

IEEE Standard for Digital Recorders for Measurements in High-Voltage Impulse Tests

Sponsor

**Power Systems Instrumentation and Measurement Committee
of the
IEEE Power Engineering Society**

Reaffirmed 26 September 2007

Approved 19 March 1998

IEEE-SA Standards Board

Abstract: This standard defines the terms specifically related to the digital recorders used for monitoring high-voltage and high-current impulse tests, specifies the necessary performance characteristics for such digital recorders to ensure their compliance with the requirements for high-voltage and high-current impulse tests, and describes the tests and procedures that are necessary to show that these performance characteristics are within the specified limits.

Keywords: digital oscilloscope, digital recorder, digitizer, high-impulse current, high-impulse voltage, impulse tests

The Institute of Electrical and Electronics Engineers, Inc.
345 East 47th Street, New York, NY 10017-2394, USA

Copyright © 1998 by the Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 1998. Printed in the United States of America.

ISBN 0-7381-0197-4

No part of this publication may be reproduced in any form, in an electronic retrieval system or otherwise, without the prior written permission of the publisher.

IEEE Standards documents are developed within the IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association (IEEE-SA) Standards Board. Members of the committees serve voluntarily and without compensation. They are not necessarily members of the Institute. The standards developed within IEEE represent a consensus of the broad expertise on the subject within the Institute as well as those activities outside of IEEE that have expressed an interest in participating in the development of the standard.

Use of an IEEE Standard is wholly voluntary. The existence of an IEEE Standard does not imply that there are no other ways to produce, test, measure, purchase, market, or provide other goods and services related to the scope of the IEEE Standard. Furthermore, the viewpoint expressed at the time a standard is approved and issued is subject to change brought about through developments in the state of the art and comments received from users of the standard. Every IEEE Standard is subjected to review at least every five years for revision or reaffirmation. When a document is more than five years old and has not been reaffirmed, it is reasonable to conclude that its contents, although still of some value, do not wholly reflect the present state of the art. Users are cautioned to check to determine that they have the latest edition of any IEEE Standard.

Comments for revision of IEEE Standards are welcome from any interested party, regardless of membership affiliation with IEEE. Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments.

Interpretations: Occasionally questions may arise regarding the meaning of portions of standards as they relate to specific applications. When the need for interpretations is brought to the attention of IEEE, the Institute will initiate action to prepare appropriate responses. Since IEEE Standards represent a consensus of all concerned interests, it is important to ensure that any interpretation has also received the concurrence of a balance of interests. For this reason, IEEE and the members of its societies and Standards Coordinating Committees are not able to provide an instant response to interpretation requests except in those cases where the matter has previously received formal consideration.

Comments on standards and requests for interpretations should be addressed to:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
P.O. Box 1331
Piscataway, NJ 08855-1331
USA

Note: Attention is called to the possibility that implementation of this standard may require use of subject matter covered by patent rights. By publication of this standard, no position is taken with respect to the existence or validity of any patent rights in connection therewith. The IEEE shall not be responsible for identifying patents for which a license may be required by an IEEE standard or for conducting inquiries into the legal validity or scope of those patents that are brought to its attention.

Authorization to photocopy portions of any individual standard for internal or personal use is granted by the Institute of Electrical and Electronics Engineers, Inc., provided that the appropriate fee is paid to Copyright Clearance Center. To arrange for payment of licensing fee, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; (978) 750-8400. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Introduction

(This introduction is not part of IEEE Std 1122-1998, IEEE Standard for Digital Recorders for Measurements in High-Voltage Impulse Tests.)

The first edition of this standard was published in 1987. The International Electrotechnical Commission (IEC) published an equivalent standard in 1991, IEC 1083-1, *Digital recorders for measurements in high-voltage impulse tests—Part 1: Requirements for digital recorders*. From the outset there has been close liaison between the two working groups and it was agreed that each working group would try to provide its parent organization with documents that were substantially and technically the same. Liaison has been maintained with Technical Committee 10 (TC 10) of the IEEE Instrumentation and Measurement Society, Waveform Measurement and Analysis. This edition of the standard incorporates comments and the responses to questions that have been received by the working group since 1987.

