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Graphene and shielding

SiO Graphene project

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KNOWLEDGE IN REALITY

Content

- Project scope
- Shielding challenge
  - New material
- SE measurement technique
- The future

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Participants

- Institute
  - RISE IVF, Mölndal
  - RISE, Linköping
  - RISE, Borås
- EMC technology
  - EMC Services
- Manufacturers, products
  - Atlas Copco Industrial Technique
  - Megger Sweden
- Manufacturers, material
  - Graphmatech
  - Biofiber Tech Sweden
  - Meva Energy

Med stöd från
VINNOVA Sveriges innovationsmyndighet
Energimyndigheten
FORMAS
Strategiska innovations-program

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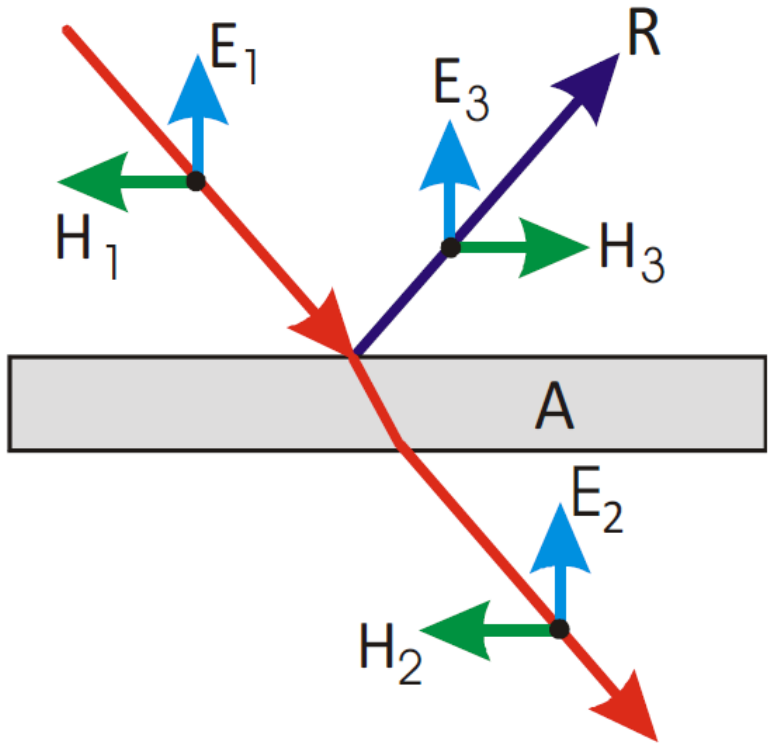
Project scope

- Shielding for EMC design
  - Main interest for manufacturers: 30 – 1000 MHz
- Replacement of existing NI-plating material
  - environmental issue
- Replacement of metal enclosure
  - cost and weight issue
- Graphene inclusion in polyimide with kept performance
  - How much is needed?
  - Mechanical performance
- Will be demonstrated in actual products from Atlas Copco Industrial Technique and Megger Sweden
- *How to measure – today focus*

Shielding definition – traditional theoretical approach



$SE = E_2^2 / E_1^2$ or SE = R+A [dB]
(shielding effectiveness)

R = Reflection loss

A = Absorption loss

R = f (wave impedance, material, frequency)

A = f (material, thickness, frequency)

Theoretical approach infinitely large plate
The multiple reflection parameter, M, is often neglected

