SCTE Lecture - EMC of Communication cables & test methods

Test set-up CoMeT

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EMC of Communication cables & test methods

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EMC of Communication cables & test methods

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  - *Radio & TV Technician, Radio Brand, Marburg, 1970*
  - *Dipl.-Ing. Communication-& Microproc. technologies,* FH Giessen *1984*
- *bedea* Berkenhoff&Drebes GmbH, Asslar *since 1985*
  - *bedea* Manufacturer of Communication Cables, Germany
- Responsible:
  - R&D Manager & RF- und EMC-measurements,
  - **Standardisation:**
  - Chairman of UK 412.3, Koaxialkabel, (German NC)
  - Secretary of CENELEC SC 46XA, Coaxial cables
  - Secretary of IEC SC 46A, Coaxial cables

Outline

- Physical Basics of Cable Screening
  - Definitions, electrical length
  - Coupling Transfer Function
- Measuring of the Screening of Cables
  - Transferimpedance & Screening attenuation
  - Screening of Connectors & Connecting Hardware
- EN 50117
  - Standards for Coaxial and CATV-cables, Screening classes
- Further development
  - Screening of Feed-throughs and EMC gaskets
- Conclusion & Discussion

Definitions, electrical length

high frequencies: Screening attenuation

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

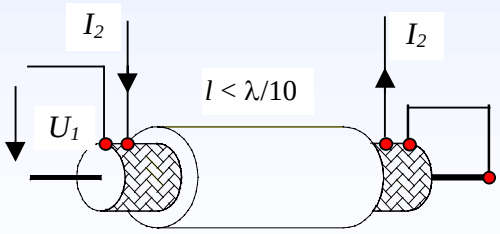
Ratio of two powers --> **length independent**

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

electrical long:

$$f > \frac{c_o}{2 \cdot l \cdot \left|\sqrt{\varepsilon_{r1}} - \sqrt{\varepsilon_{r2}}\right|}$$

low frequencies: Transferimpedance



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

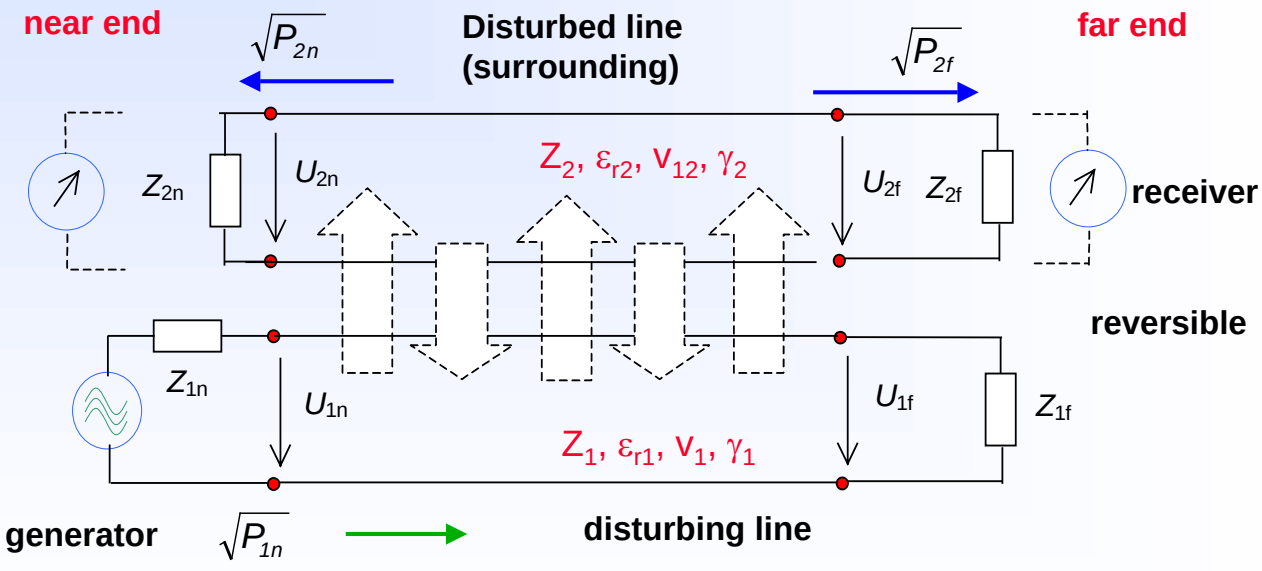
electrical short:

$$f < \frac{c_o}{10 \cdot l \cdot \sqrt{\varepsilon_{r1}}}$$

(EN 50289-1-6)

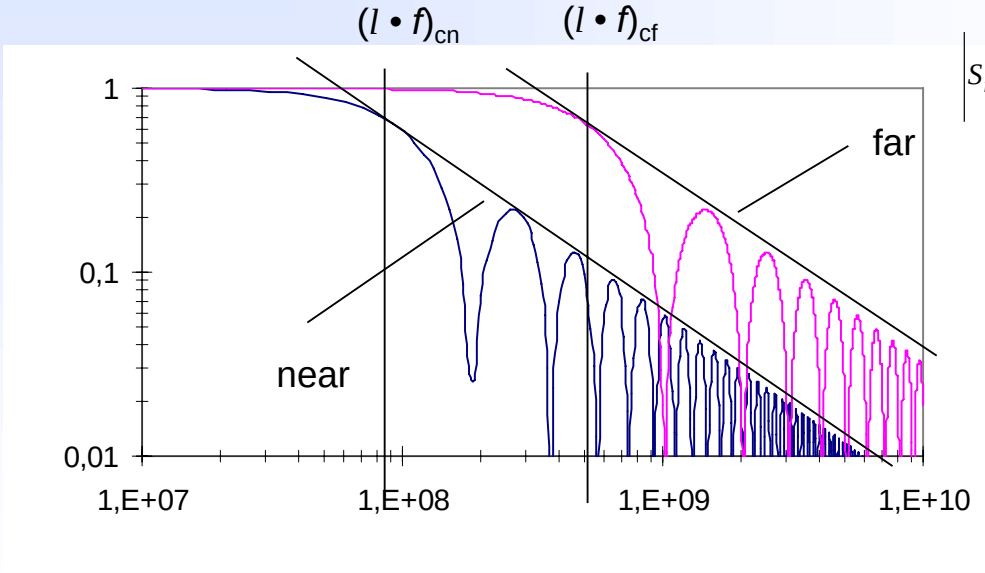
Ratio of **U/I = R** --> **length dependent (Ohms law)**

