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Date: 2020-11-04

## **Report Nr. 2020 – 02**

### **Shielding effectiveness of an enclosure type IP-Pro ALU EMC manufactured by nVent in a frequency range of 30 MHz – 4 GHz**

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This report consists of 15 numbered pages and is valid only with authentic signature. The examination results are related to equipment under test only.

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## 1 General

|                                    |   |      |     |
|------------------------------------|---|------|-----|
| <b>Equipment under test (EUT):</b> | Enclosure IP-Pro ALU EMC 26880-008 manufactured by nVent  |      |     |
| <b>EUT received:</b>               | 2020-01-27  |      |     |
| <b>Place of test facility:</b>     | EMC-Laboratory<br>Institute of Electrical Energy Systems and High Voltage Engineering (IEH)<br>KIT – Campus Süd<br>Engesserstraße 11<br>76131 Karlsruhe<br>Testing laboratory accredited by DAkkS according to DIN EN ISO/IEC 17025:2005.<br>The accreditation is valid only for the standards listed in the annex of the accreditation certificate No. D-PL-11068-09-00. |      |     |
| <b>Test date:</b>                  | 2020-01-31  |      |     |
| <b>Environmental conditions:</b>   | temperature:  | 20,8 | °C  |
|                                    | humidity:   | 33,2 | %   |
|                                    | barometric pressure:  | 1002 | hPa |
| <b>Representative customer:</b>    | Mr. Daniel Dörflinger   |      |     |
| <b>Test engineer:</b>              | M. Görtz  |      |     |
| <b>Applied standards:</b>          | Shielding effectiveness in the frequency range of 30 MHz to 1000 MHz according to VG 95373, Part 15 and in the extended frequency range of 1 GHz to 4 GHz in dependence on the mentioned standard as well as IEEE 299-2006.   |      |     |


## 2 Conclusion

Shielding effectiveness measurements of an enclosure type IP-Pro ALU EMC 26880-008 manufactured by nVent were performed in a frequency range of 30 MHz – 4 GHz.

The results of those measurements are depicted in Figure 12 to Figure 19. The additionally calculated worst-case scenario is shown in Figure 20.

Responsible for the proper execution of the measurements in accordance with acknowledged rules of technology

Karlsruhe, 2020-11-04



Dr.-Ing. Michael Suriyah  
(Head of EMC-testing)



Prof. Dr.-Ing. T. Leibfried  
(Director)

### 3 Test setup

#### 3.1 Test equipment

Table 1: Test equipment for the frequency range of 30 MHz – 1 GHz

| Name                              | Type                                    | Manufacturer | Inventory number |
|-----------------------------------|---|--------------|------------------|
| Network analyzer                  | ZVRE                                    | R & S        | 272/0074/96      |
| Power amplifier (9 kHz - 220 MHz) | BTA 0122-1000                           | BONN GmbH    | 950003           |
| Power amplifier (220 - 1000 MHz)  | BLWA 2010-200                           | BONN GmbH    | 950004           |
| Sending antenna                   | UHALP9108-G                             | Schwarzbeck  | 050084           |
| Receiving antenna                 | E-field probe, Mod.-Nr. 904, 3,6cm ball | Eaton        | 870035HO         |

Table 2: Test equipment for the frequency range of 1 GHz – 4 GHz

| Name              | Type                                    | Manufacturer       | Inventory number |
|-------------------|---|--------------------|------------------|
| Network analyzer  | ZVRE                                    | R & S              | 272/0074/96      |
| Power amplifier   | 25S1G4A                                 | Amplifier Research | 990043           |
| Sending antenna   | STLP 9149                               | Schwarzbeck        | 990042           |
| Receiving antenna | E-field probe, Mod.-Nr. 904, 3,6cm ball | Eaton              | 870035HO         |

### 3.2 Setup

The EUT was situated in a semi anechoic chamber during all measurements. The receiving antenna in the middle of the EUT was connected to the test receiver through the right interface panel. The measuring cable was guided via tunnel under the ground plane. Positions of sending antenna and EUT changed due to different measurement setup above a frequency of 1 GHz (see Table 1, Figure 1 and Figure 2).

Table 3: Position data of the test setup

|  | 30 MHz – 1 GHz           | 1 GHz – 4 GHz            |
|--|--------------------------|--------------------------|
| Height of the receiving antenna                | 1,40 m                   | 1,40 m                   |
| Distance between sending and receiving antenna | 3,1 m                    | 1,15 m                   |
| Height of sending antenna                      | 1,8 m                    | 1,42 m                   |
| Polarization of sending antenna                | vertical                 | Vertikal                 |
| Polarization of receiving antenna              | vertical                 | Vertikal                 |
| Irradiated sides                               | left, right, front, back | left, right, front, back |

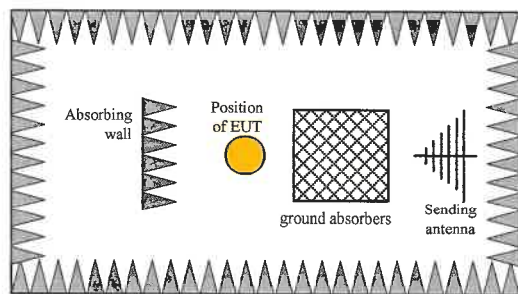


Figure 1: Setup for 30 MHz – 1 GHz

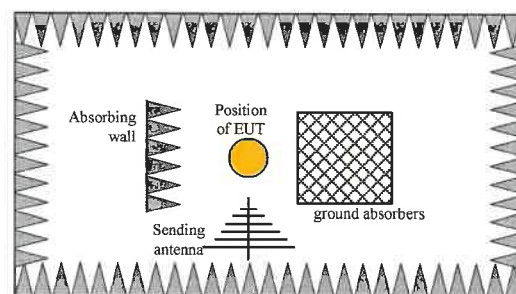


Figure 2: Setup for 1 GHz – 4 GHz

### 3.3 Measurement procedures

The measurement of the shielding effectiveness was performed according to the “middle point method” which describes an insertion-loss method.

