GROUND FAULT CIRCUIT INTERRUPTER

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"I hereby declare that I have read through this report and found that it is sufficient in terms of scope and quality to be awarded of the Degree of Bachelor in Electrical Engineering (Industrial Power)"

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Date : 4/05/06

"I declare that this report is the result of my own research except as cited in the references."

Signature : .....

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Date : 4/5/06

DEDICATION

To my parents Razlan Absah and Siti Kamaliah bt Hj Jaafar, to my sister Ely Amylin and Elya Noreen, for all their support and unconditional love throughout my college studies. To Wan Afif Akram bin Zainal Abidin, for his encouragement and motivation throughout the years.

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ABSTRACT

A ground fault circuit interrupter (GFCI) is the combination of electrical device which protects personnel by detecting potentially hazardous ground faults and quickly disconnecting power from the circuit. A potentially dangerous ground fault is any amount of current above the level that may deliver a dangerous shock. GFCI works by comparing the amount of electrical current coming into a circuit through live wire with the amount leaving through the neutral wire. If more current enters the circuit through live wire than leaves through neutral wire, there is a current leak or ground fault. The objectives of the project is to provide a protection system for critical building such as hospital, control room, including the building of Kuala Lumpur Stock Exchange (KLSE) and also to provide a prototype for the purpose of teaching and learning. A prototype of GFCI consists of 240 V wiring and controlled circuit. Circuits are simulated using OrCad. Only the control circuit is being implemented in the hardware due to constraints which is discussed in chapter 5 later. Simulation, hardware and calculation results show similarity and as a conclusion, this project has achieved its objectives which are to design a prototype circuit of GFCI.

ABSTRAK

'Ground Fault Circuit Interrupter (GFCI)' merupakan litar gabingan peranti elektrik di mana ia digunakan sebagai perlindungan daripada kerosakan bumi dengan memutuskan sambungan litar. GFCI akan bertindak memutuskan litar sekiranya ia mengesan kebocoran dengan membandingkan jumlah arus yang masuk menerusi wayar hidup dengan arus yang keluar melalui wayar neutral. Sekiranya terdapat perbezaan di antara kedua dua jumlah arus ini, GFCI akan memutuskan litar serta merta. Objektif utama projek ini adalah untuk menyediakan satu sistem perlindungan kepada bangunan-bangunan kritikal contohnya hospital, bilik kawalan dan bangunan Bursa Saham Kuala Lumpur khususnya. Selain itu ia juga menyediakan satu prototaip bagi tujuan pembelajaran dan pengajaran. Prototaip ini mengandungi dua litar iaitu litar utama dan litar kawalan. Kedua dua litar disimulasi menggunakan OrCad. Hanya litar kawalan dilaksanakan di dalam bentuk perkakasan (hardware) disebabkan oleh kekangan seperti yang dibincangkan di dalam bab 5 kemudian. Keputusan daripada pengiraan, simulasi dan experimen tidak menunjukkan banyak perbezaan. Sebagai kesimpulan, dapat dinyatakan di sini bahawa projek ini telah mencapai objektifnya iaitu untuk mereka litar prototaip GFCI.

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CHAPTER 1

INTRODUCTION

1.1 Motivation

" By (the token of) time (through the ages),
Verily man is in loss,
Except such as have faith,
And do righteous deeds and (join together)
In the mutual teaching of truth,
And of patience and constancy....."

- Surah Al-ashr -

Time is one of the important factors in life. Human always argue about time because there are always a lot of things to be done in no time. Time waits for no one, it moves on and on and nobody can do anything to stop it. This is why, not a seconds should be wasted for unnecessary things and every second of time should be appreciated as nobody in this world has the power to turn back times.

GFCI is designed based on time. This is due to the capability of GFCI to sense fault in a circuit within a few seconds. Referring to the objectives of this project which is to provide a protection system for critical building in Malaysia such as the building of Kuala Lumpur Stock Exchange (KLSE), we can see how important this building is to Malaysia economy.

The protection system in such building need to be in a great condition at all times to avoid any interruptions and disturbances. This is because all rooms in the building are connected to each other and all rooms in the building are valuable. Imagine if the protection system fails to work properly for only a few minutes and fault occurred in one of the room in the building. It will affect other rooms in the building and the time taken to repair the damage will cause million and millions of losses because the stock market is not operating

.

This is where GFCI takes place. In this situation, a GFCI should be installed in the main panel of distribution board in every room in a critical building as mentioned above. By having GFCI installed, if one room is down, no other room in that building will be affected. Since GFCI can trip within a few seconds, it will cost less time to repair it. Furthermore, GFCI is easy to maintain and besides having to do the maintenance for the whole building, one only needs to deal with a room.

