Literature Review: High Impedance Fault in Power System and Detection Techniques

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Abstract
Modern power system engineers' primary objective is to modernise the power system by making it more sustainable, intelligent, and reliable. As static, dynamic, and gradually increasing non-linear demands based on electronic devices are integrated, the behaviour of the power system network is changing. The flaws have been successfully detected and protected against over time using traditional protection systems. However, in some of these situations, the protection system is unable to identify the fault because these faults are caused when an energised conductor makes contact with a high impedance object and draws a small amount of current randomly. High Impedance Fault is the common term used to describe this fault type (HIF). Utility companies constantly struggle to find these issues in the distribution system quickly and consistently because of their behaviour.Predominantly the impedance faults can be classified as Low impedance faults (LIF) and High impedance faults (HIF). The LIF can be detected and protected by a conventional protective device. However, if High impedance fault occurs in the system, it is difficult to detect because of the low magnitude current. The overcurrent relay, which smartly detects the Low impedance faults, fails to detect the High impedance faults.

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1. INTRODUCTION:

In the distribution of electric energy, reliability and service without a break in the power source have been hallmarks of the operations of the Electric Power Distribution System (EPDS). Over-voltages or over-currents are two different ways that defects in the electrical grid are putting stress on it [1-3]. An abrupt increase in the EPDS voltage causes the over-voltage. To guard against these overvoltages, suppressing devices are utilised in the electrical networks. However, an increase in current caused by defects is known as an over-current. The defects have been detected and protected against over the years with success using traditional over-current security mechanism [4-7]. Additionally, the EPDS is more prone to malfunctions. These malfunctions can be brought on by lightning, wildfires, animals contacting live wires, or human activity. In most cases, failing to isolate the faulty section from the healthy section leads to equipment failure, explosion, cascade outages, and the risk fatalities as well as property. Most of the time, faults (such as Low Impedance or Bolted faults) are easily found and separated. Due to their randomization, small magnitude, and non-linear current behaviour, some of these flaws, however, cannot be found by conventional protection systems. These errors are categorised as typical power system functioning since they both signal a problem nor impede the electricity supply [8,9].

2. LITERATURE REVIEW:

The research in HIF detection studies has grown Since the beginning of the 1970s. The study of HIF properties received the majority of attention in research. At voltages of 15 kV and below, HIFs naturally occur. HIF detection is more difficult at lower voltages due to the intricacy involved. HIFs can occur at higher voltages as well, but the problem is significantly less at 15 kV. (Aucoin & Jones 1996). Sedighizadeh et al. and Ghaderi et al.have both provided in-depth reviews of the HIF detection approach. Any HIF detection method's major goal is to identify the most effective analytical domain. The concealed HIF traits are made visible by this analysis domain. The analysis domain modifies the obtained current signal to make it more informative [10,11]. It is essential to research the areas of analysis that can exhibit HIF's nonlinearity, non-stationarity, etc. The two basic divisions of the analysis domain used for HIF detection are the frequency domain, time-frequency domain. These two domains are mostly highlighted and discussed in this section. But this section also discussed a few different types of analysis that are used to identify HIFs [12].

2.1 HIGH IMPEDANCE FAULT:

In power system, reliability and security is most important criteria. During undetected HIF, public risk increase, energy loss in the system and fire hazard. Inorder to reduce risk, several researcher involving in analysis and study of HIF detection in the power system, it involves the identification different techniques, classification, characteristics and exactly place for location of HIF model [13,14,45].

B. Michael Aucoin *et al* [15]The problems of implementing the detection of distribution high impedance faults are outlined in this work. High impedance fault detection technology, which is capable of reliably and securely detecting a significant portion of previously unnoticed defects, has been developed and commercialised as a result of research efforts. Although this advancement is a significant achievement, utilities need to be aware of and comprehend the challenging operational and application difficulties this technology raises. Utilities can gain from enhanced high impedance fault detection with a well-planned programme for testing and implementing this technology without suffering negative service reliability implications.

Amin Ghaderi *et al*[16] With an emphasis on its detection methods, this work conducts a thorough literature review on high impedance faults, including topics such as HIF physics, modelling, and placement methodologies. Additionally, three steps are used to characterize each of the HIF detection strategies. The effectiveness of the available HIF detection methods is also evaluated using a wide range of parameters. Finally, a potential path for the HIF field's future is suggested.

Craig G. Weste*et al* [17] The invention of the microprocessor has enabled technology to identify a significant portion of high impedance defects that were previously undiscovered. Many of the HIF detectors have been shown to be safe and dependable in field tests. Utility companies need to decide whether they want to use HIF detectors in a proactive or reactive manner now that affordable, dependable equipment is available.

Mike Aucoin*et al*[18] The problems in identifying and resolving high impedance faults on distribution feeders are discussed in this work. High impedance faults are those whose current is insufficient for conventional protection system to reliably remove them. These flaws frequently manifest as fallen conductor flaws and present a risk to the general population. Reviewing the current state of this field's research and considering areas for improvement. High impedance fault detection's numerous intricate technical, legal, practical, and operational issues are covered. Although there is now no comprehensive answer to the high impedance fault issue, utilities must take action to deal with it.