Coupling is first measured with no enclosure present and afterwards with one inserted. During those measurements the distance between sending- and receiving antenna as well as the orientation and sending power  $P_0$  are kept constant.

Hence, the receiving antenna was connected through the bottom side of the EUT (see figures 8, 9, 10 and 11), a reference level for each of the four side of the EUT was recorded.

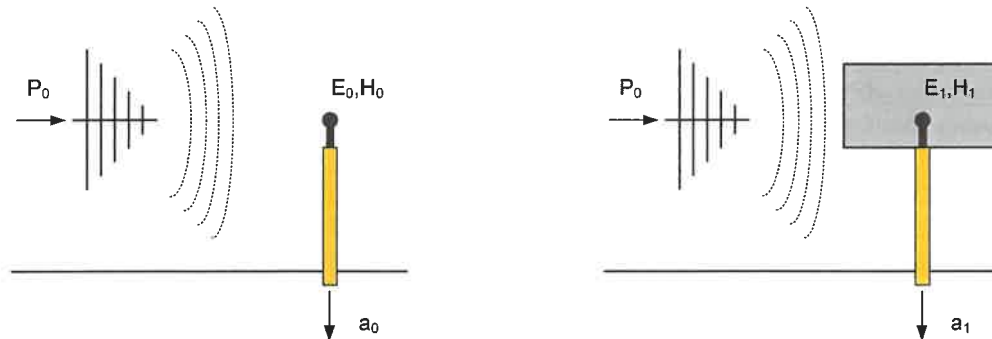


Figure 3: Illustration of insertion-loss measurement method

The enclosure shielding effectiveness  $a_s$  is the difference between the reference level  $a_0$  without and the level  $a_1$  with applied shielding (Figure 3).

$$a_s = a_0 - a_1 \text{ in dB}$$

### 3.4 Dynamic range

The dynamic range  $a_D$  is determined as the difference between reference level  $a_0$  and the level  $a_2$  without receiving antenna and a reflection free enclosed cable (Figure 4).

$$a_D = a_0 - a_2 \text{ in dB}$$

Dynamic range is a quantification for the maximum shielding effectiveness, achievable with the used test setup. It depends on the noise level of the equipment (e.g., the shielding effectiveness of the cables) and the intrinsic noise of the receiver. The reference level depends on investigated side of the EUT and therefore a dynamic range for each side was measured. Figure 5 gives an overview of the achieved dynamic in the entire frequency range.

