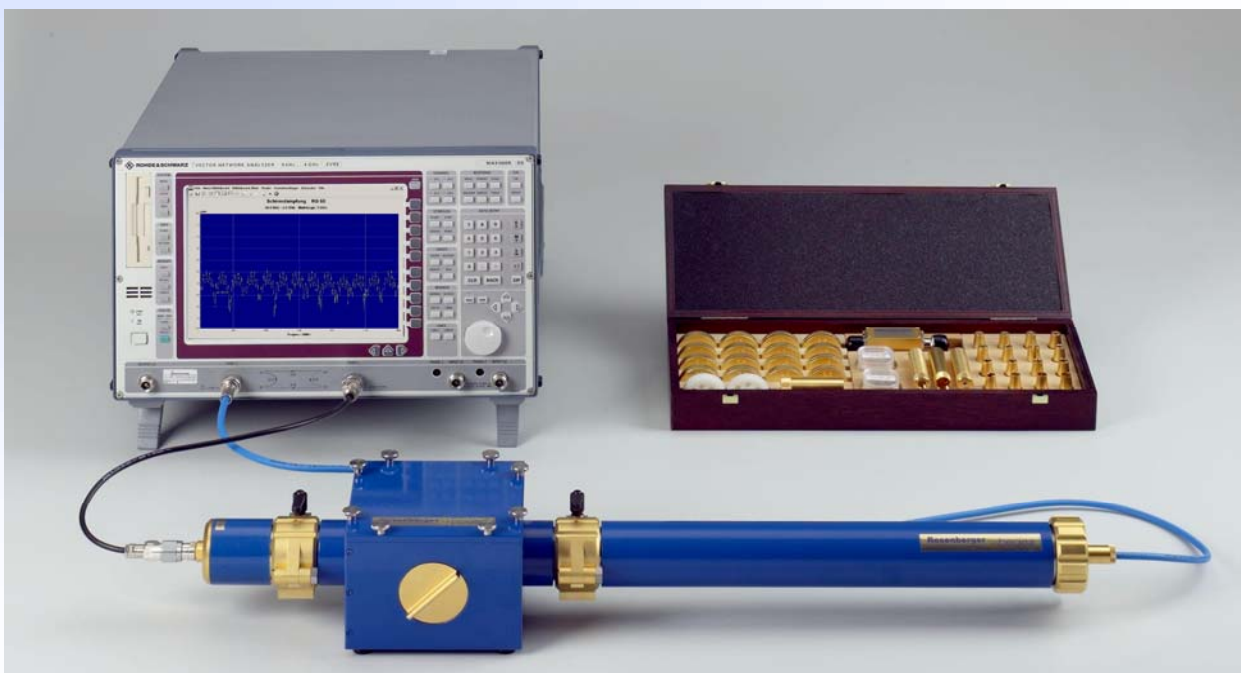


EMC of Connectors & Assemblies



EMC of Connectors & Assemblies



EMC of Connectors & Assemblies

- Author: **Bernhard Mund**
 - ◆ 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

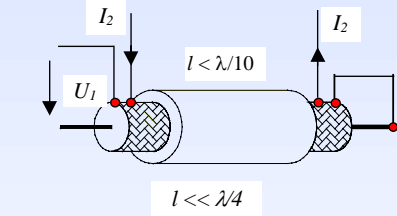
Overview

- Physical basics of screening
 - ◆ Definitions, electrical length,
 - ◆ Coupling transfer function
- Test procedures
 - ◆ Absorbing clamp procedure,
 - ◆ wire injection
 - ◆ Triaxial procedure
 - Transfer impedance short/short & short matched
 - Screening attenuation
- Calculation of Z_T into a_S
- Special connector problems
- Discussion

Definitions, electrical length

low frequencies: **Transfer impedance**

high frequencies: **Screening attenuation**

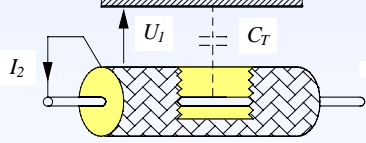


$$Z_T = \frac{U_1}{I_2}$$

[mΩ/m]

$$a_s = 10 \cdot \log(P_1 / P_2) = 20 \cdot \log(U_1 / U_2)$$

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



$$Y_T = \frac{I_2}{U_1 \cdot l}$$

[pF/m]

Ratio of **U/I = R**
--> **length dependent**

$$Z_{TE} = Z_F + Z_T$$

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:

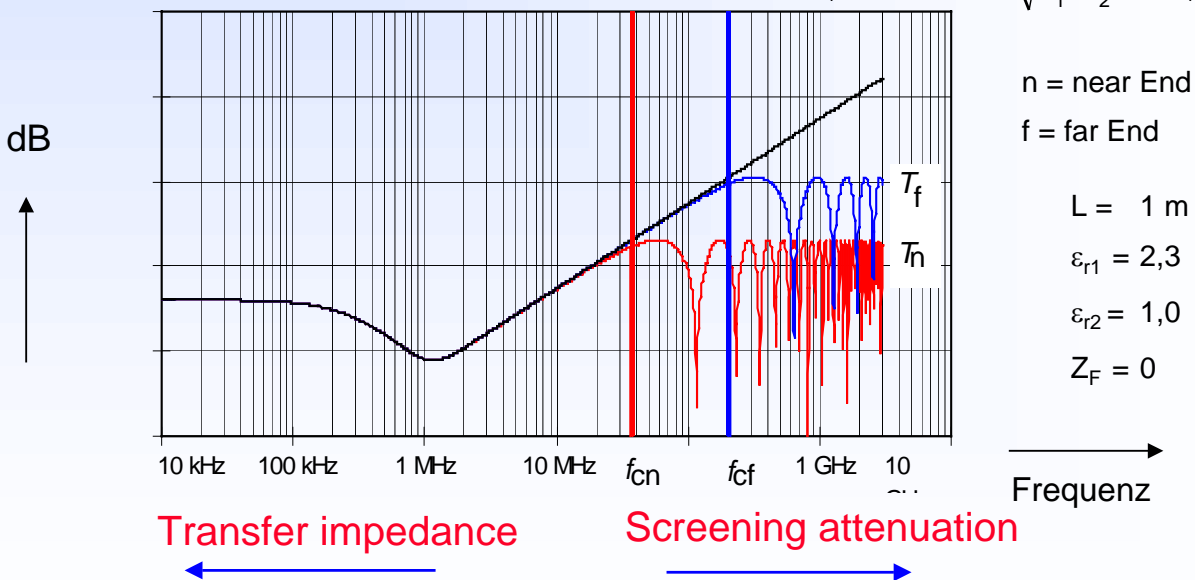
$$f < \frac{c_0}{10 \cdot l \cdot \sqrt{\epsilon_{r1}}}$$

(EN 50289-1-6)

Calculated Coupling transfer function T_{nf}

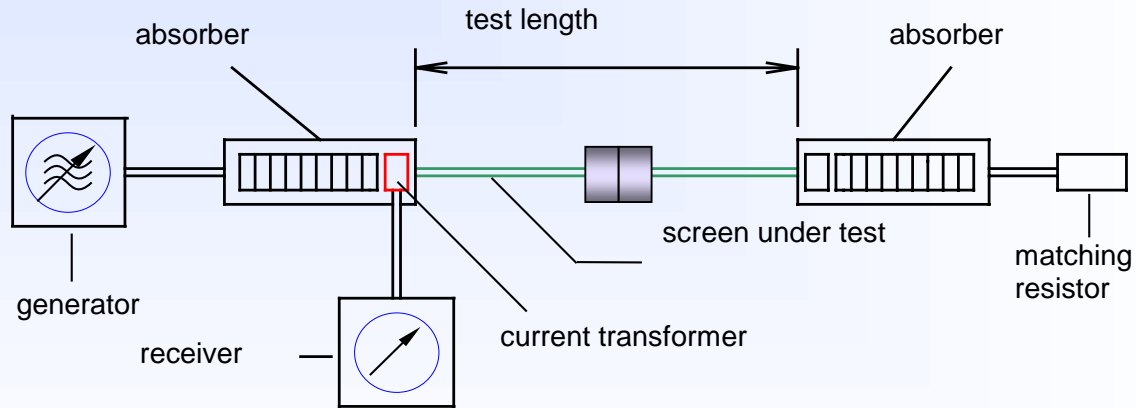
a_s and Z_T vs. frequency

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



Absorbing clamp procedure

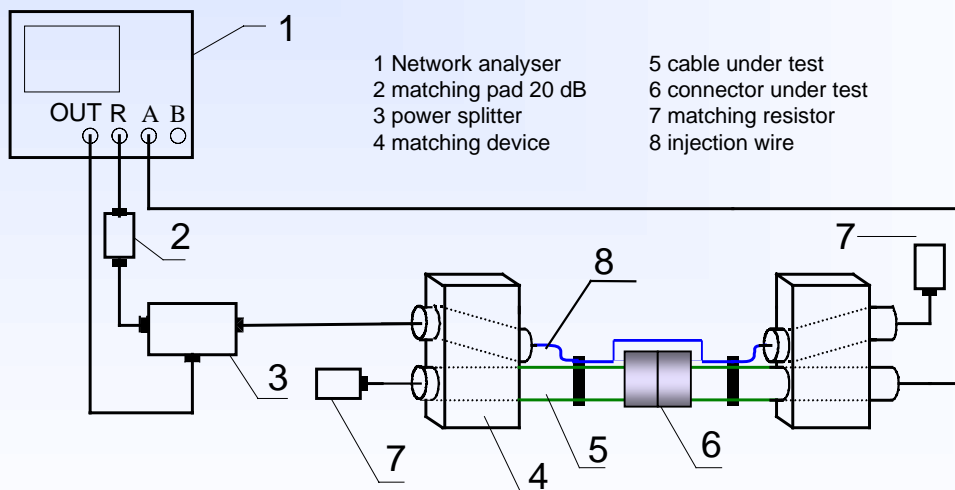
Screening attenuation from 30 MHz to 1000 MHz **MDS 21**
 500 MHz to 2500 MHz **MDS 22**



