Start Time: March 14, 2024 | 7:30 AM PDT | 10:30 AM EDT | 3:30 PM CET

Layout Optimization of Half-Bridge Topologies

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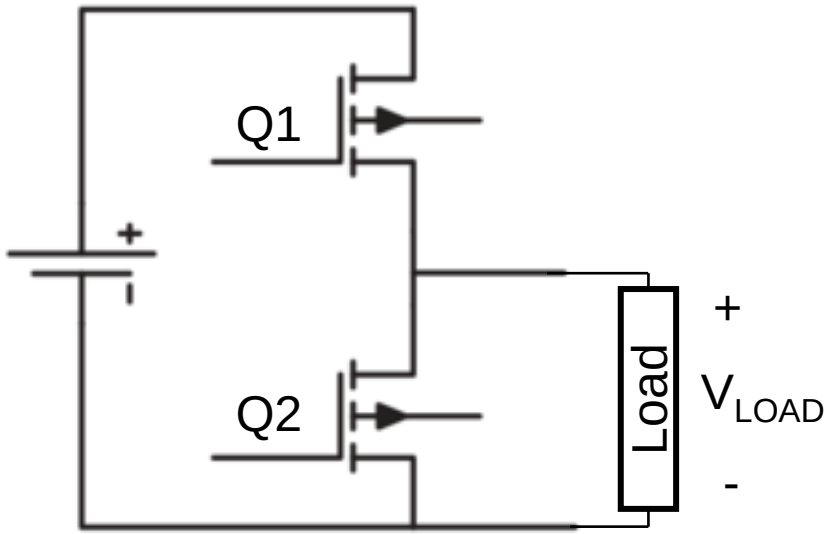
Introduction

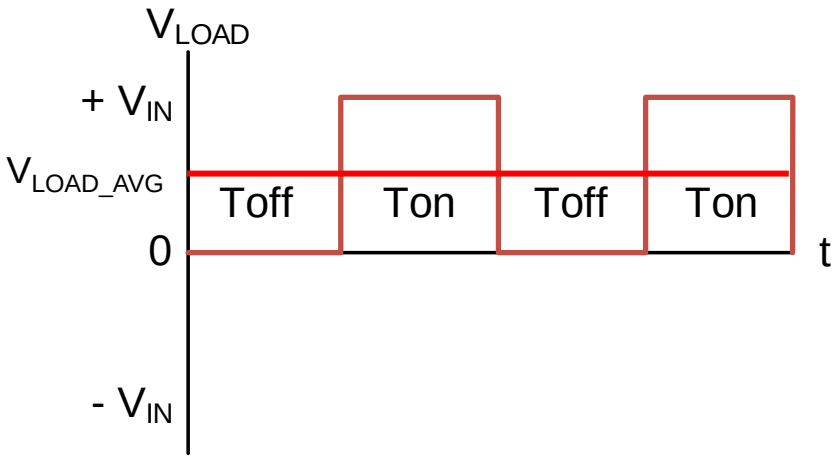
Half bridges are the most basic form of switching converters, and the *bread and butter* of MPS

- What do we understand for *Half bridge*?
- Which are the most common half bridge topologies in DC/DC conversion*?*
- How to identify the critical current paths in these topologies, and how to minimize their Electromagnetic Interferences (EMI)
- Empirical results of radiated emissions testing based on different VIN routing styles for a Buck

Half-Bridge

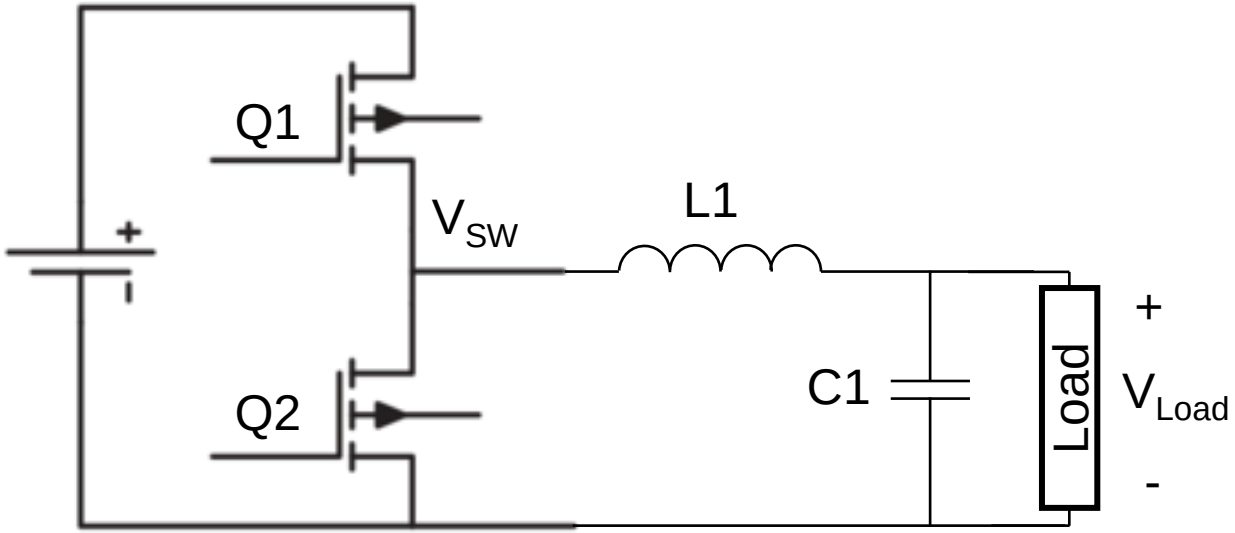


Half-Bridge

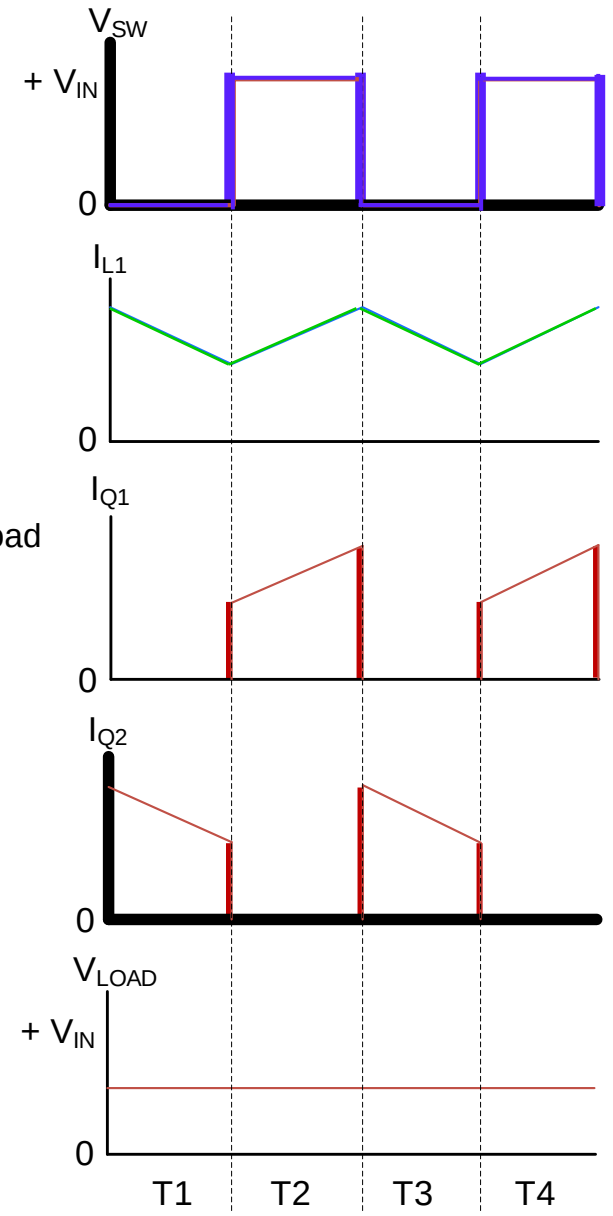


V_{LOAD_AVG} = VIN x Ton/(Ton+Toff)

Buck Converter



Buck Converter



High dV/dt

high $\frac{dV}{dt} \Rightarrow E - Field$

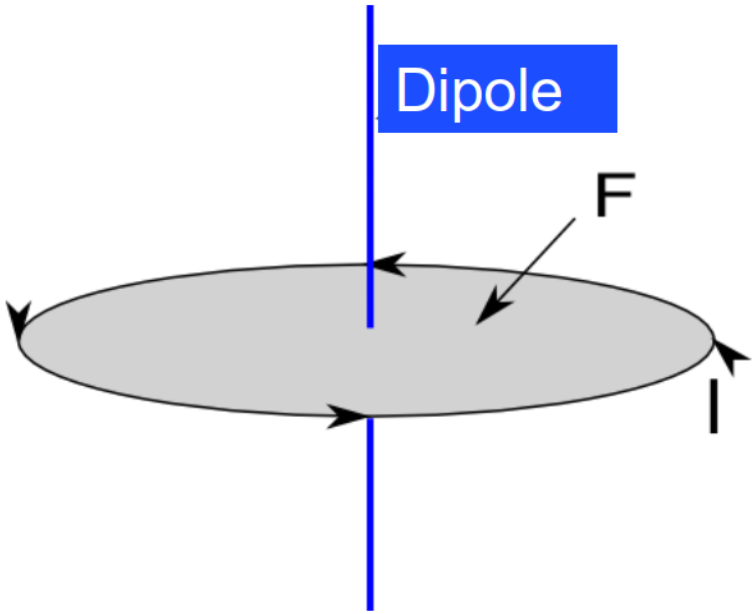
Increase with voltage
Increase with antenna size
and height above PCB

