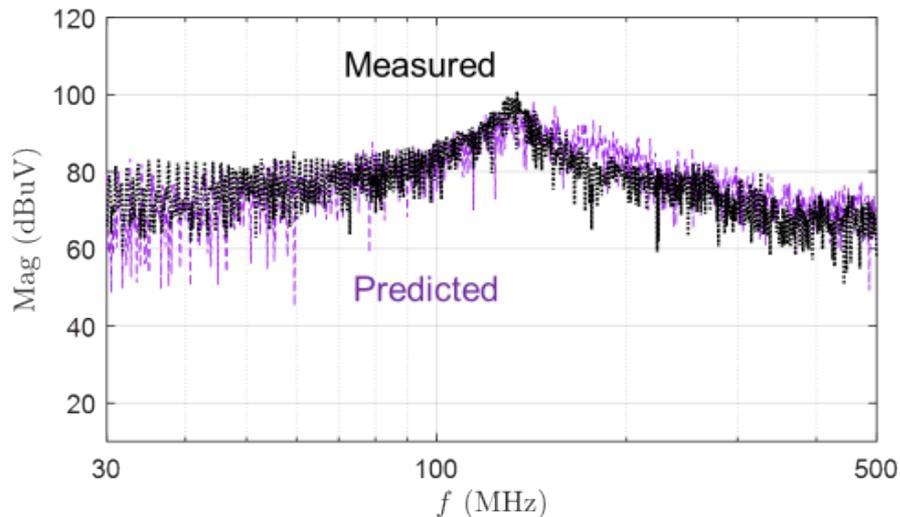
DUT: 40V Buck-Boost LED Driver



Case Study: Radiated EMI Analysis and Reduction

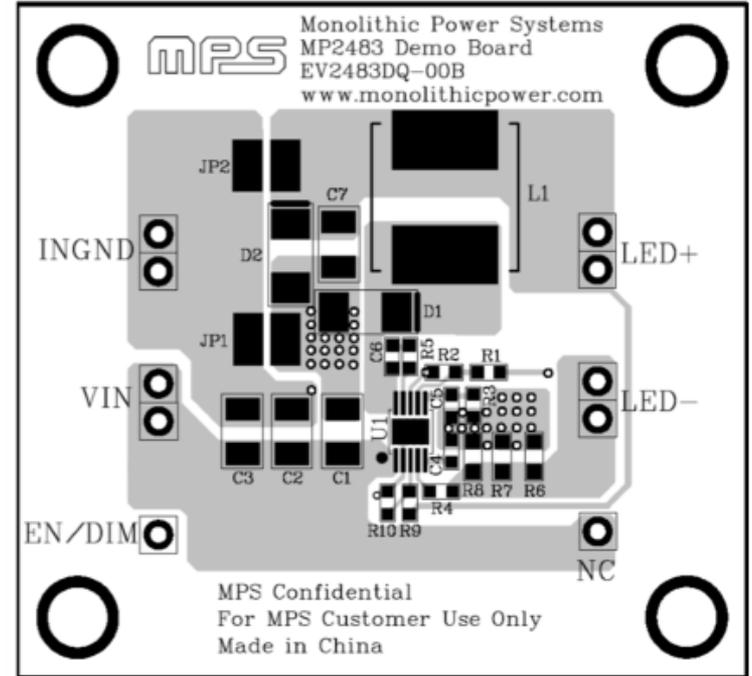
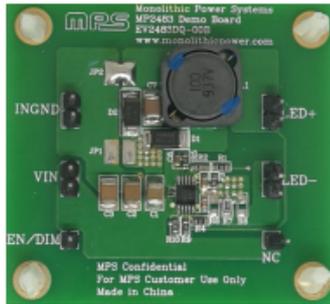
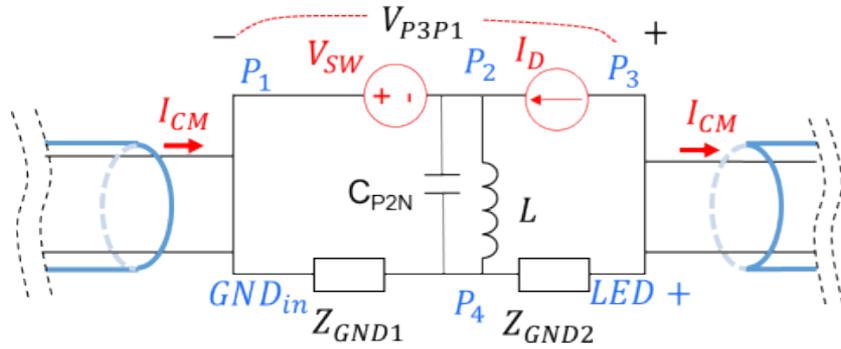


Measured vs. predicted CM terminal voltage V_{P3P1}



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?