IEC 62153-4-5 resp. EN 50289-1-6

Procedure with injection wire

Transfer impedance up to 1 GHz, matching of injection wire **20 dB min !**

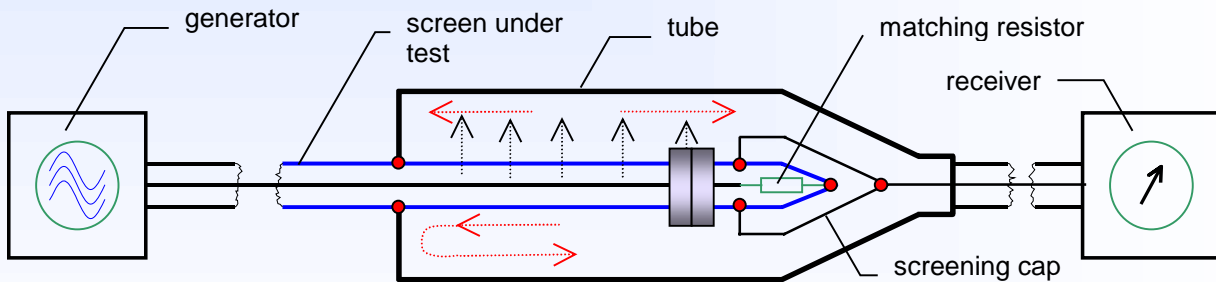


IEC 62153-4-6 resp. EN 50289-1-6

Triaxial-procedure, principle test set-up

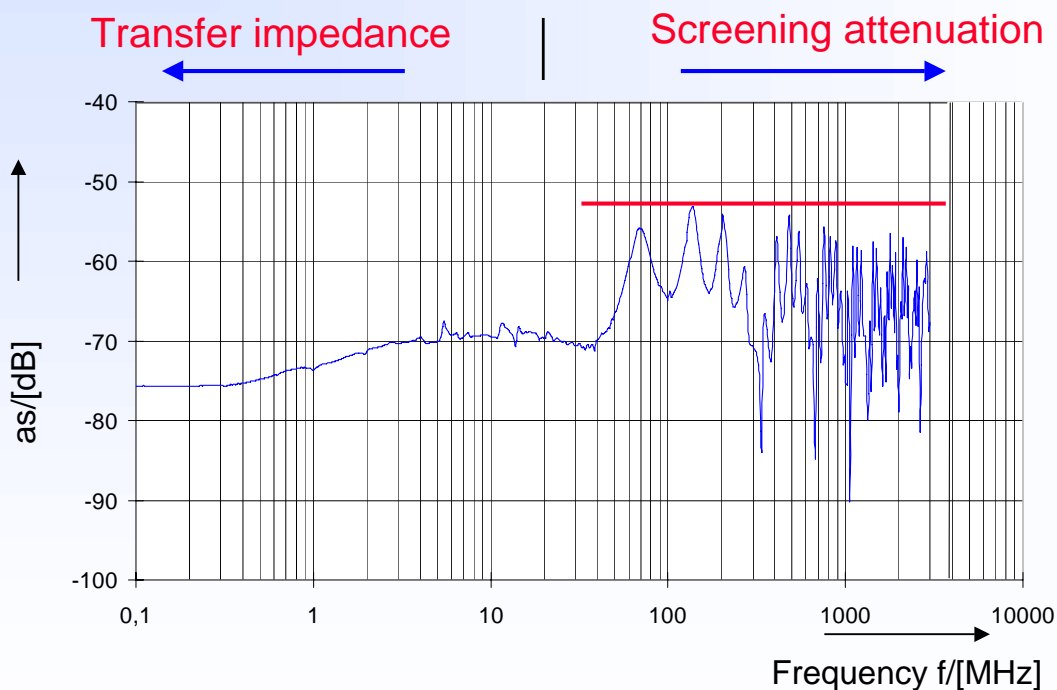
Transfer impedance and Screening attenuation

DC up to and above 12 GHz with only one test set-up



IEC 62153-4-3 Transfer impedance, IEC 62153-4-3 Screening attenuation, EN 50289-1-6,

measured Coupling transfer function RG 058



Comparison of the test procedures

- Absorbing clamp procedure
 - ◆ Screening attenuation 30 MHz to 1 GHz
- Injection wire Procedure
 - ◆ Transfer impedance up to 1 GHz
- Triaxial Procedure
 - ◆ Transfer impedance and Screening attenuation
 - ◆ DC up to 12 GHz with only one test set-up!

