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# Prevent Excessive Electrical Discharge between Conductors by Detecting High-Speed Arcing Fault Using a Spectrum of Light

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**ABSTRACT:** In power systems, unlike short circuit errors, during the events, arcing bugs produce intense light. In the past, light sensing technology has been developed as part of the detection of errors. Currently, two types of light sensors are point sensors and optical fiber. For arc flash relays, at the same time, with the over-current protocol, are used. Due to the characteristics of light sensors, the reliability and sensitivity of the relay can be affected by ambient light. In this paper, using the spectrum of light, for arc flash error detection, proposes a new approach. Electromagnetic radiation is, different atoms, when their atoms are excited, with unique wavelengths, releasing the spectrum. So in the exciting times, if a particular emission spectrum is detected, the components can be identified. Generally aluminum or copper is used for conductors. By examining the spectrum of light, arc flash can be detected quickly and accurately. In this study experiment, the conductors of aluminum and copper are used. For two items, light spectroscopy is measured by a vision spectrometer, and is recorded. By applying the proposed method, light based, arc flash is the results show that the reliability and accuracy of the fault detection process can be improved.

## I. INTRODUCTION

Other than heat energy, during arc flash events, sounds, high levels of radioactive energy are released with pressure and light [1]. This can cause serious damage to enclosed power system equipment, and to operators. More and more studies have come up with several ways to solve this problem [2-5]. Due to arc flash error, since the released probability energy is proportional to the wrong timescale, reducing decision time becomes an important part of arc flash protection design [6]. Due to the high speed of light perception, to reduce tripping time, light sensor arc used in flash relay. For arc flash protection, light sensing technology has been developed from the past [7]. In the first and second generations, the light sensing arc flash relay system used has been implemented in the past [1]. With the development of light sensing technology, the light sensitive arc flash relay was often used at power systems and different voltage levels [6-7]. Presently, point sensors and optical fiber in arch flash protection systems, the most common and integrated light sensors. During an arc flash error, to detect extreme light, point sensors and optical fiber are used [7].

Although the speed of Arc Flash Detection (AFD) is greatly improved, if ambient light is polluted, the accuracy and reliability of the existing light sensor mechanism may be affected. In AFEP (Arc Flash Error Protection) system, existing light sensing technology, a lot of studies show that it can be broken by other light sources [7-9]. In the meantime, for light directions, light point sensors are very sensitive. Due to the difficulty of the arc flash error, in AFEP system, for point sensors, finding an effective location can be very difficult. To improve the accuracy and reliability of the tripping process, and to detect the arc flash error, instead of light intensity, this paper enables the use of light spectrometers.

The study of electromagnetic radiation has been developed over the years. It is also widely used in various applications, the meaning of an electromagnetic radiation, different elements, when their atoms are excited, with a unique wavelength, releasing the spectrum. So, in exciting times, if its emission spectrum is detected, the element can be identified. For each element, since there is a unique energy level, different elements, with identical wavelengths, emitting different spectra. So, by identifying the emission wave spectrum, by other light sources, can be detected without damaging the arc flash. In this study, the identical spectra of the arc flash were obtained by different experiments; furthermore, the arc flash is based on a similar spectrum; the arcing error detection algorithm is generated.

## II. ARC FLASH SPECTRUM MEASUREMENT (AFSM)

### A. Arc Flash Test (AFT)

In this paper, with different types of conductors, arc flash tests have been developed. With different types of conductors, during the arc flash event, to measure the spectrum, as shown in figure one, spectrum measurement station for arc flash is shown. At this station, a (1:125) phase transformer, and a (0V - 140V) variable transformer are implemented to generate arc flashes for spectrum measurements. This study uses a spectrometer Coaxial Optical Fiber Sensor (COFS). Figure two shows this and it shows wide detection angles and increased accuracy.