2.2 FREQUENCY DOMAIN:

Due to the presence of an arc, HIF current is always composed of both low- and high-frequency components. In order to detect HIF, the detection approach therefore employs both low- and high-frequency analysis in the frequency domain.

A.R. Sedighi*et al* [19] real value of HIF current is compared with simulation by applying Bonferroni confidence interval with EMTP as well as switching devices are applied for creating random HIF current. This paper, the five new model of Emmanuel method is used for identified the non-linearity, FFT analysis with newly proposed method. Various models are applied for test the real value of HIF current satisfied with simulation result of HIF current. High impedance fault tested real data is collected from 20KV radial feeder in Iran, Qeshm with 19.5KM feeder length and assume 8.5KM HIF location from the source end. In this model, they utilize seven types of conduction medium at two different locations, for field fault studies. They got 42 sets of data by conducted three tests on each conductive medium for HIF current at each location. For simulation, they tested with one data on each medium is applied.

Kavaskar sekar*et al* [20]applied wavelet transforms to withdrawn the signals significant features by suppress the signal from current and minimize the signal features by data mining decision-based model to classified the HIF and Non-HIF studies. In this case studies analysis with HIF events like switching of load at linear and nonlinear, switching of capacitance, inrushing current of transformer while energizing has been applied on distribution system and actual value of this system is tested with simulation using MATLAB SIMULINK. In this method investigation of HIF on 936 total cases is simulated with HIF- 540 and non-HIF – 396. At feeder 6, the current signal is taken out and suppress their signal by Wavelet method, obtain the related features from the signal. These factors are applied at DT model fir classified the HIF and non-HIF load switching with good features. Dependability, accuracy and security parameters are investigation in the method.

Ying-Yi-Hong*et al* [21]eighteen-bus system at distribution is used for HIF evaluation in power system. The D-Wavelet transform is applied to HIF located measured features from current signal. Genetic algorithm combined with modified-K-means algorithm is applied for measurement studies. In simulation, seventeen-line feeders of radial system in eighteen busbar datas are provided, the real load level 10% is trained by SVM at various angles from 0 to 359 at four conditions, the HIF occurrence is measurement. The assumption points are addressed in this paper – HIF at single location with increase the measurement parameter facilities. Matlab Simulink is used for single line HIF occurrence. Thus, Inorder to detecting the HIF in feeder line, locating the section in distribution system. The method SVM is identified the appropriate section line (HIF)

M. Sedighizadeh*et al* [22]in this method, the important factor based on the magnitude of fault current will not lead to success to find HIF and approaches are led to characteristics of fault current. By using modelling method to simulate HIF it will analyze the behaviour of faults and creating a spark gap model. In HIF characteristics HIF frequency spectrum is equal to capacitor switching method and also in distribution systems. Current waveforms of HIF is low and high ordered harmonics, sub harmonics, it can be used to detect these faults third and fifth harmonics feeder currents results a static. Using HIF features extractors as Kalman filtering, wavelet transform etc., approaches of second and third laws of induction it will provide HIF detection. Detection has successfully completed using different algorithm as expert arc detector, energy algorithm etc.,

Lee *et al*[23] arc non-linearity led to lower ordered harmonics, as noted in this paper. The fundamental and third harmonic phasors were measured using a synchronized phasor measuringunitsat both side of the power distribution lines. These phasors were employed to ascertain the magnitude of the arc voltage and the location of the defect. The distance relay was then activated to protect HIF based on the issue's location.

Soheili *et al* [24]in order to account for Non-Linear Loads (NLLs), suggested a modified Fast Fourier Transform (FFT) approach. The technique exploited the comparative correlation between the odd harmonic currents and more realistic power system circumstances for efficient HIF detection (3rd - 7th). The approach showed promise in terms of enhanced fault detection skills for both computers simulated data and data from actual systems.

Samantaray*et al* [25]to determine the magnitude and phase of odd harmonic content in HIF current, suggested an enhanced Kalman filter approach. To create a classifier, a decision tree was trained. The author observed that a single decision tree performs worse during training and testing. Compared to ensemble decision trees (Random Forest). As a result, an ensemble decision tree and extended Kalman filter were suggested for effective HIF detection. The detection strategy yielded dependability rates of 96.27 percent for the data set with 20 dB of noise and 97.67 percent for the data set with no noise, respectively.

Frequency domain analysis can expose the hidden properties of the HIF, but their performance is limited by their inability to recognise frequency components. This is due to the fact that some disturbances, such switching and transformer energization, result in frequency domain properties that are similar to the HIF's.

2.3 Wavelet Transform (WT)

The frequency component and the time interval at which it occurs are both provided by the Wavelet Transform (WT), which is another term for the time-scale domain. This potential makes the WT a key instrument for time-varying data analysis.

Michalik *et al* [26]In order to identify faults, used the high frequency Continuous Wavelet Transform (CWT) coefficient analysis of the zero-sequence voltage and current's phase displacement characteristics. This method was successfully evaluated on a 15 kV real EPDS. The model of this particular EPDS was verified using the EMTP and the Alternative Transient Program (ATP).The technique worked well for detecting HIF and demonstrated its resilience to transient disturbances brought on the distribution systems.