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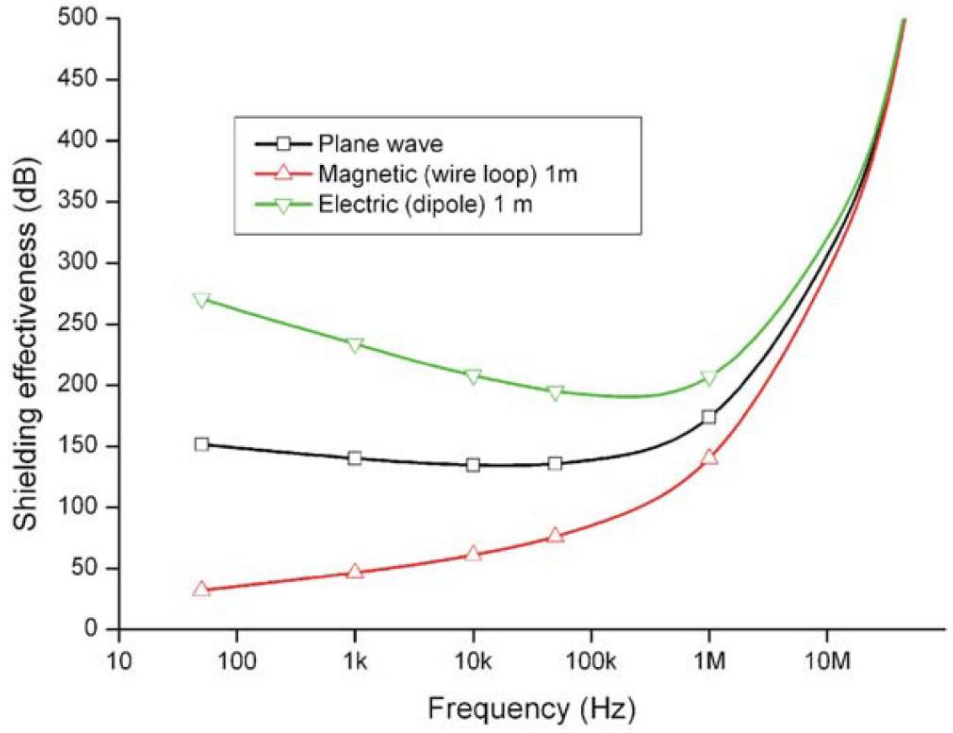
Shielding – theoretical calculation example



Shielding effectiveness for 0.5 mm Al

Ref.: HW Ott

- Only provides material influence
  - Conclusion from graph: the material is normally not a big issue
  - Not a valid assumption for Graphene?
- Matching interfaces not included
- Results at low frequency not valid
  - Geometry parameters needed
  - Often lower values for magnetic shielding

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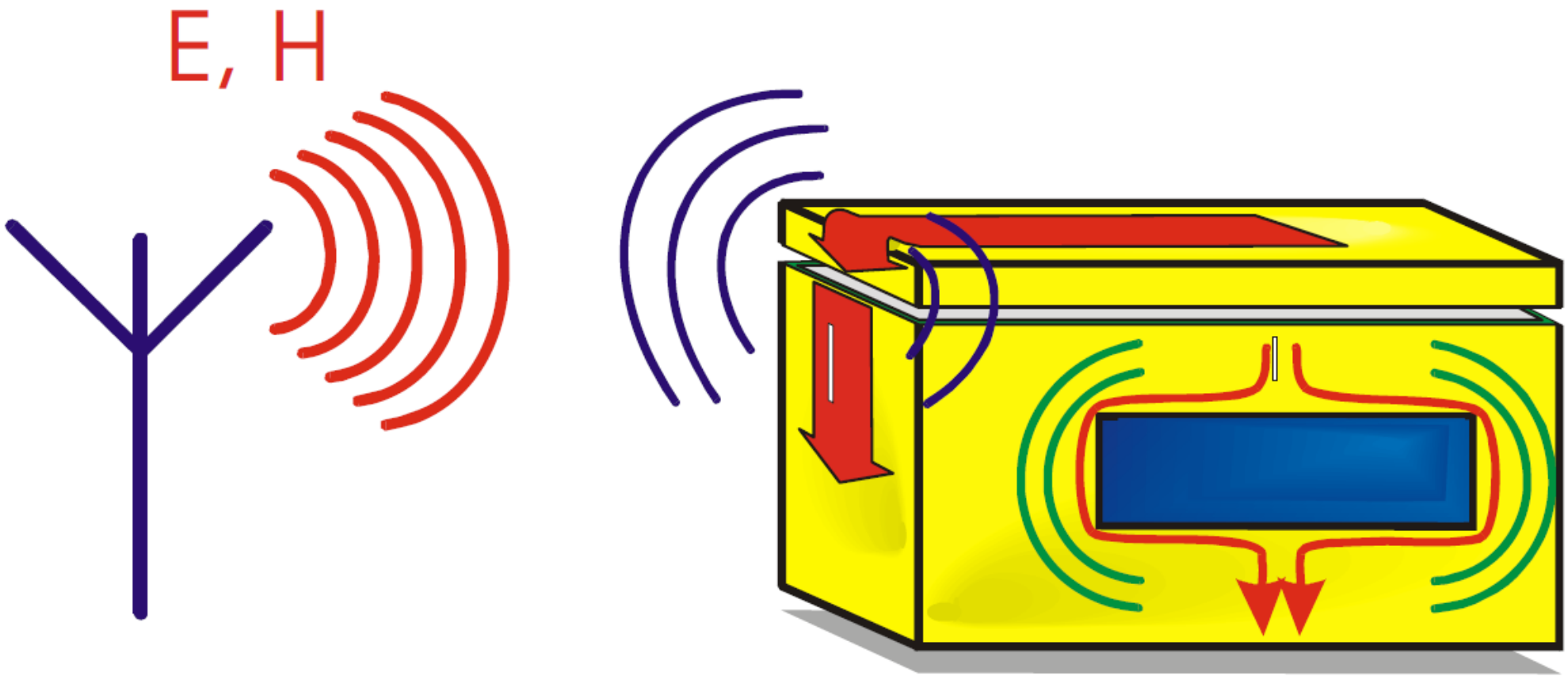
Shielding leakage - the dominant aspect



