ISSN: 2472-3703 DOI: 10.6911/WSRJ.201910_5(10).0016

Summary of Research on Fault Diagnosis of T-Connected Transmission Lines

Jie Yang[1, a], Jiahao Chen[1, b], Xiaoping Gu[1, c] and Hao Wu[1, d, *]

[1]Artificial Intelligence Key Laboratory of Sichuan Province, Automation and Information Engineering, Sichuan University of Science & Engineering, Zigong,, 643000, China

[a]yangjie100894@163.com, [b]1309087496@qq.com, [c]1690472777@qq.com
[d]wuhao801212@163.com

Abstract

According to the existing research, it summarizes three aspects from fault identification, fault location and fault classification in the T-connected transmission lines. Among them, the fault identification in the T-connected transmission lines area mainly introduces the method based on the power frequency and transient quantity; the T-connected transmission lines fault location mainly introduces the fault analysis method and traveling wave method based on the power frequency; the fault classification method based on neural network is introduced. On this basis, the difficulties and problems of T-connected transmission lines fault diagnosis at the current stage are analyzed, and the future development is prospected.

Keywords

T-connected transmission lines; fault diagnosis; fault identification inside and outside; fault location; fault classification.

1. INTRODUCTION

With the increasing demand for electric energy in people's daily production and life, the density of power grids is also increasing, and the number of T-connected transmission lines is also appearing in high-voltage and ultra-high-voltage power networks. However, these lines are often accompanied by large power plants and large systems. Their transmission lines have high transmission power and heavy loads. When the line fails, it may cause large-scale blackouts. Therefore, when it fails, it is required to quickly diagnose the fault [1-5], accurately and quickly find the fault point, and then eliminate the fault to achieve safe and stable operation of the power system transmission line.

For a long time, domestic and foreign scholars have carried out a lot of research on T-connected transmission lines fault diagnosis methods. This paper will review the fault identification, fault location and fault classification in the T-connected transmission lines area, and analyze the difficulties and problems in all aspects. And on this basis, the future T-connected transmission lines fault diagnosis method is prospected.

2. T-CONNECTION TRANSMISSION LINE INTERNAL AND EXTERNAL FAULT IDENTIFICATION

This section mainly discusses the fault identification methods inside and outside the T-connection transmission line, and mainly introduces the fault identification method based on the power frequency and transient quantity.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201910_5(10).0016

2.1. Internal and External Fault Identification Method Based on Power Frequency

The fault identification method based on the power frequency-based fault analysis method mainly uses voltage, current and line distribution parameter model to identify faults. Reference [6] identifies the faults in the zone using the phasor of the three-terminal fault voltage component of the T-connected line and the ratio of the phasor sum of the fault current component. Reference [7] uses the magnitude of the vector difference between the sum of the three-terminal fault component currents of the T-connected line and the maximum current of the three-terminal fault component current and the sum of the currents at the other ends to identify the fault in the zone, but the criterion The selection of the medium braking coefficient affects the sensitivity and reliability of fault identification. Reference [8] addresses the problems in the reference [7], it is proposed to use the sum of the maximum current in the three-terminal fault current component of the T-connection line and the other two ends and the other string angle to establish the criterion to identify the fault in the area. This criterion makes the braking term appear as the driving and braking state in the faults outside the zone. The reference [9] establishes a comprehensive criterion based on the criteria presented in the reference [7-8] to identify faults in the PV T-connected high-voltage distribution network. In [10], in order to improve the sensitivity of the internal fault criterion and the reliability of the external fault criterion, the criterion proposed in [7] is improved, and the maximum current in the three-terminal fault current component of the T-connected line is introduced. In addition, the current sinusoidal angle at both ends is used as a criterion braking coefficient to identify faults in the area.

