

# Mitigation guidelines, an example of application: Design and implementation of a Boost PFC

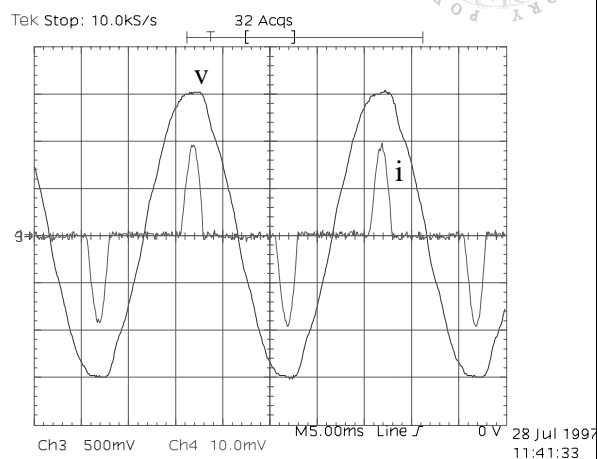
## Summary

Ac/dc conversion requirements:	600W 220 V
PFC topology:	Design considerations
Layout considerations:	Circuit PCB
EMC measurements:	Conducted noises


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## Traditional ac/dc conversion

**P = 423 W**  
**PF = 0.6**  
**THD = 130%**  
 **$V_1 = 217 V$**   
**I = 3.24 A**  
 **$I_1 = 1.96 A$**   
 **$I_1 / I = 0.6$**




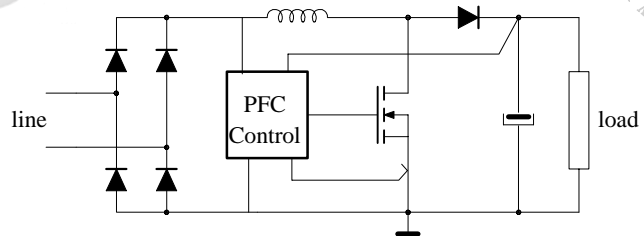
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# Active PFC Solution

Power section





**CHARACTERISTICS:**

Input voltage:  $V_{in} = 90-260V_{RMS}$

Output voltage:  $V_o = 380V$

Output power:  $P_o = 600W$

Switching frequency:  $f_s = 70kHz$

**VALUES:**

Output capacitor:  $C = 680 \mu F$


Inductor:  $L = 600 \mu H$

Mosfet: IRFP450

Diode: RURP1560

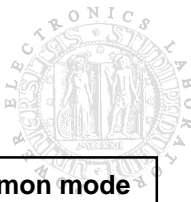
Controller: L4981A

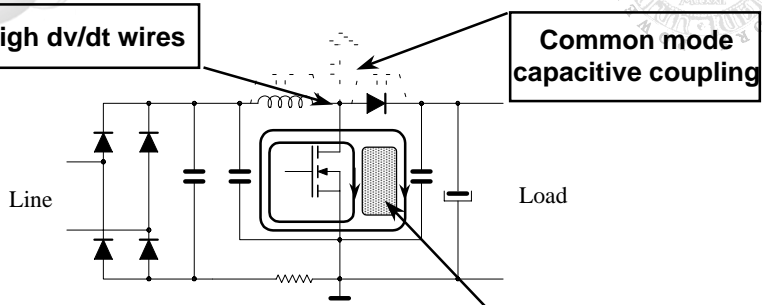
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# Active PFC Solution

Power section and related EMI aspects





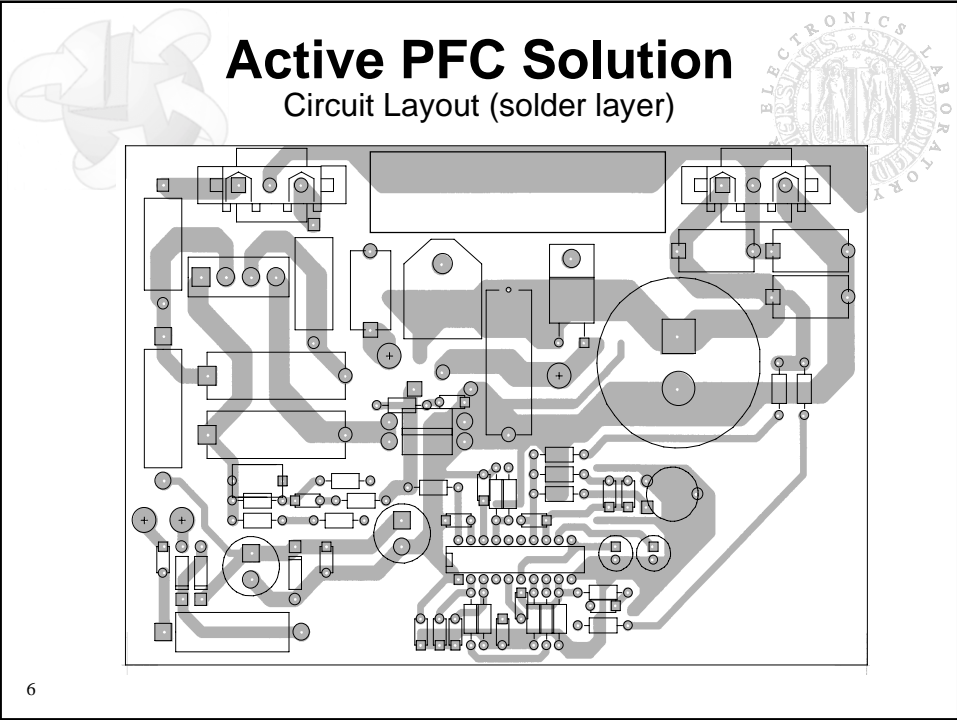
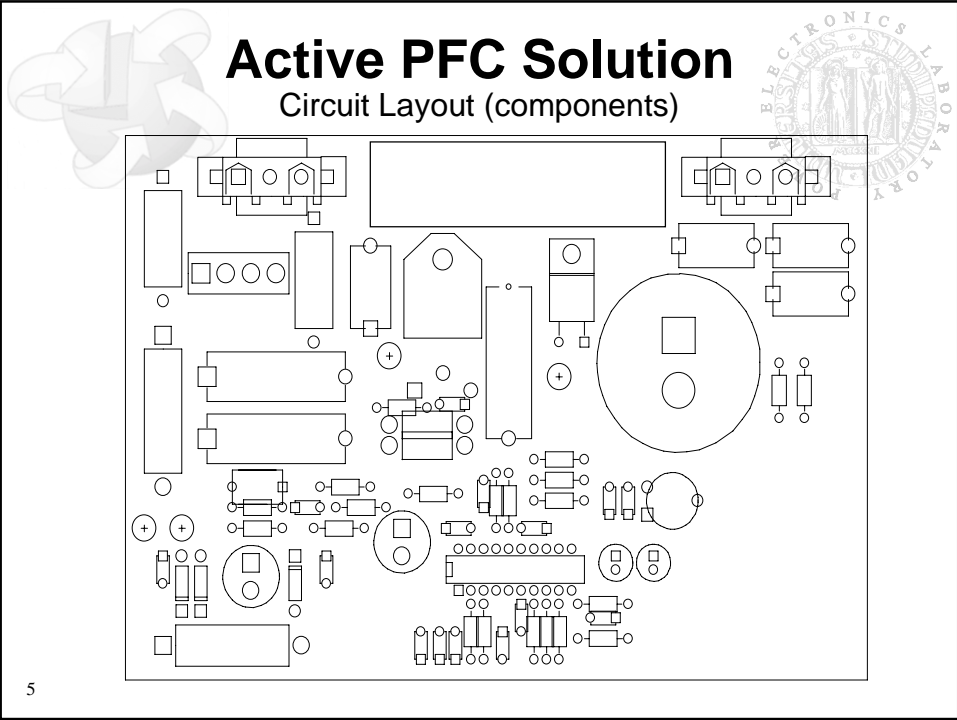
**General Considerations:**

