



IEEE Standard for Conservation Voltage Reduction (CVR) Data Collection and Management Procedures

IEEE Power and Energy Society

Developed by the
Transmission and Distribution Committee

IEEE Std 3102™-2024

STANDARDS

IEEE Standard for Conservation Voltage Reduction (CVR) Data Collection and Management Procedures

Developed by the

Transmission and Distribution Committee
of the
IEEE Power and Energy Society

Approved 26 September 2024

IEEE SA Standards Board

Recognized as an American National Standard

Abstract: Challenges in conducting measurement and verification in conservation voltage reduction (CVR) deployed feeders are faced by utilities. A standard is needed to provide procedures for electric utilities to determine the energy savings and CVR factors of their CVR programs, to define parameters for regulatory reporting, and to define standardized verification methodology selection based on standard data collection methodologies. The specification of CVR data management and collection procedures for use by the electric utility industry to enable energy savings is the purpose of this standard. Electric utilities, electric utility equipment manufacturers, software vendors, and electric utility regulatory commissions are the included stakeholders for this standard.

Keywords: conservation voltage reduction, data cleaning, data collection, data reconstruction, distribution system, energy efficiency, IEEE 3102™, methodology selection, reactive power control, voltage optimization, volt-var control

The Institute of Electrical and Electronics Engineers, Inc.
3 Park Avenue, New York, NY 10016-5997, USA

Copyright © 2025 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 24 January 2025. Printed in the United States of America.

IEEE is a registered trademark in the U.S. Patent & Trademark Office, owned by The Institute of Electrical and Electronics Engineers, Incorporated.

PDF: ISBN 979-8-8557-1569-9 STD27536
Print: ISBN 979-8-8557-1570-5 STDPD27536

IEEE prohibits discrimination, harassment, and bullying.

For more information, visit <https://www.ieee.org/about/corporate/governance/p9-26.html>.

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.

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE Standards documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page (<https://standards.ieee.org/ipr/disclaimers.html>), appear in all standards and may be found under the heading “Important Notices and Disclaimers Concerning IEEE Standards Documents.”

Notice and Disclaimer of Liability Concerning the Use of IEEE Standards Documents

IEEE Standards documents are developed within IEEE Societies and subcommittees of IEEE Standards Association (IEEE SA) Board of Governors. IEEE develops its standards through an accredited consensus development process, which brings together volunteers representing varied viewpoints and interests to achieve the final product. IEEE standards are documents developed by volunteers with scientific, academic, and industry-based expertise in technical working groups. Volunteers are not necessarily members of IEEE or IEEE SA and participate without compensation from IEEE. While IEEE administers the process and establishes rules to promote fairness in the consensus development process, IEEE does not independently evaluate, test, or verify the accuracy of any of the information or the soundness of any judgments contained in its standards.

IEEE makes no warranties or representations concerning its standards, and expressly disclaims all warranties, express or implied, concerning this standard, including but not limited to the warranties of merchantability, fitness for a particular purpose and non-infringement. IEEE Standards documents do not guarantee safety, security, health, or environmental protection, or guarantee against interference with or from other devices or networks. In addition, IEEE does not warrant or represent that the use of the material contained in its standards is free from patent infringement. IEEE Standards documents are supplied “AS IS” and “WITH ALL FAULTS.”

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.

In publishing and making its standards available, IEEE is not suggesting or rendering professional or other services for, or on behalf of, any person or entity, nor is IEEE undertaking to perform any duty owed by any other person or entity to another. Any person utilizing any IEEE Standards document, should rely upon their own independent judgment in the exercise of reasonable care in any given circumstances or, as appropriate, seek the advice of a competent professional in determining the appropriateness of a given IEEE standard.

IN NO EVENT SHALL IEEE BE LIABLE FOR ANY DIRECT, INDIRECT, INCIDENTAL, SPECIAL, EXEMPLARY, OR CONSEQUENTIAL DAMAGES (INCLUDING, BUT NOT LIMITED TO: THE NEED TO PROCURE SUBSTITUTE GOODS OR SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY, OR TORT (INCLUDING NEGLIGENCE OR OTHERWISE) ARISING IN ANY WAY OUT OF THE PUBLICATION, USE OF, OR RELIANCE UPON ANY STANDARD, EVEN IF ADVISED OF THE POSSIBILITY OF SUCH DAMAGE AND REGARDLESS OF WHETHER SUCH DAMAGE WAS FORESEEABLE.

