AUTOMATIC SYSTEM FOR UTILITY ELECTRICAL FAULT
(FAULT LOCATION DETECTION USING LabVIEW)

by

MOHD FIRDAUS BIN NOORDIN

Dissertation submitted in partial fulfilment of

the requirements for the

Bachelor of Engineering (Hons)

(Electrical and Electronics Engineering)

DECEMBER 2010

Universiti Teknologi PETRONAS

Bandar Seri Iskandar

31750 Tronoh

Perak Darul Ridzuan

CERTIFICATION OF APPROVAL

by

Mohd Firdaus Bin Noordin

A project dissertation submitted to the

Electrical and Electronics Engineering Programme

Universiti Teknologi PETRONAS

in partial fulfilment of the requirement for the

BACHELOR OF ENGINEERING (Hons)

(ELECTRICAL AND ELECTRONICS ENGINEERING)

Approved by,

____

(Dr. Nursyarizal bin Mohd Nor)

Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS

TRONOH, PERAK

DECEMBER 2010

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

MOHD FIRDAUS BIN NOORDIN

ABSTRACT

Continuous supply of electricity to domestic building is a major concern for the consumers. The consumers need a continuous electricity supply to their appliances such as refrigerator, aquarium and their alarm system. Tripping of earth leakage circuit breaker (ELCB) will break the supply to all the appliances. An automatic system to restore the supply to the appliances by turn on back the ELCB is required. But when there is a permanent fault in the system, the ELCB cannot be turned on back to normal because it will trip again due to the fault. So the objective of the project is to develop a system to detect the location of permanent fault. The location of the fault is important to be determined in a first place in order to isolate the fault from the system. So the ELCB can be reclosed back to normal position to let the appliances have the electricity supply. Software called LabVIEW is used to develop the system that can detect the location of permanent fault in a domestic electrical wiring system. The idea is when the location of fault is determined, an automatic system to isolate the Miniature Circuit Breaker (MCB) that has fault can be developed. So when the MCB that has fault has been isolated, the ELCB can be turned on without tripping again. The system that has been developed using LabVIEW will compare the value of current at live wire and the value of current at neutral wire. If the difference is more than preset value, the system will show the detection in the front panel of the software. So the location of fault is determined.

ACKNOWLEDGEMENT

First of all, I would like to express my gratitude to God for giving me the strength and health to do this project. Not forgotten to my mother and all my family members for providing everything, such as money and advises, which is most needed in this project.

I would like to thank my supervisor, Dr Nursyarizal bin Mohd Nor for sharing his knowledge and giving me the support and guidance throughout the project. I also would like to thank my co-supervisor, Mr Saiful Azrin bin Mohd Zulkifli for assisting me to design the software of the project.

My appreciation to Universiti Teknologi PETRONAS especially Electrical and Electronics Engineering Department, by providing me the necessary assets and resources, not only to accomplish my task, but to enrich my knowledge further.

Last but not least, I offer my regards to those who support me especially all my friends and technicians in Electrical and Electronics Department for contributing their assistance and ideas for this project.

TABLE OF CONTENT

CHAPTER 4: RESULTS AND DISCUSSION

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Power reliability is very important and critical to a domestic building. Some electrical equipments and appliances need to be turned on even when the occupants leave the building such as alarm system, refrigerator and aquarium ventilation system. But electrical fault may occur in a system that can break the electricity supply. Automatic system to detect the location of electrical permanent fault is designed to isolate the permanent fault from the system. So the breaker can be designed to automatically turn on the Earth Leakage Circuit Breaker (ELCB) in order to restore the supply.

1.2 Problem Statement

Tripping of Earth Leakage Circuit Breaker (ELCB) when there is no occupant inside may lead to undesired circumstances. The critical appliances such as aquarium, refrigerator and alarm system need a continuous supply of electricity to operate. The problem comes when the ELCB trips when no occupants in the house due to internal or external disturbance. When electricity supply is not available, operation of critical equipment such as alarm system will be stopped. Loss of electricity supply may also contribute to property lost due to equipment failure such as dying of exotic fish and food damage.

1.3 Objective and Scope of Studies

The main objective of this project is to develop an automatic system to detect the location of fault by using LabVIEW program. The program will be able to acquire analogue input to feed to the LabVIEW program, so that the location of fault can be determined by comparing the value of real time current at live and neutral wire for each wiring loop. The scope of study will comprise of power and control system. The student should be able to understand and design a simple domestic electrical wiring diagram. By understanding the normal practice on the wiring system, the student will have a clearer view to start the project. This project is focusing on determining the location of fault in a wiring system where it is important in designing an automatic circuit breaker which can handle the permanent fault.

CHAPTER 2

LITERATURE REVIEW

2.1 Circuit breaker

Circuit breakers are electrical switching devices for protecting and controlling the electricity supply to respective electrical circuits. Circuit breakers protect electrical circuitry from damage due to an overcurrent condition, such as an overload condition or a relatively high level short circuit or fault condition. Electrical systems in residential, commercial and industrial applications usually include a panel board for receiving electrical power from a utility source. The electrical power is then delivered from the panel board to designated branch circuits supplying one or more loads.[1]

Typically, various types of circuit interrupters are connected to the branch circuits to reduce the risk of injury, damage or fires. In the event an overcurrent condition occurs, electrical contacts within the circuit breaker will open, stopping the flow of electrical current through the circuit breaker to the equipment.[1] Circuit breakers have an operating mechanism and trip means, such as a thermal trip assembly and/or magnetic trip assembly, which are automatically releasable to effect tripping operations and manually resettable following tripping operations. Overload protection is provided by a thermal element which, when heated by the increased current, will cause the circuit breaker to trip and interrupt the power.

Use of circuit breakers is widespread in modern-day residential, commercial and industrial electric systems, and they constitute an indispensable component of such systems toward providing protection against over-current conditions. Various circuit breaker mechanisms have evolved and have been perfected over time on the basis of application-specific factors such as current capacity, response time, and the type of reset (manual or remote) function desired of the breaker.

2.2 Earth Leakage Circuit Breaker (ELCB)

An Earth Leakage Circuit Breaker (ELCB) as shown in Figure 1 is a safety device used in electrical installations with high earth impedance to prevent shock. The ELCB makes such installations much safer by cutting the power if dangerous conditions occur. In non-technical terms if a person touches something, typically a metal part on faulty electrical equipment, which is at a significant voltage relative to the earth, electrical current will flow through him/her to the earth. The current that flows is too small to trip an electrical fuse which could disconnect the electricity supply, but can be enough to kill. An ELCB detects even a small current to earth (Earth Leakage) and disconnects the equipment (Circuit Breaker).

Figure 1: Earth Leakage Circuit breaker (ELCB)

There are two types of ELCB which are:

1. Voltage operand
2. Current operand

Voltage operated ELCB is currently not been used in domestic wiring since the current operated ELCB is more reliable to be installed in household. Current-operated ELCBs are generally known today as RCD (residual current device). These also protect against earth leakage, though the details and method of operation are different.