Coupling between two lines (equivalent circuit)



equivalent circuit

Summing function S_{nf}



$$\left|S_{\substack{n\\f}}\right| = \frac{\left|2\sin\left(\frac{(\beta_1 \pm \beta_2).L_c}{2}\right)\right|}{(\beta_1 \pm \beta_2).L_c}$$

≈ sin x/x

low frequencies

$$\left|S_{\substack{n\\f}}\right| \rightarrow 1$$

high frequencies

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

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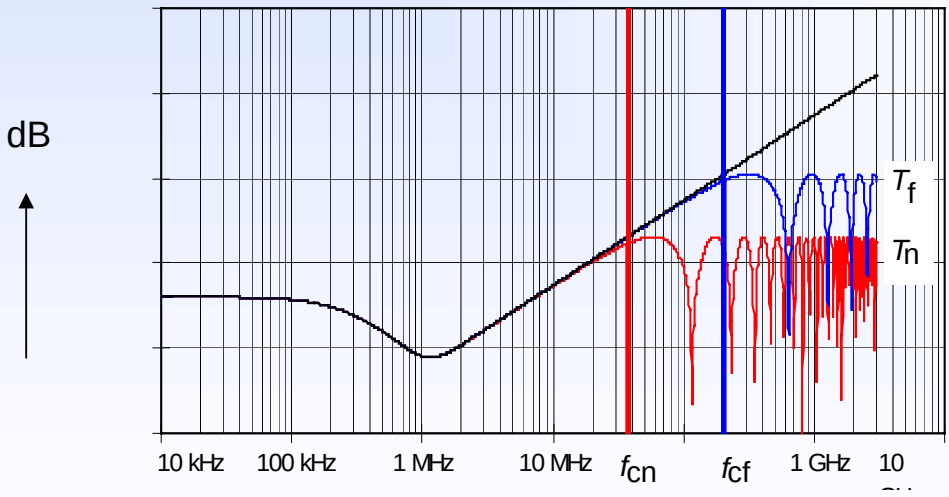
Calculated Coupling Transfer Function T_{nf}

a_s and Z_T vs frequency

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



n = near end

f = far end

L = 1 m

ε_{r1} = 2,3

ε_{r2} = 1,0

Z_F = 0

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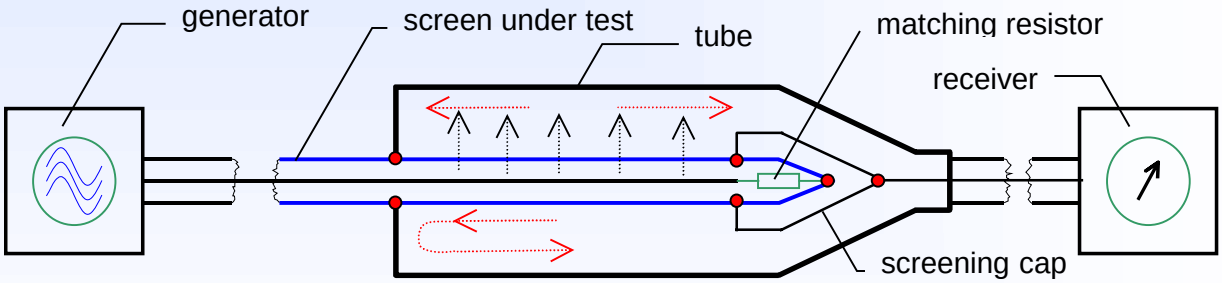
Measuring with the Triaxial test set-up *CoMeT*

Transferimpedance & Screening attenuation

few kHz up to and above 3 (8) GHz with one test set-up



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

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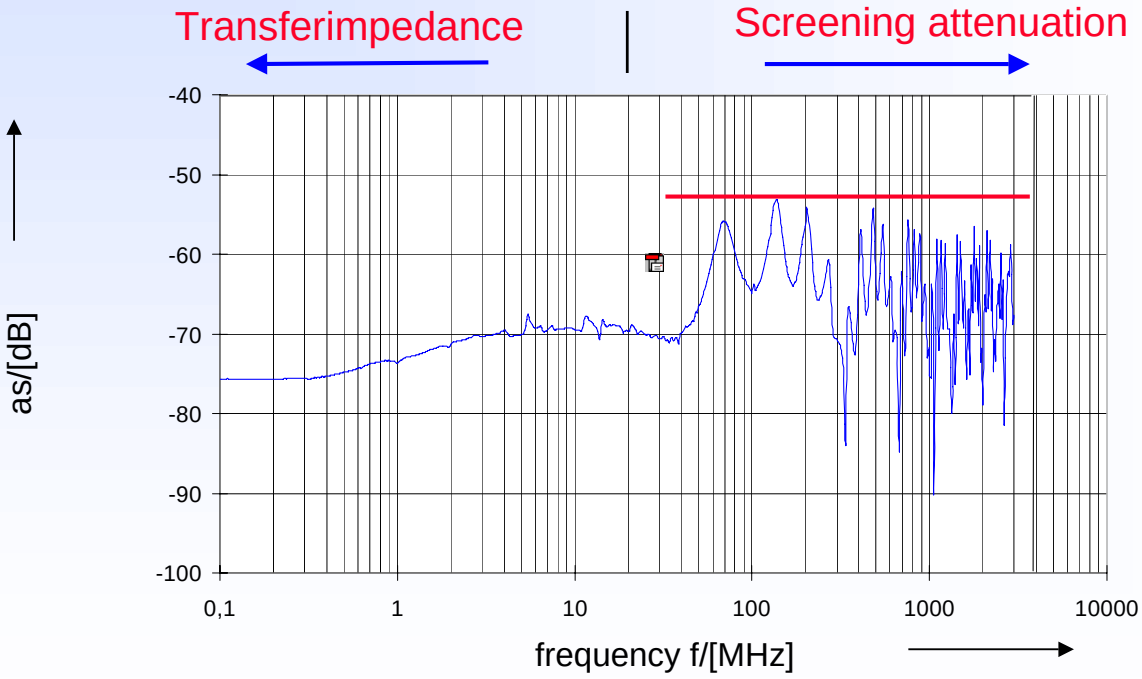
Measured Transfer function of RG 058



