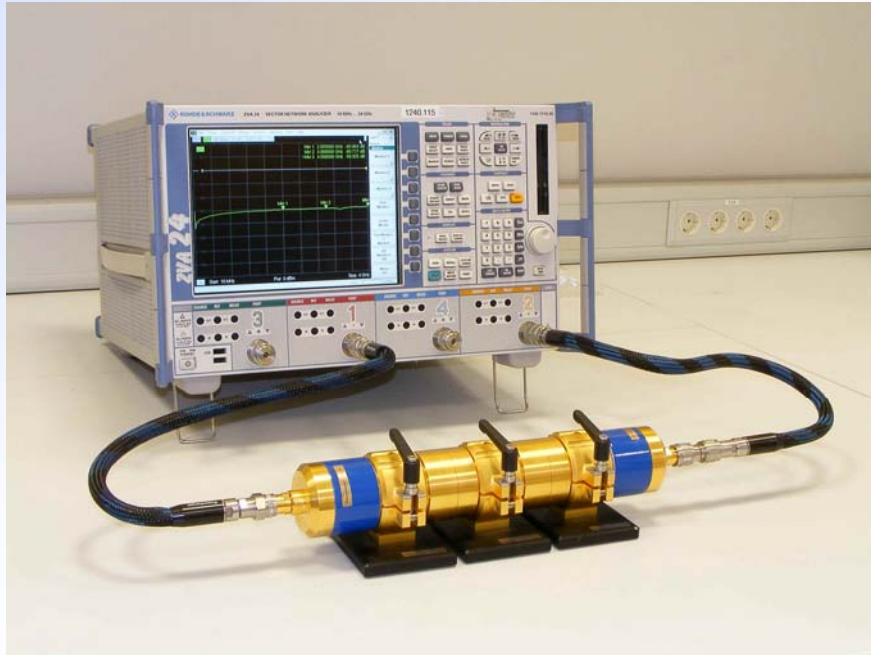


EMC of Cables & Connectors & Test methods



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1-1

EMC of Cables & Connectors & Test methods



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1-2

EMC of Connectors & Assemblies

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 - ◆ Radio & TV Technician, Radio Brand Marburg, 1968 -1971
 - ◆ Dipl.-Ing. Nachrichten- & Mikroprozessortechnik, FH Giessen, 1984
- **bedea** Berkenhoff&Drebes GmbH, Asslar, *Mitarbeiter seit 1985*
 - ◆ **bedea** Manufacturer of Communication cables, (**CATV-cables**)



- Responsible:

- ◆ R&D Manager and RF- & EMC-Measurements
- ◆ **Standardisation:**
- ◆ Chairman of VDE/DKE UK 412.3, Koaxialkabel,
- ◆ Secretary of CENELEC SC 46XA, Coaxial cables
- ◆ Secretary of IEC SC 46A, Coaxial cables

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1- 3

Outline

- Physical Basics of Cable Screening
 - ◆ Definitions, electrical length
 - ◆ Coupling Transfer Function
- Measuring of Screening of Cables & Connectors
 - ◆ Transferimpedance & Screening attenuation
 - ◆ Screening of Connectors & Connecting Hardware
- Further development
 - ◆ Screening of Feed-throughs and EMC gaskets
- Conclusion & Discussion

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1- 4

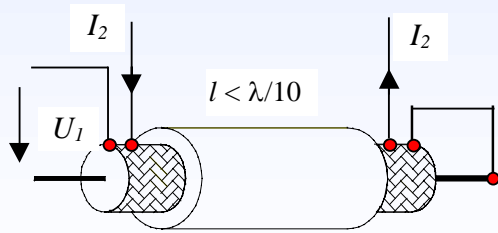
Definitions, electrical length

high frequencies: **Screening attenuation**

$$a_S = 10 \log (P_1/P_2) = 20 \log_{10} (U_1/U_2) \text{ [dB]}$$

Ratio of two powers --> **length independent**

low frequencies: **Transferimpedance**



$$Z_T = \frac{U_1}{I_2} \text{ [m}\Omega\text{/m]}$$

Ratio of **U/I = R** --> **length dependent (Ohms law)**

Wave length
 $\lambda = (c_0 \cdot v_k) / f$

electrical long:

