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DETECTION OF LOW VOLTAGE ARC SERIES FAULT AND ITS SEVERITY LEVEL USING FAST FOURIER TRANSFOR METHOD

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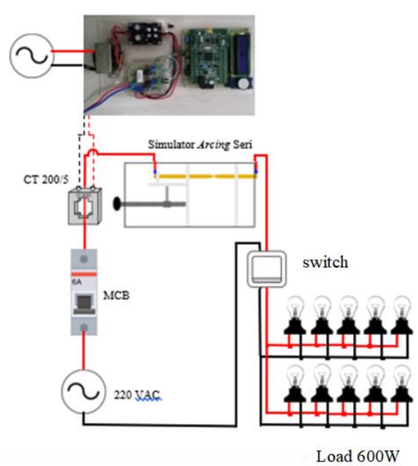
Graphical abstract



Abstract

A short circuit is an electrical fault that occurs due to two conductors in contact, which causes the resistance to be minimal, resulting in a substantial electric current. There are cases of interference that cannot be avoided. This disorder is called the arc of fire series. If the arc of fire continues continuously, heat will arise, which can damage the equipment, and fire will occur. In this study, arc series detection will be carried out at low voltage against the influence of nonlinear loads on detection performance. The data retrieval method is divided into three conditions so the detection device can distinguish interference: normal conditions, switching, and arc fire. The three condition current reading is carried out by the current transformer and read by the arc detection device. The arc detection tool processes the signal obtained from the current transformer and converts the analog signal into a digital signal. Then, an analysis is carried out using the Fast Fourier Transform method. This tool consists of rectifiers, signal conditioners, an STM32 microcontroller, and a 16 x 2 LCD. The output of this final is to create an arc detection device that can detect 100% the presence of a series of arc faults in low-voltage equipment in normal and arc fire conditions.

Keywords: Arc Detection, Fast Fourier Transform (FFT), Low Voltage, STM32, Nonlinear Load

1.0 INTRODUCTION

In the residential, industrial, and other spheres of human life, electrical energy has evolved into a basic necessity. Every year, Indonesia's consumption of electricity rises. Ignatius Jonan, minister of energy and mineral resources, claimed that five years had seen an increase in Indonesia's electricity use. Since 2014, the amount of energy used per person has been 878 kWh, followed by 918 kWh in 2015 and 956 kWh in 2016. The amount increased once more, this time by 1,012 kWh per person in 2017 and 1,064 kWh per capital in 2018 [1]. The number of customers was also accompanied by increased fire cases caused by electrical short circuits [2], [3]. Based on data from the National Disaster Management Agency, from the end of 2014 to mid-2018, there were 879 fire cases in Indonesia, of which 531 cases were caused by electrical short circuits [2].

A two-phase conductor relationship with the phase or phase with neutral that results in minimum resistance, a significant electric current, and a sharp rise in conductor rod temperature is known as an electrical short circuit [4], [5]. If the value of the electric current exceeds the conducting ability, it will cause damage to the insulation, and fire will occur [6], [7]. In order not to cause a fire, safety devices such as fuse and MCB are needed. There are cases of unavoidable interference. This disorder is called the arc series of fire. In this situation the current does not surpass the base specification [8]. Assume that there is a constant arc of fire. Then, a single-path conductor that shouldn't have a potential difference will develop one, which will eventually release energy in the form of heat and become combustible.

Loads in homes, industries, and offices have various properties, such as linear and nonlinear loads. To discover and anticipate the occurrence of an arc series fire, this experiment will be conducted research to determine the characteristics and detection of the event or arc series on the influence of nonlinear loads at low voltage using the Fast Fourier Transform (FFT) method. Based on the type of loads, it will be used as a flame arc detection parameter for nonlinear loads. To help the detection device distinguish between interference and switching and arc fire, the data retrieval method is divided into these three categories: normal conditions, switching, and arc fire. Arc fire and regular conditions will be compared to switching situations. The occurrence of interference, or not, will be reported and displayed via a 16 x 2 LCD.

2.0 METHODOLOGY

A. ARC Fault in Low Voltage Systems

Arc Fault is a spark in the electrical system that occurs when two phase conductors are in contact to each other either in same phase or phase to neutral, and a current jump passes through the sidelines between the two conductors due to sufficient voltage values. This spark then ionizes the air around so that the air everywhere becomes conductive and forms an arc [9]. The arc of fire is also usually followed by the arc flash phenomenon [10], [11]. According to NFPA [12], [13], arc flash is a phenomenon of energy release in heat and light from the ionization process (electron propagation) in the air of a material or material. The arc flash phenomenon plays an essential role in the event of a fire. Conventional safety equipment such as MCB (Miniature Circuit Breaker) and fuse cannot detect high currents and travel as expected. This is because the duration of the occurrence of short circuits is so fast that it cannot be seen by conventional safety equipment such as MCB or fuse [14], [15]. In general, arcs often occur in the electricity of medium-voltage networks and high-voltage networks. However, the arcing phenomenon in the field also often occurs in low-voltage grids. This can be proven by data that shows that electrical short circuits cause many fire events. Electrical short circuits can occur due to many things, Among other things errors in the installation of installations, Figure 1 is a condition that occurs in cables that are often pinched by objects, the presence of rodents such as mice, and the occurrence of conductor problems on the wires. One of the causes of arcs that often occurs is the presence of rodents such as mice. Rodents play a role by eliminating insulation that protects phase conductors neutrally. If the insulation is lost, the phase and neutral conductors come into contact, and arc interference occurs. In this research, the manufacture of arc detection devices at low voltage levels will be carried out by making series arc experiments in three conditions when normal, switching, and arc occurs.