From the situation mentioned above, time and money is the main reason of motivation to do this project. Both of them are very important and it can cause a bigger problem if it is not taken seriously in life. GFCI is designed to save more time in maintenance and to make life easier in the future.

1.2 Objectives of the Project

Ground Fault Circuit Interrupter (GFCI) is designed to provide a protection system for critical building such as hospital, control room, and also the building of Kuala Lumpur Stock Exchange (KLSE). All rooms in critical building should be installed with a more sensitive GFCI in the distribution board so that when fault occurred in the building, not all rooms are affected. Besides, the objective of this project is also to provide a prototype for the purpose of teaching and learning.

1.3 Scope of the Project

1. Literature Review in choosing an appropriate circuit for this project.
2. The simulation are performed with OrCad
3. Implementation of hardware
4. In order to verify the validity of the simulation, the results of the simulation are compared with both the experimental data
5. This project will concentrate on electrical appliances especially in the kitchen appliances such as kettle, water heater and toaster.

1.4 Problem Statement

GFCI is designed to solve all problems mentioned in the objectives and to produce solution for a better and more efficient protection system. Critical building needs to have GFCI installed on it to avoid any unexpected disturbances. GFCI is not only designed to save time and money, but it can also save lives especially if it is installed in the hospital.

1.5 Literature Review

Literature review is used as one of the method for the purpose of learning and to gain more knowledge in terms of project application, designing circuit and also to understand in detail on the problems which occurred to all electrical appliances especially those which are used in the kitchen. The main references for this study are:

National Semiconductor Corporation Publication (1995) [9] explains about the general description and its features on Ground Fault Interrupter. It also explains the condition of circuit during balanced and unbalanced load. Besides that, this paper also includes the internal schematic diagram for LM 1851 Ground Fault Interrupter and its typical performance characteristic. The last part of the information from this paper is on the application circuits, circuit description and its typical application.

Consumer Product Safety Commission (CPSC Doc. #99); GFCI Fact Sheet (2001) [5] give a further explanation on Ground Fault Interrupter including its function and why GFCI should be installed in all electrical appliances at house. Besides, there is also information on how to test and troubleshoot the circuit.

Electrical Machines, Drives and Power System, Sixth Edition, Theodore Wildi, Profesor Emeritus, Laval University, Prantice Hall, Pearson Educational International [3] gives further explanation on Ground Fault Circuit Breaker which functions similarly to GFCI. It is also stated how Ground Fault Circuit Breaker works to protect a person from electrical shock. It also discuss on other fault such as line to line fault, single line to ground fault and much more including how the faults occurs.

John De Armond, The "Hows" and "Whys" of Ground Fault Interrupters, (2000) [8] explains in detail about how the GFI works. It also explains more about each element used in the circuit. The articles gave an outline of the theory of GFCI and explanations on the circuit operation.

Electronic Devices and Circuit Theory, Eight Edition, Robert L. Boylestad, Lois Nashelsky, Prentice Hall, Pearson Educational International [2] is used as a reference for Electronic subjects. In this project, this book is used to study in details about the function and circuit design of an operational amplifier which include subtracting amplifier and comparators. It includes all the formula used in the circuit and it also help to improves knowledge on all electronics components.

Power Electronics Circuit, Devices and Applications, Third Edition, Muhammad H. Rashid, Pearson Educational International [1] gives more information on the operational amplifier and it helps a lot in understanding how it works and where it should be used in circuit.

Sam Goldwasser, Ground Fault Interrupters, (1998) [10] explains in details on every components used in the circuit, the function for each of them and the needs of GFCI. It gives a further explanation about what is GFCI and a circuit diagram to give a clearer view of it.

Guenter B. Finke, Differential Transformer Cores for Ground Fault Interrupter Circuit Breaker (1974) [7] gives a basic explanation on GFI circuit breaker. It shows basic diagram and information in order to understand more on this topic.

1.6 Overview of this Thesis

Chapter 1 : Introduction

This chapter briefly explains the importance of Ground Fault Circuit Interrupter (GFCI) in electrical appliances. Besides, it also describes the objectives, scope of work, problem statement and literature review. In literature review, a list of all the references used are represented and the synopsis every references are stated.

Chapter 2 : Fundamental Behind The Project Design

This chapter explains more detail on the theory of the project. It includes the original theory of GFCI, basic circuit and the theory calculation. The theory of GFCI and calculation is based on the research from all the references used. The basic circuit of GFCI is taken from the National Semiconductor Corporation Publication (1995); LM 1851 Ground Fault Interrupter.

Chapter 3 : Methodology

This chapter describes on how the project is being carried from the very beginning until the analysis process. Flow charts are shown to give a clearer view on the exact process and every process is explained in detail.

