CHARACTERIZATION OF ARC FOR DOMESTIC ELECTRICAL SYSTEM

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DEDICATION

This study wholeheartedly dedicated to my beloved parent, who have been my source of inspiration and gave me strength when I thought of giving up, who continually provide their moral, spiritual, emotional and financial support.

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ABSTRACT

Undesired arcing in domestic electrical system can be caused by worn or broken insulator, loose connections, or static electricity. The arc heat energy is a fire hazard. In electrical equipment, an arc with enough energy can melt insulator or even cause fire. The present protection system in Malaysia focus on short circuit and leakage current. The objective of the study is to characterize the arc voltage, current and frequency under various load types and short circuit. The arc through loads such as pure resistor, inductor, iron and fan is observed. Intentional arcs from a few appliances such as arc welding set is also included in this study to identify the difference from unintentional arcs. Present arc detection technique (through AFCI) includes the constant monitoring of voltage and current. Unintentional arc is identified when a few conditions are met through some signal processing. There are three types of arc which are series arc, parallel arc and live to ground arc. This study will measure the arc characteristics with different loads in series arc only because parallel arc will not affected by load then records of the current and voltage waveforms via a digital storage oscilloscope. As expected, with various load produce difference arc profile. This arc profile will further help the design of a low-cost arc detector so that it does not require signal processing. It will help increase the quality of the electrical protection system in Malaysia and reduce the cost of AFCI.

ABSTRAK

Arka yg tidak diingini dalam system elektrik domestic boleh disebabkan oleh penebat yg rapuh atau rosak, sambungan yang longgar atau elektrik static. Dalam peralatan elektrik, arka degan tenaga yang mencukupi boleh mencairkan penebat dan menyebabkan kebakaran. System perlindunagan di Malaysia buat masa ini memberi tumpuan kepada arus litar pintas dan kebocoran arus. Haba yang dihasilkan oleh arka boleh meyebabkan kebakaran.Objektif kajian ini adalah untuk menggambarkan ciri-ciri arka didalam bentuk voltan, arus dan kekerapan dalam pelbagai jenis beban dan litar pintas. Arka yang dihasilkan olah perintang, inductor, seterika dan kipas diperhatikan. Arka bertujuan dari beberapa peralatan seperti set kimpalan arka juga termasuk dalam kajian untuk mengenal pasti perbezaan daripada arka tidak bertujuan.Teknik pengesanan arka sekarang (mengunakan AFCI) memerlukan pemantauan voltan and arus berterusan. Arka tidak bertujuan dikenal pasti apabila beberapa keadaan dipenuhi melalui beberapa pemprosan isyarat. Terdapat tiga jenis arka iaitu arka siri, arka selari and arka turus ke bumi.Kajian ini akan mengukur ciri-ciri arka dengan beban yang berbeza dalam arka siri sahaja kerana beban tidak menberi kesan kepada arka selari, gelombang voltan dan arus arka direkod and disimpan melalui penyimpanan digital osiloskop.Seperti yang dijangka, dengan pelbagai beban menghasilkan profil Arka yang berbeza. Profil Arka ini akan membantu Reka bentuk pengesan Arka kos rendah supaya ia tidak memerlukan pemprosesan isyarat. Ia akan membantu meningkatkan kualiti sistem perlindungan elektrik di Malaysia dan mengurangkan kos AFCI.

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CHAPTER 1

INTRODUCTION

1.1 Introduction

An arc fault is defined as unwanted continues luminous electrical discharge between two electrodes or other points. Arcing is the first step that leads to an electrical hazard, arcing creates heat and if energy is high enough it can ignite combustible material then may lead to a fire. Normally arc is caused by a loose connection or damaged cable in the electrical system. Malaysia residential electrical protection system normally consists of Residual Current Circuit Breaker (RCCB) and Miniature Circuit Breaker (MCB) [1]. Both protection device is connected between the main electrical supply and user load where RCCB provides protection against earth leakage current and MCB protects against over current. Arc fault detection device (AFCI) is used to detect arc in an electrical system whereby replacing MCB with AFCI, where it will trip the circuit where there is an arc or over current in the circuit. Arc can create a high-frequency current on low-frequency current waveform or a sudden increase in harmonics in the electrical system. However, harmonic can also be caused by fast switching equipment in the system thus arc detectors must distinguish intended and unintended arc to prevent a hazard to occur and not interfere with high power equipment.

1.2 Problem Background

Most studies focus on short circuit and leakage current where it can cause instability to the electrical system. However, there is a lack of attention given to the arc fault. Thus, the danger of arc must be properly explained and awareness of electrical safety and hazard must be improved in our society [2]. Series and parallel arc are hard to detect due to the current flow between neutral and live are balanced. Sometimes the arc is low current thus did not trigger the overcurrent protection and the arc will continue to occur and heat nearby objects.

