



BSI Standards Publication

Instrument transformers

Part 102: Ferroresonance oscillations
in substations with inductive voltage
transformers

National foreword

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TECHNICAL REPORT



**Instrument transformers –
Part 102: Ferroresonance oscillations in substations with inductive voltage
transformers**

INTERNATIONAL
ELECTROTECHNICAL
COMMISSION

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CONTENTS

FOREWORD.....	5
INTRODUCTION.....	7
1 Scope.....	8
2 Normative references	8
3 Introduction to ferroresonance oscillations.....	8
3.1 Definition of ferroresonance	8
3.2 Excitation of steady state and non-steady state ferroresonance oscillations.....	10
4 Single phase and three phase oscillations	12
4.1 Single phase ferroresonance oscillations	12
4.2 The simplified circuit for the single phase ferroresonance oscillations.....	13
4.3 Capacitive voltage transformers.....	15
4.4 Three-phase ferroresonance oscillations.....	15
4.4.1 General	15
4.4.2 Configuration	15
4.4.3 Ferroresonance generation.....	16
4.4.4 Resulting waveform of ferroresonance oscillation	16
4.4.5 Typical oscillogram of three phase ferroresonance	19
5 Examples of ferroresonance configurations	20
5.1 Single-phase ferroresonance power line field in a 245 kV outdoor substation	20
5.2 Single phase ferroresonance oscillations due to line coupling	22
5.3 Three-phase ferroresonance oscillations.....	25
6 Inductive voltage transformer (key parts).....	26
7 The circuit of the single-phase ferroresonance configuration	28
7.1 Schematic diagram	28
7.2 Magnetisation characteristic.....	29
7.3 Circuit losses	30
8 Necessary information for ferroresonance investigation.....	31
8.1 General	31
8.2 Single phase ferroresonance.....	31
8.3 Three phase ferroresonance	32
9 Computer simulation of ferroresonance oscillations	33
9.1 General.....	33
9.2 Electrical circuit and circuit elements	33
9.3 Circuit losses	33
9.4 Examples of simulation results for single phase ferroresonance oscillations.....	33
9.4.1 General	33
9.4.2 Case 1: Transient, decreasing ferroresonance oscillation	34
9.4.3 Case 2: Steady-state ferroresonance oscillation at network frequency	34
9.4.4 Case 3: Steady-state subharmonic ferroresonance oscillation.....	35
9.4.5 Case 4: Steady-state chaotic ferroresonance oscillation	36
9.5 Simulation of three phase ferroresonance	37

10	Experimental investigations, test methods and practical measurements.....	38
10.1	General.....	38
10.2	Single-phase ferroresonance oscillations	38
10.3	Three-phase ferroresonance oscillations	41
11	Avoidance and suppression of ferroresonance oscillations	42
11.1	Flow diagram	42
11.2	Existing substations	44
11.3	New projects	44
11.4	Avoidance of ferroresonance oscillations	44
11.4.1	General	44
11.4.2	Single phase ferroresonance oscillations	44
11.4.3	Three phase ferroresonance oscillations.....	45
11.5	Damping of ferroresonance oscillation	45
11.5.1	General	45
11.5.2	Single-phase ferroresonance oscillations.....	45
11.5.3	Three-phase-ferroresonance oscillations	47
Annex A	(informative) Oscillations in non-linear circuits	49
A.1	Overview.....	49
A.2	The simplification of non-linear electrical circuits with the theorem of Thévenin.....	51
A.3	The differential equation for ferroresonance oscillations.....	51
A.4	Oscillation frequencies in ferroresonance systems	53
Bibliography	54
Figure 1	– Example of a typical magnetisation characteristic of a ferromagnetic core.....	9
Figure 2	– Schematic diagram of the simplest ferroresonance circuit	9
Figure 3	– Examples of measured single-phase ferroresonance oscillation with 16 ² / ₃ Hz oscillation.....	11
Figure 4	– Schematic diagram of a non-energised outgoing feeder bay with voltage transformers as an example in which single-phase ferroresonance oscillations can occur	12
Figure 5	– Diagram of a network situation that tends toward single-phase ferroresonance oscillations, in which they can be excited and maintained over the capacitive coupling of parallel overhead power line systems	13
Figure 6	– Electrical circuits for theoretical analysis of a single-phase ferroresonance oscillation	14
Figure 7	– Insulated network as an example of a schematic diagram of a situation in which a three-phase ferroresonance oscillation can occur.....	15
Figure 8	– Phasor diagram to explain the oscillation of the earth potential	16
Figure 9	– Laboratory test set used by Bergmann	17
Figure 10	– Domains in the capacitance C and line voltage U where different harmonic and sub-harmonic ferroresonance oscillations are obtained for a given resistance R of 6,7 Ω in Bergmann's test set.....	18
Figure 11	– Domains in the capacitance C and line voltage U where second sub-harmonic ferroresonance oscillations are obtained for a variation of the resistance R in Bergmann's test set	18
Figure 12	– Domains in the capacitance C and line voltage U where different modes of second sub-harmonic ferroresonance oscillations are obtained for a given resistance R of 6,7 Ω in Bergmann's test set.....	19
Figure 13	– Fault recorder display of a three-phase ferroresonance oscillation	20

