ANALYSIS OF EARTH LEAKAGE CIRCUIT BREAKER (ELCB) NUISANCE TRIPPING DUE TO EARTHING RESISTANCE VALUE

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"I hereby declare that I have read through this report entitle *"Analysis of Earth Leakage Circuit Breaker (ELCB) Nuisance Tripping due to Earthing Resistance Value"* and found that it has comply the partial fulfillment for awarding the degree of Bachelor of Electrical Engineering"

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A report submitted in partial fulfillment of the requirements for the degree of Bachelor of Electrical Engineering

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I declare that this report entitled *"Analysis of Earth Leakage Circuit Breaker (ELCB) Nuisance Tripping due to Earthing Resistance Value"* is the result of my own research except as cited in the references. The report has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

Signature	:	……
Name	:	Izzatul Liyana Binti Aziz
Date	:	……

To my beloved parents and my siblings

Thanks for the endless love, kindness, support and encouragement towards me upon completing this project.

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ABSTARCT

Protection against leakage current is vital in low voltage system (LV) to protect humans and equipment from electric shocks and fire risk. Residual Current Device (RCD) is a protective device, which is more reliable version of earth leakage circuit breaker (ELCB) used for protection against small leakage current. This device is a current operated device which designed to disconnect the main power supply circuit whenever fault is occurred, where the measured value of phase current and neutral current is different. Also, RCD is made to be very sensitive to the residual current in order to protect equipment and personnel effectively. However, this device is prone to tripping under the non-fault condition due to the high sensitivity and some cases make the device delay to operate. This inappropriate tripping also known as nuisance tripping, where normally the nuisance tripping of RCD is influenced by the improper earthing system, high frequency from power supplied and presence of harmonics in signal waveforms. Besides, the use of resistive and inductive loads changed the behavior of RCD as the high-power consumption delayed the operation of RCD when earth fault current occurred. Hereafter, this report is provided to investigate the residual operating current and operating time of RCD behavior towards the poor earthing resistance value, where the value of resistance is higher than the standard buildings installation. The sensitivity of RCD sample used in this research is 30mA type-AC. The voltage and frequency of circuit tested for RCD sample followed the standard buildings requirement which is 240V with frequency of 50Hz. Meanwhile, the high earthing resistance value is chosen from 1kΩ to 3.5kΩ for this research. The residual operating current of RCD is measured by using current probe (Tektronix A622) and oscilloscope while the operating time of RCD is measured by using RCD Tester (KYORITSU Model 5402D). The results show earthing system with high resistance value affect the operating time of RCD, thus lead to nuisance tripping.

ABSTRAK

Perlindungan terhadap kebocoran arus adalah penting dalam sistem voltan rendah untuk melindungi manusia dan peralatan dari kejutan elektrik dan risiko kebakaran. Peranti Arus Baki (PAB) adalah peranti perlindungan yang merupakan versi Pemutus Arus Bocor ke Bumi (PABB) yang lebih dipercayai. Ia digunakan untuk perlindungan terhadap arus kebocoran kecil. Peranti ini adalah peranti kendalian arus yang direka untuk memutuskan litar bekalan kuasa utama setiap kali berlaku kesalahan bumi, di mana ukuran nilai arus fasa dan arus neutral adalah berbeza. PAB juga direka sangat sensitif kepada arus baki untuk melindungi peralatan dan pengguna dengan berkesan. Bagaimanapun, peranti ini mudah tersandung kepada keadaan yang tidak salah, disebabkan kepekaannya yang tinggi dan terdapat beberapa kes membuatkan peranti ini lewat berkendali. Keadaan mudah tersandung ini dikenali juga sebagai gangguan tersandung, di mana biasanya hal ini dipengaruhi oleh sistem pembumian yang tidak wajar, frekuensi tinggi dari kuasa yang dibekalkan dan kehadiran harmonik dalam bentuk gelombang isyarat. Selain itu, penggunaan beban rintangan dan beban induktif juga mengubah tingkah laku PAB kerana penggunaan kuasa yang tinggi melewatkan kendalian PAB apabila berlaku kesalahan arus bumi. Selanjutnya, laporan ini disediakan untuk menyiasat arus kendalian baki dan masa kendalian PAB terhadap nilai rintangan bumi yang tinggi daripada pemasangan piawai bangunan. Kepekaan sampel PAB yang digunakan dalam kajian ini ialah 30mA jenis-AC. Voltan dan frekuensi litar yang diuji untuk sampel PAB adalah mengikut keperluan piawaian bangunan iaitu 240V beserta frekuensi 50Hz. Sementara itu, nilai rintangan bumi yang tinggi dipilih untuk kajian ini adalah dari 1kΩ hingga 3.5kΩ. Arus kendalian baki PAB diukur dengan menggunakan alatan arus (Tektronix A622) dan osiloskop. Manakala masa kendalian PAB diukur dengan menggunakan penguji PAB (KYORITSU Model 5402D). Keputusan menunjukkan sistem pembumian dengan nilai rintangan yang tinggi menjejaskan masa kendalian PAB, sehingga mengakibatkan gangguan tersandung.