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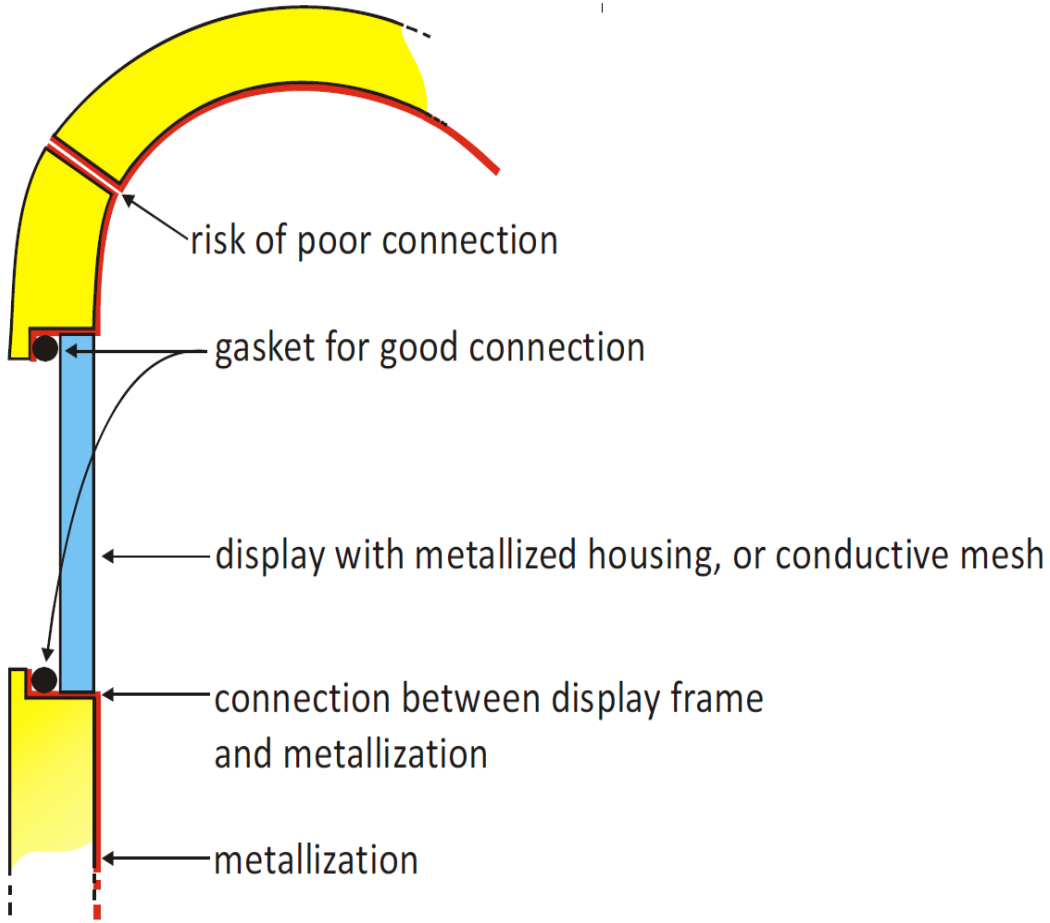
Coated parts – design challenge



