

INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Components for low-voltage surge protection –
Part 341: Performance requirements and test circuits for thyristor surge
suppressors (TSS)**

**Composants pour parafoudres basse tension –
Partie 341: Exigences de performance et circuits d'essai pour parafoudres
à thyristor (TSS)**





THIS PUBLICATION IS COPYRIGHT PROTECTED

Copyright © 2020 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.

Droits de reproduction réservés. Sauf indication contraire, aucune partie de cette publication ne peut être reproduite ni utilisée sous quelque forme que ce soit et par aucun procédé, électronique ou mécanique, y compris la photocopie et les microfilms, sans l'accord écrit de l'IEC ou du Comité national de l'IEC du pays du demandeur. Si vous avez des questions sur le copyright de l'IEC ou si vous désirez obtenir des droits supplémentaires sur cette publication, utilisez les coordonnées ci-après ou contactez le Comité national de l'IEC de votre pays de résidence.

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

Tel.: +41 22 919 02 11
info@iec.ch
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

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 It also gives information on projects, replaced and withdrawn publications.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 Just Published - 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.

IEC Customer Service Centre - 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.

Electropedia - 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 16 additional languages. Also known as the International Electrotechnical Vocabulary (IEV) online.

IEC Glossary - std.iec.ch/glossary

67 000 electrotechnical terminology entries in English and French extracted from the Terms and Definitions clause of IEC publications issued since 2002. Some entries have been collected from earlier publications of IEC TC 37, 77, 86 and CISPR.

A propos de l'IEC

La Commission Electrotechnique Internationale (IEC) est la première organisation mondiale qui élabore et publie des Normes internationales pour tout ce qui a trait à l'électricité, à l'électronique et aux technologies apparentées.

A propos des publications IEC

Le contenu technique des publications IEC est constamment revu. Veuillez vous assurer que vous possédez l'édition la plus récente, un corrigendum ou amendement peut avoir été publié.

Recherche de publications IEC -

webstore.iec.ch/advsearchform

La recherche avancée permet de trouver des publications IEC en utilisant différents critères (numéro de référence, texte, comité d'études,...). Elle donne aussi des informations sur les projets et les publications remplacées ou retirées.

IEC Just Published - webstore.iec.ch/justpublished

Restez informé sur les nouvelles publications IEC. Just Published détaille les nouvelles publications parues. Disponible en ligne et une fois par mois par email.

Service Clients - webstore.iec.ch/csc

Si vous désirez nous donner des commentaires sur cette publication ou si vous avez des questions contactez-nous: sales@iec.ch.

Electropedia - www.electropedia.org

Le premier dictionnaire d'électrotechnologie en ligne au monde, avec plus de 22 000 articles terminologiques en anglais et en français, ainsi que les termes équivalents dans 16 langues additionnelles. Egalement appelé Vocabulaire Electrotechnique International (IEV) en ligne.

Glossaire IEC - std.iec.ch/glossary

67 000 entrées terminologiques électrotechniques, en anglais et en français, extraites des articles Termes et Définitions des publications IEC parues depuis 2002. Plus certaines entrées antérieures extraites des publications des CE 37, 77, 86 et CISPR de l'IEC.



INTERNATIONAL STANDARD

NORME INTERNATIONALE

**Components for low-voltage surge protection –
Part 341: Performance requirements and test circuits for thyristor surge
suppressors (TSS)**

**Composants pour parafoudres basse tension –
Partie 341: Exigences de performance et circuits d'essai pour parafoudres
à thyristor (TSS)**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

COMMISSION
ELECTROTECHNIQUE
INTERNATIONALE

ICS 31.080.10

ISBN 978-2-8322-8304-2

**Warning! Make sure that you obtained this publication from an authorized distributor.
Attention! Veuillez vous assurer que vous avez obtenu cette publication via un distributeur agréé.**

CONTENTS

FOREWORD	6
1 Scope	8
2 Normative references	8
3 Terms, definitions, abbreviated terms and symbols	8
3.1 Parametric terms, letter symbols and definitions	9
3.2 General terms	9
3.3 Main terminal ratings	9
3.4 Main terminal characteristics	11
3.5 Additional and derived parameters	12
3.6 Temperature related parameters	12
3.7 Gate terminal parameters	13
3.8 Abbreviated terms	15
3.9 Circuit symbols	15
4 TSS types	16
5 Service conditions	18
5.1 Normal service conditions	18
5.2 Storage temperature range, T_{stgmin} to T_{stgmax}	18
6 Mechanical requirements and identification	18
6.1 Robustness of terminations	18
6.2 Solderability	18
6.3 Marking	18
6.4 Documentation	18
7 Standard test methods	19
7.1 Failure rates	19
7.2 Test conditions	19
7.2.1 General	19
7.2.2 Standard atmospheric conditions	19
7.2.3 Measurement errors	20
7.2.4 Measurement accuracy	20
7.2.5 Designated impulse shape and values	20
7.2.6 Multiple TSS	20
7.2.7 Gated TSS testing	20
7.3 Rating test procedures	20
7.3.1 General	20
7.3.2 Repetitive peak off-state voltage, V_{DRM}	21
7.3.3 Repetitive peak on-state current, I_{TRM}	21
7.3.4 Non-repetitive peak on-state current, I_{TSM}	22
7.3.5 Non-repetitive peak pulse current, I_{PP}	23
7.3.6 Repetitive peak reverse voltage, V_{RRM}	24
7.3.7 Non-repetitive surge forward current, I_{FSM}	24
7.3.8 Repetitive peak forward current, I_{FRM}	24
7.3.9 Critical rate of rise of on-state current, di/dt	25
7.4 Characteristic test procedures	26
7.4.1 General	26
7.4.2 Off-state current, I_D	26
7.4.3 Repetitive peak off-state current, I_{DRM}	27