This standard states the performance requirements for an impulse digitizer and the tests necessary to verify that these performance requirements have been met. When an impulse digitizer is used and maintained in accordance with this standard it will meet the accuracy requirements specified in IEEE Std 4-1995.

This standard was developed by the P1122 Working Group of the Digital Techniques in Electrical Measurements Subcommittee of the Power Systems Instrumentation and Measurement Committee of the IEEE Power Engineering Society.

The P1122 Working Group had the following members:

T. R. McComb, *Chair*

S. M. Benda-Berlijn
J. Csomay
K. Feser
G. J. Fitzpatrick
E. Gockenbach
S. Grzybowski

E. Hanique
J. Kuffel
W. Larzelere
A. Lux
R. Malewski

J. McBride
A. Molden
G. Rizzi
G. Schneider
K. Schon
Y. Zhang

This standard was sponsored by the Power Systems Instrumentation and Measurement Committee, which also served as the balloting committee that approved this document for submission to the IEEE Standards Board. The following persons were voting members of the balloting committee:

J. Kuffel, *Chair*

J. M. Belanger
J. A. Braun
J. M. Carr
L. Coffeen
S. W. Crampton
V. DaGrosa
G. J. Fitzpatrick
E. Hanique
R. E. Hebner
R. Hopkins
H. Kirkham

J. A. Kise
S. R. Knudsen
W. Larzelere
D. W. Lenk
D. McAuliff
J. McBride
T. R. McComb
H. M. Millican
J. H. Moran
O. Petersons

R. Reid
P. H. Reynolds
R. L. Richardson
H. M. Schneider
J. C. Smith
E. So
G. E. Stemler
D. Train
R. S. Turgel
C. F. Von Herrmann
B. H. Ward

When the IEEE-SA Standards Board approved this standard on 19 March 1998, it had the following membership:

Richard J. Holleman, *Chair*

Donald N. Heirman, *Vice Chair*

Judith Gorman, *Secretary*

Satish K. Aggarwal
Clyde R. Camp
James T. Carlo
Gary R. Engmann
Harold E. Epstein
Jay Forster*
Thomas F. Garrity
Ruben D. Garzon

James H. Gurney
Jim D. Isaak
Lowell G. Johnson
Robert Kennelly
E. G. "Al" Kiener
Joseph L. Koepfinger*
Stephen R. Lambert
Jim Logothetis
Donald C. Loughry

L. Bruce McClung
Louis-François Pau
Ronald C. Petersen
Gerald H. Peterson
John B. Posey
Gary S. Robinson
Hans E. Weinrich
Donald W. Zipse

*Member Emeritus

Valerie E. Zelenty
IEEE Standards Project Editor

Contents

1. Scope.....	1
2. References.....	1
3. Definitions.....	2
4. Conditions of use	6
4.1 Range of operating conditions	6
4.2 Reference conditions.....	6
5. Analysis of the impulse waveform	6
5.1 General.....	6
5.2 Equivalent oscillogram method	6
5.3 Procedures for reading digital records	7
6. Accuracy requirements for impulse measurements	8
6.1 Limits on overall uncertainty	8
6.2 Limits on individual uncertainties	8
6.3 Input impedance.....	11
7. Acceptance tests.....	11
7.1 Differential nonlinearity (impulse conditions).....	11
7.2 Internal noise level.....	11
7.3 Rise time	11
7.4 Interference test.....	11
7.5 Ripple.....	12
7.6 Integral nonlinearity.....	12
8. Performance tests	12
8.1 Pulse calibration.....	12
8.2 Alternative method.....	13
9. Performance checks	14
9.1 General.....	14
9.2 Pulse calibration.....	15
9.3 Alternative check	15
10. Record of performance	15
Annex A (informative) Bibliography	16

IEEE Standard for Digital Recorders for Measurements in High-Voltage Impulse Tests

1. Scope

This standard is applicable to digital recorders and digital oscilloscopes used for measurements during tests with high-impulse voltages and high-impulse currents. It covers the measuring characteristics and calibrations required to meet the measuring accuracy specified in IEEE Std 4-1995 and IEEE Std C57.98-1993 [B10].¹

The characteristics of general-purpose digital recorders are covered in IEEE Std 1057-1994 [B9]. General methods of pulse measurement are covered in IEC 60469-1 (1987-12) [B4] and IEC 60469-2 (1987-12) [B5].