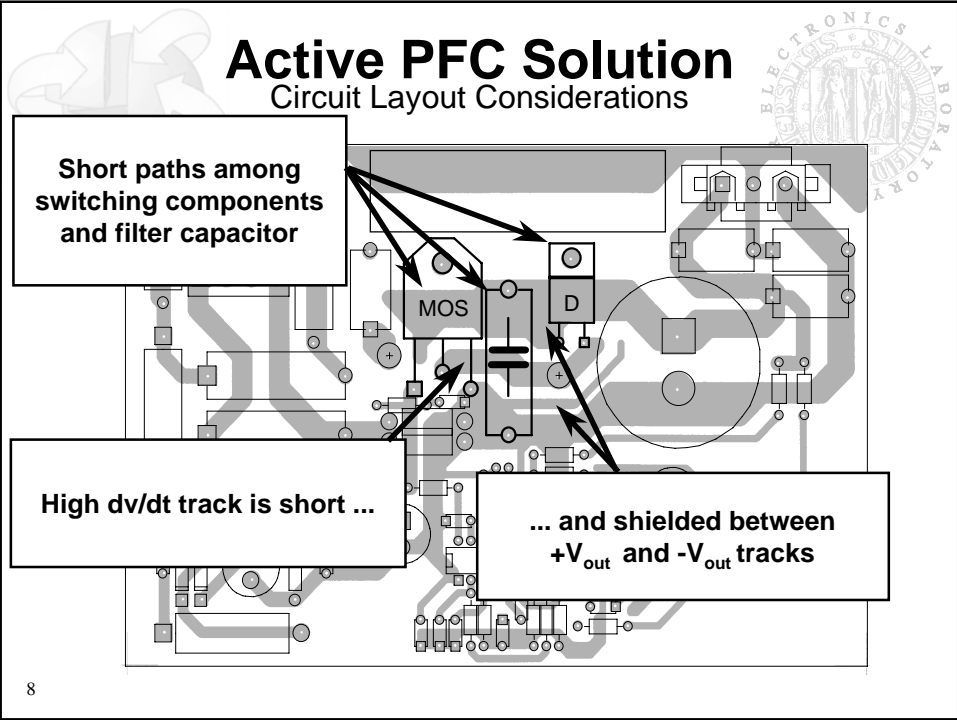
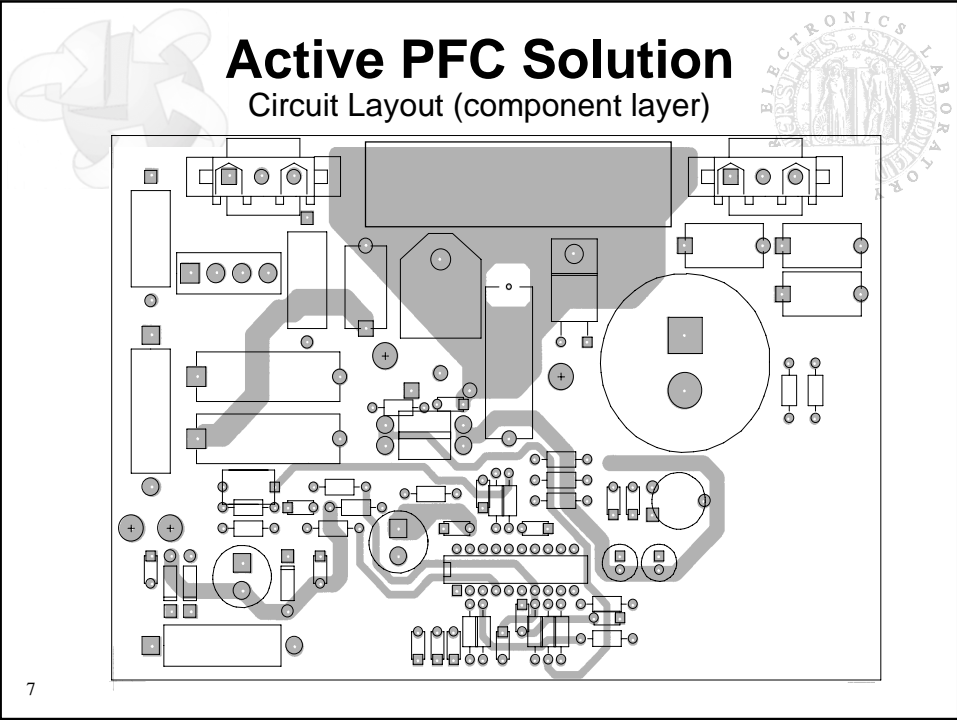
*MOSFET and DIODE are the main noise generators*