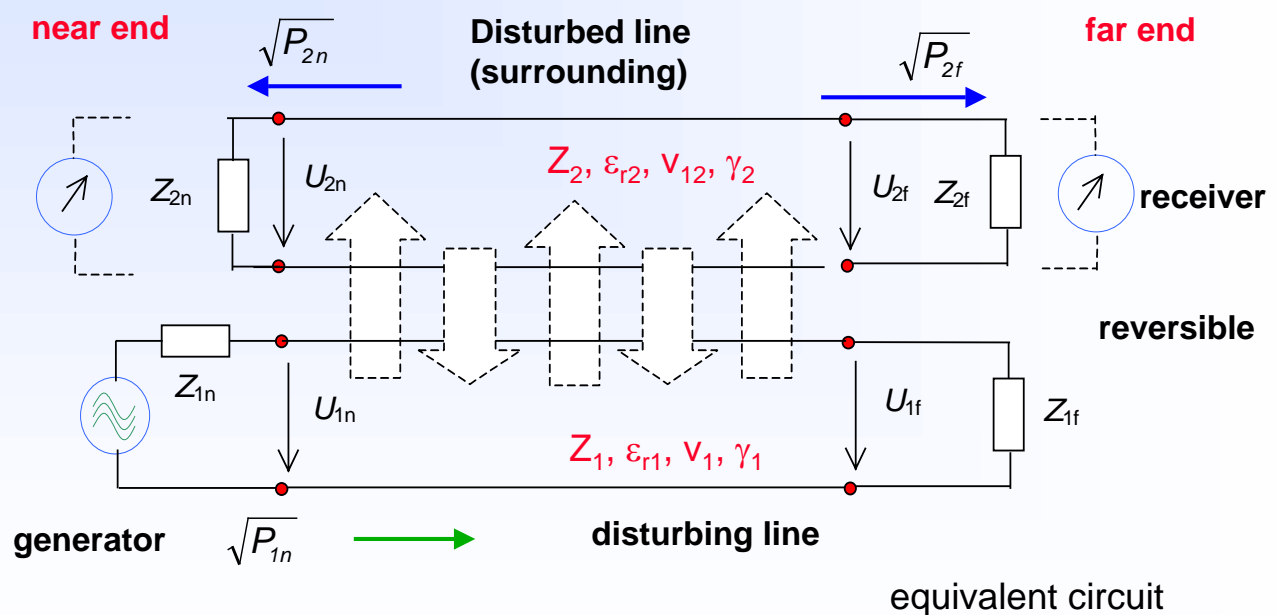
$$f > \frac{c_0}{2 \cdot l \cdot |\sqrt{\epsilon_{r1}} - \sqrt{\epsilon_{r2}}|}$$

electrical short:

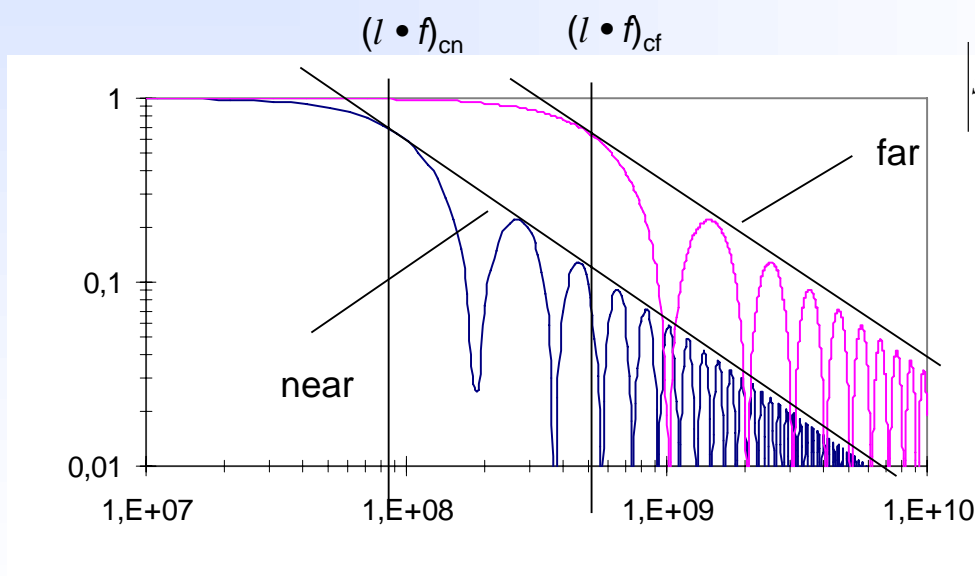
$$f < \frac{c_0}{10 \cdot l \cdot \sqrt{\epsilon_{r1}}}$$

(EN 50289-1-6)

Coupling between two lines (equivalent circuit)



Summing function S_{nf}



$$\left| S_{nf} \right| = \frac{\left| 2 \sin\left(\frac{(\beta_1 \pm \beta_2) \cdot L_c}{2}\right) \right|}{(\beta_1 \pm \beta_2) \cdot L_c}$$

$\approx \sin x/x$

low frequencies

$$\left| S_{nf} \right| \rightarrow 1$$

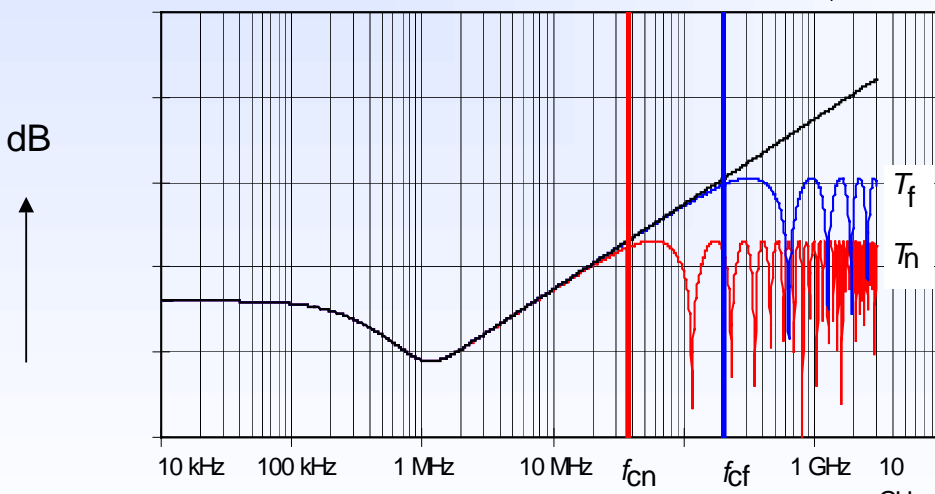
high frequencies

$$\left| S_{nf} \right| \rightarrow \frac{2}{(\beta_1 \pm \beta_2) \cdot l}$$

Calculated Coupling Transfer Function T_{nf}

a_s and Z_T vs frequency

$$T_{f,n} = (Z_F \pm Z_T) \cdot \frac{1}{\sqrt{Z_1 \cdot Z_2}} \cdot \frac{l}{2} \cdot S_{nf}$$