Chapter 4 : Results and Analysis

This chapter shows all the results taken from simulation process using OCad software and the test carried on the hardware of the project. It includes all graphs, tables and figures after the test is being carried. Results from the hardware part will also be shown to show the difference. The comparison of each results are shown and be analyzed in the analysis part.

Chapter 5 : Discussion and Suggestion

This chapter discusses all the problems and constraints occurred while carrying the project. It also includes suggestions and future works to improve the project and make it better for future used.

Chapter 6 : Conclusion

This chapter will conclude the objectives of the project and summarize the whole project.

CHAPTER 2

FUNDAMENTAL BEHIND THE PROJECT DESIGN

2.1 Ground Fault Circuit Interrupter (GFCI)

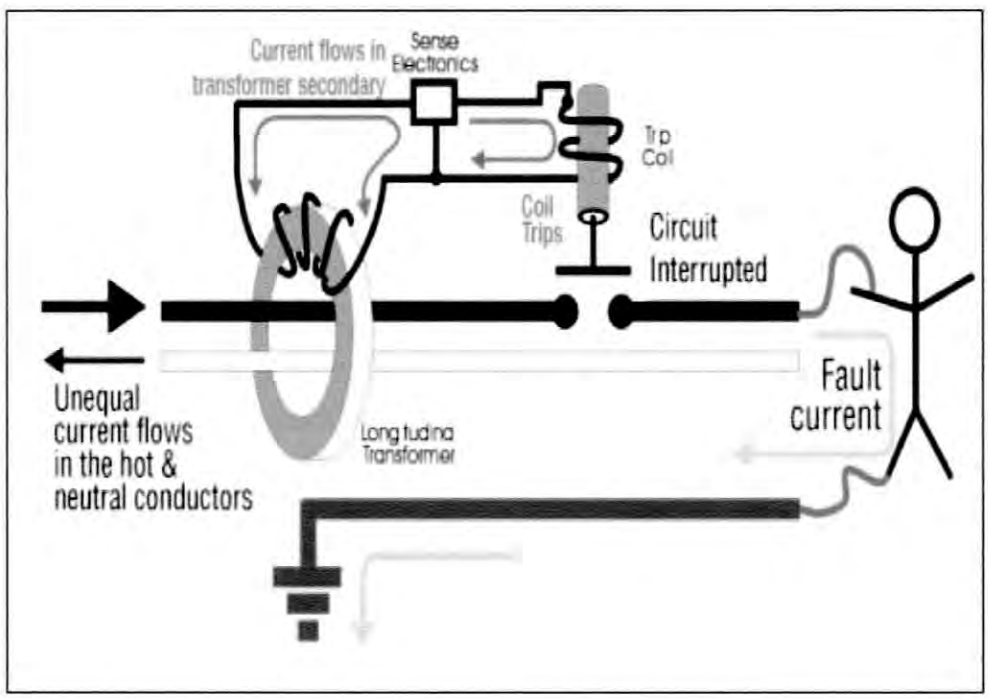

Figure 2.1 : How ground fault happen

Ground fault is defined as the momentary, usually accidental, grounding of a conducting wire. From the figure above, we can see how ground fault occurred to the stick man. Circuit breakers and fuses are there to protect a circuit from becoming

overloaded and failing. They do nothing to protect the stick man form getting a shock. GFIs, on the other hand, can protect a person from getting shocked, or electrocuted. Electricity needs a complete circuit in order to do its thing, to allow electrons to flow through a circuit to an appliance and perform some sort of function. Heating the elements of a toaster, lighting a bulb and making sweet music come from a CD are all examples of electrons flowing in a circuit.

A plug on an appliance consist a minimum of two blades sticking out of the plug. Sometimes there are three, the third being a rounded pin. On most plugs one of the blades is fatter than the other and is designed that way so one can insert the plug into a wall socket only one way. That is because manufacturers want their devices to be "cold" when the switch on the appliance is turned off. To guarantee that, they make sure that the "live" wire is always the "live" wire inside the appliance and they attach the switch to that wire. So when the toaster isn't toasting bread there is no voltage anywhere inside the toaster except for a very small piece of wire that is connected to the live side of the switch. It is the same reason that the three pronged "polarized" plugs of a three wire device are made that way.

All electrical circuits in houses are wired with three wires. One is called the "live" wire and is normally color coded with brown insulation. The second wire is called the "neutral" wire and is color coded with blue insulation. The third is a ground wire and is not meant to carry any current under normal operation. It is either color coded with green insulation or it is just a bare wire buried inside the insulation containing the other two wires.

