

# INTERNATIONAL STANDARD



**Integrated circuits – EMC evaluation of transceivers –  
Part 5: Ethernet transceivers**  
**ITU STANDARD PREVIEW**  
**(standards.iteh.ai)**

[IEC 62228-5:2021](#)

<https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021>



**THIS PUBLICATION IS COPYRIGHT PROTECTED**  
**Copyright © 2021 IEC, Geneva, Switzerland**

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm, without permission in writing from either IEC or IEC's member National Committee in the country of the requester. If you have any questions about IEC copyright or have an enquiry about obtaining additional rights to this publication, please contact the address below or your local IEC member National Committee for further information.

IEC Central Office  
3, rue de Varembe  
CH-1211 Geneva 20  
Switzerland

Tel.: +41 22 919 02 11  
[info@iec.ch](mailto:info@iec.ch)  
[www.iec.ch](http://www.iec.ch)

**About the IEC**

The International Electrotechnical Commission (IEC) is the leading global organization that prepares and publishes International Standards for all electrical, electronic and related technologies.

**About IEC publications**

The technical content of IEC publications is kept under constant review by the IEC. Please make sure that you have the latest edition, a corrigendum or an amendment might have been published.

**IEC publications search - [webstore.iec.ch/advsearchform](http://webstore.iec.ch/advsearchform)**

The advanced search enables to find IEC publications by a variety of criteria (reference number, text, technical committee, ...). It also gives information on projects, replaced and withdrawn publications.

**IEC online collection - [oc.iec.ch](http://oc.iec.ch)**

Discover our powerful search engine and read freely all the publications previews. With a subscription you will always have access to up to date content tailored to your needs.

**IEC Just Published - [webstore.iec.ch/justpublished](http://webstore.iec.ch/justpublished)**

Stay up to date on all new IEC publications. Just Published details all new publications released. Available online and once a month by email.

**Electropedia - [www.electropedia.org](http://www.electropedia.org)**

The world's leading online dictionary on electrotechnology, containing more than 22 000 terminological entries in English and French, with equivalent terms in 18 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

**IEC Customer Service Centre - [webstore.iec.ch/csc](http://webstore.iec.ch/csc)**

If you wish to give us your feedback on this publication or need further assistance, please contact the Customer Service Centre: [sales@iec.ch](mailto:sales@iec.ch).

[IEC 62228-5:2021](https://standards.iteh.ai/catalog/standards/sis/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021)

---

<https://standards.iteh.ai/catalog/standards/sis/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021>



IEC 62228-5

Edition 1.0 2021-04

# INTERNATIONAL STANDARD



---

**Integrated circuits – EMC evaluation of transceivers –  
Part 5: Ethernet transceivers**

**ITIH STANDARD PREVIEW**  
**(standards.iteh.ai)**

[IEC 62228-5:2021](https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021)

<https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021>

INTERNATIONAL  
ELECTROTECHNICAL  
COMMISSION

---

ICS 31.200

ISBN 978-2-8322-9697-4

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

## CONTENTS

FOREWORD.....	8
1 Scope.....	10
2 Normative references .....	10
3 Terms, definitions and abbreviated terms .....	11
3.1 Terms and definitions.....	11
3.2 Abbreviated terms.....	12
4 General .....	13
5 Test and operating conditions.....	14
5.1 Supply and ambient conditions.....	14
5.2 Test operation modes .....	14
5.2.1 General .....	14
5.2.2 Transceiver configuration for normal operation mode.....	15
5.2.3 Transceiver configuration for low power mode .....	15
5.3 Definition of BIN.....	15
5.4 Test configuration .....	16
5.4.1 General configuration for transceiver network .....	16
5.4.2 General configuration for single transceiver .....	18
5.4.3 Transceiver network tests – coupling ports and networks for conducted tests .....	18
5.4.4 Single transceiver tests – coupling ports and networks .....	21
5.5 Test communication and signals .....	22
5.5.1 General .....	22
5.5.2 Test signals for normal operation mode.....	22
5.5.3 Test signals for low power mode.....	23
5.6 Evaluation criteria .....	23
5.6.1 General .....	23
5.6.2 Evaluation criteria for functional operation modes.....	23
5.6.3 Evaluation criteria in unpowered condition after exposure to disturbances .....	24
5.6.4 Status classes .....	25
5.7 DUT specific information .....	26
6 Test and measurement .....	26
6.1 Emission of conducted RF disturbances.....	26
6.1.1 Test method .....	26
6.1.2 Test setup .....	26
6.1.3 Test procedure and parameters .....	27
6.2 Immunity to conducted RF disturbances.....	28
6.2.1 Test method .....	28
6.2.2 Test setup .....	28
6.2.3 Test procedure and parameters .....	29
6.3 Immunity to impulses .....	33
6.3.1 Test method .....	33
6.3.2 Test setup .....	33
6.3.3 Test procedure and parameters .....	34
6.4 Electrostatic Discharge (ESD).....	36
6.4.1 Test method .....	36
6.4.2 Test setup .....	36