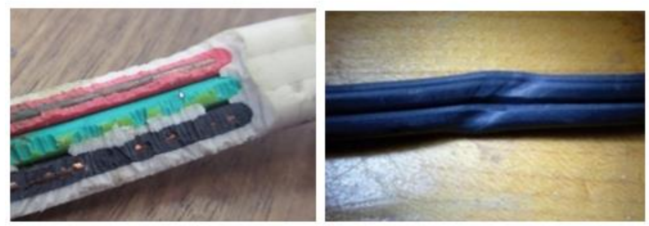


Figure 1 Damage to Wires by Rodents and Distressed by Objects

B. ARC Series

The magnitude of the arc value of the series fire is limited by its load conditions and is almost equal to the importance of the current value under normal circumstances. Therefore, what can distinguish the normal state and the arc of fire is the waveform. Arc series fire can occur due to the disconnection of the phase or neutral conductor path the series connects with the Load [16]. This phenomenon can result in gaps and potential differences. With the potential difference, a hot spot is formed in the hole due to the energy expended. In the end, the energy of a thermal nature carbonizes with insulating materials. This carbon is conductive, so it can conduct currents that can cause an electric arc of fire. The arc of fire that occurs improves the carbonization conditions, eventually producing sudden sparks.

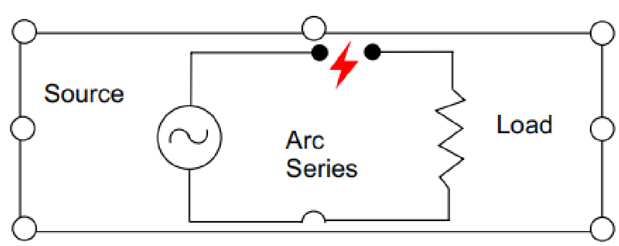


Figure 2 Arch of Fire series

Arc fire occurs between sources with parallel loads. Figure 2 describes the occurrence of the arc of the fire series. The arc of fire of the series occurs on one conductor for which there should be no gaps. This serial configuration means that the arc current of fire cannot be greater than the load current provided by the conductor.

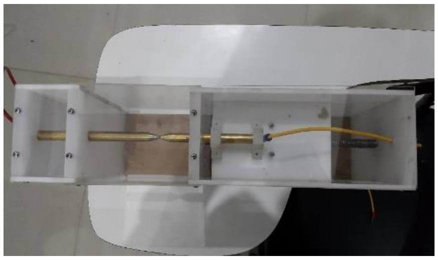


Figure 3 Series Arc Simulator

In Figure 3 is the prototype of the arc simulator series. This series arc simulator is rectangular with a length of 36 cm, a width of nine cm, and a height of 16 cm, with an acrylic casing based on wood. Two electrodes and a slider lever are mounted on the simulator. The electrodes are made of brass metal with a diameter of 10 mm. The two electrodes are mounted parallel, where one electrode rod is fixed, and the other electrode can be shifted by using the slider lever. the contact point head used is sharp. The mechanism for simulating a series arc is to slide one of the conductors with a slider lever to make a very small gap between the two conductors. because the simulation is carried out at a low voltage of 220V AC and with a fixed load of 600W, based on the results of research and measurements, the electrode distance for an arc to occur is very small because the measured current is small, so that in shifting the lever must be with very high accuracy.

C. Nonlinear LOAD

A nonlinear electrical Load can cause harmonic [17]-[18]. The current input waveform is not proportional to the input voltage, so neither the present nor the voltage output wave is the same shape. This harmonic current poses many implications for the equipment of the electric power system. Examples include high heating in capacitors, transformers, rotating electrical machines, and errors in the readings of RMS measuring instruments. A semiconductor component called a nonlinear load function as a switch every half-wave cycle. In other words, a load that calls for a variable current at all times. Examples of nonlinear loads are pumps, energy-saving lamps (LEDs), air conditioners, refrigerators, televisions, etc.

