



**BSI Standards Publication**

## **Connectors for electrical and electronic equipment — Tests and measurements**

---

Part 27-200: Additional specifications for signal integrity tests up to 2 000 MHz on IEC 60603-7 series connectors — Tests 27a to 27g

## National foreword

This Published Document is the UK implementation of IEC PAS 60512-27-200:2018.

The UK participation in its preparation was entrusted to Technical Committee EPL/48, Electromechanical components and mechanical structures for electronic equipment.

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.

© The British Standards Institution 2018  
Published by BSI Standards Limited 2018

ISBN 978 0 539 00842 5

ICS 31.220.10

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

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 31 October 2018.

### Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

---



# IEC PAS 60512-27-200

Edition 1.0 2018-10

## **PUBLICLY AVAILABLE SPECIFICATION PRE-STANDARD**



---

**Connectors for electrical and electronic equipment – Tests and measurements –  
Part 27-200: Additional specifications for signal integrity tests up to 2 000 MHz on  
IEC 60603-7 series connectors – Tests 27a to 27g**

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

ICS 31.220.10

ISBN 978-2-8322-6093-7

**Warning! Make sure that you obtained this publication from an authorized distributor.**

## CONTENTS

FOREWORD.....	8
1 Scope .....	10
2 Normative references .....	10
3 Terms and definitions .....	12
4 Overall test arrangement .....	12
4.1 General.....	12
4.2 Indirect-reference test fixtures .....	12
Annex A (normative) Indirect-reference test fixtures.....	13
A.1 General.....	13
A.2 Requirements .....	13
Annex B (normative) Measurement requirements (general).....	14
B.1 General test configuration .....	14
B.2 Termination of a cable DUT to test system.....	14
B.2.1 General .....	14
B.2.2 Interconnections between the device under test (DUT) and the calibration plane .....	15
B.2.3 Test lead return loss requirements.....	15
B.2.4 Ground plane requirements .....	18
B.2.5 Network analyzer requirements.....	18
B.3 Measurement points and spacing .....	18
B.4 Impedance matching terminations .....	19
B.4.1 General .....	19
B.4.2 Resistor terminations .....	19
B.4.3 Termination return loss performance at the calibration plane .....	20
B.4.4 Termination TCL performance at the calibration plane .....	20
B.4.5 Calibration methods.....	20
B.4.6 Two-port calibration of the test system .....	21
B.4.7 One-port calibration of the test system .....	21
B.5 General calibration plane .....	21
B.5.1 General .....	21
B.5.2 Calibration references .....	22
B.5.3 50 $\Omega$ and 100 $\Omega$ calibration reference load requirements .....	22
B.5.4 Calibration reference load return loss requirement.....	23
B.5.5 Typical test equipment performance parameters .....	23
Annex C (normative) Cabling and component test procedures using baluns .....	24
C.1 Measurement test setup and apparatus.....	24
C.1.1 General .....	24
C.1.2 Balun terminations .....	24
C.1.3 Balun requirements.....	24
C.2 Testing of cabling .....	26
C.2.1 Cabling DC resistance .....	26
C.2.2 Return loss testing of cables and channels .....	27
C.2.3 Insertion loss of cables and channels .....	29
C.2.4 NEXT loss of cables and channels.....	30
C.2.5 FEXT loss of cables and channels .....	32
C.2.6 Cable and channel propagation delay .....	34