Comparison of the test procedures

Absorbing clamp procedure



Screening attenuation 30 MHz up to 1 (2,5) GHz

Injection wire Procedure



Foto: Günther Quednau

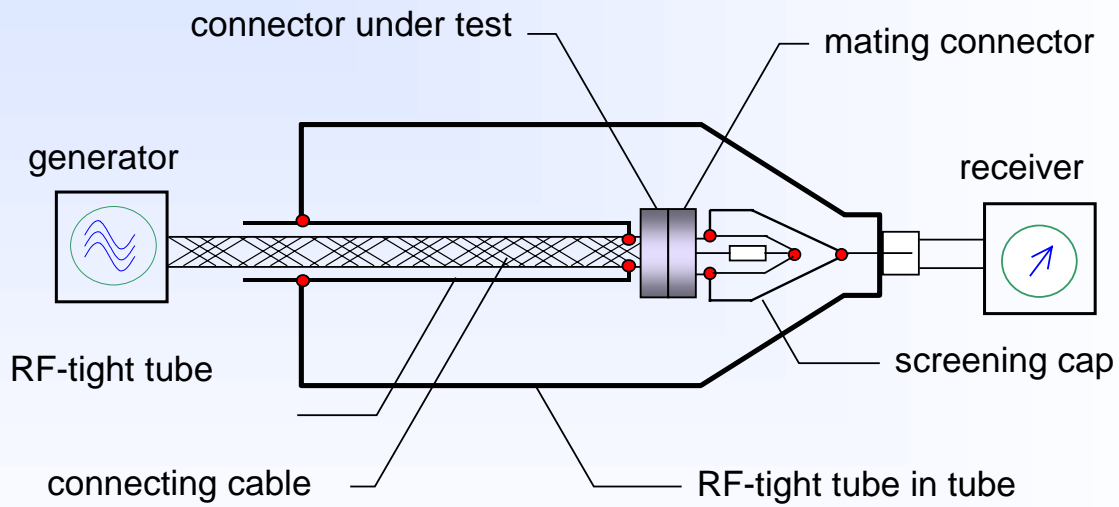
Transfer impedance up to 1 GHz

Triaxial Procedure

Transfer impedance & Screening attenuation
DC up to 12 GHz with only one test set-up!

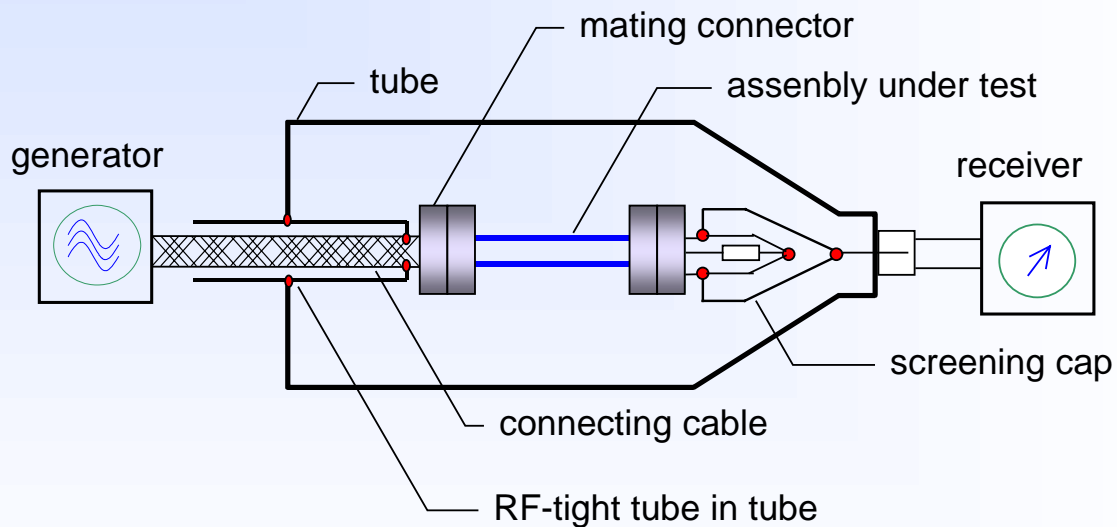


Triaxial test set-up for Connectors with “Tube in tube“



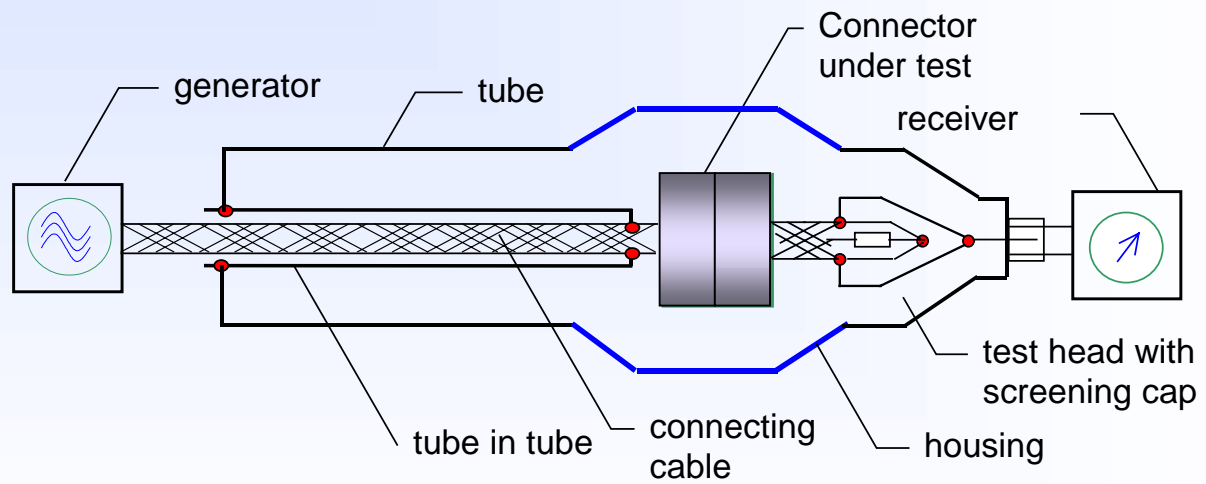
„Tube in tube“-procedure IEC 62153-4-7, Transfer impedance, Screening & Coupling attenuation of connectors and assemblies