D. Total Harmonic Distortion (THD)

The voltage and current waveforms are the sum of the primary sinusoidal waves and their harmonic waves, which is what causes the presence of the harmonic itself to occur. [13], [19]. A harmonic wave is the sum of a sinusoidal wave with a frequency multiple of its base frequency where the value of its probability is equal to its harmonic order and is of an integer value. Nonlinear loads cause harmonics. Total Harmonic Distortion (THD) is one of the harmonic indices that can determine electrical power quality. THD is differentiated into two, i.e., THD voltage (THDv) and THD current (THDi) [20]. Usually, THD is expressed in (%) to know the magnitude of the distortion produced by all harmonic-producing components [21], [22].

E. Fast Fourier Transform

A Fourier transformation, named after Joseph Fourier, is an integral transformation that restates a function in a sinusoidal base function, that is, a summation or integral sinusoidal function multiplied by several coefficients (amplitudes) [23]. This transformation has many closely related variations depending on the type of function being transformed. The result of a Fourier transformation is a signal in the frequency region. Because the signal processing uses a discrete time, the above modifications must be conditioned according to discrete conditions. The Fourier transform in the discrete-time area is known as DFT (discrete Fourier transform) [24], [25]. The use of digital signal processing produces as much data as n the data from the search. Fast Fourier Transform (FFT) performs Fourier transforms with fewer calculations developed by the algorithm. There are two types of FFT: decimation in time and decimation in frequency. Decimation in time is an FFT algorithm used to obtain signals in the frequency region from the temple area. As for decimation in frequency, it is better known as IFFT, which is to get a signal in the time area from the frequency region or the opposite of FFT. The algorithm was developed using a matrix decomposition method where W.N. is factored into a smaller matrix L. Using the FFT algorithm, the operation work to calculate the frequency spectrum can be reduced algorithmically [26]. So that the more samples analyzed, the smaller the comparison of DFT and FFT operations.

3.0 RESULT AND DISCUSSION

A. Hadware Design Experiment with NI DAQ 9246

The design of the experimental tool in this final project aims to simulate the phenomenon of arc series fire at low voltage by using nonlinear loads in the form of LEDs and incandescent lamps. This experiment was carried out under three conditions: the condition at the time of normal state, switching state, and arc fire state. The circuit scheme and experimental design are shown in Figures 4 and 5. The use of digital signal processing produces as much data as n the data from the search.

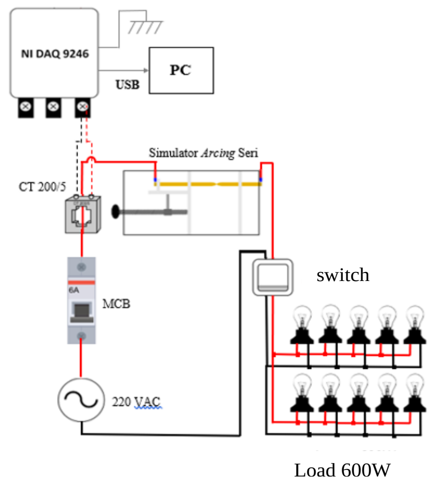


Figure 4 Scheme of the Arc Series Detection Experimental Equipment Kit

Figure 5 Design of Arc Detection Experimental Tools Series

B. Designing Hardware Experiments with Designing Hadware

The design of the flame arc detection tool experiment hardware can be seen in Figure 4 as follows. The design used in this experiment was to replace the NI DAQ 9246 with an arc detection device. This arc detection tool serves as a tool that can provide information that an arc of fire has occurred. This aims to prevent accidents in low-voltage network systems. This tool works based on the threshold value obtained in the experiment using NI DAQ 9246. The block diagram and design of the arc detection tool can be seen in Figures 6 and 7.

The design of the flame arc detection tool experiment hardware can be seen in Figure 5 as follows. The design used in this experiment was to replace the NI DAQ 9246 with an arc detection device. This arc detection tool serves as a tool that can provide information that an arc of fire has occurred. This aims to prevent accidents in low-voltage network systems. This tool works based on the threshold value obtained in the experiment using NI DAQ 9246. The block diagram and design of the arc detection tool can be seen in Figures 6 and 5.

