Specification for the testing of balanced and coaxial information technology cabling

Part 1: Installed balanced cabling as specified in the standards series EN 50173
This British Standard is the UK implementation of EN 61935-1:2009. It was derived by CENELEC from IEC 61935-1:2009. It supersedes BS EN 61935-1:2005 which is withdrawn.

The CENELEC common modifications have been implemented at the appropriate places in the text and are indicated by tags (e.g. [C]).

The UK participation in its preparation was entrusted to Technical Committee EPL/46, Cables, wires and waveguides, radio frequency connectors and accessories for communication and signalling.

A list of organizations represented on this committee can be obtained on request to its secretary.

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

© BSI 2010
ISBN 978 0 580 56601 1
ICS 33.120.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 30 April 2010

Amendments/corrigenda issued since publication

<table>
<thead>
<tr>
<th>Date</th>
<th>Text affected</th>
</tr>
</thead>
</table>
Specification for the testing of balanced and coaxial information technology cabling - Part 1: Installed balanced cabling as specified in the standards series EN 50173 (IEC 61935-1:2009, modified)
Foreword

The text of document 46/323/FDIS, future edition 3 of IEC 61935-1, prepared by IEC TC 46, Cables, wires, waveguides, R.F. connectors, R.F. and microwave passive components and accessories, was submitted to the IEC-CENELEC parallel vote and was approved by CENELEC as EN 61935-1 on 2009-10-01 with common modifications prepared by the German national committee to have the standard refer to the relevant European Standards.

This European Standard supersedes EN 61935-1:2005.

This new edition includes test methods for exogenous (alien) crosstalk. It also includes a new annex for uncertainty and variability of field test results.

The following dates were fixed:

- latest date by which the EN has to be implemented at national level by publication of an identical national standard or by endorsement (dop) 2010-07-01
- latest date by which the national standards conflicting with the EN have to be withdrawn (dow) 2012-10-01

Annex ZA has been added by CENELEC.
Endorsement notice

The text of the International Standard IEC 61935-1:2009 was approved by CENELEC as a European Standard with agreed common modifications.
Normative references to international publications with their corresponding European publications

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

NOTE When an international publication has been modified by common modifications, indicated by (mod), the relevant EN/HD applies.

<table>
<thead>
<tr>
<th>Publication</th>
<th>Year</th>
<th>Title</th>
<th>EN/HD</th>
<th>Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>–</td>
<td>–</td>
<td>Information technology - Generic cabling systems</td>
<td>EN 50173</td>
<td>Series</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>Information technology - Cabling installation - Part 1: Installation specification and quality assurance</td>
<td>EN 50174-1</td>
<td>1)</td>
</tr>
<tr>
<td>–</td>
<td>–</td>
<td>Communication cables - Specifications for test methods - Part 1-15: Electromagnetic performance - Coupling attenuation of links and channels (Laboratory conditions)</td>
<td>EN 50289-1-15</td>
<td>1)</td>
</tr>
<tr>
<td>IEC 60169-22</td>
<td>–</td>
<td>Radio-frequency connectors - Part 22: R.F. two-pole bayonet coupled connectors for use with shielded balanced cables having twin inner conductors (Type BNO)</td>
<td>–</td>
<td>–</td>
</tr>
<tr>
<td>IEC 60603-7</td>
<td>–</td>
<td>Connectors for electronic equipment - Part 7: Detail specification for 8-way, unshielded, free and fixed connectors</td>
<td>EN 60603-7</td>
<td>2009</td>
</tr>
<tr>
<td>IEC 60603-7-X</td>
<td>Series</td>
<td>Connectors for electronic equipment - Part 7-X: Detail specification for 8-way, shielded, free and fixed connectors</td>
<td>EN 60603-7-X</td>
<td>Series</td>
</tr>
<tr>
<td>IEC 60603-7-4</td>
<td>–</td>
<td>Connectors for electronic equipment - Part 7-4: Detail specification for 8-way, unshielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz</td>
<td>EN 60603-7-4</td>
<td>200X 3)</td>
</tr>
<tr>
<td>IEC 60603-7-5</td>
<td>–</td>
<td>Connectors for electronic equipment - Part 7-5: Detail specification for 8-way, shielded, free and fixed connectors, for data transmissions with frequencies up to 250 MHz</td>
<td>EN 60603-7-5</td>
<td>2009</td>
</tr>
</tbody>
</table>