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AC	–	alternating current
CB	–	Circuit Breaker
ELCB	–	Earth Leakage Circuit Breaker
GFCI	–	Ground Fault Circuit Interrupter
k	–	kilo
LV	–	Low Voltage
ms	–	mili second
PAB	–	Pemutus Arus Baki
PABB	–	Pemutus Arus Bocor ke Bumi
RCD	–	Residual Current Device
SLG	–	Single-Line-Ground
V	–	Voltage
Ω	–	Ohms
°	–	degree

CHAPTER 1

INTRODUCTION

1.1 Research Background

In low voltage (LV) electrical installation, the protection must be provided to ensure the safety for humans and equipment. The most often meant is the over-current protection that must be activated in case of exceedingly high currents in an installation. This protection can be achieved using safety fuses or circuit breakers. However, in order to protect against leakage current, which the current is too small to trip an over-current device, earth leakage circuit breakers (ELCBs) is used. This circuit breaker is used to protect humans from electric shock hazards and fire caused by earth faults. Typically, ELCBs are classified by voltage operated devices and current operated devices, where the current operated devices, also known as residual current devices is more preferable in new buildings installation due to reliability [1].

RCDs which the application is required by the LV electrical installations standard [2] is used to disconnect the circuit when earth fault occur. These devices consist of residual current transformer and electromechanical relay as the main components will open the circuit fast enough to diminish the damage caused by electric shock, thereby protect people effectively against such shocks. The phase and neutral current said to be balanced in normal condition, where the RCDs will not operate. In the meantime, RCDs is operated when there is different between phase current value and neutral current value. The difference in current is caused by fault that happen in the system. At the fault condition, the mechanism in electromechanical relay will triggered and trip the coil of RCDs whenever the residual current reaches the RCDs limit.

For LV system, the frequency from power source supplied shall not more than rated and in sinusoidal waveform to certify the good operation of RCDs. Besides, earthing system must be appropriate according to the standards [3], so that the RCDs will be operated in a correct manner. Therefore, the protection against fault condition that give harmful effect towards human body and equipment can be provided.

1.2 Motivation

Nuisance tripping of residual current devices (RCDs) are frequently related to the presence of loads, especially loads with high power consumption. Moreover, without proper earthing system, neutral-to-earth voltage magnitude will become higher than rated value. Consequently, the protection against electric shock will be ineffective.