C.2.7	TCL of cables and channels.....	34
C.2.8	TCTL of cables and channels .....	38
C.2.9	Cable and channel measurement precautions.....	40
C.2.10	Screened or shielded cable and channel measurement configurations.....	40
C.3	Permanent link test procedures.....	40
C.3.1	General .....	40
C.3.2	Permanent link measurement configurations.....	40
C.3.3	Calibration of permanent link test configurations.....	41
C.3.4	Return loss of permanent links .....	41
C.3.5	Insertion loss of permanent link .....	42
C.3.6	NEXT loss of permanent link.....	42
C.3.7	FEXT loss of permanent link .....	43
C.3.8	TCL of permanent link .....	44
C.3.9	TCTL of permanent link .....	45
C.3.10	Propagation delay of permanent link.....	46
C.4	Direct attach measurement procedures.....	47
C.4.1	Direct attach test configurations.....	47
C.5	Modular cord test procedures.....	50
C.5.1	Network analyzer test configuration .....	50
C.5.2	Test fixturing for modular cords .....	52
C.5.3	Modular cord measurements.....	52
C.6	Connecting hardware testing.....	52
C.6.1	General .....	52
C.6.2	Connecting hardware measurement configurations .....	52
C.6.3	Return loss measurements .....	53
C.6.4	Insertion loss measurements .....	53
C.6.5	NEXT loss measurements.....	54
C.6.6	Test plug characterization.....	56
C.6.7	Category 6A measurement reproducibility.....	72
C.7	Modular cord test head requirements .....	74
C.7.1	General .....	74
C.7.2	Modular cord test head NEXT loss.....	74
C.7.3	Modular cord test head FEXT loss .....	74
C.7.4	Modular cord test head return loss.....	75
C.8	Alien crosstalk measurements.....	75
C.8.1	Cabling ANEXT loss and AFEXT loss laboratory measurement procedures .....	75
C.8.2	ANEXT loss and AFEXT loss of cable .....	77
C.8.3	Connecting Hardware ANEXT loss and AFEXT loss measurements .....	79
Annex D (normative)	Cabling and component balunless test procedures.....	83
D.1	Balunless measurement requirements.....	83
D.2	Resistor terminations used with balunless measurement systems .....	83
D.3	Calibration methods .....	84
D.4	Testing of cables and cabling.....	84
D.4.1	Cabling and cable measurement procedures .....	84
D.4.2	Cabling and cable DC resistance .....	85
D.4.3	Cabling and cable return loss .....	85
D.4.4	Insertion loss of cables and channels .....	86
D.4.5	NEXT loss of cables and channels.....	87

D.4.6	FEXT loss of cables and channels .....	87
D.4.7	TCL of cabling and cables .....	88
D.4.8	TCTL of cabling and cables .....	88
D.4.9	Propagation delay of cabling and cable.....	89
D.5	Permanent link test procedures.....	89
D.5.1	General .....	89
D.5.2	Permanent link measurement configurations.....	89
D.5.3	Calibration of permanent link test configurations.....	89
D.5.4	Return loss of permanent links .....	89
D.5.5	Insertion loss of permanent link .....	90
D.5.6	NEXT loss of permanent link.....	91
D.5.7	FEXT loss of permanent link .....	92
D.5.8	TCL of permanent link .....	93
D.5.9	TCTL of permanent link .....	93
D.5.10	Propagation delay of permanent link.....	94
D.6	Balunless direct attach measurement procedures .....	94
D.7	Balunless modular cord test procedures – Balunless network analyzer test configuration .....	98
D.8	Connecting hardware test procedures .....	100
D.8.1	General .....	100
D.8.2	Connecting hardware measurement configurations .....	100
D.9	Balunless alien crosstalk for cabling, cable and connecting hardware. ....	101
D.9.1	Balunless ANEXT loss and AFEXT loss laboratory measurement procedures .....	101
D.9.2	Balunless connecting hardware ANEXT loss and AFEXT loss procedures .....	101
Annex E (informative)	Connecting hardware test fixtures .....	104
E.1	General.....	104
E.2	Additional components for connection to a network analyzer.....	105
E.3	Direct fixture .....	106
E.4	PCB based test plug assembly.....	106
E.5	Connecting hardware measurement configuration .....	107
E.6	Test fixture calibration .....	108
E.6.1	General .....	108
E.6.2	Calibration and reference plane location.....	112
E.7	DUT connections using header PCB assemblies .....	113
Bibliography	.....	114
Figure B.1	– Example 360° shielded cable termination.....	16
Figure B.2	– Example individually shielded pair cable termination.....	17
Figure B.3	– Test fixture interface pattern .....	17
Figure B.4	– Example pin and socket dimension .....	18
Figure B.5	– Resistor termination networks for balun testing.....	19
Figure B.6	– Balunless resistor termination network.....	20
Figure B.7	– Calibration plane.....	21
Figure C.1	– Measurement configurations for test balun qualification.....	26
Figure C.2	– Balun schematic diagram.....	27
Figure C.3	– Laboratory test configuration for return loss.....	28