MPQ7200
 42V, 1.2A Buck-boost or 3A Buck
 Synchronous LED Driver
 AEC-Q100 Qualified

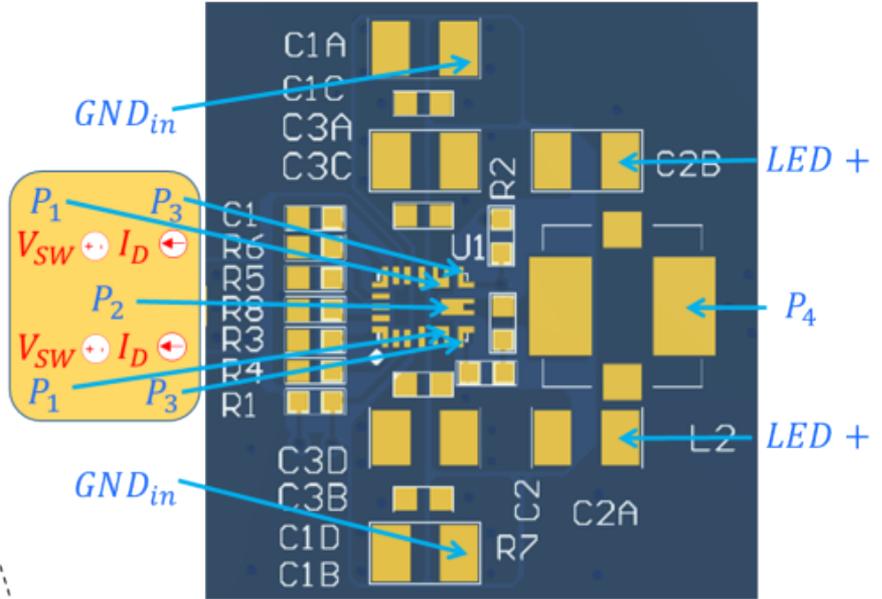
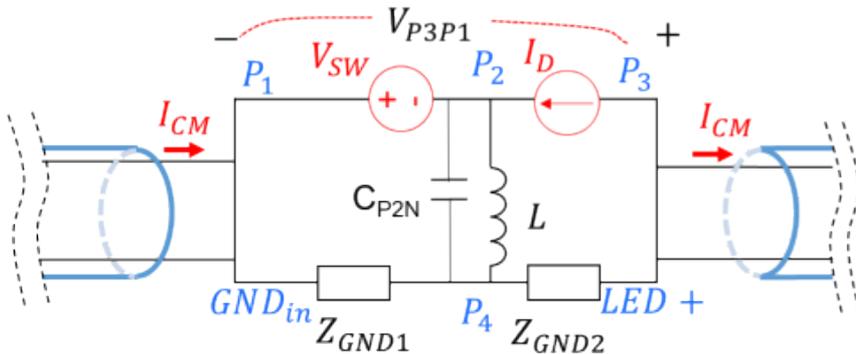
DESCRIPTION

The MPQ7200 is a high-frequency, constant current buck-boost LED driver with integrated power MOSFETs. It provides a compact solution to drive a wide range of LED current with a wide input range. The MPQ7200 can also be configured to buck mode to provide up to 3A constant load current.

FEATURES

- Wide 6V-to-42V Operating Input Range
- 44mΩ 40V Low $R_{DS(ON)}$ Internal Power MOSFET
- High Efficiency Synchronous Mode Operation
- Configurable 1.2A buck-boost or 3A buck
- Programmable LED current
- Default 2.3MHz Switching Frequency for