1.3 Problem Statement

In low voltage (LV) distribution system, the protection against leakage current and lightning strikes are essential in any electrical installation to ensure the safety for humans as well for the equipment. Therefore, residual current devices (RCDs) are mostly used to provide the protection for electrical installation in buildings area. These devices are made to be very sensitive to the earth fault current in order to protect the equipment and personnel effectively. However, because of the high sensitivity, RCDs are likely to trip under the non-fault condition and some cases make the device to delay in operation, these also known as nuisance tripping. During nuisance tripping, the protection against electric shock will become ineffective since the disconnection of supply is not occur within the time required. This may cause harmful effects on humans and equipment. Nuisance tripping occur may due to poor earthing systems, where the earthing resistance value is high. The higher the earthing resistance, the higher the possibility of RCD to take time to trigger the coil when earth fault is presented. Also, the used of different types of loads with different power consumption might cause the RCD to change its behavior,

considering that the operation is delayed when the power consumption is higher. Hence, it is very important to avoid nuisance tripping since the longest the magnitude of leakage currents flow may cause disastrous effects toward equipment and people who touched the conductor live parts.

1.4 Objectives

The objectives for study the earth leakage circuit breaker (ELCB) nuisance tripping due to earthing resistance value are:

- To investigate the residual operating current of residual current device (RCD) due to different earthing resistance value.
- To investigate the operating time of residual current device (RCD) due to different earthing resistance value.
- To investigate the effect of loads towards residual current device (RCD) operating time.

1.5 Scopes of Study

The scopes of analysis the earth leakage circuit breaker (ELCB) nuisance tripping due to earthing resistance value are:

- Design hardware of single phase installations with RCD following the Standard MS IEC 60364:2003 ‘Electrical Installation of Building’ at UTeM Electrical Wiring Laboratory.
- TT-system earthing with rated voltage of 240V is used.
- RCD (type-AC) with sensitivity of 30mA is selected as research sample.
- Resistive and inductive loads with different earthing resistance values are used in measurements of both residual operating current and operating time of RCD sample.

- Earthing resistance value is represented by using 10W power resistors with resistance value varied from 1kΩ to 3.5kΩ.
- The residual operating current of RCD is measured using current probe and oscilloscope.
- The operating time of RCD is measured using RCD Tester.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter will be discussed about several studies that have been done regarding this research earlier. The importance of protection in low voltage system are explained, where there are two types of protection, protection against over-current and protection against electric shock. The protective device against electric shock which is earth leakage current circuit breaker (ELCB) is being deliberated. ELCB is categories in voltage operated device, and current operated device as known as residual current device (RCD). RCD is more preferable in new buildings installation but often leads to nuisance tripping due to some factors. In this chapter, the factors that caused the nuisance tripping will be discussed based on the previous studies, such as poor earthing which high value of earthing resistance, high frequency and presence of harmonics.

2.2 Importance of Low Voltage Protection

The most essential in low voltage electrical installation is the protection for the equipment used. The protection can be either protect from overcurrent or protect against electric shock which can be harmful effect of electric current on human body. The overcurrent protection can be pull off using safety fuses or circuit breakers, where the task of protection is to switch out faulty circuits, and thereby protect the loads that are connected to those circuits, thus preventing the consequences of thermal overloading of conductors and fire risk. Meanwhile, the protection against electric shock can be classified

as protection against direct contact and protection against indirect contact, where direct contact means when a person is directly touches an energized unprotected part of device, while indirect contact means when a person touches normally dead part of an electrical equipment which has become live due to the insulation failure. For these protections, residual current circuit breaker that detect small earth fault current is used. Therefore, can prevent from disastrous impact towards human body and fire risk.

2.3 Circuit Breaker

Circuit breaker is a mechanical switching device used to complete, maintain, and interrupt currents flowing in a circuit during normal operating or faulted conditions. Fault current can cause danger to humans and equipment. Its due to thermal or mechanical effects occur in the circuit or related connection. Hence, the circuit breaker should operate for any fault current flowing in the circuit. The breaking capacity for breaker should be greater than or equal to the possible short-circuit current or earth fault current at the point where the breaker is installed to satisfy the circuit breakers condition. There are some specifications a circuit breaker should fulfil as a mechanical switching device [4]:

- Circuit breaker should be capable of being safely closed in on any load current or short-circuit current within the making capacity of the device.
- Circuit breaker should safely open any current that may flow through it up to the breaking capacity of the device.
- Circuit breaker should automatically interrupt the flow of abnormal currents up to the breaking capacity of the device.
- Circuit breaker should be able to carry continuously any current up to the rated current of the device.