Fig.1: AFSM Station



Fig.2: COFS

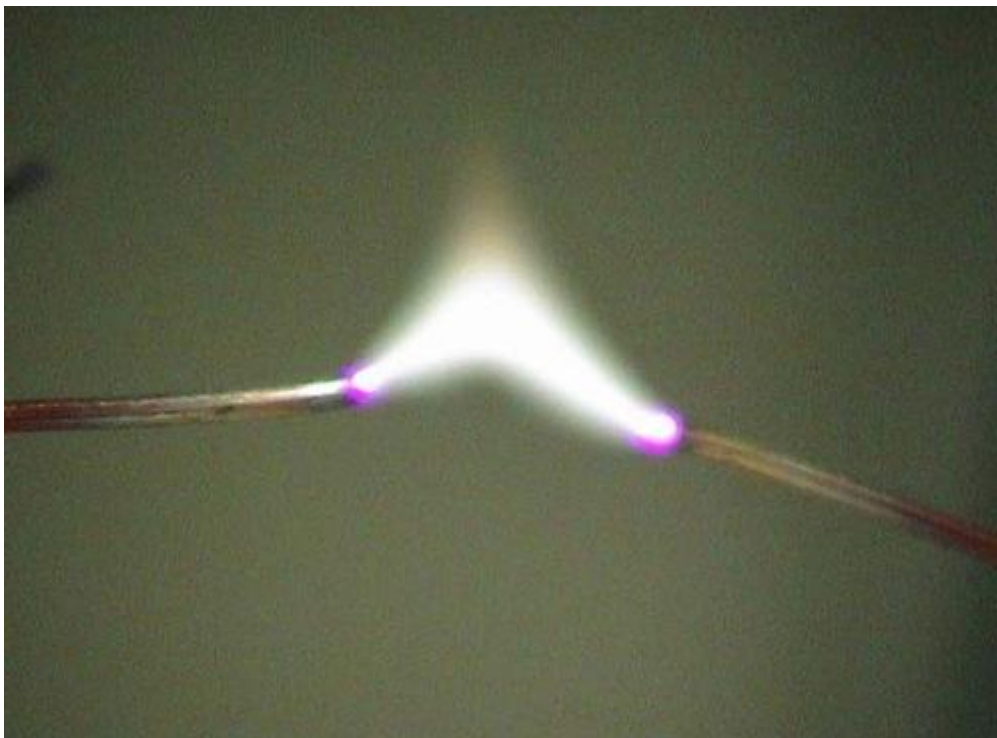
**B. Spectrum Measurement**

During the flash event, to identify the nature of the spectrum, as shown in table one, the light spectrum is estimated with different conductors.

**TABLE 1: Arc Flash Experiment**

Experiment	Conductor Type	Voltage
1	40 AWG SCAW	12500 V
2	40 AWG SAW	12500 V
3	40 AWG SCW	12500 V
4	12 AWG SCW	8750 V

*Experiment 1:* In this test, 12 AWG Solid Copper Wires (SCW) are used as arcing conductors. In this experiment, due to the limited energy of the arc flash and the thickness of the copper conductors, without the conductors, the arc flash happened. The flash arc of the test is shown in Figure 3. The spectra line is shown in Fig. 4, for lighting in a test.



**Fig.3: Arc Flash**

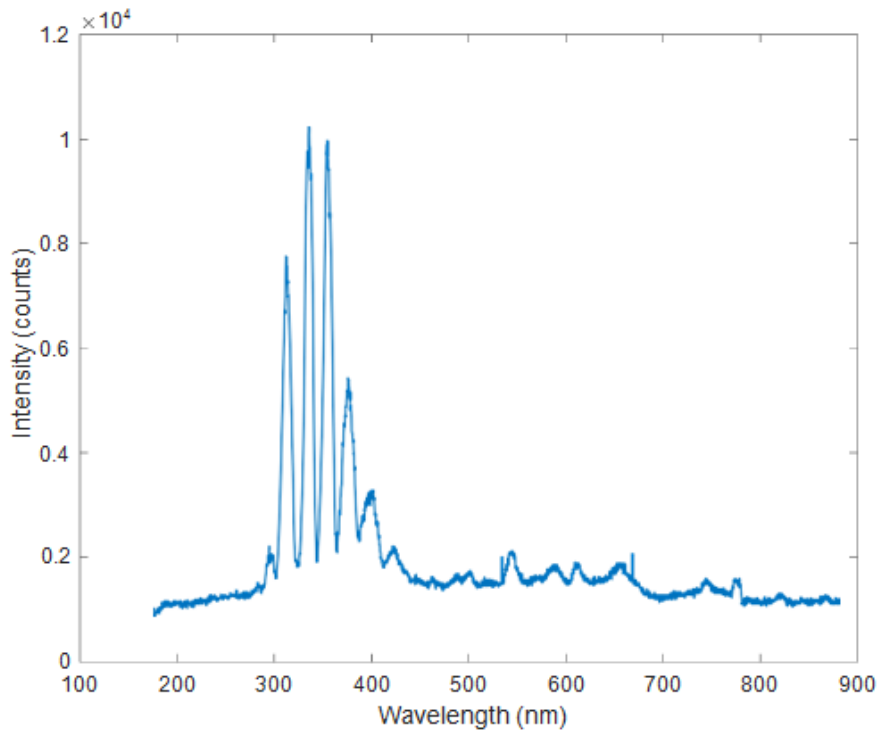


Fig.4: Experiment-1 Spectra Line

**Experiment 2:**

Here, the SCW 40 AWG is utilized as arcing conductors. Copper conductors burn with arc flash. In test two, figure 5 shows spectra line of arc flash.