High dI/dt

high $\frac{di}{dt} \Rightarrow H - Field$

Increase with current
Increase with loop size
and height above PCB

Magnetic Dipole Antenna



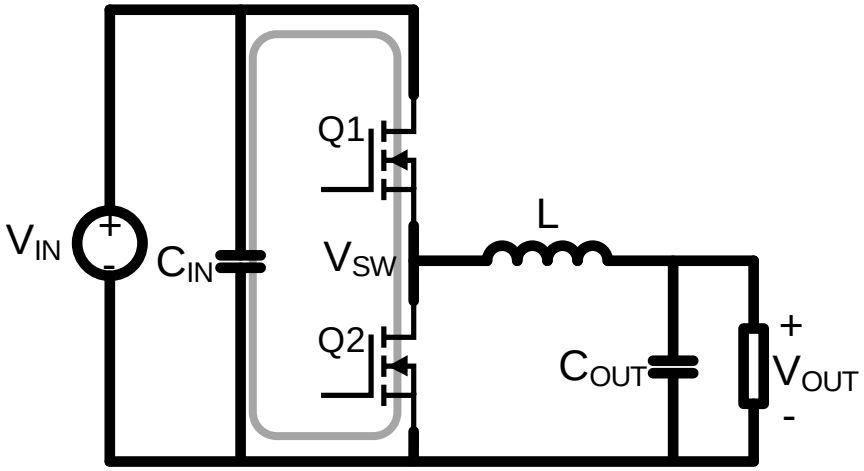
AC current flowing through a conductor creates a magnetic dipole antenna

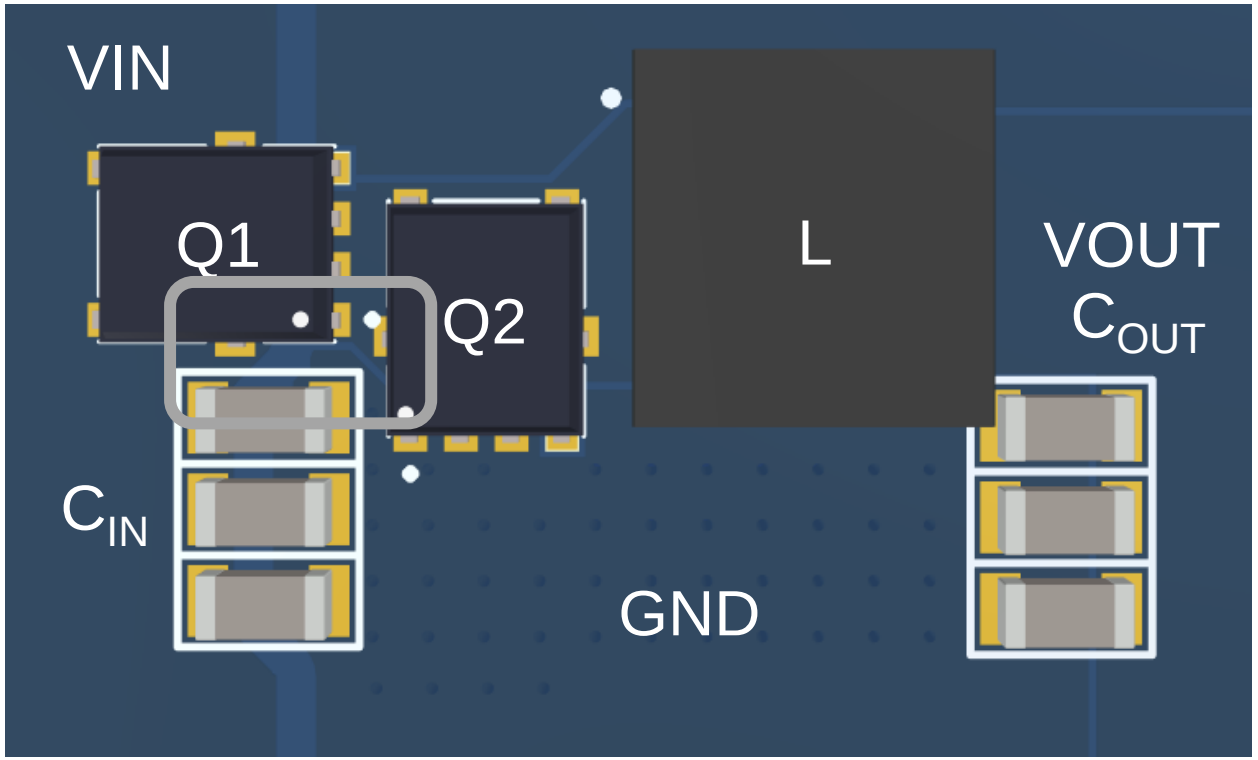
It radiates in the same way an electric dipole does