n = near end

f = far end

L = 1 m

$\epsilon_{r1} = 2,3$

$\epsilon_{r2} = 1,0$

$Z_F = 0$

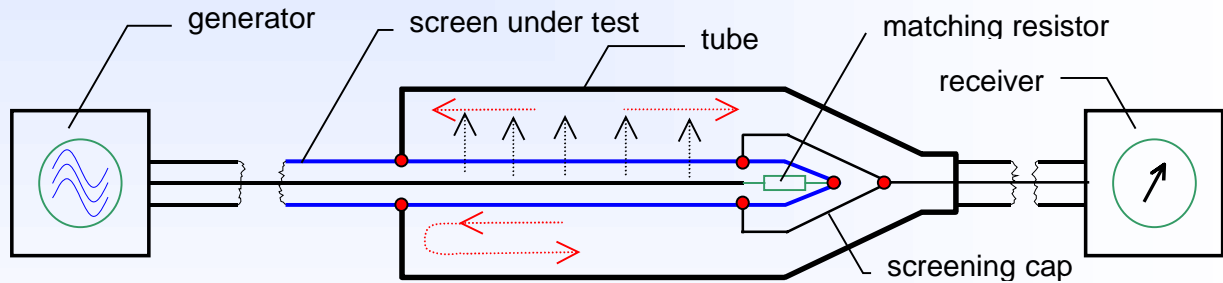
frequency

Transferimpedance

Screening attenuation

Measuring with the Triaxial test set-up *CoMeT*

Transferimpedance & Screening attenuation
few kHz up to and above 8 GHz with one test set-up

