Underground Low Voltage Distribution Networks: Automatic Fault Location

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ABSTRACT: TDR recorded signals are substantially more sophisticated than high- and medium-voltage subterranean cables or overhead transmission lines because of the numerous tees. The method created in is based on TDR, however it utilises impulse current to locate cable defects rather than impulse voltage, and it needs experienced engineers to understand the waveforms. This article offers a method for automatically finding faults in underground low voltage distribution networks that are still present today (ULVDNs). It makes advantage of Time Domain Reflectometry (TDR) device signals that are already in existence. In order to identify flaws, it analyses TDR signals using adaptive filtering, and eliminates reflections generated on by single-phase tee-offs. In order to detect three - phase power open or short circuit faults and reduce reflections generated on by single-phase tee-offs, it also pre-processes TDR signals. The method fundamentally lowers the level of interpretation expertise needed by a TDR-based fault locating device user. Real-world data is used to show the system's relative performance.

KEYWORDS: Adaptive Filtering, Distribution Network, Fault Location, Time Domain, Reflectometry.

1. INTRODUCTION

For ULVDN, power utilities need a precise and automated fault location technique. This is due to a variety of important reasons, including supply dependability, quality, lowering operational costs of repairs and altering staff work habits, and maintaining a competitive advantage via cheap tariff rates. One of the most popular techniques for detecting faults on underground cables and transmission lines is Time Domain Reflectometry [1]. TDR-based fault detection approaches have been created and effectively used in medium or high voltage cable and aerial transmission system systems, but not in ULVDN. This is because the ULVDN has a lot of 3-phase and single-phase (service cable) tee connections.

The method described in uses the TDR concept to automatically identify the problem. This technique can only be used on cable networks with 3-phase tees and cable lines having voltages between 6.6 kV and 33 kV. The wavelet transform is used in the fault localization method described in to evaluate power system fault nonlinearities in TDR data. Only 345 kV transmission lines without tees were equipped with that as well. The method in makes defect discovery easier by relying on expert knowledge [2].

Only high-voltage subterranean cable without tees has been shown with the procedure, and some human input is still required. discusses a fault-finding method that speeds up the process of locating flaws. It has only been tested on a 15 kV distribution cable network without tees and can only be recognised as a problem in three stages. TDR recorded signals might be difficult to analyse due to reflections from the network's many tee connections. Given that single-phase tees may produce reflections that mimic short circuits, it could be challenging to distinguish between short circuit and single-phase tee defects from the recorded reflections. Excellent, healthy phase reflected signals cannot be recorded if the access point is not separated from the bus bar. This is so that other feeds may get the pulse that was transmitted across the wire. The only recordings that can be made as a consequence are those that are connected to the flawed phase. Consumers experience power outages because more fuses must be removed in order to get a good phase reflected signal [3].

This paper presents an automated method for detecting problems on ULDVN that is based on clever TDR signal processing. This innovative technique not only finds defects, but also distinguishes single-phase tees from faults. Using field data collected from actual ULVDNs, the performance of the novel technique is compared to that of existing practice.TDR works by sending a pulse into the cable network from an accessible location. Any impedance mismatches in the cable network partly or fully reflect this pulse. Short circuits, open circuits, and tee joints are all examples of impedance mismatches. For both the defective and sound (healthy) phases, the reflected pulses (signals) are recorded.

Then, by visually analyzing these reflected signals or by deducting one from the other, any defects in the cable network are discovered. Several commercial ULVDN fault tools, including as the Hathaway P240, Edgcume E2760, and Biccotest T510, use this technique. Due to the complexity of the reflected signals, the primary drawback of employing these instruments for ULVDN is that specialist engineers are required to interpret the data. 15 metres broad and 20 metres long A short circuit between cores 1 and 2 occurs 40 metres along the main wire. The ideal TDR input signal, anticipated reflected signals, and anticipated outcomes are displayed for the cable model. The optimal interrogation pulse is used in the TDR system [3].

1-N and 3-N are seen in F. Two reflected pulses in the same location are shown by the bold pulses .The difference signal 1-N and 3-N are shown in Fig. 2(f), and there is just one key departure at 40 m, as anticipated. The short circuit failure at 40 m is to blame for this. The TDR signal of the 1-N phase for the cable model. A commercial TDR device was used to record it. This reflected signal exemplifies the TDR signals' intricacy. An expert engineer examines the difference or overlaid signal to see whether there are any significant deviations in the signal.

