IEEE STANDARDS ASSOCIATION

IEEE Guide for Establishing Power Transformer Capability while under Geomagnetic Disturbances

IEEE Power and Energy Society

Sponsored by the
Transformers Committee

IEEE
3 Park Avenue
New York, NY 10016-5997
USA

IEEE Std C57.163™-2015

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Documents
Document Sharing Hub
Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.
Full document details: IEEE C57.163-2015

IEEE Guide for Establishing Power Transformer Capability while under Geomagnetic Disturbances

Sponsor

Transformers Committee
of the
IEEE Power and Energy Society

Approved 3 September 2015

IEEE-SA Standards Board

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Abstract: The effects of geomagnetic disturbances (GMD) on power transformers when there is the presence of geomagnetically induced current (GIC) in a power transformer are described. Specification parameters and performance characteristics for power transformers to help minimize the risk and impact when GIC is present in the power system are established. The intent is to provide a background that can help evaluate the effect of GIC on a power transformer design and its GIC capability. This includes the evaluation techniques to determine the performance characteristics while under the influence of GIC.

Keywords: core saturation, design review, geomagnetically induced current (GIC), geomagnetically induced current signature, geomagnetic disturbances (GMD), IEEE C57.163, magnetic, monitoring, temperature gradient, testing, thermal, power transformers

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

Copyright © 2015 by The Institute of Electrical and Electronics Engineers, Inc.
All rights reserved. Published 26 October 2015. 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 978-0-7381-9897-2 STD20359
Print: ISBN 978-0-7381-9898-9 STDPD20359

IEEE prohibits discrimination, harassment, and bullying.
For more information, visit http://www.ieee.org/web/aboutus/whatis/policies/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.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Important Notices and Disclaimers Concerning IEEE Standards Documents

IEEE documents are made available for use subject to important notices and legal disclaimers. These notices and disclaimers, or a reference to this page, appear in all standards and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Standards Documents."

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

IEEE Standards documents (standards, recommended practices, and guides), both full-use and trial-use, are developed within IEEE Societies and the Standards Coordinating Committees of the IEEE Standards Association ("IEEE-SA") Standards Board. IEEE ("the Institute") develops its standards through a consensus development process, approved by the American National Standards Institute ("ANSI"), which brings together volunteers representing varied viewpoints and interests to achieve the final product. Volunteers are not necessarily members of the Institute 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 does not warrant or represent the accuracy or content of the material contained in its standards, and expressly disclaims all warranties (express, implied and statutory) not included in this or any other document relating to the standard, including, but not limited to, the warranties of: merchantability; fitness for a particular purpose; non-infringement; and quality, accuracy, effectiveness, currency, or completeness of material. In addition, IEEE disclaims any and all conditions relating to: results; and workmanlike effort. 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 his or her 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: PROCUREMENT OF 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 development 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 should be considered the approved IEEE standard.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

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, or 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 his or her views should be considered the personal views of that individual rather than the formal position of IEEE.

Comments on standards

Comments for revision of IEEE Standards documents are welcome from any interested party, regardless of membership affiliation with IEEE. However, IEEE does not provide 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 Standards Coordinating Committees 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 revisions to an IEEE standard is welcome to join the relevant IEEE working group.

Comments on standards should be submitted to the following address:

Secretary, IEEE-SA Standards Board
445 Hoes Lane
Piscataway, NJ 08854 USA

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 imply 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.

Copyrights

IEEE draft and approved standards are copyrighted by IEEE under U.S. 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, IEEE does not waive any rights in copyright to the documents.

Photocopies

Subject to payment of the appropriate fee, 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. Permission to photocopy portions of any individual standard for educational classroom use can also be obtained through the Copyright Clearance Center.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

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 ten years. When a document is more than ten 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 the IEEE-SA Website at http://ieeexplore.ieee.org/xpl/standards.jsp or contact IEEE at the address listed previously. For more information about the IEEE-SA or IEEE's standards development process, visit the IEEE-SA Website at http://standards.ieee.org.