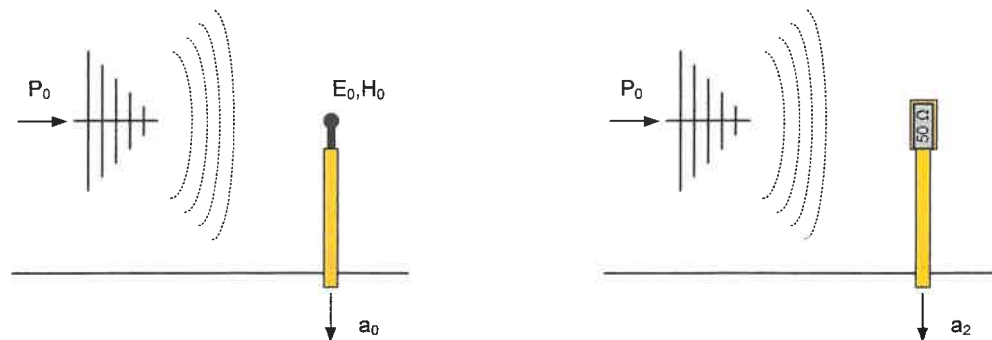


Figure 4: Determination of the dynamic range

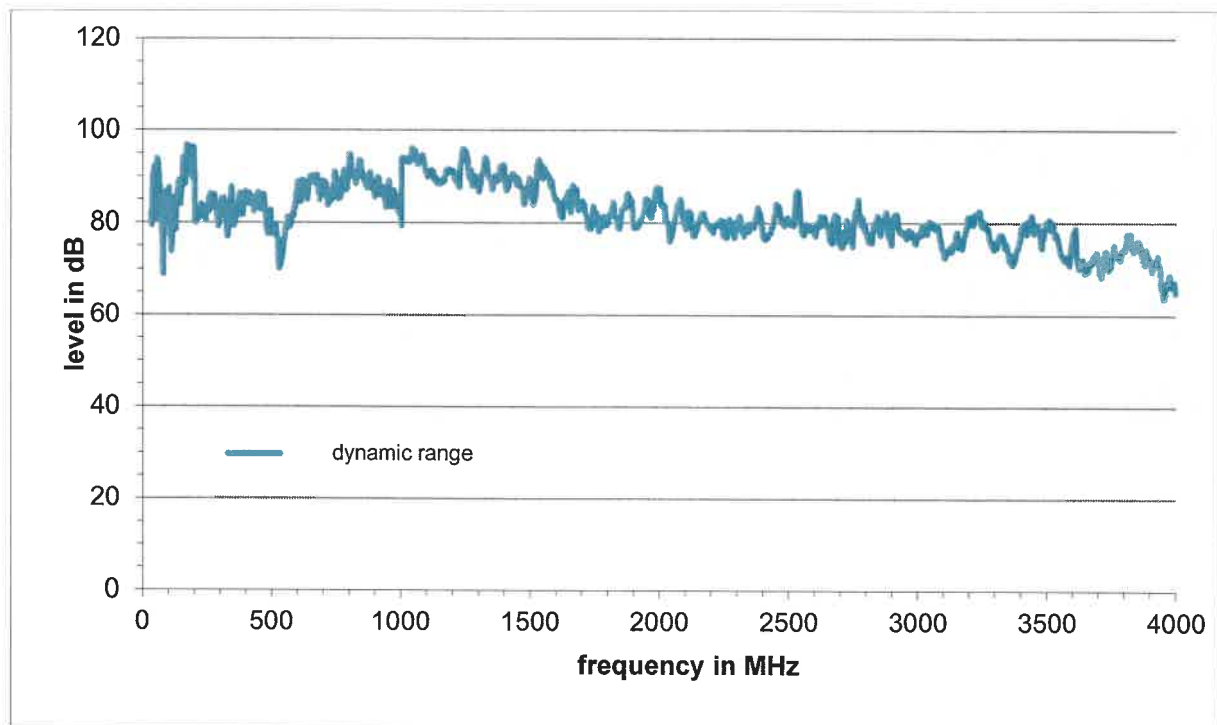


Figure 5: Achieved dynamic range from 30 MHz to 4 GHz

### 3.5 Measurement processing and illustration

In order to reduce the influence of resonances inside the EUT the measurement results for shielding effectiveness are smoothed by a moving average filter with a width of 10 frequency points.

The originally measured data is shown in figures with a dashed line whereas the smoothed shielding effectiveness curves are illustrated in red.

### 3.6 Pictures of the EUT as part of the test setup



Figure 6 : Receiving antenna



Figure 7: Dynamic range measurement



Figure 8: Left side of the EUT



Figure 9: Front side of the EUT





Figure 10: Shielding effectiveness measurement of the front side in the frequency range 30 MHz – 1 GHz



Figure 11: Shielding effectiveness measurement of the back side in the frequency range 1 GHz – 4 GHz

### 3.7 Construction and assembly of the EUT

The EUT was delivered fully assembled. The technical specifications are shown in the following illustrations:

# IP-Pro Alu EMC

## IP65 Gehäuse für den Schutz von empfindlicher Elektronik

Das Aluminium-Druckguss-Gehäuse **IP-Pro Alu EMC von nVent SCHROFF** überzeugt mit einem IP-Schutz von IP65, ist EMV-geschirmt, schock-, vibrations- und korrosionsbeständig. Es ist für Elektronik mit standardisiertem oder kundenspezifischem Formfaktor einsetzbar. Ergänzt wird die Gehäuselösung durch die Expertise von **nVent SCHROFF**, welche innovative Lösungen zur Leiterkartenfixierung, Kabelmanagement, sowie ein optimales Entwärmungskonzept beinhaltet.



| Bestell-Nummer | Hohe (mm) | Breite (mm) | Tiefe (mm) |
|----------------|-----------|-------------|------------|
| 26880-001      | 90        | 122         | 122        |
| 26880-002      | 90        | 220         | 122        |
| 26880-003      | 90        | 160         | 160        |
| 26880-004      | 90        | 260         | 160        |
| 26880-005      | 90        | 360         | 160        |
| 26880-006      | 110       | 200         | 230        |
| 26880-007      | 180       | 200         | 230        |
| 26880-008      | 110       | 330         | 230        |
| 26880-009      | 180       | 330         | 230        |
| 26880-010      | 110       | 401         | 230        |
| 26880-011      | 110       | 600         | 230        |
| 26880-012      | 110       | 402         | 310        |
| 26880-013      | 180       | 402         | 310        |
| 26880-014      | 110       | 600         | 310        |
| 26880-015      | 180       | 600         | 310        |

### KUNDENSPEZIFISCHES KONZEPT FÜR JEDE ANWENDUNG

#### Konfiguration einer flexiblen Gehäuselösung

Die Verfügbarkeit von 15 verschiedenen Dimensionen und individuelle mechanische Modifikationen, sowie Lösungen zur Leiterkartenfixierung und Kabelmanagement, ermöglichen einen Einsatz für unterschiedliche Applikationen.

#### Optimales Entwärmungskonzept

Konvektions- oder Konduktionskühlung ermöglicht eine Wärmeableitung über das Gehäuse selbst und ist an die jeweilige Anwendung anpassbar.

#### Schutz der Elektronik im Innen- und Außenbereich

- Bahn- und Verkehrstechnik
- Kommunikationstechnik
- Sicherheits- und Verteidigungstechnik
- (Industrial) IoT

#### Simulationen & Tests

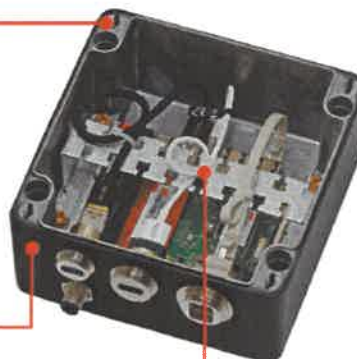
Durch thermische Simulationen, IP- oder EMV-Tests wird die Funktion des gesamten Gehäusekonzepts gewährleistet.

#### Ästhetisches Gehäuse-Design

Attraktive Gestaltung des Gehäuses durch Pulverbeschichtung, Siebdruck oder Digitaldruck mit einer hohen Resistenz der Farben gegen Umwelteinwirkungen oder Chemikalien.