2.3 Residual Current Device (RCD)

A residual current device (RCD) or a residual current circuit breaker (RCCB) widely known as a safety switch is designed to isolate power when it detects an in-balance commonly of 30 mA between the active and neutral conductor. These in-balances are commonly caused by current leakage through earth. This leakage can be caused via a faulty appliance or through the body of a person accidentally touching an energized piece of equipment. RCD/RCCB's are designed to disconnect power to the circuit when a difference of 30mA is detected. This disconnection or tripping of these breakers should happen without due delay, if the RCB/RCCB takes too long to trip the results could be fatal.[5]

RCD is designed to prevent electrocution by detecting the leakage current, which can be far smaller (typically 5–30 mA) than the currents needed to operate conventional circuit breakers or fuses (several amperes). RCDs are intended to operate within 25-40 ms, before electric shock can drive the heart into ventricular fibrillation, the most common cause of death through electric shock.[5]

The National Electrical Code requires RCD devices intended to protect people to interrupt the circuit if the leakage current exceeds a range of 4–6 mA of current (the trip setting is typically 5 mA) within 25 ms. RCD devices which protect equipment (not people) are allowed to trip as high as 30 mA of current. In Europe, the commonly used RCDs have trip currents of 10–300 mA.[3]

RCDs operate by measuring the current balance between two conductors using a differential current transformer shown in Figure 2. This measures the difference between the current flowing out the live conductor and that returning through the neutral conductor. If these do not sum to zero, there is a leakage of current to somewhere else (to earth/ground, or to another circuit), and the device will open its contacts.

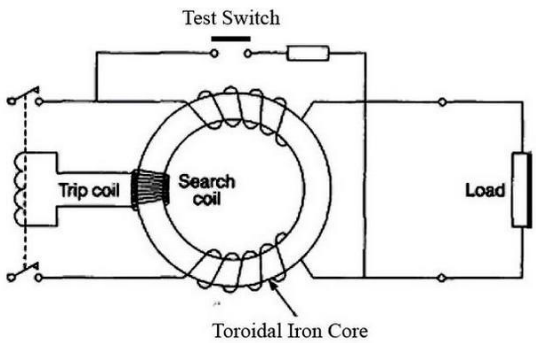

Figure 2: Tripping Mechanism of RCD

2.4 Miniature circuit breaker (MCB)

Miniature circuit breakers (MCB) are commonly used in the electrical consumer units of domestic dwellings and small industrial premises to protect and control the electrical supply to respective electrical circuits of the building. MCB often are single pole breakers and are configured to be installed in a cabinet that houses a plurality of such MCB.[5]

MCB typically include an electrical contact mounted on a movable contact carrier which rotates away from a stationary contact in order to interrupt the current path. The operating mechanism includes a movable handle that extends outside of the housing. The handle has essentially three stable positions: on, off, and tripped. These three positions tell the operator what condition the contacts are in when the handle is viewed. The trip mechanism is automatically releasable to effect tripping operations and manually resettable following tripping operations.[5] The mechanism will respond to instantaneous high current to open the contact and interrupting the current flow.

2.5 Current Transducer

Current transducers came into widespread use during the 1970s and 80s as large process plants, such as petroleum refineries, were being computerized. Most had been controlled by pneumatic control systems to that point, due to the intrinsic safety of pneumatics in flammable and explosive environments. In order for the computers to use the real time information coming from the many pneumatic process transmitters measuring temperatures, pressures, flows, levels, and other variables, their pneumatic outputs had to be converted to electronic signals using pressure to current transducers.[7]

Current transducer as shown in Figure 3 can also describe a type of sensor that measures the magnetic flux of a power conductor to sense drive motor currents for machinery and process equipment and transmits an analog milliamp or voltage signal to control systems. Solid corecurrent transducers have closed loop ring transformers that must be slipped over the temporarily open end of a power conductor. Split core current transducers have a hinged side of the transformer ring that can be temporarily opened to allow the ring to be slipped around a conductor that cannot be disconnected. They usually incorporate rectifier and adjustable output conditioning circuitry to allow specific calibrations for analog control systems.[7]

Figure 3: Current Transducer

2.6 LabVIEW

LabVIEW (shortfor Laboratory Virtual Instrumentation Engineering Work bench) is a platform and development environment for a visual programming language from National Instruments. The graphical language is named "G". Originally released for the Apple Macintosh in 1986, LabVIEW is commonly used for data acquisition, instrument control, and industrial automationon a variety of platforms including Microsoft Windows, various flavors of UNIX, Linux, and Mac OS.

LabVIEW ties the creation of user interfaces (called front panels) into the development cycle. LabVIEW programs/subroutines are called virtual instruments (VIs). Each VI has three components: a block diagram, a front panel and a connector pane. The latter may represent the VI as a subVI in block diagrams of calling VIs. Controls and indicators on the front panel allow an operator to input data into or extract data from a running virtual instrument. However, the front panel can also serve as a programmatic interface. Thus a virtual instrument can either be run as a program, with the front panel serving as a user interface, or, when dropped as a node onto the block diagram, the front panel defines the inputs and outputs for the given node through the connector pane. This implies each VI can be easily tested before being embedded as a subroutine into a larger program. The graphical approach also allows non-programmers to build programs by simply dragging and dropping virtual representations of the lab equipment with which they are already familiar.[6]

The LabVIEW programming environment, with the included examples and the documentation, makes it simpler to create small applications. This is a benefit on one side but there is also a certain danger of underestimating the expertise needed for good quality "G" programming. For complex algorithms or large-scale code it is important that the programmer possess an extensive knowledge of the special LabVIEW syntax and the topology of its memory management. The most advanced LabVIEW development systems offer the possibility of building stand-alone applications. Furthermore, it is possible to create distributed applications which communicate by a client/server scheme, and thus is easier to implement due to the inherently parallel nature of *G*-code. To maintain clean and legible user VI interfaces its best to keep these tips in mind: Keep panels simple and clean, keep a consistent style, clean up wires where ever possible, use proper terminology when labelling controls and indicators.[6]

Figure 4 and Figure 5 show the example of front panel and block diagram of LabVIEW. Front panel is the user interface for the program and block diagram is the part where the programming takes place.