1) Undated reference.
2) Valid edition at date of issue.
3) To be published.
<table>
<thead>
<tr>
<th>Publication</th>
<th>Year</th>
<th>Title</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEC 61076-3-104</td>
<td>1)</td>
<td>Connectors for electronic equipment - Product requirements - Part 3-104: Detail specification for 8-way, shielded free and fixed connectors for data transmissions with frequencies up to 1 000 MHz</td>
</tr>
<tr>
<td>IEC 61076-3-110</td>
<td>1)</td>
<td>Connectors for electronic equipment - Product requirements - Part 3-110: Rectangular connectors - Detail specification for shielded, free and fixed connectors for data transmission with frequencies up to 1 000 MHz</td>
</tr>
<tr>
<td>IEC 61156-1</td>
<td>1)</td>
<td>Multicore and symmetrical pair/quad cables for digital communications - Part 1: Generic specification</td>
</tr>
<tr>
<td>IEC 61156-5</td>
<td>1)</td>
<td>Multicore and symmetrical pair/quad cables for digital communications - Part 5: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz - Horizontal floor wiring - Sectional specification</td>
</tr>
<tr>
<td>IEC 61156-6</td>
<td>1)</td>
<td>Multicore and symmetrical pair/quad cables for digital communications - Part 6: Symmetrical pair/quad cables with transmission characteristics up to 1 000 MHz - Work area wiring - Sectional specification</td>
</tr>
<tr>
<td>IEC 61156-7</td>
<td>1)</td>
<td>Multicore and symmetrical pair/quad cables for digital communications - Part 7: Symmetrical pair cables with transmission characteristics up to 1 200 MHz - Sectional specification for digital and analog communication cables</td>
</tr>
<tr>
<td>IEC 61156-8</td>
<td>1)</td>
<td>Multicore and symmetrical pair/quad cables for digital communications - Part 8: Symmetrical pair/quad cables with transmission characteristics up to 1 200 MHz - Work area wiring - Sectional specification</td>
</tr>
<tr>
<td>ITU-T Recommendation G.117</td>
<td>1996</td>
<td>Transmission aspects of unbalance about earth</td>
</tr>
<tr>
<td>ITU-T Recommendation O.9</td>
<td>1999</td>
<td>Measuring arrangements to assess the degree of unbalance about earth</td>
</tr>
</tbody>
</table>
INTRODUCTION