Errata

Errata, if any, for all IEEE standards can be accessed on the IEEE-SA Website at the following URL: http://standards.ieee.org/findstds/errata/index.html. Users are encouraged to check this URL for errata periodically.

Patents

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 filed a statement of assurance via an Accepted Letter of Assurance, then the statement is listed on the IEEE-SA Website at http://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.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Participants

At the time this IEEE guide was completed, the Establishing Power Transformer Capability while under Geomagnetic Disturbances Working Group had the following membership:

Jane Verner, *Chair*
Gary Hoffman, *Vice Chair*
William Bartley, *Secretary*

Raj Ahuja
Javier Arteaga
Peter Balma
Jeffrey Benach
David Berrtagnolli
Daniel Blayton
Juan Castellnos
Donald Chu
Mohamed Diaby
Anthony Franchitti
Shawn Galbraith
Eduardo Garcia
Ramsis Girgis
Jeffrey Golarz
Jorge Gonzalez de la Vega
William Griesacker
Ismail Guner
Jose Izquierdo
Paul Jarman
Wayne Johnson
Kurt Kaineder
Andy Lawless
Gustavo Leal
So-young Lee
Xose Lopez-Fernandez
Thomas Lundquist
Kumar Mani
Robert Mayer
Emilior Morales Cruz
David Murray
Ali Naderian
Sanjay Patel
Verena Pellon
Brian Penny
Donald Platts
Johannes Raith
Marnie Roussell
Roderick Sauls
Markus Schiessi
Alfons Schrammel
Hemchandra Shertukde
Shane Smith
Andrew Steineman
Dejan Susa
Mark Tostrud
Jason Varnell
Kiran Vedante
Jos Veens
Rogerio Verdolin
Dharman Vir
Loren Wagenaar
Sukhdev Walia
David Wallach
Reigh Walling
Jeffrey Wright
Shuzhen Xu
Baitun Yang
Waldemar Ziomek

The following members of the individual balloting committee voted on this guide. Balloters may have voted for approval, disapproval, or abstention.

William Ackerman
Stephen Antosz
Peter Balma
William Bartley
Christopher Baumgartner
Jeffrey Benach
Wallace Binder
Thomas Blackburn
Thomas Blair
Daniel Blaydon
William Bloethe
William Boettger
Kent Brown
Paul Cardinal
Juan Castellanos
Arvind Chaudhary
Stephen Conrad
John Crouse
Willaim Darovny
Mohamed Diaby
Dieter Dohnal
Gary Donner
Fred Elliott
Joseph Foldi
Marcel Fortin
Shawn Galbraith
David Gilmer
Ramsis Girgis
Jalal Gohari
James Graham
William Griesacker
Randall Groves
Ajit Gwal
Donald Hall
John Harley
Roger Hayes
Gary Hoffman
Jill Holmes
Philip Hopkinson
Randy Horton
Richard Jackson
Laszlo Kadar
Gael Kennedy
Sheldon Kennedy
James Kinney
Zan Kiparizoski
Gary Kobet
Axel Kraemer
Neil Kranich
Jim Kulchisky
Saumen Kundu
John Lackey
Marc Lacroix
Chung-Yiu Lam
Aleksandr Levin
Thomas Lundquist
J. Dennis Marlow
Lee Matthews
Omar Mazzoni
Susan McNelly
John Miller
Michael Miller
Daniel Mulkey
Jerry Murphy
Ryan Musgrove
Ali Naderian Jahromi
K. R. M. Nair
Michael Newman
Dhiru Patel
Brian Penny
Branimir Petosic
Donald Platts

Documents
Document Sharing Hub
Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.
Full document details: IEEE C57.163-2015