6.4.3	Test procedure and parameters .....	41
7	Test report.....	43
Annex A (normative)	Ethernet test circuits .....	44
A.1	General.....	44
A.2	Test circuit for Ethernet transceivers for functional tests .....	44
A.3	Test circuit for Ethernet transceivers for ESD test.....	46
Annex B (normative)	Test circuit boards.....	49
B.1	Test circuit board for transceiver network configuration.....	49
B.2	Test circuit board for single transceiver configuration.....	51
Annex C (informative)	Test of Ethernet transceiver for radiated RF emission and RF immunity .....	53
C.1	General.....	53
C.2	General configuration for transceiver network .....	53
C.3	Tests .....	54
C.3.1	General .....	54
C.3.2	Emission of radiated RF disturbances.....	58
C.3.3	Immunity to radiated RF disturbances.....	59
Annex D (informative)	Examples for test limits for Ethernet transceiver in automotive application .....	63
D.1	General.....	63
D.2	Emission of conducted RF disturbances.....	63
D.3	Immunity to conducted RF disturbances.....	64
D.4	Immunity to impulses .....	68
D.5	Electrostatic discharge (ESD).....	68
D.6	Emission of radiated RF disturbances.....	69
D.7	Immunity to radiated RF disturbances.....	70
Annex E (informative)	Characterization of common mode chokes for EMC evaluation of Ethernet transceivers .....	72
E.1	General.....	72
E.2	Test .....	72
E.2.1	General .....	72
E.2.2	S-parameter measurement mixed mode.....	73
E.2.3	ESD damage .....	80
E.2.4	Saturation test at RF disturbances.....	82
E.2.5	Saturation test at ESD .....	85
E.2.6	TDR measurement of differential mode impedance.....	87
Annex F (informative)	Characterization of ESD suppression devices for EMC evaluation of Ethernet transceivers .....	89
F.1	General.....	89
F.2	Test .....	90
F.2.1	General .....	90
F.2.2	S-parameter measurement mixed mode.....	91
F.2.3	ESD damage .....	97
F.2.4	ESD discharge current measurement.....	100
F.2.5	Test of unwanted clamping effect at RF immunity tests.....	104
Bibliography.....		108
Figure 1 – Minimum MDI interface test network (Min-BIN).....		16
Figure 2 – Standard MDI interface test network (Std-BIN).....		16