#### Entwicklung und Integration elektronischer Komponenten

Kundenspezifische Lösungen von der Verkabelung, über Boards wie COM Carrier bis hin zu Integrationsdienstleistungen.



Das oben gezeigte Produkt ist ein EMV-geschütztes Gehäuse mit den Abmaßen H90 x B160 x T160 mm (26880-003) und hat ein integriertes embedded NUC™ Board.

## 4 Results

### 4.1 Measured shielding effectiveness from 30 MHz – 1 GHz

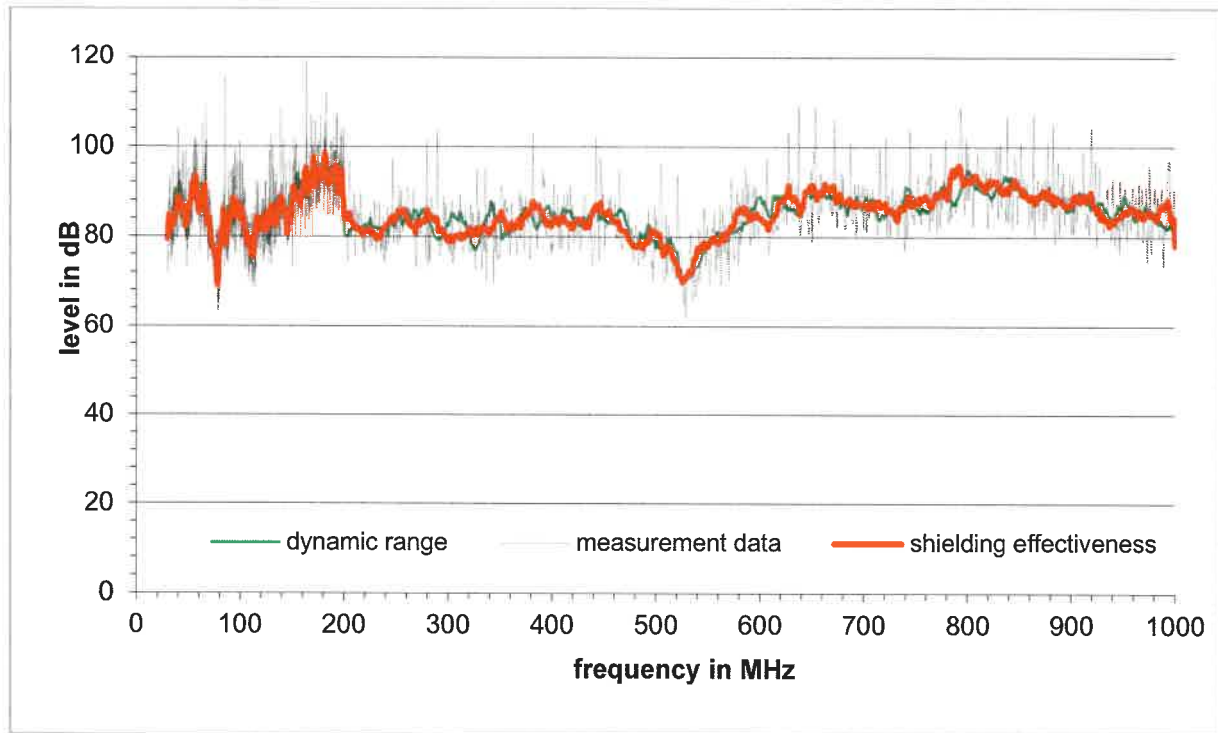