Test of cable assemblies



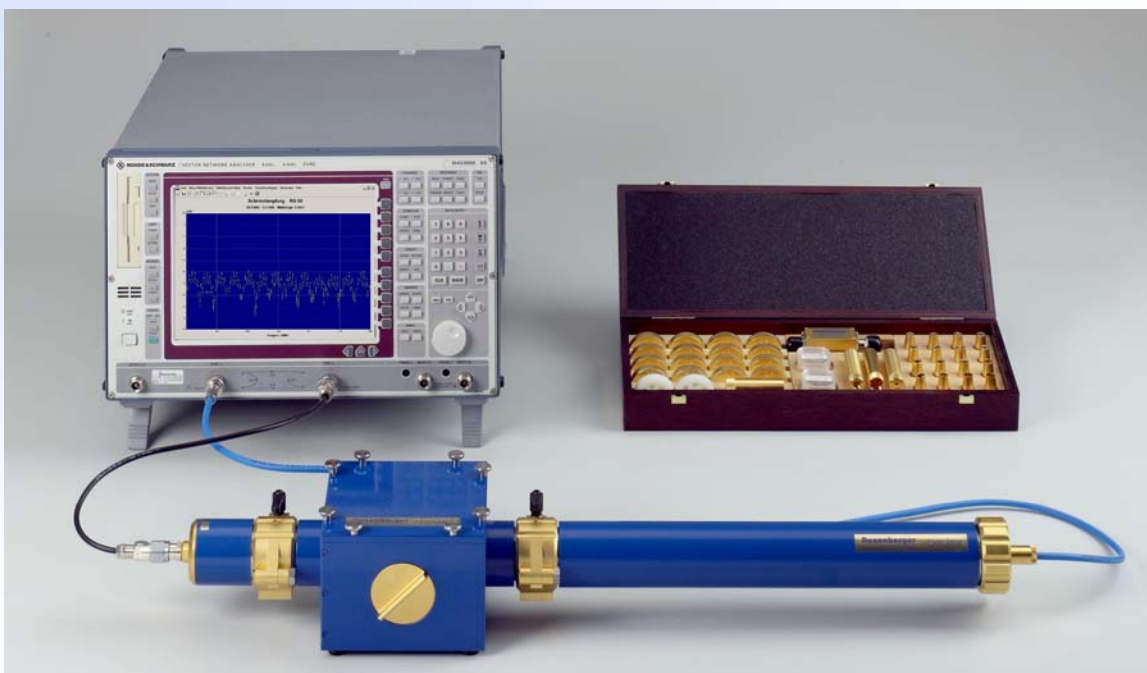
IEC 62153-4-7, “Tube in tube“ - procedure (Connectors & Assemblies)

