Two Common PCB Layout Errors that Cause Automotive Products to Fail to Meet EMC Requirements

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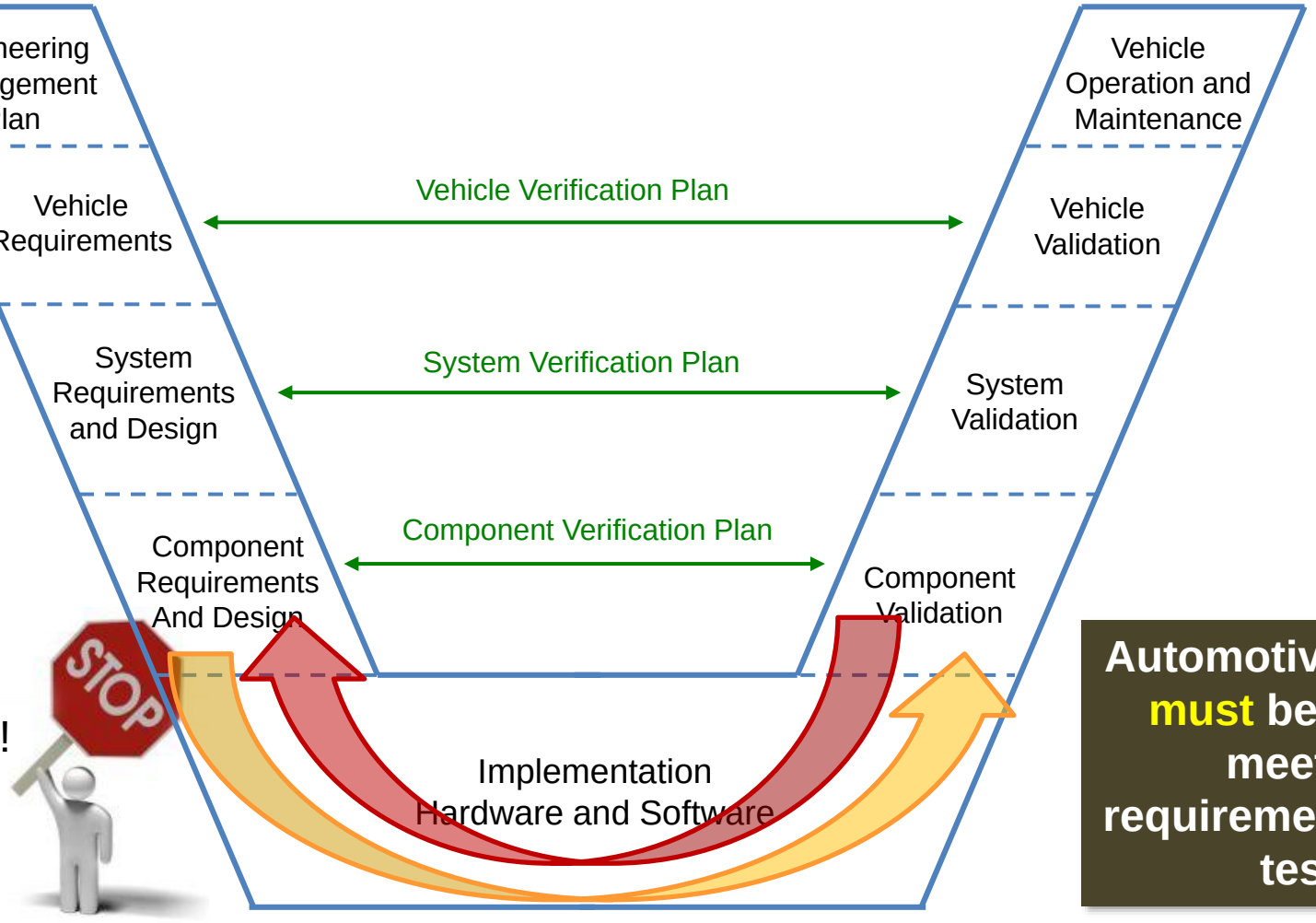
Impact of Layout on Product Compliance, Safety and Cost

This is dangerous!

This is expensive!

This is time-consuming!

This has got to stop!



Automotive components must be designed to meet all EMC requirements on the first test pass!

Recently completed article for the IEEE EMC Magazine

Common PCB Layout Errors that Cause Products to Fail to Meet Automotive EMC Requirements

- Blindly adhering to EMC design guidelines ← MOST OBVIOUS
- Failing to control transition times or bandwidths ← MOST COMMON
- Failing to follow the currents ← MOST OBVIOUS ← MOST COMMON
- Failing to identify critical traces or components ← MOST COMMON
- Having more than one “ground” ← MOST EGREGIOUS ← MOST COMMON
- Improper power bus decoupling ← MOST OBVIOUS
- Inadvertently bypassing filters. ← MOST COMMON