Figure 12: Measurement results for direct radiation on LEFT-side of the EUT

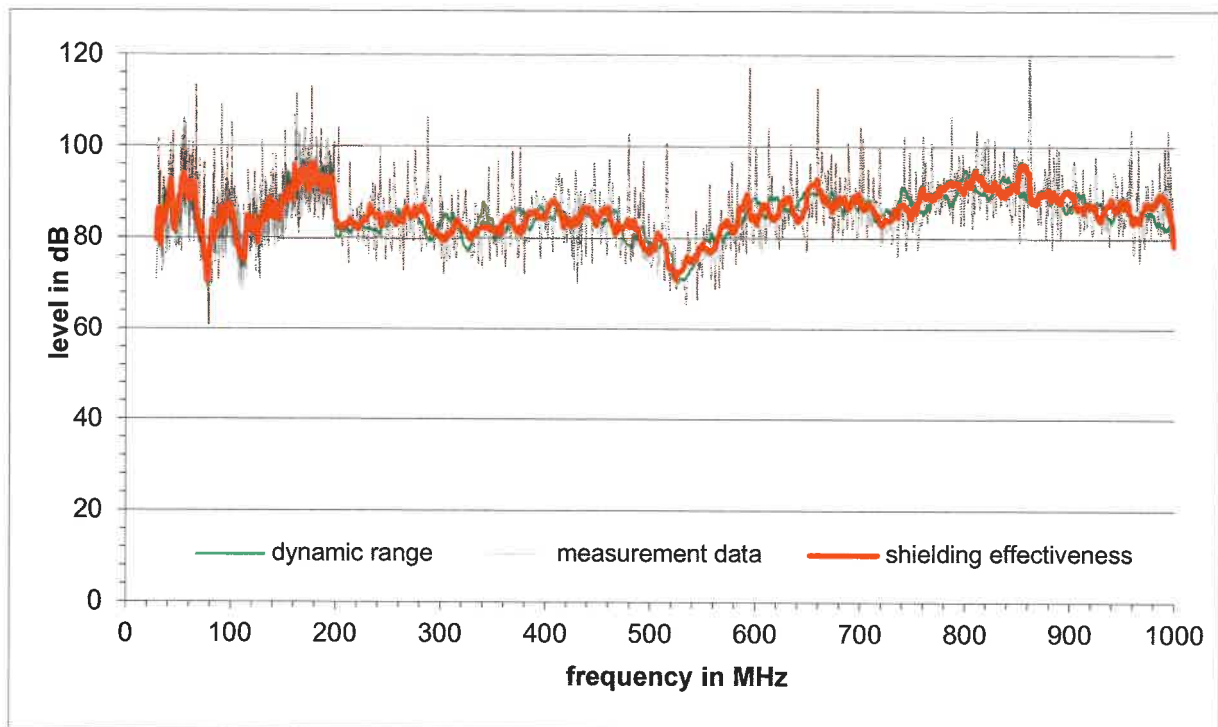


Figure 13: Measurement results for direct radiation on RIGHT-side of the EUT

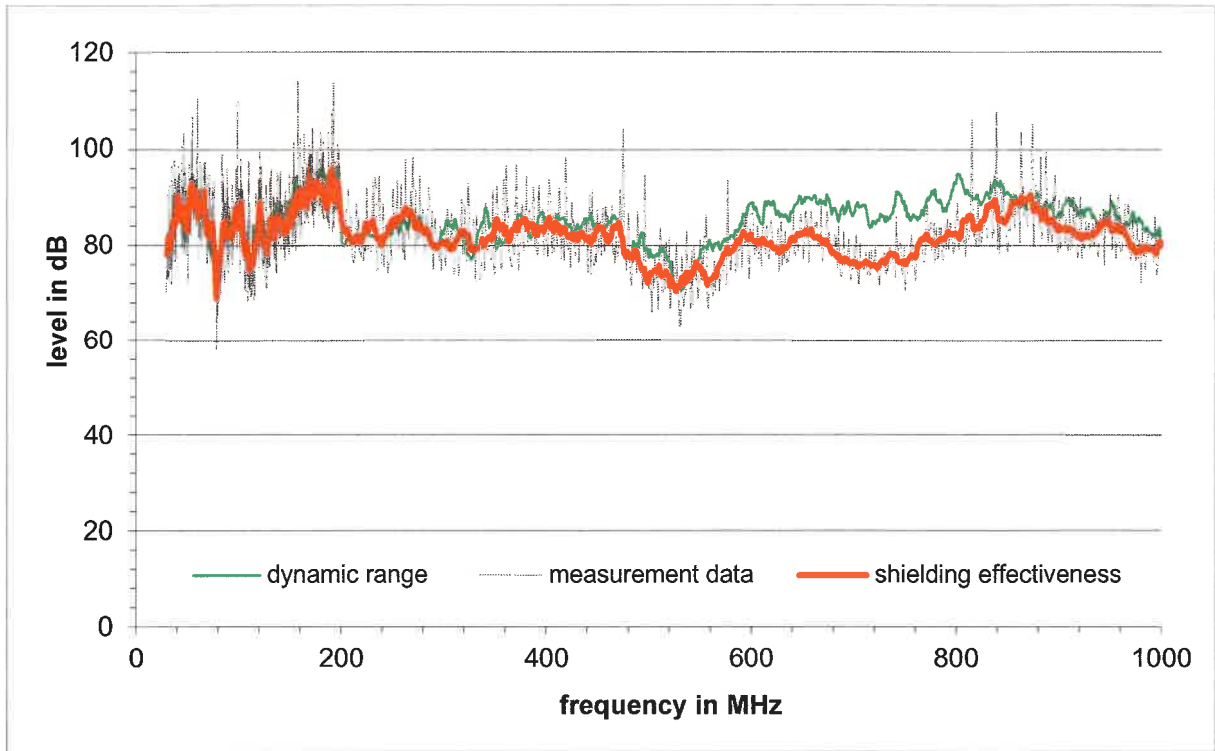


Figure 14: Measurement results for direct radiation on FRONT-side of the EUT

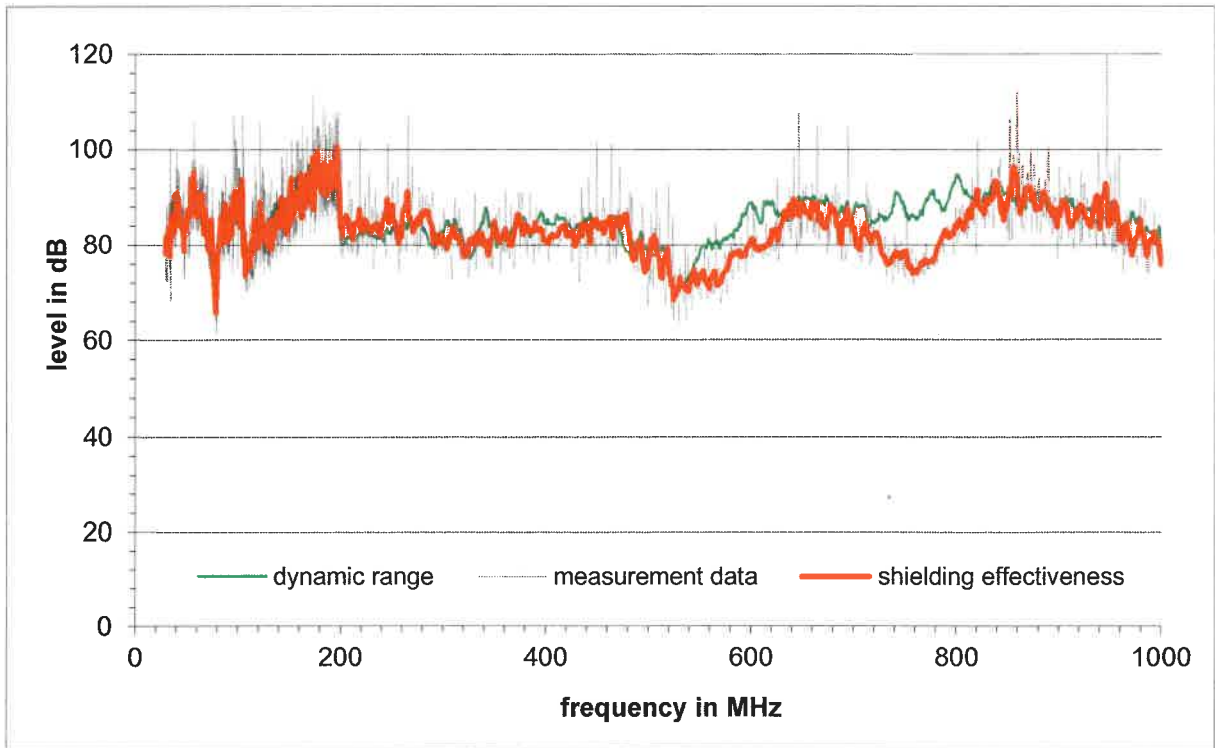