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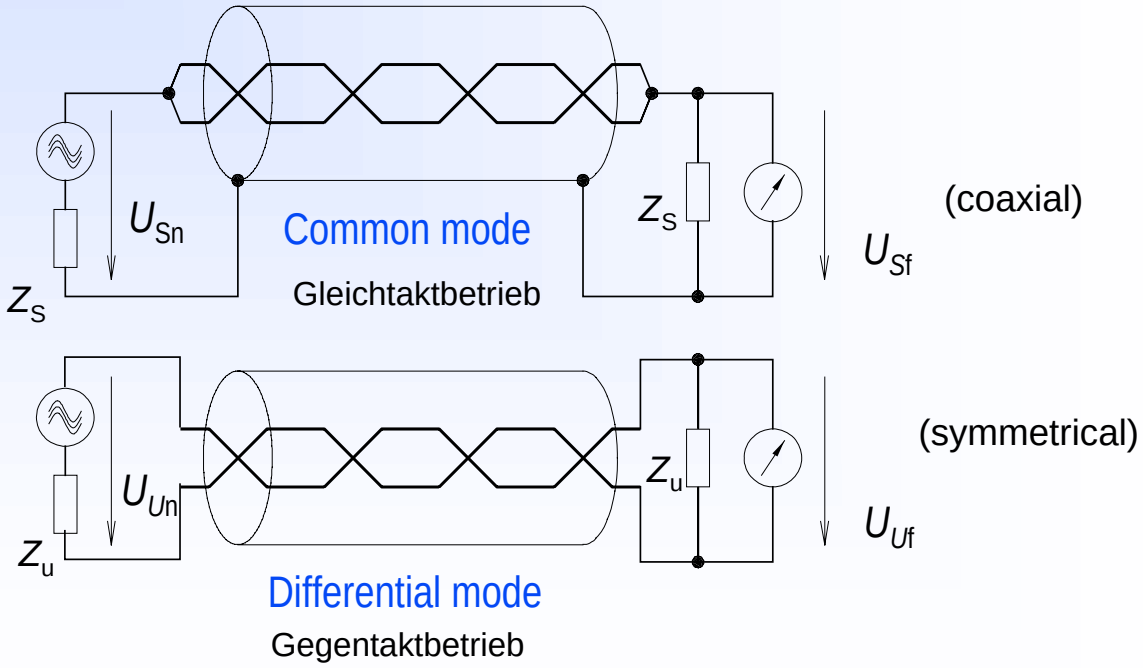
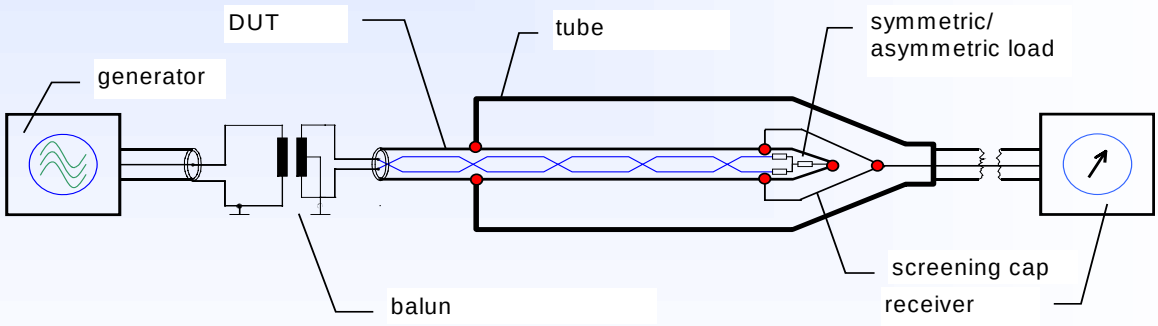
Differential & Common mode of balanced pairs



Measuring of Coupling attenuation

Coupling attenuation is the sum of 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