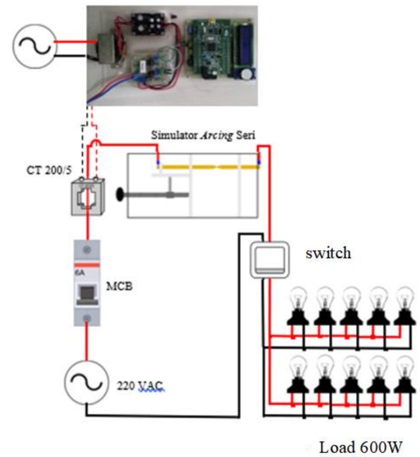


Figure 6 Designing Hardware Experiments with Arc Detection Tools

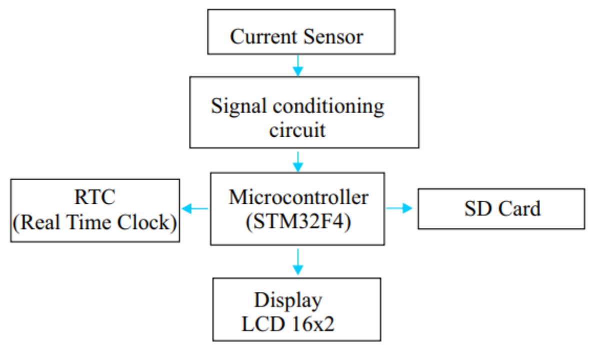


Figure 7 Block Diagram of an Arc Detector Tool

The arc detection device has several electrical circuits and equipment. This tool consists of a series of rectifiers, a circuit of signal conditioners (signal sliders), an STM32F4 microcontroller as a control tool, an RTC (Real Time Clock), an LCD indicator, and an S.D. card.

C. Data Retrieval

Data retrieval is carried out in 2 stages. The first is data retrieval with NI DAQ 9246 and data retrieval with an arc detection tool. Data collection with NI DAQ 9246 aims to determine the characteristics of the graph under normal conditions, switching, and arc of fire and determine the threshold value where this threshold value will be used for the arc detection tool that has been made. In collecting current data, NI DAQ 9246 receives a current signal from C.T. and is then connected to a computer (P.C.) via USB. N.I. Device Monitor software already in the same package as LabVIEW during the software installation will detect data acquisition output from NI DAQ 9246. Data communication between NI DAQ 9246 and LabVIEW has been designed on P.C. Inside the LabVIEW program. The DAQ Assistant is used to set up and read from NI DAQ 9246. DAQ Assistant is set using a sampling rate of 50 kS/s so that high-frequency current signal data can be recorded, and in the initial experiment, the current sampling data will be stored as a '.tdms' file. Then, the current signal data recorded in LabVIEW will be displayed in the DIAdem software. DIAdem software shows the original current signal from data retrieval. Then, the index or amount of data on DIAdem can be processed in Matlab software. In Matlab software, you can cut the desired graphic data to determine the characteristics of the three conditions. This graphical form will then be processed and converted into a frequency domain form with the FFT method with the program in Matlab that has been created. The second stage of data retrieval uses the arc detection tool that has been created. From the waveform changed to the frequency domain, a threshold will be obtained to distinguish between arc and customary conditions and switching. The arc detection tool will use the threshold value obtained from the study of the graphic characteristics of the three conditions using NI DAQ 9246. This threshold serves as a threshold or value that distinguishes arc conditions from others. This tool will detect the presence of an arc of fire through this threshold value. The threshold value will be used as a reference in creating a program on the arc detection tool that has been completed.

D. Data Processing

Data processing in the experiment using NI DAQ 9246 is by converting the time domain current signal into a frequency domain with the FFT method. The results of NI DAQ 9246 will be processed using DIAdem software using the Digital Filters feature. The basis of selecting the filter cutoff frequency component is 10kHz because the fire arc has Broadband Noise characteristics between the 10 kHz frequency to the 1 GHz frequency [27]. If the signal is not filtered, the current signal's features with an arc series fault will be challenging. Signs that have been filtered from DIAdem software are processed using Matlab software by moving indexes or data to Ms.Excel. Then to run Matlab, a link is made to Ms. Excel. With the program created in the Matlab software, the graph will be to the frequency domain area (FFT method). From the chart of these three frequency domain conditions, the arc detection tool will then use the threshold value as a reference value to distinguish the graph of the arc condition from other condition graphs. The selection of the Digital Filters setting on the DIAdem is as follows in Table 1.

Table 1 Digital filter setting on DIAdem for processing current signal

Filter mode	High Pass
Filtering Method	IIR (Infinite Impulse Response)
Cutoff Frequency	10 kHz
Filter Type	Bessel
Filter Order	2

E. Data Analysis and Testing

This subsection will explain the data used as an experiment and the data retrieval scheme of the three conditions.

Table 2 Experiment data

DATA	LED	LOAD	TOTAL	
			Power (LED+LOAD)	THDi
1	1 x 10 W	5 X 100 W 1 X 75 W 1 X 15 W	600 W	2.90%
2	2 x 10 W	4 X 100 W 2 X 75 W 2 X 15 W	600 W	4.40%
3	3 x 10 W	5 X 100 W 1 X 60 W 1 X 10 W	600 W	6.10%
4	4 x 10W	5 X 100 W 1 X 60 W	600 W	8.60%
5	5 x 10W	4 X 100 W 1 X 75 W 1 X 60 W 1 X 15 W	600 W	11.10%
6	6 x 10W	5 X 100 W 2 X 15 W 1 X 10 W	600 W	12.40%
7	7 x 10W	5 X 100 W 2 X 15 W	600 W	13.80%
8	8 x 10W	4 X 100 W 2 X 60 W	600 W	15.40%
9	9 x 10W	5 X 100 W 1 X 10 W	600 W	17.10%
10	10 x 10W	5 X 100 W	600 W	19.20%
11	20 x 30W	0W	600W	117.20%

