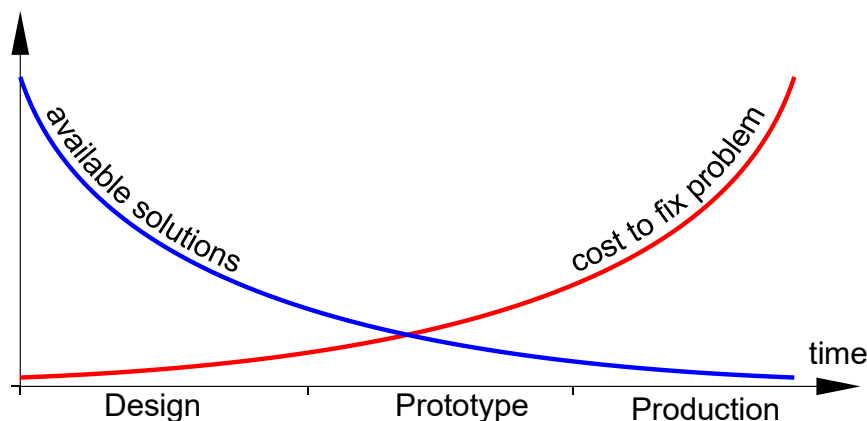


Current EMC Challenges at Grundfos

Christian Wolf, Grundfos Holding A/S

GRUNDFOS 
Possibility in every drop

Consider EMI prevention early in your design



p. 5; Henry W. Ott; Electromagnetic Compatibility Engineering; ISBN 978-0-470-18930-6; John Wiley & Sons. 2009

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EMI is one of many aspect that needs to be considered when starting a new design

The curve is drawn with inspiration from the book Electromagnetic Compatibility Engineering by Henry W. Ott.

The figure is already included in his book from 1988 "Noise Reduction Techniques in Electronic Systems, 2nd Edition, by Henry W. Ott, publisher: John Wiley & Sons, 1988, ISBN#: 0-471-85068-3." on page 6 And it is still just as valid today as it was then if not more.

Among other aspects to consider for a new design are

- Which standards apply?
- Thermal design
- Condensation
- Safety
- Acoustic noise

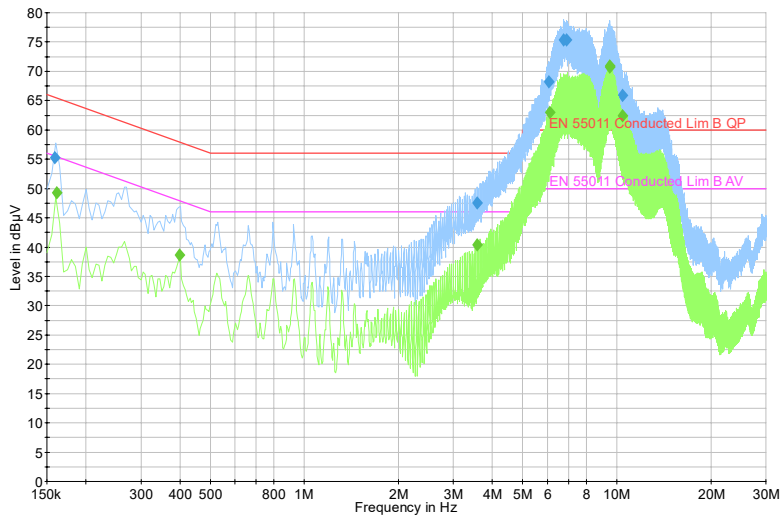
I still often see a product design where the emitted electrical noise from the product is difficult to attenuate when people realize that we have a problem with passing the emission test.

Plastic has many nice features. It is cheap and a good electrical insulator. But shielding of EMC noise is not one of them. It is

So, if the project already chosen a plastic box as enclosure, it is very expensive to modify it to include a shield.

And you can't solve the problem by adding more components.

Early prototype model



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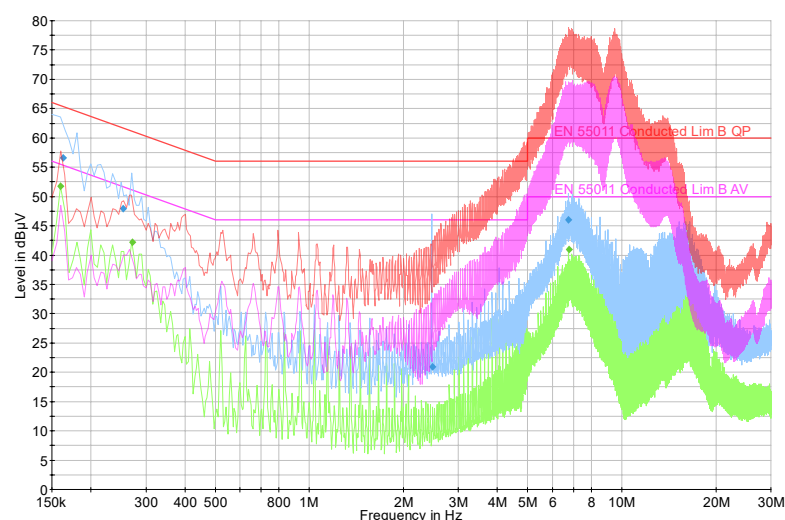
3

Test X0002

This one of the first test on the prototype.

It is clearly above the limits in the standard.

