Acradac

EMC Training and Consultancy

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EMC: Common mode stromen veroorzaakt door Power Devices, weet jij waar ze lopen?

Lex de Rijck

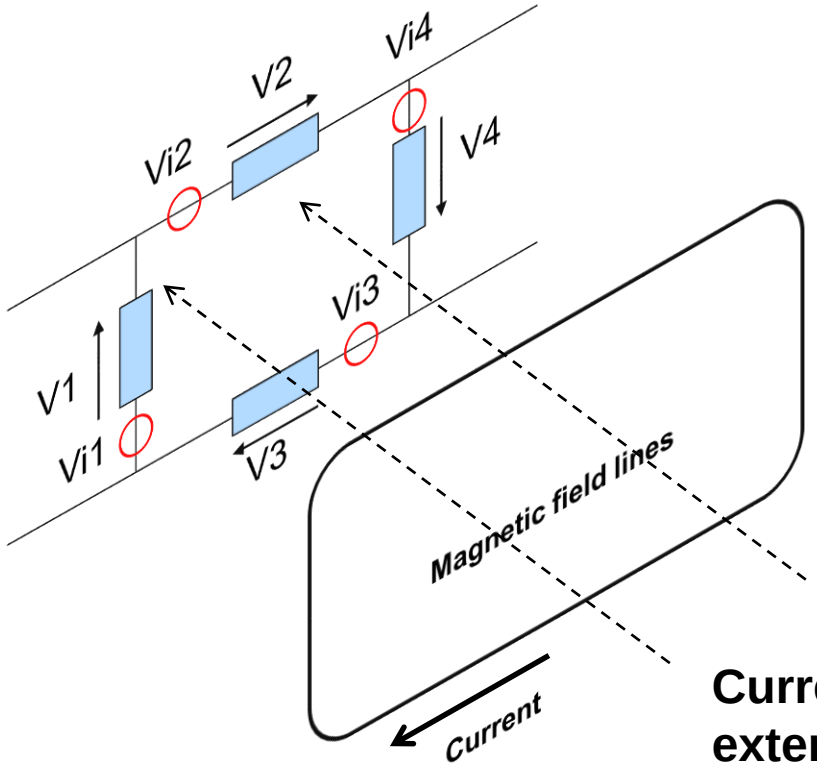
Common mode currents

- **Cause EMI emissions (both conducted and radiated)**

- **Cause self-contamination, which can lead to malfunctions**

Basic EMI principle

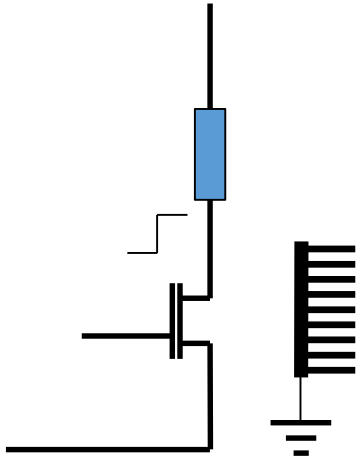
Big loops are bad for EMC and should be as small as possible (for both emission and immunity)

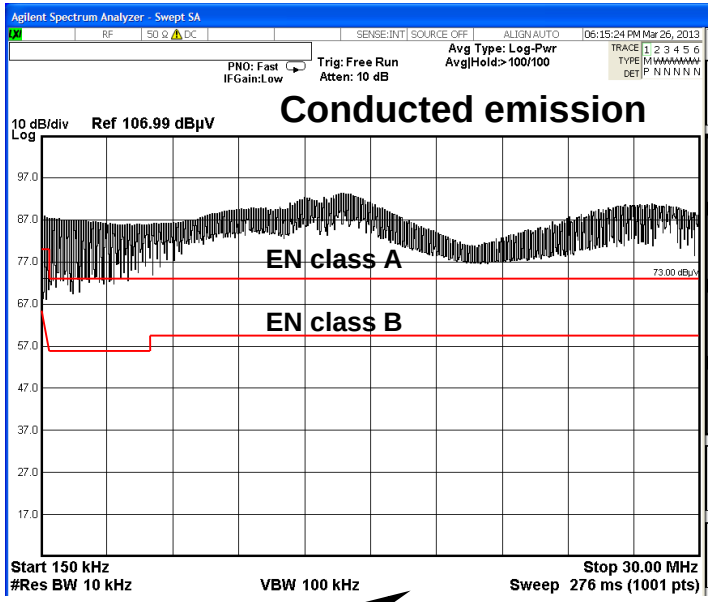


$$\oint \boldsymbol{E} \cdot d\boldsymbol{l} = -\frac{d\Phi}{dt}$$

Current loop in vicinity or an external field (Wifi, GSM, GPS, Bluetooth, RF-ID, Radio 3, home automation, radio-amateurs, CB, etc…)

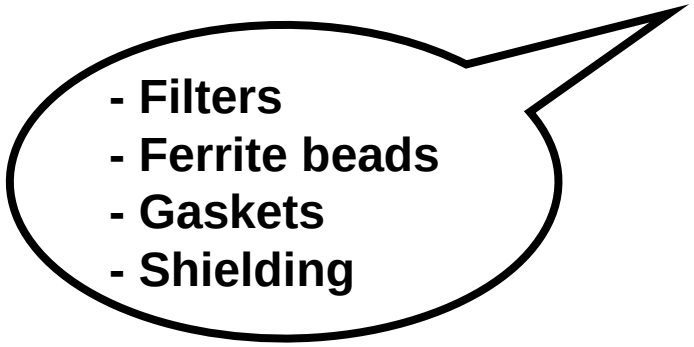
Standard issue: capacitive coupling between switching device and heat sink