Under normal conditions the current to operate a device such as a toaster or a TV travels in a circuit starting at the circuit breaker box and through the live wire into the appliance then out of the appliance and back to the power plant via the neutral wire. The "ground wire" is attached to the metal case of things like your toaster. It is there in the unlikely event that the live wire inside the appliance comes in contact with the case of, for example, toaster. If that happens, the current is carried back to earth ground and the circuit breaker trips. The neutral wire also goes back to the earth so if the toaster failed as described above, and there were no ground wire attached to the toaster, you were somehow in contact with earth ground (like

touching a kitchen faucet) your body would complete the circuit back to earth ground.

All of the current going into an appliance like toaster comes out through the neutral wire. So, if there were a "Ground Fault", i.e. the ground wire was not connected to the toaster frame, and the toaster failed as mentioned above so that the live wire was touching the frame of the toaster, and if a person were touching the kitchen faucet at the same time he were touching the toaster, the GFCI would save him.

2.2 Basic Circuit and Calculation

Basic circuits consist of a power supply and load. In normal condition, the total current flows in live line are equal to the total current flows in the neutral line. This theory is proven comparing both simulation and calculation results.

2.2.1 Circuit in normal condition

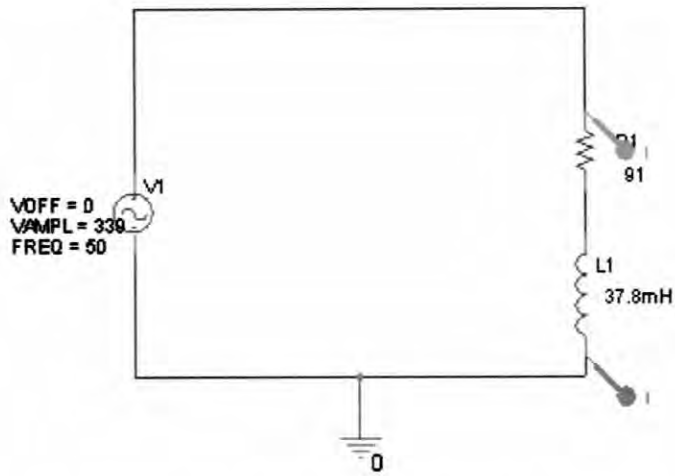

Figure 2.2 : Basic circuit in normal condition

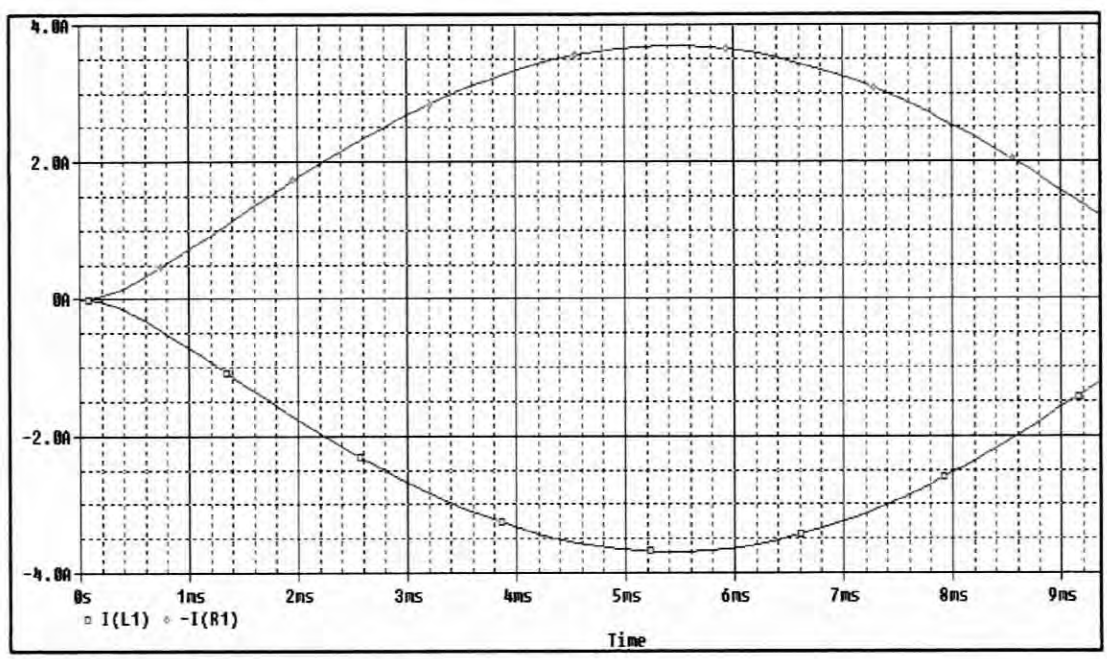

Figure 2.3 : Results from simulation

(red probe = purple graph and green probe = blue graph)