Translations

The IEEE consensus balloting process involves the review of documents in English only. In the event that an IEEE standard is translated, only the English version published by IEEE is the approved IEEE standard.

Official statements

A statement, written or oral, that is not processed in accordance with the IEEE SA Standards Board Operations Manual shall not be considered or inferred to be the official position of IEEE or any of its committees and shall not be considered to be, nor be relied upon as, a formal position of IEEE. At lectures, symposia, seminars, or educational courses, an individual presenting information on IEEE standards shall make it clear that the presenter's views should be considered the personal views of that individual rather than the formal position of IEEE, IEEE SA, the Standards Committee, or the Working Group. Statements made by volunteers may not represent the formal position of their employer(s) or affiliation(s).

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE or IEEE SA. However, **IEEE does not provide interpretations, consulting information, or advice pertaining to IEEE Standards documents.**

Suggestions for changes in documents should be in the form of a proposed change of text, together with appropriate supporting comments. Since IEEE standards represent a consensus of concerned interests, it is important that any responses to comments and questions also receive the concurrence of a balance of interests. For this reason, IEEE and the members of its Societies and subcommittees of the IEEE SA Board of Governors are not able to provide an instant response to comments, or questions except in those cases where the matter has previously been addressed. For the same reason, IEEE does not respond to interpretation requests. Any person who would like to participate in evaluating comments or in revisions to an IEEE standard is welcome to join the relevant IEEE working group. You can indicate interest in a working group using the Interests tab in the Manage Profile and Interests area of the [IEEE SA myProject system](#).¹ An IEEE Account is needed to access the application.

Comments on standards should be submitted using the [Contact Us](#) form.²

Laws and regulations

Users of IEEE Standards documents should consult all applicable laws and regulations. Compliance with the provisions of any IEEE Standards document does not constitute compliance to any applicable regulatory requirements. Implementers of the standard are responsible for observing or referring to the applicable regulatory requirements. IEEE does not, by the publication of its standards, intend to urge action that is not in compliance with applicable laws, and these documents may not be construed as doing so.

Data privacy

Users of IEEE Standards documents should evaluate the standards for considerations of data privacy and data ownership in the context of assessing and using the standards in compliance with applicable laws and regulations.

¹Available at: <https://development.standards.ieee.org/myproject-web/public/view.html#landing>.

²Available at: <https://standards.ieee.org/content/ieee-standards/en/about/contact/index.html>.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under US and international copyright laws. They are made available by IEEE and are adopted for a wide variety of both public and private uses. These include both use, by reference, in laws and regulations, and use in private self-regulation, standardization, and the promotion of engineering practices and methods. By making these documents available for use and adoption by public authorities and private users, neither IEEE nor its licensors waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate licensing fees, IEEE will grant users a limited, non-exclusive license to photocopy portions of any individual standard for company or organizational internal use or individual, non-commercial use only. To arrange for payment of licensing fees, please contact Copyright Clearance Center, Customer Service, 222 Rosewood Drive, Danvers, MA 01923 USA; +1 978 750 8400; <https://www.copyright.com/>. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Updating of IEEE Standards documents

Users of IEEE Standards documents should be aware that these documents may be superseded at any time by the issuance of new editions or may be amended from time to time through the issuance of amendments, corrigenda, or errata. An official IEEE document at any point in time consists of the current edition of the document together with any amendments, corrigenda, or errata then in effect.

Every IEEE standard is subjected to review at least every 10 years. When a document is more than 10 years old and has not undergone a revision process, 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.

In order to determine whether a given document is the current edition and whether it has been amended through the issuance of amendments, corrigenda, or errata, visit [IEEE Xplore](#) or [contact IEEE](#).³ For more information about the IEEE SA or IEEE's standards development process, visit the IEEE SA Website.

Errata

Errata, if any, for all IEEE standards can be accessed on the [IEEE SA Website](#).⁴ Search for standard number and year of approval to access the web page of the published standard. Errata links are located under the Additional Resources Details section. Errata are also available in [IEEE Xplore](#). Users are encouraged to periodically check for errata.

Patents

IEEE standards are developed in compliance with the [IEEE SA Patent Policy](#).⁵

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 by the IEEE with respect to the existence or validity of any patent rights in connection therewith. If a patent holder or patent applicant has

³Available at: <https://ieeexplore.ieee.org/browse/standards/collection/ieee>.

