

Australian/New Zealand Standard™

**Specification for the testing of balanced
and coaxial information technology
cabling**

**Part 1: Installed balanced cabling as
specified in ISO/IEC 11801 and related
standards
(IEC 61935-1, Ed.3.0 (2009) MOD)**



AS/NZS IEC 61935.1:2012

This Joint Australian/New Zealand Standard was prepared by Joint Technical Committee CT-001, Communications Cabling. It was approved on behalf of the Council of Standards Australia on 30 May 2012 and on behalf of the Council of Standards New Zealand on 27 August 2012.

This Standard was published on 7 September 2012.

The following are represented on Committee CT-001:

Australian Chamber of Commerce and Industry
Australian Communications and Electrical Alliance
Australian Communications and Media Authority
Australian Industry Group
Australian Information Industry Association
Australian Telecommunications Users Group
BICSI Australia
Communications Alliance
Consulting Interests New Zealand
Electrical and Communications Association, Qld
Electrical Compliance Testing Association
Electrical Regulatory Authorities Council
Electrical Trades Union
Energy Networks Association
Engineers Australia
National Electrical and Communications Association
New Zealand Consulting Interests
New Zealand Defence Force
Telecommunications Interests
Vendor Interests New Zealand

Keeping Standards up-to-date

Standards are living documents which reflect progress in science, technology and systems. To maintain their currency, all Standards are periodically reviewed, and new editions are published. Between editions, amendments may be issued. Standards may also be withdrawn. It is important that readers assure themselves they are using a current Standard, which should include any amendments which may have been published since the Standard was purchased.

Detailed information about joint Australian/New Zealand Standards can be found by visiting the Standards Web Shop at www.saiglobal.com.au or Standards New Zealand web site at www.standards.co.nz and looking up the relevant Standard in the online catalogue.

For more frequent listings or notification of revisions, amendments and withdrawals, Standards Australia and Standards New Zealand offer a number of update options. For information about these services, users should contact their respective national Standards organization.

We also welcome suggestions for improvement in our Standards, and especially encourage readers to notify us immediately of any apparent inaccuracies or ambiguities. Please address your comments to the Chief Executive of either Standards Australia or Standards New Zealand at the address shown on the back cover.

This Standard was issued in draft form for comment as DR AS/NZS IEC 61935.1.

Australian/New Zealand Standard™

**Specification for the testing of balanced
and coaxial information technology
cabling**

**Part 1: Installed balanced cabling as
specified in ISO/IEC 11801 and related
standards
(IEC 61935-1, Ed.3.0 (2009) MOD)**

Original was AS/NZS 3087:2000.
Previous edition AS/NZS IEC 61935.1:2006.
Second edition 2012.

COPYRIGHT

© Standards Australia Limited/Standards New Zealand

All rights are reserved. No part of this work may be reproduced or copied in any form or by any means, electronic or mechanical, including photocopying, without the written permission of the publisher, unless otherwise permitted under the Copyright Act 1968 (Australia) or the Copyright Act 1994 (New Zealand).

Jointly published by SAI Global Limited under licence from Standards Australia Limited, GPO Box 476, Sydney, NSW 2001 and by Standards New Zealand, Private Bag 2439, Wellington 6140

PREFACE

This Standard was prepared by the Joint Standards Australia/Standards New Zealand Committee CT-001, Communications Cabling to supersede AS/NZS IEC 61935.1:2006, *Testing of balanced communication cabling in accordance with ISO/IEC 11801, Part 1: Installed cabling*.

The objective of this Standard is to provide information about the test equipment and methodology for in-field testing of cabling systems in accordance with AS/NZS 3080, *Telecommunications installations—Generic cabling for customer premises (ISO/IEC 11801, Ed.2.2 (2011) MOD)**. This edition differs from the previous edition in that it includes test methods for exogenous (alien) crosstalk. It also includes a new annex for uncertainty and variability of field test results. Future standards in this series will carry the new general title as cited above. Titles of existing standards in this series will be updated at the time of the next edition.

This Standard is an adoption with national modifications and has been reproduced from IEC 61935-1, Ed. 3.0 (2009), *Specification for the testing of balanced and coaxial information technology cabling—Part 1: Installed balanced cabling as specified in ISO/IEC 11801 and related standards* and has been varied to take account of Australian/New Zealand conditions.

Variations to IEC 61935-1 are listed in Appendix ZZ.

As this Standard is reproduced from an International Standard, the following applies:

- (a) Its number appears on the cover and title page while the International Standard number appears only on the cover.
- (b) In the source text ‘this part of IEC 61935’ should read ‘this Australian/New Zealand Standard’.
- (c) A full point substitutes for a comma when referring to a decimal marker.

References to International Standards should be replaced by references to Australian or Australian/New Zealand Standards, as follows:

<i>Reference to International Standard</i>	<i>Australian/New Zealand Standard</i>
ISO/IEC	AS/NZS
11801 Information technology—Generic cabling for customer premises	3080 Telecommunications installations—Generic cabling for customer premises (ISO/IEC 11801, Ed.2.2 (2011) MOD)*

Only international references that have been adopted as Australian/Australian/New Zealand Standards have been listed.

Variations made to IEC 61935-1, Ed. 3.0 (2009) form the Australian/New Zealand variations for the purposes of the CB scheme for recognition of testing to standards for safety of electrical equipment. They are listed in Appendix ZZ.