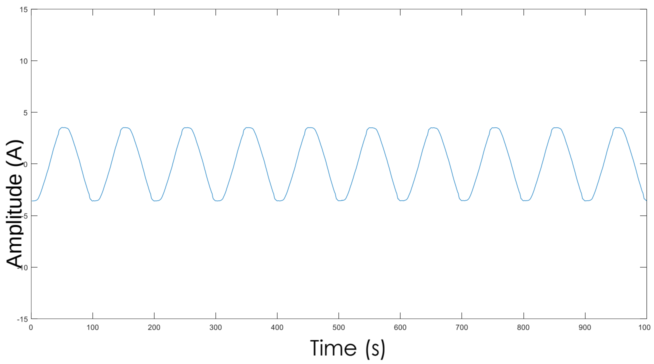
The table above describes the amount of experimental data to be retrieved. Table 2 explains that 11 data with different numbers of LED lights cause the THDi value to change, with a fixed power of 600W. In Table 3, describes the data retrieval scheme. The data retrieval schema for each condition was performed in 5 attempts from data 1 to data 11. So, there are 165 data retrieval in total. This study examines the significant influence of THDi on each condition.

Table 3 Data Retrieval Scheme

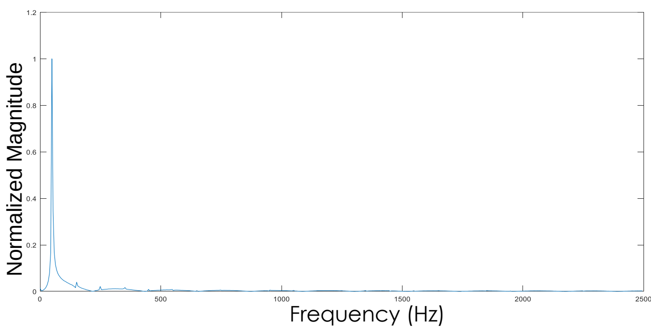
Condition	Variable	Number of Trials for Each Variable	Number of Trials
Normal	Data 1 -Data 11	5	55
Switching	Data 1 - Data 11	5	55
Arc fire	Data 1 - Data 11	5	55
	Total		**165**

F. Current Signal Characteristic of Normal Conditions

The signal graph in Figure 8 is the output of the signal under normal conditions without any arcing interference.



(a)

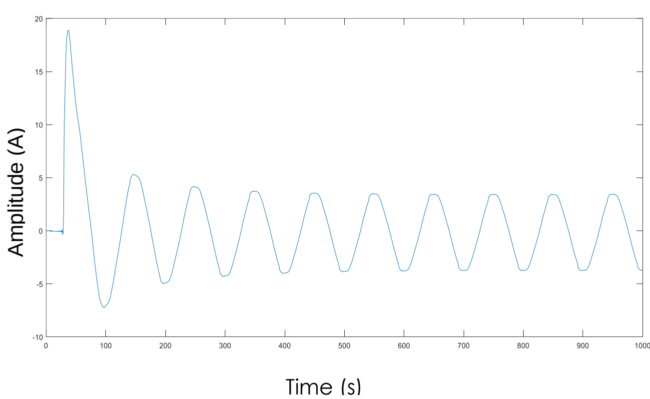


(b)

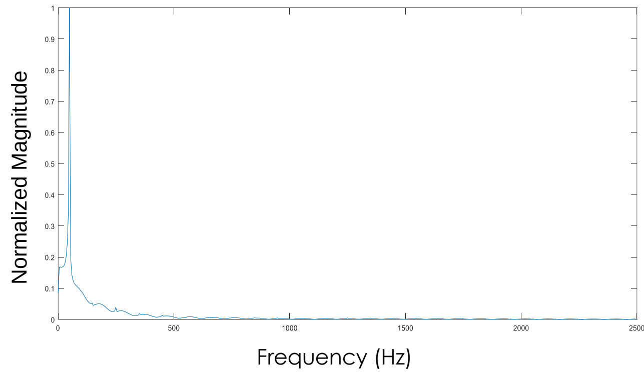
Figure 8 (a) Graph of Current Signals in Normal Condition THDi 2.9%, (b) Graph of Current Signals in Domain Frequency Normal Condition THDi 2.9%

G. Current Signal Characteristic of Switch Condition

The signal graph in Figure 9 is the output of the signal output in switching conditions with THDi 2,9%:



(a)