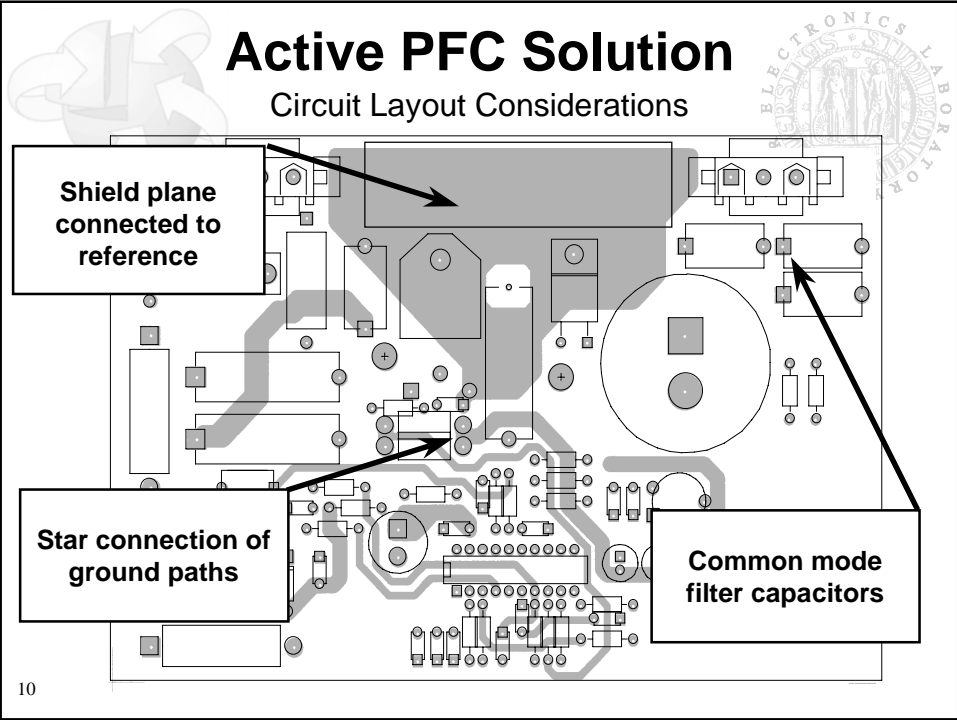
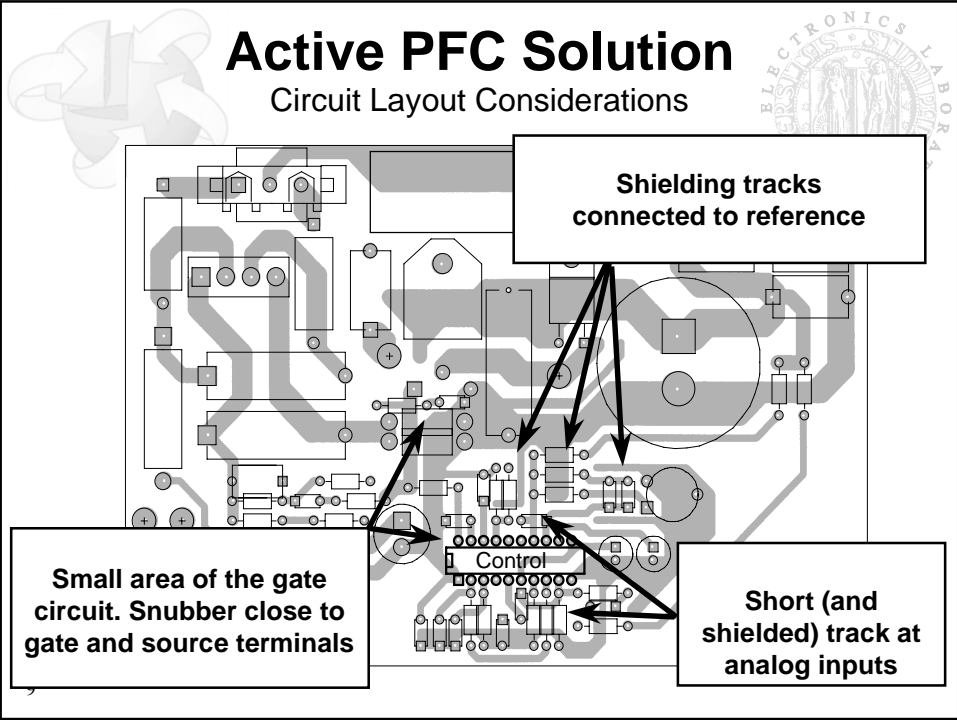
- Short wires where high dv/dt
- Small area of fast di/dt loops
- Short paths for return currents


**Careful Layout**

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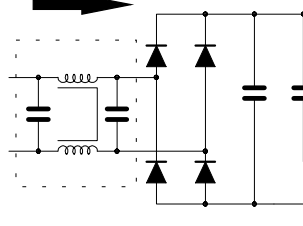


# Active PFC Solution

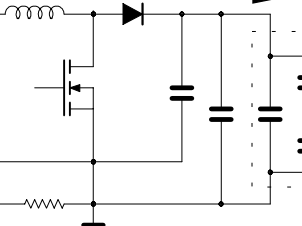
Power section with EMI Filters



**High CM impedance**

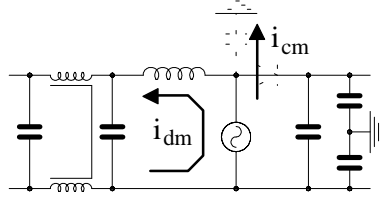


**Low CM impedance**




**Coupled inductors show high common mode inductance but low differential mode inductance:**

**Ex: 6.8 mH CM, 70 μH DM**




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# Active PFC Solution

Input filter design - Differential Mode



**Ripple amplitude**

$$\Delta I_{\max} = \frac{U_{\text{out}}}{\omega L} \cong 1.13 \text{ A}$$

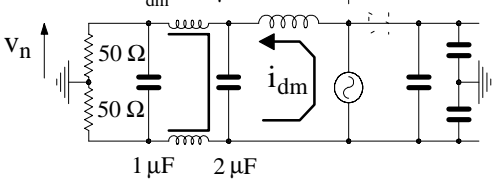
**triangular waveform**

**Differential mode input noise:**


<b>70 kHz,</b>	<b>87 dB μV</b>
<b>(peak values)</b>	
<b>140 kHz,</b>	<b>57 dB μV</b>
<b>210 kHz,</b>	<b>40 dB μV</b>
<b>280 kHz,</b>	<b>26 dB μV</b>
<b>350 kHz,</b>	<b>19 dB μV</b>
<b>420 kHz,</b>	<b>9 dB μV</b>

**a suitable margin (20 dB μV) is maintained for the common mode noise and possible resonances**

**Parameters:**  
 $L_{\text{cm}} = 6.8 \text{ mH}$   
 $L_{\text{dm}} = 70 \mu\text{H}$




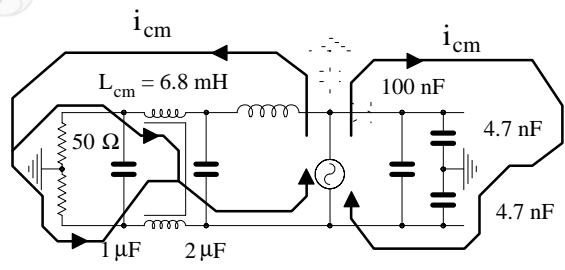
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## Active PFC Solution


Input filter design - Common Mode






- Several current return paths are present
- The main one is on the output side of the PFC
- High value of filter inductor reduces current term at the input side
- CM input side current generates DM input noise due to unsymmetrical converter topology
- *Adding CM capacitors at the input side reduces input CM voltage noise but the increased CM current causes additional DM noise*