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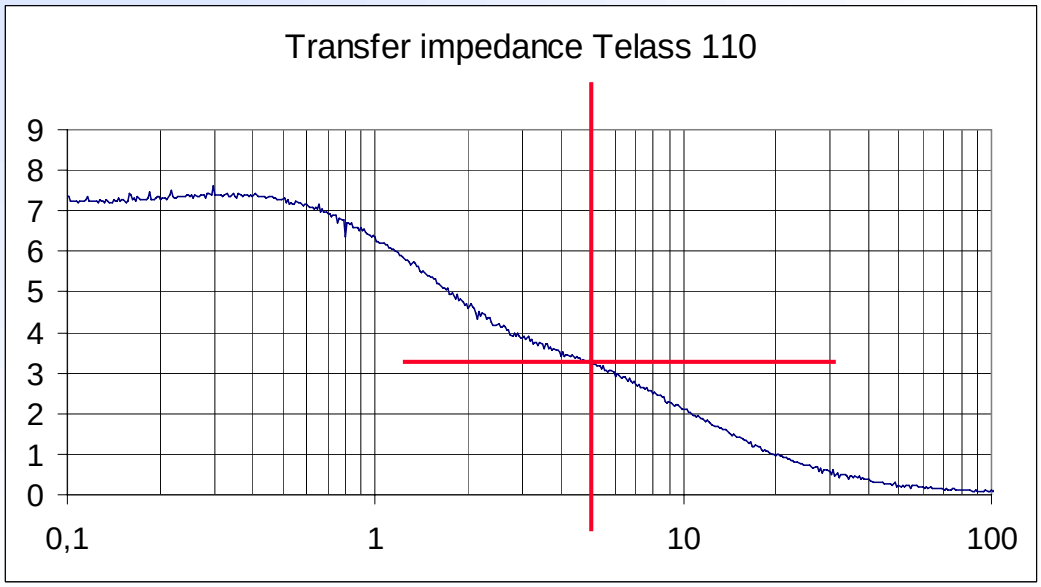
Transferimpedance Telass 110 in mOhm/m



3,5 mΩ/m @ 5 MHz

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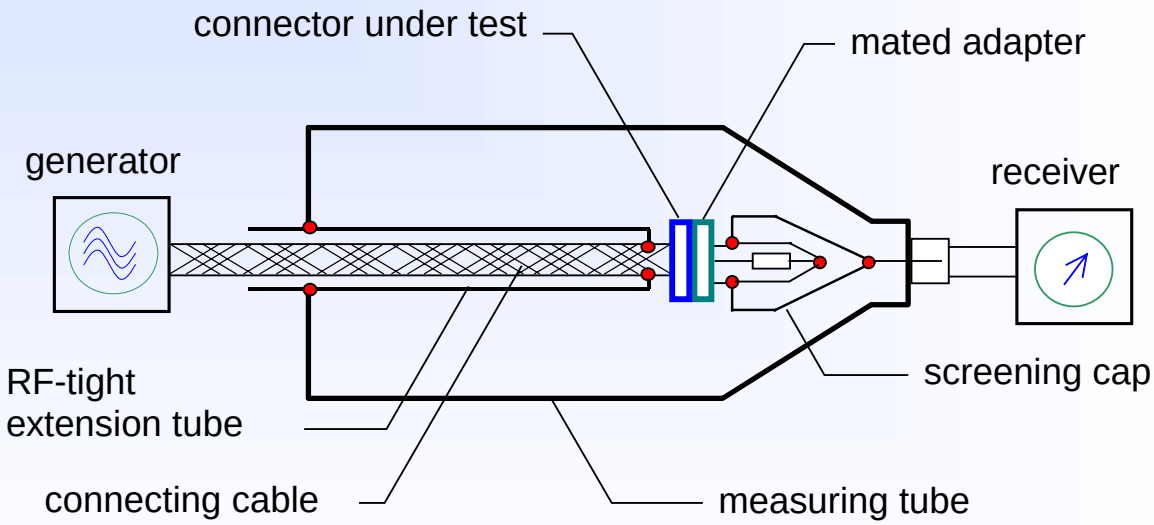
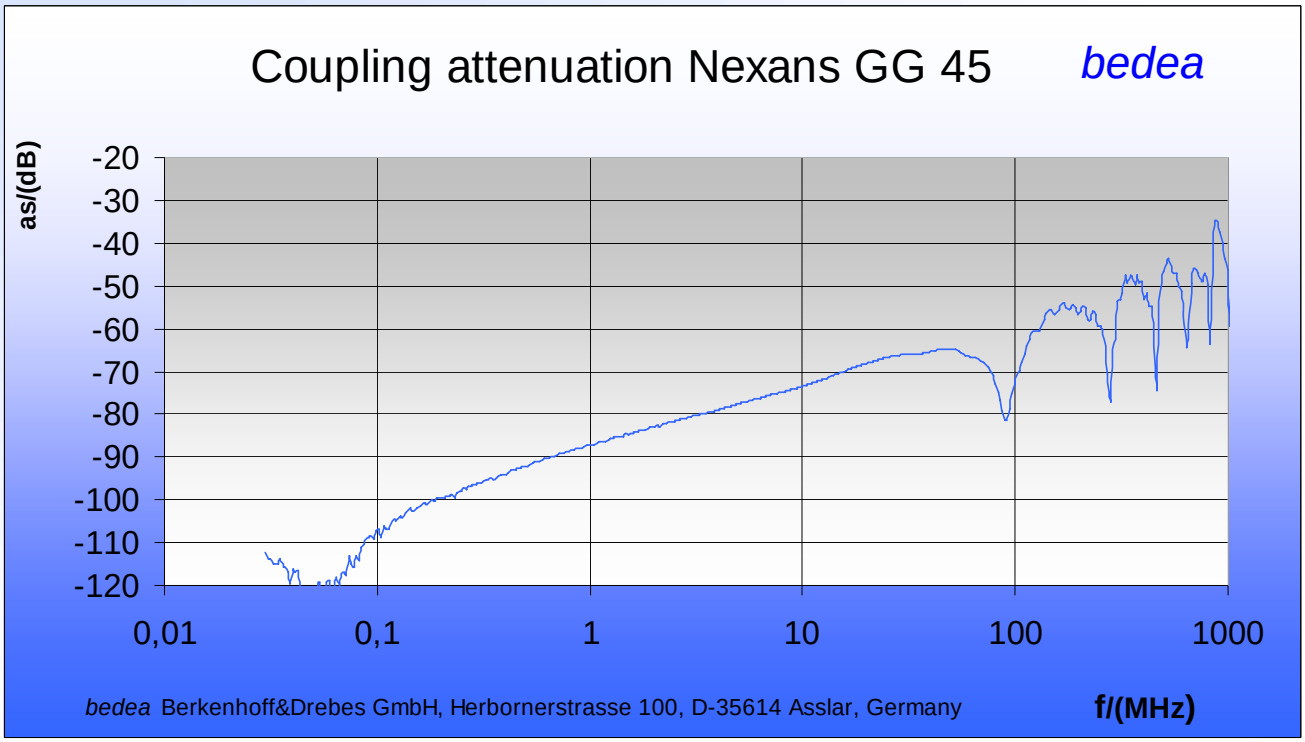
Triaxial set-up with “Tube in tube“