Figure C.4 – Laboratory test configuration for insertion loss and propagation delay measurements .....	29
Figure C.5 – Laboratory test configuration for cable and channel NEXT loss .....	31
Figure C.6 – Laboratory test configuration for FEXT loss .....	33
Figure C.7 – Laboratory test configuration for TCL .....	35
Figure C.8 – Coaxial lead through calibration .....	36
Figure C.9 – Back-to-back balun insertion loss measurement .....	36
Figure C.10 – Output terminal connection .....	37
Figure C.11 – Outer shield grounding position .....	37
Figure C.12 – Laboratory test configuration for TCTL .....	39
Figure C.13 – Laboratory test configuration for permanent link return loss and TCL measurements .....	41
Figure C.14 – Laboratory test configuration for permanent link insertion loss and propagation delay measurements .....	42
Figure C.15 – Laboratory test configuration for permanent link NEXT loss measurements .....	43
Figure C.16 – Laboratory test configuration for permanent link FEXT loss (ACRF) .....	44
Figure C.17 – Laboratory test configuration for permanent link TCL measurements .....	45
Figure C.18 – Laboratory test configuration for permanent link TCTL .....	46
Figure C.19 – Direct attach return loss test configuration .....	47
Figure C.20 – Direct attach cord insertion loss test configuration .....	48
Figure C.21 – Direct attach cord NEXT loss test configuration .....	48
Figure C.22 – Direct attach cord FEXT loss, (ACRF) test configuration .....	49
Figure C.23 – Direct attach cord TCL test configuration .....	49
Figure C.24 – Direct attach cord TCTL test configuration .....	50
Figure C.25 – Modular cord return loss test configuration .....	51
Figure C.26 – Modular cord NEXT loss test configuration .....	51
Figure C.27 – Modular cord FEXT loss, (ACRF) test configuration .....	52
Figure C.28 – Female test connector interface mating dimensions (1) .....	58
Figure C.29 – Female test connector interface mating dimensions (2) .....	59
Figure C.30 – Balun fixture PCB paddle card interface mating dimensions .....	60
Figure C.31 – Balunless fixture PCB paddle card interface mating dimensions .....	60
Figure C.32 – Example of a measurement setup for test plug NEXT loss .....	64
Figure C.33 – Example of a measurement setup for test plug FEXT loss .....	65
Figure C.34 – Direct fixture mating dimensions, top view .....	67
Figure C.35 – Direct fixture mating dimensions, front view .....	68
Figure C.36 – Direct fixture mating dimensions, side view .....	68
Figure C.37 – Modular plug placed into the plug clamp .....	69
Figure C.38 – Guiding the plug into position .....	69
Figure C.39 – Calibration planes, test plug phase reference plane, and port extensions .....	70
Figure C.40 – Examples of direct fixture short, open, load, and through artefacts .....	72
Figure C.41 – Inter-laboratory return loss variability for testing category 6A connecting hardware .....	74
Figure C.42 – 6-around-1 cable test configuration .....	78
Figure C.43 – Connecting hardware ANEXT loss measurement setup .....	80

