FAILURE ANALYSIS OF A LOW-COST DOMESTIC PERMANENT FAULT INDICATOR AND ITS SOLUTION

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DEDICATION

This project report is dedicated to my father Muhammad Aslam, and my mother Akhter Bibi, who always motivated me and prayed for my success. I am at this stage today just because of their prayers for me. I also dedicate to my wife, Nimra Anees, who supported me and appreciated me time to time. Lastly, I dedicate my project report to my siblings as well for their moral support.

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ABSTRACT

The concept of Permanent Fault Indicator (PFI) is that when a fault occurs in the circuit, the indicator will light up and continue to light up until the fault is rectified. A low-cost PFI using the neon bulb in series with a current limiting resistor is within the scope of the study. The research is about analyzing the operation of PFI based on the neon bulb, in a real scenario. Simulation, as well as laboratory experiments, were conducted for testing the response of Permanent Fault Indicator on a real scenario. The loophole (false indication when loads are connected) was identified and solved through the development of a low-cost prototype. Falstad online and Multisim™ software were used for simulation/modeling. Circuit voltage and current were monitored for analysis. In case of normal condition (load connected and no short circuit), although the neon indicator is energized, there are some millivolts (depending on load type) across the load. So these few volts are sensed by a comparator circuit (dual comparator configuration) to de-energize it's Light Emitting Diode (LED), thus enabling the user to discriminate between a short circuit and a normal condition, which was not possible with existing PFI. The developed prototype was tested on resistive as well as inductive loads, which allows the user to test whether a short circuit exists or the tripping of breaker is due to some other problem. Both indicators (Neon and LED) are energized only in case of short circuit. Deployment of a low-cost prototype integrated with PFI on distribution boards would increase the life span of the protective device by reducing their operation cycles on high fault current, as well as safety for personnel. Lastly, it would reduce unwanted power interruptions, due to long-duration unwanted tripping of circuit breakers, by resetting them after checking the status of indicators.

ABSTRAK

Konsep Permanent Fault Indicator (PFI) adalah apabila terdapat kerosakan dalam litar, penunjuk akan menyala dan ia akan terus menyala sehingga kerosakan tersebut diperbaiki. PFI kos rendah menggunakan mentol neon secara siri dengan perintang untuk menghadkan ruang lingkup kajian. Penyelidikan ini bertujuan untuk menganalisis operasi PFI dengan menggunakan mentol neon dalam senario yang sebenar. Simulasi dan eksperimen makmal telah dijalankan untuk menguji tindak balas PFI terhadap senario sebenar. Kelemahan (penunjuk palsu apabila beban disambungkan) dikenal pasti dan diselesaikan melalui pembangunan prototaip kos rendah ini. Falstad dalam talian dan perisian Multisim™ digunakan untuk simulasi / pemodelan. Voltan dan arus litar dipantau untuk analisis. Sekiranya keadaan normal (beban disambungkan dan tiada litar pintas), walaupun penunjuk neon dihidupkan, terdapat beberapa milli volt (bergantung kepada jenis beban) akan merentasi beban. Oleh itu, beberapa volt dirasakan oleh litar pembandingan (konfigurasi pembandingan berdua) akan memadamkan nyalaan Light Emitting Diode (LED), dengan itu pengguna daapt mendiskriminasikan antara litar pintas dengan keadaan biasa, yang tidak mungkin berlaku dengan PFI yang sedia ada. Prototaip yang dibangunkan telah diuji pada beban rintangan dan juga induktif, yang membolehkan pengguna menguji sama ada litar pintas wujud atau pemutusan breaker yang disebabkan oleh masalah lain-lain. Kedua-dua penunjuk (Neon dan LED) hanya akan berhidup sekiranya berlaku litar pintas. Pelaksanaan prototaip kos rendah yang disepadukan dengan PFI atas papan pengedaran akan meningkatkan jangka hayat peranti pelindung (MCB / RCCB) dengan mengurangkan kitaran operasinya apabila situasi kerosakan berpunca daripada arus tinggi, serta menjamin keselamatan kakitangan. Akhir sekali, ia akan mengurangkan gangguan kuasa yang tidak dikehendaki, yang berpunca daripada pemutusan litar yang tidak diingini dalam jangka masa yang panjang, dengan menetapkan semula mereka selepas memeriksa status penunjuk.