Compatibility between

- 2 shielding parts
- Other mating surfaces
- Shielding connectors
- Filter connection (for external filtered interface)

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Measurement technique

- 3 levels
  - Material level – survey method
  - Material level – test fixture
  - Product level
    - Standardized method – compare EUTs with CISPR 16 emission method
      - What do we find from this
    - Reference method with internal generator?
      - Tailored test object?
- Resistance measurement methods
  - Material level – LF measurement of resistance
  - Suitable for quick selection and evaluation

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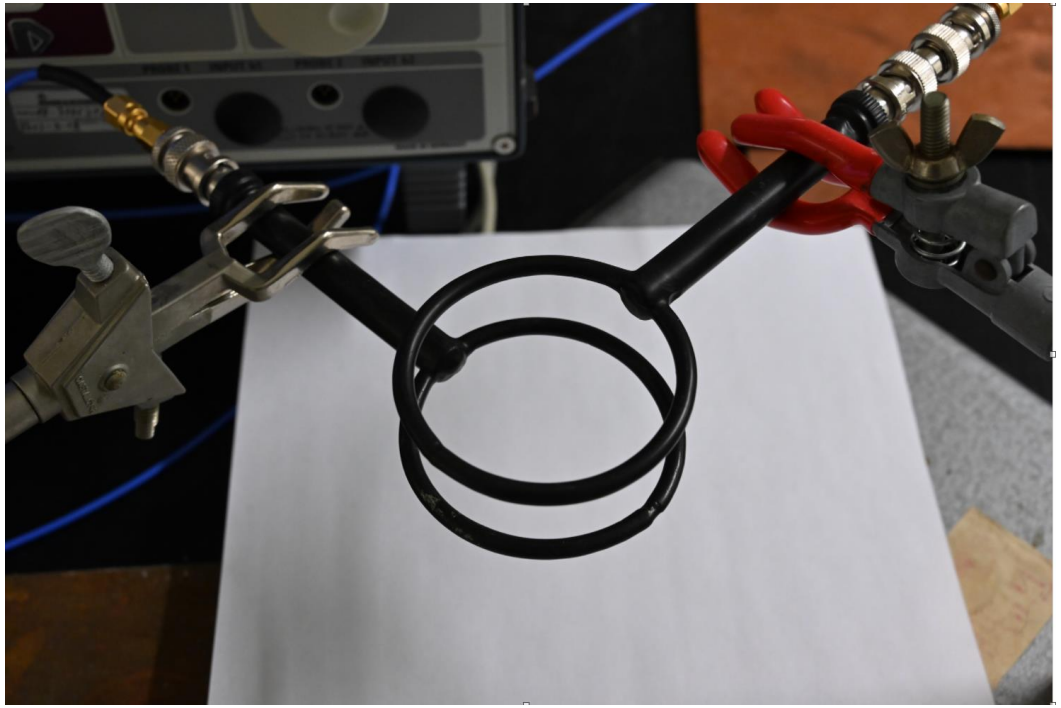
Material level test – survey method