1 Scope

2 Normative references

3 Terms and definitions

4 Reference measurement procedures for electrical properties
   4.1 General
   4.2 Test equipment considerations
      4.2.1 General
      4.2.2 Network analyzer test requirements
      4.2.3 Termination of conductor pairs
      4.2.4 Reference loads for calibration
      4.2.5 Test configurations
      4.2.6 Coaxial cables and test leads for network analyzers
      4.2.7 Balun requirements
      4.2.8 Network analyzer measurement precautions
      4.2.9 Data reporting and accuracy
   4.3 DC loop resistance
      4.3.1 Objective
      4.3.2 Test method
      4.3.3 Test equipment and set-up
      4.3.4 Procedure
      4.3.5 Test report
      4.3.6 Uncertainty
   4.4 Direct current (d.c.) resistance unbalance
      4.4.1 Objective
      4.4.2 Test method
      4.4.3 Test equipment and set-up
      4.4.4 Procedure
      4.4.5 Test report
      4.4.6 Uncertainty
   4.5 Insertion loss
      4.5.1 Objective
      4.5.2 Test method
      4.5.3 Test equipment and set-up
      4.5.4 Procedure
      4.5.5 Test report
      4.5.6 Temperature correction
      4.5.7 Uncertainty
   4.6 Propagation delay and delay skew
      4.6.1 Objective
      4.6.2 Test method
      4.6.3 Test equipment and set-up
      4.6.4 Procedure
      4.6.5 Test report
      4.6.6 Uncertainty
4.7 Near-end cross-talk (NEXT) and power sum NEXT .................................................. 28
  4.7.1 Objective ............................................................................................................... 28
  4.7.2 Test method ............................................................................................................ 28
  4.7.3 Test equipment and set-up .................................................................................... 28
  4.7.4 Procedure ............................................................................................................... 28
  4.7.5 Test report .............................................................................................................. 29
  4.7.6 Uncertainty ............................................................................................................ 30
4.8 Attenuation to crosstalk ratio, near end (ACR-N) and power sum ACR-N ............ 30
  4.8.1 Objective ............................................................................................................... 30
  4.8.2 Test method ............................................................................................................ 30
  4.8.3 Test equipment and set-up .................................................................................... 30
  4.8.4 Procedure ............................................................................................................... 30
  4.8.5 Test report .............................................................................................................. 30
  4.8.6 Uncertainty ............................................................................................................ 30
4.9 Far-end cross-talk (FEXT) and power sum FEXT .................................................... 31
  4.9.1 Objective ............................................................................................................... 31
  4.9.2 Test method ............................................................................................................ 31
  4.9.3 Test equipment and set-up .................................................................................... 31
  4.9.4 Procedure ............................................................................................................... 31
  4.9.5 Test report .............................................................................................................. 32
  4.9.6 Uncertainty of FEXT measurements ..................................................................... 32
4.10 Equal level far end crosstalk (ELFEXT) and attenuation to crosstalk ratio, far end (ACR-F) .................................................................................................................. 32
  4.10.1 Objective ............................................................................................................... 32
  4.10.2 Calculation .......................................................................................................... 33
  4.10.3 Test report ............................................................................................................ 33
  4.10.4 Uncertainty ........................................................................................................... 33
4.11 Return loss .................................................................................................................. 33
  4.11.1 Objective ............................................................................................................... 33
  4.11.2 Test method ........................................................................................................... 33
  4.11.3 Test equipment and set-up .................................................................................. 34
  4.11.4 Procedure .............................................................................................................. 34
  4.11.5 Test report ............................................................................................................ 35
  4.11.6 Uncertainty ............................................................................................................ 35
4.12 PS alien near end crosstalk (PS ANEXT – Exogenous crosstalk) ......................... 35
  4.12.1 Objective ............................................................................................................... 35
  4.12.2 Test method .......................................................................................................... 35
  4.12.3 Test equipment and set-up .................................................................................. 35
  4.12.4 Procedure .............................................................................................................. 36
4.13 PS attenuation to alien crosstalk ratio, far end crosstalk (PS ACR-F – Exogenous crosstalk) .................................................................................................................. 38
  4.13.1 Objective ............................................................................................................... 38
  4.13.2 Test method .......................................................................................................... 38
  4.13.3 Test equipment and set-up .................................................................................. 38
  4.13.4 Procedure .............................................................................................................. 40
4.14 Unbalance attenuation, near end .......................................................................... 42
  4.14.1 Objective ............................................................................................................... 42
  4.14.2 Test method .......................................................................................................... 42
  4.14.3 Test equipment and set-up .................................................................................. 42
4.14.4 Procedure ................................................................. 43
4.14.5 Test report ............................................................... 45
4.14.6 Uncertainty ............................................................... 46

4.15 Unbalance attenuation, far end .................................... 46
4.15.1 Objective ................................................................. 46
4.15.2 Test method .............................................................. 46
4.15.3 Test equipment and set-up ........................................ 46
4.15.4 Procedure ............................................................... 47
4.15.5 Test report ............................................................... 48
4.15.6 Uncertainty ............................................................... 48