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- Failing to identify critical traces or components ⟵ **MOST COMMON IN OTHERWISE GOOD DESIGNS**
- Having more than one “ground”
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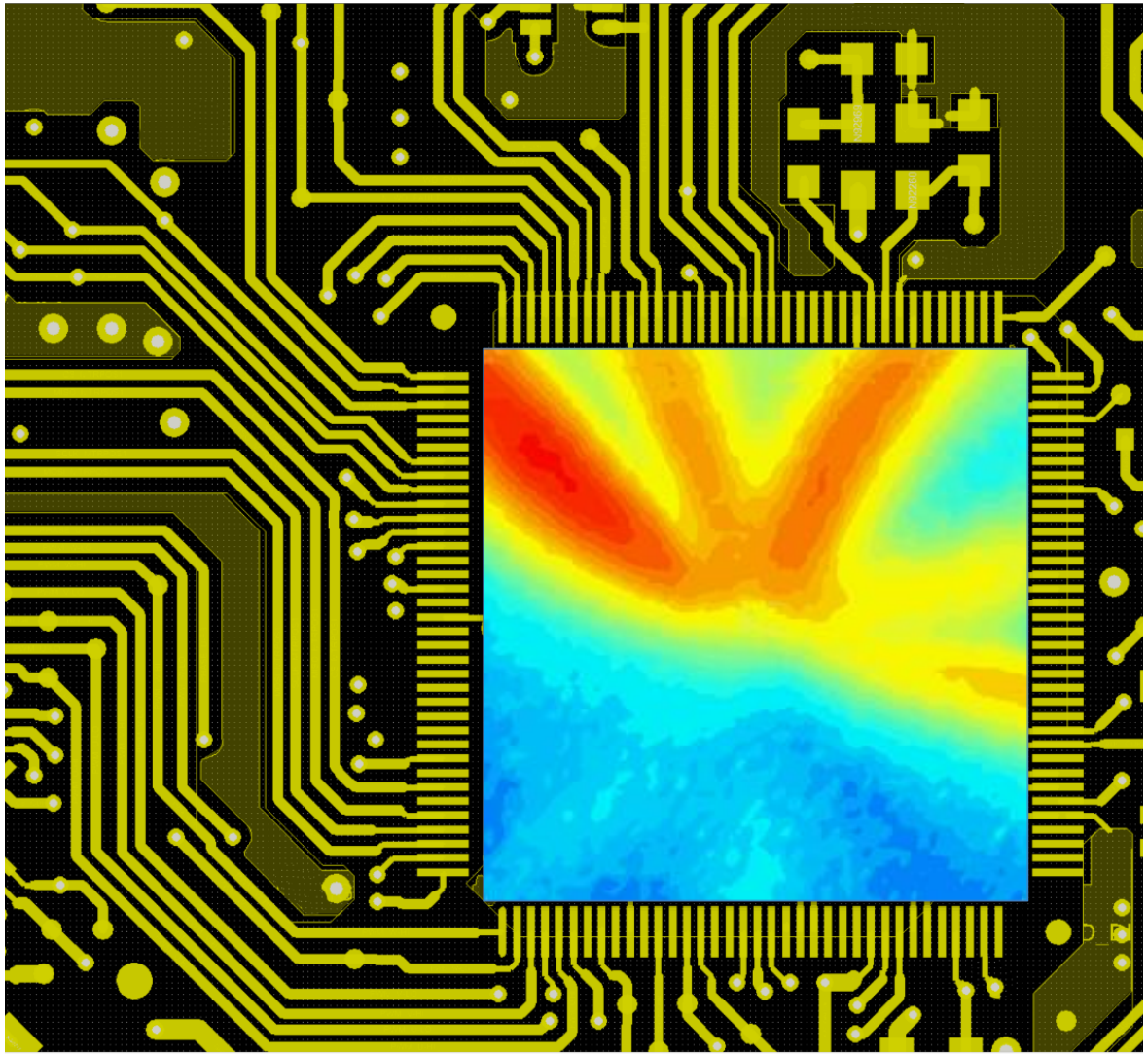
- Inadvertently bypassing filters. ⟵ **MOST COMMON IN OTHERWISE GOOD DESIGNS**

Failing to identify critical traces or components

Common Automotive Noise Sources

- IC clock harmonics driving nominally low-speed I/O
- Switching power supplies and motor drivers
- Clock and data signals with uncontrolled transition times

