ELECTRICAL CABLE FAULT DETECTION METHOD IN BUILDING USING NI MULTISIM SOFTWARE

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Abstract

It is often difficult to know whether electrical power breakdown at home is due to a faulty cable. When there is a tripping in the Distribution Board (DB), the first move would normally to switch off all of the Miniature Circuit Breakers (MCBs), and then switch on the MCB one-by-one. Once switch on, the fault can be identified by observing at the tripped MCB. Then, the next move is to locate the source of the fault that is connected to the MCB. For a fault that is due to the electrical device connected at the other end of the Switch Socket Outlet (SSO), the fault can easily be identified. However, if the fault is due to the cable, the method to confirm the fault is often difficult to do. Fault detection in the final circuit of a distribution system is always challenging. As compared to the fiber optic cable, the technician or engineer can use a power meter and a light source to detect any cable fault – for short and long distance cables. But for a very long distance fiber optic cable, that is normally more that 1km, Optical Time Domain Reflectometer (OTDR) can be used. However, for electrical power cable, the detection methods for cable fault are still under-developed. There is rarely any specific equipment to detect the cable fault. Thus, in this paper we developed a very simple method in detecting a cable fault at home and at any small building. This is possible by using few basic electrical devices and computer program called NI Multisim. From this study, three types of cable faults can be simulated such as open circuit, short circuit, and current leakage. The NI Multisim software is able to give us the measurement that could help us interpret the status of the power cable – whether it is faulty.

Keywords: *Cable faults, fault detection, switch socket outlet, short circuit, and current leakage.*

1 INTRODUCTION

The electric powers systems are complex and various interfaces involved in constructing the systems. From the end user device to the generating plant, there are varieties of electrical components that have to be integrated with each other. These components are also exposed to certain risk of failures that need to be detected as early as possible once breakdown occurs. Breakdown can happen anywhere in the power systems. This might only involve a small house, but it can also affect the whole town. Be it major or minor, the breakdown needs to be attended immediately. Downtime to electrical power systems means economic losses to the businesses and results in uncomfortable situation to residential or business entities. One of the faults that can cause electrical power breakdown is the cabling fault.

Electrical cable faults have always happened in the power systems. These faults are caused by several reasons such as overloading of existing circuits due to increase of loads, short-circuiting of the cables, cable cut due to underground trenching, and many other reasons. When breakdown happens, fault localization on the cable has to be carried out after checking the condition of the tripped protection mechanism. For a high voltage cable, fault location might easily be identified based on the monitoring system available for the cable section. However, for a low voltage system, a manual and observatory method will normally be used to carry out this exercise. Hence, there is no ultimate method in determining the fault cause. Any methods could be employed in solving this issue.

2 LITERATURE REVIEW

2.1 Fault Detection Method

Several researchers have proposed some methods in cable faults detections. These includes Time Domain Reflectometry (TDR), Time Frequency Domain Reflectometry (TFDR), Frequency Domain Reflectometry (FDR), Decomposition of the Time Reversal Operator (DORT) method, Chaotic Signal method, and etc. Shi, Troeltzsch, & Kanoun (2010) have compared the three detection methods (TDR, TFDR, and FDR) and found out that all methods can be used to detect fault in the coaxial cable and also in branches of wire network. However, they found out that TDR method is the easier method to use but susceptible to noise interruption.

Another sophisticated fault localization technique is using the DORT method. However, this method failed to locate multiple faults. Kafal, Cozza, & Pichon, (2016) have proposed a more advanced method called EDORT (Enhanced DORT) that has the capability to locate multiple faults in various systems. Soft fault is basically referring to a minor fault, for example, a dent cable. The soft fault is normally sensitive to communications cable where geometry of cable is important for the cable to function effectively.

However, for power cable, soft fault might not interrupt the operation of the power system. Thus, this method is suitable for communications cable that is sensitive to noise.