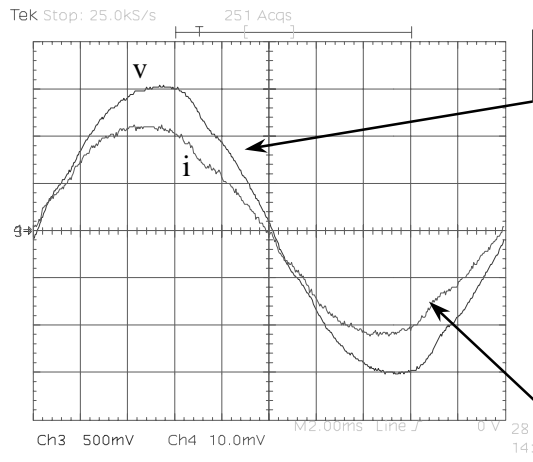
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## Prototype Tests

Input behavior

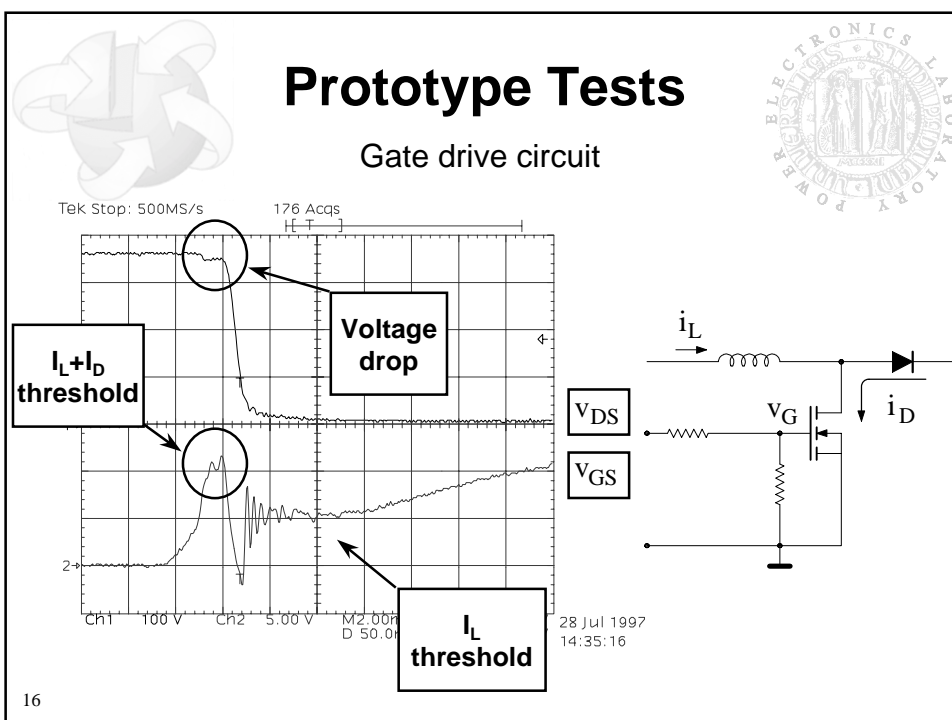
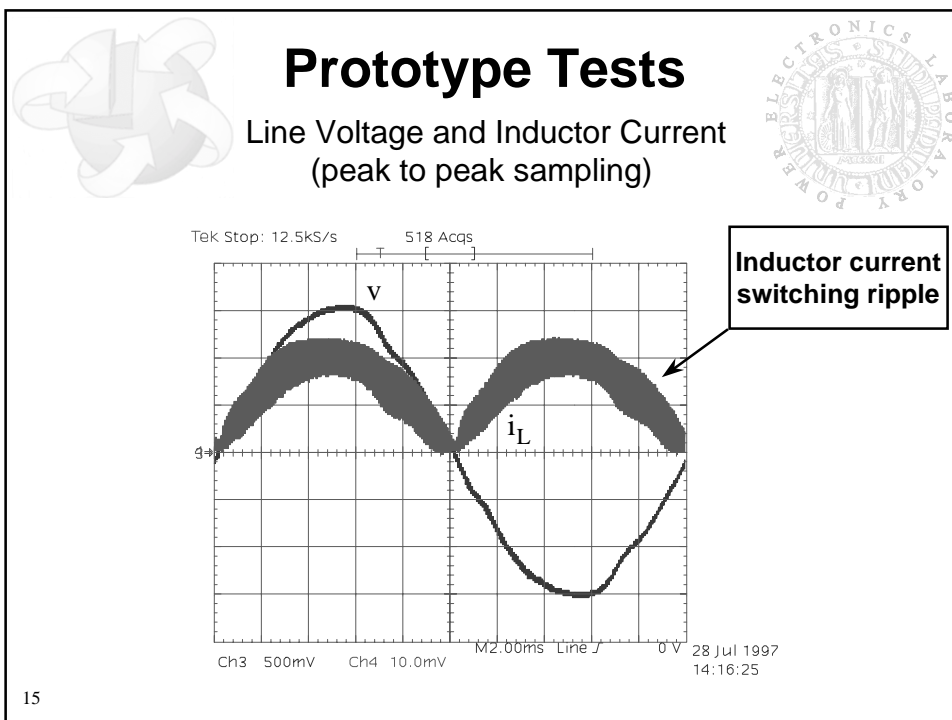