4.16 Coupling attenuation .................................................. 48

5 Field test measurement requirements for electrical properties ........................................ 48
5.1 General ................................................................. 48
5.2 Cabling configurations tested ......................................... 49
5.3 Field test parameters .................................................. 49
5.3.1 General ................................................................. 49
5.3.2 Inspection of workmanship and connectivity testing .... 50
5.3.3 Propagation delay and delay skew ............................. 51
5.3.4 Length ................................................................. 51
5.3.5 Insertion loss ........................................................... 52
5.3.6 NEXT, power sum NEXT ......................................... 52
5.3.7 ACR-N and power sum ACR-N ................................. 53
5.3.8 ELFEXT, power sum ELFEXT, ACR-F, power sum ACR-F .... 54
5.3.9 Return loss .............................................................. 55
5.3.10 Direct current (d.c.) loop resistance .......................... 55
5.4 Power sum alien crosstalk ............................................ 55
5.4.1 Objective ............................................................... 55
5.4.2 Test method ............................................................. 56
5.4.3 Test equipment and set-up ........................................ 56
5.4.4 Measuring ANEXT loss ............................................ 56
5.4.5 Measuring AFEXT loss ............................................ 57
5.4.6 Procedure ............................................................... 57
5.4.7 Calculation of PS ANEXT and PS ACR-F from measured data .......... 57
5.4.8 Selection of test ports .............................................. 60
5.4.9 Test report ............................................................... 62
5.4.10 Uncertainty of PS alien crosstalk measurements ........... 62
5.5 Data reporting and accuracy ........................................ 62
5.5.1 General ................................................................. 62
5.5.2 Detailed results ....................................................... 64
5.5.3 Summary results ..................................................... 64
5.5.4 Reporting requirements for power sum alien crosstalk .... 68
5.5.5 General ................................................................. 68
5.5.6 Consistency checks for field testers ............................ 68
5.5.7 Evaluation of consistency tests .................................. 69
5.5.8 Administration system applicability ............................ 69
5.5.9 Test equipment adapter cords for link testing ................ 69
5.5.10 User cords and channel testing ............................... 69

6 Field tester measurement accuracy requirements ..................... 69
6.1 General ................................................................. 69
6.2 Measurement accuracy specifications common to level IIE, level III, level IIIE, and level IV field testers