Figure 3 – Optimized MDI interface test network (Opt-BIN) .....	16
Figure 4 – General test configuration for tests in transceiver network for conducted tests .....	17
Figure 5 – General test configuration for unpowered ESD test .....	18
Figure 6 – Transceiver network tests – coupling ports and networks .....	19
Figure 7 – Coupling ports and networks for unpowered ESD tests .....	22
Figure 8 – Principle drawing of the maximum deviation on an I-V characteristic .....	25
Figure 9 – Test setup for measurement of conducted RF disturbances .....	27
Figure 10 – Test setup for DPI tests .....	29
Figure 11 – Test setup for impulse immunity tests .....	33
Figure 12 – Test setup for powered ESD tests – principle arrangement .....	36
Figure 13 – Test setup for powered ESD tests – stimulation and monitoring .....	37
Figure 14 – Test setup for unpowered ESD tests – principle arrangement .....	38
Figure 15 – Test setup for unpowered ESD tests – stimulation and monitoring for function validation pre and post ESD test .....	40
Figure A.1 – General drawing of the circuit diagram of test network for 100BASE-T1 and 1000BASE-T1 Ethernet transceivers for functional test using conducted test methods .....	45
Figure A.2 – General drawing of the circuit diagram of test network for 100BASE-TX Ethernet transceivers for functional test using conducted test methods .....	46
Figure A.3 – General drawing of the circuit diagram for ESD tests of Ethernet transceivers in powered mode .....	47
Figure A.4 – General drawing of the circuit diagram for ESD tests of Ethernet transceivers in unpowered mode .....	48
Figure B.1 – Example of functional conducted test board for Ethernet transceiver ICs (100BASE-T1) .....	49
Figure B.2 – Example of powered ESD test board for Ethernet transceivers ICs (100BASE-T1) .....	50
Figure B.3 – Example of unpowered ESD test board for Ethernet transceivers ICs (100BASE-T1), top layer .....	51
Figure B.4 – Example of unpowered ESD test board for Ethernet transceivers ICs (100BASE-T1), bottom layer .....	51
Figure C.1 – General test configuration for tests in transceiver network used for radiated tests .....	53
Figure C.2 – General drawing of the circuit diagram of test network for 100BASE-T1 and 1000BASE-T1 Ethernet transceivers for functional test using radiated RF test methods .....	55
Figure C.3 – Example of functional radiated test board for Ethernet transceiver ICs (100BASE-T1), top layer (DUT side) .....	56
Figure C.4 – Example of functional radiated test board for Ethernet transceiver ICs (100BASE-T1), bottom layer (external circuitry side) .....	57
Figure C.5 – Test setup for measurement of radiated RF emission .....	58
Figure C.6 – Test setup for radiated RF immunity tests .....	60
Figure D.1 – Example of limits for conducted RF emission – MDI Opt-BIN, $V_{BAT}$ and WAKE .....	63
Figure D.2 – Example of limits for conducted RF emission – local supplies .....	64
Figure D.3 – Example of limits for conducted RF immunity for functional status class A <sub>1C</sub> – MDI Opt-BIN .....	65

Figure D.4 – Example of limits for conducted RF immunity for functional status class A <sub>IC</sub> – V <sub>BAT</sub> and WAKE.....	65
Figure D.5 – Example of limits for conducted RF immunity for functional status class C <sub>IC</sub> or D <sub>IC</sub> – MDI Opt-BIN .....	67
Figure D.6 – Example of limits for conducted RF immunity for functional status class C <sub>IC</sub> or D <sub>IC</sub> – V <sub>BAT</sub> and WAKE .....	67
Figure D.7 – Example of limits for radiated RF emission for IC stripline with 6,7 mm active conductor height.....	69
Figure D.8 – Example of limits for radiated RF immunity .....	70
Figure E.1 – General electrical drawing of a CMC .....	72
Figure E.2 – Test setup for S-parameter measurements at CMC.....	73
Figure E.3 – Example of test board 4-port S-parameter measurement at CMC – mixed mode, top layer.....	74
Figure E.4 – Example of test board 3-port S-parameter measurement at CMC – single ended, top layer.....	74
Figure E.5 – Recommended characteristics for $S_{dd11}$ , $S_{dd22}$ (RL) for CMC.....	77
Figure E.6 – Recommended characteristics for $S_{dd21}$ (IL) for CMC.....	78
Figure E.7 – Recommended characteristics for $S_{cc21}$ (CMR) for CMC .....	78
Figure E.8 – Recommended characteristics for $S_{dc11}$ , $S_{dc22}$ (LCL) for CMC .....	79
Figure E.9 – Recommended characteristics for $S_{sd21}$ , $S_{sd12}$ (DCMR) and $S_{ds21}$ , $S_{ds12}$ (CDMR) for CMC .....	79
Figure E.10 – Test setup for ESD damage tests at CMC .....	80
Figure E.11 – Example of ESD test board for CMC, top layer.....	81
Figure E.12 – Test setup for RF saturation measurements at CMC .....	83
Figure E.13 – Example of RF saturation / S-parameter test board for CMC, top layer.....	83
Figure E.14 – Test setup for ESD saturation measurements at CMC.....	85
Figure E.15 – Example of ESD saturation test board for CMC, top layer .....	85
Figure E.16 – Example of ESD saturation tests results for CMC.....	87
Figure E.17 – Test setup for TDR measurement at CMC .....	87
Figure E.18 – Example of TDR test board for CMC, top layer.....	88
Figure F.1 – Arrangement of ESD suppression device within the 100BASE-T1 and 1000BASE-T1 MDI interface .....	90
Figure F.2 – Test setup for S-parameter measurements at ESD suppression device .....	91
Figure F.3 – Example of test board 4-port S-parameter measurement for ESD suppression device – mixed mode, top layer.....	92
Figure F.4 – Example of test board 3-port S-parameter measurement for ESD suppression device – single ended, top layer.....	92
Figure F.5 – Recommended characteristics for $S_{dd11}$ (RL) for ESD suppression device .....	95
Figure F.6 – Recommended characteristics for $S_{dd21}$ (IL) for ESD suppression device.....	95
Figure F.7 – Recommended characteristics for $S_{sd21}$ (DCMR) for ESD suppression device.....	96
Figure F.8 – Test setup for ESD damage tests at ESD suppression device .....	97
Figure F.9 – Example of ESD test board for ESD suppression device, top layer.....	98
Figure F.10 – Test setup for ESD discharge current measurement at ESD suppression device.....	100