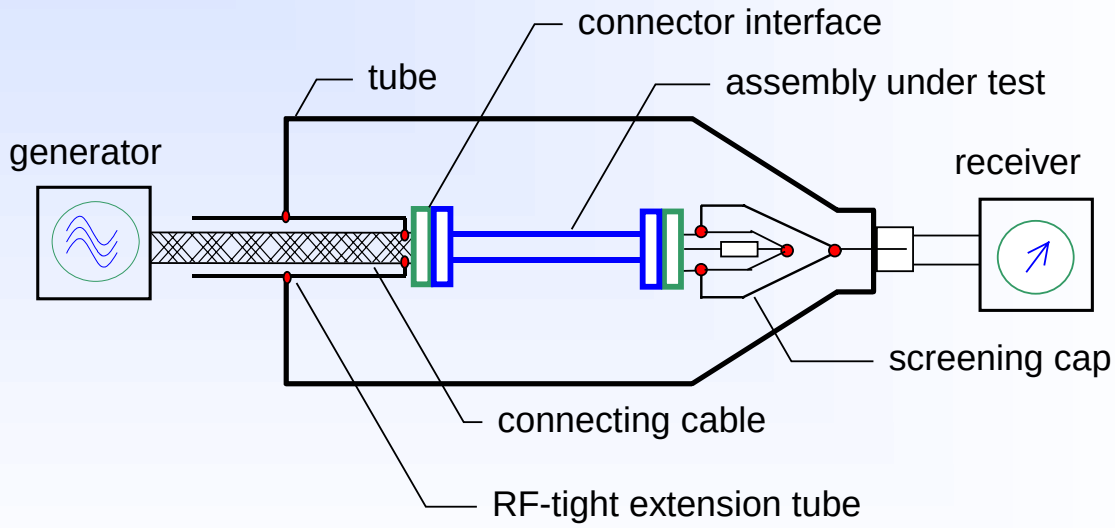


IEC 62153-4-7,Tube in tube test procedure

Coupling attenuation Nexans GG 45



Measuring of cable assemblies



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

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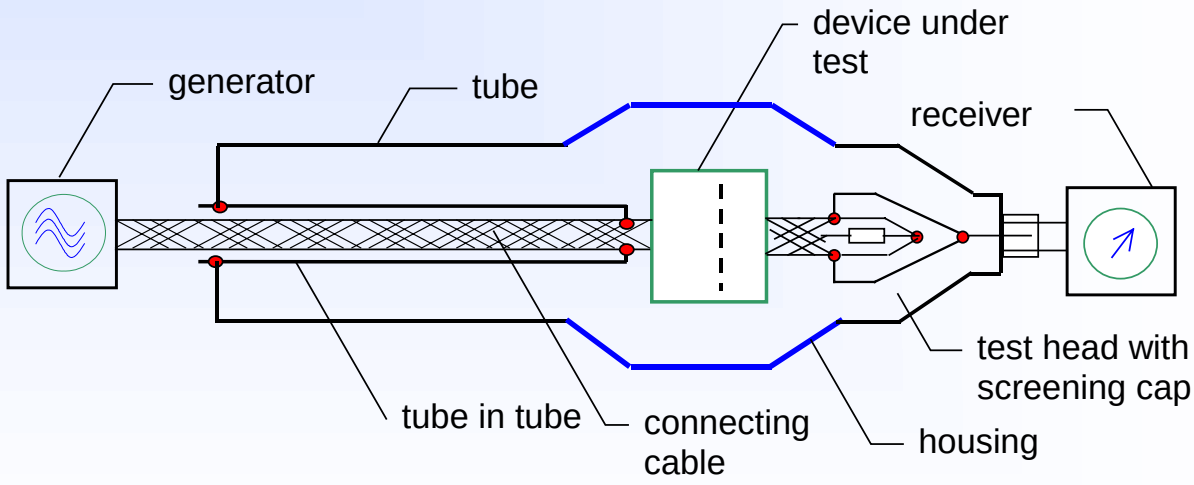
Test set-up for connecting hardware with housing