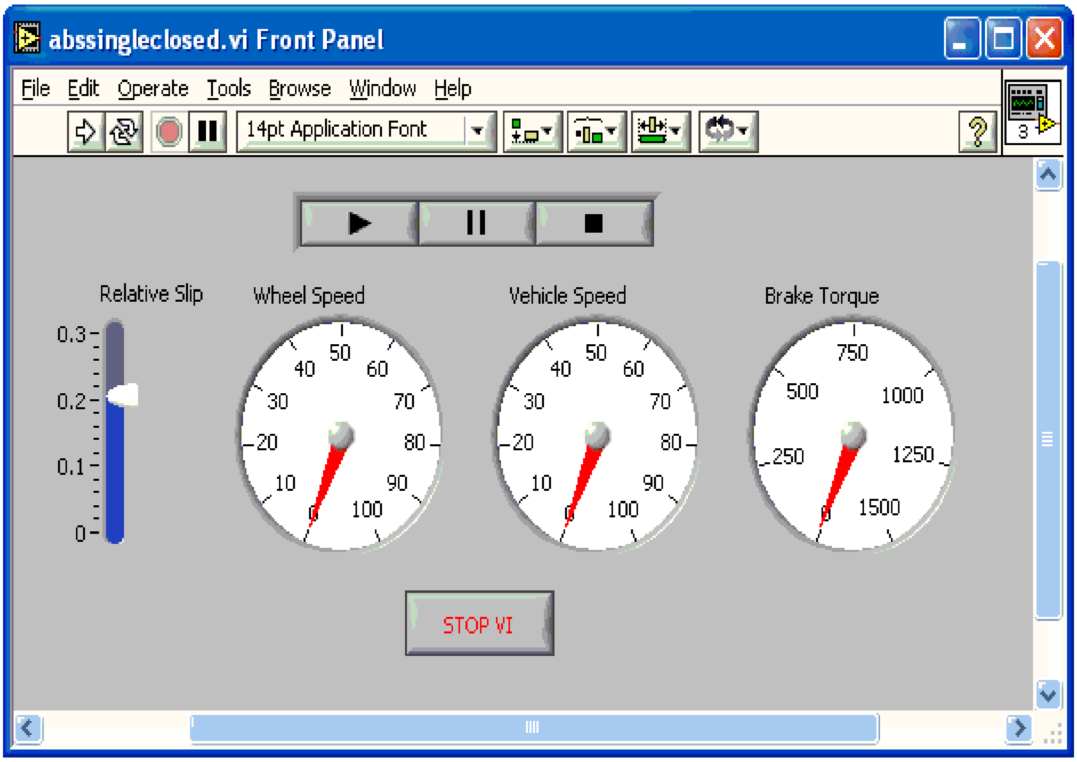

Figure 4: LabVIEW Front Panel

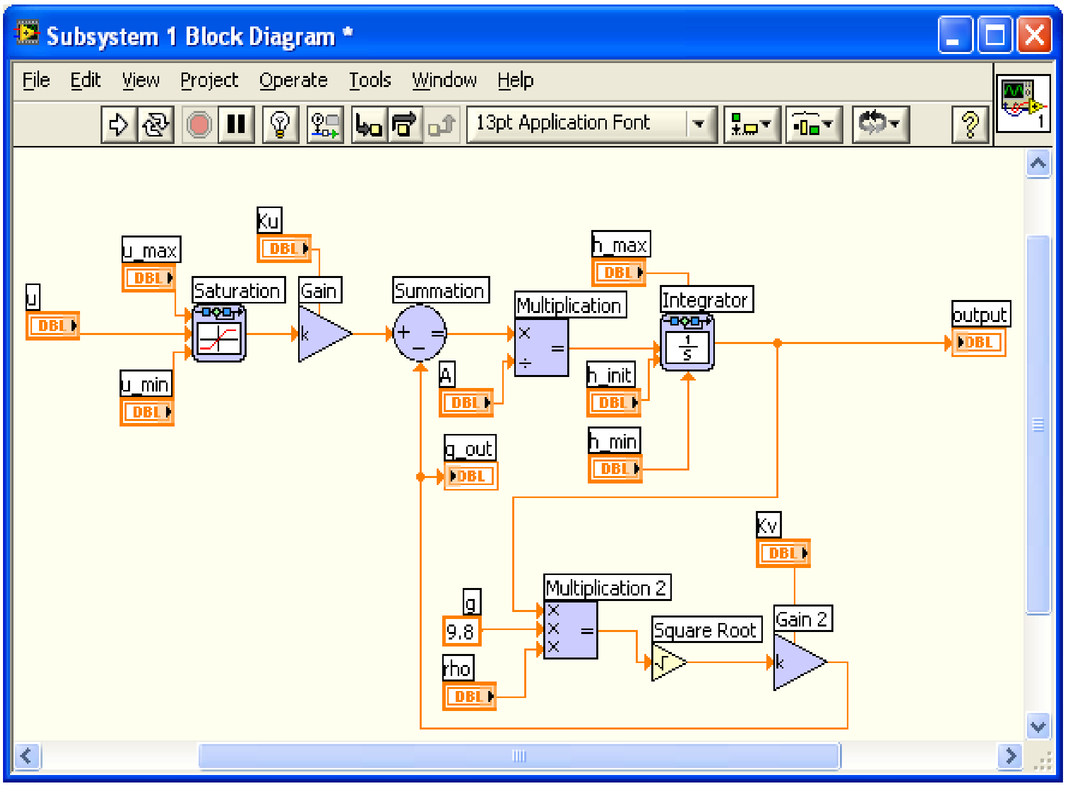

Figure 5: LabVIEW Block Diagram

CHAPTER 3

METHODOLOGY

3.1 Procedure Identification

The project is started by collecting of related data on the domestic electrical wiring procedures and practices. Some procedures are identified for the project to accomplished starting from gathering the required information until the system testing and implementation. Figure 6 below shows the project methodology.

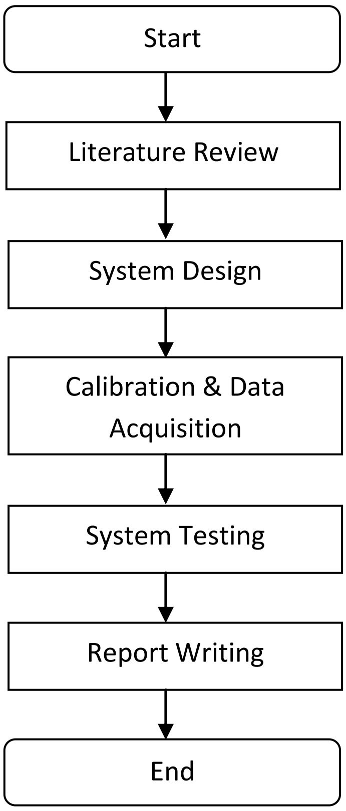

Figure 6: Project Methodology

The information of domestic electrical wiring procedures and practices is collected in the first phase. Data of domestic electrical wiring equipments such as Earth Leakage Circuit Breakers (ELCB), Miniature Circuit Breaker (MCB) and Fault behaviour are being discussed. The data about LabVIEW is also been gathered and the program is studied in order to design the program to detect the fault location.

Then the system is designed using LabVIEW software. The software embedded in the computer is acquiring analogue input data using data acquisition (DAQ) card. The system for this project is designed in computer because in the first place in order to prove the concept that the location of fault can be determined to isolate the permanent fault. The core part of this project is to detect location of fault and isolate it before reclosed back the ELCB. The system works as shown in figure 7.

