PC57.13.3

IEEE Guide for Grounding of Instrument Transformer Secondary Circuits and Cases
OUTLINE

- Scope
- References
- Need for grounding; Warning
- Definition of Instrument transformers
- Grounding secondary circuits
  - Grounding at a single location
  - Conductor size for connecting to ground
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.
Covers

The practices described in this standard apply to all instrument transformers, including capacitive voltage transformers 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 cts or vts.
Does not cover

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 reference [9] listed in clause 2. The grounding of circuits of core-balance CTs is also not discussed in this guide. The reader can find this information also in reference [9] listed in clause 2. 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 reference [12] listed in clause 2.
References

References

[9] Std. 242™*2001, IEEE Recommended Practice for Protection and Coordination of Industrial and Commercial Power Systems
References

Need for Grounding Secondary Circuits

- To protect equipment connected to the circuits
- To Protect personnel who might come into contact with the equipment

How the problem manifests

- When secondary circuit is not grounded
- When a case is not grounded

  - Voltage due to charge accumulation on an ungrounded secondary circuit or case
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 ensure that the stipulations of the National Electrical Code [1] and the National Electric Safety Code [2] are always adhered to.
Warning

Article 90.2 (A) of National Electrical Code [1] lists the installations that are covered by the Code [1] 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 National Electrical Code [1] is reproduced in Annex C.
Grounding of Instrument Transformer Secondary Circuits

- Definition of a secondary circuit for the purposes of the guide
- Issues
  - Grounding at a single location
  - Minimum size of the grounding conductor
Issues

- **Grounding at a single location**
  - Voltage at different locations of the physical ground and circuits connected to ground is different when fault currents flow
  - Convenience of testing a secondary circuit
  - Problem with forming a common neutral of more than one instrument transformers and then grounding the neutral bus
  - Isolation of all secondary circuits from ground
Issues

- Recommended point of grounding
  - switchboard or relay panel
- Grounding unused secondary windings
- Grounding examples
Grounding 3 Φ 4 Wire VT Circuits

1 Ø

3 Ø 4 W

METHOD 2

UNUSED SECONDARY

METHOD 1

SWITCHBOARD TERMINAL POINTS

(OMIT WHEN DOTTED CONNECTION USED)
Grounding 3 Φ 3 Wire VT Circuits

3 Ø 3 W

OPEN DELTA

WYE

CONNECTIONS TO GROUND BUS AT SWITCHBOARD (#12 AWG CU MINIMUM)

* GROUND ISOLATING CONNECTION

NEUTRAL NOT BROUGHT OUT
Grounding unused CTs

- Terminals at CT location
- No connection to taps
- No isolation
- Ground jumper required
ISSUES

- Minimum size of grounding conductor
  - 12 AWG required by NESC©
TYPICAL APPLICATIONS

- VT circuits
- Voltage provided from distribution transformers
Using Voltage from a Distribution Transformer

NOTE: BECAUSE OF THE TWO GROUNDS ON G(N), IT SHOULD BE SUFFICIENTLY HEAVY SO THAT STATION GROUND FAULTS WILL NOT CAUSE DAMAGE TO G(N)
Generator Neutral Grounding Transformer

- TO GEN NEUTRAL
- GROUND ISOLATING CONNECTION
- STATION GROUND MAT
- SWITCHBOARD GROUND
- PG
- PN
- TO RELAYS, OSCILLOGRAPH, ETC.

Diagram:

- Transformer with a ground isolating connection and station ground mat.
- Connections to generator neutral, switchboard ground, and relays.
Generator Neutral Grounding Transformer

TO GEN NEUTRAL

STATION GROUND MAT

CENTER TAP GROUND SOMETIMES USED SO THAT ACCIDENTAL GROUND ON PG WILL NOT COMPLETELY DISABLE GENERATOR GROUND PROTECTION

OPTIONAL CONNECTION

PG

TO RELAYS, OSCILLOGRAPH, ETC.

PN

TO GEN NEUTRAL
Generator Neutral Grounding Transformer

NOTE: BECAUSE OF INHERENT GROUND ON DISTRIBUTION STYLE TRANSFORMER INSTALL GROUND AT PANEL AND ADD ISOLATION TRANSFORMER

TO RELAYS, OSCILLOGRAPH, ETC.
Generator Grounding Transformer

GROUNDING TRANSFORMER

TO RELAYS, OSCILLOGRAPH, ETC.
Basic Synchroscope Circuit

CKT. 2

PB

25

SCOPE

25

PB

RUN

INC

CKT. 1

PN

* GROUNDING ISOLATION CONNECTION

PN

*
Synchroscope with Multiple Incoming Circuits

GROUNDING ISOLATION CONNECTION

GROUNDS NOT NECESSARILY ELECTRICALLY CLOSE
Synchroscope with Multiple Incoming and Running Circuits

GROUNDING ISOLATION CONNECTION

GROUNDS NOT NECESSARILY ELECTRICALLY CLOSE
Synchroscope with Multiple Incoming and Running Circuits using Isolating Transformers
Synchroscope with Synchronizing Lights