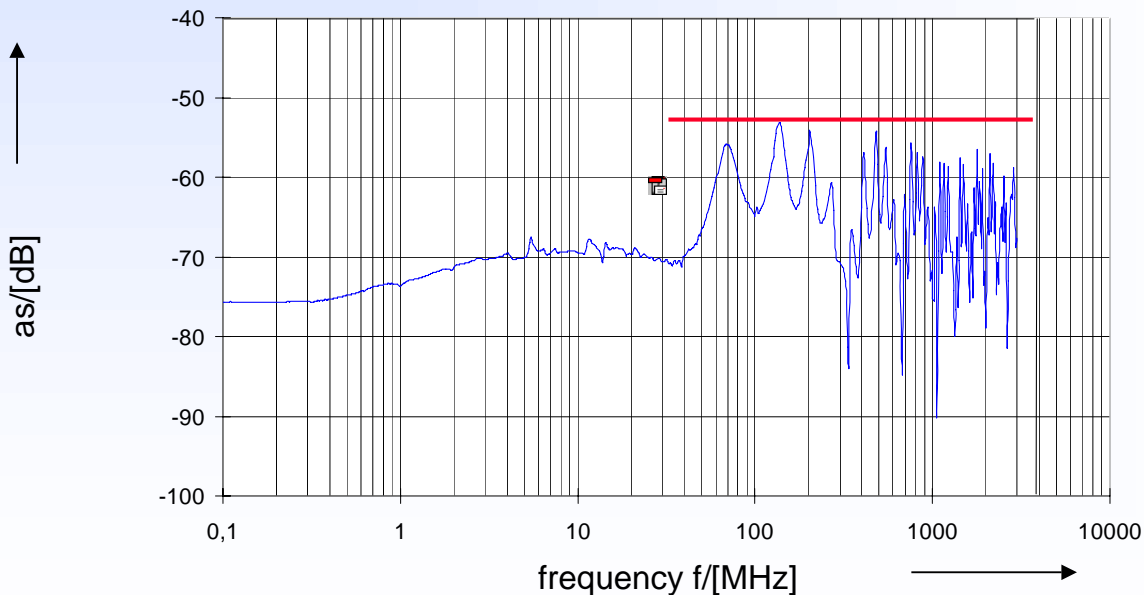


Generator and receiver are included in a modern network analyser

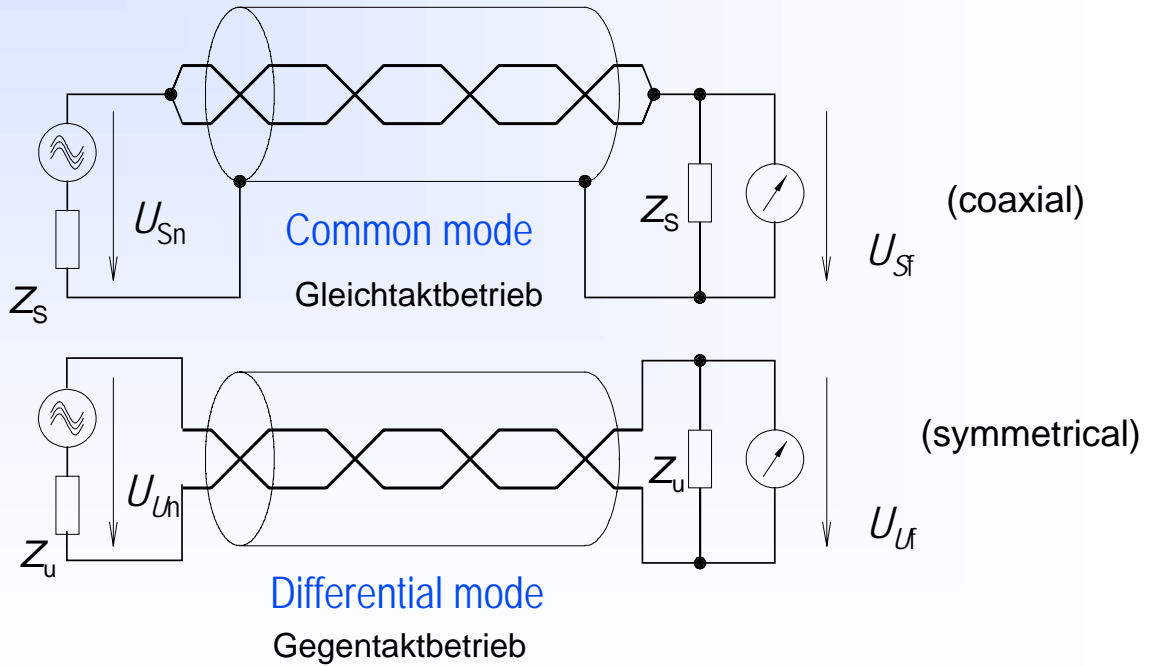
IEC 62153-4-3 Transfer impedance, IEC 62153-4-4 Screening attenuation
EN 50289-1-6 EMC on Communication cables

Measured Transfer function of RG 058

Transferimpedance | Screening attenuation

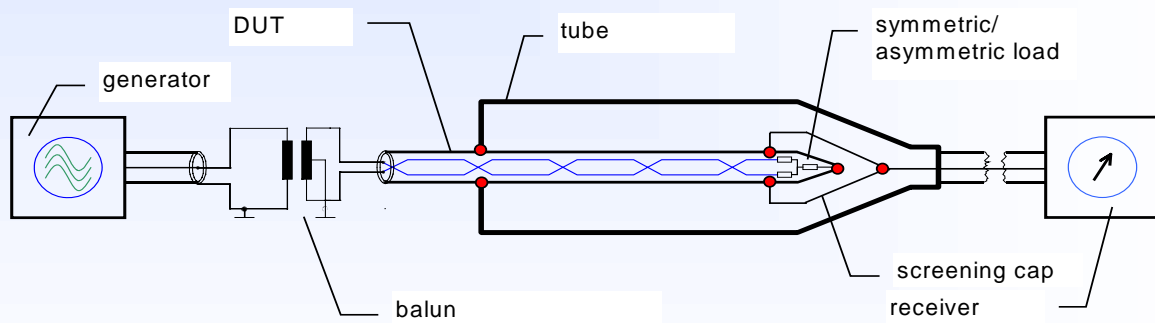


Differential & Common mode of balanced pairs



Measuring of Coupling attenuation

Coupling attenuation is the sum of the Unbalance attenuation of the pair and the Screening attenuation of the screen

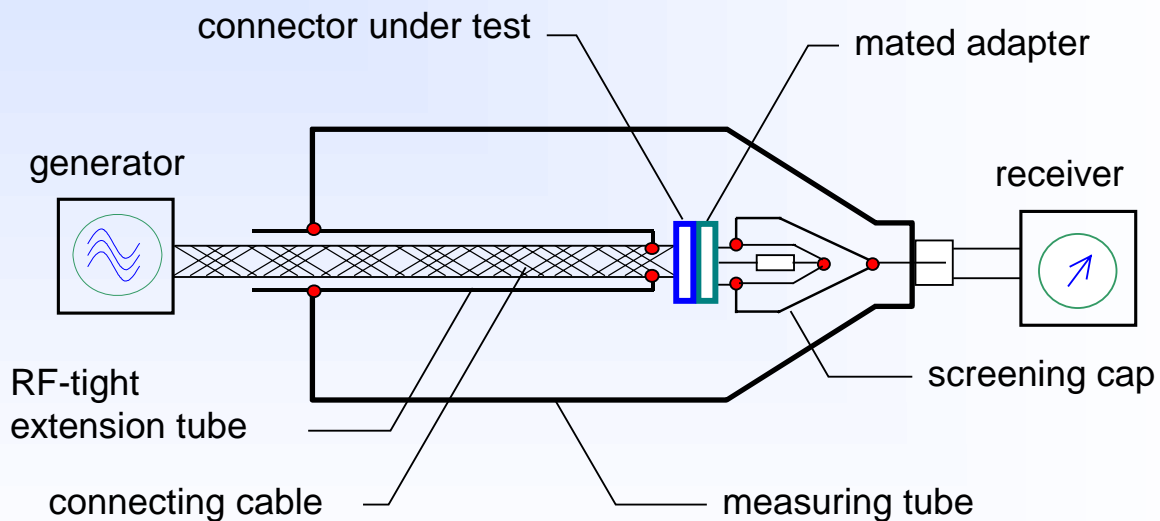


IEC/PAS 62338 Ed1, Coupling attenuation, triaxial method
IEC 62153-4-9, Coupling attenuation, triaxial method

