



IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases

IEEE Power Engineering Society

Sponsored by the
Power Systems Relaying Committee

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**Power System Relaying Committee
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IEEE Power Engineering Society**

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Abstract: The scope of the guide includes the grounding practices presently used and the practices that were not previously reported. Specifically, the issue of the grounding of cases of electronic transducers is addressed.

Keywords: current transformer, grounding of cases of instrument transformers, grounding secondary circuits of instrument transformers, instrument transformer, low energy transducer, voltage transformer

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Introduction

This introduction is not part of IEEE Std C57.13.3™-2005, IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases.

The primary emphases of this guide are personnel safety and proper performance of relays at the electric power system frequencies. The grounding and shielding of cables and other grounding considerations are not addressed. However, references dealing with these and related subjects are included in the bibliography (see Annex E).

Historically, it has been a common practice in the U.S. to connect the secondary circuits of current transformers (CTs) and voltage transformers (VTs) to the station ground. The present preferred practice is to locate a ground on the instrument transformer secondary circuit, along with suitable ground isolation test facilities, at the first point of application (switchboard or relay panel). The circuit ground isolation facilities make it convenient to test the integrity of the insulation from ground.

Previous publications have made significant contributions toward making the grounding practices more consistent in some areas. This guide includes the contributions that are generally practiced today, makes revisions where present experience and practice show them to be desirable, and suggests grounding techniques in new areas of interest. Diagrams are included to illustrate the grounding techniques.

This guide contains general and specific recommendations for grounding CT and VT secondary circuits and cases of connected equipment. The recommended practices apply to all transformers of this type, including capacitive VTs and linear couplers, irrespective of the voltage of the primary circuit or whether the primary windings are connected to the power circuits or are connected to the secondary circuits of other transformers, such as auxiliary CTs or VTs. Most diagrams included in this guide show relaying applications, but the practices are equally relevant to metering and other areas where instrument transformers are used.

Exceptions to grounding are permissible or are sometimes required when advantages obtained by not grounding, in certain instances or in certain types of installations, are considered to outweigh the safety or other advantages obtained by grounding. Such exceptions should comply with the recommendations of the National Electrical Safety Code® (NESC®) (Accredited Standards Committee C-2).^a

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^a For information on references, see Clause 2.

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Contents

1. Overview	1
1.1 Scope	1
1.2 Purpose	1
2. Normative references.....	2
3. Definitions	2
4. Need for grounding secondary circuits of instrument transformers and cases	2
5. Grounding of instrument transformer secondary circuits	3
5.1 General	3
5.2 Background.....	3
5.3 Ground connection to only one point in the secondary circuit	4
5.4 Recommended point of grounding	4
5.5 Location of connection to ground.....	5
5.6 Minimum size of conductor for ground connection.....	7
5.7 Ground connection isolation test facilities.....	8
6. Grounding of instrument transformer cases and cases of connected equipment	21
6.1 Metallic or conductive case grounding	21
6.2 Internal conductive parts—insulated cases	21
6.3 Ungrounded metallic or conductive case.....	21
7. Exceptions to grounding.....	21
8. Grounding of low-energy transducers	22
8.1 General	22
8.2 Interconnection wiring practices.....	22
Annex A (informative) Issues to consider for shielded cable applications for instrument transformers	25
A.1 General.....	25
A.2 CTs installed over shielded cables, metal bushing collars, or conduits	25
Annex B (informative) IEEE standards reviewed by the I-13—Revision of C57.13.3 Working Group.....	27
Annex C (informative) Article 90.2—Scope of the NEC.....	28
Annex D (informative) Survey of grounding practices	30
Annex E (informative) Bibliography.....	33

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1. Overview

The practices described in this guide apply to all instrument transformers, including capacitive voltage transformers (VTs) and linear couplers, irrespective of primary voltage or whether the primary windings are connected to, or are in, power circuits or are connected in the secondary circuits of other transformers as auxiliary current transformers (CTs) or VTs.

This guide does not discuss the grounding of some applications. For example, grounding of gas insulated substations and metal clad switchgear is not discussed in this guide; the reader will find these topics addressed in IEEE Std 242™¹. The grounding of circuits of core-balance CTs is also not discussed in this guide. The reader can also find this information in IEEE Std 242. Another issue that is not discussed in this guide is the practice of using separate safety and control grounds. For discussion on this topic, the reader is directed to IEEE Std 665™.

1.1 Scope

The scope of the guide includes the grounding practices presently used and the practices that were not previously reported. Specifically, the issue of the grounding of cases of electronic transducers is addressed.

1.2 Purpose

This guide provides information on the grounding of the following:

- Secondary circuits of electromagnetic CT and VT circuits
- Cases of relays, CTs, and VTs
- Secondary circuits of optoelectronic CTs and VTs

The primary emphases of this guide are personnel safety and proper performance of relays at electric power frequencies.

¹ For information on references, see Clause 2.

2. Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments or corrigenda) applies.

Accredited Standards Committee C-2, National Electrical Safety Code® (NESC®).¹

IEEE Std 242™, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems.^{2, 3}

IEEE Std 525™, IEEE Guide for the Design and Installation of Cable Systems in Substations.