Radiation increases with area and current magnitude

Identifying the Critical Loop in Different Topologies

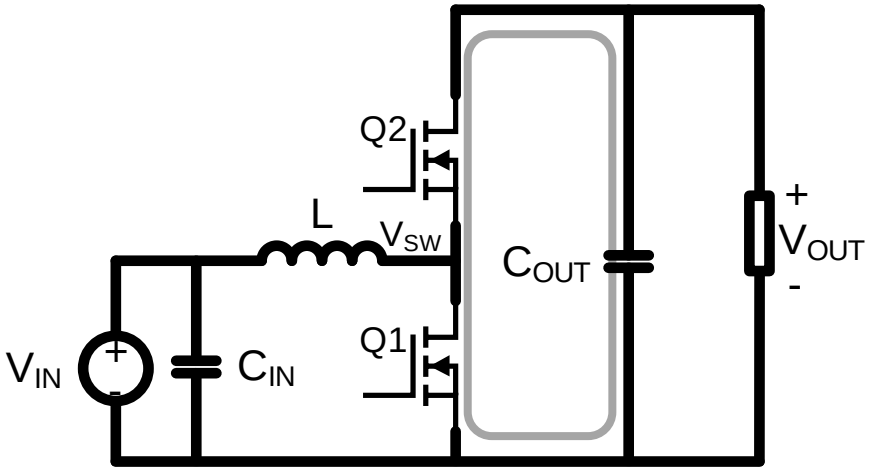
Buck Converter

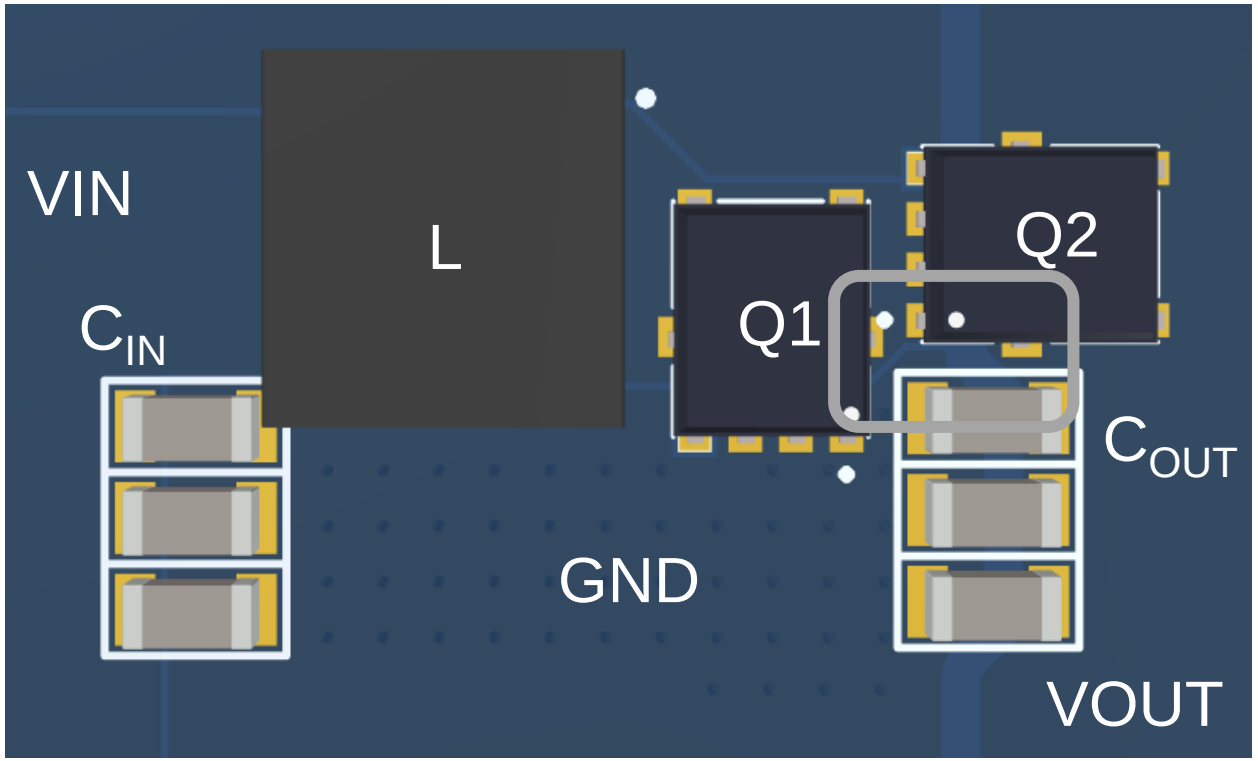




Identifying the Critical Loop in Different Topologies

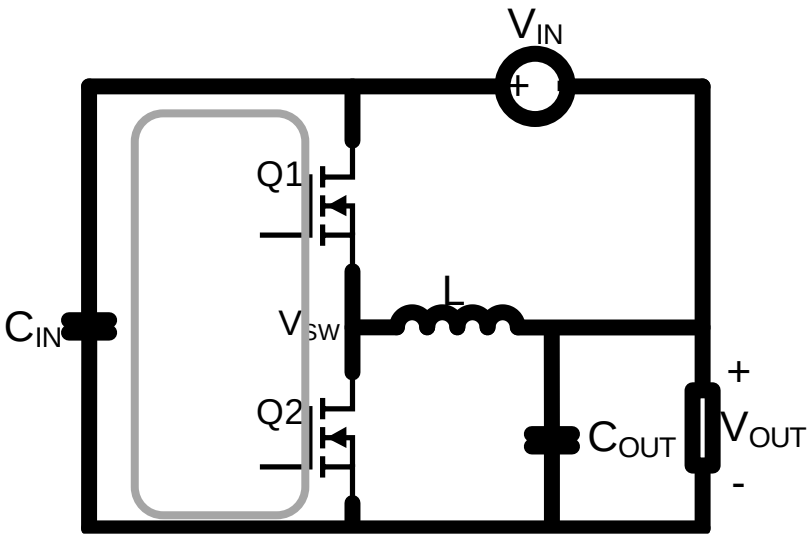
Boost Converter

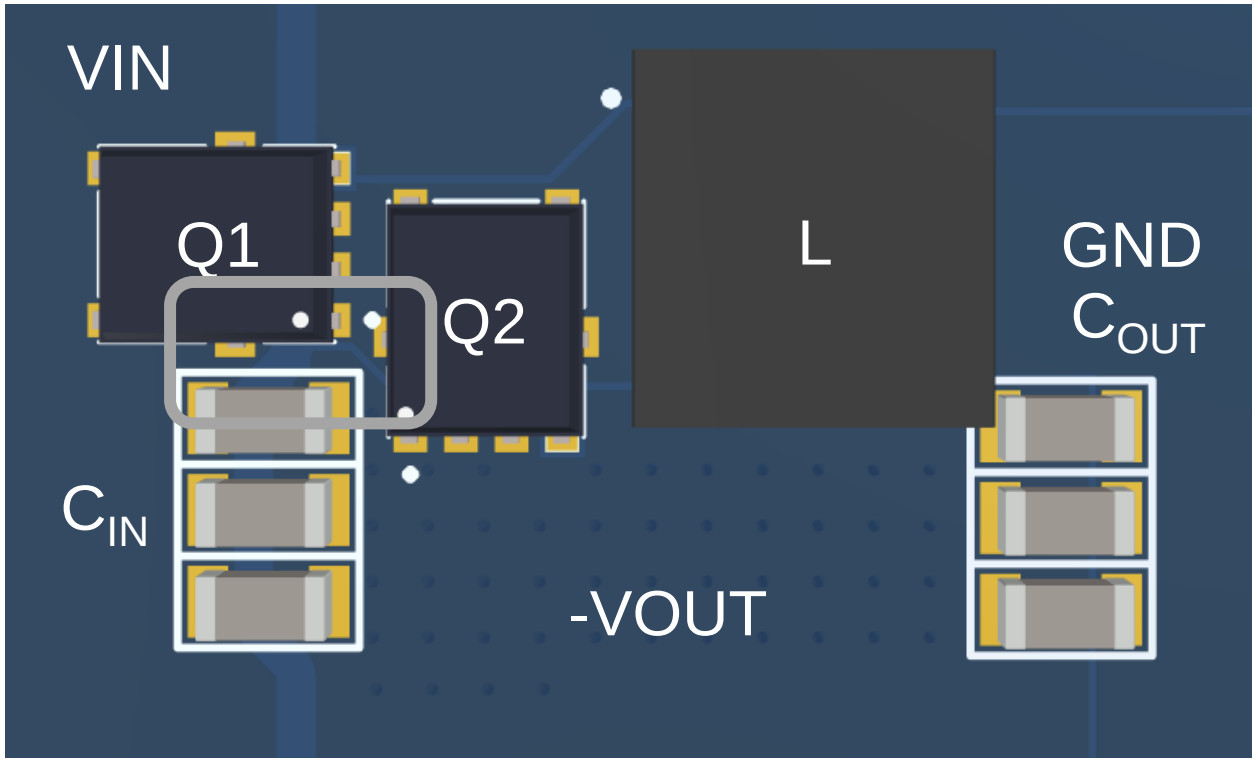




Identifying the Critical Loop in Different Topologies

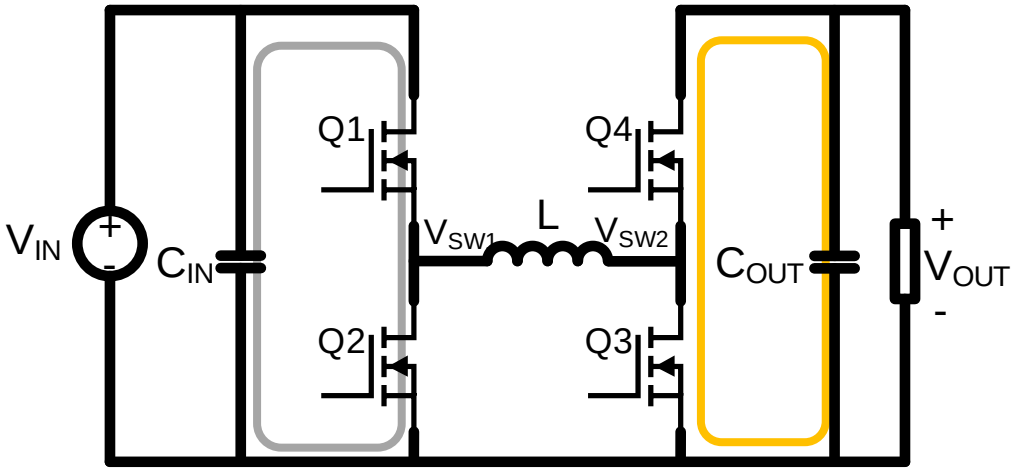
Inverting Buck-Boost Converter

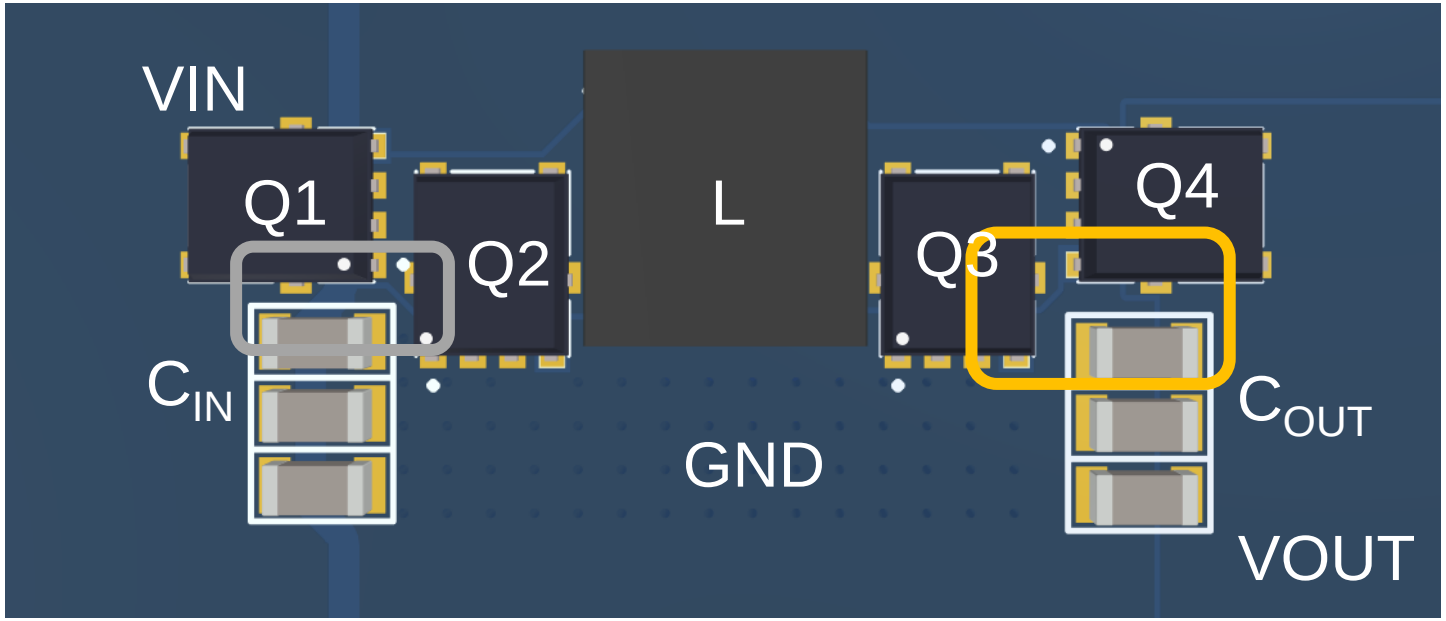




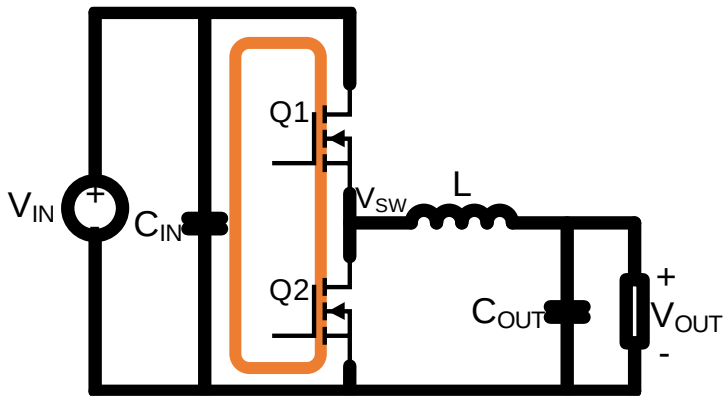
Identifying the Critical Loop in Different Topologies