Coupling attenuation of a CAT 6 Cable, S/FTP, log scale, Triaxial set up

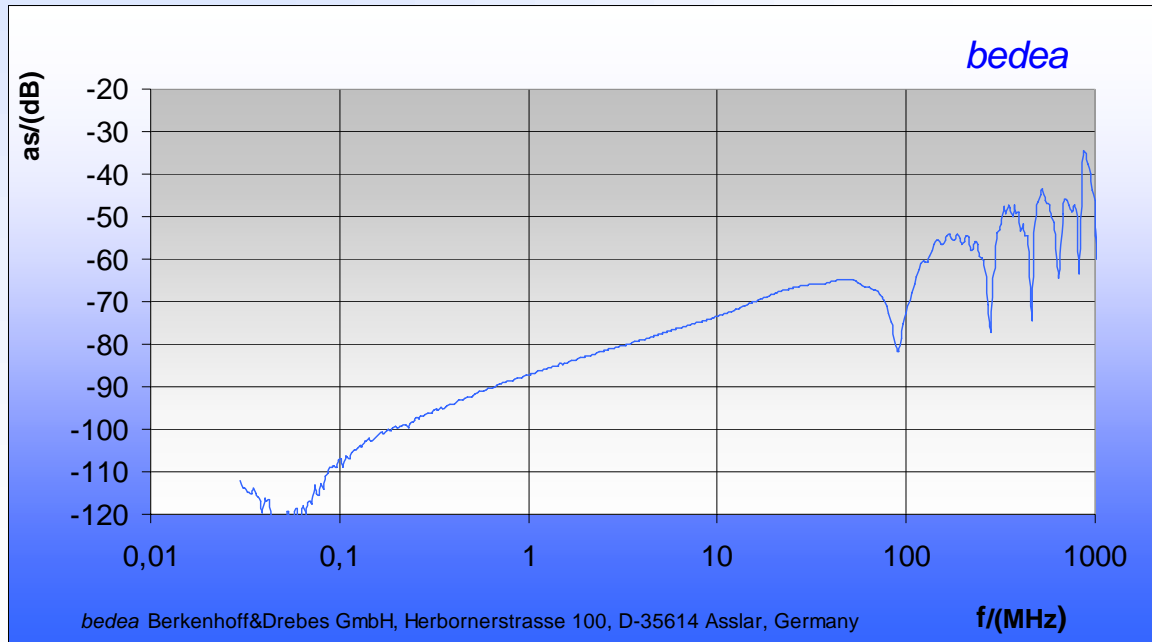


Triaxial set-up with "Tube in tube"



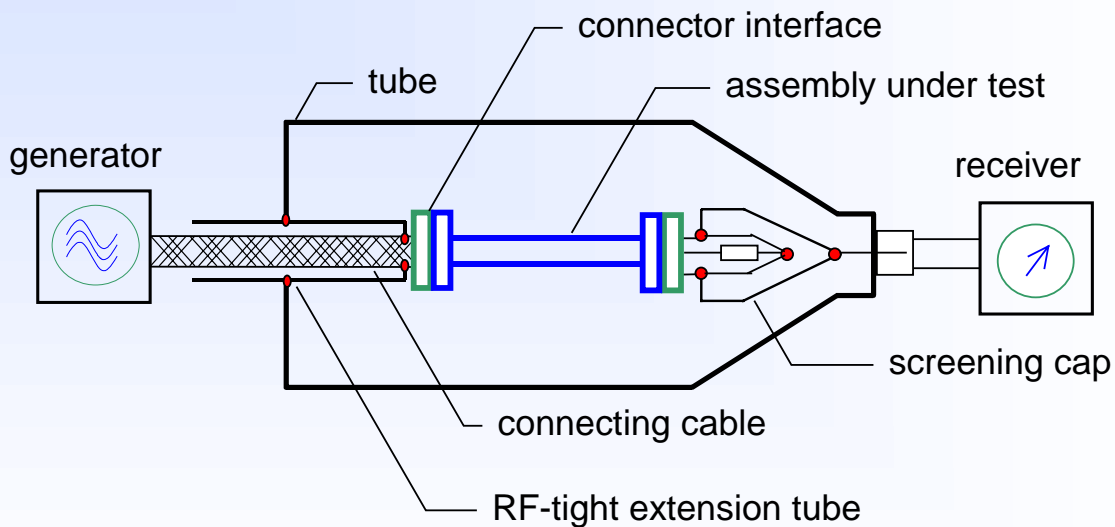
IEC 62153-4-7, Tube in tube test procedure