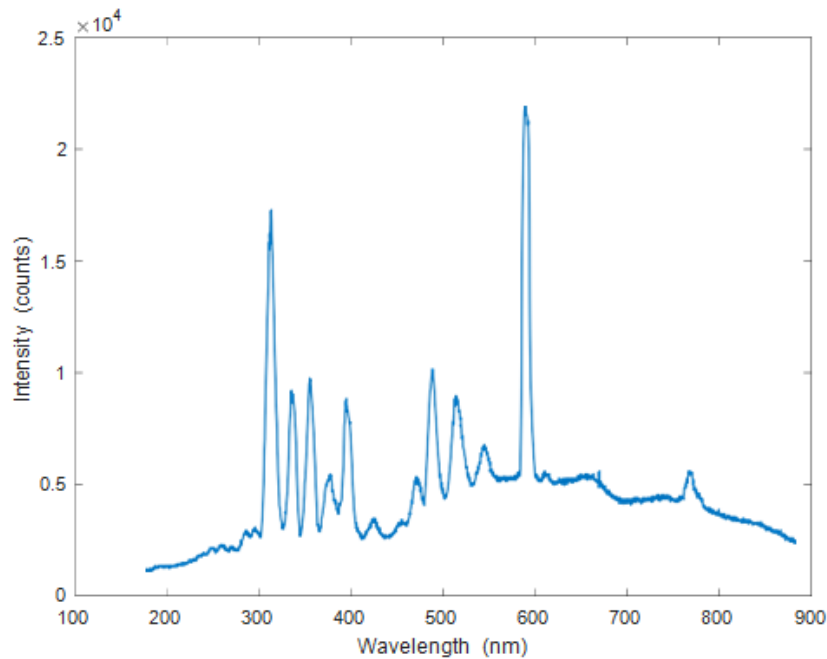


Fig.5: Experiment-2 Spectra Line

**Experiment 3:**

40 AWG Solid Aluminum Wire (SAW) is used as arcing conductors. Aluminum conductors are blazed along with the arc flash.

Arc flash spectra line in experiment-3 is shown in figure 6.

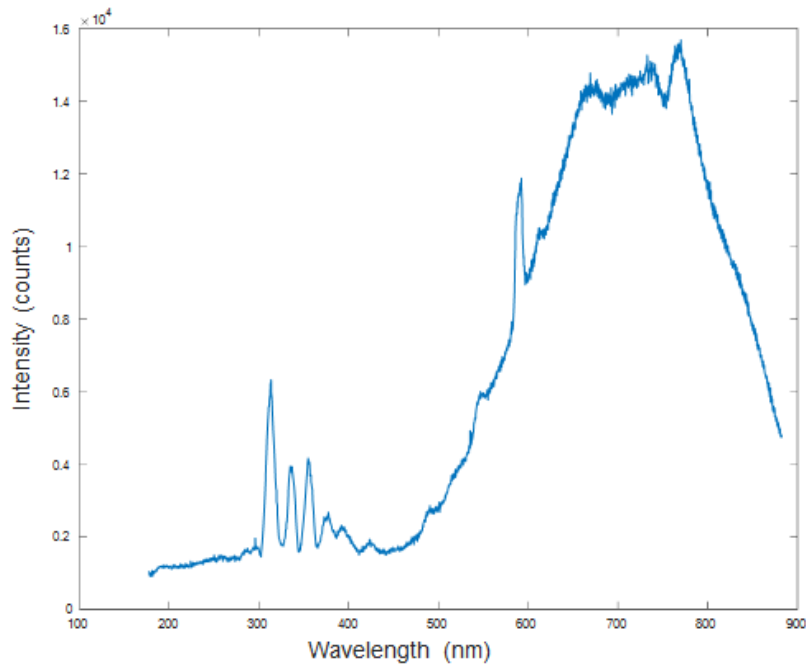


Fig.6: Experiment-3 Spectra Line

**Experiment 4:**

40 AWG Solid Copper and Aluminum Wire (SCAW) are used as arcing conductors. Both conductors are burned with the arc flash. Spectra line in experiment-4 is shown in Fig. 7.