⁴Available at: <https://standards.ieee.org/standard/index.html>.

⁵Available at: <https://standards.ieee.org/about/sasb/patcom/materials.html>.

filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE SA Website at <https://standards.ieee.org/about/sasb/patcom/patents.html>. Letters of Assurance may indicate whether the Submitter is willing or unwilling to grant licenses under patent rights without compensation or under reasonable rates, with reasonable terms and conditions that are demonstrably free of any unfair discrimination to applicants desiring to obtain such licenses.

Essential Patent Claims may exist for which a Letter of Assurance has not been received. The IEEE is not responsible for identifying Essential Patent Claims for which a license may be required, for conducting inquiries into the legal validity or scope of Patents Claims, or determining whether any licensing terms or conditions provided in connection with submission of a Letter of Assurance, if any, or in any licensing agreements are reasonable or non-discriminatory. Users of this standard are expressly advised that determination of the validity of any patent rights, and the risk of infringement of such rights, is entirely their own responsibility. Further information may be obtained from the IEEE Standards Association.

IMPORTANT NOTICE

Technologies, application of technologies, and recommended procedures in various industries evolve over time. The IEEE standards development process allows participants to review developments in industries, technologies, and practices, and to determine what, if any, updates should be made to the IEEE standard. During this evolution, the technologies and recommendations in IEEE standards may be implemented in ways not foreseen during the standard's development. IEEE standards development activities consider research and information presented to the standards development group in developing any safety recommendations. Other information about safety practices, changes in technology or technology implementation, or impact by peripheral systems also may be pertinent to safety considerations during implementation of the standard. Implementers and users of IEEE Standards documents are responsible for determining and complying with all appropriate safety, security, environmental, health, and interference protection practices and all applicable laws and regulations.

Participants

At the time this standard was completed, the Smart Distribution Working Group had the following membership:

Amin Khodaei, *Chair*
Wen Fan, *Vice Chair*
Zhaoyu Wang, *Secretary*

Hong Chun
Alfredo Contreras
Damel Goddard
Eric Gupta
Ashraful Haque

Shakil Hossan
Yuan Liao
Zixiao Ma
Zinn Morton

Paul Pabst
Ahmed Saber
Tu Anh Tran
Andrew Wilson
Yingmeng Xiang

The following members of the individual Standards Association balloting group voted on this standard. Balloters may have voted for approval, disapproval, or abstention.

Steven Bezner
Gustavo Brunello
Sean Carr
Heidemarie Caswell
Pin Chang
Larry Conrad
Katherine Cummings
Kurniawan Diharja
Wen Fan
Carl Fredericks
Fredric Friend
Shubhanker Garg
Michael Higginson

Werner Hoelzl
Amin Khodaei
Wang Lei
Greg Luri
Sal Martino
John McDaniel
Jeffrey McElray
Nayeem Ninad
Paul Pabst
Bansi Patel
Marc Patterson
Howard Penrose

Craig Preuss
James Reilly
Bartien Sayogo
Jerry Smith
Walter Struppeler
Mark Tostrud
Tu Anh Tran
Francois Trichon
John Vergis
Zhaoyu Wang
Scott Willy
Wilsun Xu
Vahraz Zamani

When the IEEE SA Standards Board approved this standard on 26 September 2024, it had the following membership:

David J. Law, *Chair*
Jon Walter Rosdahl, *Vice Chair*
Gary Hoffman, *Past Chair*
Alpesh Shah, *Secretary*

Sara R. Biyabani
Ted Burse
Stephen Dukes
Doug Edwards
J. Travis Griffith
Guido R. Hiertz
Ronald W. Hotchkiss

Hao Hu
Yousef Kimiagar
Joseph L. Koepfinger*
Howard Li
Xiaohui Liu
John Haiying Lu
Kevin W. Lu
Hiroshi Mano

Paul Nikolich
Robby Robson
Lei Wang
F. Keith Waters
Sha Wei
Philip B. Winston
Don Wright

*Member Emeritus

Introduction

This introduction is not part of IEEE Std 3102-2024, IEEE Standard for Conservation Voltage Reduction (CVR) Data Collection and Management Procedures.