Test procedure is under consideration at IEC TC46/WG 5

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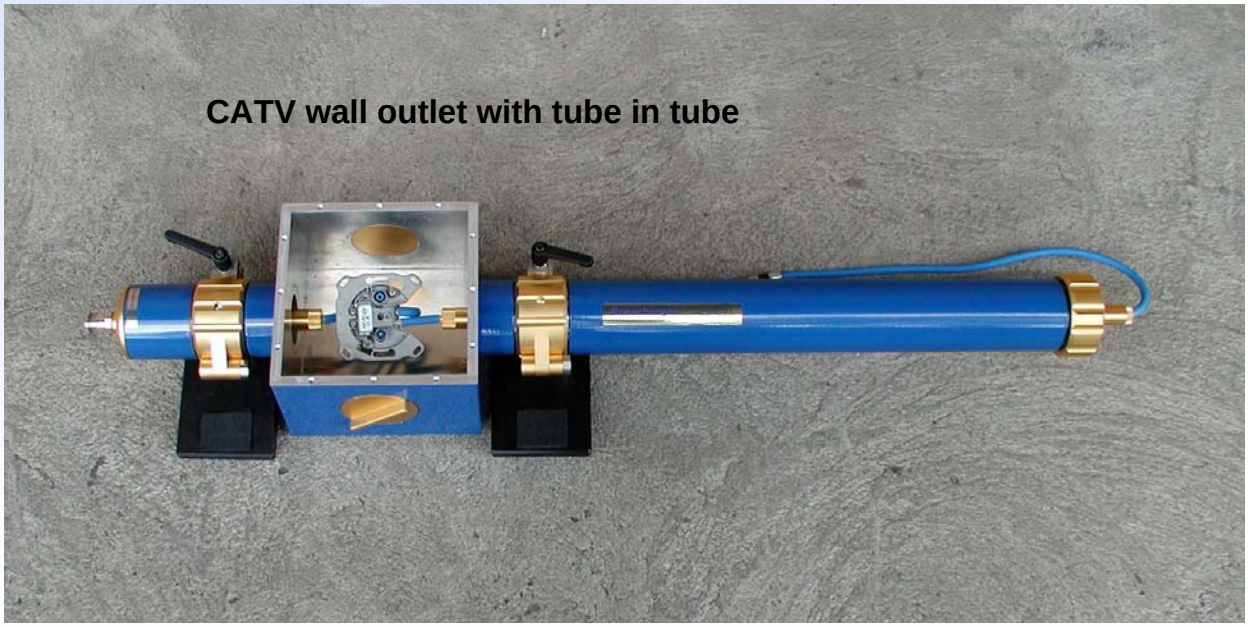
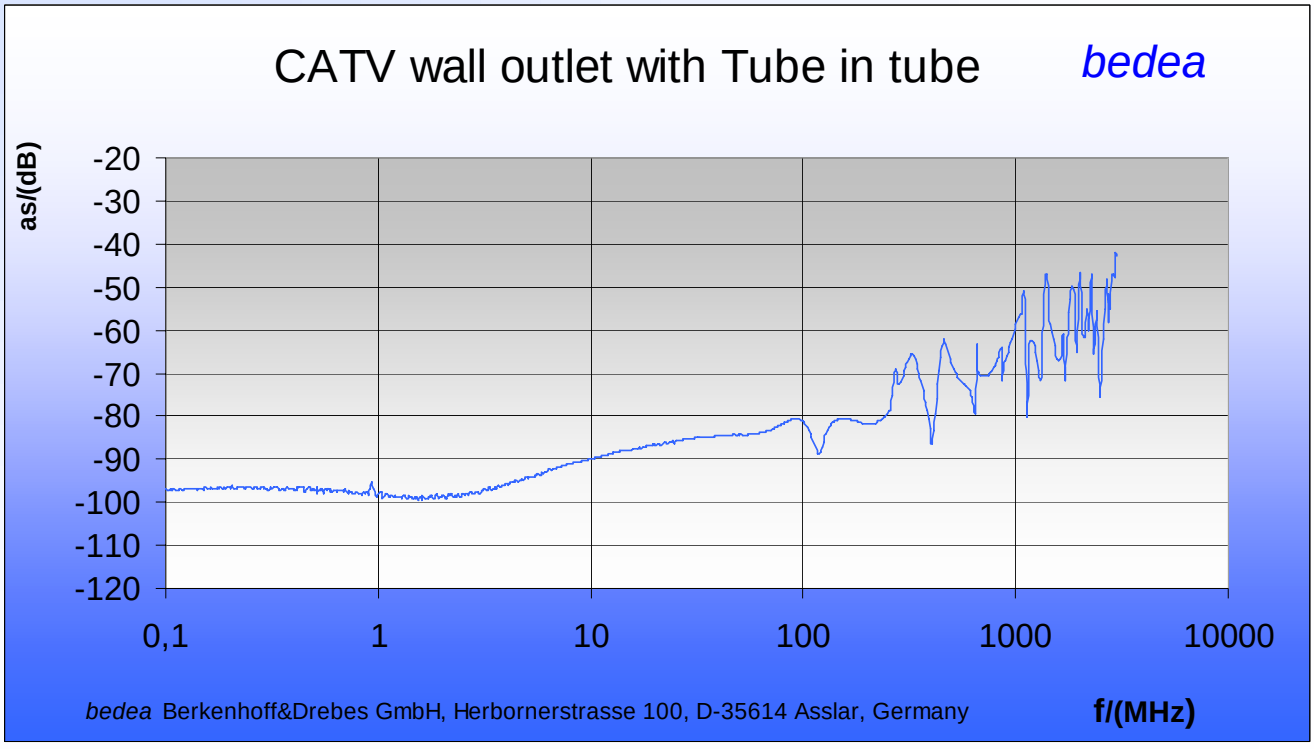
Test set-up CoMeT with housing