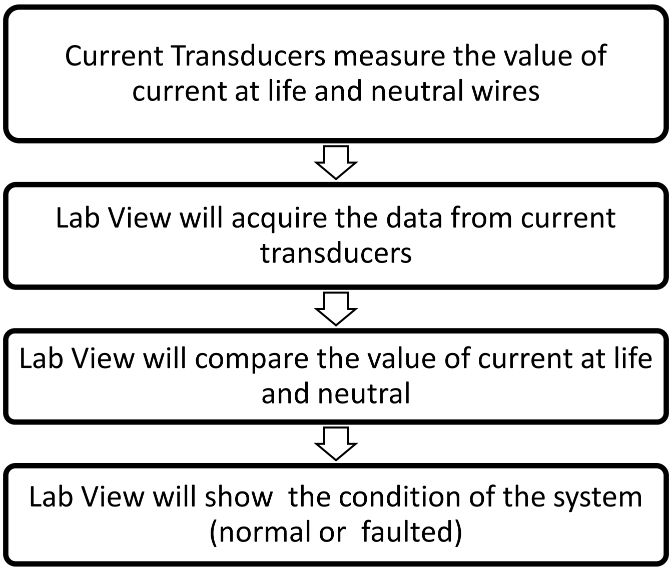

Figure 7: Flow of desired operation

During calibration and Data Acquisition, Current Transducers are used to measure the value of current at live and neutral wire. The voltage signal from the current transducers is connected to LabVIEW Connector Block (CB) connected to

Data Acquisition Card at computer. The datasheet of the current transducer used are shown in Appendix B. Then the real time analogue input will be processed in computer using LabVIEW program. The program is actually comparing the value of current at live with the value of current flowing through neutral wire. The program will show whether the system is in normal condition or experiencing fault. All the data and results gained from the project are written in a proper report.

3.2 Tolls and Equipments required

- Software
  - LabVIEW 6i
- Hardware
  - Current Transducers
  - Data Acquisition Card (DAQ card)
  - LabVIEW Connector Block

CHAPTER 4

RESULT AND DISCUSSION

4.1 Earth Leakage Circuit Breaker (ELCB) and Miniature Circuit Breaker(MCB)

Figure 8 and 9 show the location of ELCB and MCB inside the distribution box and the simple domestic electrical wiring diagram that most of the residential housing has. From figure 9, the red line is the live wire where the power is travelling to the load and the power (current) then will travel out from the load to neutral bar before it travels back to ELCB. This is where the fault can be trace where if the current travelling into the load is not equal to the current travelling out of the load, it means that a leakage of current (fault) occur at the load.

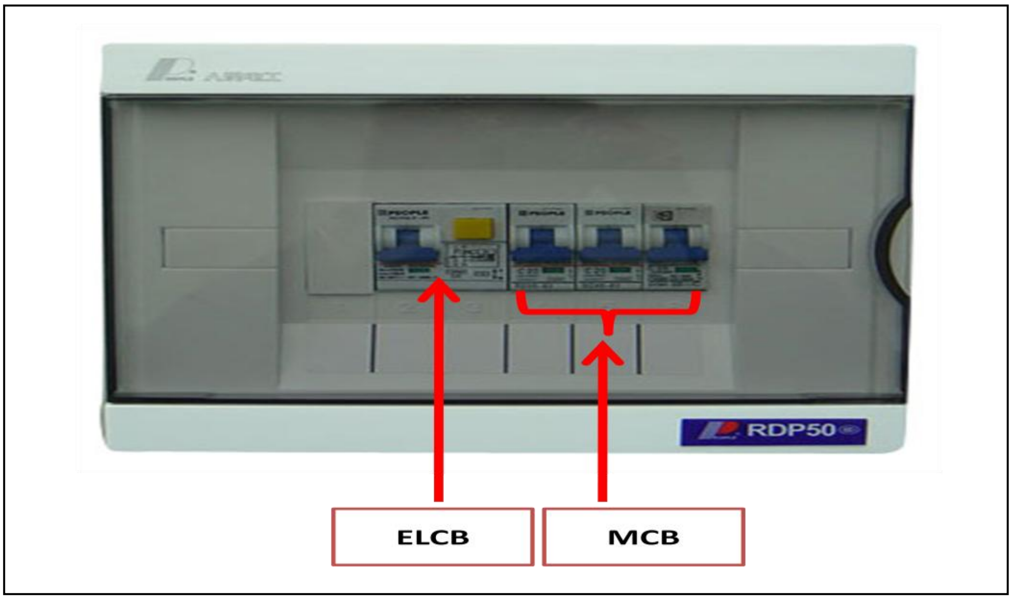

Figure 8: Consumer Distribution Box

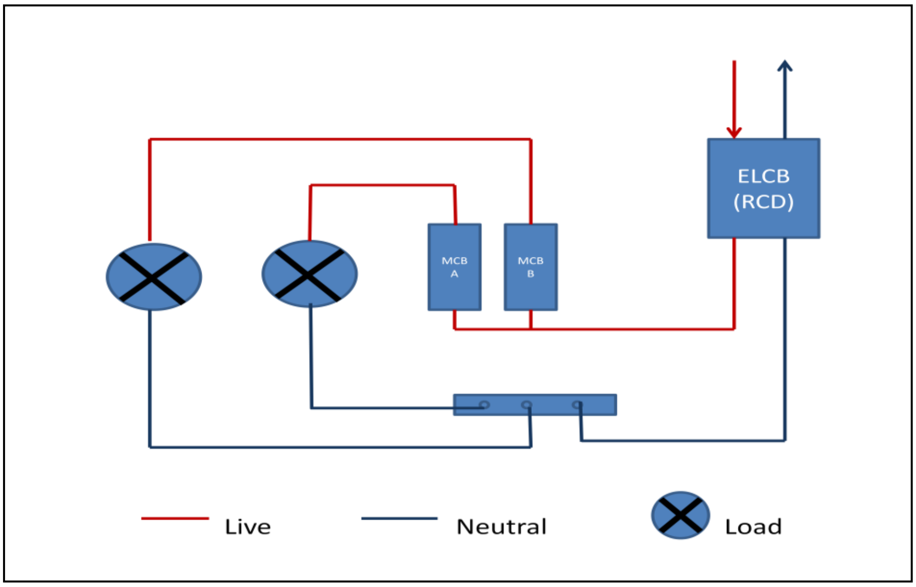

Figure 9: Simple domestic electrical wiring diagram

4.2 Example of fault current calculation (ground fault)

Fault occurs at electric kettle which has the power and voltage rating as follow:

- Rated power, P = 1500 W
- Rated voltage, V = 240V
- Ground resistant is assume 5 ohm (minimum requirement for grounding).
- Calculation :
    - During normal condition
        - $P = IV$
        - $I = \frac{P}{V}$
        - $I = \frac{1500}{240} = 6.25\ \text{A}$ (1)

- During ground fault
  - $P = I^2R$
  - $I = \sqrt{\frac{P}{R}} = \sqrt{\frac{1500}{5}} = 17.32\,A$ (2)

- From the calculation in (1) and (2), it can be seen that fault current is about three times greater than the normal current consumed by the load if the ground resistant is set to be 5 ohm. When this type of fault is occurred, the current travel through the ground conductor is consider as a leakage current where a few or no current will travel out through neutral wire to the neutral bar as shown in figure 10. So it is determined that the respective MCB is the faulted MCB and need to be turn off from the system to ensure the system is free from fault before turn on the ELCB.