- Test setup using loop antennas
  - 1 – 1000 MHz OK
- Quick simple method
  - Near field measurement
  - Impact on antenna factor?
  - Edge leakage?
  - Antenna distance not so critical
  - Ref: “A method of accurately measuring shielding effectiveness of materials in electronic products” (Douglas C. Smith)

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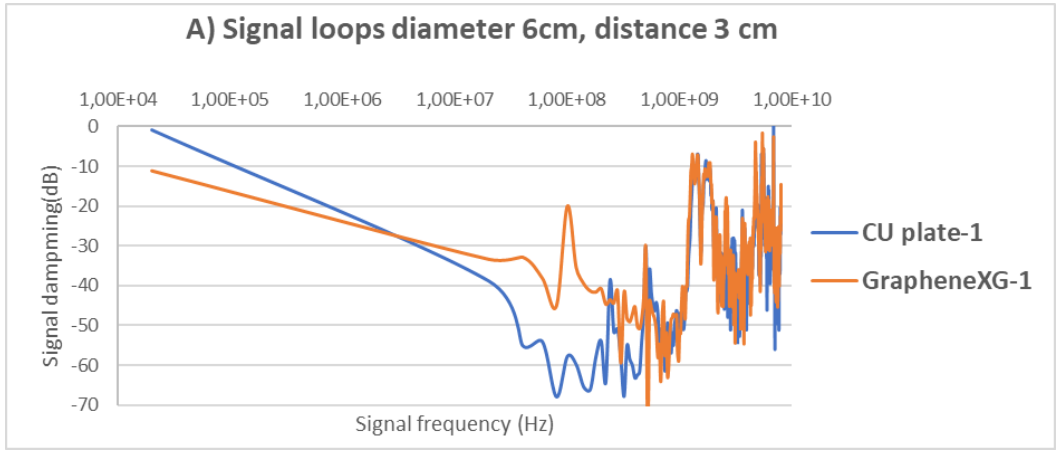
First results #1 – survey method (loops)



- Test setup using loop antennas
  - 20 kHz – 8 GHz
- Comparison with reference Cu plate
- Some resonances
  - Mainly at > 1 GHz – loop behavior
  - Below 1 GHz – setup resonances?
- Material XG-1
  - ca 20 dB difference from Cu
  - Resonance at 100 MHz

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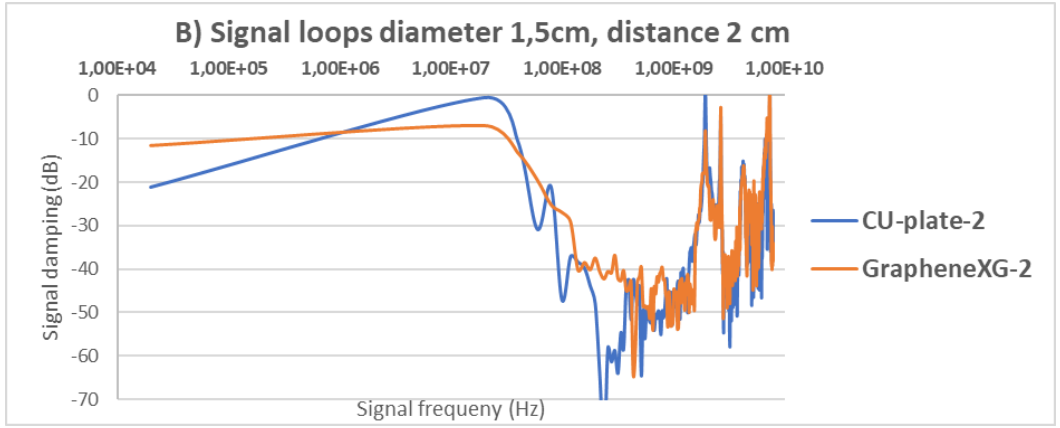
First results #2 – survey method (loops)