This standard

- a) Defines the terms specifically related to the digital recorders used for monitoring high-voltage and high-current impulse tests;
- b) Specifies the necessary performance characteristics for such digital recorders to ensure their compliance with the requirements for high-voltage and high-current impulse tests;
- c) Describes the tests and procedures that are necessary to show that these performance characteristics are within the specified limits.

2. References

This standard shall be used in conjunction with the following publication:

IEEE Std 4-1995, IEEE Standard Techniques for High-Voltage Testing.²

¹The numbers in brackets correspond to those of the bibliography in Annex A.

²IEEE publications are available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA.

3. Definitions

3.1 actual resolution (r_a): The logarithm to base 2 of the [(maximum value used, $V_{\max}$, minus the value corresponding to the baseline, V_b)/(the standard deviation of the noise, σ_n times $\sqrt{12}$)].

$$r_a = \log_2 \left(\frac{V_{\max} - V_b}{\sigma_n \times \sqrt{12}} \right)$$

NOTE—The rated resolution is the maximum resolution that could be achieved when measuring an impulse whose peak-value is equal to the full-scale range and when there is no reduction in the effective resolution caused by non-ideal behavior of the digital recorder. Reductions in resolution caused by using less than full-scale deflection can be quantified (e.g., an 8-bit recorder has a rated resolution of 1 in 256). The resolution used to record an impulse is approximately 1 in (maximum value minus minimum value). For a (maximum minus minimum) value of 198 the number of bits is reduced to 7.63 (0.37 lost bits) while for a value of 98 the number of bits is equivalent to 6.61 (1.39 lost bits). The resolution is also reduced by noise and the total reduction in resolution gives an actual resolution which is the logarithm to base 2 of the [(maximum value minus minimum value)/(the standard deviation of the noise times $\sqrt{12}$)]; see equation 97 of IEEE Std 1057-1994 [B9].

3.2 automatically processed data: The data available from the digitizer when some processing function cannot be avoided.

3.3 average code bin width (W_0): The product of the full-scale value and the rated resolution.

NOTE—The average code bin width is equal to the static scale factor.

3.4 code bin width of code k (W_k): The range of input voltage allocated to code k (see Figure 1).

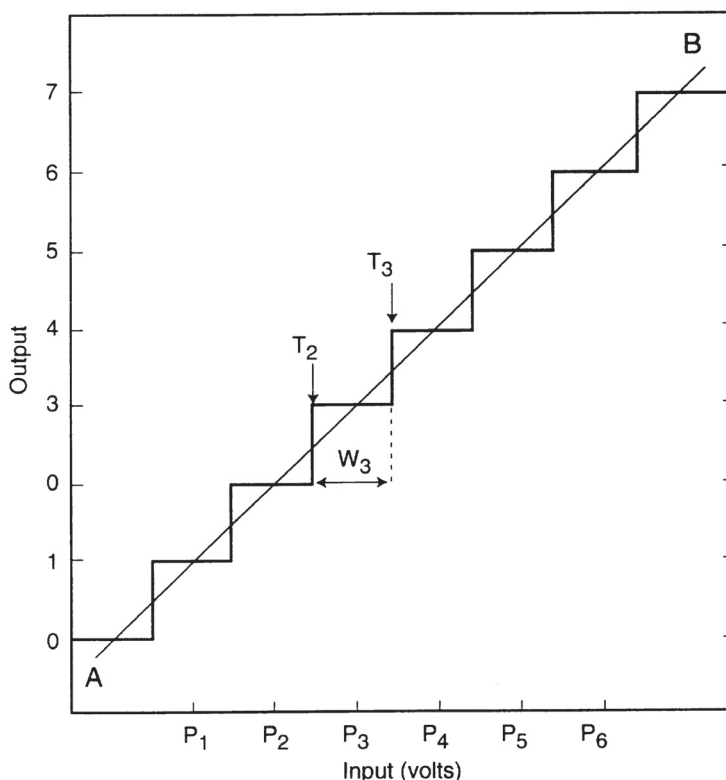


Figure 1—Quantization characteristic of an ideal 3-bit digitizer—
Code transition thresholds (T_2 and T_3), a code bin width ($W_3=W_0$), nominal voltage (P_i) of each code and the straight line joining the mid-points of the code bins