PERFORMANCE STUDY OF ARC CHARACTERIZATION FOR LINEAR AND NON-LINEAR LOADS IN AN ELECTRICAL DISTRIBUTION SYSTEM

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DEDICATION

This project report is dedicated to my father Lawan Kolo Geidam, my mother Jamila, family and well-wishers for their prayer and support.

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ABSTRACT

Arc fault is part of faults due to electrical sources that can cause fire hazard, malfunction or damage of equipment and even loss of life and properties. Many studies revealed that conventional circuit breaker lack the ability to protect an arc fault, responding only to short circuits and overloads. Therefore the need to study the performance characteristic of an arc and its properties in order to ease future design of arc detectors. The objective of the study is to characterize and study the effect of an arc on voltage and current with different loads, simulate the effect of an arc and harmonic content with different load and compare the effect of linear and nonlinear load to arc in low voltage electrical distribution system. This project proposes a mathematical model which describes the behavior of the electric arc in power circuits. The arc is studied like a circuit component and simulation was done for a series arc only with the help of MATLAB software package. Results show that occurrence of an arc gives rise to the current and a drop in the voltage for both linear and nonlinear load, it lasts in ms for linear and in seconds for the latter. Effect of the arc with an increase in load for both linear and nonlinear load has led to a decrease in both current and voltage THD. With linear load, the current THD increases while the Voltage THD decreases in the case of nonlinear load.
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ABSTRAK

Kerosakan arka adalah sebahagian daripada kerosakan disebabkan oleh sumber elektrik menjurus kepada bahaya kebakaran, kerosakan fungsi atau kerosakan peralatan, malah kehilangan nyawa dan harta benda. Banyak kajian menunjukkan bahawa pemutus litar konvensional tidak mempunyai kemampuan untuk melindungi litar dsri kerosakan arka dan hanya menangani litar pintas dan beban berlebihan. Oleh itu, keperluan untuk mengkaji ciri-ciri prestasi dan sifatnya untuk memudahkan proses rekabentuk pengesan arka di masa hadapan. Objektif kajian adalah untuk mencirikan dan mengkaji kesan arka pada voltan dan arus dengan beban yang berbeza, mensimulasikan kesan kandungan arka dan harmonik dengan beban yang berbeza di samping membandingkan kesan beban linear dan tidak linear ke atas arka pada voltan rendah sistem pengagihan. Projek ini mencadangkan model matematik yang menerangkan tingkah laku arka elektrik dalam litar kuasa. Arka dimodelkan seperti komponen litar dan simulasi dilakukan untuk arka siri hanya dengan bantuan pakej perisian MATLAB. Hasil kajian menunjukkan bahawa kejadian arka meninggikan arus dan menurunkan voltan kepada kedua-dua beban linear dan tidak linear. Ia berlangsung dalam milisaat untuk beban linear dan wujud sehingaa beberapa saat untuk beban yang tidak linear. Kesan arka dengan peningkatan beban untuk beban linear dan tidak linear mengurangkan kedua-dua THD pada arus dan voltan dengan beban linear. THD arus dan meningkat, sementara THD voltan menurun dalam kes beban tidak linear.

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LIST OF ABBREVIATIONS

NEC	-	National Electrical Code
DC	-	Direct Current
AC	-	Alternating Current
RCCB	-	Residual Current Circuit Breaker
AFCI	-	Arc Fault Circuit Interrupter
Varc	-	Arc Voltage
Iarc	-	Arc current

LIST OF SYMBOLS

W	-	Watts
Hz	-	Hertz
eV	-	electron volt
V	-	Volts
A	-	Amps
ms	-	millisecond

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CHAPTER 1

INTRODUCTION

1.1   Background of study

Energy has been the driving force for the progress and advancement in human civilization worldwide. The industrial revolution that began two centuries ago gives rise to global energy consumption increase in industrialized nations all over the world. The energy consumption per capital now serve as a barometer of prosperity of any nation's economy. This gives rise to rapid development in power system field due to exponential growth in load demand. Arc fault have been identified as a potential hazard in low-voltage (LV) system in as early as 1920's but the number of incidents related to arcing fault began to rise in the 1960's as the load demand increase[2].