The terms ‘normative’ and ‘informative’ have been used in this Standard to define the application of the annex and appendix to which they apply. A ‘normative’ annex and appendix is an integral part of a Standard, whereas an ‘informative’ annex and appendix is only for information and guidance.

* To be published.

CONTENTS

	<i>Page</i>
1 Scope.....	11
2 Normative references	12
3 Terms and definitions	13
4 Reference measurement procedures for electrical properties	15
4.1 General.....	15
4.2 Test equipment considerations	15
4.2.1 General	15
4.2.2 Network analyzer test requirements.....	15
4.2.3 Termination of conductor pairs	16
4.2.4 Reference loads for calibration	17
4.2.5 Test configurations	17
4.2.6 Coaxial cables and test leads for network analyzers.....	18
4.2.7 Balun requirements	19
4.2.8 Network analyzer measurement precautions.....	20
4.2.9 Data reporting and accuracy.....	21
4.3 DC loop resistance	21
4.3.1 Objective	21
4.3.2 Test method	22
4.3.3 Test equipment and set-up	22
4.3.4 Procedure.....	22
4.3.5 Test report.....	22
4.3.6 Uncertainty.....	23
4.4 Direct current (d.c.) resistance of balance	23
4.4.1 Objective	23
4.4.2 Test method.....	23
4.4.3 Test equipment and set-up	23
4.4.4 Procedure.....	23
4.4.5 Test report.....	24
4.4.6 Uncertainty.....	24
4.5 Insertion loss.....	24
4.5.1 Objective	24
4.5.2 Test method	24
4.5.3 Test equipment and set-up	25
4.5.4 Procedure.....	25
4.5.5 Test report.....	26
4.5.6 Temperature correction	26
4.5.7 Uncertainty.....	26
4.6 Propagation delay and delay skew	26
4.6.1 Objective	26
4.6.2 Test method	26
4.6.3 Test equipment and set-up	27
4.6.4 Procedure.....	27
4.6.5 Test report.....	27
4.6.6 Uncertainty.....	27

	<i>Page</i>
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.....	32
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 AACR-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

	<i>Page</i>
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 AACR-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.....	73
6.3	Accuracy performance requirements for level IIE field testers.....	73
6.4	Accuracy performance requirements for level III field testers.....	75
6.5	Accuracy performance requirements for level IIIE field testers.....	77
6.6	Accuracy performance requirements for level IV field testers.....	79
6.7	Accuracy performance requirements for level IV field testers over 600 MHz.....	81
6.8	Field tester requirements applicable to alien crosstalk measurements.....	81
6.9	Procedures for determining field tester parameters.....	81
6.9.1	General.....	81
6.9.2	Output signal balance (<i>OSB</i>).....	82
6.9.3	Common mode rejection (<i>CMR</i>).....	82
6.9.4	Residual NEXT.....	83
6.9.5	Dynamic accuracy.....	84
6.9.6	Source/load return loss.....	85
6.9.7	Random noise floor.....	85
6.9.8	Residual FEXT.....	85
6.9.9	Directivity.....	86
6.9.10	Tracking.....	87
6.9.11	Source match.....	87
6.9.12	Return loss of remote termination.....	87
6.9.13	Constant error term of the propagation delay measurement function.....	88
6.9.14	Error constant term proportional to propagation delay of the propagation delay measurement function.....	88
6.9.15	Constant error term of the delay skew measurement function.....	88
6.9.16	Constant error term of the length measurement function.....	88
6.9.17	Error constant proportional to length of the length measurement function.....	88
6.9.18	Constant error term of the d.c. resistance measurement function.....	88
6.9.19	Error constant term proportional to d.c. resistance of the d.c. resistance measurement function.....	89
6.9.20	Measurement floor for alien crosstalk testing during field testing.....	89
6.9.21	Measurement floor of the test device for the channel test configuration.....	89
6.10	Measurement error models.....	90
6.10.1	General.....	90
6.10.2	Error model for the insertion loss measurement function.....	90
6.10.3	Error model for the NEXT measurement function.....	91
6.10.4	Error model for the power sum NEXT measurement function.....	91
6.10.5	Error model for the ACR-N measurement function.....	91
6.10.6	Error model for the power sum ACR-N measurement function.....	92
6.10.7	Error model for the ELFEXT or ACR-F measurement function.....	92
6.10.8	Error model for the power sum ELFEXT and PS ACR-F measurement functions.....	93
6.10.9	Error model for the return loss measurement function.....	93
6.10.10	Error model for the propagation delay measurement function.....	94
6.10.11	Error model for the delay skew measurement function.....	95
6.10.12	Error model for the length measurement function.....	95
6.10.13	Error model for the d.c. loop resistance measurement function.....	95
6.11	Network analyzer measurement comparisons.....	95

	<i>Page</i>
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

	<i>Page</i>
Figure 34 – Sample scatter plot	100
Figure A.1 – Source of variability during link testing.....	103
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 IIIIE 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 IIIIE 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 ISO/IEC 11801 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.

AUSTRALIAN/NEW ZEALAND STANDARD

Specification for the testing of balanced and coaxial information technology cabling

Part 1:

Installed balanced cabling as specified in ISO/IEC 11801 and related standards (IEC 61935-1, Ed.3.0 (2009) MOD)

1 Scope

This part of IEC 61935 specifies reference measurement procedures for cabling parameters and the requirements for field tester accuracy to measure cabling parameters identified in ISO/IEC 11801. References in this standard to ISO/IEC 11801 mean ISO/IEC 11801 or equivalent cabling standards.

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 1394b¹⁾). 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)*