

Magnetizing Current, Harmonic Content and Power Factor as the Indicators of Transformer Core Saturation

Ismail Dawit, Syafruddin Hasan, and Soib Taib

Abstract

P power
 PF total (true) power factor
 PF_{disp} displacement power factor
 PF_{dist} distortion power factor
 $THDi$ percent total current harmonic distortion
 V_{rms} rms value of fundamental voltage
 μ permeability of core material

II. INTRODUCTION

The magnetic circuit is one of the most important active parts of transformer. It consists of laminated iron core and carries flux linked to windings. Energy is transferred from one electrical circuit to another through the magnetic field carried by the core. The iron core provides a low reluctance path to the magnetic flux thereby reducing magnetizing current.

The performances of transformers are also constrained by the magnetic flux limitations of the core. For ferromagnetic core transformers, we must be mindful of the saturation limits of the core. Remember that ferromagnetic materials cannot support infinite magnetic flux densities: they tend to "saturate" at a certain level (dictated by the material and core dimensions), meaning that further increases in magnetic field force (mmf) do not result in proportional increases in magnetic field flux.

Choosing the right lamination material for a particular application is an important power transformer design step, since lamination properties have a direct link to the losses power or efficiency of the transformer. Currently, important lamination properties (core loss and permeability) to be used for assessment are presented at 50 or 60 Hz, 1.0/1.5 T sinusoidal. Electromagnetic designers have to decide on the material based on this single operating point, although under practical working conditions, some transformers operate at flux density levels and frequencies beyond this point. It has been shown that choosing the lamination material that based on the lamination performance at one operating point only is not enough [1]. Designers of transformers have, however, never had data available on the specific iron losses of the materials they use for alternating flux densities higher than of the saturation value. The usual methods of measurement, applied to specimens of the material, fail completely at higher flux densities than because the power factor becomes very small and the magnetizing current very high [2]. The major nonlinear effects in transformer iron core are saturation, eddy current and hysteresis. Saturation is the predominant effect in power transformers, followed by eddy current and hysteresis effects [3]. The iron core of transformers and other electromagnetic devices is laminated so that at 50 Hz or 60 Hz (or, in general, at power frequency) skin effect is

Index Terms—Harmonic content, no-load current, power factor, saturation, transformer

I. NOMENCLATURES

B magnetic flux density
 B_r remanence magnetic flux density
 B_s saturation magnetic flux density
CROCO Cold-Rolled Grain Oriented
 H magnetic field intensity
 H_c coercivity magnetic field intensity
 H_{pk} peak value of magnetic field intensity
 H_s saturation magnetic field intensity
IEC International Electrotechnical Commission
IEEE Institute of Electrical and Electronic Engineers
 I_m magnetizing current
 I_{rms} rms value of all the current harmonic components
 $I_{1,rms}$ rms value of fundamental current
 $I_{h,rms}$ rms value of current harmonic component of order h
M4 commercial name for grain oriented silicon steel sheet's grade

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Power Electronics and Power Quality José Gabriel Oliveira Pinto, 2020-04-23 Power quality PQ is receiving more and more attention from consumers distribution system operators transmission system operators and other entities related to electrical power systems As PQ problems have direct implications for business productivity causing high economic losses the research and development monitoring technologies and power electronics solutions that ensure the PQ of the power systems are matters of utmost importance This book is a collection of high quality papers published in the Power Electronics and Power Quality Special Issue of the journal Energies It reflects on the latest investigations and the new trends in this field

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Advanced Power System Analysis and Dynamics L.P. Singh, 2006 This Book Is A Result Of Teaching Courses In The Areas Of Computer Methods In Power Systems Digital Simulation Of Power Systems Power System Dynamics And Advanced Protective Relaying To The Undergraduate And Graduate Students In Electrical Engineering At I I T Kanpur For A Number Of Years And Guiding Several Ph D And M Tech Thesis And B Tech Projects By The Author The Contents Of The Book Are Also Tested In Several Industrial And Qip Sponsored Courses Conducted By The Author As A Coordinator The Present Edition Includes A Sub Section On Solution Procedure To Include Transmission Losses Using Dynamic Programming In The Chapter On Economic Load Scheduling Of Power System In This Edition An Additional Chapter On Load Forecasting Has Also Been Included The Present Book Deals With Almost All The Aspects Of Modern Power