Modern electric grids are rapidly evolving in terms of transmission, generation, and distribution as utilities transition toward greener and more resilient energy operations. Conservation voltage reduction (CVR) is an energy efficiency measure that reduces energy consumption through feeder-level voltage reduction. One salient feature of CVR is that energy consumption by the customers can be reduced without significantly impacting equipment operation. Utilities are looking to leverage this benefit to its full potential while designing an energy-efficient distribution system. Though energy savings and peak load reduction through CVR is not random in nature, it does depend on multiple external factors i.e., weather variables, feeder length, and customer type. CVR measurement and verification (M&V) is to measure CVR factors, energy savings, and peak load reduction through CVR deployment. This standard focuses on CVR factor for energy only. CVR M&V is challenging considering the stochastic nature of consumer loads, a lack of benchmark load consumption measurement during the CVR period, various data availability issues, and the fact that distinguishing the changes in load and energy consumption due to voltage reduction from other impact factors is not a straightforward task. A defined procedure for data collection, data processing and energy savings calculation that minimizes these effects is, therefore, required.

Contents

1. Overview	10
1.1 Scope	10
1.2 Purpose	10
1.3 Word usage	11
2. Definitions, acronyms, and abbreviations	11
2.1 Definitions	11
2.2 Acronyms and abbreviations	11
3. Data collection	12
3.1 General	12
3.2 Categories	12
3.3 SCADA versus AMI data	12
3.4 Data resolutions	13
3.5 Current to power conversion	13
3.6 Detection of accurate CVR status	13
3.7 Data compression	13
4. Data cleaning	15
4.1 General	15
4.2 Anomalies data cleaning	15
4.3 Data cleaning for irregular ON/OFF cycling	19
4.4 Data cleaning with load shift	20
4.5 Substation with LTC and LVRs	21
4.6 Utility with VVO system with end of line (EOL) voltage control	22
4.7 Additional cleaning	22
5. Data reconstruction	23
5.1 Requirement of data reconstruction	23
5.2 Variables to consider for data reconstruction	23
5.3 Data reconstruction approaches	24
6. Methodology	26
6.1 General	26
6.2 Descriptions of methodologies being utilized by utilities	26
6.3 Descriptions of emerging methodologies	36
6.4 Pros and cons of the CVR evaluation methodologies	36
6.5 Identifications of the true range of CVR factors	37
6.6 Utilization of CVR factors	38
6.7 Methodology selection	39
Annex A (informative) Bibliography	43

IEEE Standard for Conservation Voltage Reduction (CVR) Data Collection and Management Procedures

1. Overview

Utilities face challenges in conducting measurement and verification in conservation voltage reduction (CVR) deployed feeders. A standard is needed to provide procedures for electric utilities to use to determine the CVR factor and energy savings of their CVR programs, define parameters for regulatory reporting, and define standardized verification methodology selection based on standard data collection methodologies.

1.1 Scope

This standard specifies a set of procedures for CVR data collection and management. Functional requirements, procedures and scenarios are defined as follows:

- a) Identification of cycling schedule disruptions and required data cleaning.
- b) Compression rates to archive values.
- c) Detection of accurate CVR status.
- d) Identification of load shifts and how to deal with these in terms of measurement and verification.
- e) Data cleaning and reconstruction approaches for anomalous data.
- f) Procedures for determining CVR factor range and system-level CVR factor.
- g) Procedures for data adequacy based on accurate CVR status, and power and voltage data.
- h) Methodology selection and assumption validation based on data availability.

1.2 Purpose

The purpose of this standard is to specify CVR data management and collection practices for use by the electric utility industry to enable accurate CVR benefits assessment.

1.3 Word usage

The word *shall* indicates mandatory requirements strictly to be followed in order to conform to the standard and from which no deviation is permitted (*shall* equals *is required to*).^{6,7}

The word *should* indicates that among several possibilities one is recommended as particularly suitable, without mentioning or excluding others; or that a certain course of action is preferred but not necessarily required (*should* equals *is recommended that*).

The word *may* is used to indicate a course of action permissible within the limits of the standard (*may* equals *is permitted to*).

The word *can* is used for statements of possibility and capability, whether material, physical, or causal (*can* equals *is able to*).