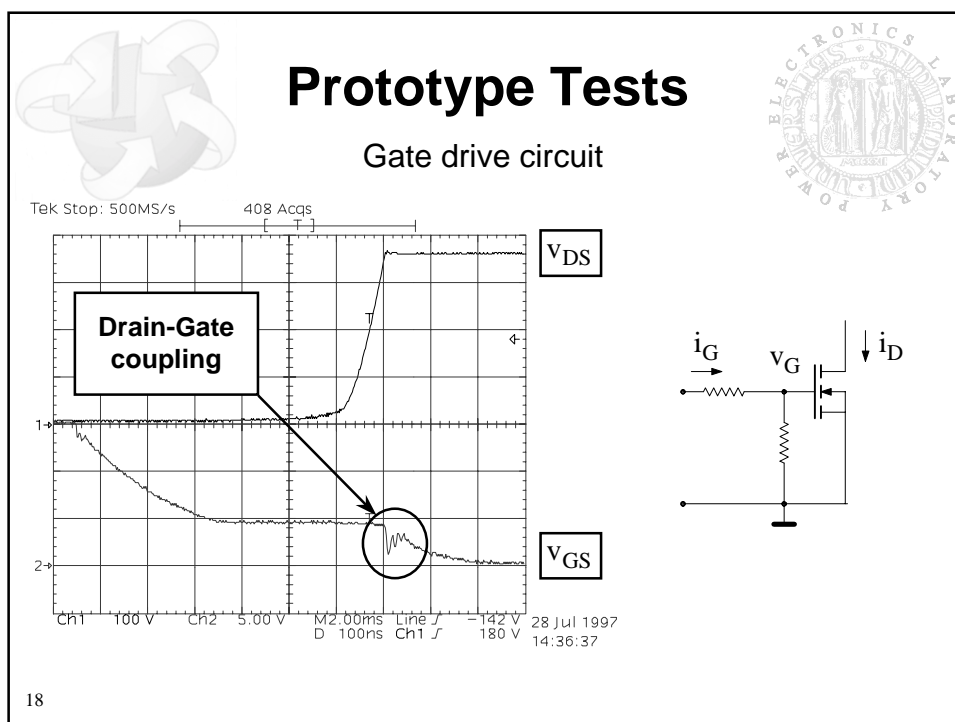
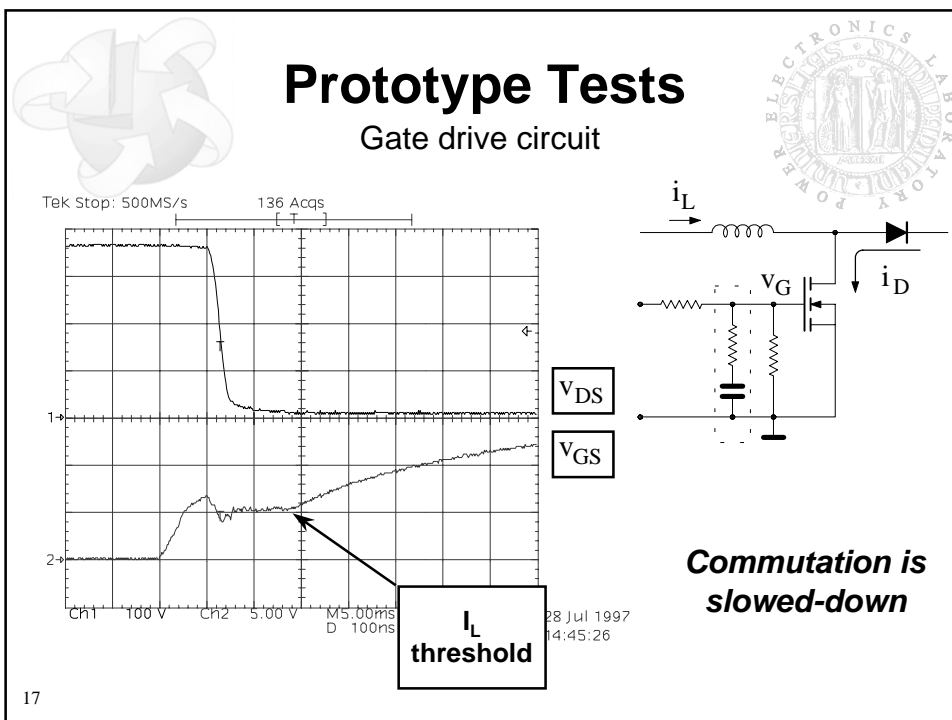
Line Voltage

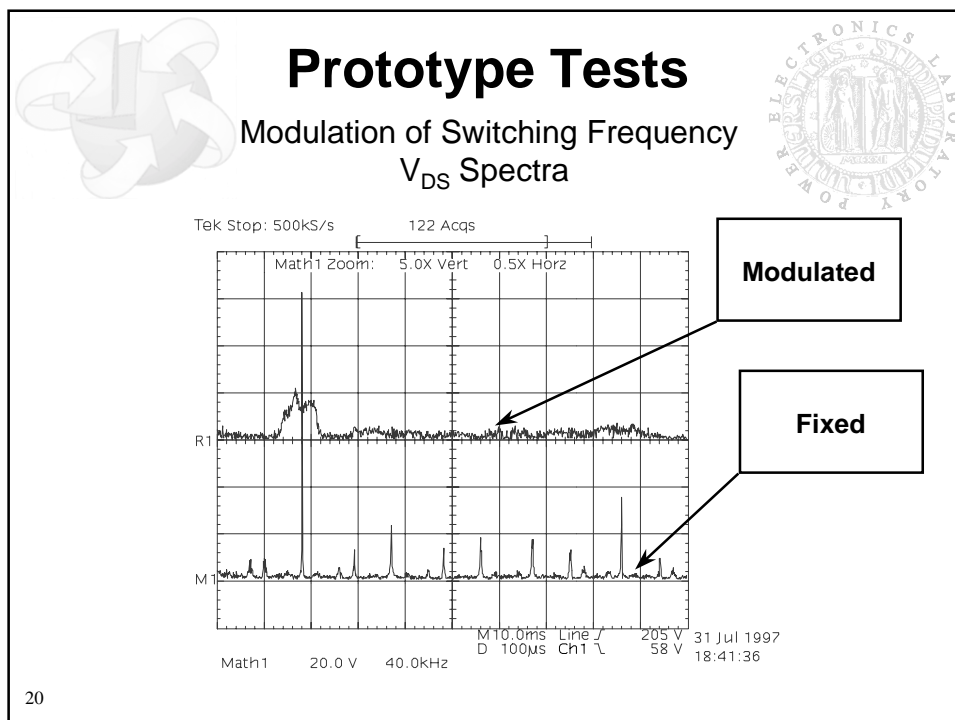
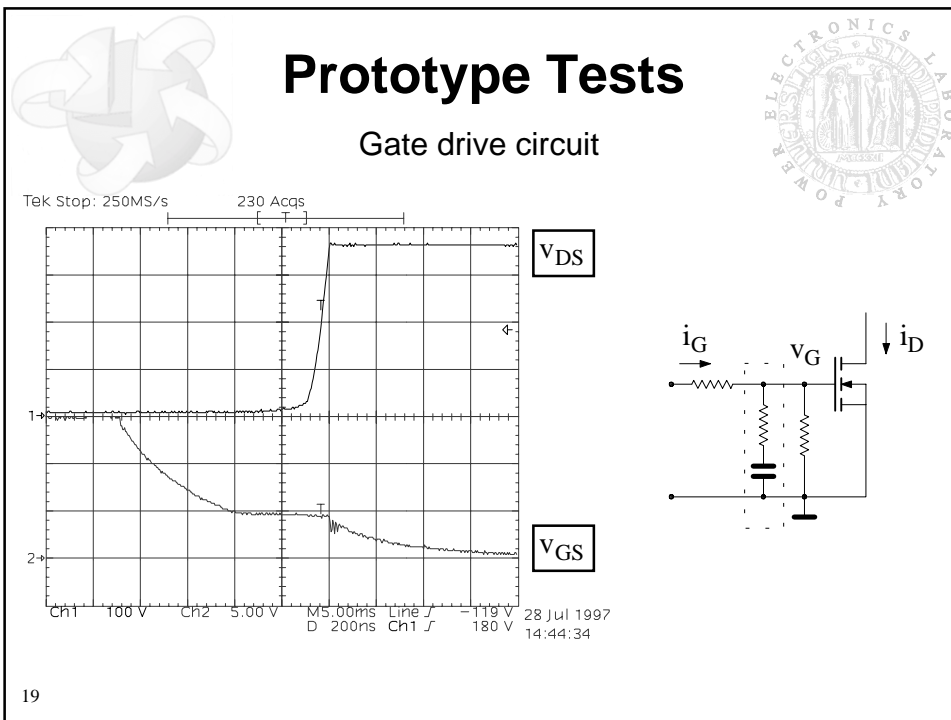
Line current