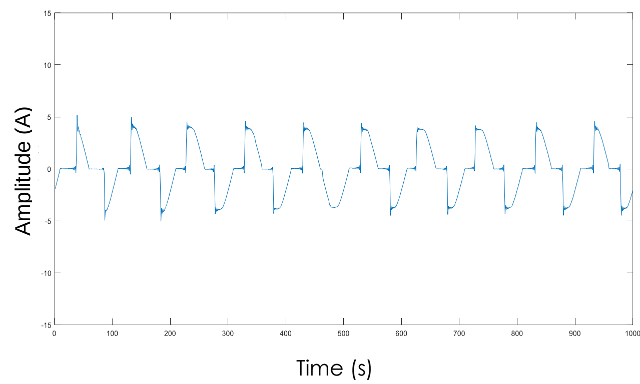


(b)

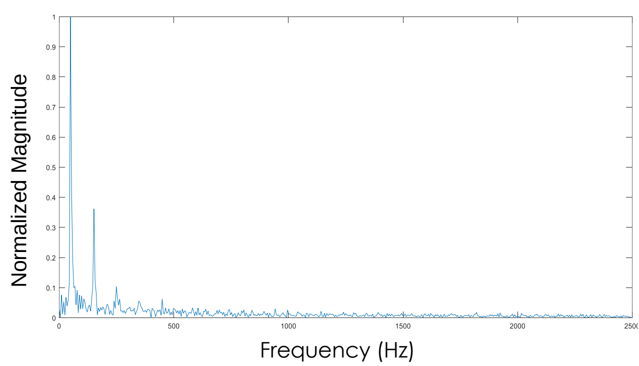
Figure 9 (a) Graph of Current Signals in Switching Condition THDi 2.9%, (b) Graph of Current Signals Domain Frequency in Switching Condition THDi 2.9%

H. Current Signal Characteristic of Arcing Condition

The graphic image in Figure 10 is the result of the signal output after an arc occurs in the system



(a)



(b)

Figure 10 (a) Graph of Current Signals in Switching Condition THDi 2.9%, (b) Graph of Current Signals Domain Frequency in Switching Condition THDi 2.9%

Normalized Magnitude

I. Analysis of Threshold Value Determination for ARC Detection

This subsection explains how to determine the threshold value on the frequency domain graph. The threshold is a value that distinguishes arc conditions from other conditions and will be used in arc detection programs as a reference value. The threshold value can be determined by combining all three conditions that have been normalized. From the graph in Figure 11, you will see the graph's location of the arc's condition, switching, and routine. Here is a sample of data 5.