7.4.4	Repetitive peak reverse current, I_{RRM}	27
7.4.5	Breakover voltage, $V_{(BO)}$ and current, $I_{(BO)}$	27
7.4.6	On-state voltage, V_T	29
7.4.7	Holding current, I_H	33
7.4.8	Off-state capacitance, C_O	34
7.4.9	Forward voltage, V_F	37
7.4.10	Peak forward recovery voltage, V_{FRM}	37
7.4.11	Critical rate of off-state voltage rise, dv/dt	38
7.4.12	Variation of holding current with temperature	38
7.4.13	Gate-to-adjacent terminal peak off-state voltage and peak off-state gate current, V_{GDM} , I_{GDM}	38
7.4.14	Gate reverse current, adjacent terminal open, I_{GAO} , I_{GKO}	39
7.4.15	Gate reverse current, main terminals short-circuited, I_{GAS} , I_{GKS}	40
Annex A (informative) Common impulse waveshapes		41
A.1	General.....	41
A.2	Types of impulse generator.....	41
A.3	Impulse generator parameters	41
A.3.1	Glossary of terms.....	41
A.3.2	Virtual parameters	42
A.4	Impulse generators typically used for surge protector testing	44
A.4.1	General.....	44
A.4.2	Impulse generators with a defined voltage waveform	44
A.4.3	Impulse generators with a defined current waveform.....	44
A.4.4	Generators with defined voltage and current waveforms	45
Annex B (informative) Glossary of IEC 60747-6 [10] thyristor terms		48
B.1	General.....	48
B.2	Thyristor types	48
B.3	Basic terms defining the static voltage-current characteristics of triode thyristors.....	49
B.4	Basic terms defining the static voltage-current characteristics of diode thyristors.....	51
B.5	Particulars of the static voltage-current characteristics of triode and diode thyristors.....	52
B.6	Terms related to ratings and characteristics; principal voltages.....	54
B.7	Terms related to ratings and characteristics; principal currents	55
B.8	Terms related to ratings and characteristics; gate voltages and currents.....	57
B.9	Terms related to ratings and characteristics; powers, energies and losses.....	59
B.10	Letter symbols	61
B.10.1	General.....	61
B.10.2	List of letter symbols.....	62
Annex C (informative) Additional parametric tests		64
C.1	General.....	64
C.2	Temperature derating.....	64
C.3	Thermal resistance, R_{th}	64
C.4	Transient thermal impedance, $Z_{th}(t)$	65
C.5	Gate reverse current, on-state, I_{GAT} , I_{GKT}	66
C.6	Gate reverse current, forward conducting state, I_{GAF} , I_{GKF}	67
C.7	Gate switching charge, Q_{GS}	68
C.8	Peak gate switching current, I_{GSM}	70

C.9 Gate-to-adjacent terminal breakover voltage, $V_{GK(BO)}$, $V_{GA(BO)}$ 71

Annex D (normative) Preferred values 72

D.1 General..... 72

D.2 $V_{(BO)}$ and V_{DRM} 72

D.3 C_O , V_{DRM} and I_{PP} 73

D.4 I_H 74

D.5 I_{PP} and time to half value (duration)..... 74

Bibliography..... 75

Figure 1 – Fixed voltage, two terminals: a) reverse blocking and b) reverse conducting 15

Figure 2 – Gated reverse blocking: a) P gate b) N gate and c) P & N gate 16

Figure 3 – Gated reverse conducting: a) P gate and b) N gate 16

Figure 4 – Bidirectional: a) 2 terminal fixed voltage and b) gated 16

Figure 5 – Switching quadrant characteristics: a) fixed-voltage TSS and b) gated TSS 17

Figure 6 – TSS non-switching characteristics: a) reverse blocking b) reverse conducting 17

Figure 7 – Test circuit for verifying repetitive peak off-state voltage (V_{DRM})..... 21

Figure 8 – Test circuit for verifying repetitive peak on-state current, I_{TRM} 21

Figure 9 – Repetitive peak on-state current waveforms 22

Figure 10 – Test circuit for verifying non-repetitive peak on-state current, I_{TSM} 23

Figure 11 – Test circuit for verifying non-repetitive peak pulse current, I_{PP} 24