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An Update on Power Quality Dylan Lu, 2013-03-27 Power quality is an important measure of fitness of electricity networks With increasing renewable energy generations and usage of power electronics converters it is important to investigate how these developments will have an impact to existing and future electricity networks This book hence provides readers with an update of power quality issues in all sections of the network namely generation transmission distribution and end user and discusses some practical solutions

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provide them with the necessary knowledge to further their profession as electrical engineers *Fundamentals of Electrical Design - Module 4 - Understanding Transformers Power Distribution and Utilization* , Guide to RRB Junior Engineer Stage II Electrical & Allied Engineering 3rd Edition Disha Experts,2019-01-30 Guide to RRB Junior Engineer Stage II Electrical Allied Engineering 3rd Edition covers all the 5 sections including the Technical Ability Section in detail The book covers the complete syllabus as prescribed in the latest notification The book is divided into 5 sections which are further divided into chapters which contains theory explaining the concepts involved followed by Practice Exercises The Technical section is divided into 11 chapters The book provides the Past 2015 2014 Solved questions at the end of each section The book is also very useful for the Section Engineering Exam **Guide to RRB Junior Engineer Stage II Electrical & Allied Engineering 4th Edition** , Guide to RRB Junior Engineer Stage II Electrical Allied Engineering 3rd Edition covers all the 5 sections including the Technical Ability Section in detail The book covers the complete syllabus as prescribed in the latest notification The book is divided into 5 sections which are further divided into chapters which contains theory explaining the concepts involved followed by Practice Exercises The Technical section is divided into 11 chapters The book provides the Past 2014 2015 2019 Solved questions at the end of each section The book is also very useful for the Section Engineering Exam Energy Efficiency in Electric Motors, Drives, Power Converters and Related Systems Mario Marchesoni,2020-06-25 Today there is a great deal of attention focused on sustainable growth worldwide The increase in efficiency in the use of energy may even in this historical moment bring greater benefit than the use of renewable energies Electricity appears to be the most sustainable of energies and the most promising hope for a planet capable of growing without compromising its own health and that of its inhabitants Power electronics and electrical drives are the key technologies that will allow energy savings through the reduction of energy losses in many applications This Special Issue has collected several scientific contributions related to energy efficiency in electrical equipment Some articles are dedicated to the use and optimization of permanent magnet motors which allow obtaining the highest level of efficiency Most of the contributions describe the energy improvements that can be achieved with power electronics and the use of suitable control techniques Last but not least some articles describe interesting solutions for hybrid vehicles which were created mainly to save energy in the smartest way possible **The Electric Power Engineering Handbook - Five Volume Set** Leonard L. Grigsby,2018-12-14 The Electric Power Engineering Handbook Third Edition updates coverage of recent developments and rapid technological growth in crucial aspects of power systems including protection dynamics and stability operation and control With contributions from worldwide field leaders edited by L L Grigsby one of the world s most respected accomplished authorities in power engineering this reference includes chapters on Nonconventional Power Generation Conventional Power Generation Transmission Systems Distribution Systems Electric Power Utilization Power Quality Power System Analysis and Simulation Power System Transients Power System Planning Reliability Power Electronics Power System Protection Power System

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Harmonic Generation Effects Propagation and Control J. C. Das, 2017-10-24 This book provides coverage of generation effects and control of harmonics including interharmonics and measurements measurements and estimation of harmonics harmonic resonance and limitations according to standards It serves as a practical guide to undergraduate and graduate students as well as practicing engineers on harmonics The concepts of modeling filter designs and harmonic penetrations propagations in industrial systems distribution and transmission systems are amply covered with the application of SVCs and FACTS controllers Harmonic analysis in wind and solar generating plants are also discussed Many case studies and practical examples are included to emphasize real world applications The appendices are devoted to Fourier analysis pertinent to harmonic analysis and solutions to the problems included throughout the book

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