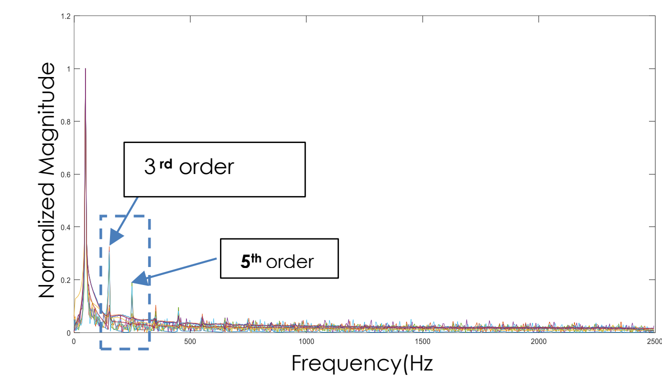


Figure 11 Merging of Data Frequency Domain Signal Graphs 5

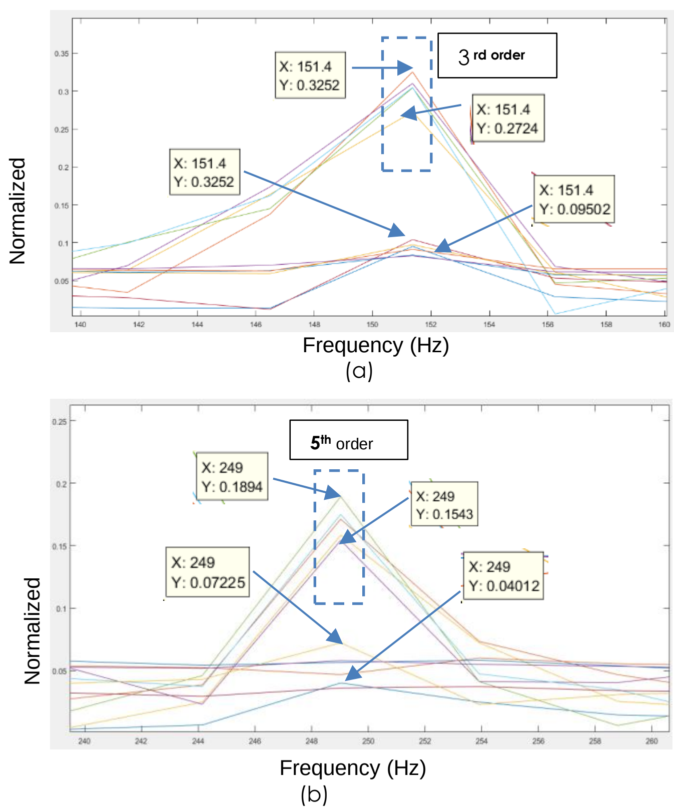


Figure 12 (a) 3 rd order chart. (b) 5 th order charts

In Figure 12, the chart displayed are the charts on order three and order five. Each graph contains a graph of all three conditions. Each condition has five experimental charts. The diagram that has the highest peak value is the arc graph character. At the same time, the chart below is the switching chart character and the standard chart. After research, the arc graph always has the highest peak value in Table 4 compared to other conditions. At the same time, the second chart below it is always a switching chart. In determining the threshold value, the threshold value must be above the peak value of the highest switching graph and below the lowest peak value of the arc of fire. This is because the value above the peak of the switching graph states the area of occurrence of the arc of fire.

Table 4 Peak Values of 3rd Order and 5th Order from Data 5

Data	Normal		Highest Switching		Lowest Arching		Highest Arching	
	3rd ORDE	5th ORDE	3rd ORDE	5th ORDE	3rd ORDE	5th ORDE	3rd ORDE	5th ORDE
DATA5	0,09502	0,04012	0,1039	0,07225	0,2724	0,1543	0,3252	0,1894

The 5 data is a sample of how to retrieve the values per order of each data. Each data will be taken its value of order three and order 5. The highest arc peak point value will be used to determine the severity later. This method of collecting number data is carried out from data 1 to data 11. In Table 5 are the results of the values obtained from 11 data.

Table 5 Peak Values of 3rd Order and 5th Order from data all Data

Data	Normal		Highest Switching		Lowest Arching		Highest Arching	
	3rd ORDE	5th ORDE	3rd ORDE	5th ORDE	3rd ORDE	5th ORDE	3rd ORDE	5th ORDE
DATA1	0,03941	0,02123	0,09844	0,04458	0,1481	0,05105	0,3616	0,156
DATA2	0,04447	0,02427	0,0909	0,0557	0,1379	0,058	0,2925	0,1277
DATA3	0,06049	0,0223	0,0913	0,05163	0,2798	0,1032	0,377	0,167
DATA4	0,07766	0,02992	0,1128	0,06999	0,2431	0,1163	0,3605	0,1647
DATA5	0,09502	0,04012	0,1039	0,07225	0,2724	0,1543	0,3252	0,1894
DATA6	0,09642	0,05036	0,1438	0,0689	0,3031	0,1796	0,3652	0,2116
DATA7	0,1192	0,05474	0,1479	0,08789	0,3117	0,1904	0,4123	0,2168
DATA8	0,1206	0,07026	0,09659	0,1148	0,3364	0,1857	0,4005	0,2243
DATA9	0,1376	0,07543	0,1297	0,09745	0,3393	0,1731	0,376	0,2344
DATA10	0,14	0,09017	0,1367	0,1204	0,3031	0,2023	0,3895	0,2571
DATA11	0,7737	0,5957	0,8653	0,8204	0,6831	0,5587	0,7819	0,6791

From the results of retrieving all the data, it can be concluded that the 11th data with a maximum THDi or the entire LED load has a very high peak point compared to the ten data. Therefore, to determine the threshold value, you cannot use data 11. The threshold value is selected from data 1 to data 10 only. To determine the threshold value from ten data by determining the highest switching peak point value in each order and the lowest arc peak point value with the condition that it remains above the highest peak value of switching. For the peak point value, the average chart is ignored because the peak point value is at the bottom. The threshold value will be obtained in the area between the highest switching peak point value and the lowest arc peak point value. Here are the results.

Table 6 Highest Switching Value and Lowest Arcing Value in 3rd Order and 5th Order

The Highest Switching		The Lowest Arc	
3rd Order	**5th Order**	**3rd Order**	**5th Order**
0.1479	0.1204	0.1481	0.1543

From the Table 6 above, the threshold value of each order can be determined. On order 3 (140Hz-160Hz), it can be concluded that the threshold value is between 0.1479 - 0.1481. On the fifth order (240Hz-260Hz), it can be supposed that the threshold value is between 0.1204-0.1543. Researchers have determined the threshold value on the 3rd order with a value of 0.1480 and on the 5th order with a value of 0.123. With this value, it will be able to distinguish the condition of the arc of fire from other diseases.