Figure 15: Measurement results for direct radiation on BACK-side of the EUT

### 4.2 Measured shielding effectiveness from 1 GHz – 4 GHz

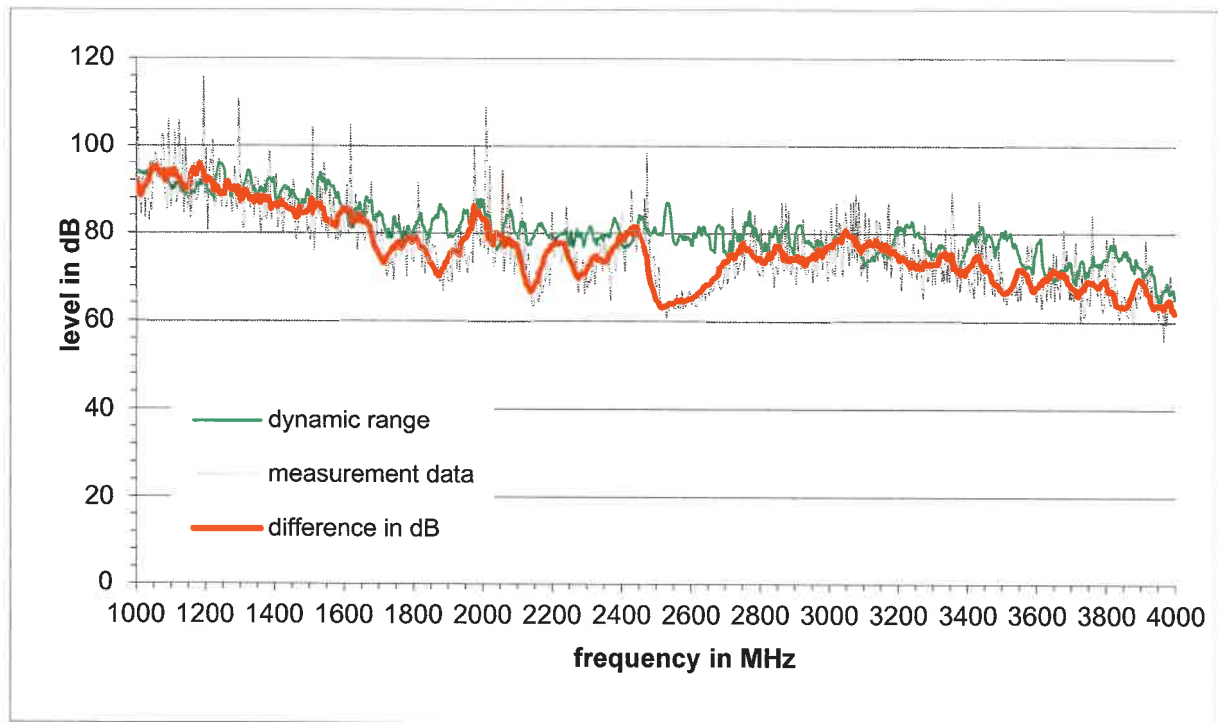


Figure 16: Measurement results direct radiation on LEFT-side of the EUT

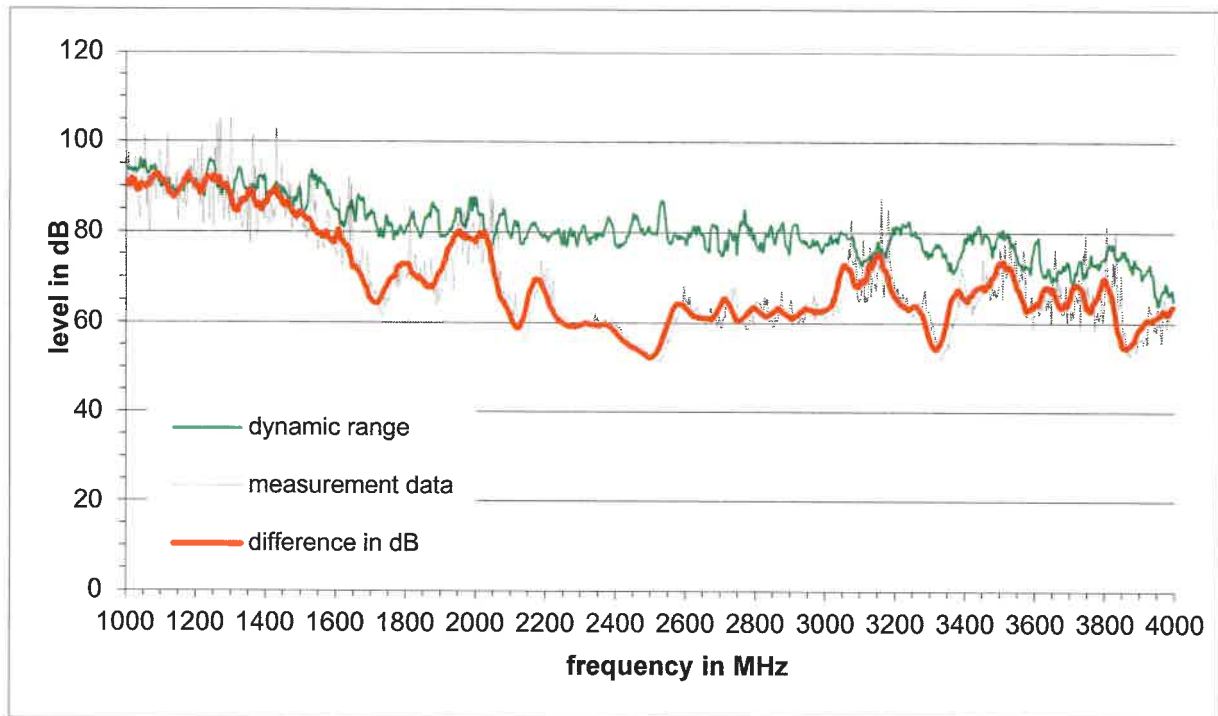


Figure 17: Measurement results for direct radiation on RIGHT-side of the EUT

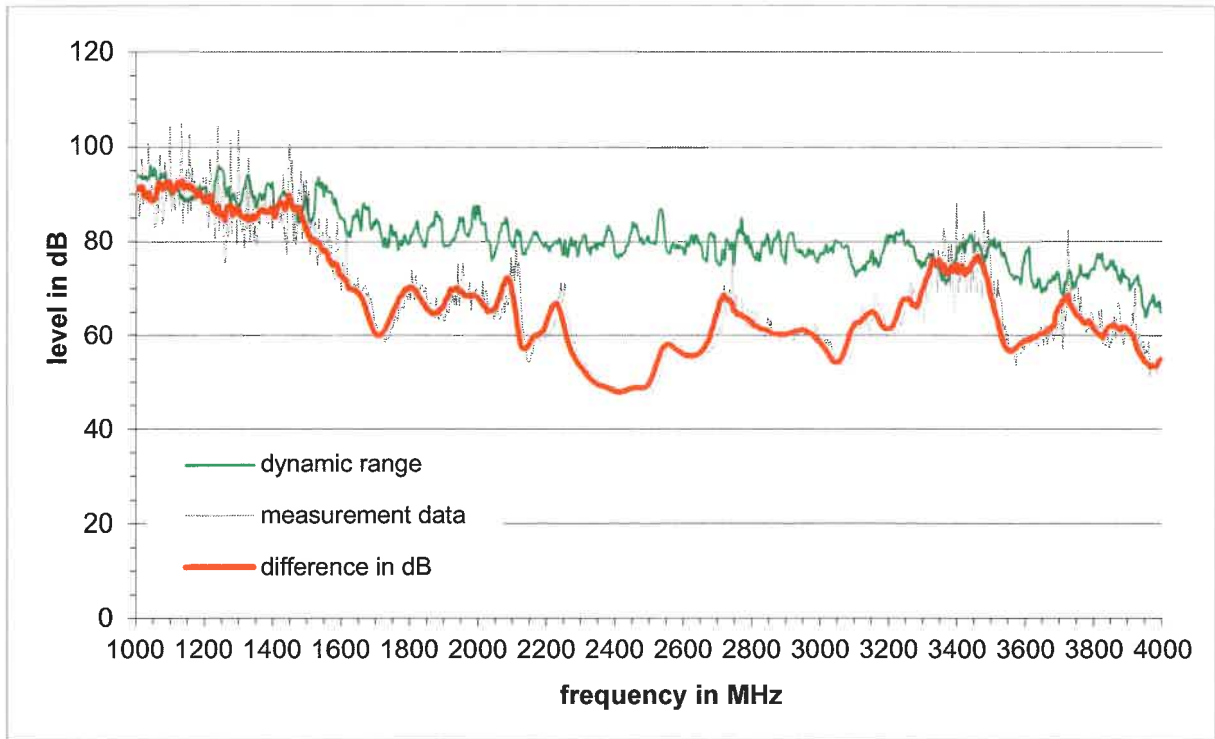