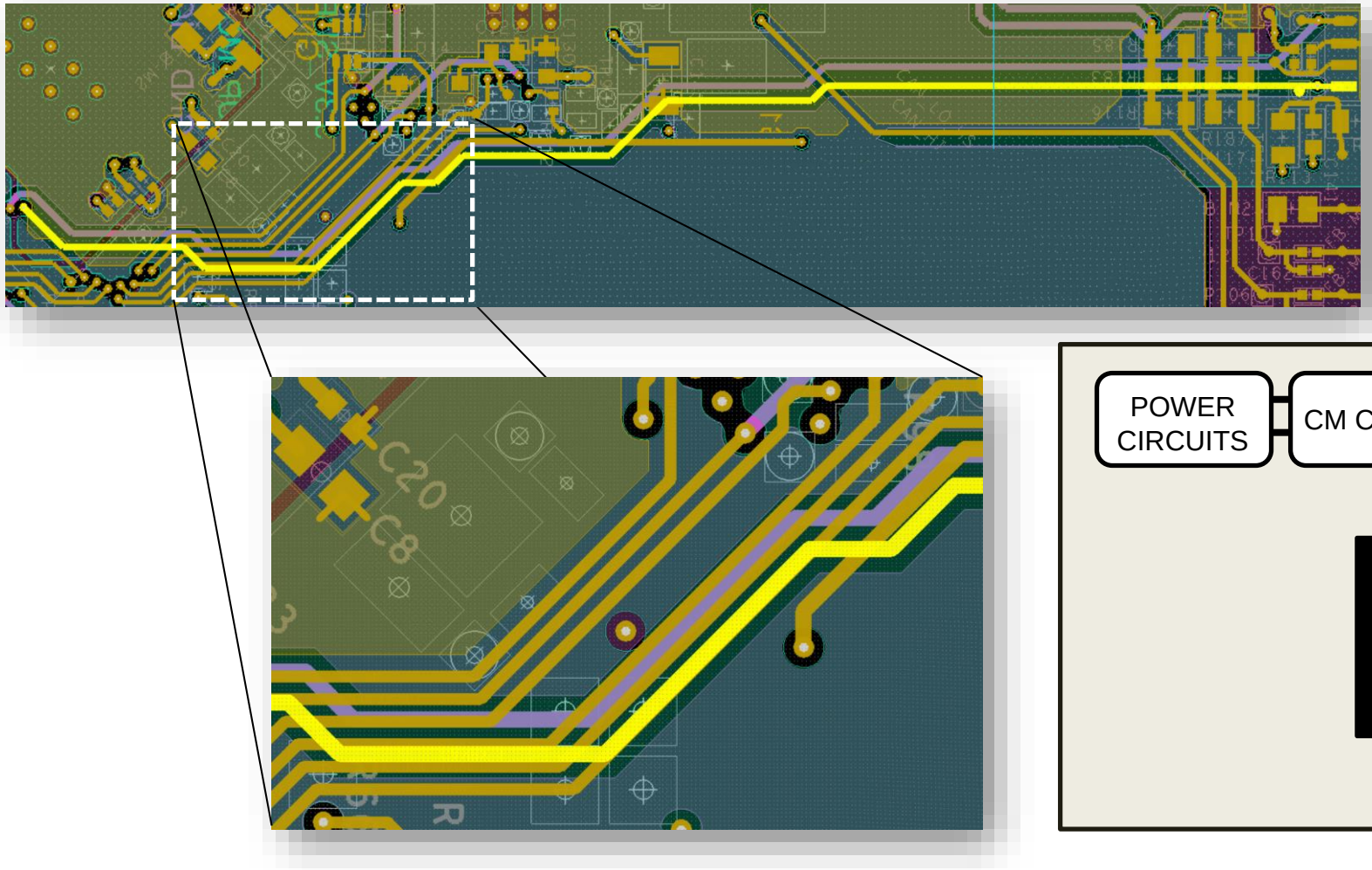
IC clock harmonics driving nominally low-speed I/O

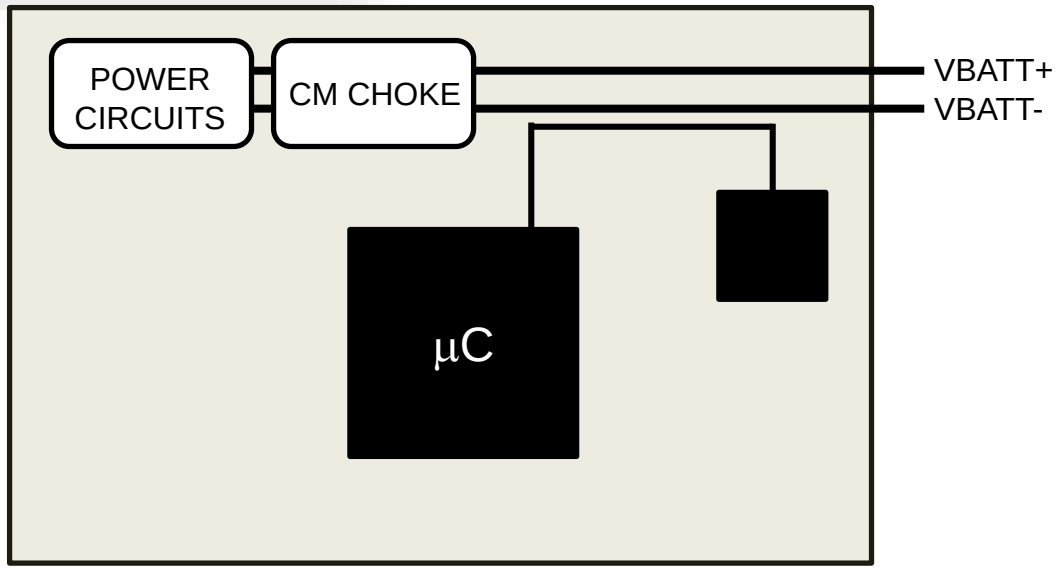


Internal switching noise may be present on any output or input pin of a high-speed component!