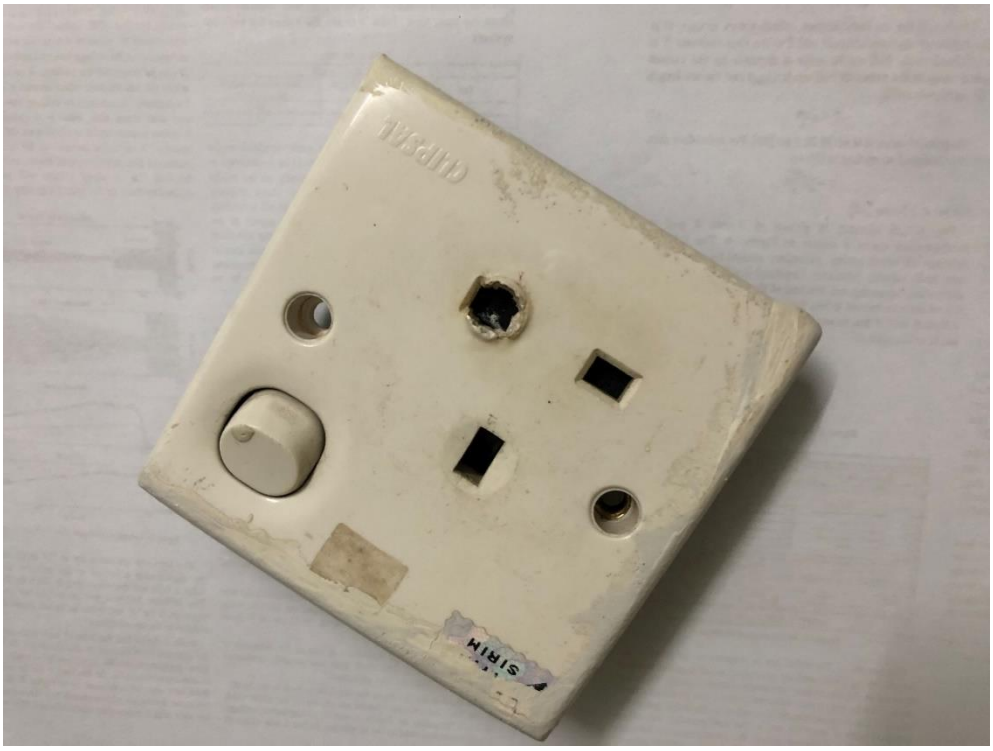

Figure 1.1: 3Pin Plug Damage by Arcing

Arcing can create high heat that melts the electrical equipment and insulator, arc occurs when contact between the conductor is loose or there is a gap between conductor where the voltage between conductor high enough to breakdown. The arc heat energy is created in expense of I^2R in the electrical loss then transform to heat energy. Thus, it is important to remove the arc to avoid equipment damage or insulation melt.

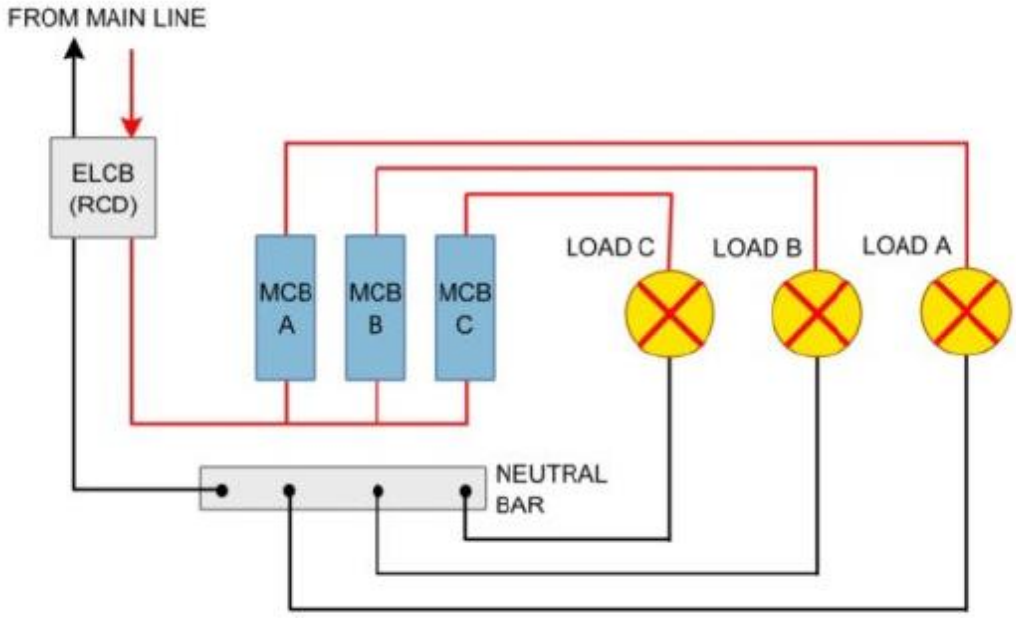

Figure 1.2: Malaysia Domestic Wiring Protection [3]

Both MCB and RCCB are unable to detect arc occurrences in the electrical system due to their detection mechanism. Where RCCB measures the difference between Live and Neutral line. MCB used a bimetallic strip to detect the overcurrent which unable to capture inrush current. Due to an arc occur repeating but in a very short time (10microsecond) thus will not trigger the MCB and if the arc occurs between Live and Neutral line the current between Live and Neutral is a balance. Thus, the awareness of the danger of arc fault needs to be addresses and shared to the public to avoid an accident in the future and the safety standard in Malaysia need to include Arc Fault Circuit breaker (AFCB).

1.3 Research Objectives

The objectives of this study are:

(a) To study the arc characteristic on term of voltage, current, and frequency.

(b) To analyse the effect of an arc with resistive and inductive load.

(c) To compare intentional arc and unintentional arc from a few appliances.

(d) To provide arc profile for future low-cost arc detector.

1.4 Scope of the Study

This study focuses on Malaysia low voltage residential condition where the voltage is 230Vrms 50Hz. The variation of load test is conducted only in the series arc condition due to parallel does not affect the load. This study will not consider air pressure and humidity.

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