This procedure is performed for each phase's combination. The Compare and Contrast (C&C) technique is a common name for this traditional approach. If one of the reflected signals under examination is faulty, the key departures appear. Otherwise, in the ideal scenario, there will be no major critical deviations. Due to impedance variations throughout the wire, this is not true in the actual world.as well as noise the reflected signal will have amplitude fluctuations. These amplitude fluctuations may indicate deviations that are comparable to those produced by faults. There are three major drawbacks to the C&C technique of fault finding. First, as previously said, amplitude fluctuation may create issues when analyzing reflected signals. Second, at any one time, this technique can only handle two signals. If the defective phase signal is unknown, this may be an issue. Third, ULVDN restricts the recording of reflected signals.

This is because of live line testing, as was mentioned in the introduction. As a consequence, it's not always possible to capture both good and bad phase reflected signals without a client power loss. Three groups may be made based on the quantity of signals that are reflected in a broken 3-phase live ULVDN cable that lacks blocking inductors to stop the pulse from entering the feeder: Three reflected signals from an access point may be recorded using a single fuse that has blown or been removed. The reflected signals that may be collected, for instance, must be coupled with Red phase if the Red phase fuse is blown or deleted.

Signals such as Red-Blue (RB), Red-Neutral (RN), and Red-Yellow (RY) will reflect if the Red fuse blows (RY) [4] Possibly recorded. To capture more reflected signals, another fuse has to be removed. As a result, customers can suffer power outages. To record five reflected signals from an access point, two fuses must be removed. If the Red and Blue fuses blow in this scenario, it could still be able to intercept the reflected signals RN, RB, BN, and BY without further affecting the customer's power. The adaptive filtering approach serves as the foundation of the implemented intelligent processing. Echo cancellation, speech modelling, multipath correction, and radar signal processing have all had success with adaptive filters [5].

2. DISCUSSION:

For ULVDN, POWER utilities require a precise and automated fault location method. This is attributable to a variety of important reasons, including supply dependability, product quality, lower operational costs for repairs, altered staff work procedures, and maintenance of a competitive advantage via low tariff rates. One of the most used techniques for identifying problems in transmission lines and subterranean cables is time domain reflectometry (TDR). TDR-based fault detection approaches have been developed and effectively used in high or medium voltage cable or overhead transmission network systems, but not in ULVDN.

The approach developed in is based on TDR, but instead of utilising impulse voltage to find cable faults, it uses impulse current, and it requires expert engineers to comprehend the waveforms. The approach outlined in makes use of the TDR idea to detect the issue automatically. This method can only be used on cable lines with voltages between 6.6 kV and 33 kV, and it can only be utilised on cable networks with 3-phase tees. The wavelet transform is used to evaluate power system fault transients in TDR data in the fault localization method described in. It was exclusively used on 345 kV transmission lines that did not have tees. The method described in makes defect identification easier by relying on expert knowledge.

The technique has only been shown for high-voltage underground cable without tees, and some human input is still necessary. explains a fault-finding system that automates the process of discovering defects. It can only be identified as a concern in three phases and has only been tested on a 15 kV distribution cable network without tees. TDR recorded signals might be difficult to analyse due to reflections from the network's many tee connections. Given that single-phase tees may produce reflections that mimic short circuits, it could be challenging to distinguish between short circuit and single-phase tee defects from the recorded reflections. Excellent, healthy phase reflected signals cannot be recorded if the access point is not separated from the bus bar. This is so that other feeds may get the pulse that was transmitted across the wire.

As a result, the only recordings that may be produced are those that are linked to the defective phase. Additional fuses must be removed in order to capture a healthy phase reflected signal, resulting in power interruptions for consumers. This paper presents an automated method for detecting problems on ULDVN that is based on clever TDR signal processing. This innovative technique not only finds defects, but also distinguishes single-phase tees from faults. Using field data collected from actual ULVDNs, the performance of the novel technique is compared to that of existing practice[6].

TDR operates by transmitting a pulse from a reachable site into the cable network. Any cable network impedance mismatches will partially or completely reflect this pulse.