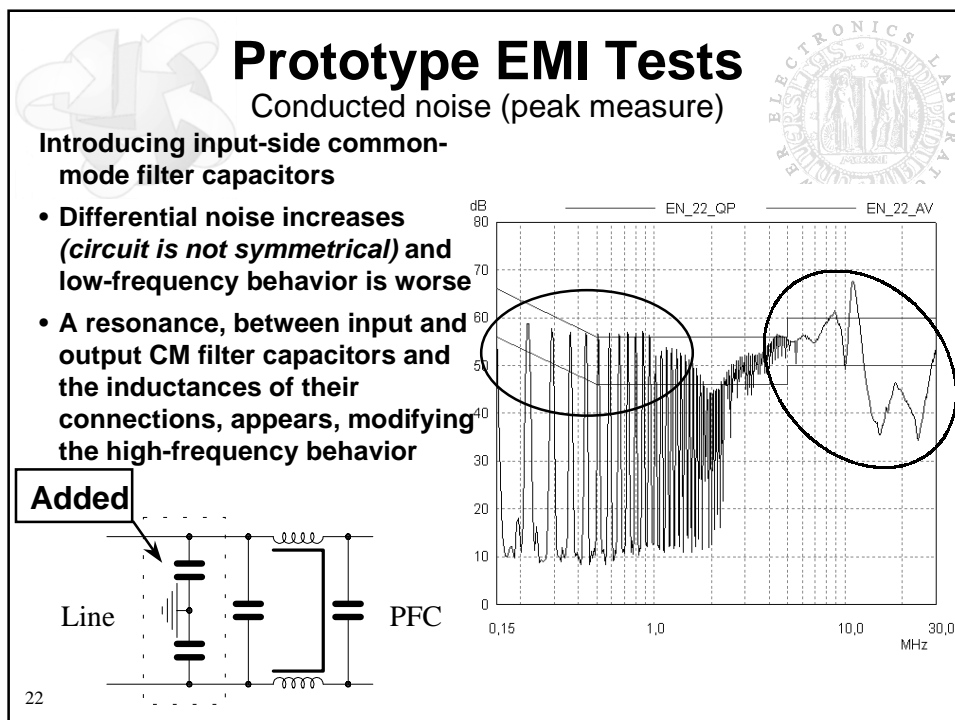
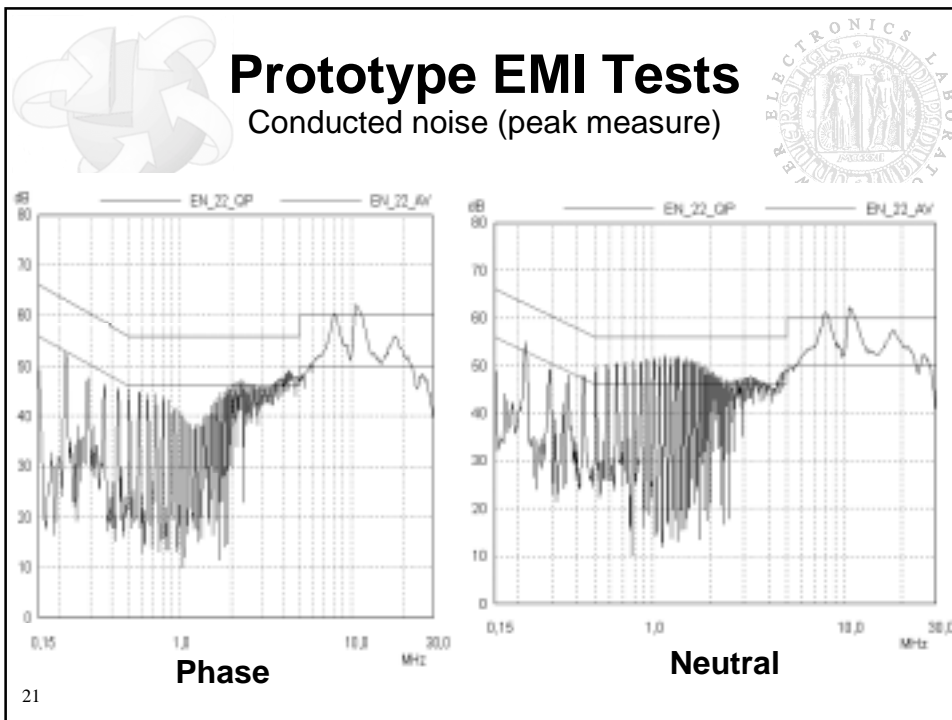
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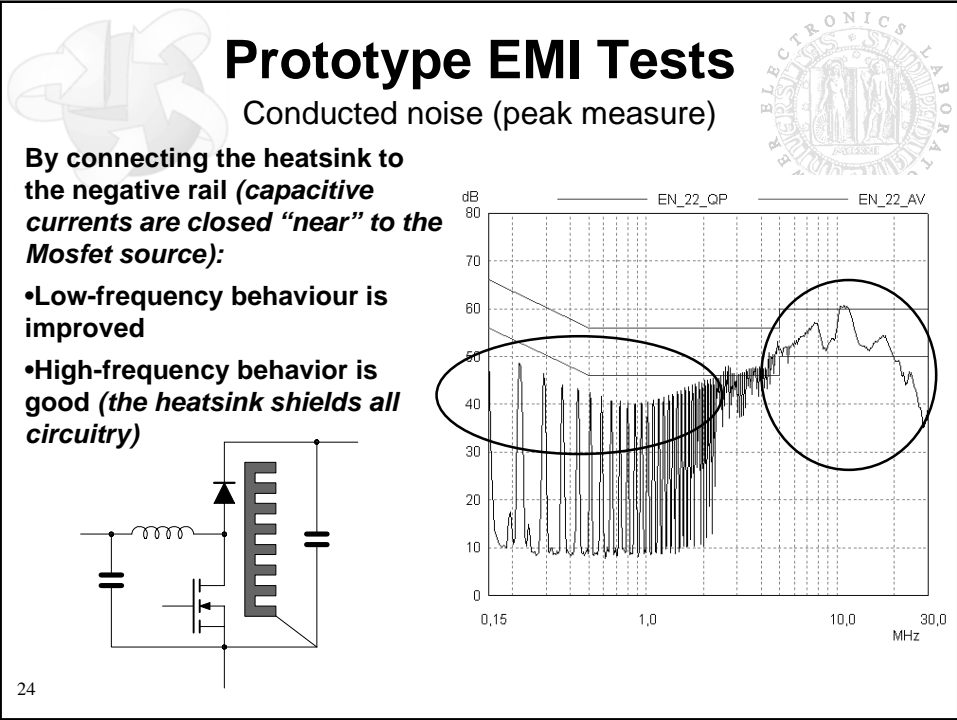
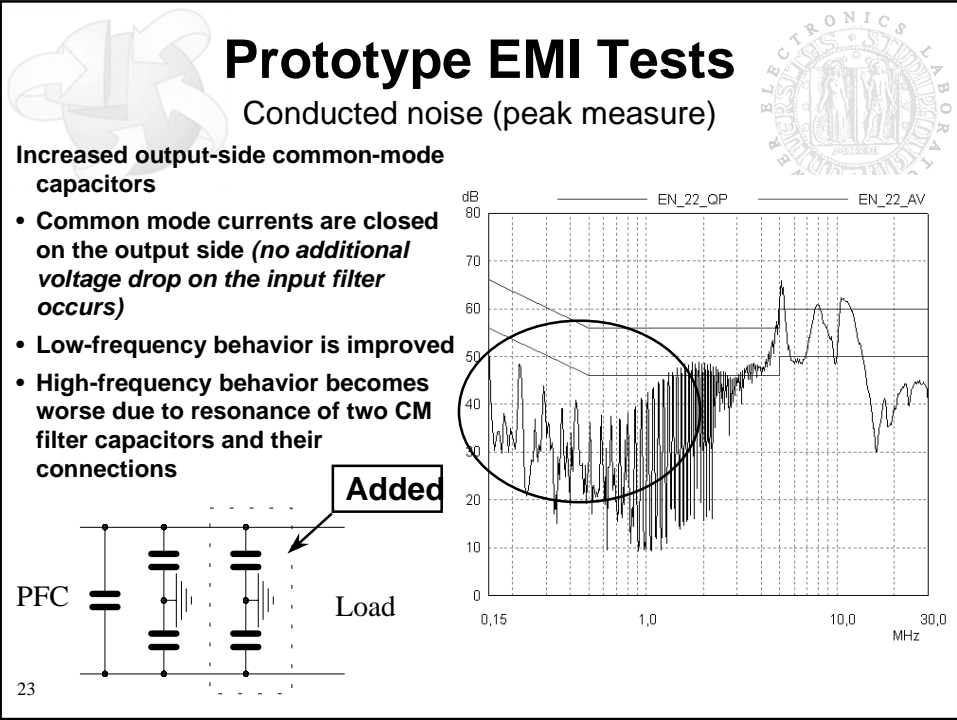