Figure 18: Measurement results for direct radiation on FRONT-side of the EUT

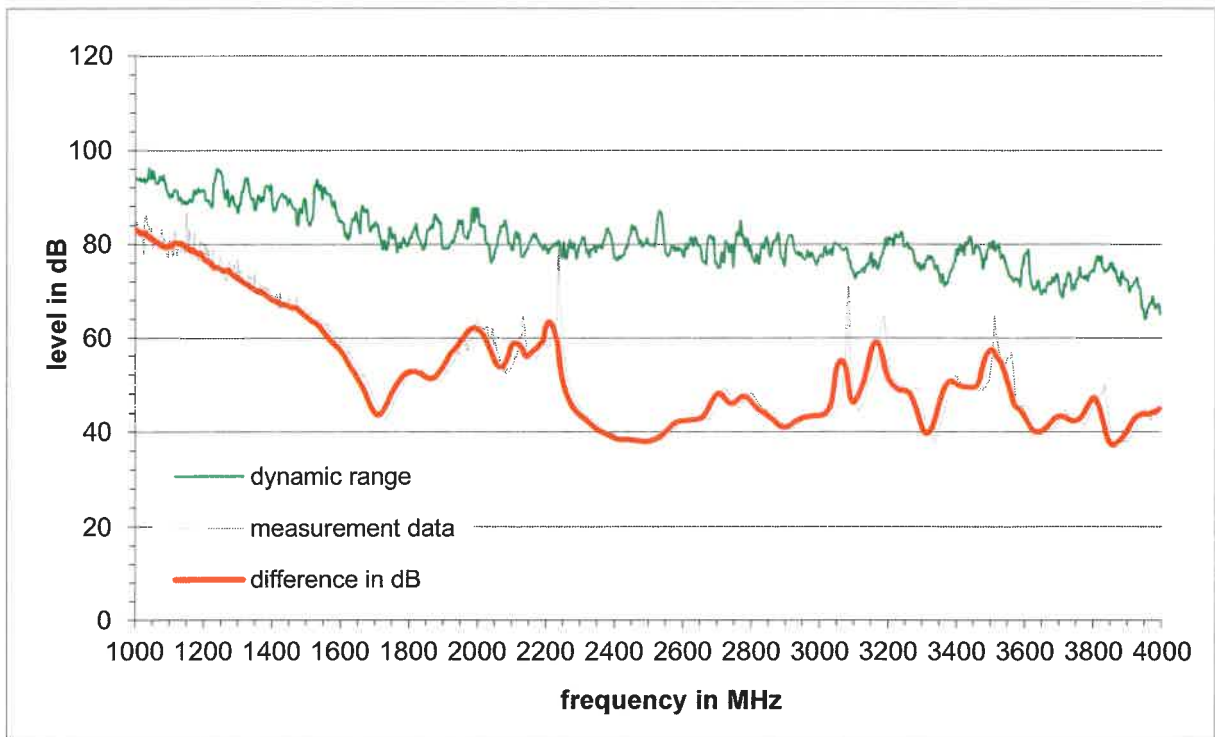


Figure 19: Measurement results for direct radiation on BACK-side of the EUT

### 4.3 Worst-case scenario

Additionally to the measurements above, with direct radiation on one side of the EUT, an overall worst-case scenario was calculated, using the total minimum shielding effectiveness of the