IC clock harmonics driving nominally low-speed I/O

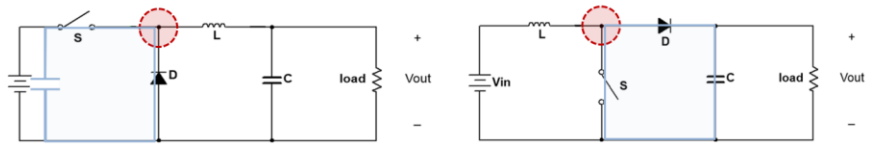
Look for signals coupled to I/O lines that carry HF power onto or off of the board.





Switching power supplies and motor drivers

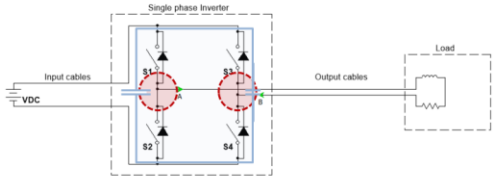
Power Inverters / Motor Drivers



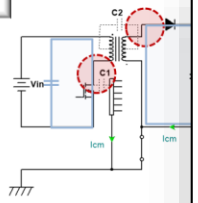
DC-DC buck converter

DC-DC boost converter

Identify the switching voltages.
Identify the switching current paths.



DC-AC inverter



Flyback convert

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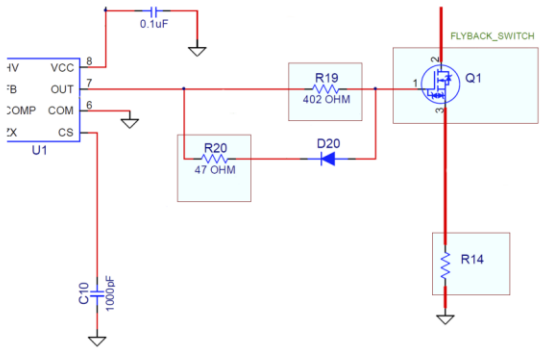
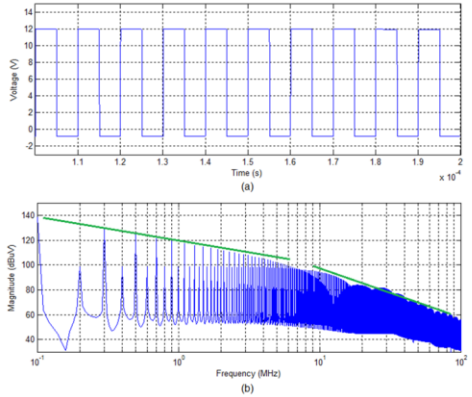
Identify the switching voltage nodes and the switching current loops.

(These are the only places where the transition times are virtually uncontrolled.)

Controlling Transition Times





Years ago, this was absolutely forbidden, because slowing the transition decreased the efficiency of the switch. Today, switches are so fast that controlling the transition time is often necessary to attenuate harmonics that are thousands of times higher than the switching frequency.

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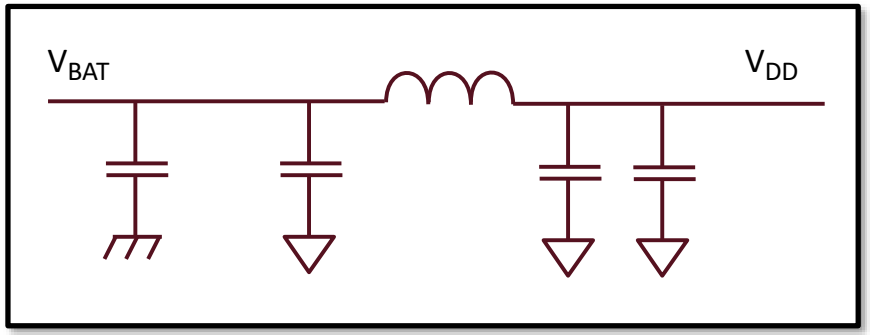
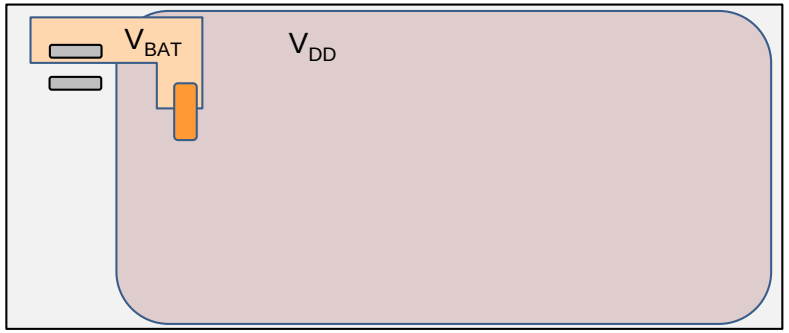
And then ...

Control the transition time!

Inadvertently bypassing filters.