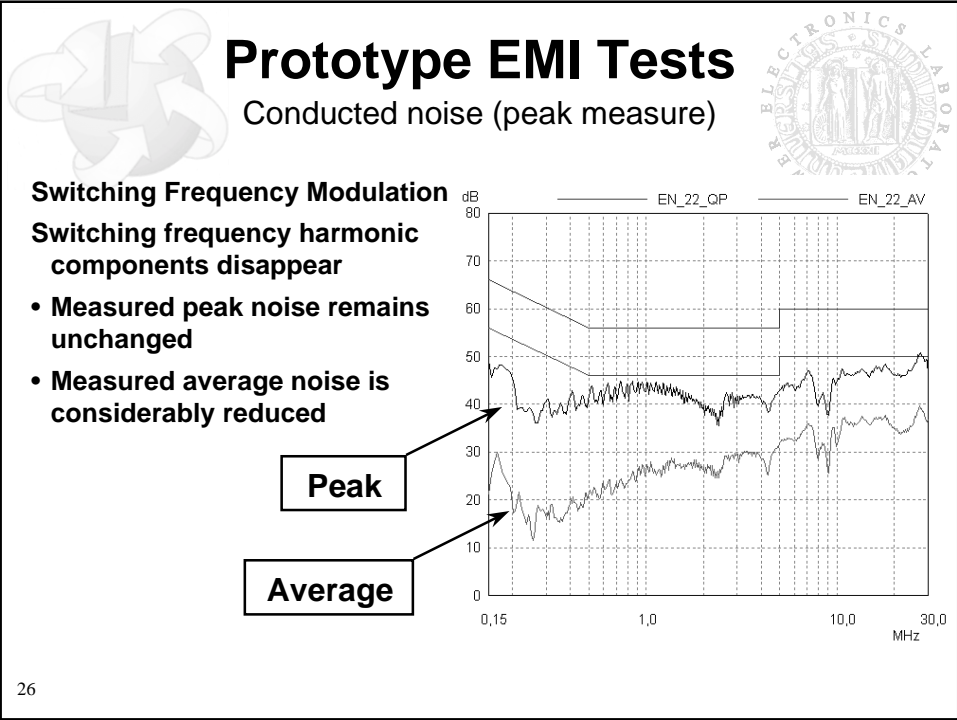
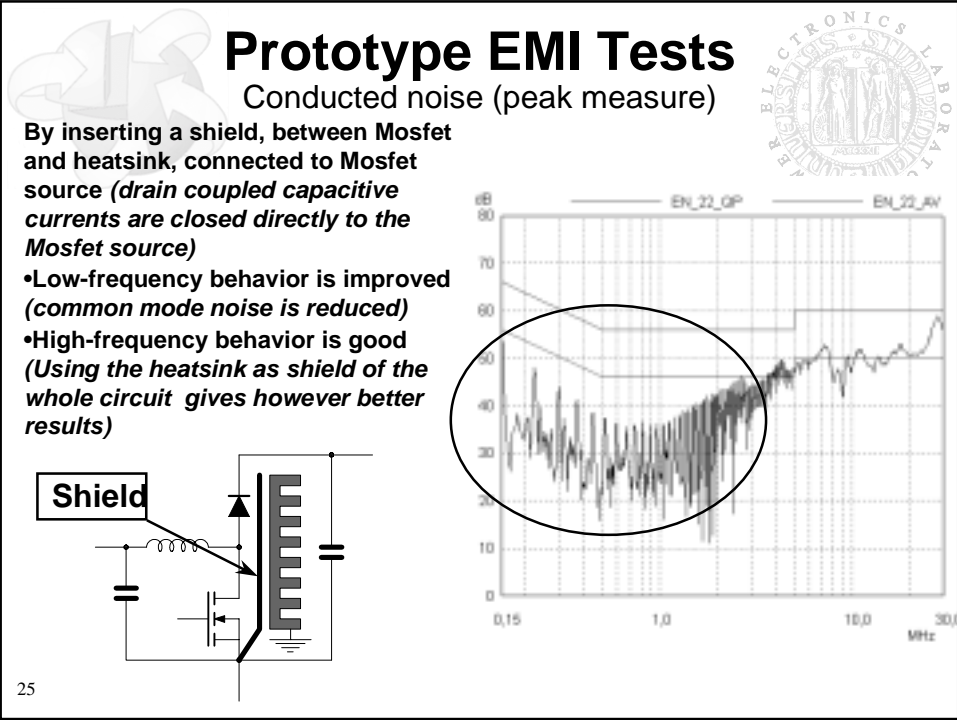


