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Instrument transformers

Part 102: Ferroresonance oscillations in substations with inductive voltage transformers

National foreword

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A list of organizations represented on this committee can be obtained on request to its secretary.

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

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INTERNATIONAL ELECTROTECHNICAL COMMISSION

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

FOREWORD

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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- withdrawn,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.

IMPORTANT – The 'colour inside' logo on the cover page of this publication indicates that it contains colours which are considered to be useful for the correct understanding of its contents. Users should therefore print this document using a colour printer.

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 $\vec{\hat{B}}$ 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 $\vec{B}_S$. 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 $\hat{\vec{B}}$ 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