Lai *et al* [27] the current and voltage signals were derived from an EPDS is simulated. These signals were split out into several signals with various frequencies using the Discrete Wavelet Transform (DWT). The pattern classifier known as the closest neighbour approach was fed the current and voltage signals with a variety of frequency ranges to assess whether they were HIF or not. This strategy might have been applied to online instruction. The author posited that by customising HIF data, this technique might function as a decision support software package for HIF detection that might be used in an alert system.

Ibrahim *et al*[28] developed a detection method for extra high voltage transmission lines using coupling capacitance voltage transformer measurements of the voltage signal. Using a recursive algorithm, the approach created high frequency wavelet coefficients and summed their absolute values over the course of one cycle. When increased value exceeds a predetermined threshold, the condition is recognised as HIF.

Sarlak *et al* [29] in order to distinguish HIF from non-HIF cases, created a pattern recognition method that began with the acquisition of the preliminary information set using wavelet decomposition of three cycles after disturbance, the selection of the most significant feature by PCA, and the feeding of these features to the SVM. By obtaining only current aspects of the signal, the authors used a real-world system to illustrate this strategy, with a detection rate of 98.30%.

Baqui *et al*[30]a method for the precise discrimination of capacitor-switching, load-switching- LIF, and HIF was devised. To more efficiently address the issue of HIF detection in distribution systems, the researchers combined DWT and Neural Network (NN). By breaking down the DWT, it is possible to obtain the integrated content of high and low frequencies. This approach made use of the multilayer perceptron NN structure and Levenberg-Marquardt back-propagation learning algorithm.

Mahari and Sayed [31]a high voltage transmission network HIF detection system was proposed. This technique made use of instrument transformers' voltage and current information. The signal was first decomposed using wavelet transform (WT), the wavelet coefficient was then computed, and the wavelet coefficient was then compared to a threshold value for a specific time period. The event would be labelled as HIF if there was any absolute difference between the predefined threshold and wavelet coefficient. The use of pilot wire protection methods to fault detection was also covered by the authors.

Sergio *et al* [32]a approach based on DWT and an evolving neural network was proposed. The technique identified geographical and temporal patterns in the current signal. Different decomposition levels and wavelet families, including Haar, Symlet, Daubechies, Coiflet, and

Biorthogonal, were explored to provide the optimum discriminative properties for HIF detection.. The suggested method's classifier performance was compared to that of established techniques such multilayer perceptron NN, PNN, and SVM. The overall findings demonstrated that, because Simple Evolving Connectionist System (SECS) created non-stationary signal, it was a pretty appropriate approach for HIF detection when combined with Bior2.8 wavelet.

Time-scale domain analysis is now used in around 40% of HIF detection methods due to the advantages of the methods. Designing a systematic HIF detection approach in the time-scale domain is difficult, nevertheless, because of the mother wavelet selection, limited high frequency support, and low interpretability (loss of feature resolution).

In signal processing, discontinuities, non-stationary patterns, and repetitive patterns of the signal were identified using time-frequency analysis (TFA). The S- and TT-transform combined with a probabilistic neural network was proposed by Samantaray et al. (2008) as a pattern recognition technique to identify and classify HIF (PNN). The effectiveness of this method was demonstrated on a conventional radial and mesh distribution scheme. The HIF identification rate of PNN was demonstrated to be 93.80 percent and 93.05 percent when combined with S-Transform and TT-Transform features, respectively. A cycle for post-fault signal processing and a cycle for PNN training were required for the feature extraction process, and a total processing time of 0.04 s was reported.

Ghaderi *et al* [33] looked into the use of the TFA approach for an actual EPDSthe data acquired from field testing carried out by connecting an electrified line to tree branches, grass, and concrete surfaces in both dry and wet conditions. The effectiveness of this strategy was evaluated using a new set of evaluation criteria (precision, consistency, security, speed, thoroughness, and safety). The technique demonstrated a good detection rate of 100% using a 20 ms input window. However, there were a lot of false positives, which caused unnecessary tripping.

2.4 Mathematical Morphology

The time domain technique is used to extract the HIF signals' temporal irregularity. Mamishev et al. found that the appearance of HIFs caused a certain amount of chaos in the phase currents or voltages in an EPDS. Fractal geometry was used to explore the chaotic characteristics of HIFs. The performance of the temporal network was characterised using the root mean square current value. The approach demonstrated a 4 s detection speed.