Alvaro Portillo
Iulian Profir
Reynaldo Ramos
Leslie Recksiedler
Jean-Christophe Riboud
John Roach
Michael Roberts
Charles Rogers
Oleg Roizman
Thomas Rozek
Dinesh Sankarakurup
Daniel Sauer
Roderick Sauls
Bartien Sayogo
Devki Sharma
Hemchandra Shertukde
Hyeong Sim
Jeremy Smith
Jerry Smith
Gary Smullin
Sanjib Som
Wayne Stec
Michael Swearingen
Malcolm Thaden
Michael Thompson
Mark Tostrud
James Van De Ligt
Jason Varnell
Kiran Vedante
John Vergis
Jane Verner
Loren Wagenaar
David Wallach
Reigh Walling
John Wang
Joe Watson
Kenneth White
Jeffrey Wright
Kipp Yule
Waldemar Ziomek

When the IEEE-SA Standards Board approved this guide on 3 September 2015, it had the following membership:

John D. Kulick, *Chair*
Jon Walter Rosdahl, *Vice Chair*
Richard H. Hulett, *Past Chair*
Konstantinos Karachalios, *Secretary*

Masayuki Ariyoshi
Ted Burse
Stephen Dukes
Jean-Philippe Faure
J. Travis Griffith
Gary Hoffman
Michael Janezic
Joseph L. Koepfinger*
David J. Law
Hung Ling
Andrew Myles
T. W. Olsen
Glenn Parsons
Ronald C. Petersen
Annette D. Reilly
Stephen J. Shellhammer
Adrian P. Stephens
Yatin Trivedi
Philip Winston
Don Wright
Yu Yuan
Daidi Zhong

*Member Emeritus

Copyright © 2015 IEEE. All rights reserved.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Introduction

This introduction is not part of IEEE Std C57.163-2015, IEEE Guide for Establishing Power Transformer Capability while under Geomagnetic Disturbances.

This guide has been developed to address the global impact of geomagnetic disturbances (GMD) on the reliable operation of bulk electric system (BES) including power transformers. The Standards Subcommittee of the IEEE Power and Energy Society Transformers Committee responded by assembling a working group to develop this guide. The intent of this guide is to provide a common framework for considering the capability of power transformers while under the impact of geomagnetic disturbances. This IEEE Transformer Committee guide is the first industry document of its type and facilitates the evaluation and understanding of performance of transformers under GMD conditions.

Copyright © 2015 IEEE. All rights reserved.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Contents

1. Overview 1
1.1 Scope 1

2. Normative references 2

3. Definitions 2

4. Background 3

5. Effects of GIC on power transformers 4
5.1 Basics of the effects of dc on power transformers 4
5.2 Additional var demand and current harmonics associated with GIC 7
5.3 Thermal effects of GIC 8
5.4 Other effects of GIC in transformers 8

6. Thermal response of transformers to GIC 8
6.1 Thermal effects of dc current 8
6.2 Typical signature/profile of GIC 13
6.3 The effect of the short duration of GIC pulses on transformer temperatures 15
6.4 Procedure for calculation of thermal response of windings and structural parts to a GIC profile 16
6.5 Example of calculation of thermal performance to a typical GIC profile 18

7. GIC capability of a transformer design 21
7.1 GIC magnetic capability 21
7.2 GIC thermal capability 24

8. Evaluation of susceptibility of existing fleet of transformers to effects of GIC 27
8.1 Design-based susceptibility 27
8.2 GIC level-based susceptibility 28
8.3 Total GIC susceptibility 28

9. Specifications 29
9.1 GIC signature 29
9.2 Recommended temperature limits 30
9.3 Recommended design review requirements 31
9.4 Testing 31

10. Transformer GIC monitoring 32
10.1 Monitoring 32
10.2 Predicting part-cycle core saturation 34

Annex A (informative) Bibliography 36

Copyright © 2015 IEEE. All rights reserved.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

Documents
Document Sharing Hub
Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.
Full document details: IEEE C57.163-2015

IEEE Guide for Establishing Power Transformer Capability while under Geomagnetic Disturbances

IMPORTANT NOTICE: IEEE Standards documents are not intended to ensure safety, security, health, or environmental protection, or ensure against interference with or from other devices or networks. Implementers 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.