TDR principle has been predominantly used in fiber optic cable testing and commissioning works. A testing machine called OTDR (Optical Time Domain Reflectometer) has been used widely by field technicians and engineers in telecommunications industries to do the testing and commissioning of their fiber optic network. However, at the early stage of the OTDR test-gear development, the machine could not measure accurately the cable with a distance of less than 500 m or 1 km. The machine will give wrong measurement of the properties of lights once 1310 nm or 1550 nm of light-wavelengths are to be injected in the fiber optic cable core of that distance. The OTDR shows values of attenuation (in dB), loss (in dB), light dispersion spectrum (in case of cable cut), and etc. that should help the engineers know the fiber optic cable status.

TDR is also used in electrical wiring fault detection. A study done by Shirkoohi (2015) created models to simulate and detect fault in straight wire and coaxial cables. He used the Quick Wave FDTD solver software to do the simulation and test. He found out that there are similarities between the types of cables under study.

A method developed by Wang, Zhang, Xu, & Wang (2011) utilizes the chaotic signal as a probe to locate wiring fault in a power system. Many other researchers utilize extensively the application of time and frequency domain in the cable for the purpose of developing the effective fault detection technique in an electrical cable. Time and frequency domain from the electromagnetic theory have been used to understand forward and inverse models in cable fault detection and predict the reflectometry responses of the fault that occur in the cabling system (Lundquist & Furse, 2011). Other researcher also developed some techniques that are utilizing the time and frequency domain to find the best suited method in cable fault localization.

Some of the popular fault detection methods that are used nowadays have advantages and disadvantages and are tabulated as follows:

TABLE 1. Fault Detection Method

Method	**Advantages**	**Disadvantages**
Visual Inspection	The most common and easy method. Often solve most breakdown problem without having sophisticated testing equipment	Might be time consuming. For underground cable and long-distant cable, visual inspection is not suitable.
Continuity Check	Give quick status of the breakdown cable	For a long cable, continuity check might be a problem.
X-rays	Can detect any kind of defect, provides location information	Mobility of the system is not possible due to its weight and complexity.
Thermal Imaging (Thermography)	Give hot-spot information. Can help operator to do preventive maintenance before fault happens.	Not all faults can be detected by this method.
Reflectometry	Only need one access terminal to do the testing.	Different cable types might require certain type of testing equipment. No universal test-gear can be used for different cable types, properties, and etc.

In this paper, we utilize the application of computer software to simulate and detect fault in the electrical cable. We once constructed a physical model to do the detection manually using a fuse, a light bulb, an ammeter, and two probes. Then, this model was created in the NI Multisim software as part of electrical wiring system at a premise. After that, faults were simulated in the wiring system. Ammeter reading shows how the fault behaves. The readings of the ammeter in the software can be compared with the physical reading to understand the faults that happened in the physical system. Basically, this software was used to simulate the physical faults that happened at the instant of time which if were done physically, we could not capture the electrical behavior of the faults – at the instant when the fault occur. Thus, the simulation can detect the type of faults and show other faults in the wiring system that happen during that time. Another advantage is that the faults that occur in the whole wiring system can be sectionalized and evaluated separately.

2.2. NI Multisim Software

NI Multisim is simulation software developed by National Instrument (NI) that can be used for practical application in designing, prototyping, and testing electrical circuits. The software can be used to simulate faults and help us understand the behaviour of faults at each circuit. This software is chosen because it could verify the method that we are proposing in identifying the fault location using an ammeter and a light bulb. Thus, this novel technique can be used by any technicians or engineers once faults incident happen in any premises. However, the application is only for a single phase low voltage system which covers a voltage of 220 V to 240 V and below.

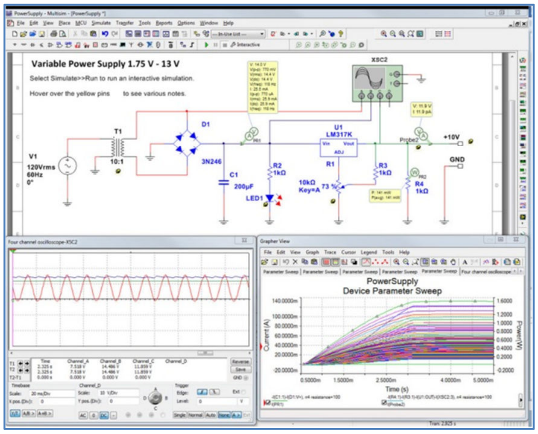

FIGURE 1. NI Multisim Interface

3 METHODOLOGY

We wish to design a simple device that can be used to detect wiring fault at home. The device consist of an ammeter and a light bulb connected together as shown in FIGURE 2. This same model was constructed using the NI Multisim software and fault simulation was carried out. This model is called Fault Detection device (FD).

