IEEE/PES Transformers Committee
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# Proposed Test to Determine Zo for Transformers with Interconnected Windings

**-- Technical Presentation, Monday, March 8, 4:45 p.m. --**

**by Girolamo (Gerry) Rosselli**

## 1. Abstract

Power Transformer manufacturers provide a test report that includes information about the measured positive and zero sequence impedances. This impedance is determined by tests as described by the IEEE/ANSI Standard C57.12.90. This Standard covers a variety of transformer connections such as wye-delta, delta-wye, and some three winding transformers, but it excludes transformers with interconnected windings like wye-delta-ZigZag. To date, no reference is given as to how this information can be obtained.

San Diego Gas & Electric (SDG&E) uses interconnected winding transformers in certain applications to provide a stable ground/neutral reference point. This configuration is also used to maintain an $X_0/X_1$ ratio of 3 or less for the high voltage system (effectively grounded system), provide a 30-degree phase-shift, and supply a neutral for the low voltage distribution side.

The purpose of this tutorial session is to provide a new way to test interconnected transformers for the zero-sequence impedance using symmetrical components to solve the line-to-ground fault general equations. These equations are then modified into a form that is easily implemented by both transformer manufacturers and utilities. The final equation reflects results in Volts, Amperes, and Percent Reactance. This test is valid for any two- or three-winding transformers because a natural installation equivalent test is utilized for a single line-to-ground fault with a balanced three-phase voltage at the source.

## 2. Learning Objectives

Attendees of this tutorial session will learn a new way to test interconnected windings transformers using symmetrical sequence components to solve the line-to-ground fault general equations and obtain an accurate value for the zero-sequence reactance of the transformer.

## 3. Learning Outcomes

The information learned from this session should help utility and manufacturer attendees in two different ways:

1. Utility Attendees: Should be able to go back and use the new equations to test interconnected transformers for the zero-sequence impedance. The test is performed at a reduced voltage and current, and the results are later proportionally calculated at rated values. This test is valid for any three-phase transformer connection regardless of the type. Besides a zero-sequence test, the positive-sequence test can also be performed to check the reactance value, and then it can be compared to the manufacturer's Test Report. The source voltage can be a portable generator for this test.

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2. Manufacturers Attendees: Should be able to test any transformer, including interconnected winding per the new standard, and also obtain the zero-sequence impedance using the new proposed equation. They will also be able to discuss these new testing requirements with their customers.

## 4. Presenter's Biographies

**Girolamo (Gerry) Rosselli:** Mr. Rosselli is presently a Principal Engineer at San Diego Gas & Electric. He joined San Diego Gas & Electric as a Substation Engineer in 1981, and in 1985 joined the System Protection group as a Relay and Protection Engineer. One of his major accomplishments is the coordination of the transmission and subtransmission systems of the Island of Guam. He has written an article on 500 kV Series Capacitors for T&D Magazine in 1987. He presented the paper, "Transformer Test to Calculate $Z_0$ for Interconnected Windings Transformers Using Symmetrical Sequence Components" to both Georgia Tech and the Western Protective Relay Conferences in 2003. He is a member and former Chairman of IEEE/PES Society San Diego Chapter, and a Registered Professional Engineer in the State of California. He received his B.S. degree in Electrical Engineering from the University of Illinois in 1978. Upon graduation, he was employed by Commonwealth Edison Company, where he worked on the planning side of the distribution systems, as well as electrical planning for high-rise buildings for the central Chicago area.