Figure C.44 – Connecting hardware AFEXT loss measurement setup .....	81
Figure C.45 – Example connector configurations for alien crosstalk .....	82
Figure D.1 – Balunless resistor termination network.....	84
Figure D.2 – Laboratory test configuration for cabling and cable return loss and TCL measurements .....	85
Figure D.3 – Laboratory test configuration for cabling and cable insertion loss, TCTL, and propagation delay measurements – Alternate test configuration for return loss and TCL.....	86
Figure D.4 – Laboratory test configuration for cabling and cable NEXT loss.....	87
Figure D.5 – Laboratory test configuration for cabling and cable FEXT loss (ACRF) .....	88
Figure D.6 – Laboratory test configuration for permanent link return loss and TCL measurements .....	90
Figure D.7 – Laboratory test configuration for permanent link insertion loss, TCTL, and propagation delay measurements – Alternate test configuration for return loss and TCL .....	91
Figure D.8 – Laboratory test configuration for permanent link NEXT loss measurements .....	92
Figure D.9 – Laboratory test configuration for permanent link FEXT loss (ACRF).....	93
Figure D.10 – Balunless direct attach cord return loss test configuration.....	95
Figure D.11 – Balunless direct attach insertion loss, TCTL, and propagation delay test configuration – Alternate test configuration for return loss and TCL .....	96
Figure D.12 – Balunless direct attach cord NEXT loss test configuration.....	97
Figure D.13 – Balunless direct attach cord FEXT loss, (ACRF) test configuration .....	98
Figure D.14 – Balunless modular cord NEXT loss test configuration .....	99
Figure D.15 – Balunless modular cord return loss test configuration .....	100
Figure D.16 – Connecting hardware ANEXT loss measurement setup.....	102
Figure D.17 – Connecting hardware AFEXT loss measurement setup .....	103
Figure E.1 – Test head assembly with baluns attached .....	104
Figure E.2 – Test head assembly showing shielding between interconnecting sockets .....	105
Figure E.3 – Plug direct fixture.....	106
Figure E.4 – PCB based plug.....	107
Figure E.5 – PCB based plug assembly with adapter .....	107
Figure E.6 – An example of a connecting hardware measurement configuration .....	108
Figure E.7 – Test fixture interface .....	109
Figure E.8 – Open calibration standard applied to balunless test interface .....	109
Figure E.9 – Short calibration standard applied to balunless test interface .....	110
Figure E.10 – Load calibration standard applied to test interface .....	110
Figure E.11 – A loop back through standard applied to a balunless test interface .....	111
Figure E.12 – Test plug attached to the test interface .....	111
Figure E.13 – Direct fixture mounted to the test head interface .....	112
Figure E.14 – Calibration reference plane .....	112
Figure E.15 – Back-to-back through calibration.....	113
Table A.1 – IEC 60603-7 series, 8-way connector types detail specifications and respective detail connector test procedures standards .....	13
Table B.1 – Interconnection return loss.....	16
Table B.2 – Minimum number of measurement points .....	19



Table B.3 – Calibration reference load return loss requirement .....	23
Table C.1 – Test balun performance characteristics .....	25
Table C.2 – Category 6, 6A and 8 test plug NEXT loss limit vectors .....	55
Table C.3 – Category 5e test plug NEXT loss limit vectors .....	55
Table C.4 – Category 6, 6A and 8 connecting hardware NEXT loss requirements for case 1 and case 4 .....	56
Table C.5 – Category 5e, 6, and 6A test plug NEXT loss ranges .....	62
Table C.6 – Category 8 test plug NEXT loss ranges .....	63
Table C.7 – Test plug FEXT loss ranges .....	64
Table C.8 – Category 5e, 6 and 6A test plug return loss requirements .....	66
Table C.9 – Category 8 test plug return loss requirements .....	66
Table C.10 – Direct fixture performance .....	68
Table C.11 – Category 6A NEXT loss measurement reproducibility between laboratories .....	73
Table C.12 – Category 6A FEXT loss measurement reproducibility between laboratories .....	73
Table C.13 – Category 5e, 6, and 6A modular cord test head return loss .....	75
Table C.14 – Category 8 modular cord test head return loss .....	75

## INTERNATIONAL ELECTROTECHNICAL COMMISSION

---

**CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT –  
TESTS AND MEASUREMENTS –****Part 27-200: Additional specifications for signal integrity tests up to  
2 000 MHz on IEC 60603-7 series connectors – Tests 27a to 27g**

