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IEEE Guide to Describe the Occurrence and Mitigation of Switching Transients Induced by Transformers, Switching Device, and System Interaction

IEEE Power & Energy Society

Sponsored by the
Transformers and Switchgear Committee

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USA

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Abstract: The performance of transformers in the presence of oscillatory transients is addressed in this guide. Oscillatory transients are typically produced by the interaction of the switching device, transformer, load, and system. This guide describes operating conditions that may produce oscillatory switching transient voltages damaging to the transformer insulation system. It discusses the electrical characteristics of the source, switching device, transformer, load and the nature of their transient interaction. It discusses several mitigation methods. Two generic examples are included. This guide focuses on mechanical switching devices and does not address semiconductor switching devices.

Keywords: IEEE C57.142, mitigation, oscillatory, snubber, switching device, transformer, transient

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

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Introduction

This introduction is not part of IEEE Std C57.142-2010, IEEE Guide to Describe the Occurrence and Mitigation of Switching Transients Induced by Transformers, Switching Device, and System Interaction.

Recent attention has focused on the transient voltage interaction of a switching device, system characteristics, and transformer due to a number of transformer internal winding failure reports. The conditions causing the event are of considerable practical interest because the transformers that failed had passed all standard induced, high potential, and impulse voltage tests required in transformer standards. Additionally, these transformers were further protected with surge arresters. It has been understood for some time that switching events can generate transient voltages on the terminals of the transformer. These transients voltages can be damped, oscillatory, triangular, or exponential, and can occur as a combination of these forms. Generally, these transient voltages are below the maximum arrester protective levels. Because of this, it was felt that these wave forms could not produce any damage to the insulation structure of the transformer. However, even with a much lower magnitude, these oscillatory switching voltages have the potential to produce very large internal voltages if the oscillatory frequency is near one of the winding natural frequencies. This situation can take place at any voltage but primarily occurs at 38 kV and below. These facts were brought to the attention of the industry in a paper by Musil, et al., [B26].[a] The authors suggest that the internal transformer insulation may well be overstressed when an oscillatory voltage is applied at the winding terminal, even if the voltage magnitude is below the surge arrester's protective level or transformer terminal insulation level.

This situation was studied by the IEEE PES Switchgear Committee, and resulted in changes incorporated in 5.17.1 of IEEE Std C37.010™-1999, where readers were advised of the issue. The IEEE PES Transformers Committee began studying this situation in 1996, and formed a Working Group on Switching Transients Induced by Transformer/Switching Device Interaction in 1997, and started work on a guide under an original project authorization request (PAR) approved by the IEEE-SA Standards Board in 2000. This project expired in 2006, and a replacement project authorization (PAR) was approved by the IEEE-SA Standards Board in 2007 under joint sponsorship by the Transformer Committee and the Switchgear Committee. This Guide is the product of the work of this jointly sponsored Working Group.

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IEEE Guide to Describe the Occurrence and Mitigation of Switching Transients Induced by Transformers, Switching Device, and System Interaction

1. Overview

1.1 Scope

This guide addresses the application of transformers in the presence of oscillatory switching transients. These oscillatory transients are typically produced by the interaction of the switching device, transformer, load, and system. This guide defines operating conditions that may produce switching voltages damaging to the transformer insulation system. It discusses the electrical characteristics of the system source, switching device, transformer, and load and the nature of their transient interaction. It outlines several mitigation methods. Two examples are included.

This guide recognizes that many devices and/or system operations can produce oscillatory transient waveforms. The focus of this guide is on the interaction between a transformer, the system, and a switching device as a result of several reports of transformer internal winding failures.

This guide focuses only on mechanical switching devices and does not cover semiconductor switching devices.

Transformers that are inductively loaded (reactors, or stalled or accelerating motors) are not covered by this document but are addressed by several other referenced publications.