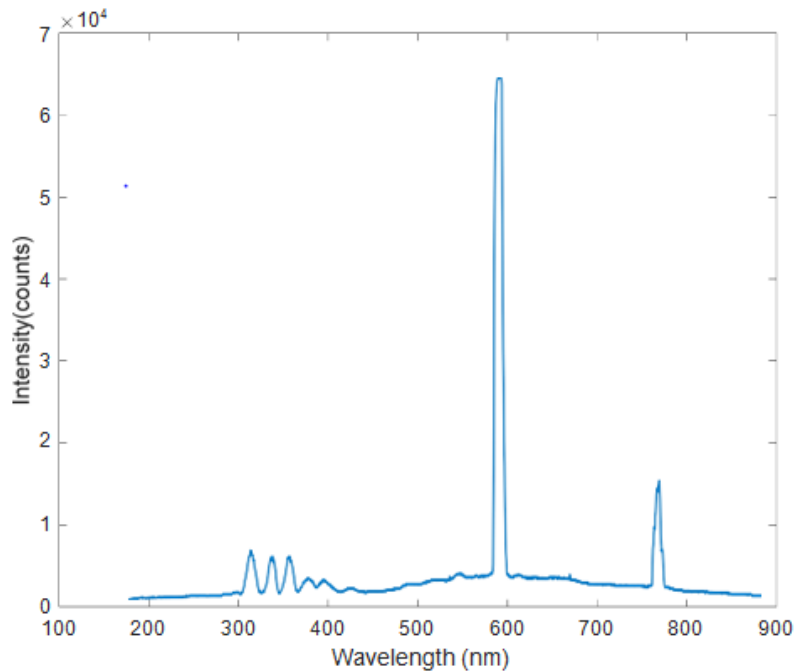
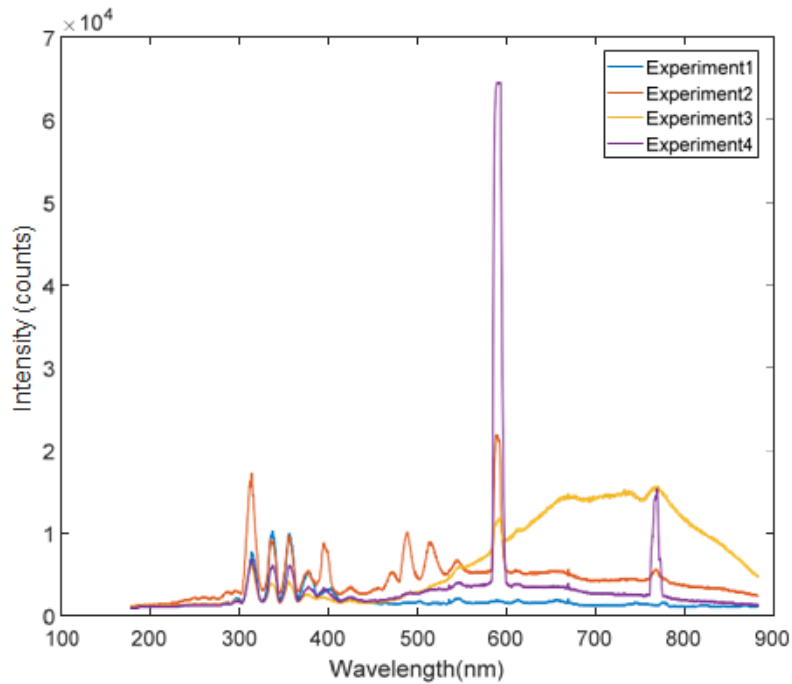


Fig.7: Experiment-4 Spectra Line

In figure eight, for different light wavelengths, displays the light spectrum. To show the unique spectrum of arc flash, figure nine shows the spectra line for all experiments. As shown in, each time, when the arc flash occurs,



peaks range from three hundred wavelengths to four hundred wavelengths. According to past research, most airborne emission spectra are from ionized nitrogen. From other light sources, to distinguish the spectra line of arc flash, under different circumstances, the spectra of daylight, fluorescent and LED were measured. They are, respectively; figure eleven to figure thirteen are showed. In figure thirteen, the direct daylight spectrometer directly faces the sunlight. Indirect daylight face different directions, were measured under the shadow area. Each of them, on a clear day, has been measured simultaneously.