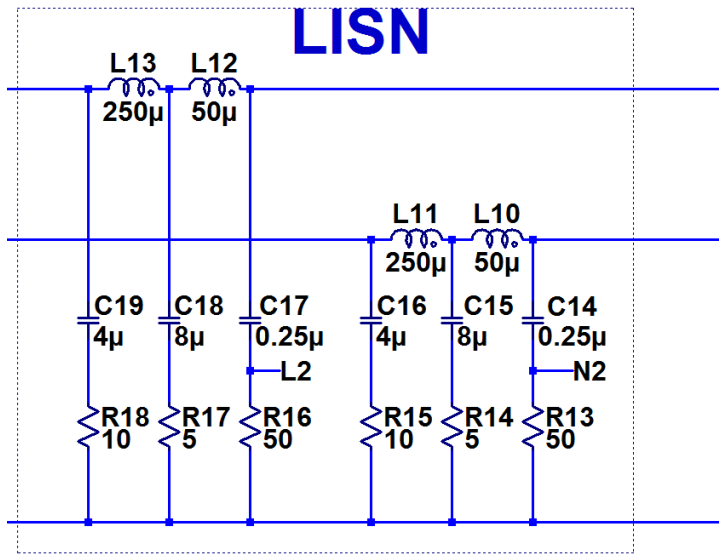


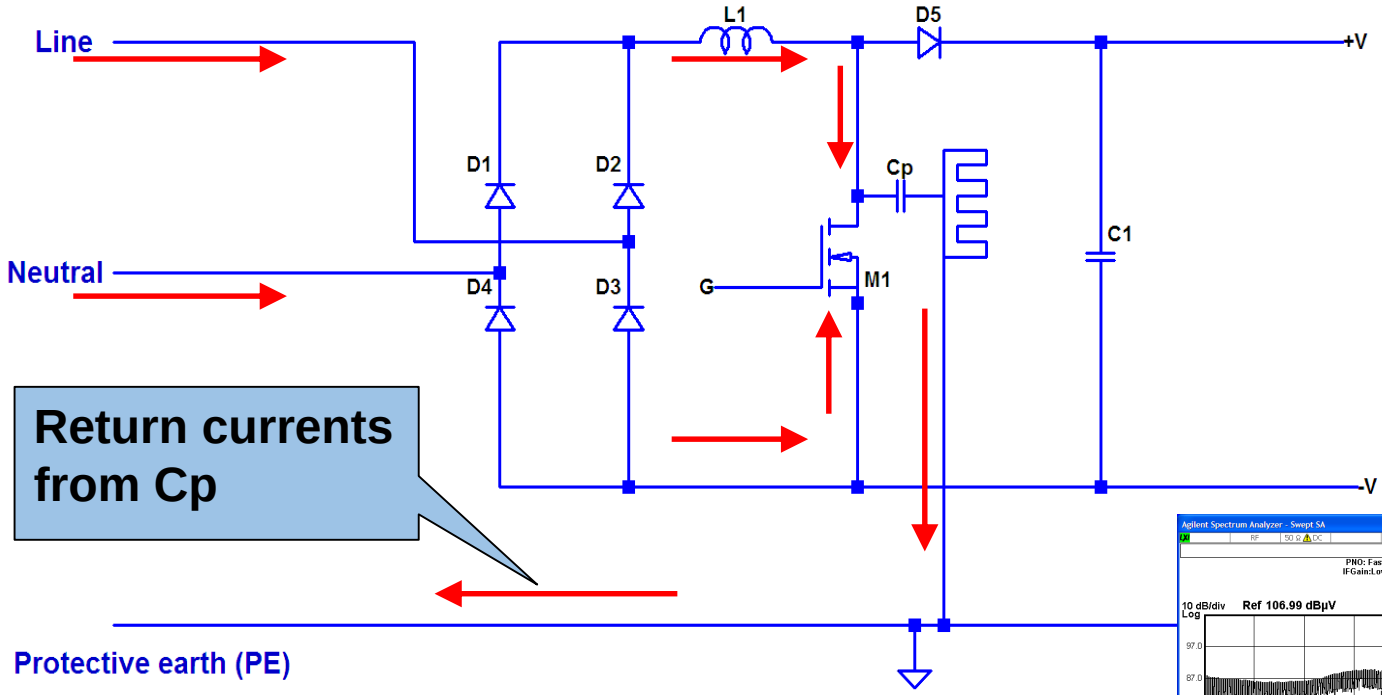
- Filters
- Ferrite beads
- Gaskets
- Shielding

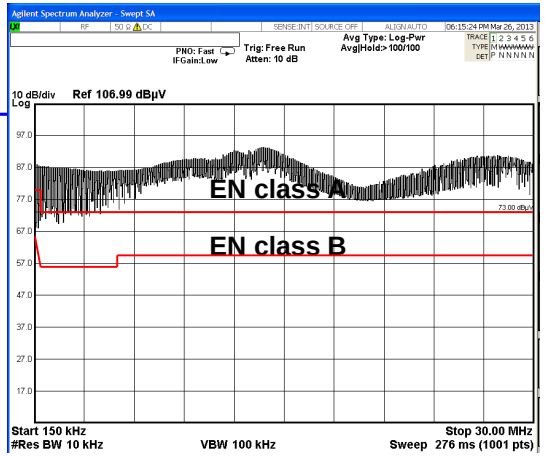
Are they necessary?



Example 1: power factor corrector

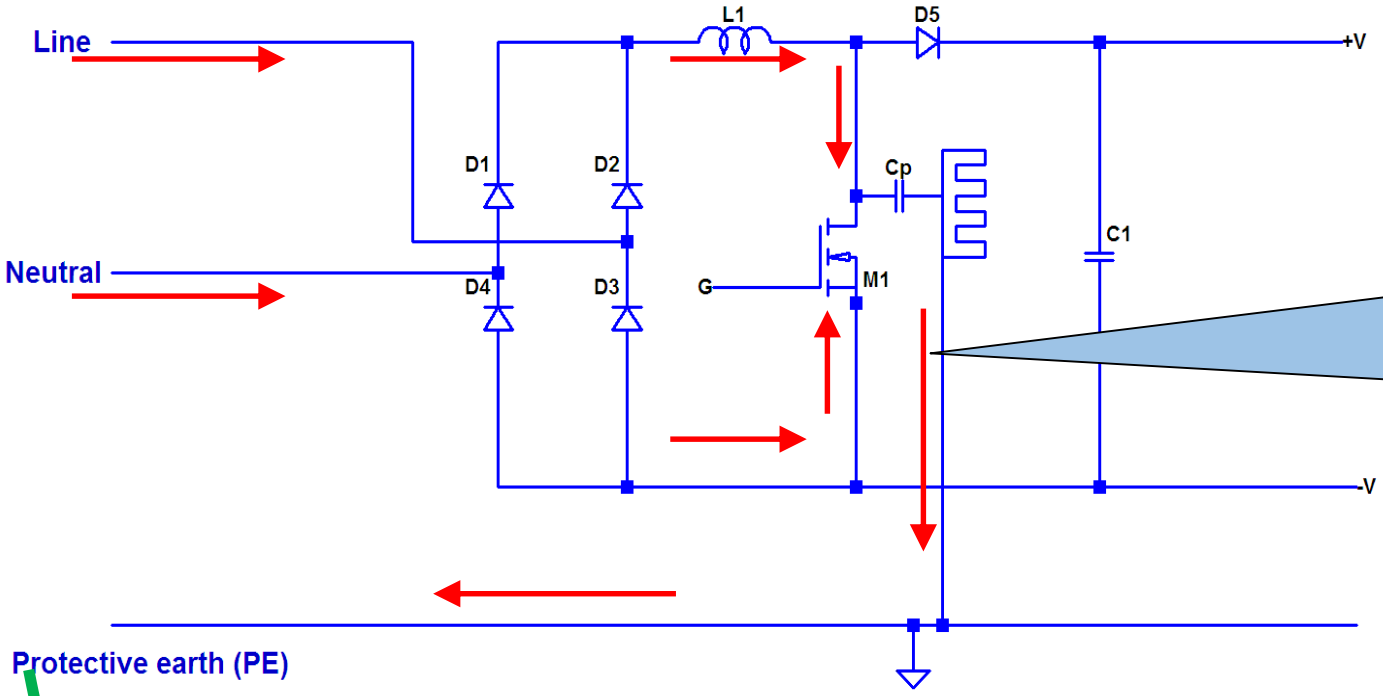






Generally, the heat sink is connected to the ground.
This is the worst possible scenario

Example 1: power factor corrector



Return current from Cp makes a large loop:

- increases Conducted Emission
- causes self-contamination

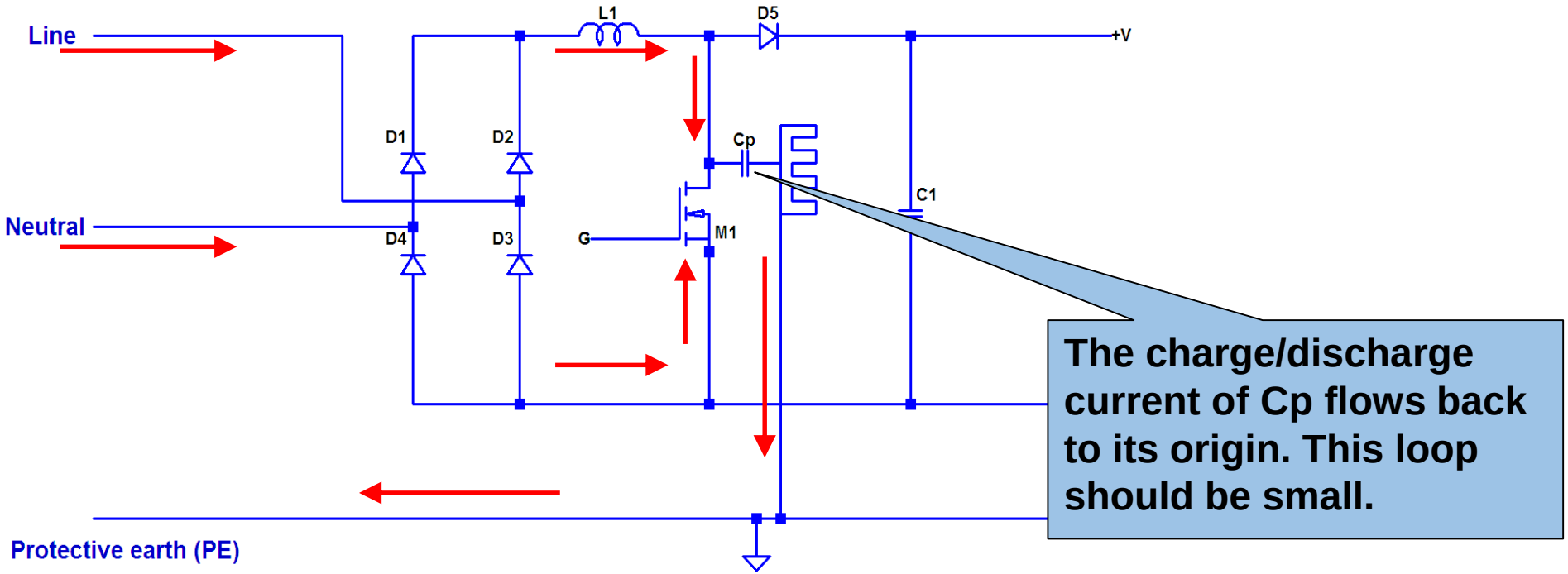
Big loops are bad for EMC and should be as small as possible

Reduce loop of the return current

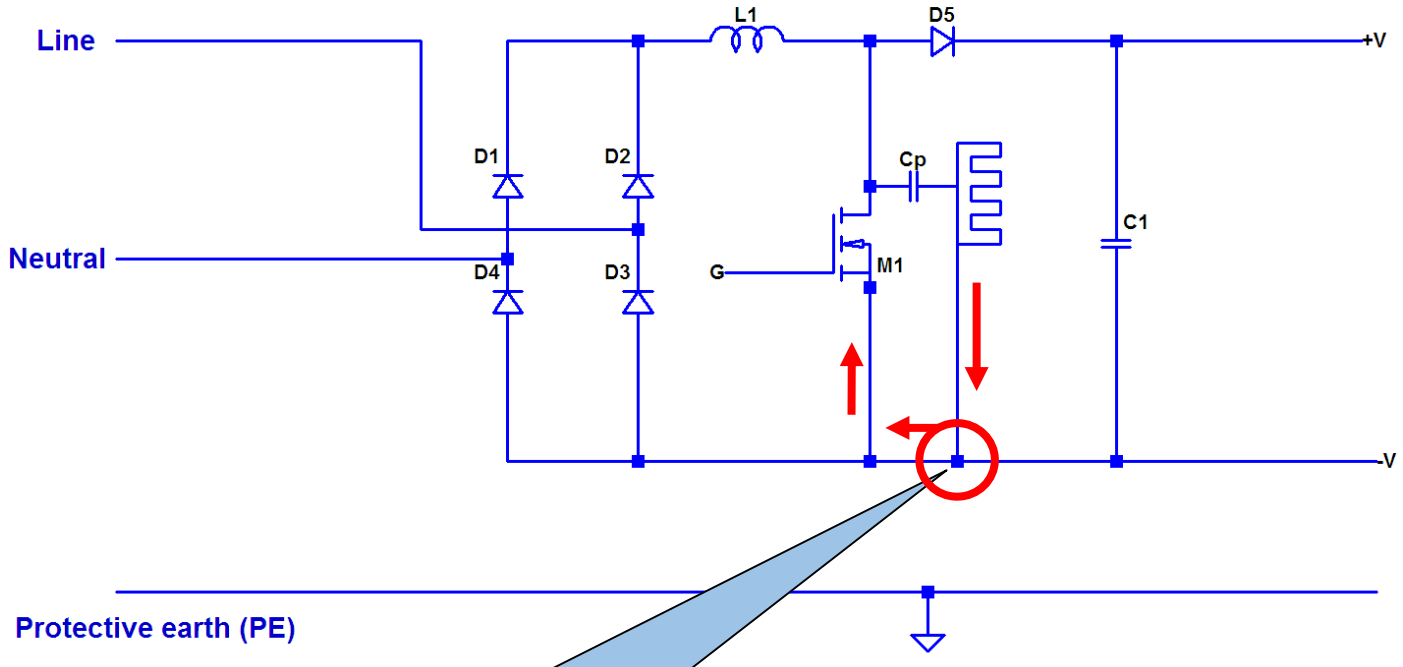
Reduce loop of the return current

How?