Suresh Gautam *et.al*[34]The use of MM to identify high impedance defects in a power distribution system that would otherwise go unnoticed by the overcurrent protection method is outlined in this paper. To create a technique that can be incorporated as a separate module with a digital overcurrent relay, an MM-based tool is suggested, constructed, and tested. Voltage waveforms collected at the substation are used in the detecting process. The suggested technique is made to work concurrently and aid in the detection of an HIF by the current protective system. With a 1 second detection delay, this method is quick. All of the HIF cases that were simulated were recognised by the approach, demonstrating its dependability, even with fault currents that were less than 5% of the full load feeder current. Since there were no erroneous operations for other system disturbances, it also demonstrates security. The method takes advantage of the low computational overhead that all MM-based tools have by default, which is a plus for real-time applications. The technique has been successfully tested on various standardised test feeders with various disturbance types and locations at various onset periods, as well as for various pre-fault loading.Gautham and Brahma*et.al* a technique to find HIFs using mathematical morphology was presented (MM). To increase its accuracy, the technique was used in conjunction with a standard over-current relay. Using Power System Computer Aided Design (PSCAD) to create the signals and MATLAB for implementation, the method was comprehensively tested on two distinct standard IEEE test systems. With a maximum detection delay of 1 s, the MM-based technique delivered a 100% detection rate on both standard systems.

Sarlak & Shahrtash*et.*al[35] a technique using Multi-resolution Morphological Gradient (MMG) oriented feature extraction was suggested. This technique made use of a three-half-cycle post-disturbance current signal. The data for the HIF, harmonic load, and Insulator Leakage Current (ILC) came from field measurements, while the data for other EPDS events came from simulations. NNs with MMG feature vectors (multi-layer perceptron). Additionally, a contrast between MMG features and alternative techniques was conducted (Fourier transform, TT-transform, S-transform, and WT). On a practical EPDS, the approach was successfully shown with a respectable prediction performance of 98.30 percent.

Yun-shik *et al* [36]A method for HIF detection on a low-voltage DC electric grid using MM was described. For DC systems and power transmission equipment, EMTP use the HIF model (AC - DC and DC - DC converters). Three different MM filters' features were compared, and it was found that starting to close certain operators allowed one to see the HIF.

Kavaskar sekar*et al*[37] on the basis of MM, an improved HIF detection methodology was presented. To find HIFs, current waveforms were employed. With a maximum detection delay time of 80 ms, the suggested approach could identify and distinguish HIFs from other transient circumstances and LIFs. Numerous cases of fault location, fault inception time, and pre-fault loading were investigated in order to assess the effectiveness of the suggested strategy. The findings of the suggested method are reliable, secure, and rapid to detect under a variety of transient settings.

2.5 Soft Computing Approaches:

A new HIF detection technique was proposed by Soheili and Sadeh (2017) and is based on the idea of logical thinking. A larger identification area and higher detection rates are produced through the application of different fundamental features. The developed technique could successfully identify and separate switching actions from HIFs. Together, the capacity to conceal features' weaknesses and a sound scheme for HIF detection result. Another benefit of using evidential reasoning is that it takes unpredictability into account.

Aziz *et al* [38]A method for HIF detection in distribution networks using ANFIS was presented. The simulation data was created under a variety of fault scenarios and examined under various system settings. Third harmonics of three-phase currents were demonstrated to be a superior input for HIF identification and localization in terms of their magnitude and phase angle.

N. Narasimhulu*et al* [39] This paper introduces a hybrid technique for identifying and categorising high impedance faults in power distribution systems. In order to improve classification performance, the gravitational search algorithm is hybridised with artificial neural networks. The execution is improved in light of the GSA calculation and the ANN is used to distinguish the blame signal from the reference signal. Whether there is an HIF problem or no defect, the yield of the proposed approach is identified and arranged. The standard procedures of the appropriation framework are first evaluated. The signals are then measured and the shortcomings are connected. At that point, these are given to the increased ANN procedure's contribution, which provides the dataset for dissecting the system exhibits.

Zadeh*et al*[40] In a distribution system using ANN, introduced a novel pattern recognition method for the identification of HIF. By using simulation data under various fault and no-fault scenarios, the ANN was trained and evaluated.A computer model of power distribution systems was used to study the performance of the technology after it had been implemented on a board for a digital signal processor.

Jota & Jota*et al*[41]A technique was presented in an EPDS with an unstable load pattern. The monitoring controller in the feeder was utilised by the author to periodically examine the system setup. A group of synthetic neurons was trained to identify the common patterns. When the training phase was over, the neuron set emerged as the monitoring system's decision-making architect. As a result, the neuron-set constantly inspected the feeders and categorised them according to pre-established standard patterns, producing positive returns.

Mohsen Ghalei Monfared Zanjani*et al* [42] This article suggests a new Phasor Measurement Unit (PMU)-based algorithm for High Impedance Fault (HIF) detection (PMU). Because the fault current is so low, over current protection relays have a tough time detecting this type of failure. This research suggests an index for HIF detection based on phasor change. PMU measures the phasors to produce the square sum of errors. The calculation of errors uses two different sorts of data. Data from samples makes up the first, and data from estimates makes up the second. However, this indicator is insufficient to confirm the existence of an HIF. To differentiate load switching from HIF, a new index is therefore introduced.Since this third harmonic has a unique behaviour during HIF, the second index makes use of this present angle. The verification of the suggested strategy is carried out using several EMTP/MATLAB simulated instances.