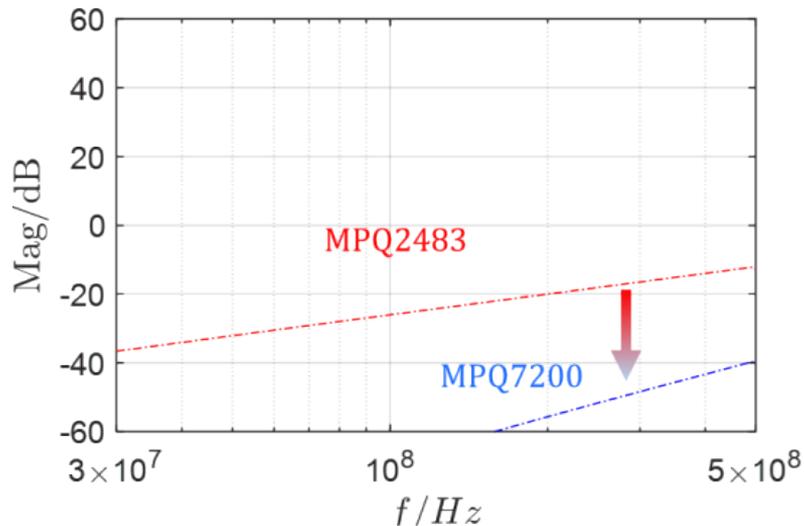
Redesign the IC



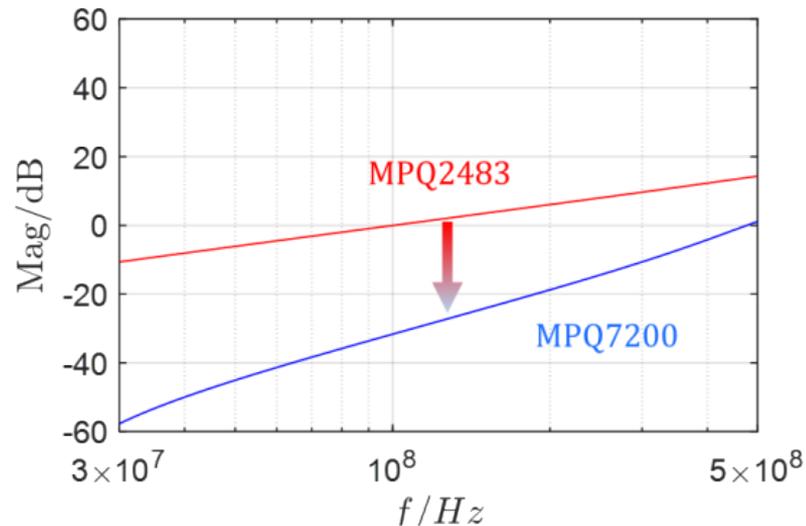
Z_{GND1} (nH)	Z_{GND2} (nH)
1.5	0.4

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

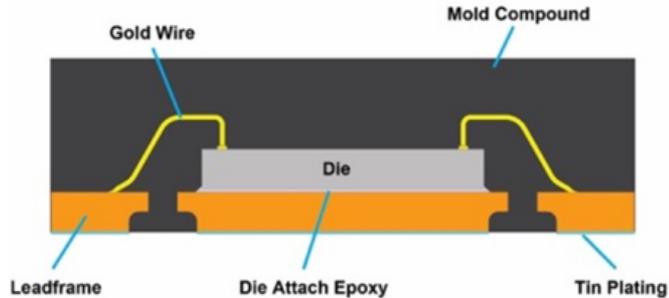


Noise Source to Terminal CM voltage Transfer Gain Reduced 30dB

Further Reduce the Impedance Inside the Package

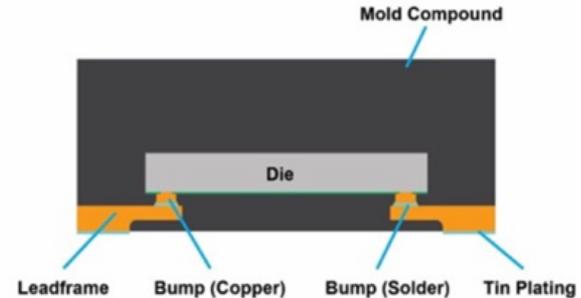
MPQ2483

Wire Bond



MPQ7200

Mesh Connect™
(No Wire Bond)



Z_{wire} (nH)

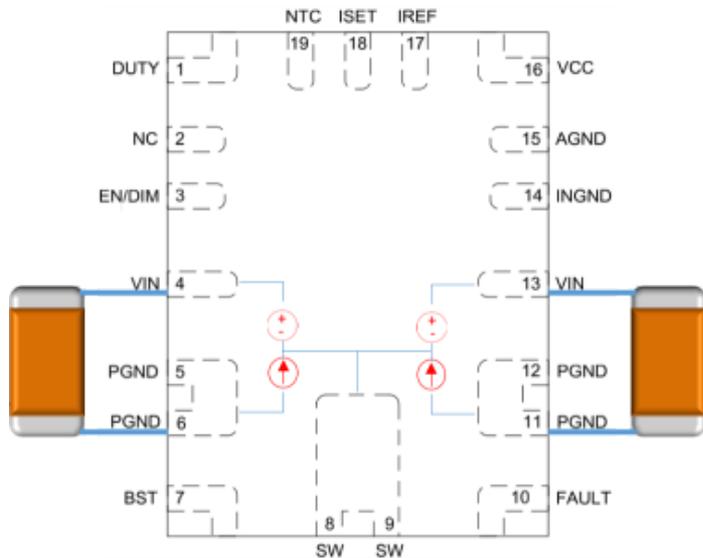
1.9

Z_{bump} (nH)