Figure 12 – Test circuit for verifying critical rate of rise of on-state current (di/dt) 25

Figure 13 – Half sine-wave di/dt test circuit 26

Figure 14 – Test circuit for off-state current, I_D at V_D 27

Figure 15 – Test circuit for breakover, $V_{(BO)}$ and $I_{(BO)}$ and on-state voltage, V_T 28

Figure 16 – Voltage and current waveforms versus time for a fixed-voltage TSS showing switch-on, on-state and switch-off events 28

Figure 17 – Waveform expansions of Figure 16 30

Figure 18 – Voltage and current waveforms versus time for a gated TSS showing switch-on, on-state and switch-off events..... 31

Figure 19 – Waveform expansions of Figure 18 32

Figure 20 – Test circuit for holding current, I_H 33

Figure 21 – Test circuit for holding current with additional DC bias 34

Figure 22 – Test circuit for capacitance measurement 34

Figure 23 – Test circuit for capacitance measurement with external DC bias 35

Figure 24 – Test circuit for capacitance measurement of multi-terminal TSS..... 36

Figure 25 – Diode voltage and current waveforms versus time showing V_{FRM} and rising current di/dt 37

Figure 26 – Test circuit for exponential critical rate of off-state voltage rise, dv/dt 38

Figure 27 – Test circuit for gate-to-adjacent terminal peak off-state voltage and current, V_{GDM} and I_{GDM} 39

Figure 28 – Test circuit for gate reverse current, adjacent terminal open, I_{GAO} , I_{GKO} 39

Figure 29 – Test circuit for gate reverse current, main terminals short-circuited, I_{GAS} , I_{GKS} 40

Figure A.1 – Current or voltage impulse amplitude versus time showing a 10 % to 90 % T_1 front time and T_2 time to half value 43

Figure A.2 – Voltage impulse amplitude versus time showing a 30 % to 90 % T_1 front time and T_2 time to half value	43
Figure B.1 – Particulars of the static characteristic of unidirectional thyristors	52
Figure B.2 – Particulars of the static characteristic of bidirectional thyristors	53
Figure B.3 – a) Approximation of the on-state V_T - I_T characteristic b) Approximation of the reverse V_R - I_R characteristic	60
Figure C.1 – Test circuit for thermal resistance and impedance	65
Figure C.2 – Thermal impedance versus time	66
Figure C.3 – Test circuit for gate reverse current, on-state, I_{GAT} , I_{GKT}	67
Figure C.4 – Test circuit for gate reverse current, forward conducting state, I_{GAF} , I_{GKF}	68
Figure C.5 – Test circuit for gate switching current, gate switching charge and gate-to-adjacent terminal breakover voltage, I_{GSM} , Q_{GS} , $V_{GK(BO)}$, $V_{GA(BO)}$	69
Figure C.6 – Test circuit of an integrated gate diode TSS for gate switching current, gate switching charge and gate-to-adjacent terminal breakover voltage I_{GSM} , Q_{GS} , $V_{GK(BO)}$, $V_{GA(BO)}$	70
Figure C.7 – Overall and expanded clamping waveforms for a P-type gate TSS showing $V_{GK(BO)}$ and Q_{GS} measurement ($di_K/dt = 10 \text{ A}/\mu\text{s}$, $V_{GG} = -72 \text{ V}$)	71
Figure D.1 – $V_{(BO)}/V_{DRM}$ ratio against V_{DRM}	72
Figure D.2 – $V_{(BO)}$ vs V_{DRM}	73
Figure D.3 – Capacitance variation with DC bias	73
Figure D.4 – I_{PP} versus Duration for various 10/1 000 current ratings	74
Table 1 – Types of TSS	17
Table 2 – Breakover ramp rate test values	29
Table A.1 – Voltage impulse generators	44
Table A.2 – Current impulse generators	45
Table A.3 – Voltage and current impulse generators	46
Table A.4 – Other voltage and current impulse generators	47
Table B.1 – Additional general subscripts	61
Table B.2 – Principal voltages, anode-cathode voltages	62
Table B.3 – Principal currents, anode currents, cathode currents	62
Table B.4 – Gate voltages	63
Table B.5 – Gate currents	63
Table B.6 – Sundry quantities	63
Table B.7 – Power loss	63

INTERNATIONAL ELECTROTECHNICAL COMMISSION

COMPONENTS FOR LOW-VOLTAGE SURGE PROTECTION –

Part 341: Performance requirements and test circuits for thyristor surge suppressors (TSS)

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 61643-341 has been prepared by subcommittee 37B, Components for low-voltage surge protection, of IEC technical committee 37: Surge arresters.

This second edition of IEC 61643-341 cancels and replaces the first edition published in 2001. This edition constitutes a technical revision.

This edition includes the following significant technical changes with respect to the previous edition: Addition of performance values.

The text of this standard is based on the following documents:

FDIS	Report on voting
37B/218/FDIS	37B/220/RVD

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

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 61643 series, under the general title *Components for low-voltage surge protective devices*, can be found on the IEC website.

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

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