Patrick *et al*[43] In order to describe the voltage at the HIF point as a factor of the current, employed a nonlinear system. The equations often used simulate the feeder during an HIF contain uncertain variables, which were calculated using the NN. Since the suggested NN was dynamically trained online, no prior training was necessary, and it did not call for thresholds to be empirically tuned in terms of compatibility with the operational relay. Current and voltage readings from the substation were used in the procedure. A comparison with past publications revealed that the method provided a correct estimate of the HIF distances from the relay site.

3. High Impedance Fault Model

The base model of HIF is modelled by Emmanuel in – 1990 [44]. This model has two diodes in anti-parallel with series resistance R_P and R_N with respect to D_1 and D_2. The voltage V_1 and V_2 represent voltage of arcing in tree or conducting surface.

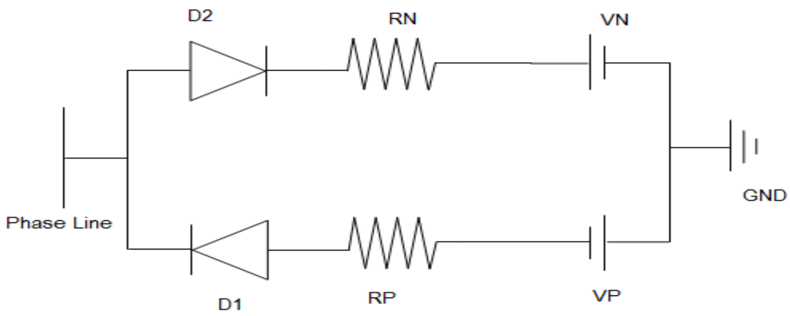

Figure 1: Source with Two Resistor and Diode

HIF model is shown in Fig 1. Diode D_1 and D_2 are connect to DC voltage source V_P and V_N respectively. To sustain the unbalanced voltage magnitude, the V_P and V_N of DC sources is varied randomly in the system. By varying the different value of V_P and V_N, the extinction of arc period is rise up by boosting the randomness in the signal. Asymmetry rises in fault current by randomly change the value of R_P and R_N.

From the simulation result, V_P and V_N represent the arcing voltage of the fault location. This model has fault current from source to ground when V_F is greater than V_P ($V_F > V_P$). when V_F is lesser than V_N ($V_F < V_N$), the fault current gets back flow to the source. When V_P is equal V_N, zero current enter into the circuit. By varying the value of R_P and R_N, V_P and V_N randomly (Table 1), the fault current is analyzed with different charactertics of HIF using MATLAB SIMULINK

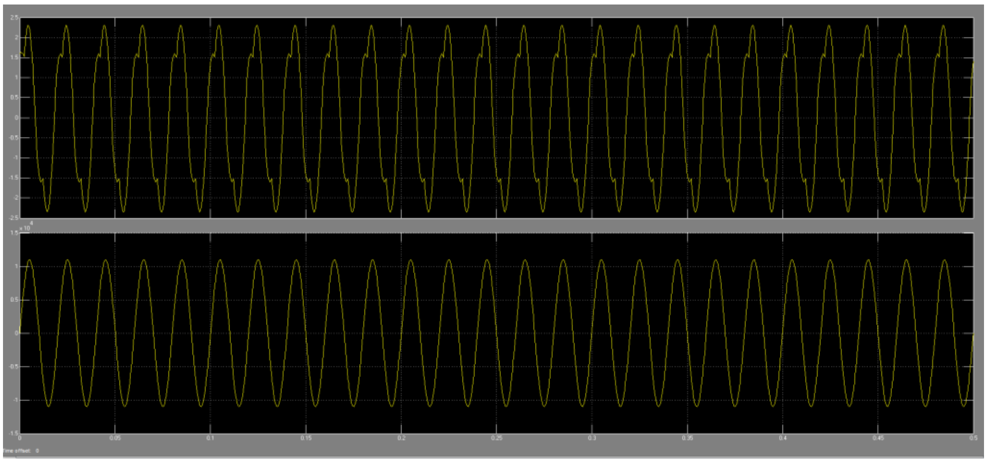

Fig 2 HIF current waveform at fault location

In Fig 2 low magnitude current shows that line conductor tied with high impedance object due to disturbance. The magnitude of positive and negative cycles attains different magnitude 2.5A and 3.5A respectively, result in asymmetrical current signal of HIF. The charactertics of voltage and current in Fig 3 shows non linearity due to arc extinction. The level of intermittence of the arc is also represented across zero crossing. The second and third harmonics rises because of arc extinction and non-linearity arises in the current signal with FFT of 5.45% and 18.96% respectively. During HIF, the voltage and current charactertics at fault location, the voltage remains constant and current alone shows non linearity with current magnitude attains low. Thus, HIF model Fig 1 shows the completed charactertics of HIF behaviour and its properties which in turn selected for proposed system