- Test setup using loop antennas
  - 20 kHz – 8 GHz
- Comparison with reference Cu plate
- Much smaller probe
  - Poor resolution < 100 MHz
  - Less resonances
    - Less coupling loop-mtrl?
    - Less edge leakage?
    - Mainly at > 3 GHz – loop behavior
- Material XG-2
  - Approx. same as Cu
  - Resolution probably limited

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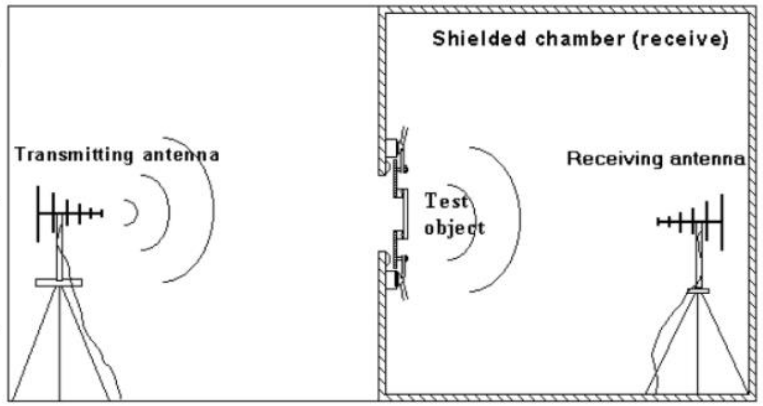
Material level test – Mode Stirred Chamber (MSC)



Shielding effectiveness measurements according to IEEE-STD-299, principle.

- Test setup using mode-stirred chamber
- High quality method
  - Far field measurement
  - but only useable for approx. f > 500 MHz
- Complex setup, special equipment
  - IEC 61726 (passive component test)
  - MIL STD-285 and MIL-DTL 83528 are only using fixed antenna
- Example showing gasket measurement
  - Source: KI report 2004:2E “Ageing of shielding joints” (Lena Sjögren)

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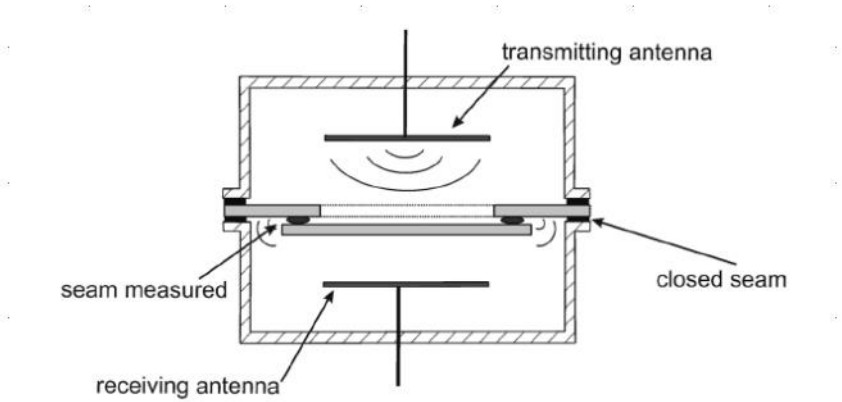
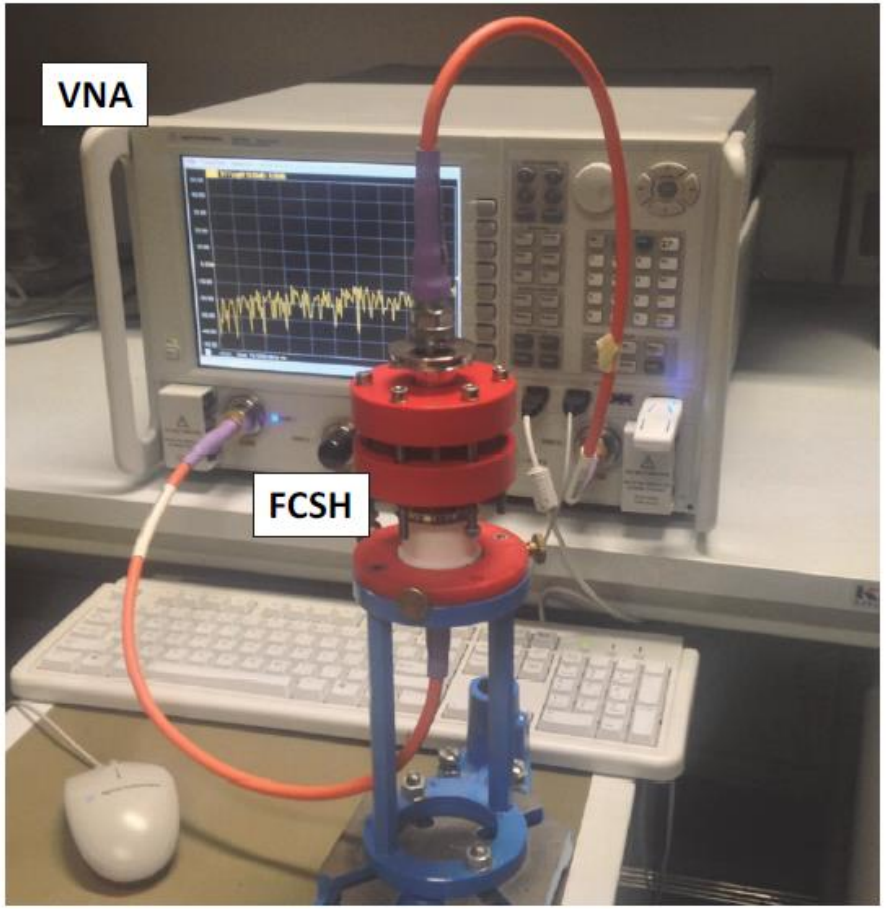
Material level test – small test fixture