Coupling attenuation Nexans GG 45



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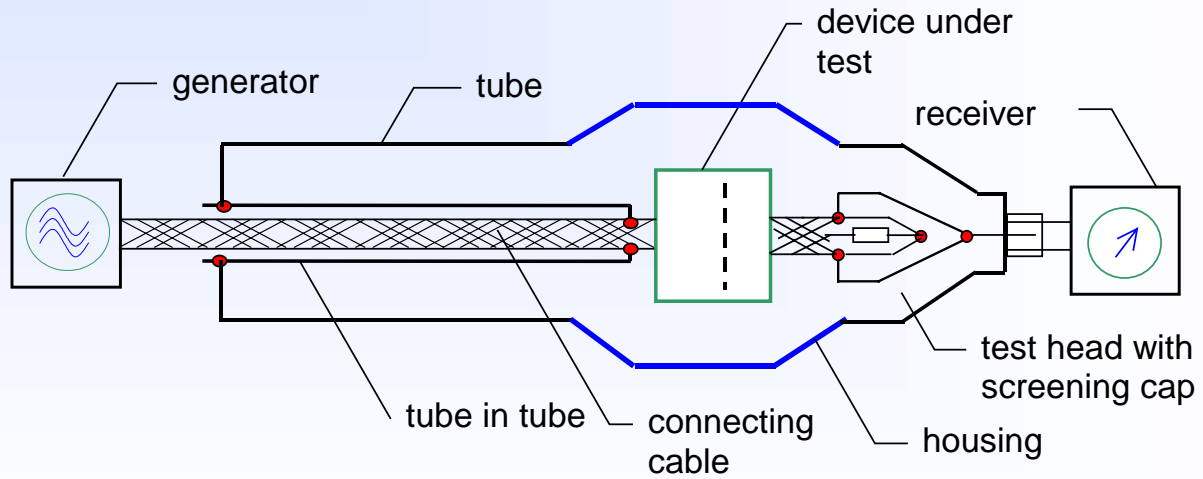
Measuring of cable assemblies



IEC 62153-4-7, Tube in tube test procedure (connectors & assemblies)

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Test set-up for connecting hardware with housing



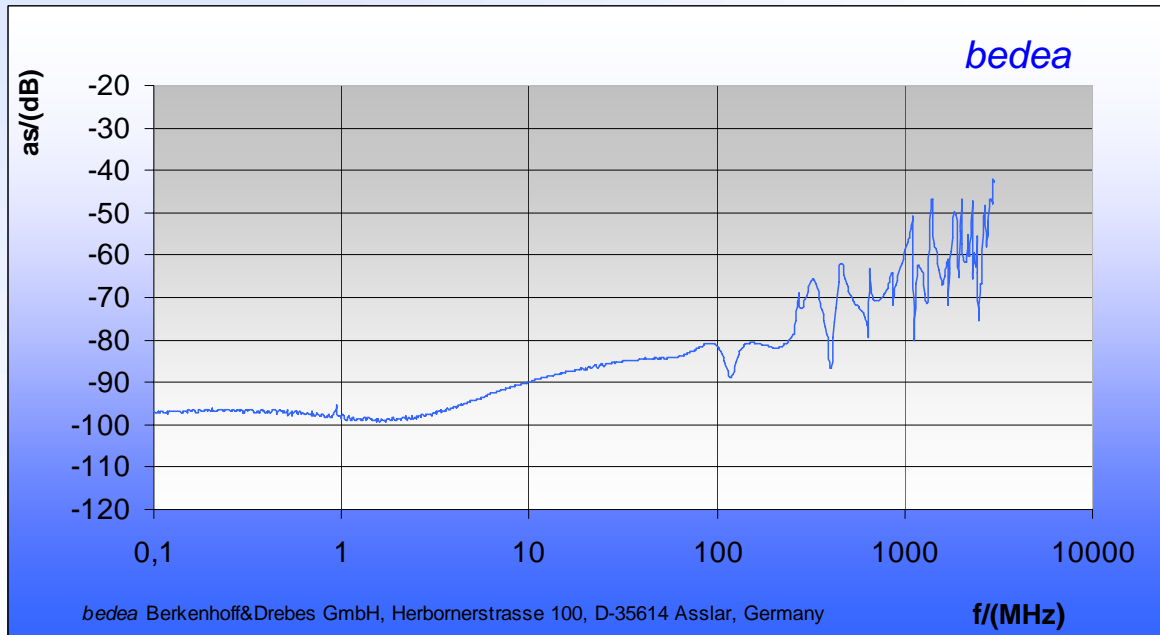
Test procedure is under consideration at IEC TC46/WG 5

Test set-up CoMeT with housing



CATV wall outlet with tube in tube

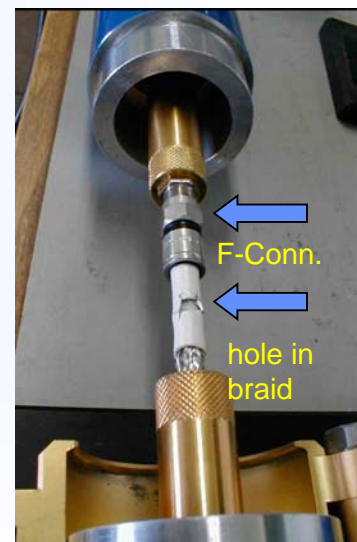
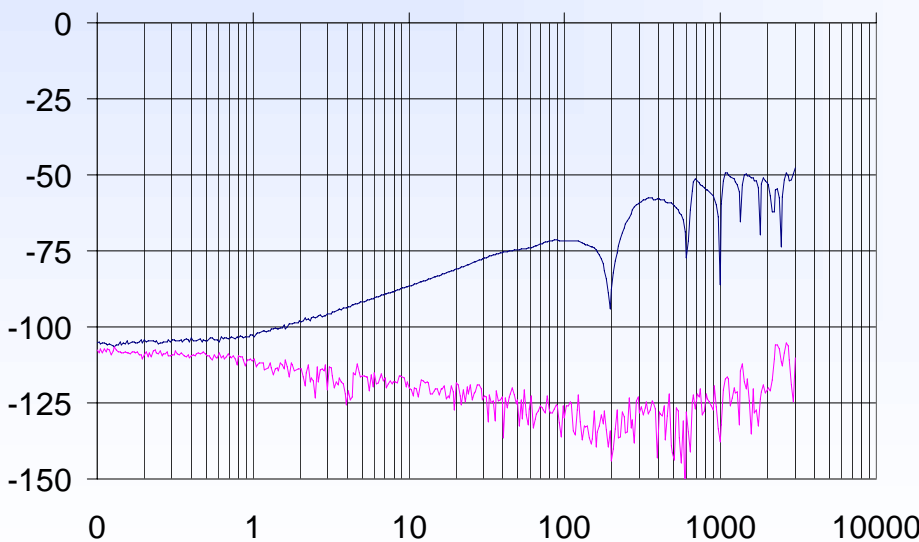
CATV wall outlet with Tube in tube



