INRUSH CURRENT SEMINAR
Orlando, Monday, October 15, 2001

1. Abstract

All electromagnetic apparatus with iron cores have varying degrees of magnetic remnance, which retains a substantial portion of the magnetic induction to which the core is driven until polarity is reversed at the power source. This characteristic of iron means that when magnetizing power is removed, as with opening a switch, that the core remains magnetized. When power is reapplied to the core, the magnetic state to which the core will next be driven depends on the phase angle of the source relative to the retained magnetic state of the core. If the phase angle is identical to the state when the circuit was switched off, then magnetizing current will remain well behaved, and of very small amplitude. However, if the phase angle is sufficiently out phase and at a voltage zero, a very large inrush current will result. This seminar examines the inrush condition, looking at causal factors, amplitude with size and type of transformer as well as the effect of source impedance. Analytical examination of harmonics is considered as well as the impact on differential protection. Speakers include manufacturers and users in an open dialogue with plenty of opportunity for audience interaction!

2. Learning Objectives

Highlights of this seminar will be the following:

- Fundamentals of inrush
- Circuit analysis without and with resistance included
- Algorithms for inrush calculations
- Typical inrush currents versus power ratings, winding connections, core materials, and other factors
- Energy levels, wave shapes and second harmonic determination
- Impact on differential protection, and false tripping avoidance
- Operating practice at the user end

3. Proposed Learning Outcomes

A much better understanding of inrush currents and what to expect when transformers are applied in both step-down and step-up conditions as well as the impact of delta or grounded wye winding connection schemes. The audience will gain an appreciation for how inrush current changes with time, including the first half cycle, the first full cycle, and the 1/10th second points, so important to over-current protection. The audience will also see the impact of inrush on differential relays and learn how to use the second harmonic to control false tripping.

4. Presenters' Credentials

Dr. Ramsis Girgis: Dr. Ramsis S. Girgis (F'93) is presently Manager of the Development Engineering. Department in the Power Transformer Division of ABB Power T&D Company located in St. Louis, Missouri. He is also the leader of the global ABB R&D activities in the transformer -core performance area. Ramsis was born in Egypt in 1946. He received his Ph.D. degree from the University of Saskatchewan, Canada, in Electrical Power Engineering in 1978. Dr. Girgis has about 35 years of R&D experience in the area of power, distribution, and high frequency transformers, rotating machines, and pulse power components. His main areas of interest are electromagnetics and noise of electric power equipment. He has published and presented over 50 scientific papers in IEEE, IEE, CIGRE, and other international journals. He is presently the chairman of the IEEE Work Group on no load and load loss testing of power and distribution transformers and is a member of several working groups and subcommittees in the IEEE Transformers Standards Committee. He co-authored chapters in two recent electrical engineering handbooks on transformer design and transformer noise. He is the past Technical Advisor representing the US National Committee in the IEC Power Transformer Technical Committee (14).

Gary L Kobet: Is a Project Specialist, System Protection & Analysis for the Tennessee Valley Authority (TVA) in Chattanooga, Tennessee. His responsibilities include scoping relaying schemes for transmission and generation projects, as well as relay setpoint calculations and post-fault analysis. He has been involved in various working groups of the IEEE/PES Power System Relaying Committee for the past two years. Previously he worked as a field engineer and as power quality specialist. Mr. Kobet earned the B.S.E. (electrical) from the University in Alabama in Huntsville in 1989 and the M.S.E.E. from Mississippi State University in 1996. He is a member of the IEEE Power Engineering Society, CIGRE', Eta Kappa Nu, Tau Beta Pi, and is a registered professional engineer in the state of Alabama.

Glenn Swift: Presently a senior research engineer with APT Power Technologies, a manufacturer of DSP-based protective relays and recording networks. Has worked for Westinghouse Canada, Federal Pioneer Electric, Ontario Hydro, Metropolitan-Vickers (UK) and others. Professor of electrical engineering at the University of Manitoba for 36 years. Transactions and conference papers, and patents, in the areas of protection, control and heat transfer within large transformers. Current member of MT-1 of IEC TC-14 on transformer loading, IEEE TC subcommittee on transformer loading, and the IEEE PSRC (Power System Relaying Committee). Senior Life Member of the IEEE. BS and MS from the University of Alberta, PhD from the Illinois Institute of Technology.

Phil Hopkinson: Presently holds the position of Fellow-Engineer at the Global Research Center of Square D/Schneider Electric in Raleigh, North Carolina. Phil is a long-service member of the transformer engineering fraternity, where he has been employed in the design, development and engineering management of Square D, Cooper Industries and General Electric Companies over his 35-year professional career. Phil is a registered professional engineer, he holds a bachelor of Science degree in electrical engineering from Worcester Polytechnic Institute, a masters degree in System Science from Brooklyn Polytech, and is a graduate of GE's A-B-C Courses Advanced Engineering Program. He is currently The TA to IEC TC 14 (Power Transformers), Chairman of the IEEE PES Policy Development Coordinating Committee, Chairman of NEMA's Energy Policy Task Force within The Government Affairs Committee, a member of NEMA's Power Equipment Board Of Directors, a member of NEMA's Transformer Section, a member of IEEE SCC 28 on Electromagnetic Fields, and a member of IEC TC 106 on Electromagnetic Fields. Phil is a Senior Member of IEEE and currently holds 13 US Patents.