Shielded box for shielding effectiveness measurements in the near field.

Gasket measurement
Source: KI report 2004:2E “Ageing of shielding joints” (Lena Sjögren)



Source: “RF shielding performance of thin flexible graphene nanoplatelets-based papers” (Tamburrano et al), IEEE 2014

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Test fixture aspects

- Test setup using small test fixture
  - FCSH = Flanged Coaxial Sample Holder
- Higher quality method
  - Near field measurement
  - Low resolution < 100 MHz
  - E or H-field probes?
- Relatively simple equipment
- Standard ASTM D4935-18 (intended for gaskets) can be used as reference

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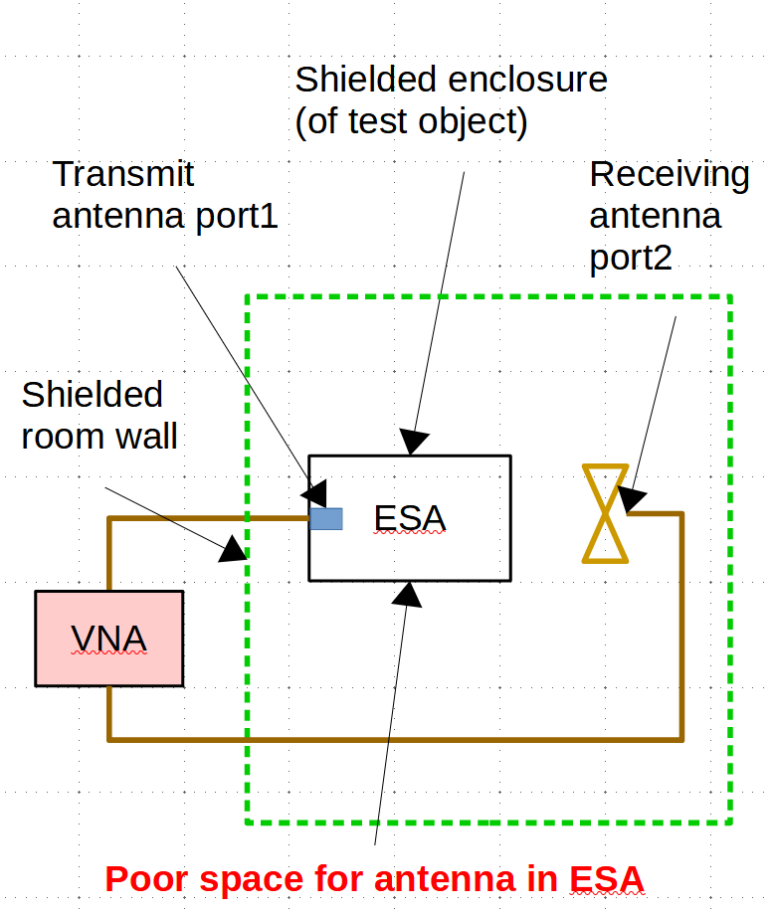
Shielding test method, product level



