SCTE Lecture - EMC of Communication cables & test methods

Test set-up CoMeT

EMC of Communication cables & test methods

Bernhard Mund, bedea Berkenhoff&Drebes GmbH, Herbornerstrasse 100, D-35614 Asslar, Germany, bmund@bedea.com
EMC of Communication cables & test methods

Author: Bernhard Mund,
- 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

\[ a_S = 10 \log \left( \frac{P_1}{P_2} \right) = 20 \log_{10} \left( \frac{U_1}{U_2} \right) \text{ [dB]} \]

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

**Low frequencies**: Transferimpedance

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

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

\[ \lambda = \frac{c_0 \cdot \nu}{f} \]

\[ f > \frac{c_o}{2 \cdot l \cdot \sqrt{\varepsilon_{r_1} - \varepsilon_{r_2}}} \]

**Electrical long**:

\[ f \leq \frac{c_o}{10 \cdot l \cdot \sqrt{\varepsilon_{r_1}}} \]

\((EN \ 50289-1-6)\)

Coupling between two lines (equivalent circuit)

**Near end**

\[ U_{2n} \]

\[ Z_{2n} \]

**Disturbed line (surrounding)**

\[ U_{2f} \]

\[ Z_{2f} \]

\[ Z_1, \varepsilon_{r_1}, v_1, \gamma_1 \]

\[ Z_1, Z_{2f}, v_{12}, \gamma_2 \]

**Far end**

\[ U_{2f} \]

\[ Z_{2f} \]

**Generator**

\[ \sqrt{P_{1n}} \]

**Reversing**

\[ \sqrt{P_{2n}} \]

\[ \sqrt{P_{2f}} \]

**Receiver**

\[ U_{1f} \]

**Disturbing line**

\[ \sqrt{P_{1f}} \]

**Equivalent circuit**
**Summing function \( S_{nf} \)**

\[
(S \cdot f)_{cn} \quad (S \cdot f)_{cf}
\]

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

\[ \approx \frac{\sin x}{x} \]

- **low frequencies**
  \[ \left. S_{nf} \right| \rightarrow 1 \]

- **high frequencies**
  \[ \left. S_{nf} \right| \rightarrow \frac{2}{(\beta_1 \pm \beta_2) \cdot f} \]

**Calculated Coupling Transfer Function \( T_{nf} \)**

\[
T_{nf} = \left( Z_F \pm Z_T \right) \cdot \frac{1}{\sqrt{Z_1 \cdot Z_2}} \cdot \frac{f}{2} \cdot S_{nf}
\]

- \( n = \) near end
- \( f = \) far end

\( L = 1 \text{ m} \)
\( \varepsilon_{r1} = 2.3 \)
\( \varepsilon_{r2} = 1.0 \)
\( Z_F = 0 \)
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

Measured Transfer function of RG 058
Differential & Common mode of balanced pairs

Differential mode
Gegentaktbetrieb

Common mode
Gleichtaktbetrieb

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

Transfer impedance Telass 110 in mOhm/m

3.5 mΩ/m @ 5 MHz
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)

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

![Image of CATV wall outlet with tube in tube](image_url)

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CATV wall outlet with Tube in tube

![Image of CATV wall outlet with Tube in tube](image_url)

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Bernhard Mund, bedea Berkenhoff&Drebes GmbH, Herbornerstrasse 100, D-35614 Asslar, Germany, bmund@bedea.com
### EN 50117 Coaxial cables

<table>
<thead>
<tr>
<th>EN 50117-1, Ed.2</th>
<th>Coaxial Cables, Generic specification</th>
<th>2002</th>
<th>2006</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>EN 50117-2-1 Ed1</strong>&lt;br&gt;<strong>EN 50117-2-1 Ed2</strong> &lt;br&gt;(replaces 50117-2)</td>
<td>Indoor drop cables for systems operating at 5 MHz - 1 000 MHz</td>
<td>2005</td>
<td></td>
</tr>
<tr>
<td><strong>EN 50117-2-2 Ed1</strong> &lt;br&gt;(replaces 50117-3)</td>
<td>Outdoor drop cables for systems operating at 5 MHz - 1 000 MHz</td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td><strong>EN 50117-2-3 Ed1</strong> &lt;br&gt;(replaces 50117-4)</td>
<td>Distribution and trunk cables for systems operating at 5 MHz - 1 000 MHz</td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td><strong>EN 50117-2-4 Ed1</strong> &lt;br&gt;(replaces 50117-5)</td>
<td>Indoor drop cables for systems operating at 5 MHz - 3 000 MHz</td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td><strong>EN 50117-2-5 Ed1</strong> &lt;br&gt;(replaces 50117-6)</td>
<td>Outdoor drop cables for systems operating at 5 MHz - 3 000 MHz</td>
<td>2004</td>
<td></td>
</tr>
<tr>
<td><strong>prEN 50117-4-1 Ed1</strong></td>
<td>Indoor drop cables for systems operating at 5 MHz - 3 000 MHz</td>
<td>2007</td>
<td></td>
</tr>
</tbody>
</table>