4 Switch Buck-Boost

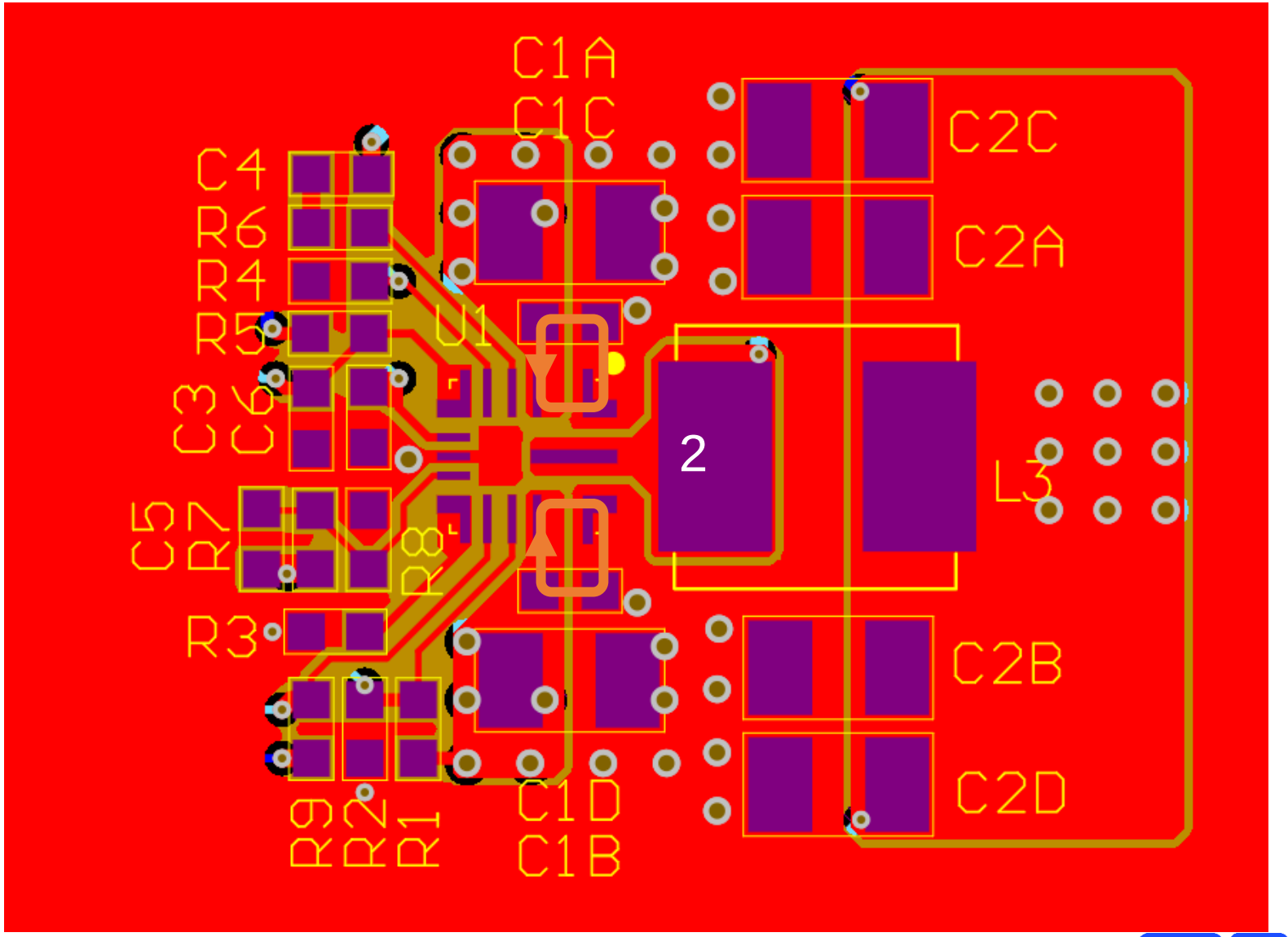




Monolithic Buck IC Layout

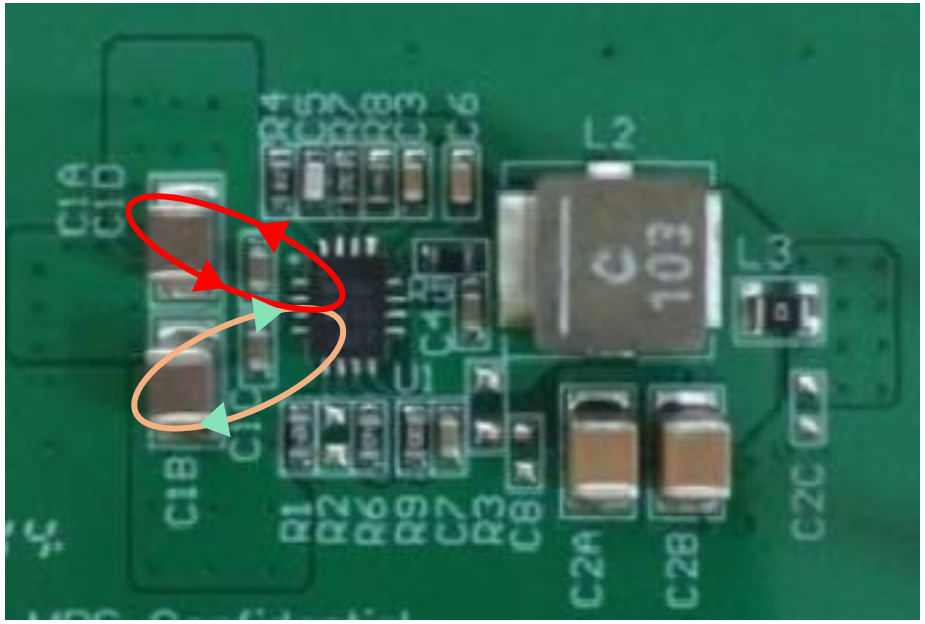


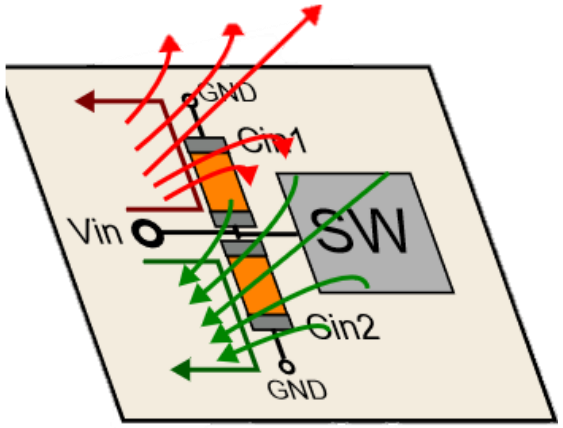
1. Minimize C_{IN} loop
2. Small SW polygon

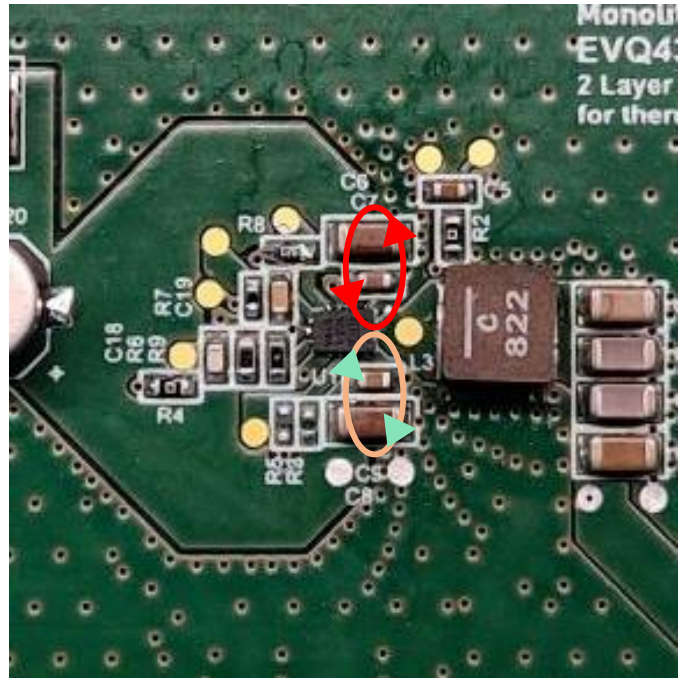


Symmetric Capacitors at V_{IN}

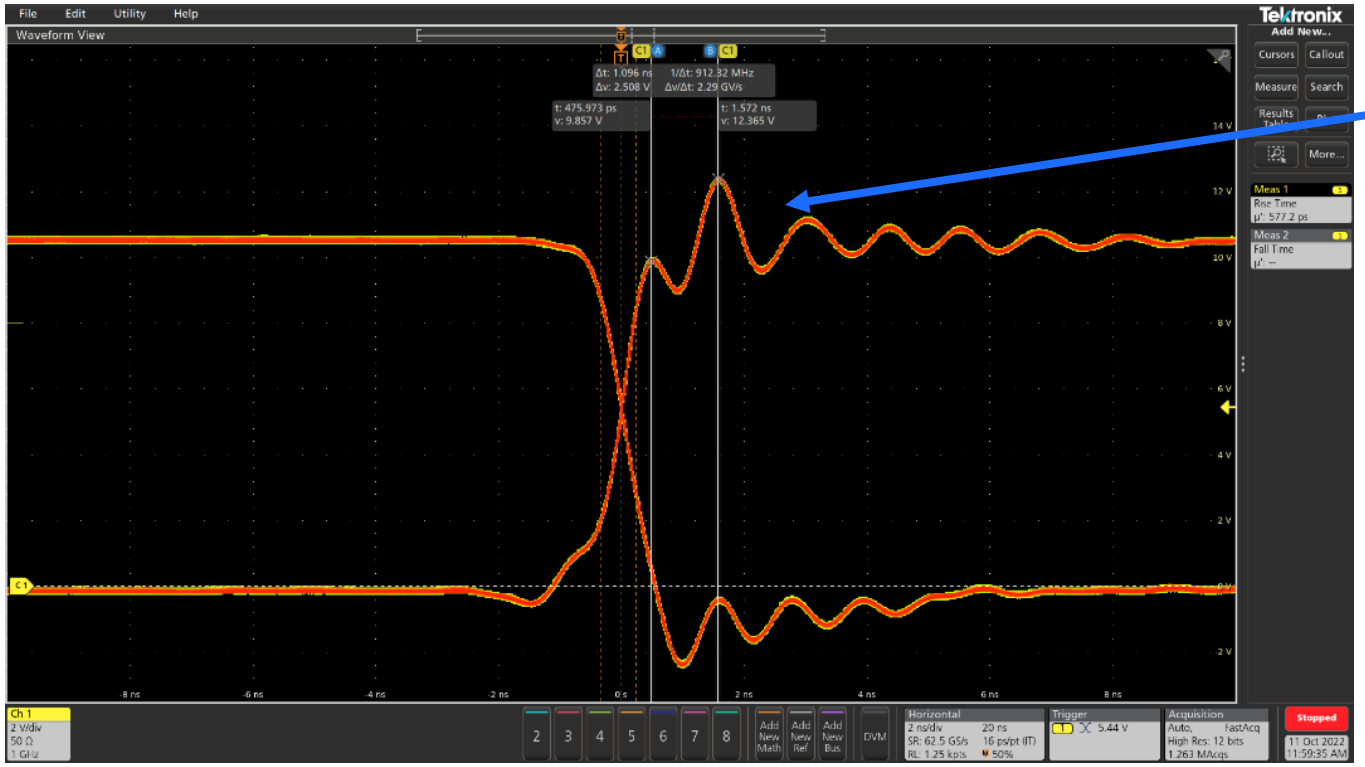
When placing the input capacitors symmetrically, creating two opposing current loops, the magnetic fields created by dI/dt cancel each other as they have opposite directions.