larger connectors and connecting hardware

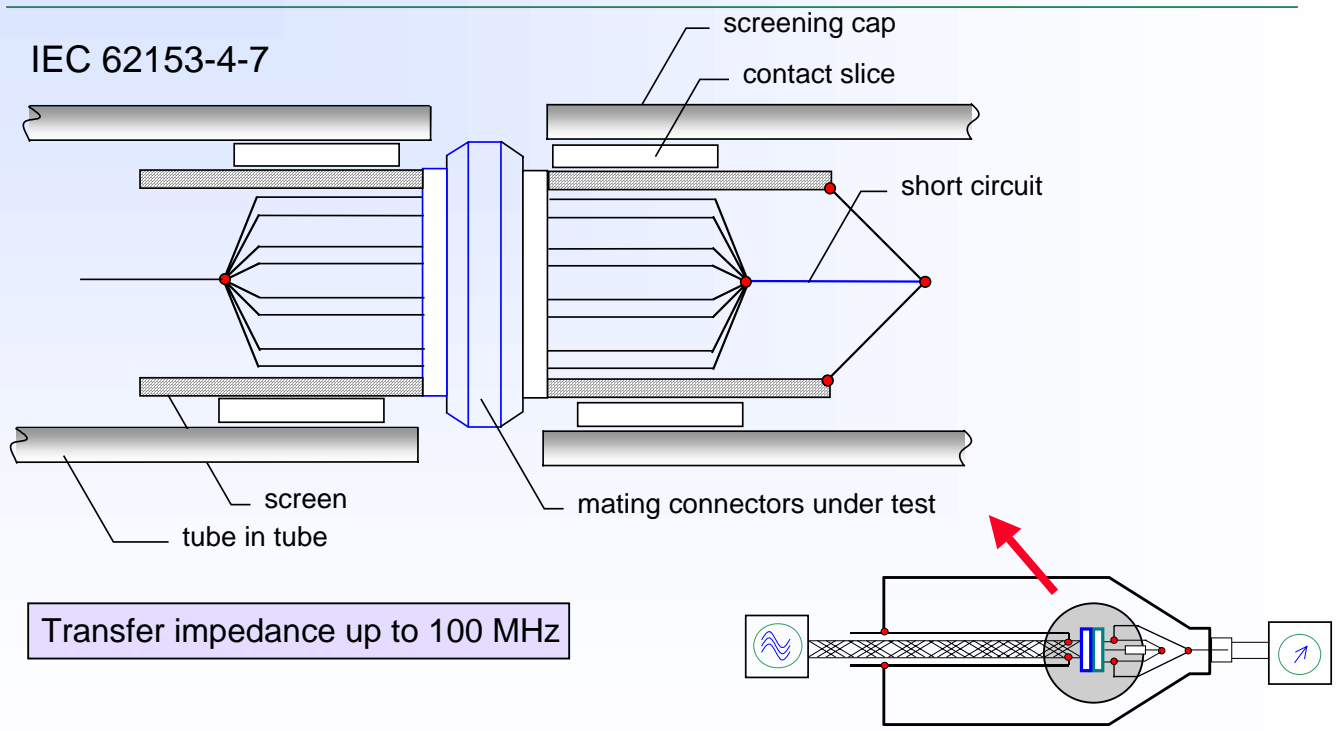


IEC 62153-4-7

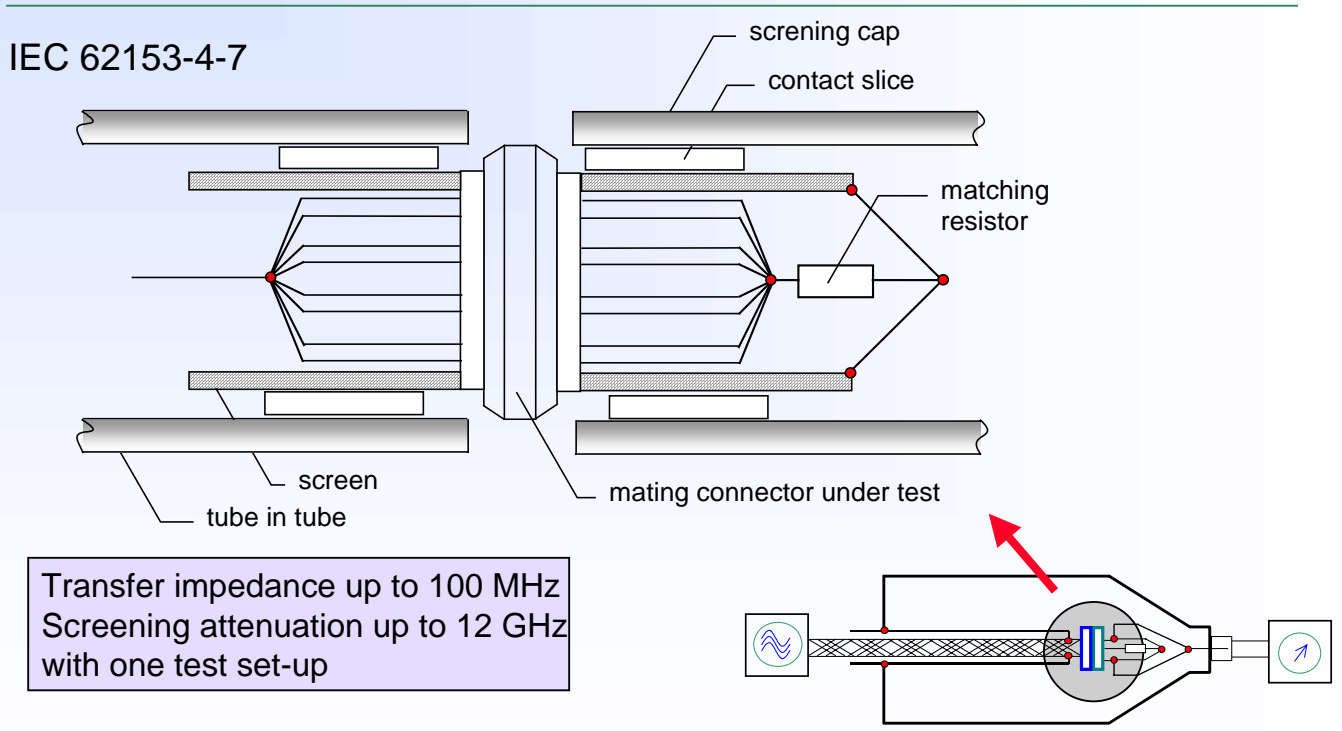
Triaxial procedure with housing and „Tube in tube“