EN 50117 Coaxial cables

EN 50117-1, Ed.2 EN 50117-1 (Amd1)	**Coaxial Cables, Generic specification**	2002 2006
	Sectional specifications for CATV cables	
EN 50117-2-1 Ed1 **EN 50117-2-1 Ed2** (replaces 50117-2)	Indoor drop cables for systems operating at 5 MHz - 1 000 MHz	2005
EN 50117-2-2 Ed1 (replaces 50117-3)	Outdoor drop cables for systems operating at 5 MHz - 1 000 MHz	2004
EN 50117-2-3 Ed1 (replaces 50117-4)	Distribution and trunk cables for systems operating at 5 MHz - 1 000 MHz	2004
EN 50117-2-4 Ed1 (replaces 50117-5)	Indoor drop cables for systems operating at 5 MHz - 3 000 MHz	2004
EN 50117-2-5 Ed1 (replaces 50117-6)	Outdoor drop cables for systems operating at 5 MHz - 3 000 MHz	2004
	Sectional Specification for cables for BCT cabling in accordance with EN 50173	
prEN 50117-4-1 Ed1	Indoor drop cables for systems operating at 5 MHz - 3 000 MHz	2007

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EN 50117 - Screening classes for CATV cables

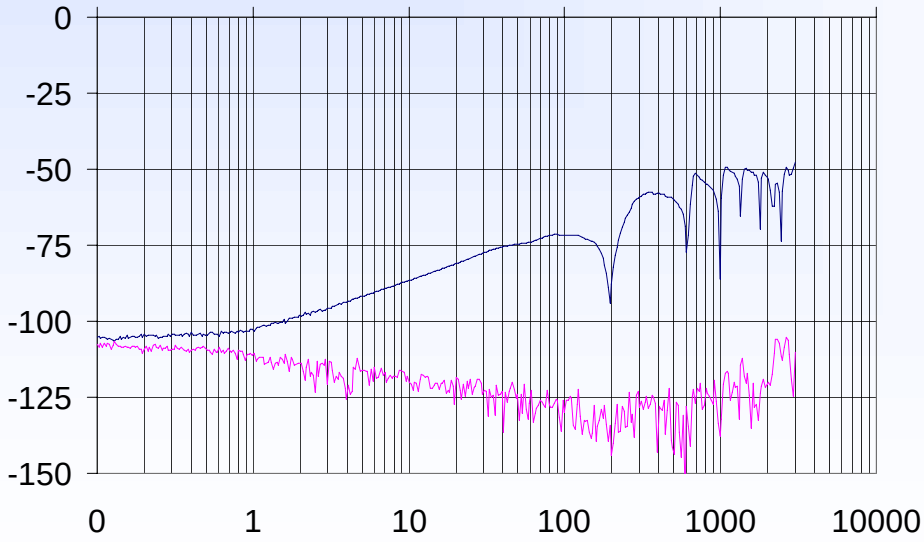
Screening class	5 - 30 MHz	30 -1000 MHz	1 GHz – 2 GHz	2 GHz – 3 GHz
B	15 mOhm/m	75 dB	65 dB	55 dB
A	**5 mOhm/m**	**85 dB**	**75 dB**	**65 dB**
A+	2,5 mOhm/m	95 dB	(85 dB)	(75 dB)
A++	0.9 mOhm/m	105 dB	(95 dB)	(85 dB)
C	*50 mOhm/m*	*75 dB*	*65 dB*	*55 dB*

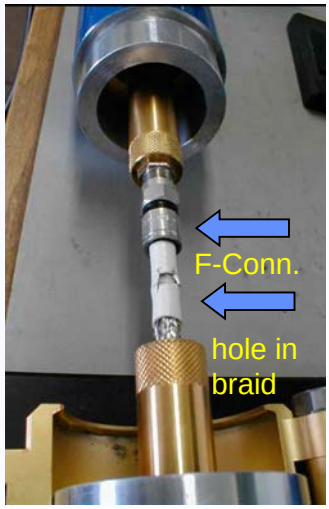
Measuring with the triaxial Method according to EN 50289-1-6 after Bending test

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

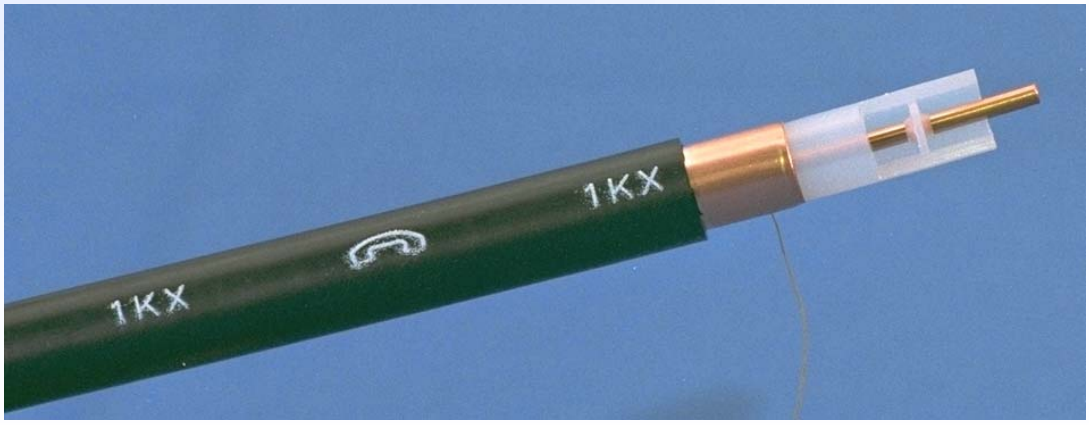
Well screened CATV-Cable with F-Connector