The current that a circuit breaker can carry continuously, typically for a duration of more than eight hours called the rated current (I_N). When the ambient temperature is between -5°C to 40°C, the rated current requires not to make a temperature rise in excess of the specified values. The different parts of a circuit breaker specified by different

temperature rise limits. According to standard IEC 60947 [5] and IEC 60898 [6], if the current passing through a circuit breaker is 105% to 113% of its rated current, the circuit breaker will not operate (trip). Meanwhile, if the current passing through it is 130% to 145% of the rated current, it will take one to two hours to trip.

A circuit breaker commonly installed in a metal-enclosed cubicle for dead-front or draw out type of construction. Metal barriers between circuit breakers and busbars provide increased safety in service. Also, generally it be equipped with auxiliary contact, alarm contacts, push-button control, position indicator, and key interlock [7]. Table 2.1 shows the different types of circuit breaker and their characteristics. The types of circuit breaker such as Miniature Circuit Breaker (MCB), Moulded Case Circuit Breaker (MCCB), Air Circuit Breaker (ACB), Vacuum Circuit Breaker (VCB), Earth Leakage Circuit Breaker (ELCB), and Residual Current Device (RCD) or Residual Current Circuit Breaker with or without overload have different function and characteristics. As example, MCB and MCCB are used to protect against the short circuit and overload currents, while ELCB and RCD or RCCB used to protect against small leakage current that can cause electric shock.

2.4 Earth Leakage Current

The current flowing from the conductive parts of the installation to earth in the absence of an insulation fault is known as earth leakage (residual) current. This current could flow from any conductive part or the surface of non-conductive part to earth such as a human body if a conductive path was available, especially when there is no earthing connection in the installation. Generally, an earthing system is included in electrical installation to provide the protection against shock hazard if there is an insulation failure. The earthing system involved an earthing conductor that bonds the equipment to the earth. If there is fault occur in the insulation between conductor (line) and touchable conductive parts, the voltage is shifted to earth and the resulting current flow will cause a fuse to blow or trip a circuit breaker in order to prevent from shock hazard. Even if there is no insulation failure, there is possible of shock hazard to occur if the interruption of the leakage current

currents flowing through the earthing conductor happens, such as someone touching the equipment without earthing system and equipment with earthing system at the same time.

Leakage current split in two different types, AC leakage current and DC leakage current. DC leakage current usually applies only to end-product equipment, not to power supplies, while AC leakage current is caused by a parallel combination of capacitance and DC resistance between a voltage source (AC line) and the earth conductive parts of the equipment. Usually, different from AC impedance of various parallel capacitances, the leakage current caused by the DC resistance is insignificant. The current flowing in earth conductor is measured by connecting a specially designed meter for measuring leakage current in series with the earthing connection. For very low leakage currents, a network consisting of either a resistor or a resistor and capacitor combination is used replacing the meter. Then, voltage drop across the network is measured using sensitive AC voltmeter.

2.5 Earth Leakage Circuit Breaker (ELCB)

Earth Leakage Circuit Breaker (ELCB) is one of the types of circuit breakers besides Moulded Case Circuit Breaker (MCCB), Vacuum Circuit Breaker (VCB), Oil Circuit Breaker (OCB) and Residual Current Device (RCD) or Residual Current Circuit Breaker (RCCB). In contrast with other devices which mostly used to protect from overcurrent, this ELCB is used in electrical installation to protect equipment and protect humans from electric shock hazards and fire caused by earth faults that too small to trip an overcurrent device.