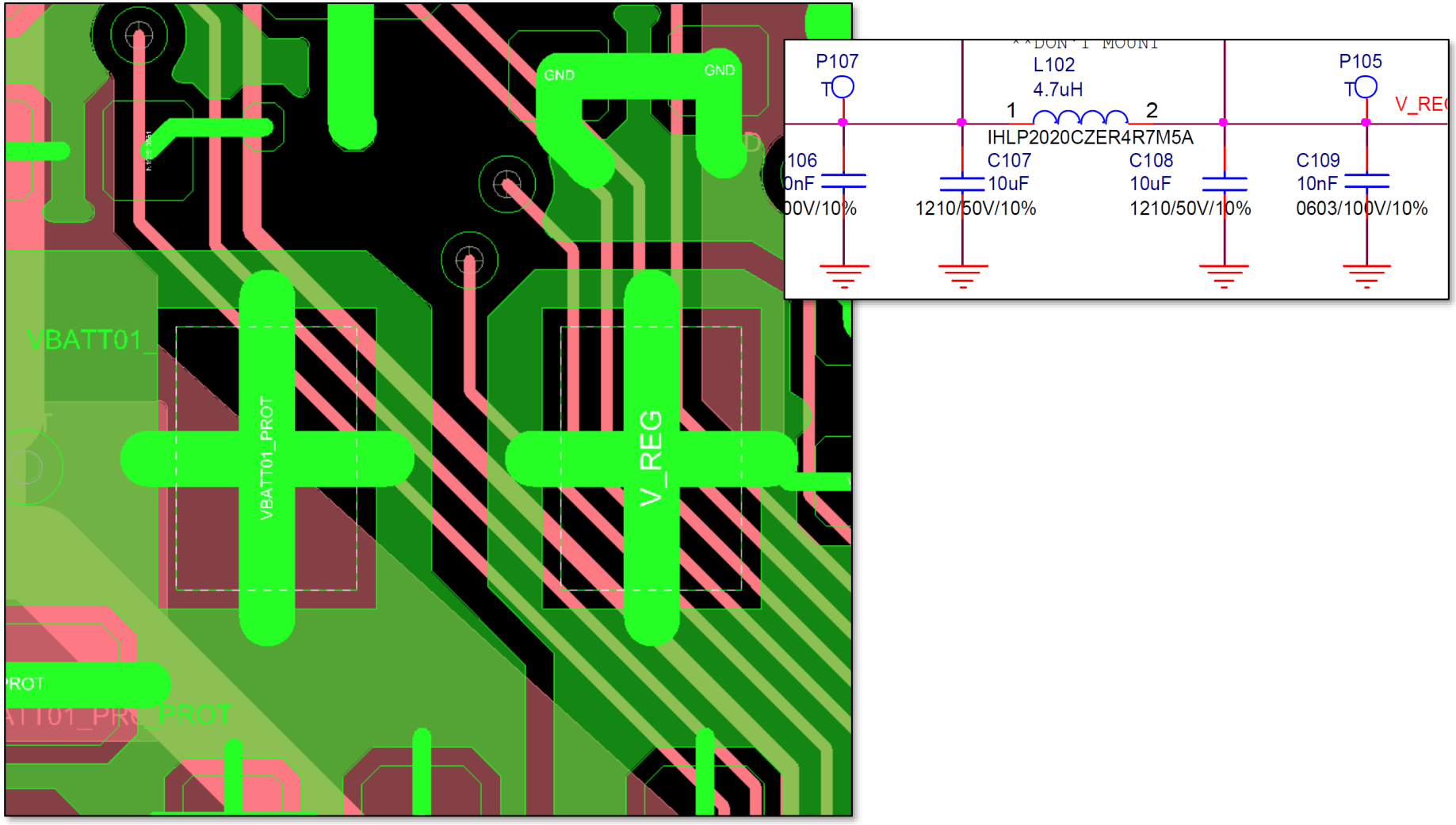
Design a good filter and don't unintentionally bypass it.