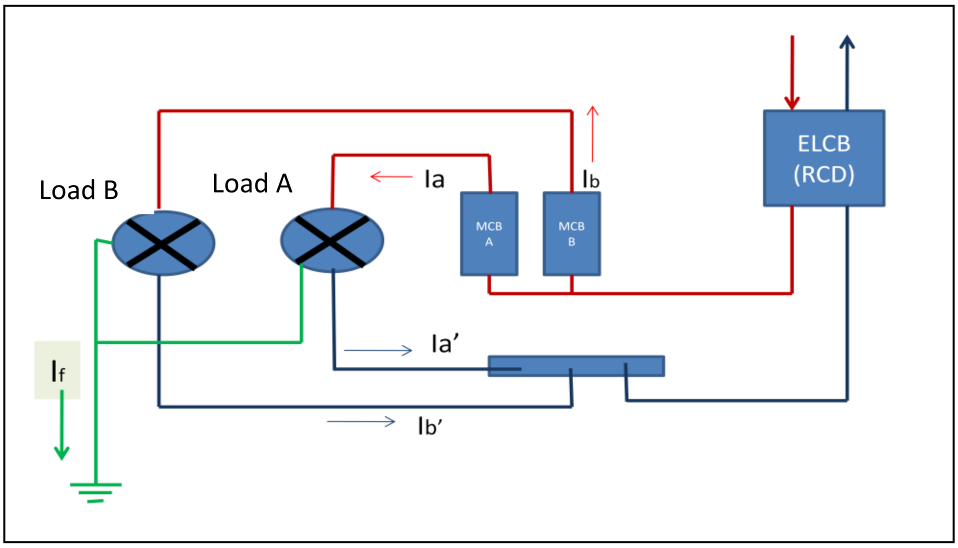

Figure 10: Ground fault

- I_f is the fault current that travels through ground conductor to the earth. For load A, the current at live wire is labelled as *Ia* and current at its neutral wire is labelled as I_a'. It is same to load B. When the value of current I_a' is less that I_a, there is leakage current at load A. So according to the system design, MCB A should be tripped off in order to reclose the ELCB when there is no fault in the system. The system will only trip the MCB when the different of current reach 30 mA. The value of 30 mA is same as the tripping condition of a standard ELCB.

- The tripping condition is set to be as follows:
    - If $I_a'-I_a$ = 30 mA, trip MCB A
    - If $I_b'-I_b$ = 30mA, trip MCB B
    - Then, reclose ELCB

- Current transducer is giving output voltage, so assumption is made that 30mA equals to 3V transducer output. Then at the programming part at LabVIEW, 3V is used as the maximum voltage difference to compare the data.

4.3 LabVIEW Block Diagram and Front Panel

LabVIEW is used as a program to control and determine the location of fault. The program consists of two parts which are Block Diagram and Front panel. Figure 11 shows the block diagram and Figure 12 shows the Front Panel of LabVIEW that has been programmed to detect the location of fault.

Block diagram is where the programming part in LabVIEW takes place. The interesting part is the program is written using symbols and icons and connected by wires. Figure 11 shows the block diagram of the project.

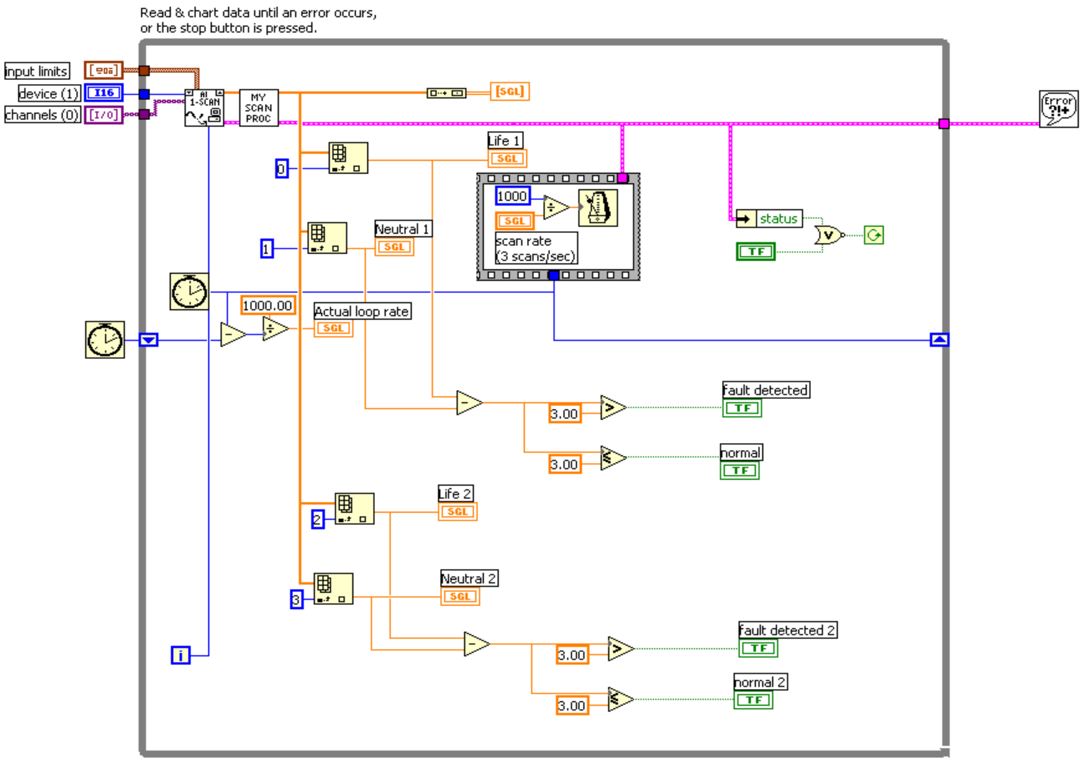

Figure11: Program Block Diagram in LabVIEW

Front panel is the graphic user interface in LabVIEW as shown in Figure 12. The front panel has been design to display four graphs of current with different colours (red, yellow, green and blue). It also will display the value of current measured in real-time basis where the scan rate is 3scan/secs. Stop button is also included in the front panel to make the user easier to stop the program. There are four indicators which will light up when the system is running to show the current condition of the system.