0.007

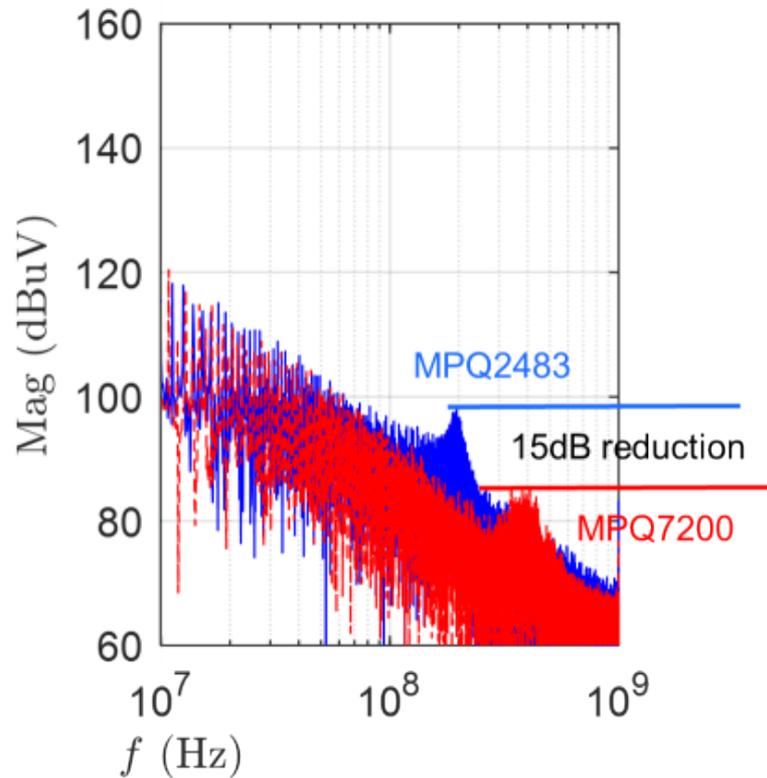
Reduce the Switching Noise

MPQ7200 (QFN3x4)

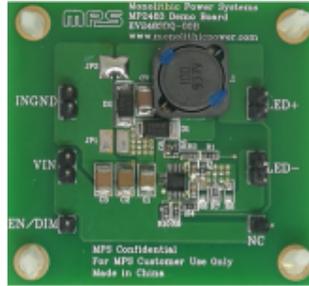


Splitting symmetric noise source

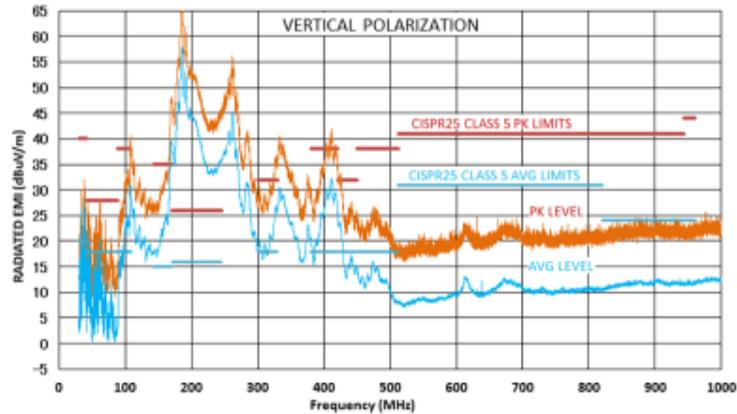
Switching Noise Spectrum Comparison



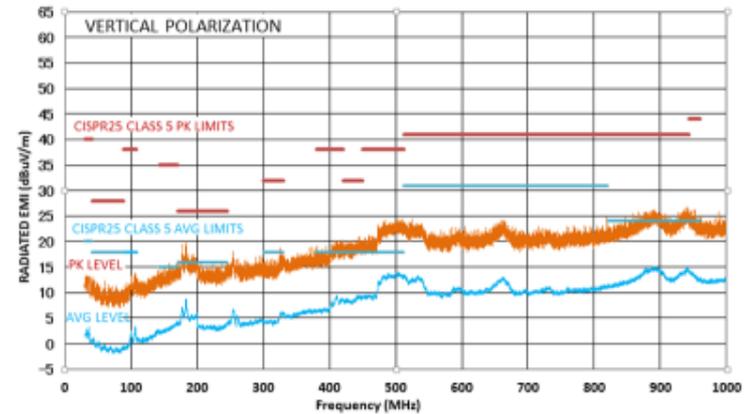
Buck-Boost EMI Comparison – 1st Gen vs. 2nd Gen



1st Gen, MPQ2483, not optimized for EMI



2nd Gen, MPQ7200 optimized for EMI



Max 45dB reduction after redesign the IC!