- Approach:
  - Measure the attenuation through the enclosure
- Alternatives:
  - Figure: Standard IEEE 299 for radiated cabinet measurement
  - CISPR25 method for conducted measurements (transfer methods)
  - Many IEC standards for cables and connectors
    - Not relevant
- Cons for IEEE 299:
  - 30-300 MHz not covered for enclosures
  - Interfaces of connectors and cables may be missed in IEEE method
  - Electronic HW influence not included

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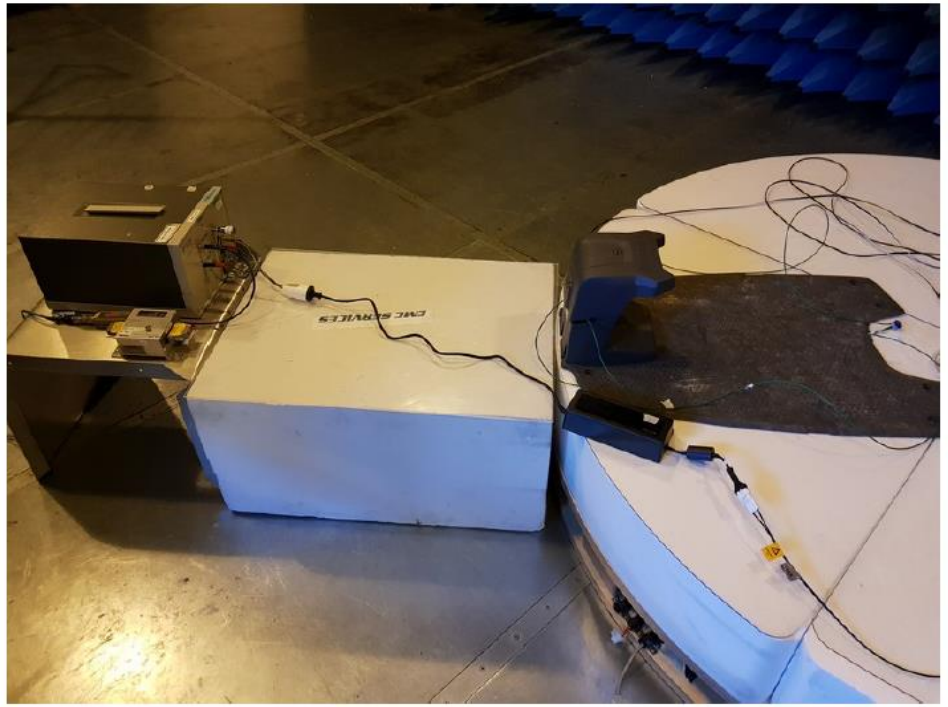
Product level EMC testing, EN standard

Radiated emission



Conducted emission

EUT placed on specified height from GRP – tabletop or floor standing

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Handling resonances in measurement

Smoothing of result may be made in 3 domains

- Geometry domain: mode stirring
  - Averaging of angle of incidence by changing the chamber
- Frequency domain
  - Smoothing by averaging over a frequency bandwidth
- Antenna domain
  - Averaging by turning the object

Future projects

- SiO Graphene program welcomes new initiatives
- In particular with focus on electronics
- Ideas?

Response from audience

- Tips från coacherna?

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