Example 1: power factor corrector



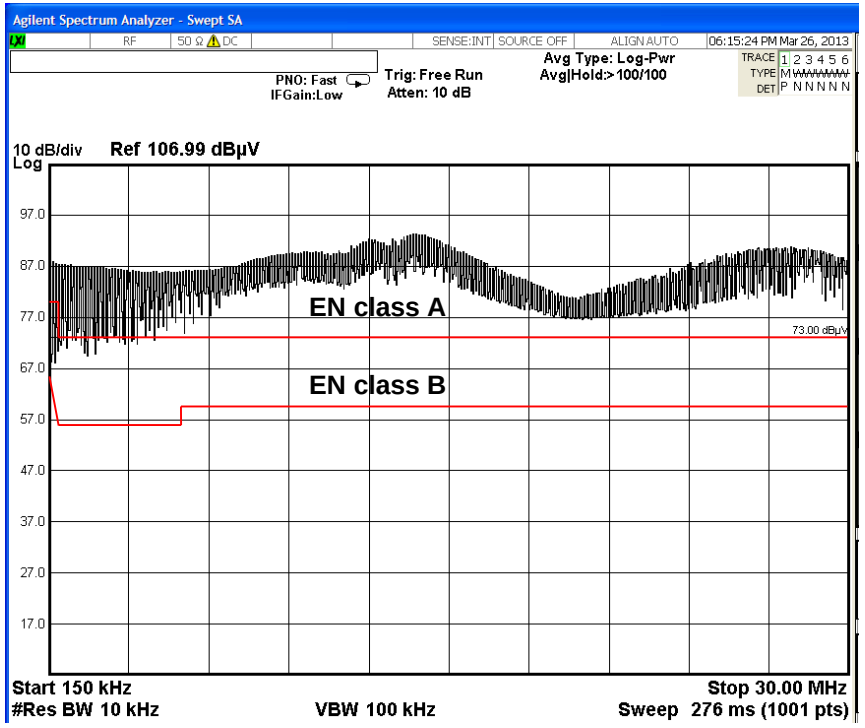
Example 1: power factor corrector



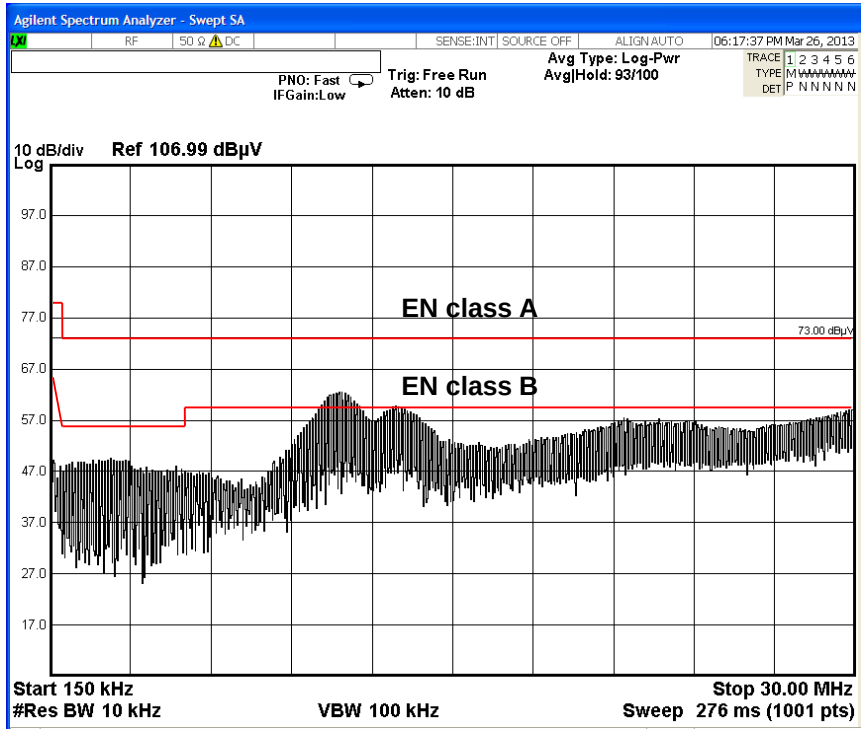
Connect the heat sink to the negative voltage (will have a mechanical impact)

Example 1: power factor corrector

Conducted EMI-measurement:

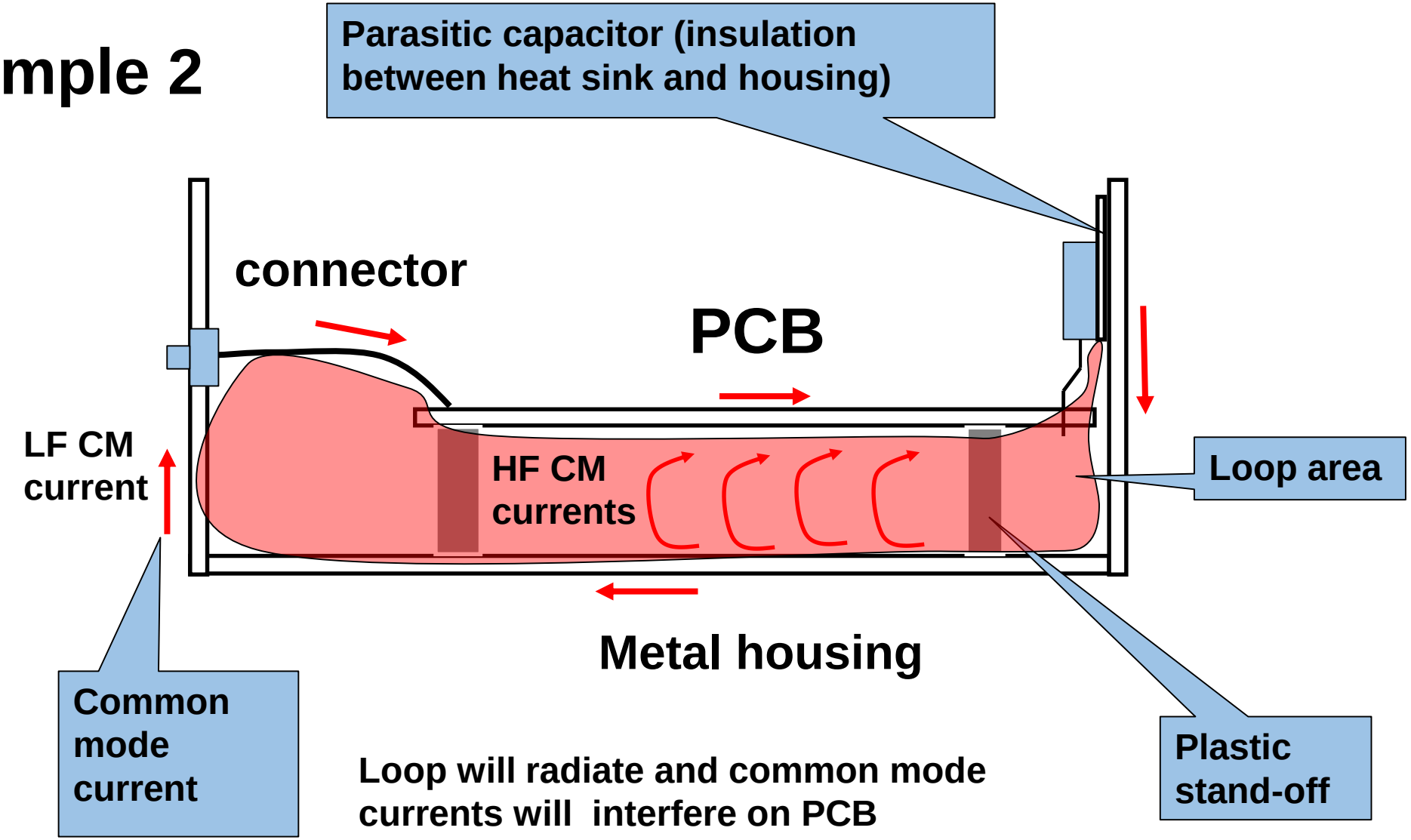


Heat sink to gnd

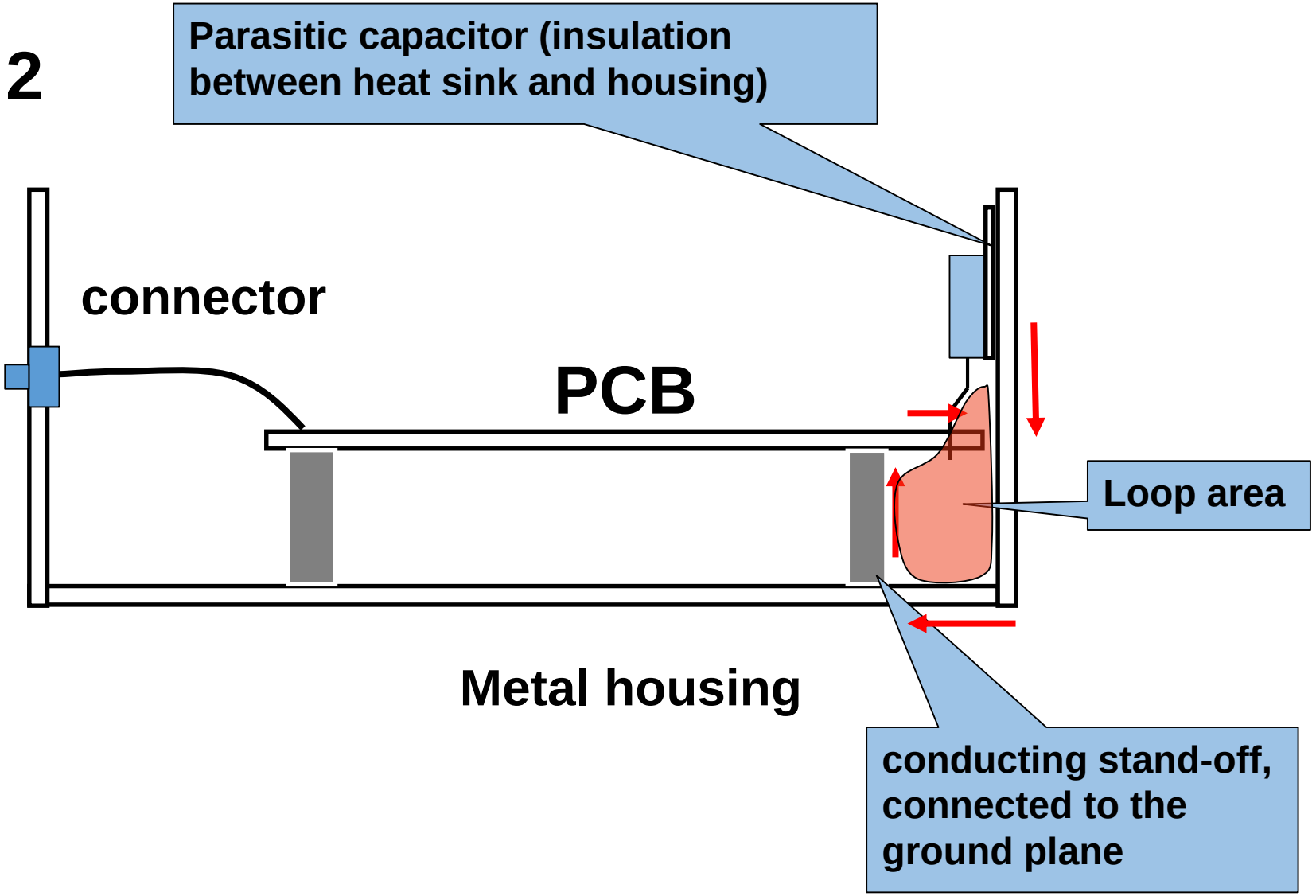


Heat sink to V-

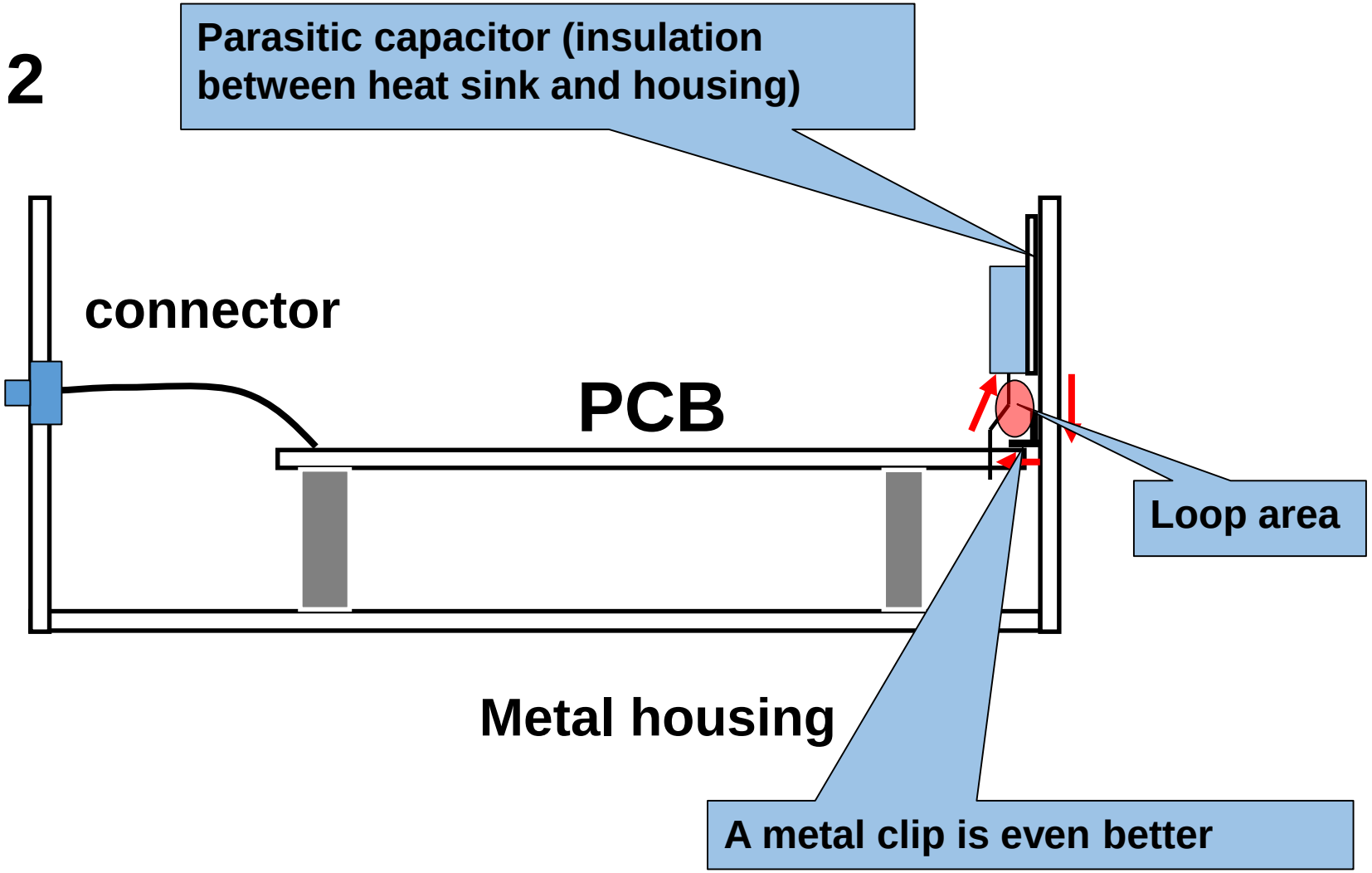
Example 2


Parasitic capacitor (insulation between heat sink and housing)
connector
PCB
LF CM current
HF CM currents
Loop area
Metal housing
Common mode current
Plastic stand-off
Loop will radiate and common mode currents will interfere on PCB