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### EN 50117 - Screening classes for CATV cables

<table>
<thead>
<tr>
<th>Screening class</th>
<th>5 - 30 MHz</th>
<th>30 - 1000 MHz</th>
<th>1 GHz – 2 GHz</th>
<th>2 GHz – 3 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>B</td>
<td>15 mOhm/m</td>
<td>75 dB</td>
<td>65 dB</td>
<td>55 dB</td>
</tr>
<tr>
<td>A</td>
<td>5 mOhm/m</td>
<td>85 dB</td>
<td>75 dB</td>
<td>65 dB</td>
</tr>
<tr>
<td>A+</td>
<td>2.5 mOhm/m</td>
<td>95 dB</td>
<td>(85 dB)</td>
<td>(75 dB)</td>
</tr>
<tr>
<td>A++</td>
<td>0.9 mOhm/m</td>
<td>105 dB</td>
<td>(95 dB)</td>
<td>(85 dB)</td>
</tr>
<tr>
<td>C</td>
<td>50 mOhm/m</td>
<td>75 dB</td>
<td>65 dB</td>
<td>55 dB</td>
</tr>
</tbody>
</table>

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

Außenleiter \( D+d_0 \)
Innenleiter \( d \)
Isolation \( D \)
Außenmantel \( AD \)
EMC of Feed-throughs & EMC Gaskets

**Problem:**
EMC of Feed-throughs & EMC Gaskets

**Problem in Standardised Surrounding**
- Feed in RF-wave
- Measure RF-wave

**Equivalent Circuit**
- \( Z_L, I_{Line} \)
- \( Z_L, I_{Line} \)

**Y** represents the Transfer impedance

**Generator & Receiver**
- Generator & receiver are included in the NWA

Bernhard Mund, bedea Berkenhoff&Drebes GmbH, Herbornerstrasse 100, D-35614 Asslar, Germany, bmund@bedea.com
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

<table>
<thead>
<tr>
<th>Standard</th>
<th>Description</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC TR 62153-4-1</td>
<td>Introduction to EMC measurements</td>
<td>46/199/DTR</td>
</tr>
<tr>
<td>IEC 62153-4-3</td>
<td>Surface transfer impedance - Triaxial method</td>
<td>2006-03</td>
</tr>
<tr>
<td>IEC 62153-4-4</td>
<td>Shielded screening attenuation, test method for measuring the screening attenuation &quot;a_s&quot; up to and above 3 GHz</td>
<td>2006-05</td>
</tr>
<tr>
<td>IEC 62153-4-7</td>
<td>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</td>
<td>2006-04</td>
</tr>
<tr>
<td>IEC 62153-4-9</td>
<td>Coupling attenuation, triaxial method</td>
<td>46/190/CDV</td>
</tr>
<tr>
<td>IEC 62153-4-10</td>
<td>Shielded screening attenuation test method for measuring the Screening Effectiveness of Feedtoughs and Electromagnetic Gaskets</td>
<td>46/xxx/CD</td>
</tr>
<tr>
<td>EN 50289-1-6</td>
<td>Communication cables - Specifications for test methods Part 1-6: Electrical test methods -Electromagnetic performance (includes IEC 62153-4-3 and IEC 62153-4-3)</td>
<td>2003</td>
</tr>
</tbody>
</table>
Conclusion 1

- The Screening effectiveness 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.

Conclusion 2

- **Advantages of the triaxial test-set-up:**
  - simple and easy sample preparation
  - only one test set up for $Z_T$, $a_S$, and $a_C$
  - high sensitivity up to and above 125 dB
  - no radiation of electromagnetic energy
  - covers the whole frequency 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
CoMeT
Coupling Measuring Tube

bedea distributor in UK:
www.quadrant-ltd.co.uk

SCTE Lecture meeting - EMC of Communication Cables & Test methods

Literature


[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