GROUNDING ISOLATION CONNECTION

GROUPS SHOULD BE ELECTRICALLY AS CLOSE AS PRACTICAL

THIS CONTACT PERMITS THE TWO VOLTAGE CIRCUITS TO BE SEPARATELY GROUNDED
Grounding Distribution Station with one Φ used for Instrumentation

NOTE: BECAUSE OF THE TWO GROUNDS ON G(N), IT SHOULD BE SUFFICIENTLY HEAVY SO THAT STATION GROUND FAULTS WILL NOT CAUSE DAMAGE TO G(N)
Grounding 1 Φ CT Circuit
Grounding 1 φ CT Circuit

A

CP

CN

* GROUND ISOLATION CONNECTION

BURDEN
Grounding 3 Φ CT Circuit

TERMINALS AT CT LOCATION

SWITCHBOARD TERMINALS

GROUND ISOLATION CONNECTION
Grounding 3 Φ CT Circuit

TERMINALS AT CT LOCATION

SWITCHBOARD TERMINALS

A

B

C

GROUND ISOLATION CONNECTION
Grounding V Connected CT Circuit
Delta-Delta Connected CTs in a Differential Protection Relay
Delta-Wye Connected CTs in a Differential Protection Relay
Percentage Bus Differential Scheme

SWITCHBOARD TERMINALS

GROUND ISOLATION CONNECTION

CTK. 1

TO CTS ON CKT. 2

TO CTS ON CKT. 3

RESTRAINT

OPERATE

PHASE A

PHASE B

PHASE C

A

B

C

CD1A
CD1B
CD1C
CD1N
CD2A
CD2B
CD2C
CD2N
CD3A
CD3B
CD3C
CD3N

IEEE POWER ENGINEERING SOCIETY
Ring Bus or Breaker and a Half Scheme

SWITCHBOARD TERMINALS (MAY BE SLIDING LINK TYPE TO FACILITATE TESTING)

GROUND ISOLATING CONNECTION

CONTROL HOUSE GROUND BUS

TERMINALS AT CT LOCATION

TO METERS, RELAYS, ETC.
Multiple use of CTs

- ONE SET OF CTs ON DOUBLE-BREAKER LINE
- ISOLATING CTs
- LINE RELAYS
- GROUND ISOLATION CONNECTION
- DIFFERENTIALLY CONNECTED OVERCURRENT RELAYS
- SWITCHBOARD TERMINALS (MAY BE SLIDING LINK TYPE TO FACILITATE TESTING)
Grounding of Cases

- Grounding metallic conductive cases
- Insulated cases with conductive internal parts
- Ungrounded metallic cases or internal parts
  - Protected by suitable barriers or elevated to prevent contact if operating voltage exceeds 1,000 V
Exceptions to Grounding

- If the primary windings of instrument transformer circuits are connected to circuits of less than 1000 V with no live parts or wiring exposed or accessible to other than qualified persons, the circuits may not be grounded.
Exceptions to Grounding

For instrument transformer cases, the cases or frames of CTs may not be grounded if the primary windings are not over 150 V to ground and are used exclusively to supply current to meters.
Exceptions to Grounding

Cases of instruments, meters, and relays operating at less than 1000 V on switchboards having exposed live parts on the front of panels are not usually grounded. Mats of insulating rubber or other suitable floor insulation is provided where the voltage to ground exceeds 150 V.
Exceptions to Grounding

Instruments, meters, and relays, whose current-carrying parts operate at voltages to ground of 1000 V and over, are isolated by elevating them or protecting them by suitable barriers, grounded metal or insulating covers, or guards. In such situations, the cases are not usually grounded.
Grounding of Low-Energy Transducers

[Diagram showing the grounding of a low-energy sensor with a relay or IED, with an optional capacitive shield for high-frequency EMI reduction, and a note indicating 10 nF for grounding.]

*Optional capacitive shield grounding at source and for high-frequency EMI reduction.*
Grounding of Low-Energy Transducers

10 nF*

*Optional capacitive shield grounding at source and for high-frequency EMI reduction.
Grounding of Low-Energy Transducers

- Relay or IED
- 10 nF
- Optional capacitive shield grounding at source and for high-frequency EMI reduction.

Intermediate Summing Amplifier

- Sensor 1
- Sensor 2
- Sensor 3
Annex A

Grounding of shielded cables

- To consider current carrying capacity of the shield
- Cables with spiral design shields are grounded at both ends
- Cables with drain wires are grounded at one end
Annex A

CTs installed over shielded cables
Annex B

IEEE Standards reviewed by the WG
Annex C

-Clause 90.2, Scope of National Electricity Code
  - Type of installations covered by the Code
  - Type of installations not covered by the Code
  - Special permission
ANNEX D

Survey of Grounding Practices

- Approximately one-third of the respondents do not ground voltage transformers “at the first point of use” as described in the Guide. The Working Group is of the opinion that grounding “at the first point of use” is better than grounding at other locations.

- Almost all respondents indicated that current transformers are grounded “at the first point of use” as described in the Guide.