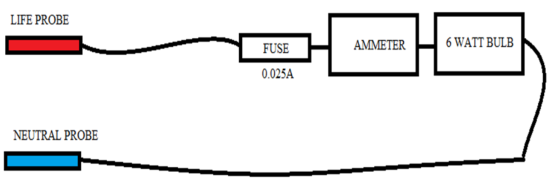

FIGURE 2: Proposed Cable Test Set-up

Since the bulb's power rating is 6 Watt, therefore the maximum current for this circuit is 0.025A (supposed that the incoming supply is 240V and the power factor is unity – to ease the calculation).

$$P = VIcos\theta \quad (1)$$
$$6W = (240V)I(1)$$
$$I = \frac{6W}{(240V)(1)}$$
$$I = 0.025A$$

Thus, a fuse with 0.025A is chosen.

When both of the probes are connected to the home wiring system, such as switch socket outlet, the ammeter will show the current reading for that system. A good condition wiring system will show the value of current around or below 0.03A. If suddenly the current exceed or goes too far below this value, then the system is at fault.

FIGURE 3 shows the construction of wiring system by using the NI Multisim software. SYSTEM 1, SYSTEM 2 and SYSTEM 3 represent the switch socket outlet. Table 2 shows the fault conditions for this system. The Fault Detection 1 (FD1), Fault Detection 2 (FD2), and Fault Detection 3 (FD3) are connected to the SYSTEM 1, SYSTEM 2, and SYSTEM 3 respectively.

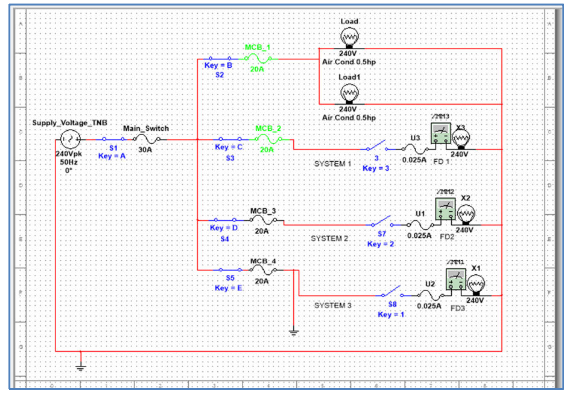

FIGURE 3. Wiring System using NI Multisim

TABLE 2. Fault Conditions Set-up

System	Fault Set
SYSTEM 1	No Fault
SYSTEM 2	Leakage
SYSTEM 3	Short

4 RESULT AND ANALYSIS

FIGURE 4 shows the result when SYSTEM 1 and SYSTEM 2 were ON, while SYSTEM 3 was switched OFF.

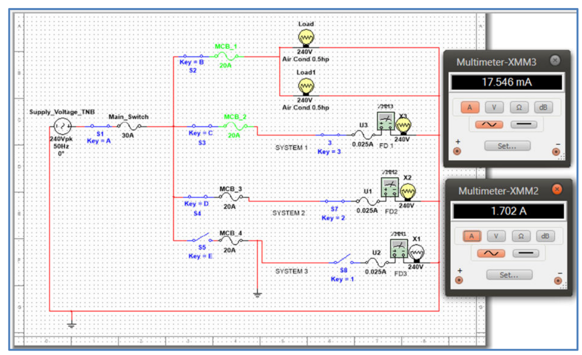

FIGURE 4. Current Measurement for SYSTEM 1 and SYSTEM 2

It can be seen that for SYSTEM 1 that has no fault, the value of current measured was 17.546mA (0.017A) which is almost near to 0.025A. For the SYSTEM 2 that has been set to leakage fault, the current measured was 1.702A. Since the current exceed the limit, the fuse for FD2 burnt as seen in FIGURE 5.