6.3 Accuracy performance requirements for level IIE field testers

6.4 Accuracy performance requirements for level III field testers

6.5 Accuracy performance requirements for level IIIE field testers

6.6 Accuracy performance requirements for level IV field testers

6.7 Accuracy performance requirements for level IV field testers over 600 MHz

6.8 Field tester requirements applicable to alien crosstalk measurements

6.9 Procedures for determining field tester parameters

6.9.1 General

6.9.2 Output signal balance (OSB)

6.9.3 Common mode rejection (CMR)

6.9.4 Residual NEXT

6.9.5 Dynamic accuracy

6.9.6 Source/load return loss

6.9.7 Random noise floor

6.9.8 Residual FEXT

6.9.9 Directivity

6.9.10 Tracking

6.9.11 Source match

6.9.12 Return loss of remote termination

6.9.13 Constant error term of the propagation delay measurement function

6.9.14 Error constant term proportional to propagation delay of the propagation delay measurement function

6.9.15 Constant error term of the delay skew measurement function

6.9.16 Constant error term of the length measurement function

6.9.17 Error constant proportional to length of the length measurement function

6.9.18 Constant error term of the d.c. resistance measurement function

6.9.19 Error constant term proportional to d.c. resistance of the d.c. resistance measurement function

6.9.20 Measurement floor for alien crosstalk testing during field testing

6.9.21 Measurement floor of the test device for the channel test configuration

6.10 Measurement error models

6.10.1 General

6.10.2 Error model for the insertion loss measurement function

6.10.3 Error model for the NEXT measurement function

6.10.4 Error model for the power sum NEXT measurement function

6.10.5 Error model for the ACR-N measurement function

6.10.6 Error model for the power sum ACR-N measurement function

6.10.7 Error model for the ELFEXT or ACR-F measurement function

6.10.8 Error model for the power sum ELFEXT and PS ACR-F measurement functions

6.10.9 Error model for the return loss measurement function

6.10.10 Error model for the propagation delay measurement function

6.10.11 Error model for the delay skew measurement function

6.10.12 Error model for the length measurement function

6.10.13 Error model for the d.c. loop resistance measurement function

6.11 Network analyzer measurement comparisons
6.11.1 General .....................................................................................................95
6.11.2 Adapters....................................................................................................95
6.11.3 Comparison methods.................................................................................98
Annex A (informative) Uncertainty and variability of field test results..................102
Annex B (normative) Reference laboratory test configuration for alien crosstalk testing.....106
Annex C (informative) General information on power sum alien crosstalk performance
of installations ....................................................................................................................109
Bibliography........................................................................................................................110

Figure 1 – Resistor load........................................................................................................16
Figure 2 – Reference planes for permanent link and channel ................................................18
Figure 3 – 180° hybrid used as a balun .................................................................................19
Figure 4 – Loop resistance measurement .............................................................................22
Figure 5 – DC resistance unbalance measurement ...............................................................24
Figure 6 – Insertion loss test configuration ...........................................................................25
Figure 7 – NEXT test configuration .....................................................................................28
Figure 8 – FEXT test configuration .......................................................................................31
Figure 9 – Return loss test configuration .............................................................................34
Figure 10 – ANEXT measurement .........................................................................................36
Figure 11 – Alien far end crosstalk measurement.................................................................39
Figure 12 – Unbalance attenuation, near end test configuration ............................................43
Figure 13 – Back-to-back balun differential mode insertion loss measurement ....................44
Figure 14 – Back-to-back balun common mode insertion loss measurement .......................44
Figure 15 – Unbalance performance test of the measurement balun ....................................45
Figure 16 – Unbalance attenuation far end test configuration ................................................47
Figure 17 – Correct pairing .................................................................................................50
Figure 18 – Incorrect pairing ...............................................................................................51
Figure 19 – Schematic diagram to measure channel ANEXT loss ........................................56
Figure 20 – AFEXT loss measurement test configuration .....................................................57
Figure 21 – Flow chart of the alien crosstalk test procedure ................................................61
Figure 22 – Example of equipment tolerance region (NEXT) ...............................................63
Figure 23 – Block diagram for measuring output signal balance ...........................................82
Figure 24 – Block diagram to measure common mode rejection .........................................83
Figure 25 – Block diagram for measuring residual NEXT ....................................................84
Figure 26 – Block diagram for measuring dynamic accuracy ...............................................84
Figure 27 – Principle of measurement of residual NEXT .......................................................86
Figure 28 – Principle of alternate measurement of residual FEXT .........................................86
Figure 29 – Alien crosstalk measurement floor test for the channel test configuration ...........89
Figure 30 – Alien crosstalk measurement floor test for the link test configurations ..............90
Figure 31 – Construction details of special patch cord adapter .............................................96
Figure 32 – Interfaces to channel by field test and laboratory equipment to compare test results ........................................................................................................................97
Figure 33 – Interfaces to link test configuration by field test and laboratory equipment to compare test results ..............................................................98
Table 1 – Test balun performance characteristics .........................................................20
Table 2 – Estimated uncertainty of unbalance, near end measurement .........................46
Table 3 – Estimated uncertainty of unbalance, far end measurement ..............................48
Table 4 – Summary of reporting requirements for field test equipment ..............................65
Table 5 – Minimum reporting requirement for PS ANEXT and PS AACR-F .....................68
Table 6 – Worst case propagation delay, delay skew, d.c. resistance and length measurement accuracy for level IIE, level III and level IV test instruments ...............................70
Table 7 – Worst case insertion loss, NEXT, ACR-N, ELFEXT/ACR-F and return loss measurement accuracy for level IIE test instruments ........................................71
Table 8 – Worst case insertion loss, NEXT, ACR-N, ELFEXT/ACR-F and return loss measurement accuracy for level III test instruments ........................................71
Table 9 – Worst case insertion loss, NEXT, ACR-N, ELFEXT/ACR-F and return loss measurement accuracy for level IIIE test instruments ......................................72
Table 10 – Worst case insertion loss, NEXT, ACR-N, ELFEXT/ACR-F and return loss measurement accuracy for level IV test instruments .......................................72
Table 11 – Propagation delay, delay skew, d.c. resistance and length accuracy performance specifications ........................................................................................................73
Table 12 – Level IIE field tester accuracy performance parameters per IEC guidelines ....74
Table 13 – Level III field tester accuracy performance parameters per IEC guidelines ....76
Table 14 – Level IIIE field tester accuracy performance parameters per IEC guidelines ....78
Table 15 – Level IV field tester accuracy performance parameters per IEC guidelines ....80
INTRODUCTION