2. Definitions, acronyms, and abbreviations

2.1 Definitions

For the purposes of this document, the following terms and definitions apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.⁸

2.2 Acronyms and abbreviations

AMI	advanced metering infrastructure
CVR	conservation voltage reduction
DER	distributed energy resource
EOL	end of line
LTC	load tap changer
LVR	line voltage regulator
MAD	median absolute deviation
MAE	mean absolute error
MAPE	mean absolute percentage error
MSE	mean squared error
M&V	measurement and verification
PMU	phasor measurement unit
p.u.	per unit
RMSE	root mean square error
SCADA	supervisory control and data acquisition
VVO	volt-var optimization
ZIP	impedance current power

⁶The use of the word *must* is deprecated and cannot be used when stating mandatory requirements, *must* is used only to describe unavoidable situations.

⁷The use of *will* is deprecated and cannot be used when stating mandatory requirements, *will* is only used in statements of fact.

⁸*IEEE Standards Dictionary Online* is available at: <http://dictionary.ieee.org>. An IEEE account is required for access to the dictionary, and one can be created at no charge on the dictionary sign-in page.

3. Data collection

3.1 General

Measurement and verification (M&V) analysis uses various data to quantify the conservation voltage reduction (CVR) effects including energy savings, peak demand reduction, and CVR factor. Regardless of the M&V method, a crucial part of any CVR program starts with data collection (Hosseini et al., 2022 [B11]).⁹ CVR assessment shall include at least the following supervisory control and data acquisition (SCADA) data: feeder power and voltage data, temperature, and CVR ON and OFF status; all data shall include timestamps to Universal Time Coordinated (UTC).

3.2 Categories

The CVR impacts can be measured by CVR factor for energy.¹⁰ The CVR factor for energy is defined as the ratio between the percentage change in energy and the associated percentage change in voltage (Hosseini et al., 2020 [B10]). Based on the commonly utilized CVR M&V methodologies, which are discussed in [Clause 6](#), data are classified into two categories: required and optional, as detailed below.

Table 1—Data classified into categories based on requirement

Data point	Required/optional	Notes
Real power	Required	Single-phase quantities are required when single-phase regulators are used, three-phase when gang-operated voltage control is used.
Voltage	Required	Single-phase quantities are required when single-phase regulators are used, three-phase when gang-operated voltage control is used.
CVR status	Required	—
Timestamps	Required	—
Reactive power	Optional	—
Feeder-tie recloser status, breaker status, switch status	Optional	For load shift detection.
Substation transformer tap status points	Optional	Example points are auto/manual, local/remote, low-limit alarm, high-limit alarm.
Current	Optional/required	Optional if power measurements are available; required if power measurements are unavailable.
Power factor	Optional/required	Optional if power measurements are available; required if power measurements are unavailable.
Energy demand	Optional	—
Peak demand	Optional	—

3.3 SCADA versus AMI data

Utilities, evaluators, regulatory commissions, and other stakeholders (as applicable) shall discuss and reach agreement on what is most accurate and available data sources for the data required from [Table 1](#). For example, SCADA may be evaluated as the best source because the required data are straight-forward to retrieve, easily understood and interpreted, and available so that all savings are captured, or advanced metering infrastructure (AMI) may be evaluated as the best source because the data collected shows actual consumption reduction and savings for utility customers even though the data collected does not include distribution circuit losses and

⁹The numbers in brackets correspond to those of the bibliography in [Annex A](#).

¹⁰CVR factor can be calculated for energy and power. The CVR factor for power is defined as the ratio between the percentage change in power and the associated percentage change in voltage (Hosseini et al., 2020 [B10]).

there are much higher volumes of data to analyze. However, calculating CVR factors and energy savings for individual customers shall use the following AMI data: voltage, energy, CVR status, and timestamps.

3.4 Data resolutions

High resolution data may result in concerns including but not limited to data storage capacity, data availability, managing large files, and logging SCADA historians. Utilities shall select the data resolutions based on the availability and discussion with evaluators. The recommended time interval is as follows in the order from minimum to maximum values: 1 min, 5 min, 15 min, 30 min, and 60 min.

Distinctions should be made between calculating CVR factor for power versus energy. Higher resolution data should be used for power CVR factor (e.g., 1 min), while both higher and lower resolution data may be used for the energy CVR factor (e.g., 60 min). The time interval shall match the power and voltage data resolution.