Same cable with one small hole, 3 mm



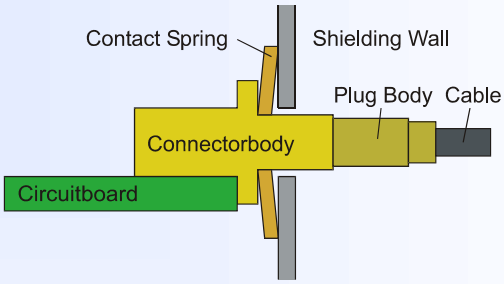


Technik & Installation von CATV-Kabeln



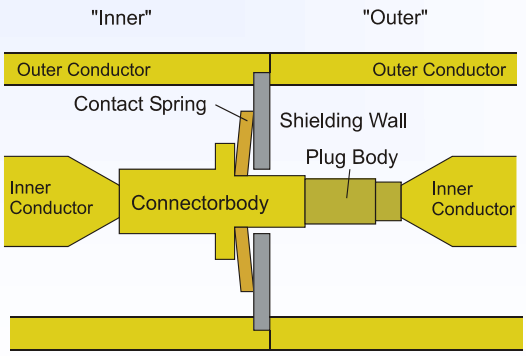
EMC of Feed-throughs & EMC Gaskets

Problem:
EMC of Feed-throughs & EMC Gaskets



Problem in Standardised Surrounding

feed in RF-wave



measure RF-wave

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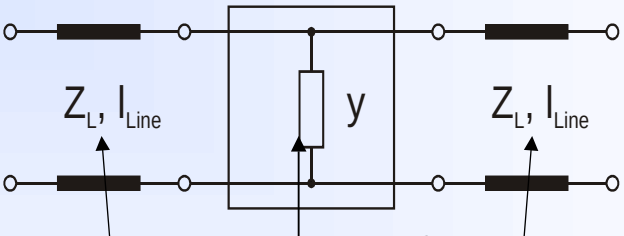
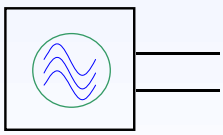
EMC of Feed-throughs & EMC Gaskets

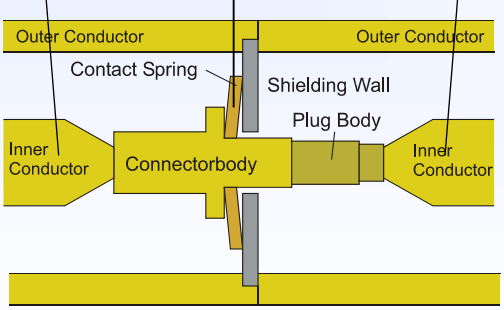
equivalent circuit



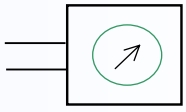
Y represents the Transfer impedance

generator





receiver



Generator & receiver are included in the NWA

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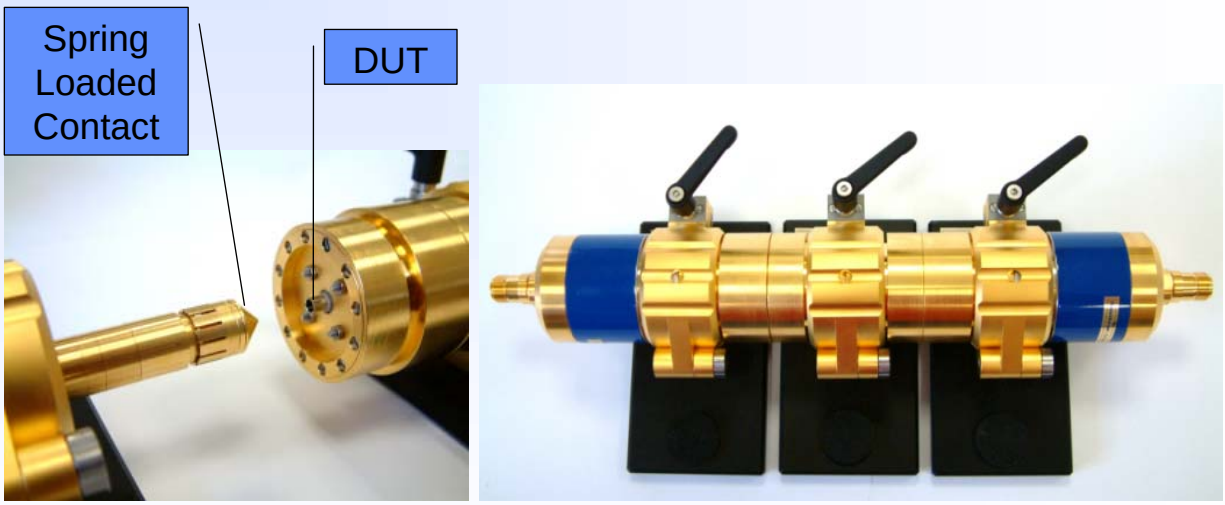
Test set-up for Feed-throughs & gaskets



the procedure is under disccussion 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	Coupling attenuation, triaxial method	46/190/CDV
IEC 62153-4-10	Shielded screening attenuation test method for measuring the Screening Effectiveness of Feedtroughs 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 62153-4-3)	2003

Conclusion 1

- The Screening effectivenes of Communication cables is described in the lower frequency range by the **Transferimpedance 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 **Transferimpedance Z_T** as well as the **Screening attenuation a_S** in the frequency range from 100 kHz up to and above 3 GHz with one test set-up
- Furthermore, the **Coupling attenuation a_C** of screened balanced pairs may be measured.
- Test set-up is in accordance with EN 50289-1-6 / IEC 62153-4-3/-4-5

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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
  - no radiation of electromagnetic energy
  - covers the whole frequencvy range
  - high reproducibility
- Standards and Screening classes for CATV-cables are given in the EN 50117 series
- Further developments is a set-up to measure the EMC of Feed-throughs & EMC Gaskets
- Contact & further questions *bmund@bedea.com - www.bedea.com*

EMV-KLASSE EMC-CLASS A® EN 50117 bedea

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 62153-4-4 Tube in tube IEC 62153-4-9, Coupling attenuation - Triaxial method, EN 50289-1-6 EMC on Communication cables, EN 50117 Coaxial cables, EN 50117-2-1 to -2-5, Sectionals of CATV cables