Telecommunication cabling, once specified uniquely by each telecommunications application, has evolved into a generic cabling system. Telecommunications applications now use the series EN 50173 cabling standard to meet their cabling requirements. Formerly, connectivity tests and visual inspection were deemed sufficient to verify a cabling installation. Now users need more comprehensive testing in order to ensure that the link will support telecommunications applications that are designed to operate on the generic cabling system. This part of IEC 61935 addresses reference laboratory and field test methods and provides a comparison of these methods.

Transmission performance depends on cable characteristics, connecting hardware, patch cords and cross-connect cabling, the total number of connections, and the care with which they are installed and maintained. This standard provides test methods for installed cabling and pre-fabricated cable assemblies. These test methods, where appropriate, are based on those used for components of the cable assembly.

This Part 1 contains the test methods required for installed cabling. Part 2 contains the test methods required for patch cords and work area cables.
1 Scope

This part of EN 61935 specifies reference measurement procedures for cabling parameters and the requirements for field tester accuracy to measure cabling parameters identified in series EN 50173. This standard does not apply to EN 50173-4.

This International Standard applies when the cable assemblies are constructed of cables complying with the IEC 61156 family of standards, and connecting hardware as specified in IEC 60603-7 family of standards or IEC 61076-3-104 and IEC 61076-3-110. In the case where cables and/or connectors do not comply with these standards, then additional tests may be required.

This standard is organized as follows:

- reference laboratory measurement procedures on cabling topologies are specified in Clause 4. In some cases, these procedures may be used in the field;
- descriptions and requirements for measurements in the field are specified in Clause 5;
- performance requirements for field testers and procedures to verify performance are specified in Clause 6.

NOTE 1 This standard does not include tests that are normally performed on the cables and connectors separately. These tests are described in IEC 61156-1 and IEC 60603-7 or IEC 61076-3-104 and IEC 61076-3-110 respectively.

NOTE 2 Wherever possible, cables and connectors used in cable assemblies, even if they are not described in IEC 61156 or IEC 60603-7, IEC 61076-3-104 or IEC 61076-3-110, are tested separately according to the tests given in the relevant generic specification. In this case, most of the environmental and mechanical tests described in this standard may be omitted.

NOTE 3 Users of this standard are advised to consult with applications standards, equipment manufacturers and system integrators to determine the suitability of these requirements for specific networking applications.

This standard relates to performance with respect to 100 Ω cabling. For 120 Ω or 150 Ω cabling, the same principles apply but the measurement system should correspond to the nominal impedance level.

Field tester types include certification, qualification and verification. Certification testing is performed for the rigorous needs of commercial/industrial buildings to this standard. Qualification testing is described in IEC 61935-3. Qualification testing determines whether the cabling will support certain network technologies (e.g., 1000BASE-T, 100BASE-TX, IEEE 1394b). Qualification testers do not have traceable accuracy to national standards and provide confidence that specific applications will work. Verification testers only verify connectivity.

Throughout this document, 4-pair cabling is assumed. The test procedures described in this standard may also be used to evaluate 2-pair balanced cabling. However, 2-pair cabling links that share the same sheath with other links are tested as 4-pair cabling.

---

1) IEEE 1394b: 2002, High Performance Serial Bus (High Speed Supplement)