Challenges with integrated Half-Bridge DC/DC



Monolithic IC with extremely fast switching

11V to 5V, 2.5A, 2.2MHz

- Rise time: 577ps
- Fall time: 900ps
- Ringing frequency: 800MHz to 900MHz
- Excellent efficiency requires good layout

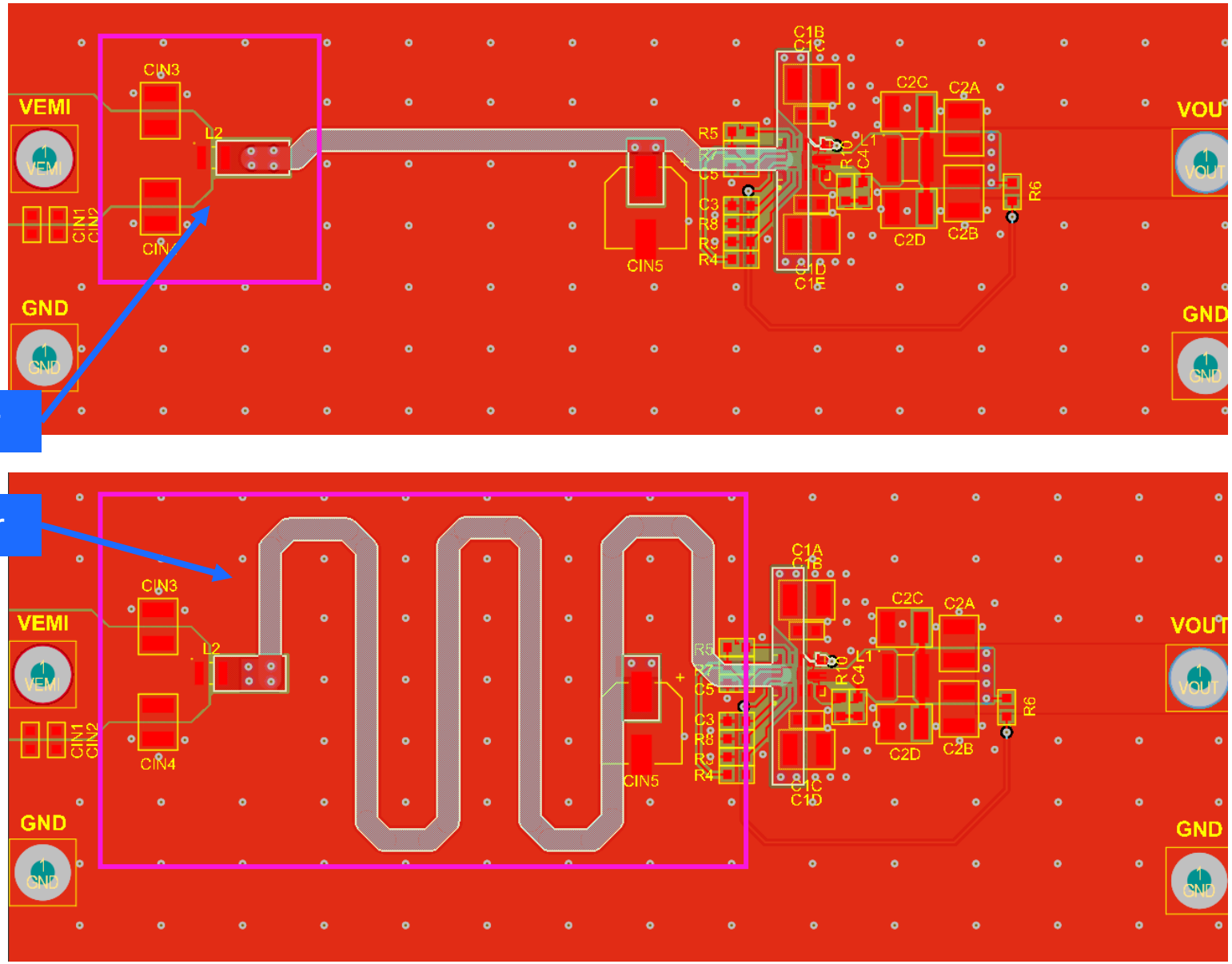
Empirical Investigation on Radiated Emissions

VIN Routing Style

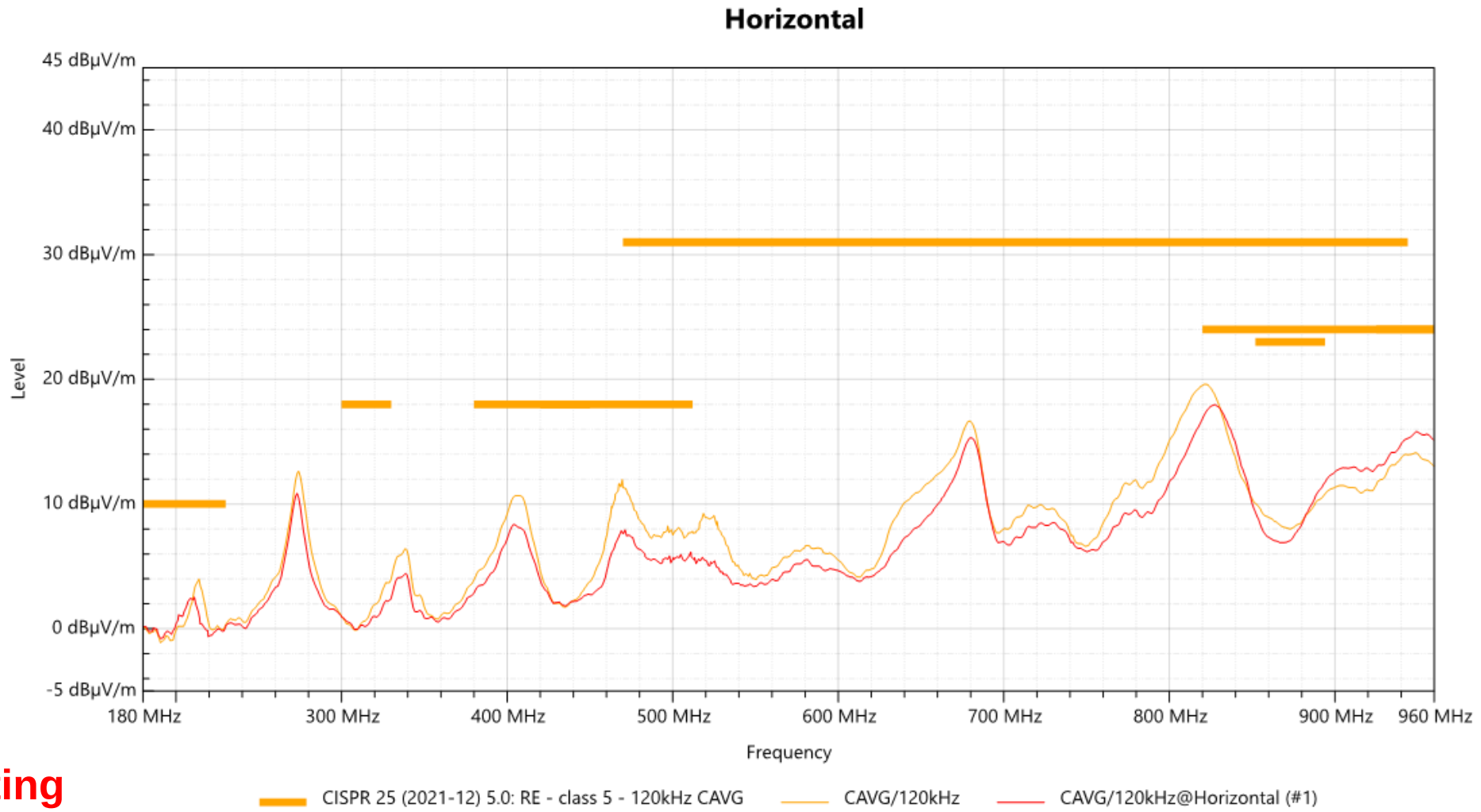
How the Input Trace Affects Radiated Emissions