Triaxial procedure, tube in tube with short circuit

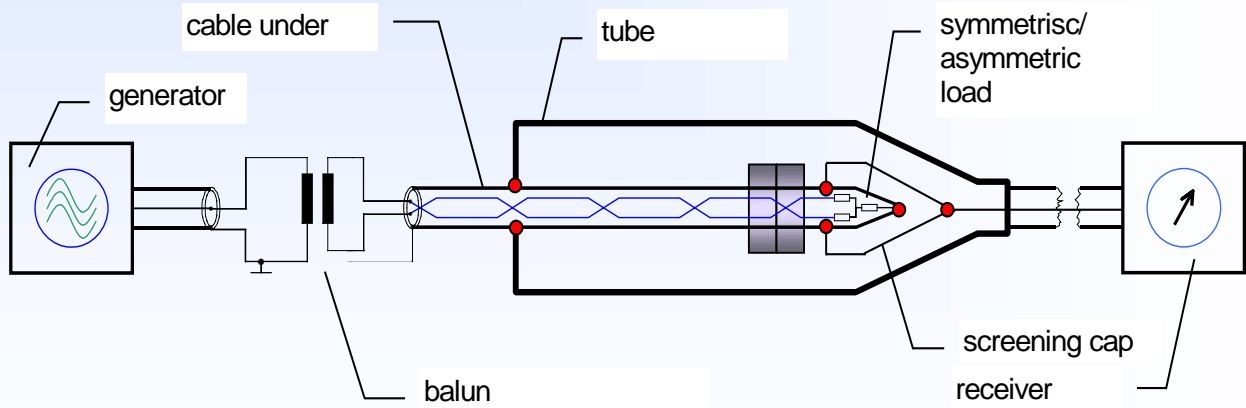


Triaxial procedure, tube in tube, matched



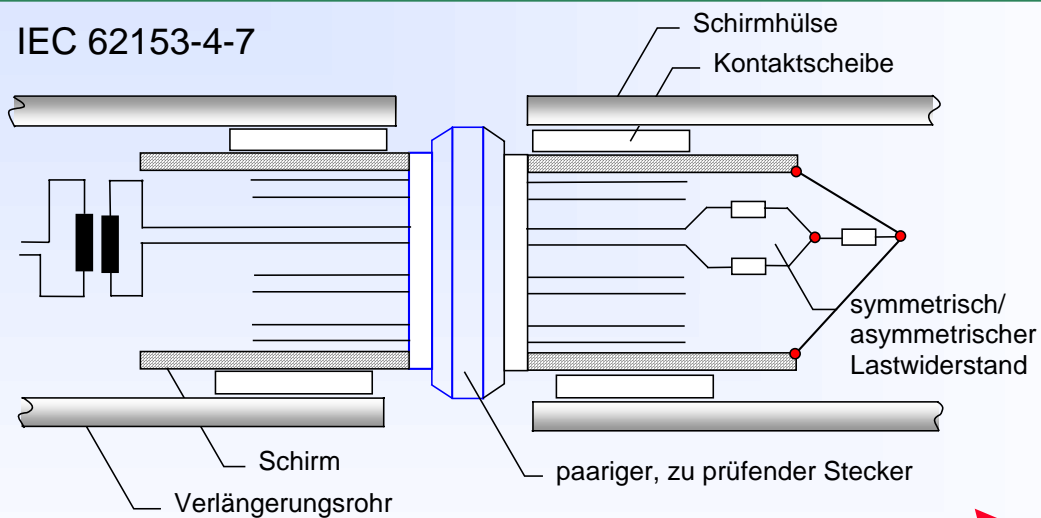
Measuring of Coupling attenuation

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

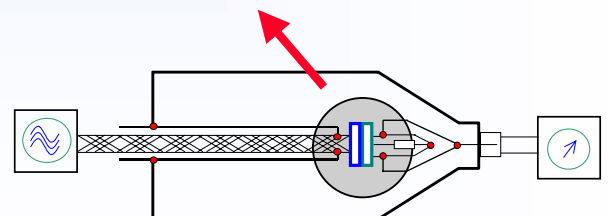


Triaxial procedure, tube in tube with symm/asymm

IEC 62153-4-7



Transfer impedance up to 100 MHz
 Screening attenuation up to 12 GHz
 Coupling attenuation up to 1,2 GHz



Calculation of Transfer impedance into Screening attenuation

general:

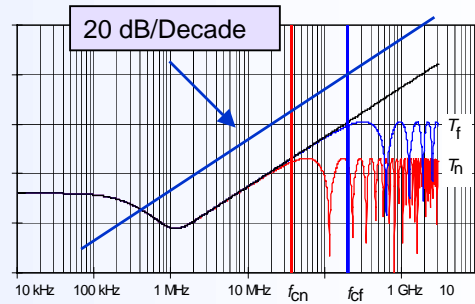
$$a_s = 20 \cdot \log_{10} \left| \frac{\sqrt{Z_1 \cdot Z_2}}{Z_T \cdot l} \right|$$

20 dB/Decade:

$$a_s = -20 \cdot \log_{10} \frac{Z_T}{\sqrt{Z_1 Z_2} \omega \left| \frac{l}{v_2} \pm \frac{l}{v_1} \right|}$$

$$a_s = -20 \cdot \log_{10} \frac{Z_T c_0}{\sqrt{Z_1 Z_2} \omega \left| \sqrt{\epsilon_{r2}} \pm \sqrt{\epsilon_{r1}} \right|}$$

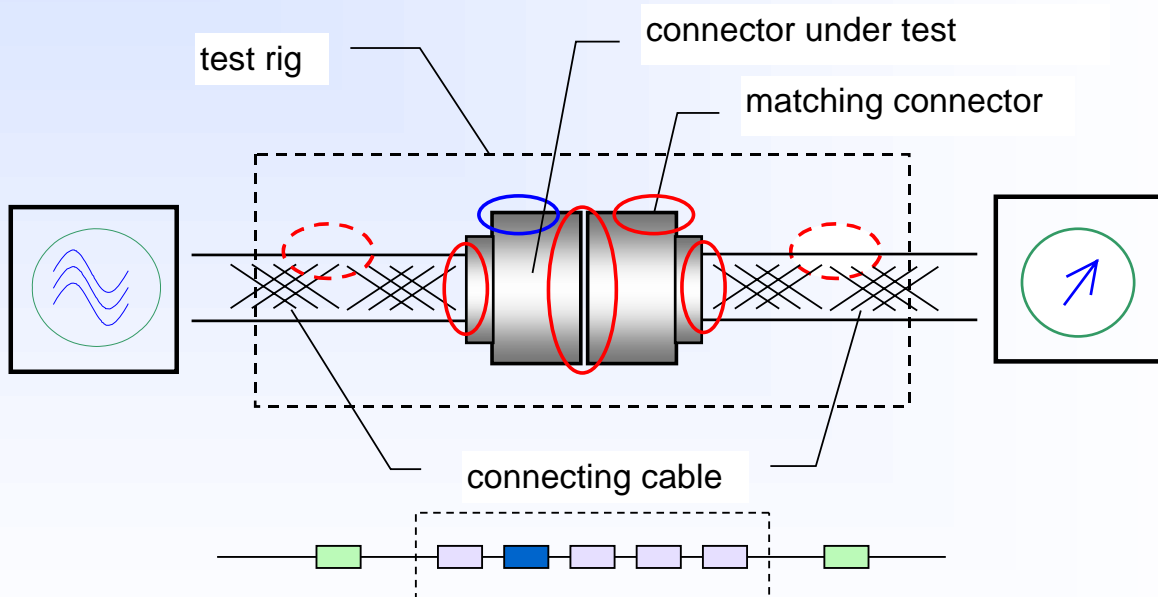
The outer circuit (Z_2) influences the screening attenuation