Arc fault is part of faults due to electrical sources that can cause fire hazard, malfunction or damage of equipment and even loss of life and properties. Malaysia alone, Fault in electrical sources is at the top of list among the leading causes of fire hazard according to the statistics of Fire and Rescue Department, it is shown that fire hazard due to electrical sources has recorded more than 5,300 cases in the past three years[3].

Many studies revealed that conventional circuit breaker lack the ability to protect an arc fault, responding only short circuits and overload. Therefore the need arises to detect and protect arc fault in order to prevent damages. Most advanced countries use arc fault detection device like Arc Fault Circuit Interrupter (AFCI), which has the ability to immediately cut off any circuit once it detects an arc fault therefore reducing damage.

Arc fault is considered to be the most serious fault in a LV switchboard. This fault generates heat and can cause explosion if it is not detected and isolated properly

in the early stage of arc. It tends to be of high resistance between the conductors with a resistance similar to many loads and is not a short across a circuit [4]. Arc fault can be caused by several reasons such as loose or improper connections, electrical wire insulation chewed by rodents, frayed appliance or extension cords, pinched or pierced wire insulation, damaged electrical appliances, cracked wire insulation stemming from age, heat, corrosion, or bending stress.

This research study considers an arc fault initiated by over voltage, melted bridge and contact opening. The arcing fault current is often insufficient to operate the overcurrent devices as it is limited by the impedance of the arc and therefore the breaker will not trip due to arc. Therefore the need to study performance characteristic of an arc for both linear and nonlinear load to familiarize with its properties in order to design a low-cost detector that is flexible with load change in the future.

1.2   Problem Statement

Arc fault is part of faults due to electrical sources that can cause fire hazard, malfunction or damage of equipment, severe pain to people leaving around and even loss of life and properties. Many studies revealed that conventional circuit breaker lack the ability to protect an arc fault. Rather, they respond to short circuits and overload. Therefore the need to detect and protect arc fault that may arises in order to prevent damages.

Most advanced countries use an arc fault detection device like Arc Fault Circuit Interrupter (AFCI), AFCI has the ability to cut off any circuit immediately it detects an arc fault and this will reduce damage. AFCI technology is expensive although it is part of electrical outlet feeding circuit requirement in residential buildings by electrical codes of Canada and USA since 21st century. Therefore the need to study performance characteristic of an arc and its properties in order to ease design of future detectors.

1.3   Objectives

The main objectives of this research are
   a) To study and characterize the effect of arc on voltage and current with different load.
   b) To simulate the effect of an arc and harmonic content with different load (linear and nonlinear)
   c) To compare the effect of an arc on linear (incandescent lamps, electric iron and stove) and nonlinear load (rectifiers, tv, printers, computers) in low voltage electrical distribution system.

1.4   Scope of Study

   (a) This study focuses on Malaysia low voltage residential condition in which the voltage is 240Vrms 50Hz.
   (b) The analysis of the performance of arc characterization is conducted in series arc condition only.
   (c) Software implementation using Matlab.

1.5   Thesis Organization

   The project report is outlined in the following manner

   The chapter 1 elaborate performance study of arc characterization and provide relevant background information, the problem statement, objective, scope as well as the significant of the research. Chapter 2 reviewed past related work on performance study of arc characterization. It consists of an introduction, discussion of the theoretical framework, critical analysis of related research works and a conclusion.

   Chapter 3 discusses the Methodology adopted in great detail how this research works was conducted, the research design and how the flowchart was implemented

using MATLAB. Chapter 4 entails the analyses of results obtained from MATLAB after the simulation of the effect of both linear and nonlinear load in a circuit with series electrical arc. Chapter 5 concludes from the results analyses, recommendations and some suggestions on future works.

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