1st order filter

2nd order filter



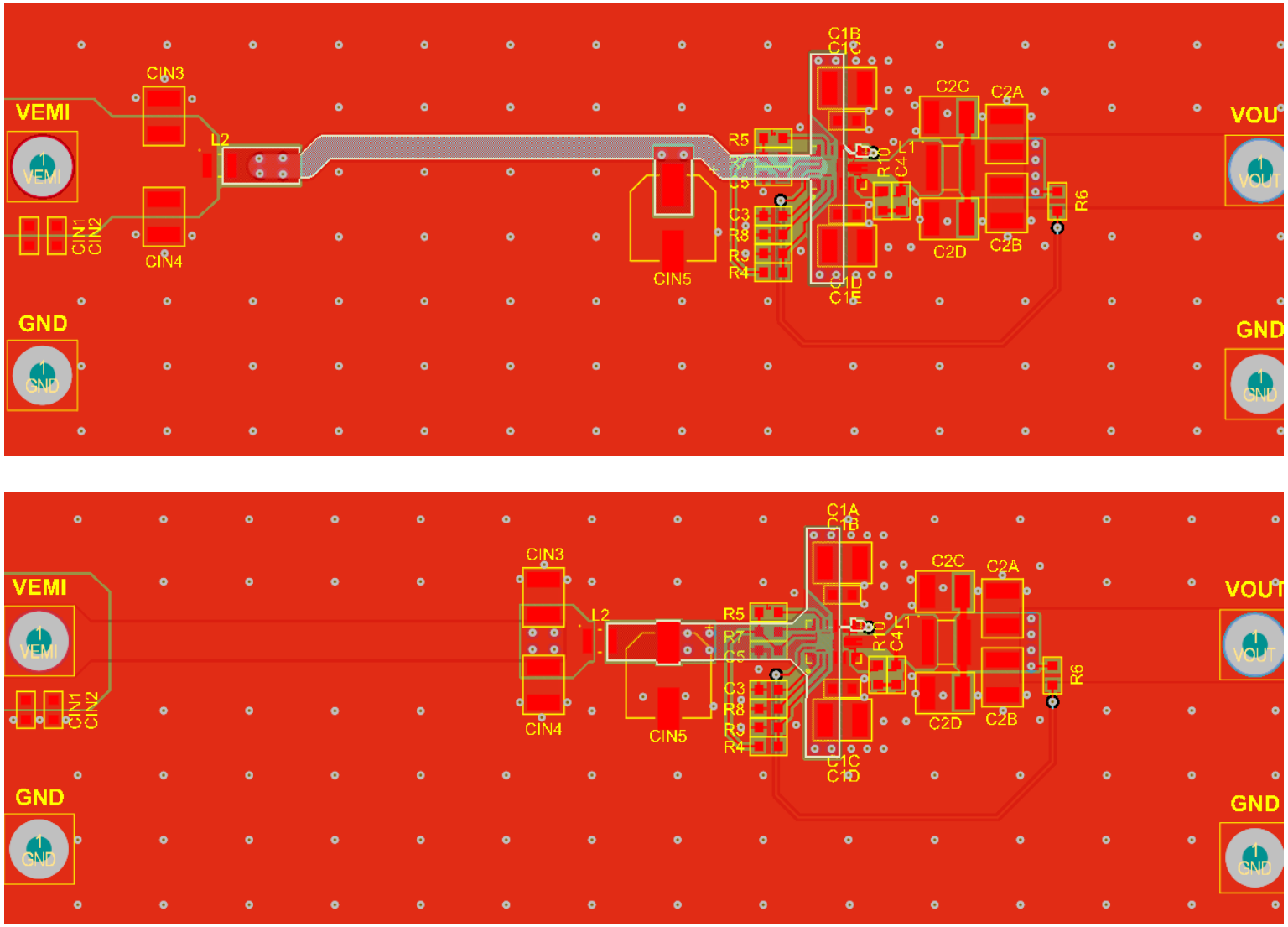
How the Input Trace Affects Radiated Emissions



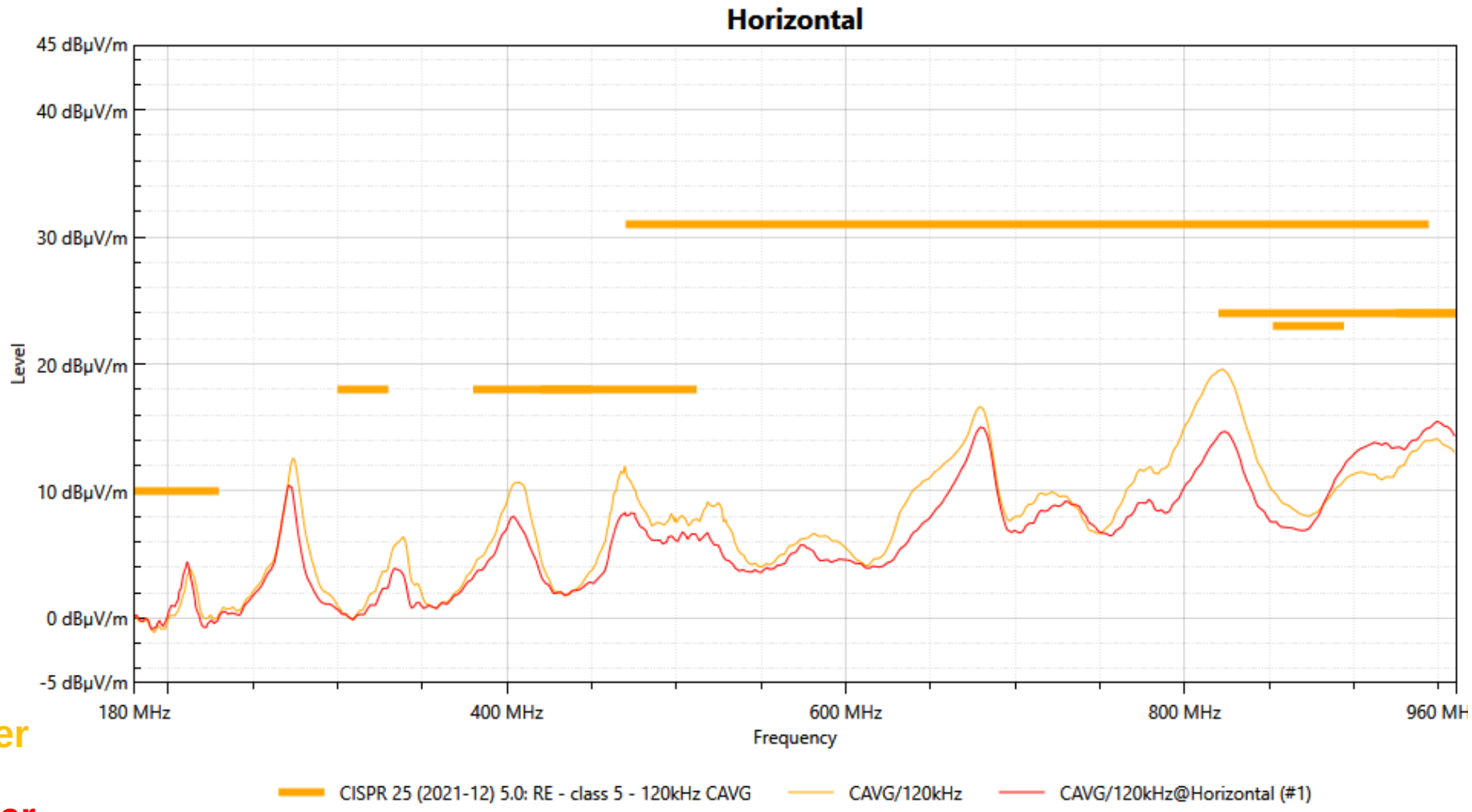
Straight Line

Zig-Zag Routing

How EMI Filter Placement Affects Radiated Emissions



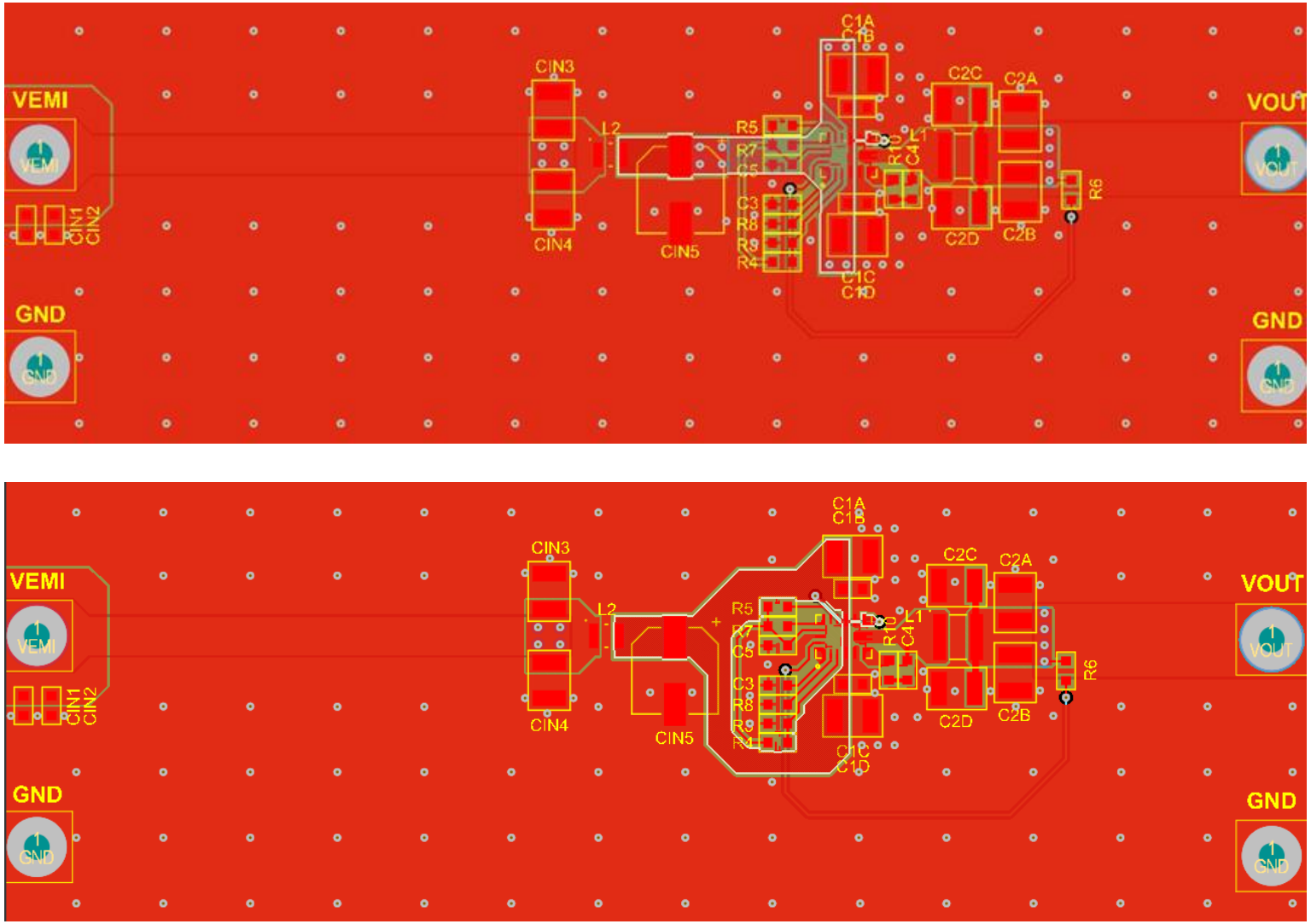
How Filter Placement Affects Radiated Emissions