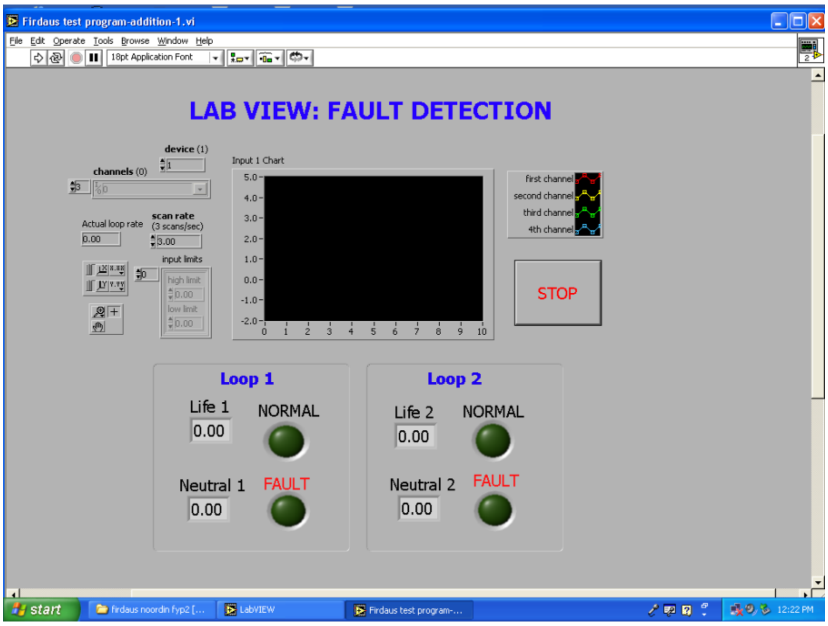

Figure12: Program Front Panel in LabVIEW

4.3.1 Data Acquisition

The program has been designed to acquire voltage signal from current transducers. Figure 13 shows a connector block is used to acquire the voltage signal from current transducers where four analogue input ports have been selected. The Connector Block is then connected to LabVIEW Data Acquisition Card that attach to computer’s motherboard. The LabVIEW program that has been created for acquiring the data from Data Acquisition Card is also shown in Figure 14 and 15.

Figure13: Connector Block

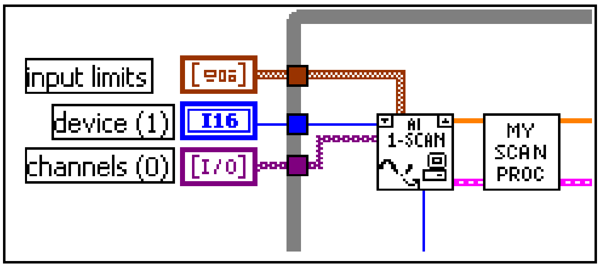

Figure 14: A part of program that acquire voltage input from Data Acquisition Card

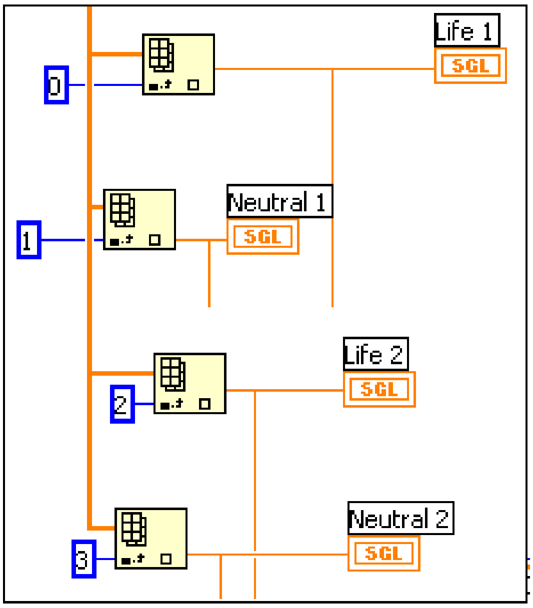

Figure 15: Four inputs that feed to the program

4.3.2 Data Comparison and Fault Detection

The value of current at live wire and neutral wire in voltage form is compared respectively in the program. The value of current at live wire from loop 1 is compared to the value of current at neutral wire from loop 1. The same operation is performed to loop 2. The value difference is set to be 3V for the system to detect fault. Figure 16 and 17 show the program for comparing the voltage values from current transducers.

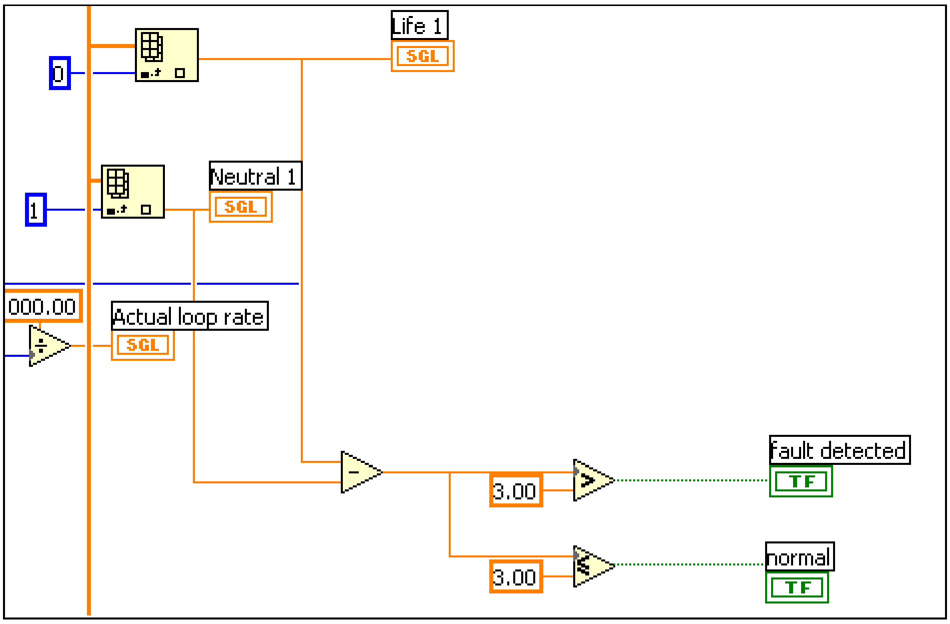

Figure 16: Program to compare values of current at live and neutral wire in loop 1