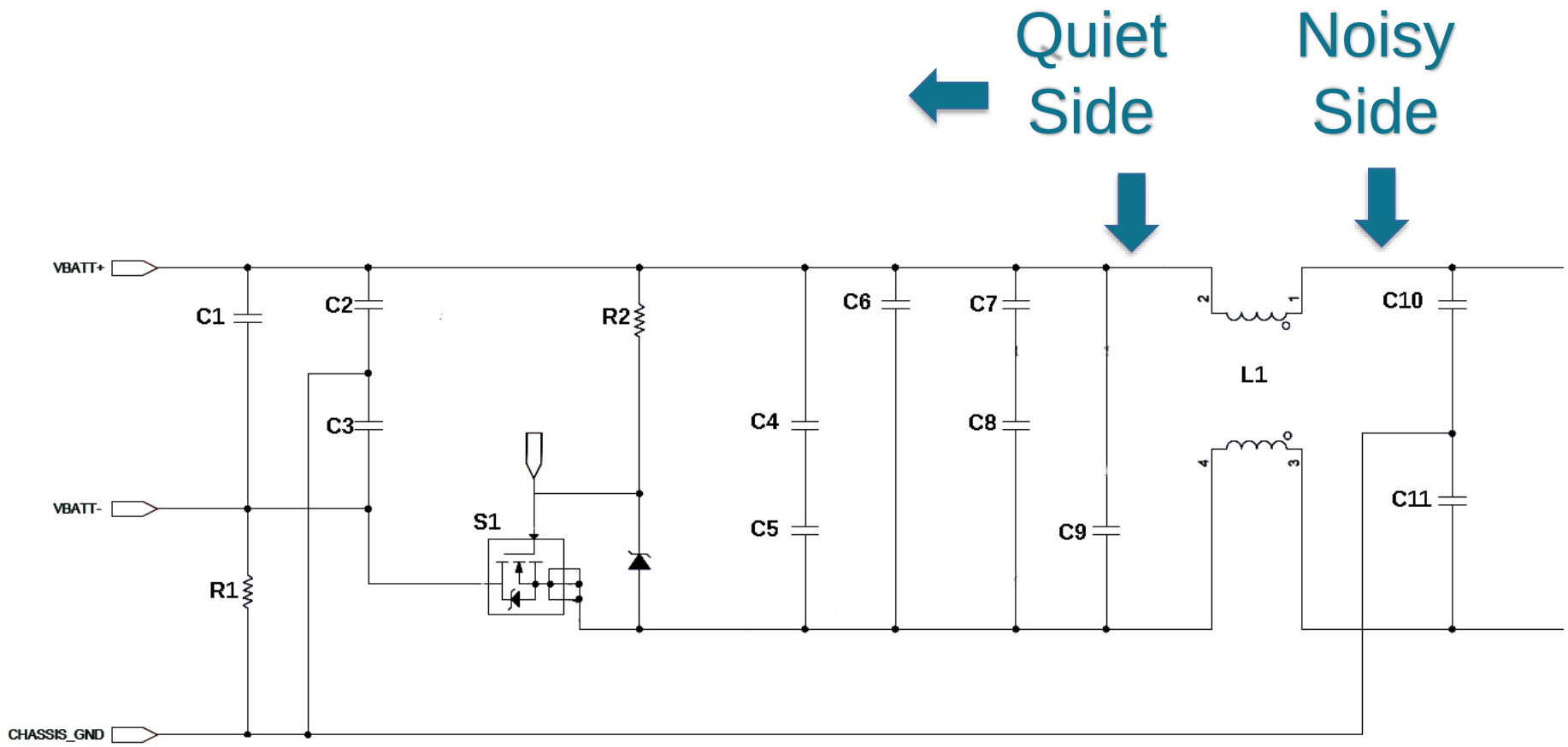


Remember that the LISN is measuring the voltage relative to CHASSIS ground. If your digital ground has a voltage relative to chassis ground, it will appear in your measurement.

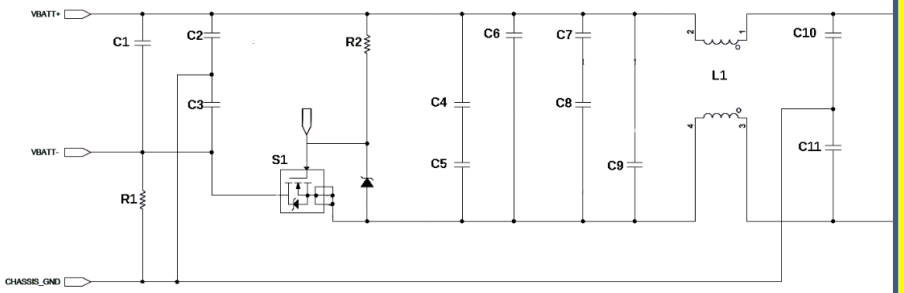
Magnetic Field Coupling from Filter Inductor