2.2. Transient Quantity Based Internal and External Fault Identification Method

The principle of fault identification based on transients is mainly based on the high-frequency transient component generated when the transmission line is faulty, to determine whether a fault has occurred. In recent years, domestic and foreign scholars have conducted a lot of research in this direction. In [11], the voltage and current signals measured by the relay terminal of the T-connection line are supplied to a second-order Taylor-Kalman-Fourier (T2KF) filter to estimate the instantaneous value of the voltage and current signal phasors, and then The phasor information is used to obtain the positive sequence impedance to identify the fault segment, but the DC component of the fault current exponential decay will affect the fault identification. In [12], the bior3.1 wavelet is used to decompose the three-terminal raw current signal of the T-connected line, and then the decomposed signal is reconstructed, and the reconstructed signal is used to solve the running current and the suppressing current of each phase. Finally, the three-phase corresponding phase is compared. The relationship between current and suppression current identifies faults within and outside the zone. Different from the fault identification algorithm proposed in [12], the reference [13] discriminates the faults in the zone by comparing the polarity of the fault current detected by the Haar wavelet function at each end of the T-connected line, but the reliability and safety of the algorithm are not discussed. And other issues. In [14], Literature [14] combines the high-speed stop filtering properties of the busbar, and continuously processes the current sampling information by three mathematical morphology-based filters, the transients generated by the output faults are then compared with three predetermined thresholds to determine the faults within the zone.

3. T CONNECTION TRANSMISSION LINE FAULT LOCATION

Various short-circuit faults often occur on the transmission line. Some of these faults are obvious and easy to identify, but some faults are not obvious (such as short-circuit through large transition resistance), which is relatively difficult to identify. Fault location is also called fault location. For a transmission line, it means that after the line fails, the position of the fault point is quickly and accurately determined according to different fault characteristics. At present, the methods for fault location mainly include fault analysis method and traveling wave method based on power frequency.

3.1. Fault Location Based on Fault Analysis Method of Power Frequency

The method of using the power frequency method is simple and low in cost, and has always been the research direction of power system workers. However, the data processing cycle of this method is long, and the fault location error is large in actual operation [15-20]. In [17], considering the distributed capacitance, different voltage sequence components are used for the symmetrical and asymmetrical faults to measure the high-voltage/ultra-high voltage T-connection line based on the centralized parameter line model. In [18], the distributed parameter modeling is used to identify the faulty branch by the phase relationship of the ranging function constructed by the model, and then the ranging function is used to locate the fault point. The algorithm differs from the traditional algorithm for discriminating the fault branch and re-ranging. It can directly measure the fault. There is no deadband in the vicinity of the T-node in the fault branch identification, but the algorithm is applied narrowly. In [19], a new method for fault location of T-type high-voltage lines based on phase characteristics of ranging function is proposed. The method uses the feature of phase-crossing of the ranging function when the selected reference point on the faulty branch matches the fault point. It breaks the traditional mode of judging the faulty branch and then fault location, and can measure the distance without discriminating the faulty branch in advance. The reference [20] uses the parameter calculation method for T-type fault location, which is more complicated and puts higher requirements on signal acquisition.

3.2. Fault Location Based on Traveling Wave Method

In the study of transient traveling wave method, accurate fault location is generally achieved by analyzing the time when the traveling wave reaches the busbar [21-26]. In [23], the discrete wavelet transform is used to detect and compare the first peak time of each end bus of the fault, and then the traveling wave theory is used to identify the fault location. On the basis of the analysis of the traveling wave propagation characteristics of the T-series transmission line, in[24] uses the folding and reflection characteristics of the fault traveling wave to discriminate the faulty branch of the T-connection line and to measure the fault, but it is difficult to identify the traveling wave head. In [25], the cubic B-wavelet transform modulus maxima algorithm is used to extract the fault characteristics to identify the non-dead zone fault branch of the T-connected line, and the wavelet energy spectrum algorithm is used to judge the faulty branch when the fault dead zone occurs. Finally, the three-end is used. The ranging method realizes fault location. In[26] combines the faulty branch and the solution of the fault distance, and obtains the ranging result in one step. When solving the fault distance, the double-ended traveling wave principle is directly used, so the possibility of misjudgment may also occur.