This IEEE document is made available for use subject to important notices and legal disclaimers. These notices and disclaimers appear in all publications containing this document and may be found under the heading "Important Notice" or "Important Notices and Disclaimers Concerning IEEE Documents." They can also be obtained on request from IEEE or viewed at http://standards.ieee.org/IPR/disclaimers.html.

1. Overview

1.1 Scope

This guide describes the effects of geomagnetic disturbances (GMD) on power transformers when there is the presence of geomagnetically induced current (GIC) in a power transformer. It establishes specification parameters and performance characteristics for power transformers to help minimize the risk and impact when GIC is present in the power system. The intent is to provide a background that can help evaluate the effect of GIC on a power transformer design and its GIC capability. This includes the evaluation techniques to determine the performance characteristics while under the influence of GIC.

It does not include the effect of GIC on other power system devices beyond power transformers and accessories. It does not discuss mitigation techniques and mitigation devices such as neutral-blocking devices on equipment beyond power transformers and accessories.

Copyright © 2015 IEEE. All rights reserved.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

2. Normative references

The following referenced documents are indispensable for the application of this document (i.e., they must be understood and used, so each referenced document is cited in text and its relationship to this document is explained). For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

IEEE Std C57.12.00™, IEEE Standard for General Requirements for Liquid-Immersed Distribution, Power, and Regulating Transformers.[1, 2]

IEEE Std C57.12.80™, IEEE Standard Terminology for Power and Distribution Transformers.

IEEE Std C57.91™, IEEE Guide for Loading Mineral-Oil-Immersed Transformers and Step-Voltage Regulators.

IEEE Std C57.110™, IEEE Recommended Practice for Establishing Liquid-Filled and Dry-Type Power and Distribution Transformer Capability When Supplying Nonsinusoidal Load Currents.

IEC 60076-7, Power Transformers—Part 7: Loading Guide for Oil-Immersed Power Transformers.[3]

3. Definitions

For the purposes of this document, the following terms and definitions apply. For other terms, the standard transformer terminology available in IEEE Std C57.12.80™ shall apply. The *IEEE Standards Dictionary Online* should be consulted for terms not defined in this clause.[4]

geoelectric field: The electric field within the earth. A geomagnetic disturbance of sufficient intensity and duration changes the earth's magnetic field thereby inducing atypical electric fields in the earth. The horizontal field near the surface of the earth, typically measured in V/km and characterized by the earth surface potentials, induces the flow of geomagnetically induced currents in power systems.

geomagnetic disturbance (GMD): A disturbance of the magnetic field of the earth caused by the ejection of plasma from the sun, due to coronal mass ejections (CME) and high speed solar wind streams, and its interaction with the earth's magnetic field. The changing magnetic field induces voltages in the loops formed by transmission lines, grounded-wye transformers, and the paths through earth between the transformer neutrals. The changing magnetic field induces the changes in the geoelectric field and the earth and surface potentials, resulting in the flow of geomagnetically induced current (GIC).

quasi-dc potentials: The potentials existing in geoelectric field, characterized by relatively slowly time-varying values of same polarity. Quasi-dc potentials are also commonly referred to as earth surface potentials.

T-beam: A T-shaped beam used in shell form transformers. T-beams are typically made of non-magnetic steel and are located at the bottom and may also be at the top of the core, supporting the core passing through the coils and the winding assembly.

---

[1] The IEEE standards or products referred to in this clause are trademarks of the Institute of Electrical and Electronics Engineers, Inc.
[2] IEEE publications are available from the Institute of Electrical and Electronics Engineers, Inc., 445 Hoes Lane, Piscataway, NJ 08854, USA (http://standards.ieee.org/).
[3] IEC publications are available from the International Electrotechnical Commission (http://www.iec.ch/). IEC publications are also available in the United States from the American National Standards Institute (http://www.ansi.org/).
[4] *IEEE Standards Dictionary Online* subscription is available at:
http://www.ieee.org/portal/innovate/products/standard/standards_dictionary.html.