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LIST OF ABBREVIATIONS

PFI	-	Permanent Fault Indicator
AC	-	Alternating Current
DC	-	Direct Current
UTM	-	Universiti Teknologi Malaysia
RCCB	-	Residual Current Circuit Breaker
MCB	-	Miniature Circuit Breaker
ELCB	-	Earth Leakage Circuit Breaker
RCD	-	Residual Current Device
IoT	-	Internet of Things
CLR	-	Current Limiting Resistor
LV	-	Low Voltage
HV	-	High Voltage
TDR	-	Time Domain Reflectrometry
DB	-	Distribution Board
PCB	-	Printed Circuit Board
SoC	-	System On Chip
SMD	-	Surface Mount Device
LED	-	Light Emitting Diode
IC	-	Integrated Circuit

LIST OF SYMBOLS

Ω	-	Ohm
RM	-	Ringgit Malaysia
R	-	Resistance
I	-	Current
mV	-	milli volts
mA	-	milli amperes
K	-	Kilo
M	-	Mega
W	-	Watt
A	-	Amperes
V	-	Volts
P	-	Power
Hz	-	Hertz

CHAPTER 1

INTRODUCTION

1.1 Background of Study

An electrical fault is an abnormal state, resulting from the failure of equipment, including rotating machines and transformers, human errors and ambient factors. The results of these faults are the destruction of equipment, interruption to electric flows, and if not properly monitored, sometimes may lead to the death of humans, birds, and animals.

The most common permanent faults at the residential/domestic level include a short circuit (phase shorted to neutral) and earth fault (phase gets in touch with some metal body of enclosure or equipment). Talking about incidents occurred in Malaysia from 2005 to 2011, electrical fault resulted in 405 accidents, which resulted in 191 casualities (Abd Azzis *et al.*, 2013). Therefore besides awareness about the hazard and electrical safety, consideration of reliable protective devices, as well as an indication about the status of the system, is of great concern.

There are certain protective devices available to monitor overcurrent or short circuit and ground fault. These include Miniature Circuit Breaker (MCB) and Residual Current Circuit Breaker (RCCB). When tripping of these protective devices occurs due to fault, there is a need for monitoring existence of permanent fault to let user know about status, and take action by locating and rectifying fault before reclosing protective device, thus preventing further damage not to protective device only, but also reduce risk factor of injury to personnel. PFI serves this role to indicate the existence of a permanent fault in domestic applications.

1.2 Problem statement

The operation of PFI in the real world is not as desired. If a protective device trips, PFI is still energized giving a false indication, though no fault is existing. Improvement is required in PFI to allow the user to discriminate between a normal and a short circuit condition.

1.3 Research Goal

1.3.1 Research Objectives

The objectives of the research include:

(a) To conduct simulations/modelling for PFI to identify the loophole.

(b) To conduct Experimentation/testing for failure analysis of PFI.

(c) To propose and test a possible solution for the identified loophole.

1.4 Scope of the Study

The scope of the research include:

(a) This research is only limited to 240 Vac (single-phase low voltage domestic testing).

(b) PFI is energized from mains supply so availability of mains supply at incoming circuit breaker is assumed to be available for operation of PFI.

(c) The failure(denying operation) of a protective device (MCB/RCCD) is not taken into consideration for PFI testing.

(d) Testing is done in the lab on lighting resistive (heating) and available Inductive load.

(e) The solution for the loophole is in the form of some hardware.

(f) PFI can be integrated with IoT for smart data transfer, however, the development of IoT is not the scope of this research.

1.5 Outline of Report

This report consists of 6 Chapters. Chapter 1 elaborates introduction including objectives, scope, and summary of the project. Chapter 2 discusses the theory and literature review of faults detection techniques and specifically the deployment of the neon bulb as PFI. Multiple papers are used to review the different techniques deployed relating to fault detection.

In Chapter 3, the methodology for research is presented. The simulations and experiments of existing PFI as well as the development and testing of a prototype integrated with existing PFI on different loads, along with the discussion on results, are presented in Chapter 4. The planning and design matrix for the semester I and II are presented in Chapter 5. Last but not least, the conclusion and recommendation for future works are presented in Chapter 6.

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