## FOREWORD

- 1) The International Electrotechnical Commission (IEC) is a worldwide organization for standardization comprising all national electrotechnical committees (IEC National Committees). The object of IEC is to promote international co-operation on all questions concerning standardization in the electrical and electronic fields. To this end and in addition to other activities, IEC publishes International Standards, Technical Specifications, Technical Reports, Publicly Available Specifications (PAS) and Guides (hereafter referred to as "IEC Publication(s)"). Their preparation is entrusted to technical committees; any IEC National Committee interested in the subject dealt with may participate in this preparatory work. International, governmental and non-governmental organizations liaising with the IEC also participate in this preparation. IEC collaborates closely with the International Organization for Standardization (ISO) in accordance with conditions determined by agreement between the two organizations.
- 2) The formal decisions or agreements of IEC on technical matters express, as nearly as possible, an international consensus of opinion on the relevant subjects since each technical committee has representation from all interested IEC National Committees.
- 3) IEC Publications have the form of recommendations for international use and are accepted by IEC National Committees in that sense. While all reasonable efforts are made to ensure that the technical content of IEC Publications is accurate, IEC cannot be held responsible for the way in which they are used or for any misinterpretation by any end user.
- 4) In order to promote international uniformity, IEC National Committees undertake to apply IEC Publications transparently to the maximum extent possible in their national and regional publications. Any divergence between any IEC Publication and the corresponding national or regional publication shall be clearly indicated in the latter.
- 5) IEC itself does not provide any attestation of conformity. Independent certification bodies provide conformity assessment services and, in some areas, access to IEC marks of conformity. IEC is not responsible for any services carried out by independent certification bodies.
- 6) All users should ensure that they have the latest edition of this publication.
- 7) No liability shall attach to IEC or its directors, employees, servants or agents including individual experts and members of its technical committees and IEC National Committees for any personal injury, property damage or other damage of any nature whatsoever, whether direct or indirect, or for costs (including legal fees) and expenses arising out of the publication, use of, or reliance upon, this IEC Publication or any other IEC Publications.
- 8) Attention is drawn to the Normative references cited in this publication. Use of the referenced publications is indispensable for the correct application of this publication.
- 9) Attention is drawn to the possibility that some of the elements of this IEC Publication may be the subject of patent rights. IEC shall not be held responsible for identifying any or all such patent rights.

A PAS is a technical specification not fulfilling the requirements for a standard, but made available to the public.

IEC PAS 60512-27-200 has been processed by subcommittee 48B: Electrical connectors, of IEC technical committee 48: Electrical connectors and mechanical structures for electrical and electronic equipment.

The text of this PAS is based on the following document:

This PAS was approved for publication by the P-members of the committee concerned as indicated in the following document

Draft PAS	Report on voting
48B/2652/DPAS	48B/2673/RVDPAS

Following publication of this PAS, which is a pre-standard publication, the technical committee or subcommittee concerned may transform it into an International Standard.

A list of all parts of IEC 60512 series, under the general title *Connectors for electrical and electronic equipment – Tests and measurements* can be found on the IEC website.

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 PAS shall remain valid for an initial maximum period of 3 years starting from the publication date. The validity may be extended for a single period up to a maximum of 3 years, at the end of which it shall be published as another type of normative document, or shall be withdrawn.

**IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.**

## CONNECTORS FOR ELECTRICAL AND ELECTRONIC EQUIPMENT – TESTS AND MEASUREMENTS –

### Part 27-200: Additional specifications for signal integrity tests up to 2 000 MHz on IEC 60603-7 series connectors – Tests 27a to 27g

#### 1 Scope

This part of IEC 60512 covers additional, supplemental specifications for signal integrity and transmission performance test methods of IEC 60512-27-100, for connectors using de-embedded crosstalk measurements, which are specified in respective parts of IEC 60603-7 standards for connecting hardware applications up to 2 000 MHz.

These additional specifications are also applicable for testing the related lower frequency connectors. However, the test methodology specified in the detail specification for any given connector remains the reference conformance test for that connector.

Test procedures of IEC 60512-27-100 affected by these supplemental methods and procedures are:

- insertion loss, test 27a;
- return loss, test 27b;
- near-end crosstalk (NEXT) test 27c;
- far-end crosstalk (FEXT), test 27d;
- transverse conversion loss (TCL), test 27f;
- transverse conversion transfer loss (TCTL), test 27g.

Other test procedures referenced here are:

- transfer impedance ( $Z_T$ ), see test procedures in IEC 62153-4-6 or IEC 62153-4-7.
- for coupling attenuation ( $a_C$ ), see test procedures in IEC 62153-4-7 or IEC 62153-4-12.

#### 2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

IEC 60050-581, *International Electrotechnical Vocabulary (IEV) – Part 581: Electromechanical components for electronic equipment*

IEC 60512-1, *Connectors for electronic equipment – Tests and measurements – Part 1: General*

IEC 60512-26-100, *Connectors for electronic equipment – Tests and measurements – Part 26-100: Measurement setup, test and reference arrangement and measurements for connectors according to IEC 60603-7 – Tests 26a to 26g*

IEC 60512-27-100, *Connectors for electronic equipment – Tests and measurements – Part 27-100: Signal integrity tests up to 500 MHz on 60603-7 series connectors – Tests 27a to 27g*