4. FAULT CLASSIFICATION BASED ON NEURAL NETWORK

The existing T-connection transmission line fault diagnosis mainly focuses on fault branch identification and fault point location, and there are few researches on fault classification. Reference [27] uses single-ended measured voltage and current information to obtain reactive power to classify T-connected line faults. In [28], the transient energy combined with the voltage traveling wave is combined with the support vector machine to classify the T-connection transmission fault types. However, the accuracy of the algorithm in the classification of ground faults needs to be improved. In [29], the discrete wavelet transform is used to extract the transient signal energy that can be used for fault classification from the three-phase voltage signal to realize fault classification, and the extracted feature quantity is trained by probabilistic neural network (PNN) to improve the two phases. The accuracy of the ground fault classification.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201910_5(10).0016

5. DIFFICULTIES AND RECOMMENDATIONS OF THE STUDY

From the category point of view, the method of diagnosing T-connection transmission line fault is divided into three aspects: fault identification, fault location and fault classification. However, in essence, all three are to locate the fault, but their respective requirements for positioning are different. From the simulation results, the existing T-connection transmission line fault diagnosis algorithm can better locate the fault, but there are still some problems to be solved.

In the fault identification of the T-connection transmission line area, the fault identification method in the T-connection line based on the power frequency is improved by the current differential protection. The distributed capacitance current will have certain influence on the identification, but the existing area there are few considerations in this regard for internal and external fault identification literature. The fault identification based on the transient amount of the T-connected line is limited by the method of acquiring the fault transient information. In the fault location of the T-connection line, the synchronization problem of the fault information extracted by the three-end will have certain influence on the reliability and accuracy of the algorithm, and the extraction of the faulty singular point is crucial for the fault location based on the traveling wave method. Research on the classification of T-connection transmission line faults is currently rare, and power workers are required to conduct a lot of research on this. According to the existing literature, the research on T-connection transmission line fault diagnosis algorithms based on different methods has its corresponding problems to be solved. This is to be further studied by researchers in relay protection of transmission lines.

6. RESEARCH OUTLOOK

In recent years, with the development of artificial intelligence theory and related disciplines, and the concept of the country's strong smart grid, the future of the power grid will surely develop along a high degree of intelligence and automation. At this stage, how to effectively combine artificial intelligence technology with traditional T-connection transmission line fault diagnosis technology will become a new problem we face.

ACKNOWLEDGEMENTS

Sichuan University of Science and Engineering talent introduction project (2017RCL53); The Project of Sichuan Provincial Academician (Expert) workstation of Sichuan University of Science and Engineering (2018YSGZZ04); Sichuan University of Science and Engineering Postgraduate Innovation Fund Project (y2019011).

REFERENCES

[1] M Behnam, S.P Majid, A Sadegh. Unsynchronised fault-location technique for three-terminal lines[J]. IET Generation Transmission & Distribution,2015,9(15):2099-2107.

[2] J.F An. Application of multi-terminal lines current differential protection[J]. Power system protection and control,2008(21):93-96.

[3] H.C Shu, F Gao, X.Y Chen, etc. A Study on Accurate Fault Location Algorithm of EHV T-Connection to Three Terminals[J]. Proceedings of The Chinese Society for Electrical Engineering, 1998(06): 41-45.

[4] W.J Zhang, H,F Wang, B.T He. Traveling-wave Differential Protection on Teed Transmission Lines[J]. automation of electric power system,2007(03):61-66.

[5] Z.Y Liao, W.L Bao, W.N Yang, etc. Current Status and Prospects of Current Differential Protection for High Voltage Lines[J]. Relay, 1999(01):4-7+23.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201910_5(10).0016

[6] J.L SoNan, X.Y Deng, R.S Li, etc. Principle of T-type transmission line pilot protection based on fault component comprehensive impedance[J]. electric power automation equipment, 2009, 29(12):4-9.

[7] H.L Gao, S.F Jiang. Study on new criterion of current differential protection for Teed lines[J]. Relay, 2001(09):6-9+16.

[8] B Li, T Luo, Z.Q Bo. A novel differential protection criterion based on super-imposed fault component for T-type transmission line[J]. Power system protection and control, 2011,39(15):1-6+12.

[9] T Wang, Y Liu, F.T Li, etc. Research on the current differential protection where PV access to the high voltage distribution network with T-type[J]. Power system protection and control,2015,43(13): 60-65.

[10] J Liu, N.L Zan, K Li. Differential current protection of T-type transmission lines[J]. electric power automation equipment,2008(10): 58-63.