Table 1: Value of R_P and R_N, V_P and V_N

SI. No	R_P	R_N	V_P	V_N
1	3000	3250	4300	4550
2	3100	3300	4350	4600
3	3200	3350	4450	4675
4	3250	3400	4510	4725

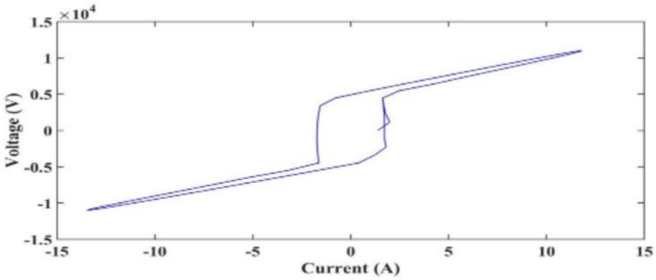

Fig 3 Voltage and Current Characteristics of HIF

4. HIF Characteristics:

The HIF's most prevalent characteristic is that it frequently coexists with an electric arc. The following list of physical and electrical features brought on by the HIF:

4.1 Low current: due to distribution line is linked to a high impedance component, the HIF current seems to be very small in amplitude. Table 2 displays the expected fault current on distinct contacting surfaces (John et al. 1996).

Table 2 current of HIF on different conductive medium:

SI. No	Conductive medium in nature	Current in Ampere
1	Dry sand or Asphalt	<1
2	Dry Grass	25
3	Wet Grass	50
4	Wet Sod	40
5	Wet Sand	15
6	Dry Sod	20
7	Reinforced concrete	75

4.2 Intermittence of the arc: During the fault, there is improper contact between the conductor and the fault surface. Thus, an arc produces a small number of conduction cycles, accompanied by a large number of non-conduction cycles. When the conductor voltage is greater than the air's breakdown voltage, which is maintained between the conductor and a contacting surface, an arc is ignited. On the other hand, the arc extinction happens when the magnitude of the voltage drops below the break-down voltage.

4.3 Asymmetrical current signal: Positive and negative half-cycles have distinct peak value. The break down voltage for positive and negative cycles differs, which is the cause of this.

4.4 Current build-up and shoulder: The current's strength gradually increases until it maintains a constant value for several cycles.

4.5 Randomness: The arc's heat alters the fault resistance, which in turn causes the fault current's amplitude to fluctuate.

4.6 Low- and high-frequency components: Harmonics in the current signal are caused by non-linearity and arcing.

4.7 Non-linearity: Due to the presence of the arc, the voltage and current relationship during HIF is nonlinear.

5. Statement of the problem:

Most of the overhead lines in the distribution system are outside and exposed to the elements. It is more likely that these lines will make direct physically contact with a high-impedance object. A fault known as a high impedance fault thus exists. These failures are considered to be part of normal system operation because they do not indicate any defects or interrupt the power supply. A broken or intact conductor attached to a high-impedance object frequently results in a high impedance problem. The Distribution System suffers energy loss as a result of such flaws. Additionally, coming into contact with a leaning tree that is already in close proximity to a live wire might be fatal.Additionally, when a live conductor is improperly connected to a high impedance object, an arc is created, which ultimately results in fire. High impedance faults are hence the cause of risk to people and their property. Rapid and accurate high impedance fault detection in the distribution system is required to reduce the risk of fire and maintain operational dependability.

6. Conclusion:

Understanding the nature of the HIF and its modelling-based detection techniques has been made easier by the literature already mentioned. But the earlier studies have been unable to find every HIF. In addition, these literature reviews show that very few researchers took into account NLLs. NLLs, like as televisions, fluorescent tubes, etc., are now more prevalent than ever before in the distribution network. The previously suggested strategy might not work because of how closely HIFs and NLLs behave while they are transiently interacting. Therefore, a new HIF detection method has been designed and developed with the following study work objectives: to study on HIF characteristics and choose a suitable HIF model. To research and precisely model the EPDS in real life using many types of usual loading circumstances. To choose a feature extraction technique that requires minimal computation and information process time [46,47]. To make the HIF detection algorithm more effective with greater variety in NLLs and higher performance in all detection criteria (Accuracy, Dependability, and Security). To minimise the HIF detecting delay and to quickly activate the relay.

Reference:

1. Aziz, MS, Abdel, MA, Moustafa, H & Zahab, EA 2012, ‘High impedance faults analysis in distribution networks using an adaptive neuro fuzzy inference system’, Electric Power Component Systems, vol. 40, no. 11, pp. 1300-1318.
2. A. Girgis, Wenbin Chang, Elham Makram, “Analysis of high impedance fault generated signals using a Kalman Filtering Approach” IEEE Transactions on Power Delivery, Vol. 5, No. 4, November 1990 pp 1714-1724
3. V. Veerasamy, N. A. Wahab, R. Ramachandran, M. Mansoor, M. Thirumeni, and M. L. Othman, ‘‘High impedance fault detection in medium voltage distribution network using discrete wavelet transform and adaptive neuro-fuzzy inference system,’’ Energies, vol. 11, no. 12, p. 3330, Nov. 2018
4. A. M. Gaouda and M. M. A. Salama, “Power quality detection and classification using wavelet multi-resolution signal decomposition,” IEEE Trans. Power Delivery, vol. 14, No. 4, pp. 1469-1475, Oct. 1999.
5. Y- Zhang, X. Wang, J. He, Y. Xu, F. Zhang, and Y. Luo, ‘‘A transfer learning-based high impedance fault detection method under a cloud-edge collaboration framework,’’ IEEE Access, vol. 8, pp. 165099–165110, 2020
6. B. D. Russell and C. L. Benner, “Arcing fault detection for distribution feeders: Security assessment in long term field trials,” IEEE Trans. Power Del., vol. 10, no. 2, pp. 676–683, Apr. 1995.
7. N. Zamanan, J. Sykulski, A. K. Al-Othman," Arcing High Impedance Fault Detection Using Real Coded Genetic Algorithm “, Proceeding of the Third IASTED Asian Conference, Power and Energy Systems, 2-4 April, Phuket, Thailand
8. M. Michalik, M. Łukowicz, W. Rebizant, S. J. Lee, and S. H. Kang," New ANN-Based Algorithms for Detecting HIFs in Multi grounded MV Networks", 43rd International Universities Power Engineering Conference, UPEC2008, 1-4 Sept. 2008, pp.1 – 5
9. M. Sedighizadeh, S. M. Shahrtash, M. Farmahini, " Analysis and comparison of high impedance fault detection methods", 17th International Power System Conference, PSC2002, Nov. 2002, Tehran, Iran
10. Aljohani, A. Centralized Fault Detection and Classification for Motor Power Distribution Centers Utilizing MLP-NN and Stock well Transform. In Proceedings of the 2020 IEEE PES Innovative Smart Grid Technologies Europe (ISGT-Europe), The Hague, The Netherlands, 26–28 October 2020
11. Hastie, T, Tibshirani, R & Friedman, J 2009, ‘The Elements of Statistical Learning: Data Mining, Inference, Prediction’, Springer Verlag, New York.
12. M. Mishra and P. K. Rout, ‘‘Detection and classification of micro-grid faults based on HHT and machine learning techniques,’’ IET Gener., Transmits. Distrib., vol. 12, no. 2, pp. 388–397, Jan. 2018.
13. A. Lazkano, J. Ruiz, L. A. Leturiondo, and E. Aramendi, "High impedance arcing fault detector for three-wire power distribution networks," in Proc. 10th. Mediterranean Electrotechnical Conf., vol. 3, May 29-31, 2000, Lemesol, Cyprus, pp. 899-902.

14. B. Michael Aucoin, Robert H. Jones" High Impedance Fault Detection Implementation Issues" IEEE Transactions on Power Delivery, Vol. 11, No. 1, January 1996
15. Amin Ghader, Herbert L. Ginn, Hossein Ali Mohammadpour" High impedance fault detection: A review"Electric Power Systems Research Volume 143, February 2017, Pages 376-388
16. Craig G. Wester "High Impedance Fault Detection on Distribution Systems" 1998 Rural Electric Power Conference Presented at 42nd Annual Conference
17. Mike Aucoin" Status of High Impedance Fault Detection"IEEE Transactions on Power Apparatus and Systems (Volume: PAS-104, Issue: 3, March 1985)
18. Sedighi, AR 2014, 'A new model for high impedance fault in electrical distribution system', International Journal of Scientific Research in Computer Science and Engineering, vol. 2, no. 4, pp. 6-12.
19. Kavaskar, S, Mohanty, NK, Sahoo, AK 2018, 'High impedance fault detection using wavelet transform', International Conference on Smart city Energy Security and Power held on 28-30 March 2018 at C.V Raman College of Engineering, Bhubaneshwar, Odisha.
20. Ying-Yi Hong and Wei-Shun Huang" Locating High-Impedance Fault Section in Electric Power Systems Using Wavelet Transform, -Means, Genetic Algorithms, and Support Vector Machine" Hindawi publishing corporation 2015
21. Sedighizadeh, M, Rezazadeh, A & Elkalashy, NI 2010, 'Approaches in high impedance fault detection A chronological review', Advances in Electrical and Computer Engineering, vol. 10, no. 3, pp. 114 –128.
22. Lee, C, Park, J, Shin, J & Radojevie, Z 2006, 'A new two-terminal numerical algorithm for fault location, distance protection, and arcing fault recognition', IEEE Transaction on Power Systems, vol. 21, no. 3, pp. 1460–1462.
23. Soheili, A & Sadeh, J 2017, 'Evidential reasoning-based approach to high impedance fault detection in power distribution systems,' IET Generation, Transmission & Distribution, vol. 11, no. 5, pp. 1325- 1336.
24. Samantaray, SR 2010, 'Decision tree-initialized fuzzy rule-based approach for power quality events classification', IET Generation, Transmission & Distribution, vol. 4, no. 4, pp. 530-537.
25. M. Michalik, M. Łukowicz, W. Rebizant, S. J. Lee, and S. H. Kang," New ANN-Based Algorithms for Detecting HIFs in Multi grounded MV Networks", 43rd International Universities Power Engineering Conference, UPEC2008, 1-4 Sept. 2008, pp.1 – 5
26. T. M. Lai, L. A. Snider, E. Lo, Member, and D. Sutanto" High-Impedance Fault Detection Using Discrete Wavelet Transform and Frequency Range and RMS Conversion" IEEE TRANSACTIONS ON POWER DELIVERY, VOL. 20, NO. 1, JANUARY 2005
27. Ibrahim, DK, Zahab, EMA & Saleh, SM 2010, 'Real time evaluation of DWT based high impedance fault detection in EHV transmission', Electrical Power System Research, vol. 80, no. 8, pp. 907-914.
28. Sarlak, M & Shahrtash, SM 2011, 'SVM based method for high impedance fault detection in distribution networks', COMPEL International Journal of Computers Mathematics Electrical and Electronics Engineering, vol. 30, no. 2, pp. 431-450.