previously recorded values. Figure 20 shows the worst-case shielding effectiveness of the EUT after smoothing of resonance frequencies. The dynamic ranges are all the same due to the symmetrical setup. The minimal shielding effectiveness reaches from 37 dB as a minimum value at around 3861 MHz to 92 dB as a maximum value at around 197 MHz.

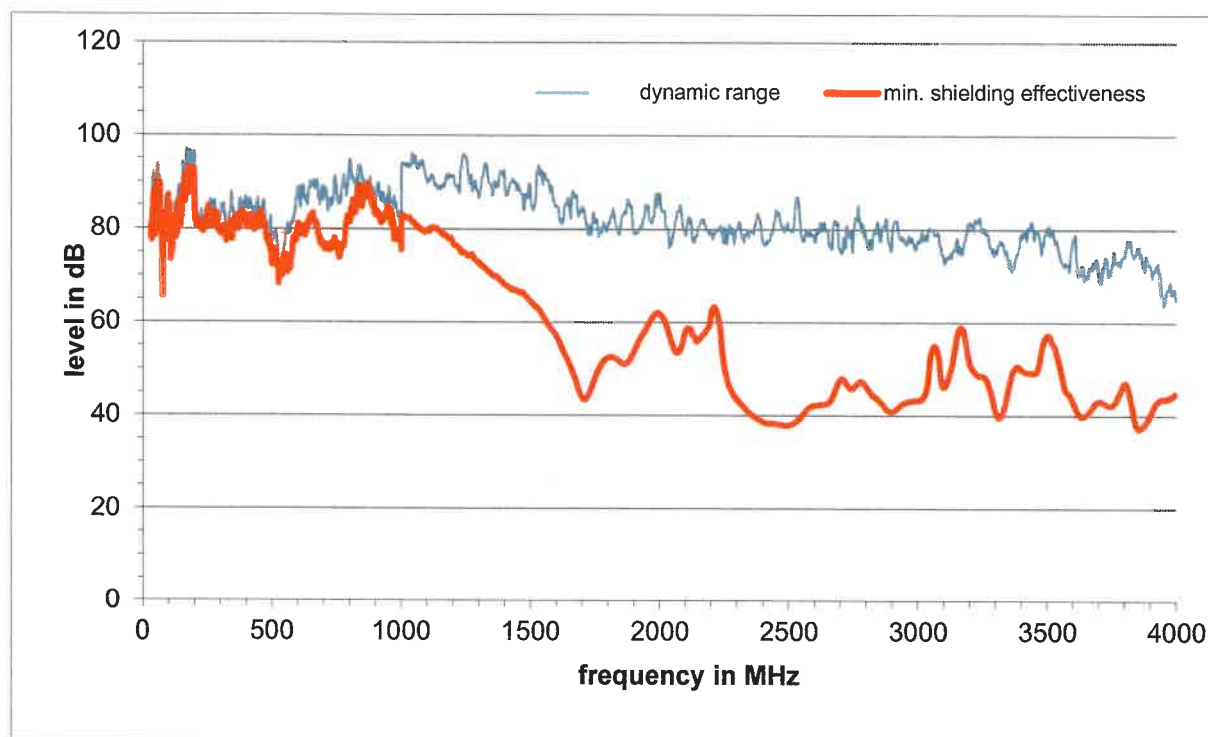


Figure 20: Worst case scenario