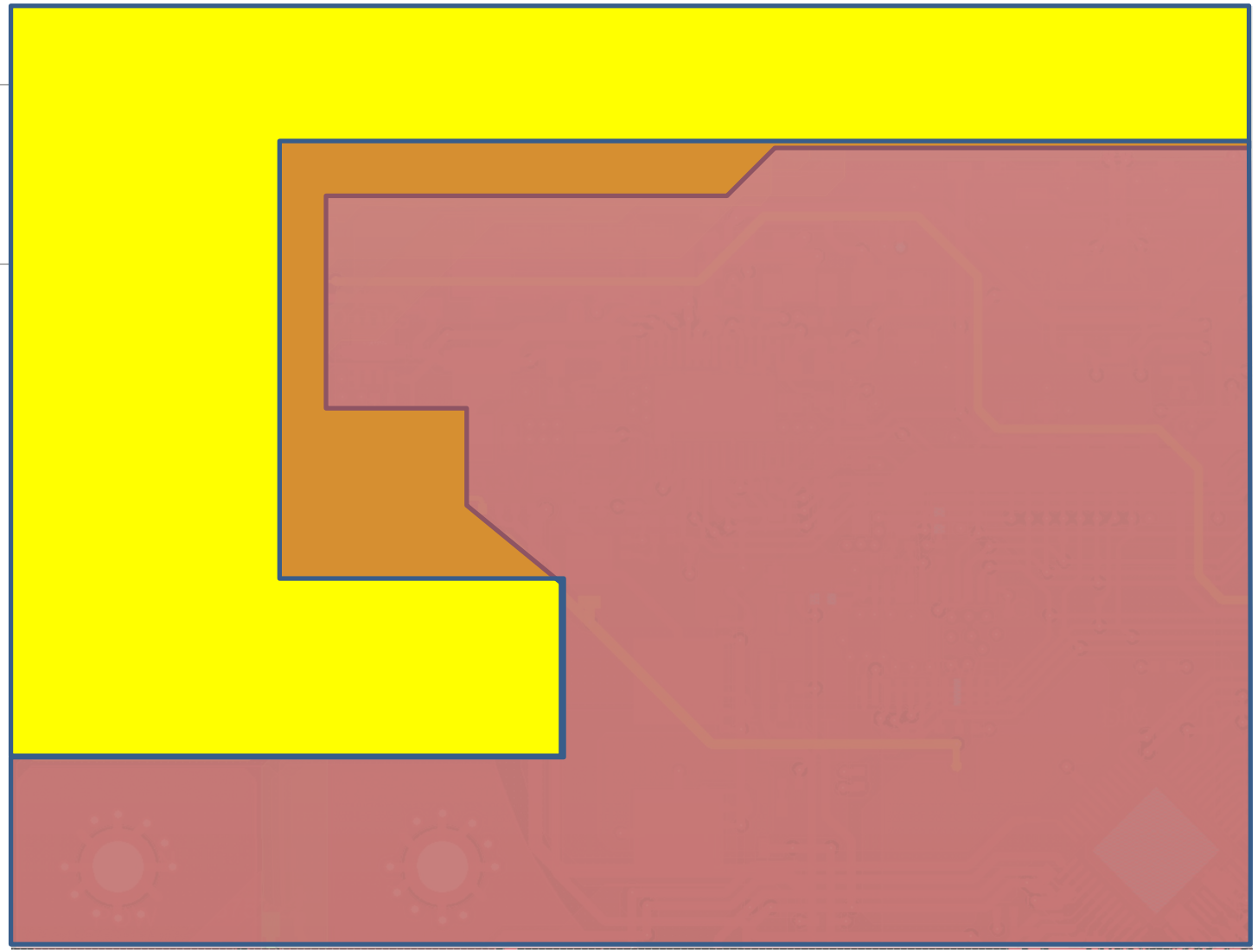


Example 1: Power Input Filter

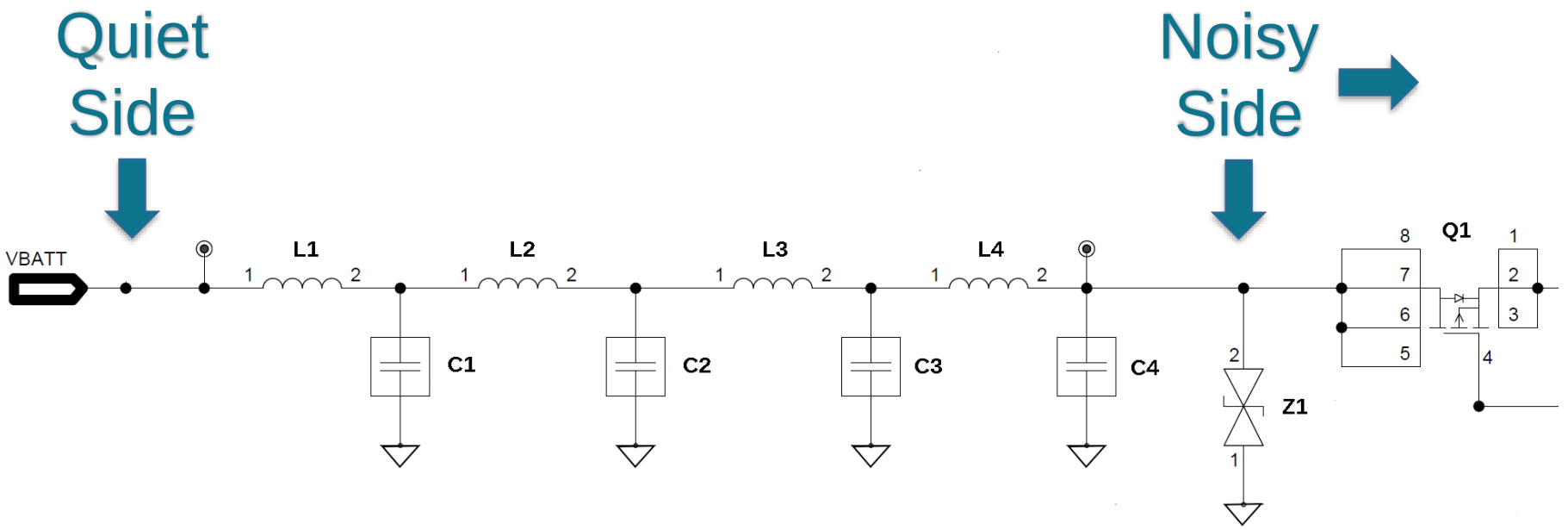


Example 1: Power Input Filter





Four-Stage Power Input Filter Design Example



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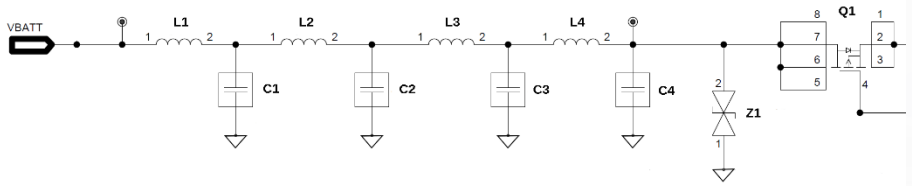
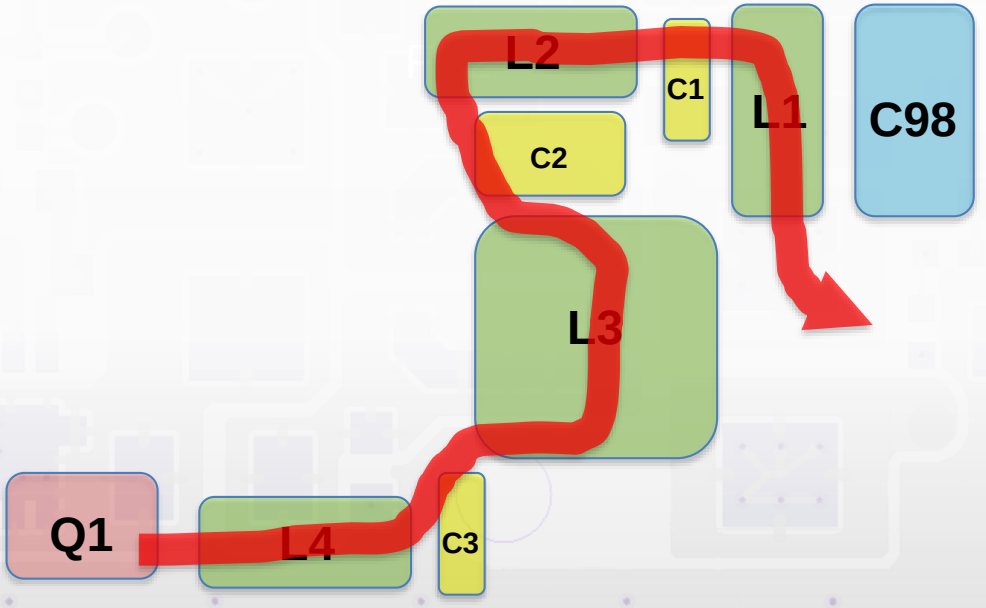




Just one more thing … regarding ground

Boards on or near metal structure:

- Connect to it! That connection is your board ground.
- Bond (at RF) everything that leaves the board or is electrically large to that ground.

