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Impact of Metal Oxide Varistor on the Occurrence of Ferroresonance Oscillations in Transformers

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***Abstract*—The impact of a parallel Metal Oxide Varistor (MOV) on the transformer's ferroresonance oscillations is examined in this paper. It is anticipated that an arrester generally causes ferroresonance mitigation. But for a sustained ferroresonance, sometimes MOV fails to protect the transformer. To investigate this effect, MATLAB SIMULINK has been used for time-domain simulation. A single phase unloaded transformer has been simulated. A two-term polynomial of order seven is used to simulate the transformer's magnetization characteristic. Linear resistance is used to model the core loss. The impact of changing the input voltage has been investigated. MOVs with different characteristics have been taken and the points of breakdown have been found out under sustained ferroresonance. This work can help to choose MOV of proper rating for specific transformer application.**

***Keywords*— Ferroresonance, Metal Oxide Varistor (MOV), Power transformer, Overvoltage, Nonlinear core losses effect**

I. Introduction

The complex nonlinear electrical phenomenon known as ferroresonance can result in overvoltages in the transformer. This can be unsafe and many times higher than the equipment's typical ratings. Usually, it involves a saturable core inductance of the transformer and a capacitor. The capacitive effect can be brought in the system by transmission line capacitance or similar effect due to other equipment connected with the transformer. Usually, some kind of system disruption causes it to start, like when transformer feeder lines are disconnected or a circuit breaker connected in series with a voltage transformer opens. Although studies on resonance in transformers were published as early as 1907 [1], the term "ferroresonance" was first used in the literature in 1920 [2]. In the 1940s, Rudenberg completed the first analytical study [3]. Later, in the 1950s, Hayashi produced more accurate and thorough work [4]. The two primary focuses of subsequent research have been on ferroresonance study at the system level [5,6] and enhancing transformer models [7,8]. In [9,10], the effects of implementing MOV in the distribution environment are discussed. In transformers, the effectiveness of metal oxide arresters subjected to ferroresonance circumstances is examined in [11]. The arresters have been shown to have a mitigating effect on the chaotic ferroresonance in articles [12,13]. But it has been found that the ferroresonance may run for a long time which may cause overheating in the arrestor or even burn out. In addition to examining how MOV affects a ferroresonance circuit's overall behaviour, the current paper attempts to determine the MOV's breakdown point under conditions of sustained ferroresonance.

II. System Modeling without MOV

Representation of saturable transformer core appropriately in the simulation is the most challenging task. In this study, the saturation behaviour of the transformer is represented by a non-linear inductor. To find out a reliable equation of the saturable inductor, the B-H curve of the transformer's core material is extracted. For that a special laboratory setup [14] has been arranged as shown in Fig. 1. The instantaneous voltage & current with respect to time was recorded.

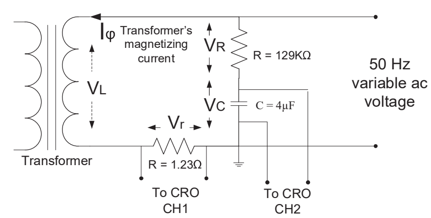

Fig. 1. Transformer B-H loop Measurement Circuit [14]

Rating of the single-phase transformers used for this experiment is given below:

Transformer: Single phase, 450 VA, 0-250-433V / 0-250-433V / 2 V, 50 Hz, major insulation 25 kV level

The hysteresis loop obtained as shown in Fig 2.

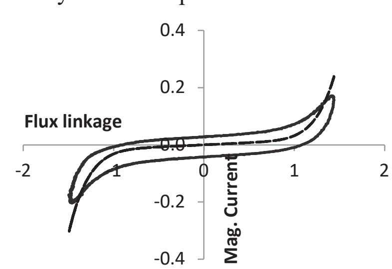

Fig. 2. Experimental (continuous) and Simulated (dashed) curves for magnetizing current vs. Flux linkage

After using MATLAB's curve fitting tool to approximate this B-H loop with a suitable nonlinear equation, the following polynomial relation was determined to be adequate.

$$i_\lambda = 0.015\lambda + 0.013\lambda^7 \quad (1)$$

Here λ = flux linkage, i_λ= magnetizing current.