Example 2

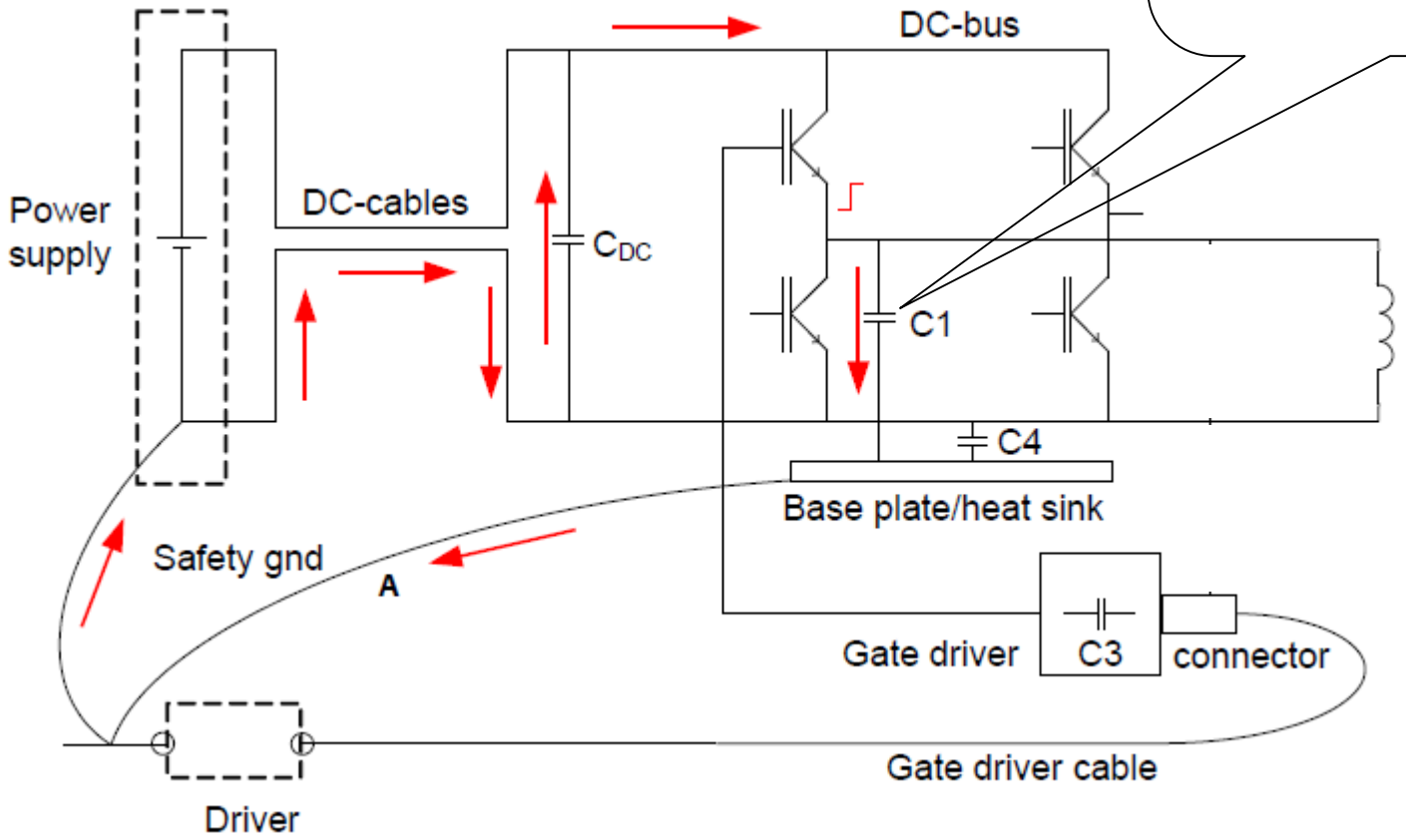

Parasitic capacitor (insulation between heat sink and housing)
connector
PCB
Loop area
Metal housing
conducting stand-off, connected to the ground plane

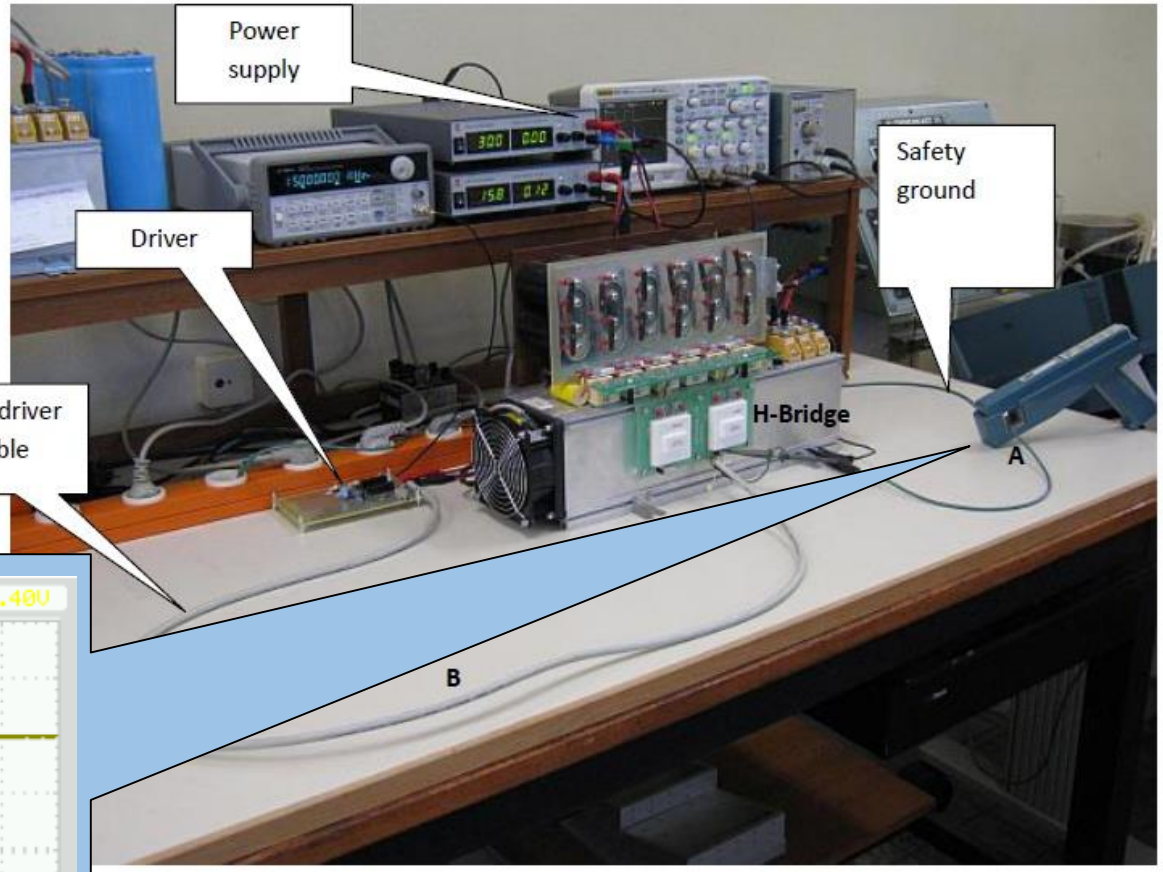
Example 2


Parasitic capacitor (insulation between heat sink and housing)
connector
PCB
Loop area
Metal housing
A metal clip is even better