Figure 14 – Switching fields in the 245 kV substation in which single-phase ferroresonances occur	21
Figure 15 – Examples of oscillations of single-phase ferroresonance when switching off the circuit breaker in Figure 14	22
Figure 16 – Single-phase schematic of the network situation on the 60 kV voltage level in the area of substations 1, 2, and 3	23
Figure 17 – Tower schematic of the common stretch of overhead lines between substations 1 and 2.....	24
Figure 18 – Ferroresonance oscillations recorded in line no. 5 at Substation 2	24
Figure 19 – Single-line diagram of the 170-kV substation (left) and the 12-kV substation (right); where during switching operation three phase ferroresonance oscillations occurred	25
Figure 20 – Oscillograms of the three-phase voltages at inductive voltage transformer T04 (Figure 19).....	26
Figure 21 – Schematic circuit of voltage transformer and the simplification for ferroresonance studies	27
Figure 22 – Circuit for the analysis of single-phase ferroresonance oscillation	29
Figure 23 – Example of a hysteresis curve of a voltage transformer core measured at 50 Hz.....	30
Figure 24 – Schematic diagram for three phase ferroresonance oscillation	32
Figure 25 – Transient decreasing ferroresonance oscillation with the fifth subharmonic 50/5 Hz (10 Hz)	34
Figure 26 – Steady state ferroresonance oscillation with network frequency	35
Figure 27 – Steady state ferroresonance oscillation with 10 Hz.....	36
Figure 28 – Steady state chaotic ferroresonance oscillation	37
Figure 29 – Example of the connection of a measuring resistor for capturing the current signal through the voltage transformer’s primary winding at terminal N (see connection diagram in Figure 30).....	39
Figure 30 – Current measurement through voltage transformer’s primary winding and the voltage at the secondary winding.....	40
Figure 31 – Measurement of a single-phase ferroresonance oscillation.....	41
Figure 32 – Measurement of three-phase ferroresonance oscillations with an oscilloscope.....	42
Figure 33 – Flow diagram for analysis and avoidance of ferroresonance oscillations.....	43
Figure 34 – Electrical circuit with damping device (red circles) connected to the secondary winding of the voltage transformer	45
Figure 35 – Example of successful damping of single-phase ferroresonance oscillations of $16^{2/3}$ Hz.....	46
Figure 36 – Damping of the ferroresonance oscillation in the open delta connection of the voltage transformers in the feeder bay	47
Figure 37 – Damping of ferroresonance oscillations with voltage transformer in the star point of the power transformer	48
Figure A.1 – A simplified electrical circuit for the analysis of ferroresonance oscillation	49
Figure A.2 – Diagram for the derivation of non-linear differential equation of second order.....	52
Figure A.3 – A non-linear oscillation system.....	53
Table 1 – Types of excitation and possible developments of ferroresonance oscillations.....	10
Table 2 – Parameters	31

INTERNATIONAL ELECTROTECHNICAL COMMISSION

INSTRUMENT TRANSFORMERS – PART 102: FERRORESONANCE OSCILLATIONS IN SUBSTATIONS WITH INDUCTIVE VOLTAGE TRANSFORMERS

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IEC 61869-102, which is a technical report, has been prepared by IEC technical committee 38: Instrument transformers.