Copyright © 2015 IEEE. All rights reserved.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015

temperature gradient: In transformers, temperature gradients are most frequently used to indicate the difference between the temperature the core, winding, or other transformer components and adjacent oil temperature in kelvin (K) in response to a change in loading.

tie-plates: Structural members typically utilized in core form transformers to tie the top and bottom core yokes and clamping structures together, which maintain clamping force on the windings. They are also known as flitch plates or tie-bars.

4. Background

Geomagnetic disturbance (GMD) is a naturally occurring phenomenon of a disturbance in the earth's magnetic field that starts with activity in the sun. Various events can occur on the surface of the sun, which can produce strong and complex magnetic fields. Sunspots, which are relatively cool areas shielded by complex magnetic fields, can give rise to solar flares and coronal mass ejections (CME). The CME can be visualized as an enormous ball of plasma that travels outward into space. When a CME is directed toward the earth, it interacts with the earth's magnetic field. One effect is to direct charged particles toward the earth's magnetic poles where, upon impacting the upper atmosphere, cause the phenomenon commonly known as the northern lights (aurora borealis), and southern lights (aurora australis). When a CME interacts with the magnetosphere, the movement of the geomagnetic field relative to the conductive ionosphere increases the magnitude of currents flowing 100 km to 150 km above the earth's surface in the *electrojets,* which are currents in the order of millions of amperes. These electrojet currents induce quasi-dc potential in series with the transmission lines, which in turn drives the flow of geomagnetically induced current (GIC) wherever there is a path for them to flow. It is the GIC that flows in the transmission lines which affects the power grid, i.e., the transmission systems and the power transformers. This flow is depicted in Figure 1.

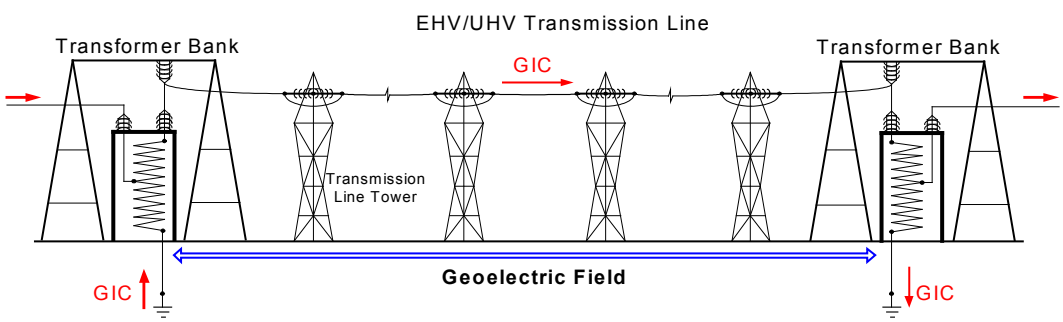

Figure 1—GIC flow in a power network

GIC is quasi-dc current because of its generally low frequency, typically 0.01 Hz to 0.5 Hz. At these frequencies the high-voltage (HV) network is essentially resistive; thus, inductance, capacitance, and the effects of magnetic coupling can be ignored in the calculation of steady-state GIC levels.

A GMD event can last one to two days, and continually generates low to moderate levels of GIC relative to the maximum GIC during the event. The periods of high intensity GIC are generally of the most concern for power system impacts and operation.

This guide provides some engineering information to help gain a better understanding of the extent of the potential problems, and to understand that GIC risk is not uniform across the system. It is highly dependent on the actual characteristics of the GMD event and each part of the power system. Factors that influence the degree of risk to power transformers include:

— Geomagnetic latitude

— Local earth resistivity

Copyright © 2015 IEEE. All rights reserved.

Documents
Document Sharing Hub

Authorized licensed use limited to: Tsinghua University. Downloaded on February 26,2026 at 21:59:39 UTC from IEEE Xplore. Restrictions apply.

Full document details: IEEE C57.163-2015