Cable with small hole, tube in tube, 0,5 m

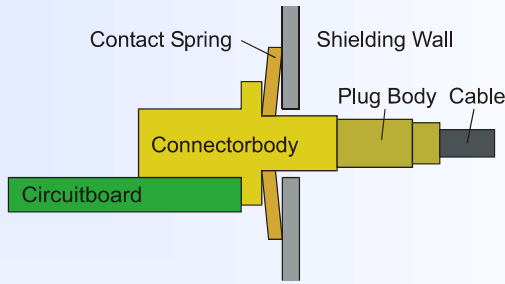
Well screened CATV-Cable with F-Connector

Same cable with one small hole, 3 mm

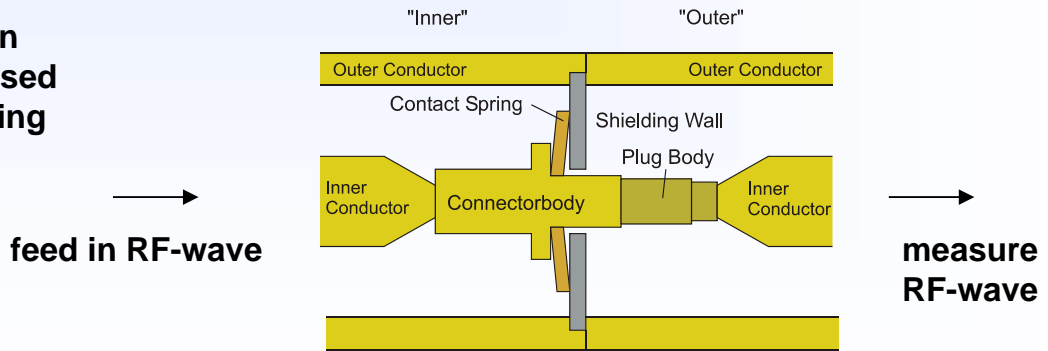


EMC of Feed-throughs & EMC Gaskets

Problem:
EMC of
Feed-throughs
& EMC Gaskets

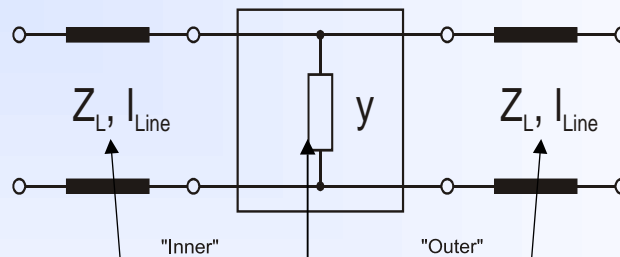


Problem in
Standardised
Surrounding



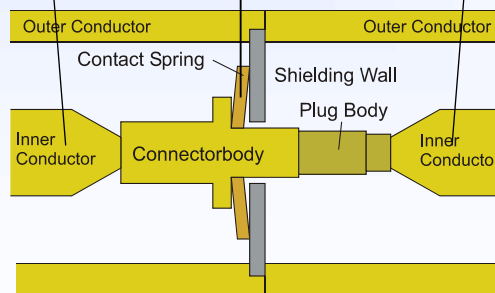
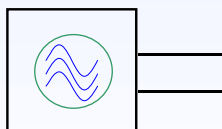
EMC of Feed-throughs & EMC Gaskets