The text of this technical report is based on the following documents:

Enquiry draft	Report on voting
38/440A/DTR	38/445/RVC

Full information on the voting for the approval of this technical report can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all the parts in the IEC 61869 series, published under the general title *Instrument transformers*, can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the stability date indicated on the IEC web site under "<http://webstore.iec.ch>" in the data related to the specific publication. At this date, the publication will be

- reconfirmed,
- withdrawn,
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

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INTRODUCTION

During the last twenty years ferroresonance oscillations in substations with inductive voltage transformers according to IEC 61869-3 or with combined transformers according to IEC 61869-4 were discussed in the international Cigré working groups and in IEEE committees in the US.

The results were published in Cigré [1] technical report or IEEE [2] publications.

The reasons for these publications were the more frequent occurrence of ferroresonance oscillations in substations. As a consequence of the price pressure on the operating authorities and the component manufacturers such as instrument transformers, power transformers and grading capacitors for high-performance circuit breakers have led to an increasingly higher exploitation of the system and components.

This trend results in:

- a) the shift from normal rated voltage U_{pr} in the direction of the maximum permitted highest voltage for equipment U_m (IEC 60071-1 [3]);
- b) increasing the flux density \vec{B} by reducing the cross-section of the core of the inductive voltage transformer;
- c) the reduction of the substation capacitance by using new components (e.g. MV and HV instrument transformers) leads to an increase of the excitation-voltage for the non-linear circuits;
- d) reduction of the actual burden in the substation by using digital meters and relays with burden of approximately 1 VA, while still specifying the high nominal burden (50 VA to 400 VA) for the inductive voltage transformer. However, even these higher burdens are often not sufficient to prevent ferroresonance oscillations.

PART 102: INSTRUMENT TRANSFORMERS – FERRORESONANCE OSCILLATIONS IN SUBSTATIONS WITH INDUCTIVE VOLTAGE TRANSFORMERS

1 Scope

This part of IEC 61869 provides technical information for understanding the undesirable phenomenon of ferroresonance oscillations in medium voltage and high voltage networks in connection with inductive voltage transformers. Ferroresonance can cause considerable damage to voltage transformers and other equipment. Ferroresonance oscillations may also occur with other non-linear inductive components.

2 Normative references

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

IEC 61869-3, *Instrument Transformers – Part 3: Specific requirements for inductive voltage transformers*

IEC 61869-5, *Instrument Transformers – Part 5: Specific requirements for capacitive voltage transformers*

3 Introduction to ferroresonance oscillations

3.1 Definition of ferroresonance

Ferroresonance refers to non-linear oscillations that can occur in switching facilities where inductive components with a ferromagnetic core, together with capacitances and an AC voltage source comprise a system capable of oscillation. Numerous reports and publications on occurrences of ferroresonance have already been documented in the first half of the last century. A classic example of these occurrences comes from R. Rüdenberg [4]. His research was only done for fundamental frequencies; others carried out research on harmonics and subharmonics. A modern, didactically prepared introduction to ferroresonance problems can be found in K. Heuck and K.-D. Dettmann [5]. Much-cited basic examinations of the wide variety of ferroresonance oscillations were described by Bergmann [6, 7]. A review article on the problem was presented at the Cigré Conference in 1974 [1].

All ferromagnetic materials only allow themselves to be magnetised to a certain saturation flux density B_S . If inductive voltage transformers are magnetised over their saturation flux density,

the relationship between the magnetic field strength \vec{H}_{eff} and the magnetic flux density \vec{B} are given by a strong non-linear characteristic (Figure 1). This means that the main inductance of an inductive voltage transformer in excess of the saturation flux density will collapse to a small fraction. This occurrence of core saturation plays an important role in the phenomena of ferroresonance.

Ferroresonance oscillations will only occur in configurations in high and medium voltage substations or in sections of networks. Single phase oscillations will occur in systems in which the high voltage winding of the inductive voltage transformer is connected in series with a