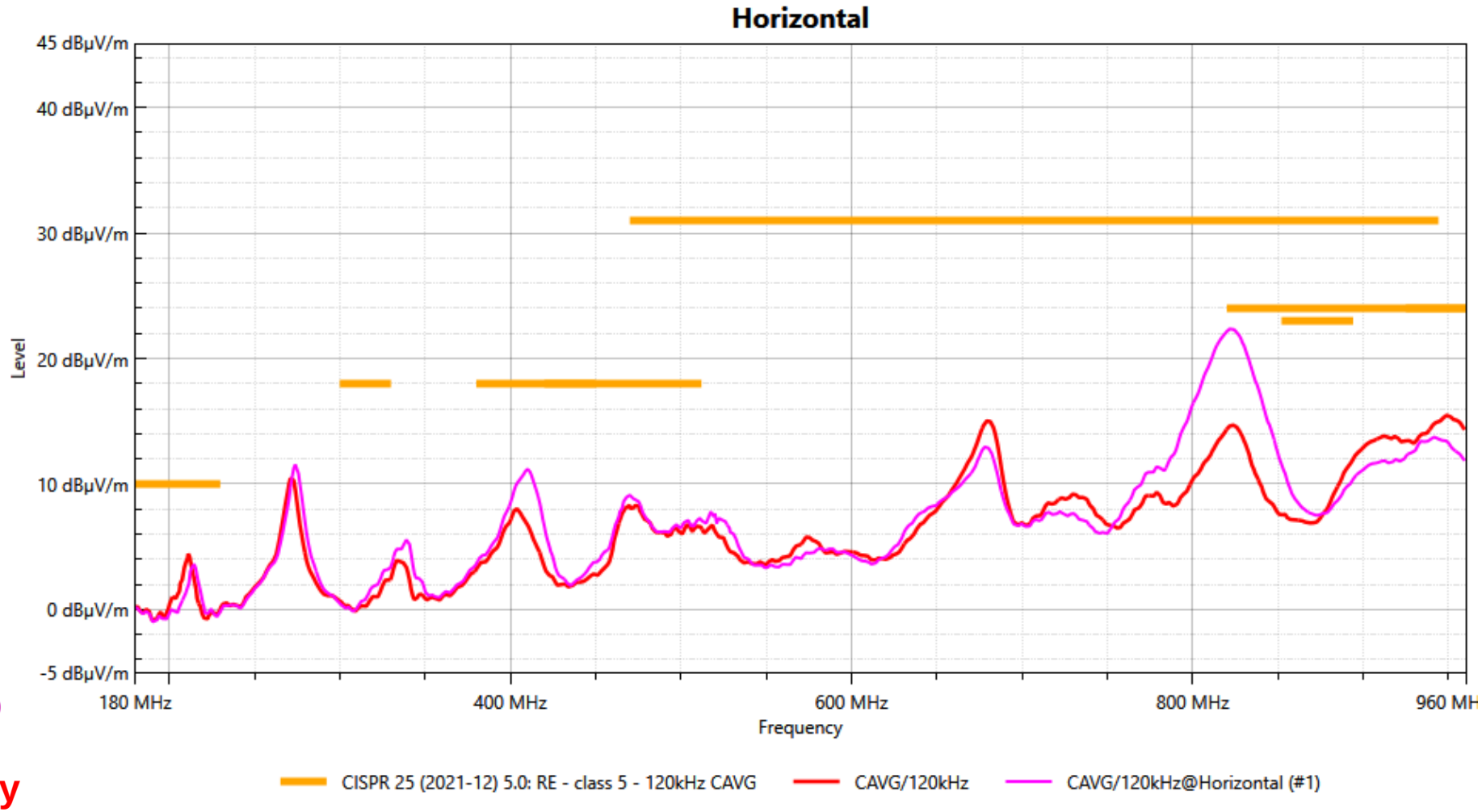
Long Distance to Filter

Short Distance to Filter

How the VIN Layer Affects Radiated Emissions



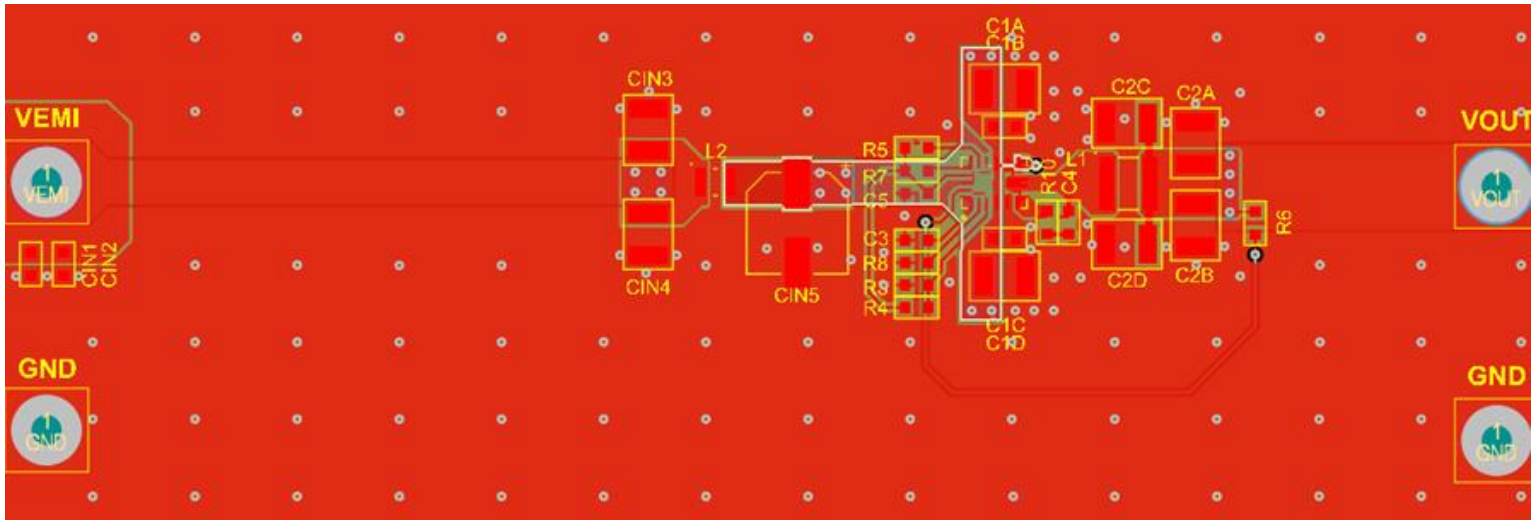
How the VIN Layer Affects Radiated Emissions