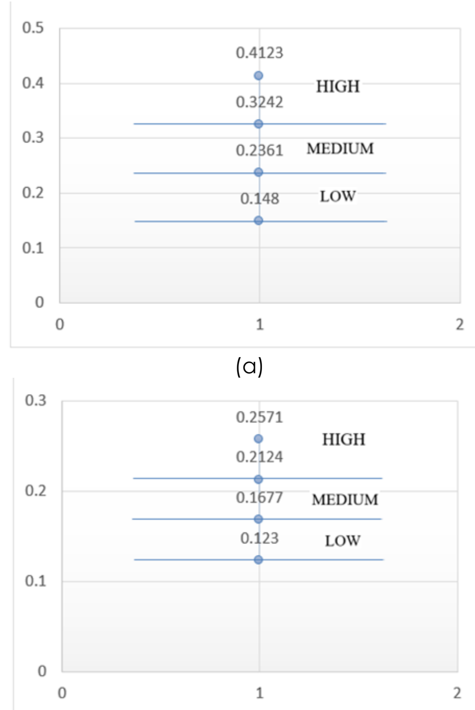
J. Determining The Severity of the Arc Fire

The severity of the occurrence of arcs of fire is divided into three levels: low arcs, medium flame arcs, and high flame arcs. To determine the severity value, that is, between the predetermined threshold value and the highest fire arc peak point value of each order. Among these values are divided into three regions.

Table 7 Threshold Value and Highest Arc Peak Value

Value	3rd Order	5thOrde
Threshold	0,148	0,123
The Highest arc	0,4123	0,2571

Table 7 displays the third and fifth-order threshold and highest arc values. On order 3, the severity can be determined from the value 0.148-0.4123. Among these values will be divided into three regions. The first area is the low arc with a 0.148-0.2361. The second region is the medium arc of fire with a value of 0.2361-0.3242, and the third area is the arc of high flames with a value of 0.3242 and above. On order 5, the severity can be determined from the value 0.123-0.2571. Among these values will be divided into three regions. The first area is the low arc, with a 0.123-0.1677. The second region is the medium arc of fire, with a value of 0.1677-0.2124, and the third area is the arc of high flames, with a value of 0.2124 and above. Here is a picture of the graph in Figure 13.



(b)

Figure 13 (a) 3rd order severity, (b) 5th order severity

K. Accuracy Trial of Arc Detection Tool Program

In this subsection will be displayed the results of experiments or tests of the arc detection program that has been created. For 3rd order, the arc threshold of fire is used at 0.148. For 5th order, the arc threshold of fire is used at 0.123. In this detection tool has been programmed, if there is a peak point past the threshold value, it will be displayed in the 16x2 LCD that there is a low, medium, or high arc. Furthermore, if only one of the orders detects an arc of fire, then the LCD will still display that an angle of fire occurred. Table 8 is the values used for testing the arc detection program that has been designed on the Arc Detection Tool.

Table 1 Result of the Arc Detector Tool

Condition	Data	Number of trials	Success
Normal	1	5	100%
	2	5	100%
	3	5	100%
	4	5	100%
	5	5	100%
	6	5	100%
	7	5	100%
	8	5	100%
	9	5	100%
	10	5	100%

Condition	Data	Number of trials	Success
Switching	1	5	40%
	2	5	60%
	3	5	40%
	4	5	40%
	5	5	60%
	6	5	40%
	7	5	40%
	8	5	60%
	9	5	60%
	10	5	40%

Condition	Data	Number of trials	Success
Arching	1	5	100%
	2	5	100%
	3	5	100%
	4	5	100%
	5	5	100%
	6	5	100%
	7	5	100%
	8	5	100%
	9	5	100%
	10	5	100%

4.0 CONCLUSION

Data collection experiments were carried out several times to show results following several conditions in the field. The graphs during normal, switching, and arc conditions have different graph shape characteristics. Changes in THDi values affect the 3rd order and 5th order peak values in the frequency domain signal for all conditions. The 3rd and the 5th order as reference points in tool detection. The electrode distance when simulating the arc simulator, determines the severity. The wider the electrode distance, the more severe. The arc severity condition will be distinguished by the detection program into three parts, namely Low arc, Medium arc, and High arc. From the research results,The FFT method cannot work efficiently or optimally at very high THDi and The FFT method cannot work efficiently or optimally to distinguish arc conditions from switching conditions. Arc detection devices using the FFT method can work optimally if used without switching, namely the device is turned on after switching, for example using a 24-hour load. In the test results of the investigation, testing under normal conditions, the detection tool has a success rate of 100%. This means that the detector does not detect the presence of arcing. Testing during arcing conditions, the sensor can see it correctly with a 100% success rate, which means the detection device can detect an arc of fire well. However, when testing under switching conditions, the detector has a success rate of 40% -60%, meaning that when switching, the sensor can detect the presence of arcing, and some do not. With a lot of data retrieval, it can be concluded whether the arc detection tool can function correctly. The limitation of this study was the type of electrode used in road-shaped experiments, and the researchers only focused on low voltages. To complete and perfect further research, other types of electrodes can be added and can be with different voltage levels.

Nomenclature

CT	= current transformator
FFT	= fast fourier transform
(THD	= total harmonic distortion
(kWh)	= kilo watt hour
LCD	= liquid crystal display
NFPA	= national fire protection association
MCB	= mini circuit breaker
LED	= light emitting diode
AC	= alternating current

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Conflicts of Interest

The author(s) declare(s) that there is no conflict of interest regarding the publication of this paper.

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