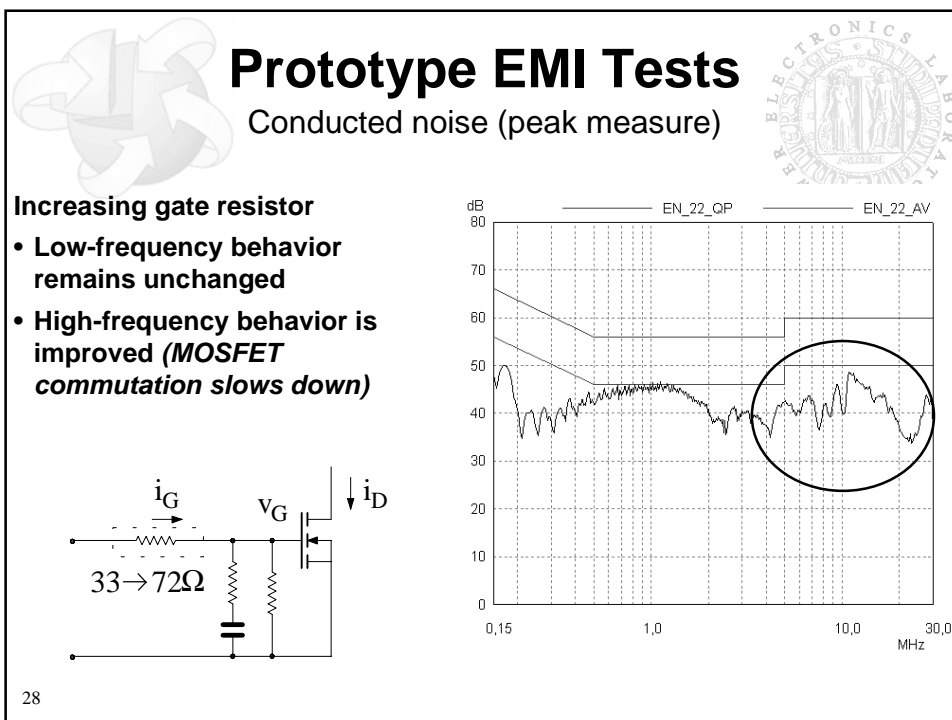
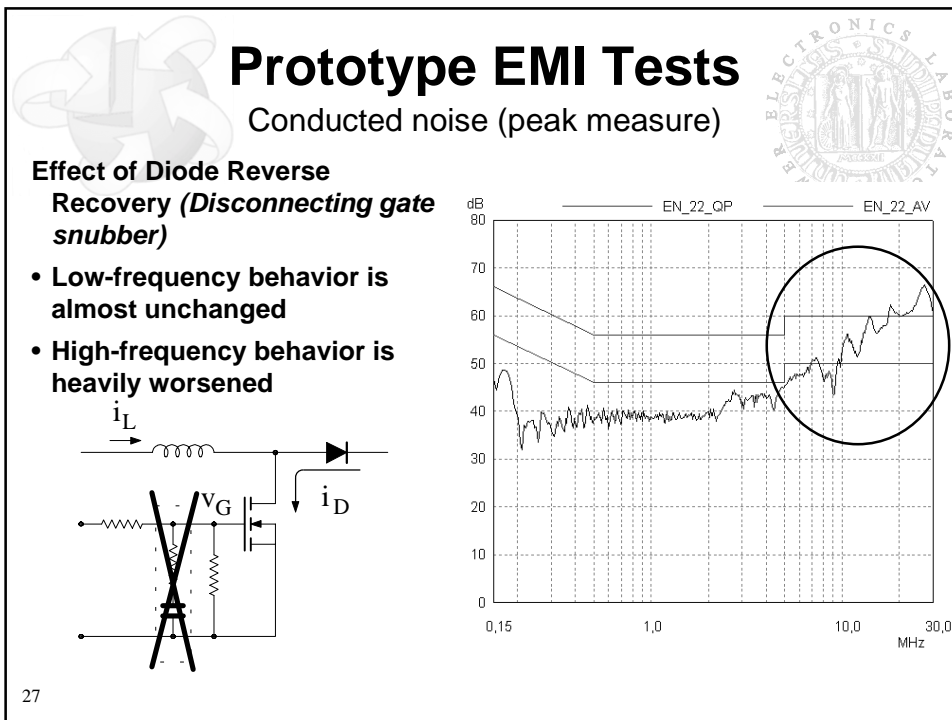










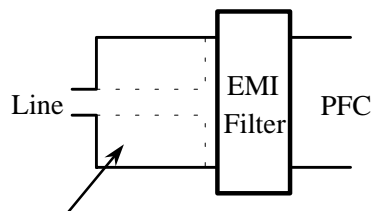


## Effect of Incorrect Filter Layout

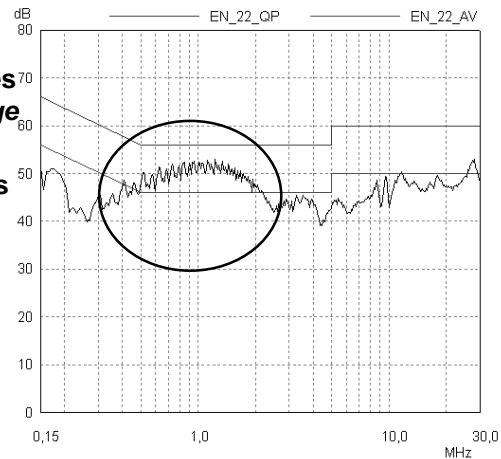
By spreading the ac wires close to the input filter (filter inductors inside plastic can)

- Low-frequency behavior becomes worse (*input wires capture leakage magnetic field of filter inductor*)

- High-frequency behavior remains unchanged



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## Conclusions

- It is important to consider common mode and differential mode noise separately
- Incorrect current return paths increase noises
- Low-frequency noises are mainly of differential mode
- Common mode currents must have a short return path
- Paralleling of filters should be avoided (to prevent resonance)
- Metal-can filters are preferable

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