Transfer impedance Screening attenuation

- l length of cable under test;
- Z_1 characteristic impedance of the cable;
- Z_2 characteristic impedance of the outer circuit;
- ϵ_{r1} Dielectric constant of the cable;
- ϵ_{r2} Dielectric constant of the outer circuit;
- v_1 velocity ratio of the cable;
- v_2 velocity ratio of the outer circuit;
- c_0 velocity of light in vacuum;
- ω circular frequency = $2\pi f$

Common problems on connector test



Kopplungswiderstände addieren sich !

Conclusion 1

- The screening effectiveness of Cables & Connectors is given as **Transfer impedance Z_T** in the lower frequency range and as **Screening attenuation a_s** in the upper frequency range
- At screened balanced Cables and Connectors the **Coupling attenuation a_c** is the measure of the screening effectiveness as sum of the Unbalance attenuation of the pair and the screening attenuation of the screen.
- Test procedures for Cables & Connectors are **Absorbing clamp procedure**, **Injection wire procedure** and the **Triaxial procedure**
- With the Triaxial procedure (**CoMeT**) the **Transfer impedance Z_T** and the **Screening attenuation a_s** of Cables & Connectors can be measured in the frequency range from DC up to 12 GHz with one test set-up.
- Furthermore, the **Coupling attenuation a_c** as sum of the Unbalance attenuation of the pair and the screening attenuation of the screen can be measured with the **Triaxial procedure**

Conclusion 2

- With the Triaxial test procedure the **Transfer impedance Z_T** can be measured with short circuit or matched.
- The Triaxial test procedure is standardised in **IEC 62153-4-3/-4-4** and in **EN 50289-1-6** for cables, and in **IEC 62153-4-7** for connectors
- Whereas EMC-test procedures are established well for Communication cables,
- there are different open questions on testing of Cables & Connectors,
- especially concerning connecting cables/connection techniques of the connectors under test, matching of connectors and influence of mated connectors.
- Further information: www.bedea.com, Messtechnik
- contact persons:
- Thomas.schmid@rosenberger.de, rdamm@bedea.com, bmund@bedea.com

International standards for Triaxial procedure

IEC TR 62153-4-1	Introduction to EMC measurements	2007-11
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	2008-03
IEC 62153-4-10	Shielded screening attenuation test method for measuring the Screening Effectiveness of Feedtroughs and Electromagnetic Gaskets	2009-05
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)	2002

Literatur

- [1] Bernhard Mund, Thomas Schmid: Messen der Schirmdämpfung von Steckverbindern, Kabeldurchführungen und EMV-Dichtungen, 3. Anwenderkongress Steckverbinder 2009, Vogel Verlag, Würzburg
- [2] Bernhard Mund: EMC of Cables & Connectors & Test methods, EMC Zurich 2007
- [3] Bernhard Mund: Measuring the EMC on RF-connectors and connecting hardware, Tube in tube test procedure, IWCS (International wire & cable symposium) 2004, Philadelphia
- [4] Thomas Hähner und Bernhard Mund: Measurement of the screening effectiveness of connectors & cable assemblies: International Wroclaw Symposium on Electromagnetic Compatibility, EMC 2002
- [5] Thomas Hähner und Bernhard Mund: Background, content and future of the EMC measurement standard prEN 50289-1-6, Open / shielded test methods, International Wroclaw Symposium on Electromagnetic Compatibility, EMC 2000
- [6] Otto Breitenbach, Thomas Hähner und Bernhard Mund: Kabelschirmung im Frequenzbereich von MHz bis GHz, erweiterte Anwendung eines einfachen Meßverfahrens, Frequenz 1-2/1999 S. 18-28.
- [7] Lauri Halme, Rauno Kytönen, "Background and introduction to EM screening (shielding) behaviours and measurements of coaxial and symmetrical cables, cable assemblies and connectors", IEE Colloquium on screening effectiveness measurements, Savoy Place London, 6 May 1998

Thanks for your attention



*www.bedeia.com
bmund@bedeia.com*

EMC of Connectors & Assemblies

bedeia

bedeia Berkenhoff & Drebes GmbH, D-35614 Asslar, Germany



ca. 325 MA
ca. 35 Mio EUR

seit 1995 selbständig durch
Management-Buy-out

1. Ziel ist die Erhaltung
der Arbeitsplätze !

- Hersteller von
Kommunikationskabeln

- Monofile (Techn. Fäden)
- Feinseile
- Zieh- und Presswerkzeuge
- Messtechnik

www.bedeia.com

- Lichttechnik
www.bedeia.akzent.com