Figure F.11 – Example of ESD discharge current test board for ESD suppression device, top and bottom layer .....	101
Figure F.12 – Example of test results and recommended limits for remaining ESD discharge current after the MDI test network for ESD suppression device .....	103
Figure F.13 – Test setup for RF clamping test at ESD suppression device .....	104
Figure F.14 – Example of test board RF clamping test at suppression device, top layer .....	105
Figure F.15 – Recommended test power levels for RF clamping tests at ESD suppression device .....	107
Table 1 – Overview of measurements and tests .....	13
Table 2 – Supply and ambient conditions for functional operation .....	14
Table 3 – Definition for transceiver configuration for normal operation mode .....	15
Table 4 – Definition for transceiver mode configuration for low power mode .....	15
Table 5 – Selection recommendation of MII interfaces for transceiver network configuration .....	18
Table 6 – Transceiver network tests – component value definitions of coupling ports and networks .....	20
Table 7 – Definitions of coupling ports for unpowered ESD tests .....	22
Table 8 – Definition for transceiver mode configuration for normal operation mode .....	23
Table 9 – Evaluation criteria for Ethernet transceiver .....	24
Table 10 – Definition of functional status classes .....	25
Table 11 – Settings of the conducted RF measurement equipment .....	27
Table 12 – Conducted emission measurements .....	28
Table 13 – Specifications for DPI tests .....	30
Table 14 – DPI tests for functional status class A <sub>IC</sub> evaluation of Ethernet transceivers .....	31
Table 15 – DPI tests for functional status class C <sub>IC</sub> or D <sub>IC</sub> evaluation of Ethernet transceivers .....	32
Table 16 – Specifications for impulse immunity tests .....	34
Table 17 – Parameters for impulse immunity test .....	34
Table 18 – Impulse immunity tests for functional status class A <sub>IC</sub> evaluation of Ethernet transceivers .....	35
Table 19 – Impulse immunity tests for functional status class C <sub>IC</sub> or D <sub>IC</sub> evaluation of Ethernet transceivers .....	35
Table 20 – Specifications for ESD tests .....	41
Table 21 – ESD tests in powered mode for functional status class A <sub>IC</sub> , C <sub>IC</sub> and D <sub>IC</sub> evaluation of Ethernet transceivers .....	42
Table 22 – ESD tests in unpowered mode for functional status class D <sub>IC</sub> evaluation of Ethernet transceiver ICs .....	43
Table B.1 – Parameter ESD test circuit board .....	52
Table C.1 – Settings of the radiated RF measurement equipment .....	59
Table C.2 – Radiated RF emission measurements .....	59
Table C.3 – Specifications for radiated RF immunity tests .....	61
Table C.4 – Radiated RF immunity tests for functional status class A <sub>IC</sub> evaluation of Ethernet transceivers .....	62
Table D.1 – Example of limits for conducted RF emission – test cases with recommended limit classes .....	64