[11] K Abhishek, B.P Suresh, B.N.V. Phanendra. Taylor-Kalman-fourier filter based back-up protection for teed-transmission line[C]. International Conference on Computing, Communication and Networking Technologies (ICCCNT). JUL 03-05, 2017.

[12] B Bhalja, R. P Maheshwari. New differential protection scheme for tapped transmission line[J]. IET Generation Transmission & Distribution, 2008, 2(2): 271-279.

[13] M.M Eissa. A new digital relaying scheme for EHV three terminal transmission lines[J], Electric Power Systems Research. 2005,73(2):107–112.

[14] M Khodadadi, S.M Shahrtash. A New Noncommunication-Based Protection Scheme for Three-Terminal Transmission Lines Employing Mathematical Morphology-Based Filters[J]. IEEE Transactions on Power Delivery,2013,28(1):347-356.

[15] S.F Li, C.J Fan, W.Y Yu, etc. Adaptive Fault Location Method for Three-Terminal Transmission Line[J]. Transactions of China Electrotechnical Society, 2004,19(10):59-64.

[16] X Chen, Y.L Zhu, Y.F Gao, etc. A New Fault Location Algorithm for High-voltage Three-terminal Transmission Lines Based on Fault Branch Fast Identification[J]. Automation of electic power systems, 2016,40(4): 105-110.

[17] G.L Yang, J.X Yin, Q.M Le, etc. Fault locating based on fault voltage sequence components for T-type connection EHV lines[J]. Electric Power Automation Equipment, 2008(09): 31-35.

[18] F.H Lin, Z.P Wang, H.M Zeng. A Novel Fault Location Algorithm Based on Phase Characteristics of Fault Location Function for Three-terminal Transmission Lines[J]. Proceedings of the CSEE, 2011,31 (13):107-113.

[19] Z.P Wang, F.H Lin, H.M Zeng. Accurate Fault Location Algorithm For Three-terminal Transmission Lines Using Matching Idea[J]. High Voltage Engineering, 2009,35(10):2427-2433.

[20] S.H Shi, B.T He, W.J Zhang. Fault Location for HV Three-terminal Transmission Lines[J]. Proceedings of the CSEE, 2008(25):105-110.

[21] A Ahmadimanesh, S.M Shahrtash. Time-time-transform-based fault location algorithm for three-terminal transmission lines[J]. IET Generation, Transmission & Distribution, 2013,07(05): 464-473.

[22] F Zhang, J Liang, T Du, etc. Accurate Fault Location Algorithm Based on Traveling Waves for Teed-circuits[J]. High Voltage Engineering, 2009(03): 527-532.

[23] P. Chiradeja, C. Pothisarn. Identification of the fault location for three-terminal transmission lines using discrete wavelet transforms[J]. Transmission & Distribution Conference & Exposition: Asia and Pacific[C], 2009:1-4.

ISSN: 2472-3703 DOI: 10.6911/WSRJ.201910_5(10).0016

[24] L Zhang, F Zhang, J Liang, etc. Carrier-based modulation for three-level inverter without low-frequency oscillations of neutral point voltage[J]. Electric Power Automation Equipment, 2010,30 (04):46-50.

[25] M Wang, L Zhu, G.Q Zhang, etc. A New Fault Location Algorithm for T-Line Based on Wavelet Energy Spectrum[J].Journal of Vibration, Measurement & Diagnosis, 2018,38(03): 479-485.

[26] Z.L Wang, M.G Liu. Traveling Wave Fault Location for Teed Transmission Line Based on Solutions of Linear Equations[J]. Power System Technology,2014,38(04):1046-1050.

[27] Z Mohamed , E.S Ragab , G.M Amer. An investigated reactive power measurements-based fault-identification scheme for teed transmission lines[J]. 2019,136:185-200.

[28] H Livani, C.Y Evrenosoglu,. A fault classication and localization method for three-terminal circuits using machine learning[J]. IEEE Transactions on Power Delivery, 2013,28(4):2282-2290.

[29] R.K.V Bhupatiraju, V.S Samba, S.S Dhanikonda,Venkata Ramana Rao PULIPAKA. Transient- and probabilistic neural network-based fault classication in EHV three-terminal lines[J]. Turkish Journal of Electrical Engineering & Computer Sciences, 2018,26(11):974-986.