equivalent
circuit

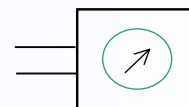


Y represents the
Transfer impedance

generator

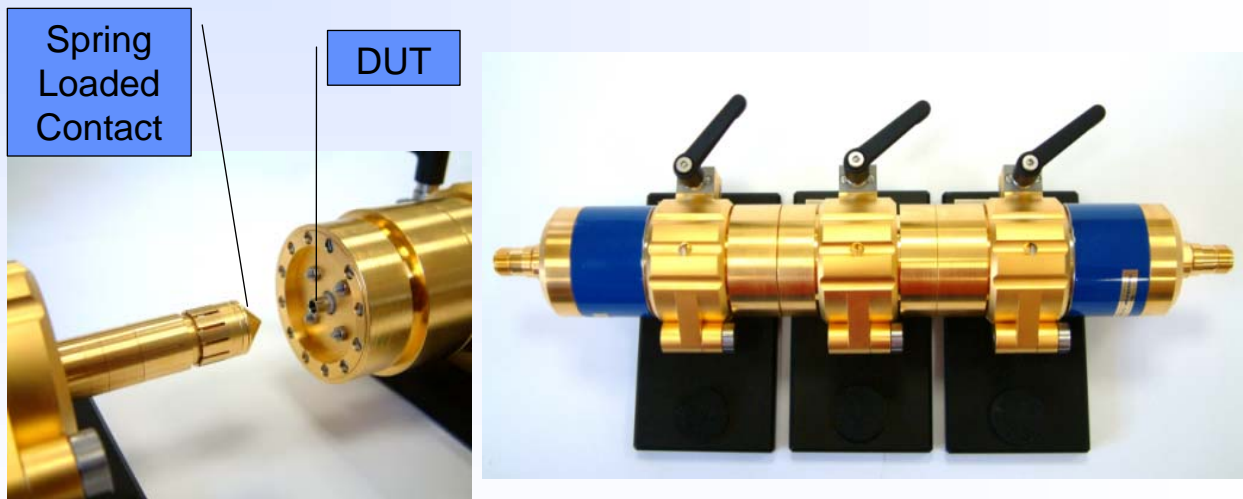


receiver



Generator & receiver are included in the NWA

Test set-up for Feed-throughs & gaskets



the procedure is under discussion at IEC TC46/WG5 as **IEC 62153-4-10**

International Standards for triaxial set-up

IEC TR 62153-4-1	Introduction to EMC measurements	46/199/DTR
IEC 62153-4-3	Surface transfer impedance - Triaxial method	2006-03
IEC 62153-4-4	Shielded screening attenuation, test method for measuring of the screening attenuation "a _s " up to and above 3 GHz	2006-05
IEC 62153-4-7	Shielded screening attenuation, test method for measuring the Transfer impedance Z _T and the screening attenuation a _S of RF-Connectors up to and above 3 GHz; Tube in Tube method	2006-04
IEC 62153-4-9 IEC/PAS 62338 Ed1	Coupling attenuation, triaxial method	46/190/CDV
IEC 62153-4-10	Shielded screening attenuation test method for measuring the Screening Effectiveness of Feedthroughs and Electromagnetic Gaskets	46/xxx/CD
EN 50289-1-6	Communication cables - Specifications for test methods Part 1-6: Electrical test methods -Electromagnetic performance (includes IEC 62153-4-3 and IEC 62153-4-4)	2002

Conclusion 1

- The Screening effectiveness of Communication cables is described in the lower frequency range by the **Transfer impedance Z_T** and in the upper frequency range by the **Screening attenuation a_S** .
- At screened balanced cables, the **Coupling attenuation a_C** is the measure of the screening effectiveness as the sum of the **Unbalance attenuation** of the pair and the **Screening attenuation** of the screen.
- With the test system **CoMeT** of **bedea** one can measure the **Transfer impedance Z_T** as well as the **Screening attenuation a_S** in the frequency range from 100 kHz up to 8 GHz with one test set-up
- Furthermore, the **Coupling attenuation a_C** of screened balanced pairs may be measured.
- Test set-up is in acc. with EN 50289-1-6 & IEC 62153-4-3/-4-5/-4-7
- The Standards IEC 62153-4-9 & IEC 62153-4-10 are in preparation

Conclusion 2

- **Advantages of the triaxial test-set-up:**
 - ◆ simple and easy sample preparation
 - ◆ only one test set up for Z_T , a_S & a_C
 - ◆ high sensitivity up to and above 125 dB (only limited by the NWA)
 - ◆ no radiation of electromagnetic energy
 - ◆ covers the whole frequency range from 10 kHz to 8 GHz
 - ◆ high reproducibility
- Further developments is a set-up to measure the EMC of Feed-throughs & EMC Gaskets
- This presentation & further information: www.bedeas.com
- Contact person & further questions bmund@bedea.com

CoMeT Coupling Measuring Tube Rohde & Schwarz ZVRE



www.bedeia.com
bmund@bedeia.com



Literature

- [1] Halme, L./Szentkuti, B.: The background for electromagnetic screening measurements of cylindrical screens. Tech. Rep. PTT(1988) Nr. 3.
- [2] Breitenbach, O./Hähner T.: Kabelschirmung im Übergang von MHz- zu GHz-Frequenzen. ntz Bd. 46(1993) H.8, S. 602-608.
- [3] L. Halme, R. Kytönen, "Background and introduction to EM screening (shielding) behaviours and measurements of coaxial and symmetrical cables, cable assemblies and connectors", Colloquium on screening effectiveness measurements, Savoy Place London, 6 May 1998, Reference No:1998/452.
- [4] O. Breitenbach, T. Hähner, B. Mund, "Screening of cables in the MHz to GHz frequency range extended application of a simple measuring method", Colloquium on screening effectiveness measurements, Savoy Place London, 6 May 1998, Reference No:1998/452.
- [5] T. Hähner, B. Mund, "Test methods for screening and balance of communication cables", 13th international Zurich EMC Symposium, February 16-18 1999
- [6] Bernhard Mund, IWCS (International wire and cable symposium) 2004-08-17, Measuring the EMC on RF-connectors and connecting hardware, Tube in tube test procedure
- [7] IEC 62153-4-3 Transfer impedance, IEC 62153-4-4 Screening attenuation IEC 62153-4-7 Tube in tube IEC 62153-4-9, Coupling attenuation - Triaxial method, EN 50289-1-6 EMC on Communication cables,