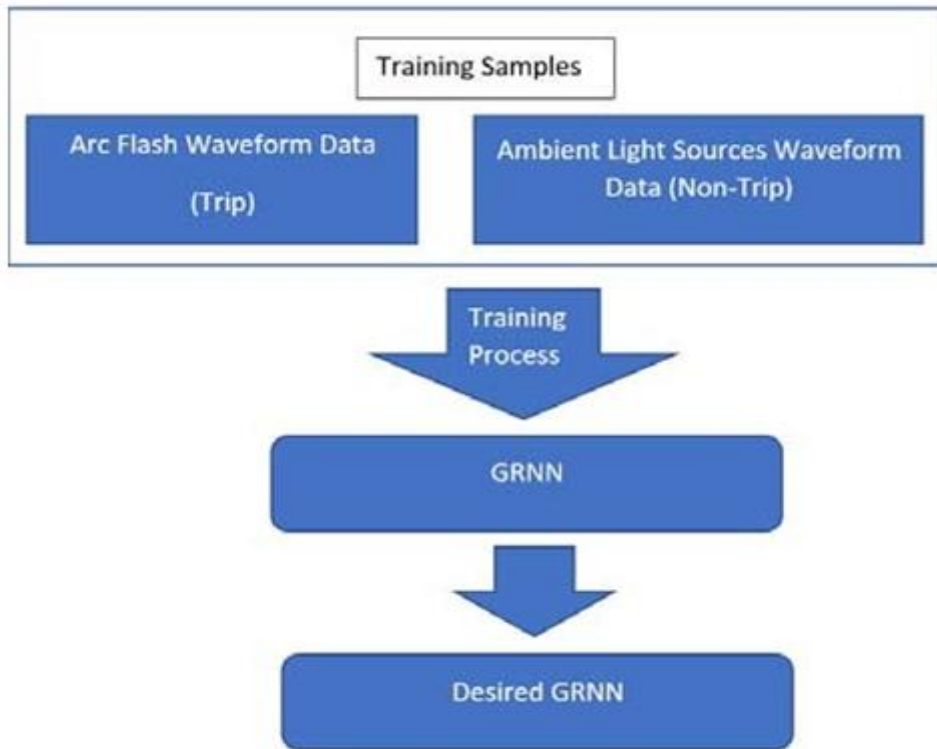


**Fig.8: All Experiments Spectra Line**

From spectra line of different sources, as it is shown, aluminum and copper emit distinct spectral lines. However, the conductors are irrespective of the material. During arc flash events, from ionized nitrogen, unique UV method detects. Therefore, in the unique UV signature detection process is considered the impulse signal.

**AFD Algorithm**

From stimulating light, to get enough spectral equipment, with 0.1nm resolutions and 200nm to 1100 nm limitations, a standard silicon CCD array sensor is used in this study. So this proposed method is the arc flash shows the ability to reduce the energy of the action, thus reducing the risks. Due to the wide detection range, the CCD sensor has an excellent response to ultraviolet spectrum. This greatly benefits the proposed application.



**Fig.9: Training Process of GRNN**

With the spectra data, to provide a positive arc flash fault diagnosis, in this paper, with the GRNN (General Regression Neural Network), a fault detection algorithm has been developed. Using training datasets, for prediction and classification, GRNN has been created. GRNN with less training models, since it can be configured, for measurement system applications, GRNN is very practical. During arc flash events, to specify the identity of the spectra, the derivative of the spectra line is computed in equation 1.



**Fig.26: Detection Process of GRNN**

$$I_D = \frac{d(B)}{d(A)} \quad (1)$$

Where,

B = Intensity of Spectra (Counts).

A = Spectrum Wavelength (nm).



$I_D$  = Derivative of intensity.

After using the Savitzky-Golay digital filter, by applying GRNN, the characteristics of light are not affected by the most common ambient light sources; so it is very easy to identify. Further, this effectively reduces the possibility of misdiagnosis. Because of this, spectrum-based AFD system is to improve the reliability, accuracy and speed of the detection process, an arc flash protection is created as application.

### III. CONCLUSION

In this paper, light spectrum based, AFD method is proposed. By using the optic spectrometer, under different circumstances, the spectrum of arc flash faults is measured and analyzed. With the most common ambient light sources, by comparing, between 300nm and 400nm, for flash detection operations in ionized nitrogen spectra, are regarded as potential spectrum signals. By GRNN and Savitzky-Golay FIR smoothing filter, to provide detection signals, arc flash light spectrum line can be implemented. From system simulation, based on the proposed spectrum, with improved accuracy, speed and reliability, AFD method shows a very great ability.

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