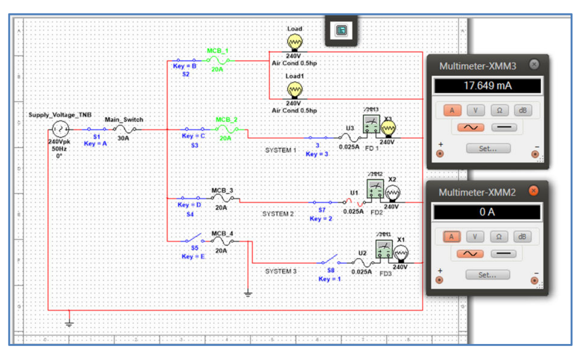

FIGURE 5. Fuse for FD2 Burnt

FIGURE 6 shows the result and current measured for all system. The current measured for SYSTEM 1 was 8.834mA, SYSTEM 2 was 856.917mA and the current measured for SYSTEM 3 was 0A due to the short circuit fault. Due to the short circuit fault that was set to SYSTEM 3, it can be seen that the Main Switch triggered as shown in FIGURE 7. This is what actually happened in a real life situation, when there is a short circuit fault, the main switch will trip.

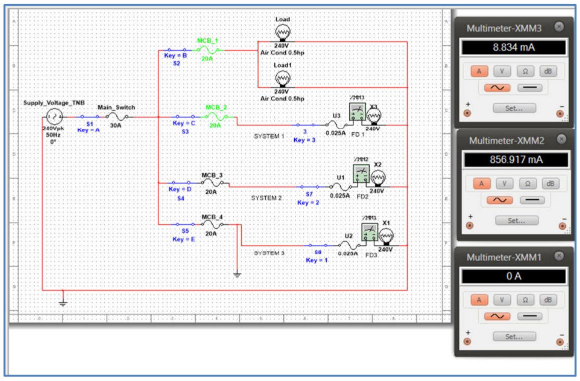

FIGURE 6. Current measured for FD1, FD2 and FD3

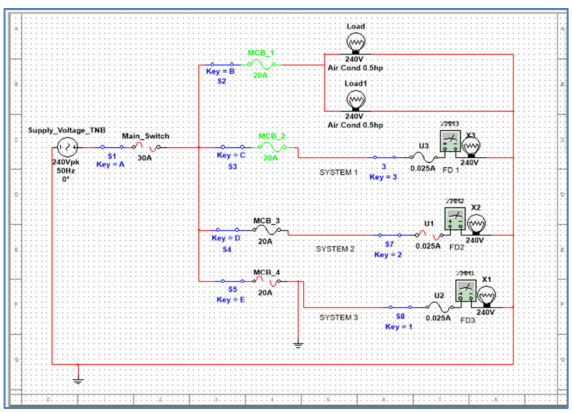

FIGURE 7: Main Switch Triggered

TABLE 3. Current Measurement when SYSTEM 3 was OFF

System	**Fault Set**	**Status**	**Measured Current (A)**
SYSTEM 1	No Fault	ON	0.017
SYSTEM 2	Leakage	ON	1.702
SYSTEM 3	Short	OFF	0

TABLE 4. Current Measurement when All Systems were ON (Just Before the Main Switch Triggered)

System	**Fault Set**	**Status**	**Measured Current (A)**
SYSTEM 1	No Fault	ON	0.008
SYSTEM 2	Leakage	ON	8
SYSTEM 3	Short	OFF	0

TABLE 5. Current Measurement when All Systems were ON (After the Main Switch Triggered)

System	**Fault Set**	**Status**	**Measured Current (A)**
SYSTEM 1	No Fault	ON	0
SYSTEM 2	Leakage	ON	0
SYSTEM 3	Short	OFF	0

4 CONCLUSION

Basically, there are three types of fault, open circuit, short circuit and leakage. By using a Fault Detection device, the fault of the power system can be detected by measuring and comparing the amperes or the current readings of the system. From the simulation, we found out that the Fault Detection device can detect if there is any leakage current. And if there is a fault, the reading of ammeter of FD will rise to a certain value and the fuse will burn. In this study, by using FD we can even check if there is short circuit fault in the system. However, it is impossible to see the fault in real life since this type of fault will cause the main switch to trigger within a second.

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