On a larger scale

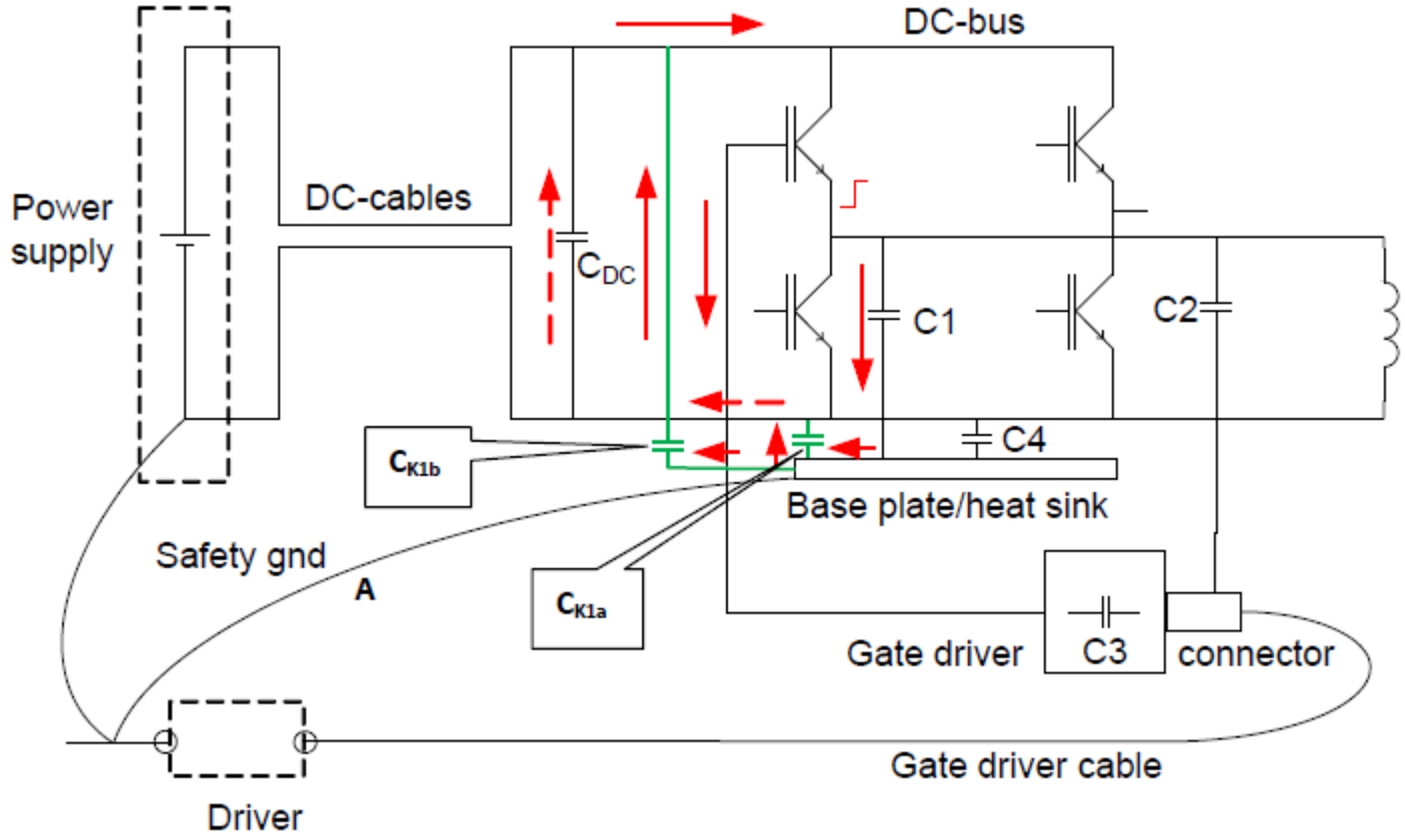
Parasitic capacitor between IGBT module and heat sink (6 nF!!!)





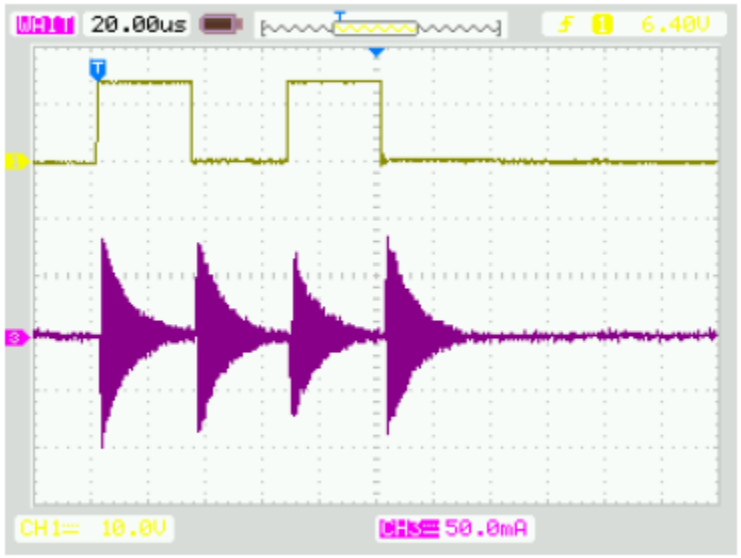
The resonance is caused by the parasitic capacitance and the induction of the return path