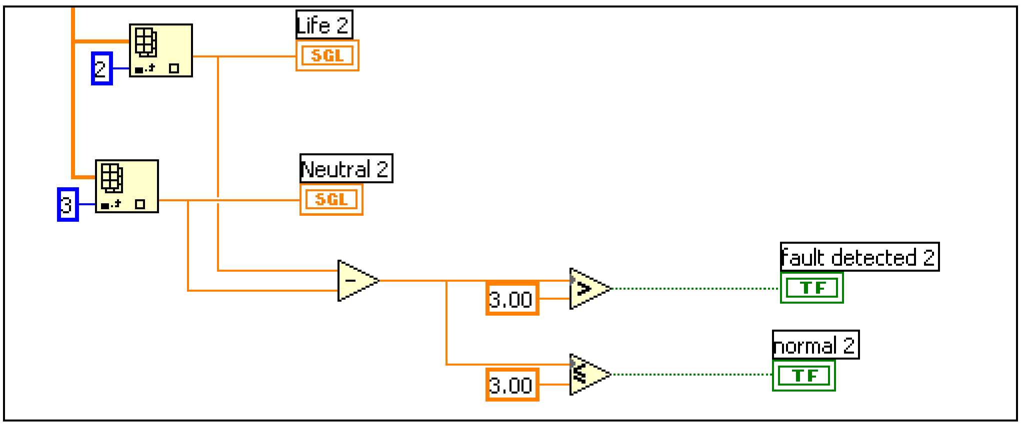

Figure 17: Program to compare values of current at live and neutral wire in loop 2

The graph of current values (in voltage form) is shown in front panel. The scan rate for this program is set to be 3 seconds per scan. For two loops system, the program requires four input channels and four different graphs are shown with different colours. There are two indicators in each loop showing the current condition of the system whether in normal condition or detecting fault. The front panel also shows the values of current at live and neutral wire which are recorded from current transducers. Figures 18 to 21 show the front panel in various condition of the system.

Figure 18 shows the system is in normal condition where no fault is detected. The front panel will show the value of current at both live and neutral wire. The value of live current will be compared to the value of current at neutral wire and the normal condition indicator will light up when the different is less that preset value (3V). The red graph represents the live current at loop 1, yellow represents the neutral current at loop 1, the green represents live current at loop 2 and the blue graph represents the neutral current at loop 2. The graphs show the value of current respect to time (secs).

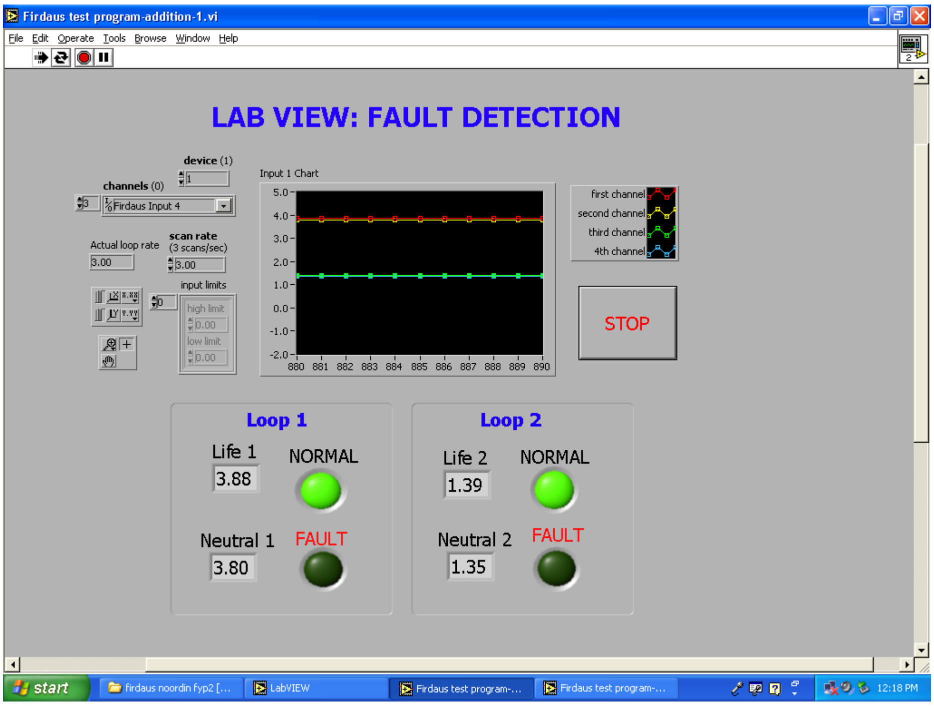

Figure 18: System in normal condition

Figure 19 shows that fault has been detected at loop 1 and loop 2 remains in normal condition. The value different between live and neutral current at loop 1 is more that 3V, so the system will detect loop 1 as the location of fault.

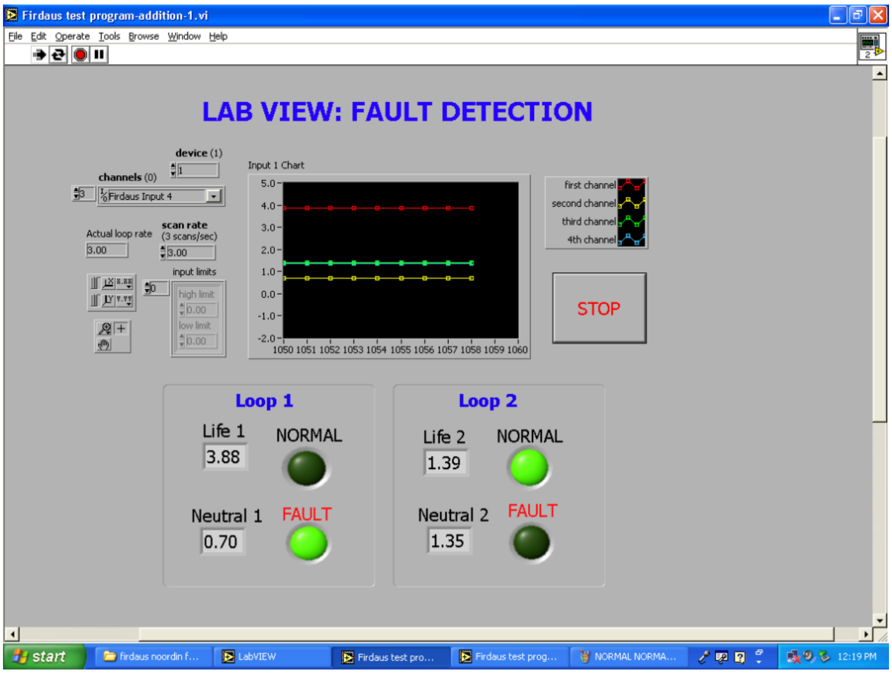

Figure 19: Fault detected at Loop 1

Figure 20 shows a fault is detected at loop 2. The result is about the same with result shown in Figure 18 but the location of fault detected is different. The figure shows that when LabVIEW detects the difference is 3.37V which is more than 3V at live and neutral wire at loop 2, so it will declare that the loop 2 is experiencing fault. So the location of fault can be determined.