It is possible for tee joints, short circuits, and open circuits to have impedance mismatches. Both the sound (healthy) and defective phases' reflected pulses (signals) are recorded. Then, by visually comparing these reflected signals or by deducting one from the other, any defects in the cable network are discovered. Many commercial ULVDN fault location equipment, such the Edgcume E2760 and Hathaway P240, use this technique. Due to the complexity of the reflected signals, the primary drawback of employing these instruments for ULVDN is that specialist engineers are required to interpret the data. A short circuit develops between cores 1 and 2 at a distance of 20 metres and a width of 15 metres, 40 metres along the main wire [7].

the cable model's 1-N phase TDR signal for the cable model shown in Figure 1. It was captured with a commercial TDR gadget. The complexity of the TDR signals is shown by this reflected signal. To determine if there are any major signal variations, a skilled engineer evaluates the difference or superimposed signal. This process is carried out for every combination of phases. This conventional strategy is often referred to as the Compare and Contrast (C&C) method. The main departures show up if one of the reflected signals under evaluation is flawed. Otherwise, in a perfect world, there wouldn't be any significant crucial deviations. This is not true in the real world due to impedance fluctuations along the cable. in the model [8]

As well as noise the reflected signal will have amplitude fluctuations. These amplitude fluctuations may indicate deviations that are comparable to those produced by faults.
There are three major drawbacks to the C&C technique of fault finding. First, as previously said, amplitude fluctuation may create issues when analyzing reflected signals. Second, at any one time, this technique can only handle two signals. If the defective phase signal is unknown, this may be an issue. Third, ULVDN restricts the recording of reflected signals. As was said in the introduction, this is the result of live line testing. As a result, it is sometimes difficult to record both good and poor phase reflected signals without a client power loss. Three categories may be made out of the quantity of reflected signals in a damaged 3-phase live ULVDN cable that lacks blocking inductors (to stop the pulse from entering the feeder):

- A single blown or removed fuse enables three reflected signals from an access point to be captured[9].
- Recording five reflected signals from an access point requires the removal of two fuses (either blown or removed).

The method of adaptive filtering is the foundation of the used intelligent processing. For noise elimination, voice modelling, multi - path correction, and radar data processing, adaptable filters have indeed been utilised with effectiveness. Figure 1 depicts the flowchart for the brand-new fault location system based on TDR. The core components of a finite impulse response (FIR) adaptive filter are an input signal, a data to compare, an output capacitor signal, and an error signal [10].

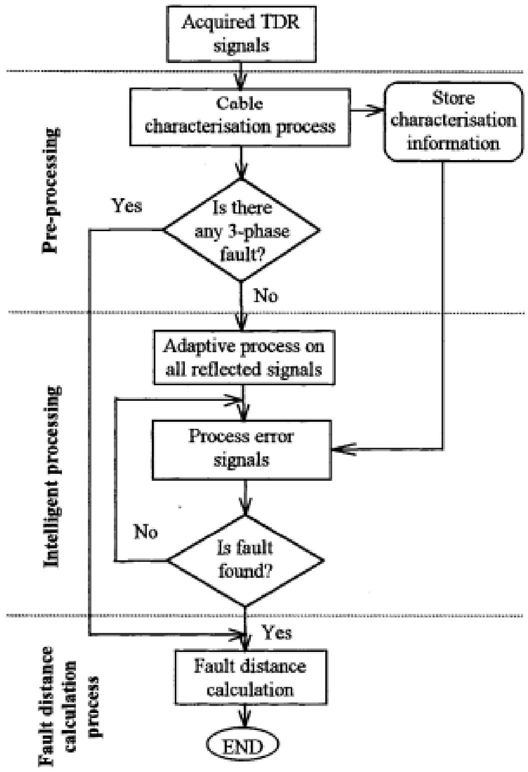

Figure 1: flowchart for the new fault location system based on TDR.

3. CONCLUSION:

In this work, a novel approach to ULVDN fault discovery is given. This method is entirely automated and is based on information gathered from an existing TDR device. It does away with the requirement for human interpretation and makes it possible for TDR users to identify problems with ULVDN cables. According to early testing, the distinctive technique has the capacity to identify problems. Using field data collected from actual ULVDNs, the relative performance of the new and old TDR techniques is assessed. The first two reflected signals that were captured from a real cable network are Red-Yellow (RY) and Red-Blue (RB), as indicated. The signals that the substation reflected were captured. It was a RY short circuit that caused the failure 45 metres from the substation. A negative reflection is seen in the two reflected signals at a distance of 8 metres from the substation. The three-phase tee connection is at blame for this. The short circuit issue causes a second negative reflection of the RY reflected signal at a distance of 45 metres. Around 45 metres, the RB reflected signal slightly degrades. The impact of the short circuit between the Red and Yellow phases is to blame for this. Each data set displays two exits, one before 10 metres and the other before 30 metres. A 3-phase tee or 3-phase short circuit problem might exist since the initial departure (10 m) is negative in both measurements. The positive second departure is seen in both data sets (30 m). Therefore, it is determined that this place may have an open circuit problem.