Production model



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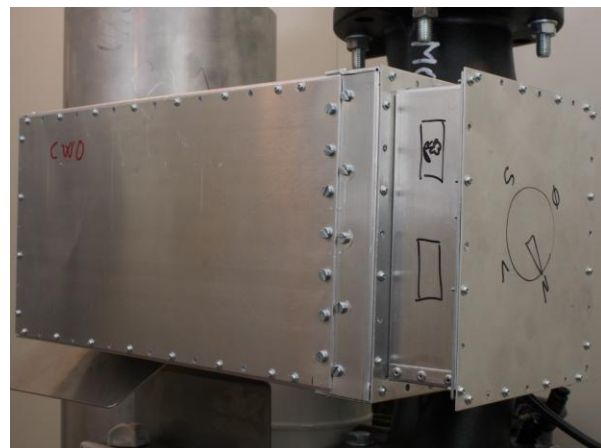
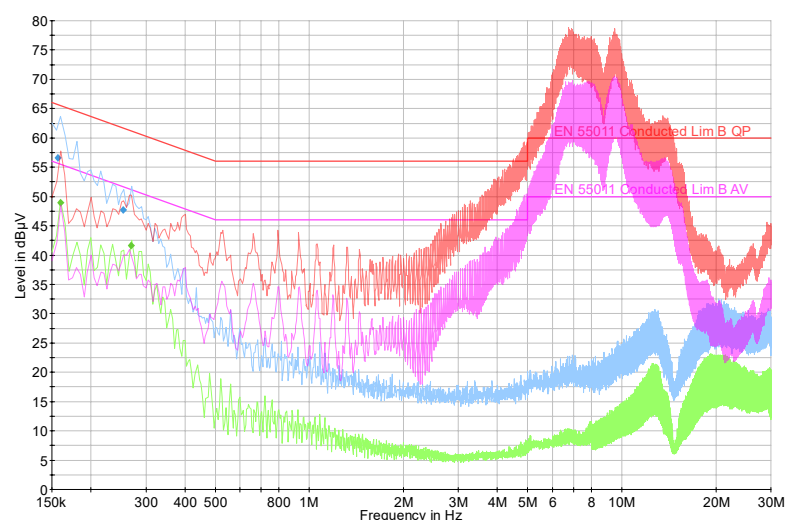
Test 0002

Essentially the same schematic for filter + motor drive so no change in filter components.

Substantial modifications has been applied to the mechanical design of the aluminium heatsink which is the bottom of the enclosure.

For comparison, the result from Test X0002 is superimposed as a semi-transparent picture. (Fade animation).

Extra shielded model



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Test 0010

Essentially the same schematic for filter + motor drive so no change in filter components

Substantial modifications has been applied to the mechanical design by adding more shielding in order to enclose both the inverter+motor and the mains filter in their own Faraday cage.

For comparison, the result from Test X0002 is superimposed as a semi-transparent picture. (Fade animation).

Round-robin test



- What is a round-robin test?
- Round-robin test for radiated noise in the frequency range 30 MHz to 200 MHz shows differences up to 20 dB in measured noise level!
- Reason for the discrepancy?

In experimental methodology, a round-robin test is an interlaboratory test (measurement, analysis, or experiment) performed independently several times.

Source: https://en.wikipedia.org/wiki/Round_robin_test

One would expect that a test performed at an accredited test facility would yield the same test result within a few dB for the emitted noise.

The main reason is that the standard CISPR 16-1-2 does not describe how the main cables shall be terminated at high frequency to the reference plane when leaving the test chamber.

Measurement example

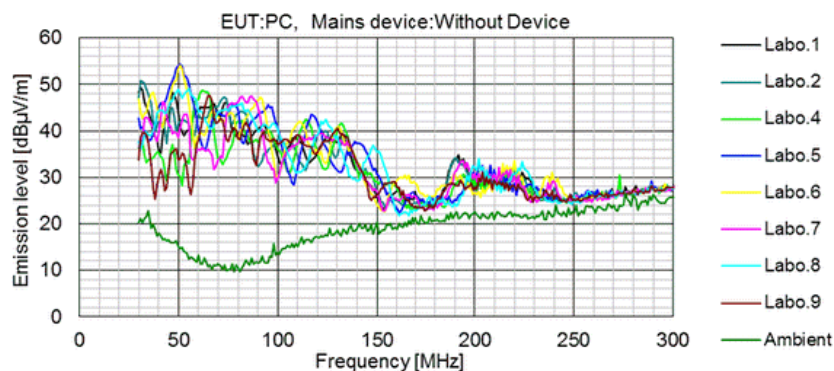


Fig. 23. RF Emissions from Tower PC under Condition 1, "Without Device" *excerpt from*

S. Okuyama, K. Osabe, K. Tanakajima and H. Muramatsu,
 "Investigation on effectiveness of very high frequency line impedance stabilization network (VHF-LISN)
 for measurement reproducibility,"
 2013 *International Symposium on Electromagnetic Compatibility*, Brugge, Belgium, 2013, pp. 174-179.

The figure is Fig. 23. RF Emissions from Tower PC under Condition 1, "Without Device" from

S. Okuyama, K. Osabe, K. Tanakajima and H. Muramatsu, "Investigation on effectiveness of very high frequency line impedance stabilization network (VHF-LISN) for measurement reproducibility," 2013 *International Symposium on Electromagnetic Compatibility*, Brugge, Belgium, 2013, pp. 174-179.

keywords: {Power cables;Frequency measurement;Power measurement;Poles and towers;Antenna measurements;Generators;Impedance;Very High Frequency Line Impedance Stabilization Network (VHF-LISN);power cable;radiated emission;comparability among sites;measurement reproducibility},

If you want a more in-depth explanation of the phenomena either Morten Sørensen from FORCE Technology or my colleague Kim Jensen from Grundfos is much more into the subject.

Conclusion



- Always include EMC considerations early in the design phase to maximize options for solutions and to minimize cost to achieve compliance with EMC limits
- Try to achieve more than 6 dB margin for radiated emission in the range from 30 MHz to approximately 200 MHz because the test result can vary a lot from one test facility to another test facility even with the exact same test setup due to how the standard is defined