Most major automotive system control components

Boards far from any metal structure:

- Designate your board ground (0-V reference).
- **Either** bond (at RF) everything that leaves the board or is electrically large to that ground
- **Or**, control transition times and essentially filter everything.

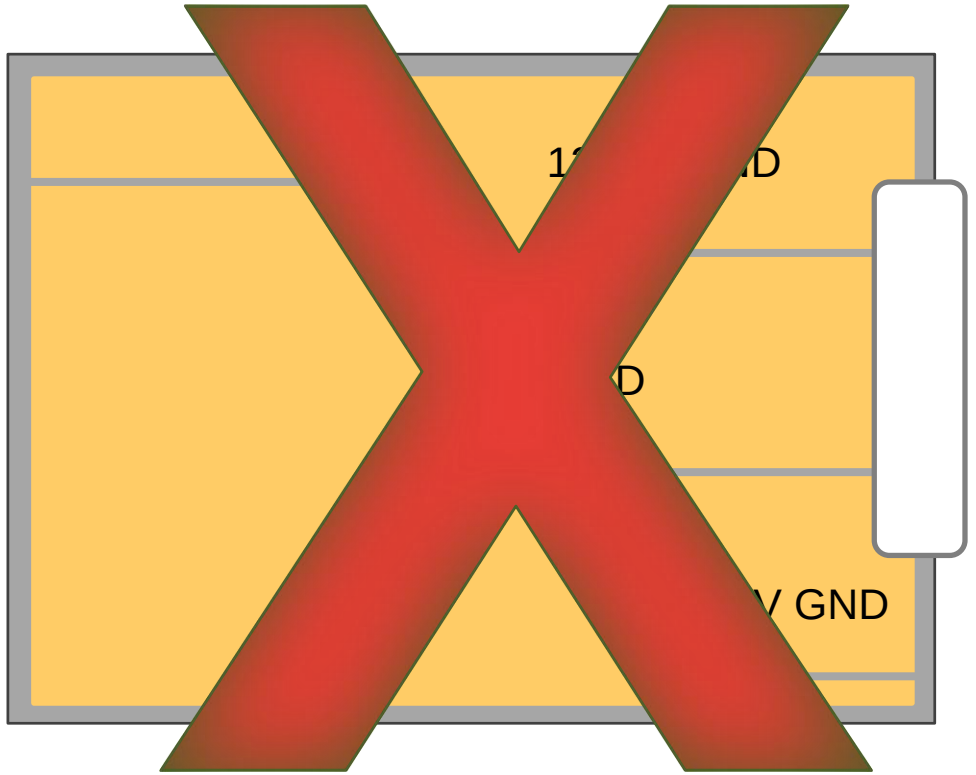
Many sensors, small actuators,

and

components mounted in rearview mirror

Provide 1 solid ground plane under all digital logic

If you only remember one thing from this presentation …



DO NOT DO THIS!