3.5 Current to power conversion

If power sensors and measurements are unavailable, current sensors, along with estimated power factor, shall be used. One approach is to utilize the system-wide power factor. The utilities shall carry out internal studies on power factor based on the feeders in their service territory. Utilities may use an average, or weighted average, of all power factors calculated from different types of feeders (e.g., industrial, residential, commercial) in different times of the year (e.g., winter, fall, spring, summer). If the power sensor is not installed, the current data is converted to power to fill the missing power data as follows in [Equation \(1\)](#):

$$P_t = \sqrt{3} \times V_t \times I_t \times PF \quad (1)$$

where

P_t is the power value at time interval t
 V_t is the phase-to-phase voltage
 I_t is the current in amperes
 PF is the power factor

If this approach is utilized, it may reduce the accuracy of the CVR factor. This equation assumes a three-phase balanced system. If the system is unbalanced, the calculation shall be done for each phase and summed over to obtain the power value.

3.6 Detection of accurate CVR status

The CVR ON/OFF status and percent reduction shall be determined based on the CVR control communication signals and field measurements collected from the voltage regulating equipment that is assigned to implement CVR (W. Fan et al. [\[B7\]](#)).

3.7 Data compression

Data compression is an integral part of effective data management and recovery. The following concepts are important elements for upholding data integrity and ensuring data quality:

- Lossy versus lossless compression:
 - Lossy compression refers to data compression where part of the information is lost.
 - Lossless compression refers to the recovery of all original data when data is decompressed.

A data archive server does not have to archive all raw values by keeping only the datapoints with significant changes and further filtering them out, and the data quality can be still acceptable for accurate M&V analysis. The following two variables, exception deviation and compression deviation, should be utilized to configure the archive behavior:

- Exception versus compression deviation:
 - Exception deviation is defined as the threshold of the minimum change in value required for a new datapoint to be considered for archiving. Figure 1(a) illustrates that if a new datapoint deviates from the previously archived datapoint by an amount greater than the specified exceptional deviation rate, it is archived; otherwise, it is not archived.
 - Compression deviation is defined as the degree of deviation capable of altering the data trend, aimed at further filtering data and reducing storage needs. Figure 1(b) illustrates that if a new datapoint falls out from the current trend slope, it is archived; otherwise, it is not archived.

The exception and compression rates should be set in a way so that the archived raw data comprise of, for example, 10% or less of bad quality data (e.g., outliers). The exception and compression rates should also be set to avoid significant errors considering CVR M&V evaluates small changes in voltage and energy consumption less than 5%.

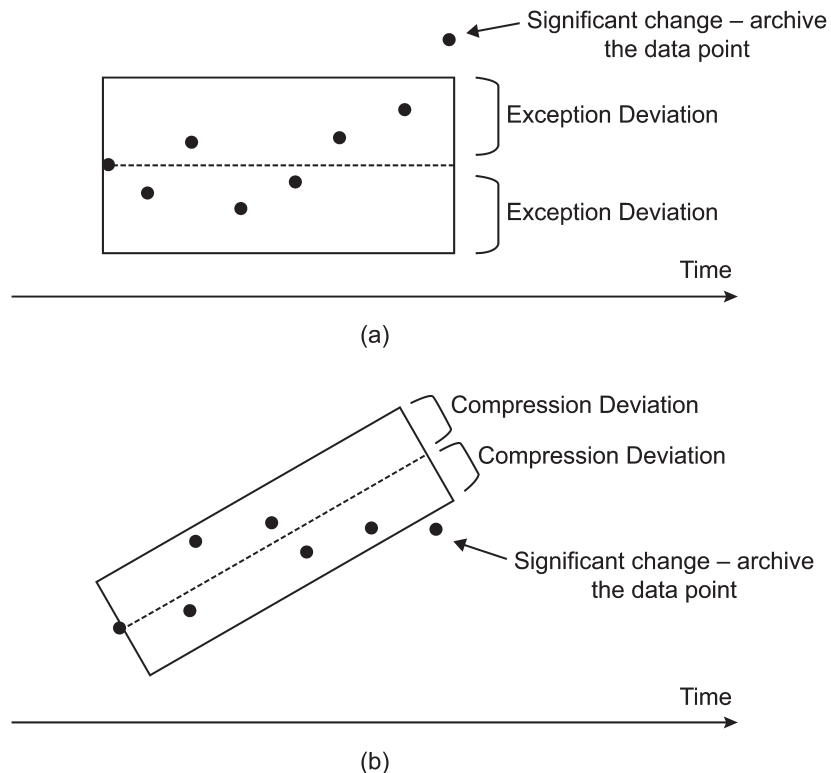


Figure 1—Exception and compression deviation illustrations