Table D.2 – Example of limits for conducted RF immunity – test cases with recommended limit classes for functional status class A <sub>IC</sub> .....	66
Table D.3 – Example of limits for conducted RF immunity – test cases with recommended limit classes for functional status class C <sub>IC</sub> or D <sub>IC</sub> .....	68
Table D.4 – Example of limits for impulse immunity – Class I .....	68
Table D.5 – Example of limits for impulse immunity – test cases with recommended limit classes for functional status class C <sub>IC</sub> or D <sub>IC</sub> .....	68
Table D.6 – Example of limits for powered and unpowered ESD tests – test cases with recommended limits for functional status class A1 <sub>IC</sub> , A2 <sub>IC</sub> , A3 <sub>IC</sub> , C <sub>IC</sub> or D <sub>IC</sub> .....	69
Table D.7 – Example of limits for radiated RF emission – test cases with recommended limit classes .....	70
Table D.8 – Example of limits for radiated RF immunity – test cases with recommended limit classes .....	71
Table E.1 – Test procedure and parameters for 3-port test board characterization for CMC .....	75
Table E.2 – Test procedure and parameters for S-parameter measurements at CMC .....	76
Table E.3 – Required S-parameter measurements for CMC .....	77
Table E.4 – Test parameters for ESD damage tests at CMC .....	81
Table E.5 – Required ESD tests for damage for CMC .....	82
Table E.6 – Test procedure and parameters for RF saturation tests at CMC .....	84
Table E.7 – Required RF saturation tests for CMC .....	84
Table E.8 – Test procedure and parameters for ESD saturation tests at CMC .....	86
Table E.9 – Required ESD saturation tests for CMC .....	86
Table E.10 – ESD saturation break down voltage classes for CMC .....	86
Table E.11 – Test procedure and parameters for TDR measurement at CMC .....	88
Table E.12 – Required TDR measurements for CMC .....	88
Table F.1 – Specification of ESD suppression device .....	89
Table F.2 – Test procedure and parameters for 3-port test board characterization for ESD suppression device .....	93
Table F.3 – Test procedure and parameters for S-parameter measurements at ESD suppression device .....	94
Table F.4 – Required S-parameter measurements for ESD suppression device .....	94
Table F.5 – Test parameters for ESD damage tests at ESD suppression device .....	99
Table F.6 – Required ESD tests for damage for ESD suppression device .....	99
Table F.7 – Test parameters for ESD discharge current measurement at ESD suppression device .....	102
Table F.8 – Required current measurement for ESD suppression device .....	102
Table F.9 – Recommended limits for remaining ESD discharge current after the MDI test network for ESD suppression device .....	103
Table F.10 – Limit classes and related applied ESD test voltages .....	104
Table F.11 – Test procedure and parameters for RF clamping tests at ESD suppression device .....	106
Table F.12 – Required RF clamping tests for ESD suppression device .....	107

INTERNATIONAL ELECTROTECHNICAL COMMISSION

**INTEGRATED CIRCUITS –  
EMC EVALUATION OF TRANSCEIVERS –**

**Part 5: Ethernet transceivers**

**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.

International Standard IEC 62228-5 has been prepared by subcommittee 47A: Integrated circuits, of IEC technical committee 47: Semiconductor devices.

The text of this International Standard is based on the following documents:

Draft	Report on voting
47A/1115/FDIS	47A/1117/RVD

Full information on the voting for its approval can be found in the report on voting indicated in the above table.

The language used for the development of this International Standard is English.

This document was drafted in accordance with ISO/IEC Directives, Part 2, and developed in accordance with ISO/IEC Directives, Part 1 and ISO/IEC Directives, IEC Supplement, available at [www.iec.ch/members\\_experts/refdocs](http://www.iec.ch/members_experts/refdocs). The main document types developed by IEC are described in greater detail at [www.iec.ch/standardsdev/publications](http://www.iec.ch/standardsdev/publications).