REFERENCE:

[1] J. De Nunes and A. Bretas, "on Automatic Fault Location in Unbalanced Distribution Networks. an Extended Impedance Based Fault Location Formulation," *Pscc.Ee.Ethz.Ch*, 2011.

[2] V. Singh, R. Gupta, and I. Neamtiu, "Automatic fault location for data structures," in *Proceedings of CC 2016: The 25th International Conference on Compiler Construction*, 2016.

[3] J. Lee, "Automatic fault location on distribution networks using synchronized voltage phasor measurement units," in *American Society of Mechanical Engineers, Power Division (Publication) POWER*, 2014.

[4] D. D. Sabin, C. Dimitriu, D. Santiago, and G. Baroudi, "Overview of an automatic underground distribution fault location system," in *2009 IEEE Power and Energy Society General Meeting, PES '09*, 2009.

[5] J. S. Collofello and L. Cousins, "Towards automatic software fault location through decision-to-decision path analysis," *AFIPS Proc. 1987 Natl. Comput. Conf.*, 1987.

[6] S. I. Firstman and B. Glues, "Optimum Search Routines for Automatic Fault Location," *Oper. Res.*, 1960.

[7] T. Kato, G. Ueta, and S. Ishii, "Automatic Diagnosis of Fault Locations in Power Transformer Impulse Test using Self-Organizing Map," *IEEJ Trans. Power Energy*, 2002.

[8] C. V. Pellon, T. E. Potter, S. C. Sekar, M. T. Parker, and P. Smith, "Aircraft electrical system monitoring with arc fault circuit protection and automatic fault location," in *SAE Technical Papers*, 2006.

[9] L. F. Grisales, O. D. Montoya, A. Grajales, R. A. Hincapie, and M. Granada, "Optimal Planning and Operation of Distribution Systems Considering Distributed Energy Resources and Automatic Reclosers," *IEEE Lat. Am. Trans.*, 2018.

[10] G. Weng, F. Huang, J. Yan, X. Yang, Y. Zhang, and H. He, "A fault-tolerant location approach for transient voltage disturbance source based on information fusion," *Energies*, 2016.

[11] Panwar, K, Murthy, D, S, "Analysis of thermal characteristics of the ball packed thermal regenerator", Procedia Engineering, 127, 1118-1125.

[12] Panwar, K, Murthy, D, S, "Design and evaluation of pebble bed regenerator with small particles" Materials Today, Proceeding, 3(10), 3784-3791.

[13] Bisht, N, Gope, P, C, Panwar, K, " Influence of crack offset distance on the interaction of multiple cracks on the same side in a rectangular plate", Frattura ed Integrità Strutturale" 9 (32), 1-12.

[14] Panwar, K, Kesarwani, A, "Unsteady CFD Analysis of Regenerator", International Journal of Scientific & Engineering Research, 7(12), 277-280.

[15] Singh, I., Bajpai, P. K., & Panwar, K. "Advances in Materials Engineering and Manufacturing Processes

[16] Panwar, K, Murthy, D, S, "Analysis of thermal characteristics of the ball packed thermal regenerator", Procedia Engineering, 127, 1118-1125.

[17] Panwar, K, Murthy, D, S, "Design and evaluation of pebble bed regenerator with small particles" Materials Today, Proceeding, 3(10), 3784-3791.

[18] Bisht, N, Gope, P, C, Panwar, K, " Influence of crack offset distance on the interaction of multiple cracks on the same side in a rectangular plate", Frattura ed Integrità Strutturale" 9 (32), 1-12.

[19] Panwar, K, Kesarwani, A, "Unsteady CFD Analysis of Regenerator", International Journal of Scientific & Engineering Research, 7(12), 277-280.

[20] Singh, I., Bajpai, P. K., & Panwar, K. "Advances in Materials Engineering and Manufacturing Processes