29. Baqui, I, Zamora I, Mazón, J & Buigues, G 2011, 'High impedance fault detection methodology using wavelet transform and artificial neural networks', Electrical Power System Research, vol. 81, no. 7, pp. 1325-1333.
30. Mahari, A & Seyed, H 2015, 'High impedance fault protection in transmission lines using a WPT-based algorithm', International Journal of Electrical Power and Energy Systems, vol. 67, no. 1, pp. 537–545.
31. Sergio, S, Costa, P, Gouvea, M, Lacerda, A, Alves, F & Leite, D 2018, 'High impedance fault detection using power distribution networks using evolving neural networks', Electric Power Systems Research, vol. 154, pp. 474-483.
32. Ghaderi, A, Ginn, HL & Mohammadpour, A 2017, 'High impedance fault detection A review', Electrical Power System Research, vol. 143, no.1, pp. 376-388.
33. Suresh Gautam and Sukumar M. Brahma" Detection of High Impedance Fault in Power Distribution Systems Using Mathematical Morphology" IEEE Transactions On Power Systems, 2012 IEEE
34. Sarlak, M & Shahrtash, SM 2011, 'High impedance fault detection using combination of multilayer perceptron neural networks based on multi resolution morphological gradient features of current waveform', IET Generation, Transmission & Distribution, vol. 5, no. 5, pp. 588-95.
35. Yun-Sik, O, Joon, H, Gi-Hyeon, G, Doo-Ung, K, Chul-Ho, N, Chul, H, Toshihisa, F & Tomonobu, S 2016, 'Detection of high impedance fault in low-voltage DC distribution system via mathematical morphology', Journal of International Council on Electrical Engineering, vol. 6, no. 1, pp. 194–201.
36. Kavaskar, S & Mohanty, NK 2017, 'Combined Mathematical Morphology and Data Mining Based High Impedance Fault Detection', 1 st International Conference on Power Engineering, Computing and Control, 2- 4 March 2017, VIT University, Chennai. Published in Energy Procedia, vol. 117, pp.417-423
37. Aziz, MS, Abdel, MA, Moustafa, H & Zahab, EA 2012, 'Highimpedance faults analysis in distribution networks using an adaptive neuro fuzzy inference system', Electric Power Component Systems, vol. 40, no. 11, pp. 1300-1318.
38. N. Narasimhulu, D. V. Ashok Kumarand M. Vijaya Kumar" Detection and Classification of High Impedance Fault in Power Distribution System using Hybrid Technique"Journal of Circuits, Systems and ComputersVol. 29, No. 08, 2050118 (2020)
39. Zadeh, HK 2005, 'ANN-based high impedance fault detection scheme: Design and implementation', International Journal of Emerging Electrical Power System, vol. 4, no. 2, pp. 1–14.
40. Jota, PR & Jota, FG 1999, 'Fuzzy detection of high impedance faults in radial distribution feeders', Electrical Power System Research, vol. 49, no. 3, pp. 169–174.
41. Mohsen Ghalei Monfared Zanjani, Hossein Kazemi Karegar, Hasan Ashrafi Niaki, Mina Ghalei Monfared Zanjani"High Impedance Fault Detection of Distribution Network by Phasor Measurement Units"Smart Grid and Renewable Energy Volume 4, Issue 3 (June 2013)
42. Patrick, EF, Adriano, PM, Jean, PR & Ghendy, C 2018, 'Non-linear high impedance fault distance estimation in power distribution systems: A continually online-trained neural network approach', Electric Power Systems Research, vol. 157, pp. 20–28.

43. Emmanuel, A, Cyganski, D, Orr, JA, Shiller, S & Gulachenski, EM 1990, 'High impedance fault arcing on sandy soil in 15 kV distribution feeders: contribution to the evaluation of the low frequency spectrum', IEEE Transaction on Power Delivery, vol. 5, no. 2, pp. 673–686.
44. S. Lavanya, S. Prabakaranand N. Ashok Kumar"Behavioral Dynamics of High Impedance Fault Under Different Line Parameters"International Journal of Electrical and Electronics Research (IJEER), Volume 10, Issue 2 | Pages 370-374,2022
45. Khushwant Rai, Farnam Hojatpanah, Firouz Badrkhani Ajaei,Josep M. Guerrero, Katarina Grolinger"Deep learning for high-impedance fault detection and classification: transformer-CNN"Neural Computing and Applications, 2022
46. Lucas Girotode Oliveira,Mateus de L. Filomeno,Luiz FernandoColla,H.Vincent Poor,"Analysis of typical PLC pulses for sensing high-impedance faults based on time-domain reflectometry"International Journal of Electrical Power & Energy Systems ,Volume 135, February 2022,