The committee has decided that the contents of this document will remain unchanged until the stability date indicated on the IEC website under "<http://webstore.iec.ch>" in the data related to the specific document. At this date, the document will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

**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.**

## iTeh STANDARD PREVIEW (standards.iteh.ai)

[IEC 62228-5:2021](#)

<https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021>

# INTEGRATED CIRCUITS – EMC EVALUATION OF TRANSCEIVERS –

## Part 5: Ethernet transceivers

### 1 Scope

This part of IEC 62228 specifies test and measurement methods for EMC evaluation of Ethernet transceiver ICs under network condition. It defines test configurations, test conditions, test signals, failure criteria, test procedures, test setups and test boards. It is applicable for transceiver of the Ethernet systems

- 100BASE-T1 according to ISO/IEC/IEEE 8802-3/AMD1;
- 100BASE-TX according to ISO/IEC/IEEE 8802-3;
- 1000BASE-T1 according to ISO/IEC/IEEE 8802-3/AMD4

and covers

- the emission of RF disturbances;
- the immunity against RF disturbances;
- the immunity against impulses;
- the immunity against electrostatic discharges (ESD).

### 2 Normative references

[IEC 62228-5:2021](https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021)

<https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d2f9f/iec-62228-5-2021>

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 61967-1, *Integrated circuits – Measurement of electromagnetic emissions – Part 1: General conditions and definitions*

IEC 61967-4, *Integrated circuits – Measurement of electromagnetic emissions, 150 kHz to 1 GHz – Part 4: Measurement of conducted emissions, 1 ohm/150 ohm direct coupling method*

IEC 62132-1, *Integrated circuits – Measurement of electromagnetic immunity – Part 1: General conditions and definitions*

IEC 62132-4, *Integrated circuits – Measurement of electromagnetic immunity 150 kHz to 1 GHz – Part 4: Direct RF power injection method*

IEC 62215-3, *Integrated circuits – Measurement of impulse immunity – Part 3: Non-synchronous transient injection method*

IEC 62228-1, *Integrated circuits – EMC evaluation of transceivers – Part 1: General conditions and definitions*

ISO 10605, *Road vehicles – Test methods for electrical disturbances from electrostatic discharge*

ISO 21111-2, *Road vehicles – In-vehicle Ethernet – Part 2: Common physical entity requirements*

ISO 7637-2, *Road vehicles – Electrical disturbances from conduction and coupling – Part 2: Electrical transient conduction along supply lines only*

ISO/IEC/IEEE 8802-3:2017, *Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet*

ISO/IEC/IEEE 8802-3:2017/AMD1:2017, *Amendment 1 – Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet – Physical layer specifications and management parameters for 100 Mb/s operation over a single balanced twisted pair cable (100BASE-T1)*

ISO/IEC/IEEE 8802-3:2017/AMD4:2017, *Amendment 4 – Information technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 3: Standard for Ethernet – Physical layer specifications and management parameters for 1 Gb/s operation over a single twisted-pair copper cable*

Electronic Components Industry Association, EIA-198-1, *Ceramic Dielectric Capacitors Classes I, II, III and IV*

## iTeh STANDARD PREVIEW (standards.iteh.ai)

### 3 Terms, definitions and abbreviated terms

For the purposes of this document, the terms and definitions given in IEC 61967-1, IEC 62132-1, IEC 62228-1, as well as the following apply.

<https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1914023297ec/iec-62228-5-2021>

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

- ISO Online browsing platform: available at <http://www.iso.org/obp>
- IEC Electropedia: available at <http://www.electropedia.org/>

#### 3.1 Terms and definitions

##### 3.1.1

##### **100BASE-T1 transceiver**

transceiver 100 Mbit/s via single balanced twisted pair, with a functionality according to ISO/IEC/IEEE 8802-3/AMD1 (100BASE-T1)

##### 3.1.2

##### **100BASE-TX transceiver**

transceiver 100 Mbit/s via two balanced twisted pairs, with a functionality according to ISO/IEC/IEEE 8802-3(100BASE-TX)

##### 3.1.3

##### **1000BASE-T1 transceiver**

transceiver 1000 Mbit/s via single balanced twisted pair, with a functionality according to ISO/IEC/IEEE 8802-3/AMD4 (1000BASE-T1)