Common mode return currents



The capacitors are Y-Capacitors

Common mode return currents

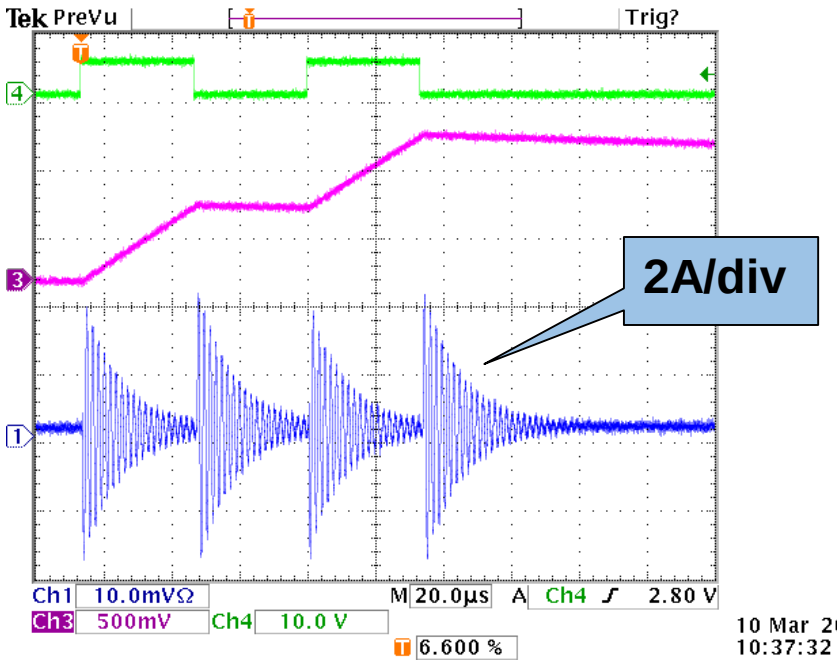


Without Y-capacitors

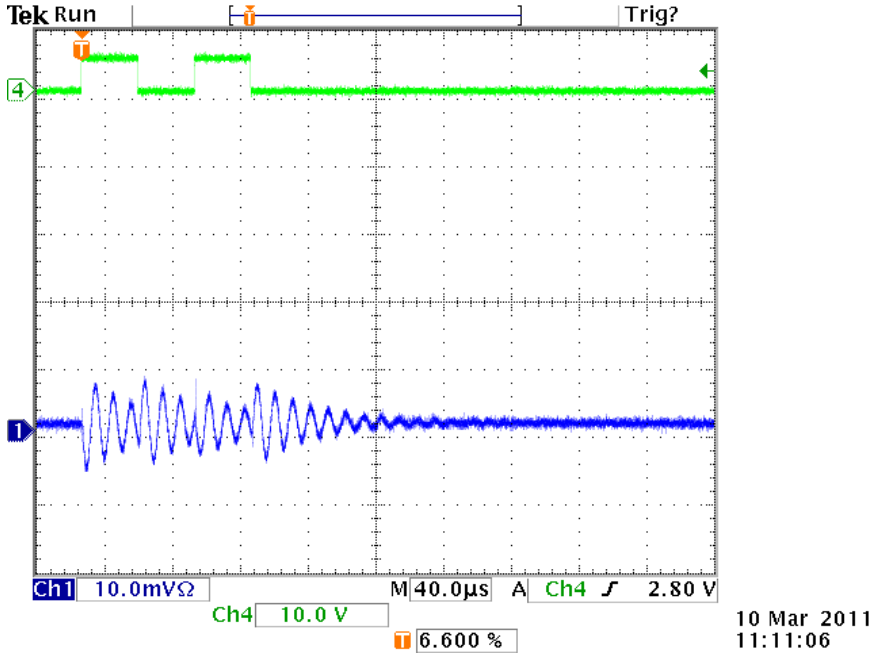
With Y-capacitors

Common mode return currents

Results differ, depending on the circuit



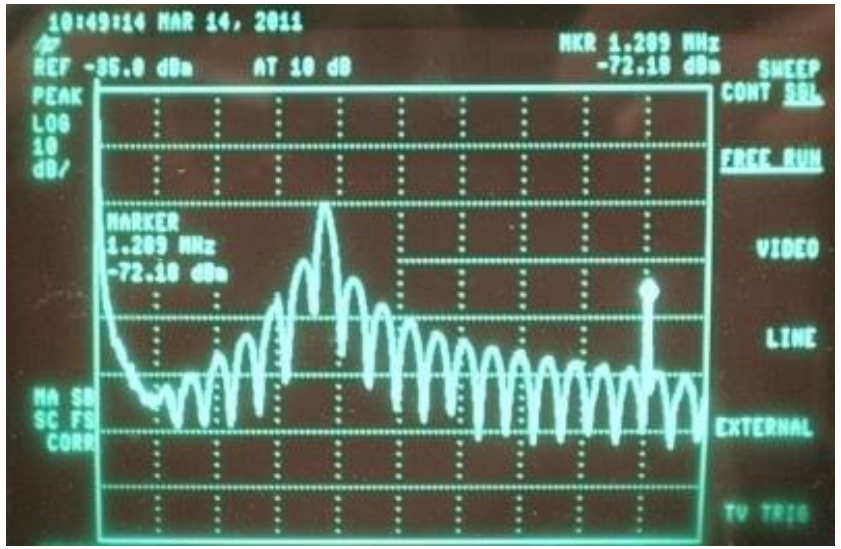
Without Y-capacitors

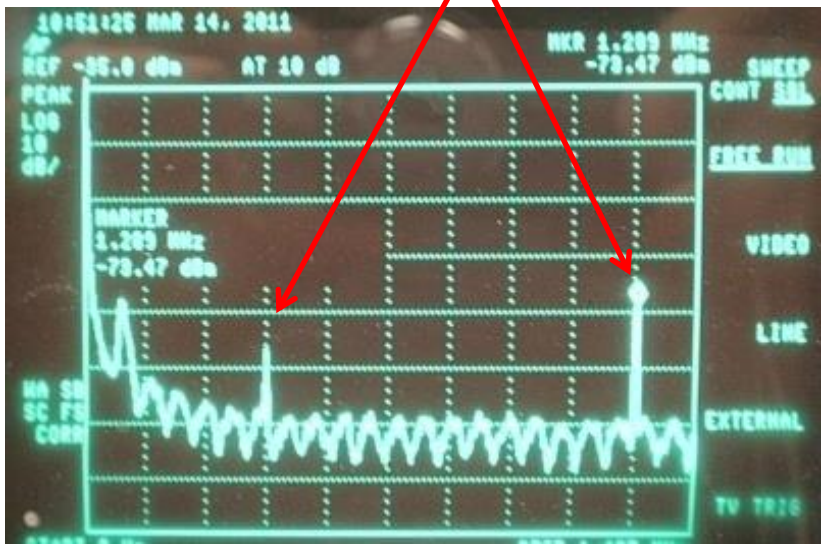


With Y-capacitors

Difference in measured radiation

(Not related to CM)





Without Y-capacitors

With Y-capacitors

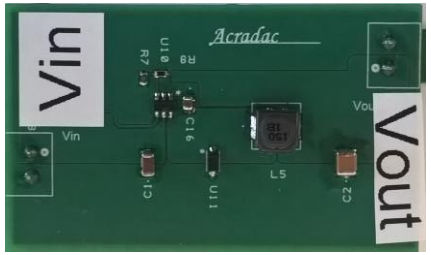
Common mode return path

- **Visualize the parasitic capacitor between switching component and cooling surface**
- **Analize the path of its charge/discharge current**
- **Reduce its loop**

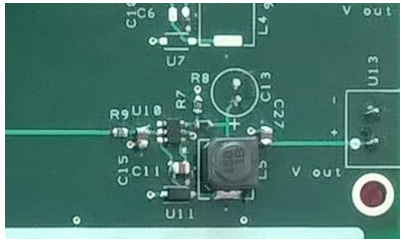
Reducing loops always works

Buck converter on PCB

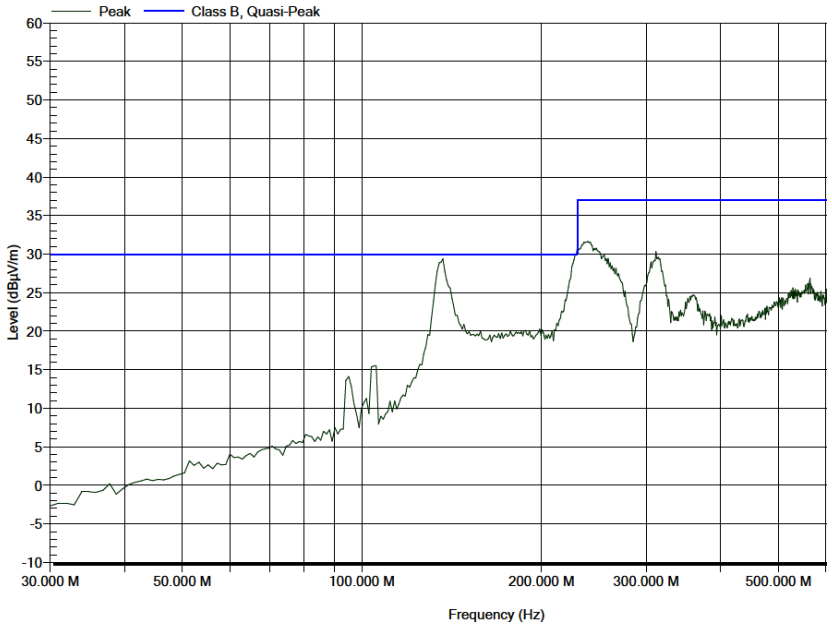
Manufacturer's reference design

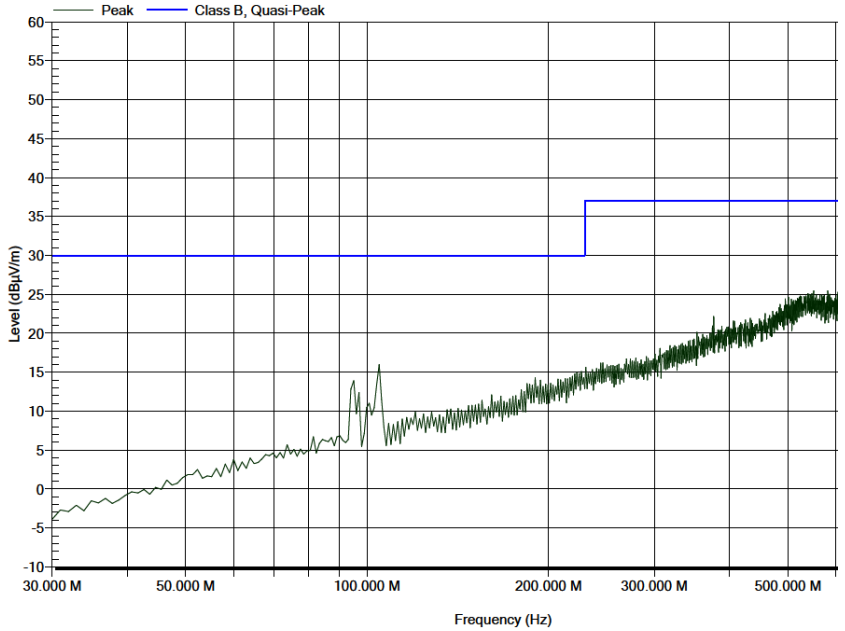


Proper layout with reduced loops



Radiated emission





Analyzing the return currents and reducing their loops can easiliy decrease EMI with 20-25 dB without the need for filters, ferrite beads or shielding

Want to know more?

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