IEEE Std 665™, IEEE Guide for Generating Station Grounding.

IEEE Std 1143™, IEEE Guide on Shielding Practice for Low Voltage Cables.

IEEE Std C62.92™, IEEE Guide for the Application of Neutral Grounding in Electrical Utility Systems.

NFPA 70, National Electrical Code® (NEC®).⁴

3. Definitions

For definitions of terms used in this guide, see IEEE Std C37.100™-1992 [B8]⁵ and *The Authoritative Dictionary of IEEE Standards Terms* [B2].

4. Need for grounding secondary circuits of instrument transformers and cases

It is necessary to ground secondary circuits of instrument transformers for protecting the protection, monitoring, and control equipment that are connected to them and for the safety of personnel who might come into contact with them. The primary circuits of instrument transformers are at high voltages; in many cases, they are in the range of hundreds of kilovolts. There is a (stray) capacitance between the high-voltage circuit and the secondary circuit of the instrument transformer. If a secondary circuit is not grounded, there will be a capacitance between the secondary circuit and the ground. The capacitances between the high-voltage circuit and the secondary circuit of the instrument transformer, and the capacitance between the secondary circuit and ground, are now connected in series and act like a voltage divider. A charge could accumulate on the secondary winding of the instrument transformer. Depending on the relative values of the two capacitances, the electrostatic potential of the secondary circuit with respect to ground could be substantial. This potential rise of the secondary circuit could damage the equipment connected to it; one of the failure modes could be insulation failure in the protection and control devices. The high electrostatic potential of the secondary circuit of the instrument transformer would be a hazard for personnel who might come into contact with the circuit. Because of these reasons, grounding has received attention in many standards, recommended practices, and guides. While these standards provide sufficient guidance, the

¹ The NESC is available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

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⁴ The NEC is published by the National Fire Protection Association, Batterymarch Park, Quincy, MA 02269, USA (<http://www.nfpa.org/>). Copies are also available from the Institute of Electrical and Electronics Engineers, 445 Hoes Lane, P.O. Box 1331, Piscataway, NJ 08855-1331, USA (<http://standards.ieee.org/>).

⁵ The numbers in brackets correspond to those of the bibliography in Annex A.

reader is advised to make certain that the grounding regulations provided in the National Electrical Code® (NEC®) (NFPA 70) and the National Electrical Safety Code® (NESC®) (Accredited Standards Committee C-2) are always adhered to. (Article 90.2 (A) of the NEC lists the installations that are covered by the Code, and Article 90.2 (B) lists the installations that are not covered by the Code. For immediate reference, Article 90.2 of the NEC is reproduced in Annex C.) If the secondary circuit of an instrument transformer is grounded, the capacitance between the secondary circuit and ground is short-circuited and electrostatic potential does not build up on the secondary circuit.

Similarly, there is a (stray) capacitance between the primary circuit and the case of a device used in the power system environment. If the case is not grounded, there is a (stray) capacitance between the case and the ground. These two capacitances form a series circuit that acts as a voltage divider. In this case also, the electrostatic potential of the case could be substantial. This would be a hazard for personnel who might come in contact with the case. The grounding of the case short-circuits the capacitance between the case and the ground and keeps the case at ground potential—eliminating the hazard. As stated in the previous paragraph, the reader must adhere to the requirements of the NEC and the NESC.

WARNING

Grounding of secondary circuits is an issue of safety of personnel and equipment connected to the secondary circuits. The reader is urged to consider it seriously and follow the stipulations of relevant standards and always adhere to the stipulations of the NEC and the NESC. Article 90.2 (A) of the NEC lists the installations that are covered by the Code, and Article 90.2 (B) lists the installations that are not covered by the Code. For immediate reference of the readers, Article 90.2 of the NEC is reproduced in Annex C.

5. Grounding of instrument transformer secondary circuits

5.1 General

The issue of grounding instrument transformers requires insight into the operation of power systems during normal working conditions and during faults between one or more phases to ground. In these cases, parts of the fault currents flow in the ground path and raise the voltage of the grounding grids in generating stations and substations. When this happens, different locations in the generating stations and substations are at different potentials. These differences are taken into consideration when choosing the manner in which the secondary circuits of the CTs and VTs are connected. This clause examines the relevant issues on the grounding needs and practices.

Specific issues addressed in this clause include grounding at a single location on a secondary circuit, location of the ground, marking of ground connections, and the minimum size of conductor used for grounding the secondary circuits.

5.2 Background

Each secondary circuit of CTs and VTs is usually a completely self-contained metallic circuit. The circuit is insulated from ground, except at one point in the circuit where it is solidly grounded through a conductor of adequate size. (See 5.6 for conductor size and 5 for permissible exceptions.)

For the purposes of this guide, an instrument transformer (CT or VT) secondary circuit consists of a set of three-phase secondary windings of the instrument transformers and all the coils, contacts, and other components connected to those windings by insulated metallic wires. In single-phase applications, the instrument transformer secondary circuit consists of the secondary winding of the instrument transformer and all the coils, contacts, and other components connected to that winding by insulated metallic wires.