##### 3.1.4

##### **global pin**

pin that carries a signal or power, which enters or leaves the application board without any active component in between

**3.1.5****local pin**

pin that carries a signal or power, which does not leave the application board

**3.1.6****mandatory components****pl**

components needed for proper function and/or technical requirement of IC as specified by the IC manufacturer

**3.1.7****switch**

IC with integrated Ethernet transceivers and switch functionality as defined in ISO/IEC/IEEE 8802-3

**3.2 Abbreviated terms**

ASIC	Application specific integrated circuit
BIN	Bus interface network
BIST	Built in self-test
CMC	Common mode choke
CDMR	Common to differential mode conversion ratio
CMR	Common mode rejection
DCMR	Differential to common mode conversion ratio
DPI	Direct RF power injection
DTT	Data transfer test
DUT	Device under test
FPGA	Field programmable gate array
GMII	Gigabit media independent interface
GPIO	General purpose input or output
IL	Insertion loss
INH	Inhibit
LCL	Longitudinal conversion loss
LPF	Low pass filter
MDI	Medium dependent interface
MII	Media independent interface
PCB	Printed circuit board
PRBS	Pseudo random bit stream
PHY	Ethernet single transceiver
RGMII	Reduced gigabit media independent interface
RL	Return loss
RS-FEC	Reed Solomon forward error correction
SBC	System base chip
SGMII	Serial gigabit media independent interface
SNR	Signal-to-noise ratio
S-parameter	Scattering parameter
SQI	Signal quality indicator
TDR	Time domain reflectometry

TLP	Transmission line pulse
VNA	Vector network analyzer

#### 4 General

The intention of this document is to evaluate the EMC performance of Ethernet transceivers under application conditions in a minimal network.

The evaluation of the EMC characteristics of Ethernet transceivers shall be performed for the implemented functional operation modes as defined in Table 1 under network condition for conducted RF emission and RF immunity tests and impulse immunity tests and on a single transceiver IC for electrostatic discharge tests.

The aim of these tests is to determine the EMC performance on dedicated pins of the Ethernet transceiver which are considered as EMC relevant in the application. For an Ethernet transceiver, these pins are global pins like MDIP, MDIN,  $V_{BAT}$  and WAKE as well as local pins like power supply inputs ( $V_{DDX}$ ). The global pin WAKE is given as an example and represents any global pin other than MDI and voltage supply  $V_{BAT}$ .

If the DUT includes additional product specific EMC relevant pins (functions), it shall be tested as well. The test conditions and failure validation criteria shall be adapted to the definitions for the standard functionality of Ethernet transceivers.

The test methods used for the EMC characterization are based on the international standards for IC EMC tests and are described in Table 1.

IEC 62228-5:2021  
<https://standards.iteh.ai/catalog/standards/sist/70278798-8a4c-4822-8c35-1f14f02d29f7/iec-62228-5-2021>  
**Table 1 – Overview of measurements and tests**

Configuration	Test	Test method	Evaluation	Functional operation mode
Transceiver network	RF conducted emission (EMI)	150 $\Omega$ direct coupling (IEC 61967-4)	Spectrum	Normal
	RF conducted immunity (RF)	DPI (IEC 62132-4)	Function	Normal
				Low power
	Impulse immunity (IMP)	Non-synchronous transient injection (IEC 62215-3)	Function	Normal
ESD powered	Contact discharge (ISO 10605)	Function	Normal	
			Low power	
Single transceiver	ESD unpowered	Contact discharge (ISO 10605)	Damage	Unpowered

The 150  $\Omega$  direct coupling, DPI and impulse immunity test methods are chosen for the evaluation of the conducted EMC characteristic of transceivers in network condition. These three test methods are based on the same approach using conductive coupling. Therefore, it is possible to use the same test board for all tests in functional operation mode, which reduces the effort and increases the reproducibility and comparability of test results.

Powered ESD test will be performed using the same approach of testing the Ethernet transceiver under network conditions but a modified test board is used because of RF and ESD tests cannot be combined on one test board if all specific test conditions of each test method should be covered.