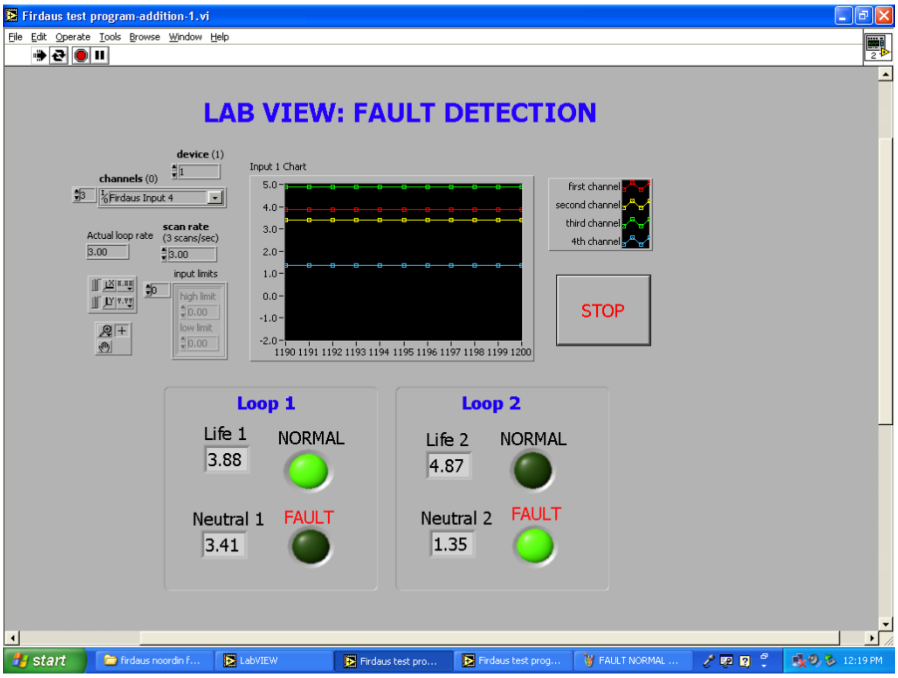

Figure 20: Fault detected at Loop 2

Figure 21 shows that fault is detected at booth location (loop1 and loop 2). The value difference at live and neutral wire for both loops are more than 3V, so the system detects the fault at both loops.

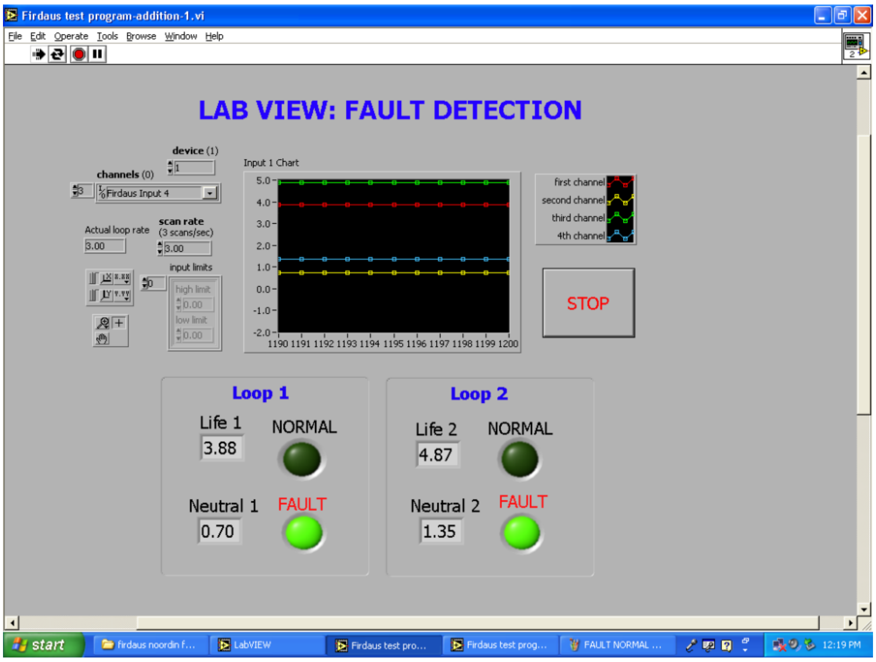

Figure 21: Fault detected at both Loop

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 Conclusion

The LabVIEW program that has been designed is able to detect the location of fault in a domestic electrical system. The purpose of determining the location of fault is to isolate the permanent fault in a system before the other system turn on back the Earth Leakage Circuit Breaker (ELCB). This is to ensure the reliability of power supply to protect the critical equipments in domestic building. LabVIEW is seen to be a good medium to develop the program because it can acquire real time analogue input data as well as performing the logical part to detect the fault. So when the location of fault is determined, an automated system to isolate the faulted Miniature Circuit Breaker (MCB) can be designed to cater for both temporary and permanent faults. The designed system will give a lot of advantages for consumers to protect their equipments and properties when they are not around. So the objective to design a system that can determine the location of fault in domestic electrical wiring system is achieved.

5.2 Recommendation

Current transducers are used to measure the value of current at live and neutral wires. But there are many types of current transducers available in the market. It is recommended to use the clamping type current transducer rather than using the Printed Circuit Board (PCB) type. The clamping type gives a better efficiency but the cost is much higher than the PCB type. For future works, it is recommended to use a latest version of LabVIEW software and the Data Acquisition (DAQ) Card. The latest version used will be easier in term of designing and finding the resources to refer.

REFERENCES

[1] Trevor Linsley, “ Advanced Electrical Installation Work”, Newnews Fifth Edition, 2008.

[2] Residential Wiring, second edition, Gary J. Rockis, Suzanne M. Rockis and Thomas E. Proctor.

[3] Guide to The Selection & Use of Residual Current devices, RT214:2005 Edition 1.

[4] http//:www.electronics-manufacturers.com

[5] http://en.wikipedia.org/wiki/Residual-current_device

[6] http://www.bookrags.com//wiki/LabVIEW

[7] http://www.wisegeek.com/what-are-current-transducers.htm

[8] http://www.ni.com/labview/whatis/

[9] http://www.ee.buffalo.edu/faculty/paololiu/edtech/roaldi/tutorials/labview.htm

[10] Moriarty PJ, Gallagher BL, Mellor CJ, Baines RR, P. J.; Gallagher, B. L.; Mellor, C. J.; Baines, R. R. (October 2003). "Graphical computing in the undergraduate laboratory: Teaching and interfacing with LabVIEW". American Journal of Physics (AAPT) 71 (10): 1062–1074. doi:10.1119/1.1582189.

[11] http://www.thecircuitdetective.com/index.htm

[12] http://zone.ni.com/devzone/cda/tut/p/id/4290

[13] http://www.ni.com/pdf/manuals/370719c.pdf

APPENDICES

APPENDIX A

No.	Detail/ Week	1	2	3	4	5	6	7		8	9	10	11	12	13	14
1	Project Work Continue								Mid Semester break							
2	Submission of Progress Report 1															
3	Project Work Continue															
4	Submission of Progress Report 2															
5	Seminar (compulsory)															
5	Project work continue															
6	Poster Exhibition															
7	Submission of Dissertation (soft															
8	Oral Presentation															
9	Submission of Project															

Suggested milestone

Process

APPENDIX B