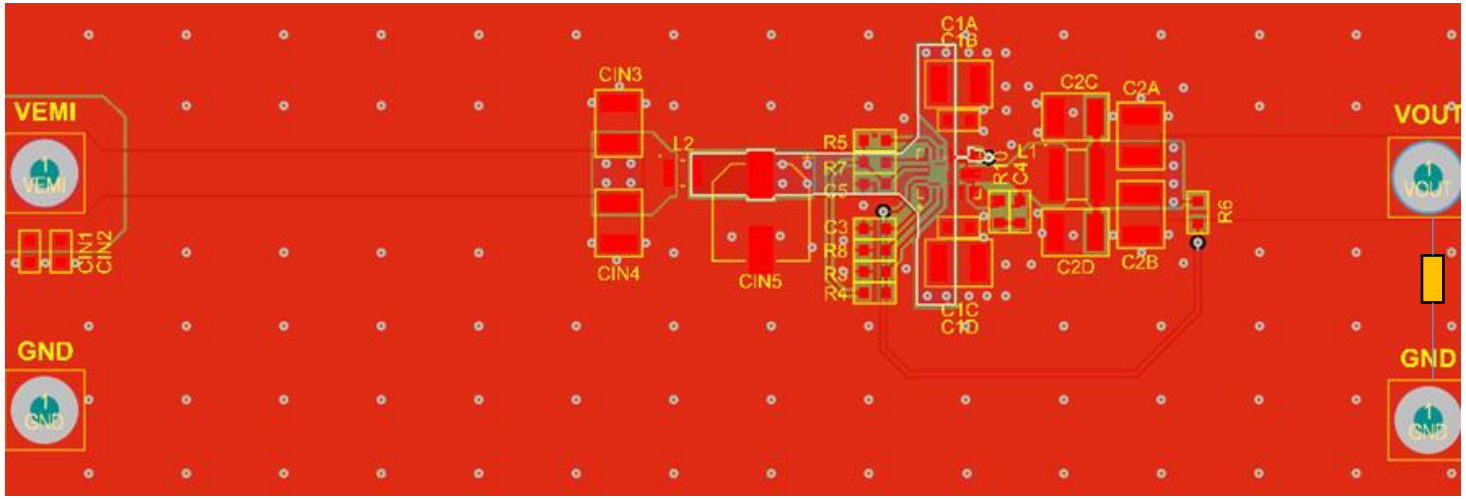


VIN Exposed on Top

VIN Routed Internally

How the Load Used Affects Radiated Emissions

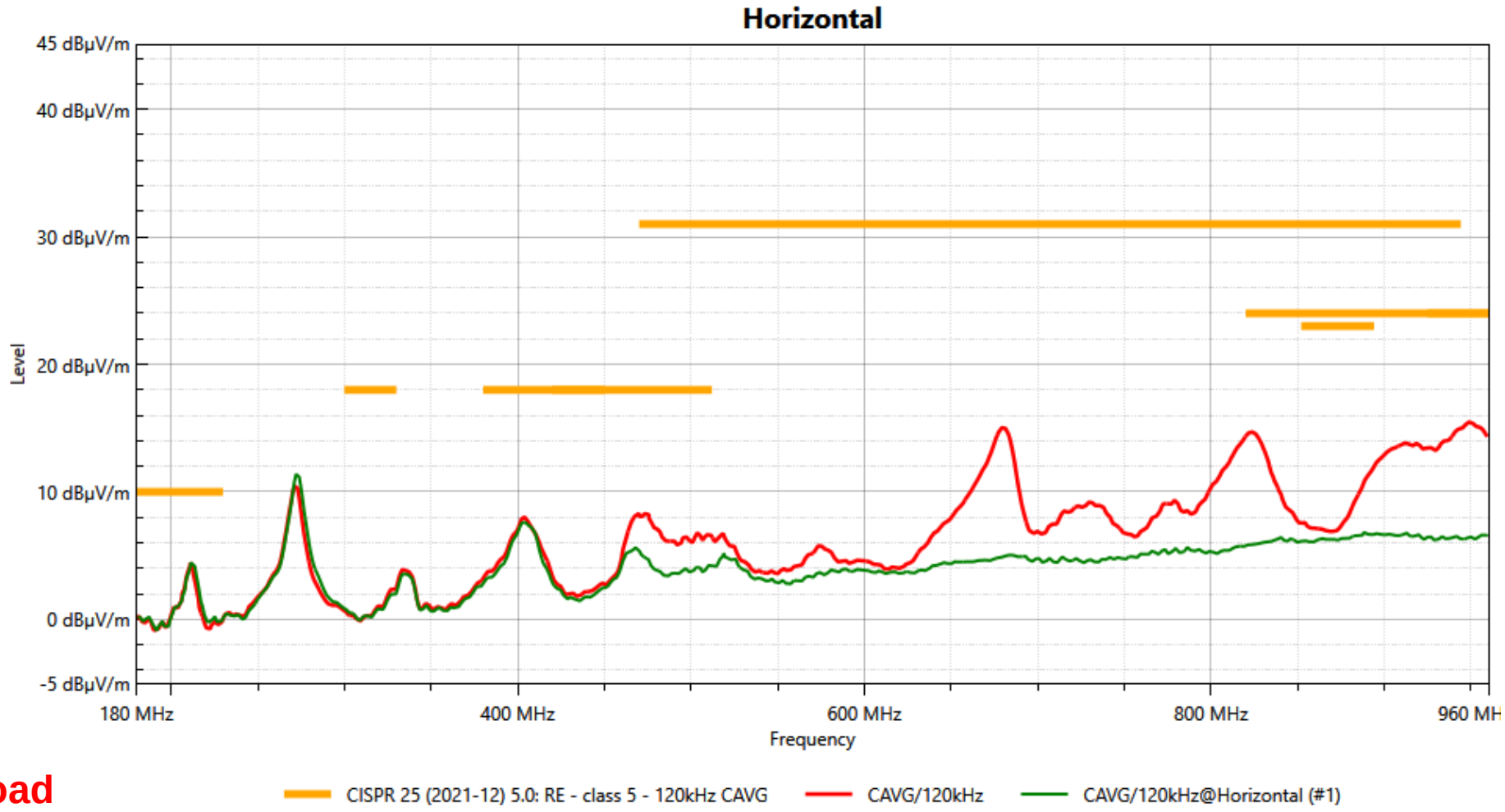




How the Load Used Affects Radiated Emissions

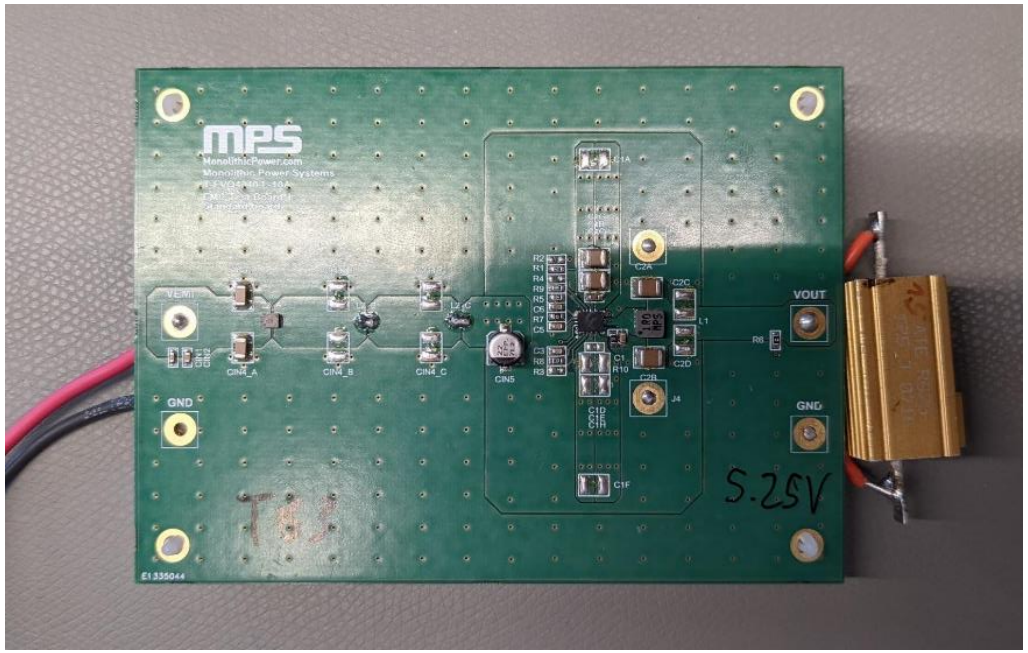
HF Filter on the Load

No HF Filter on the Load

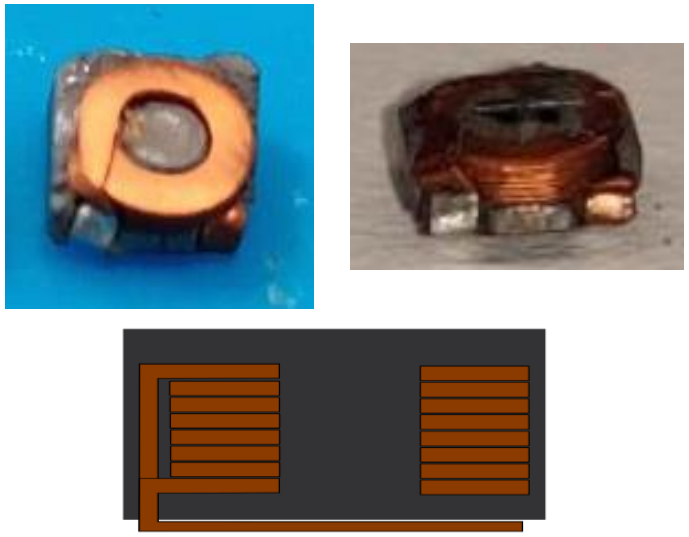


Methodology

The input harness follows CISPR 25 standards. The output resistor is connected to the PCB with short cables.

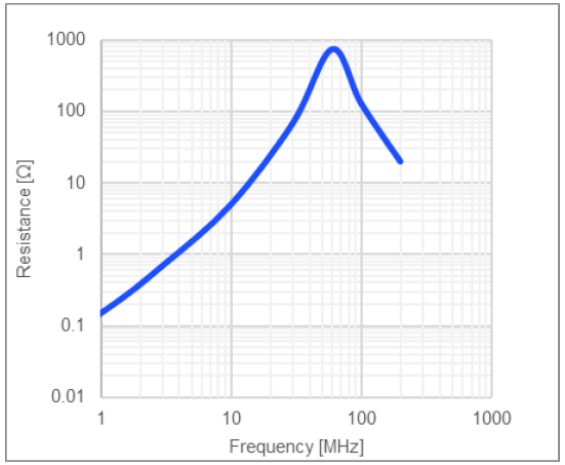


Test Set-Up



Shielded (molded)

ACR



C_P = 8pF

Conclusions

- There are endless DC/DC topologies, but the most common types in low voltage applications are all based on a half-bridge
- Learning how to analyze and what to look for in a half-bridge DC/DC will give you the tools to correctly design most DC/DC converters
- The key item is to locate the “hot loop,” and minimize its size, inductance and coupling effect by:
  - Placing the decoupling capacitors tightly
  - Placing it far from connectors and harnesses
  - Properly designing and placing filtering

Q&A

Let us know your questions!