ISSN: 2664-9640

Exploring the influence of 110kV transmission line TV disconnection on distance protection and its solutions

Wanxin Chen*, Chenyu Zhao, Yushan Wang

School of Electric Power Engineering, Nanjing Institute of Technology, Nanjing, China

*Corresponding author: 1960684601@qq.com

Abstract

Through an accident caused by TV disconnection and not blocking the automatic protection device during power transmission operation of 110kV substation, the causes of the accident in the case are analyzed, and some available solutions are given for TV disconnection, and in PSCAD/EMTDC simulation software Build a logic criterion model for the coordinated action of TV disconnection and distance protection to verify the reliability of the solution.

Keywords

Distance protection; TV disconnection; blocking error; misoperation.

1. Introduction

When the TV disconnection fault occurs in the voltage transformer, the voltage of the TV secondary circuit will be abnormal, which will affect the correct action of the relay protection and automatic devices, resulting in the occurrence of relay protection and automatic device malfunction accidents[1-3]. Therefore, in engineering applications, TV disconnection is generally used as an auxiliary function of relay protection and automatic device, and logical judgment is carried out together with distance protection. When the transmission line does not fail, the protection outlet is blocked to prevent the malfunction of the protection device.

2. Case introduction

One day, after the transformation of a 110kV substation, after the power transmission operation after the transformation, the TV hanging busbar is running, the protection device connected to the 110kV busbar acts as a relay protection, the circuit breaker trips, the recloser fails to automatically close, and the distance protection starts. , the TV is connected to the bus and the protection continues to operate. Since the switches of the other two substations connected do not trip, it is judged that there is no fault in the line, so it is considered that the protection has malfunctioned[4]. The fault information printed by the line protection has only two points: PTDX (PT disconnection) and DZ1CK (oscillation I section distance protection exit). According to the fault information, the specific cause cannot be immediately analyzed. Finally, the operation steps of the TV hanging on the network are mentioned before the power transmission operation, and the normal power transmission is finally restored[5-7].

In order to analyze the impact of TV disconnection on protection, a simulation model was built using PSCAD/EMTDC simulation software for research. Assuming that the total length of the transmission line is 200kM, a grounding short-circuit fault and TV disconnection occur at a distance of 100kM from the protection device. First, simulate the electrical quantity waveform when the ground fault occurs at the fault point, then simulate the electrical quantity waveform when the TV disconnection occurs at the fault point, and finally simulate the result when the TV disconnection is added and the result is blocked. The circuit model is shown in Figure 1.

ISSN: 2664-9640

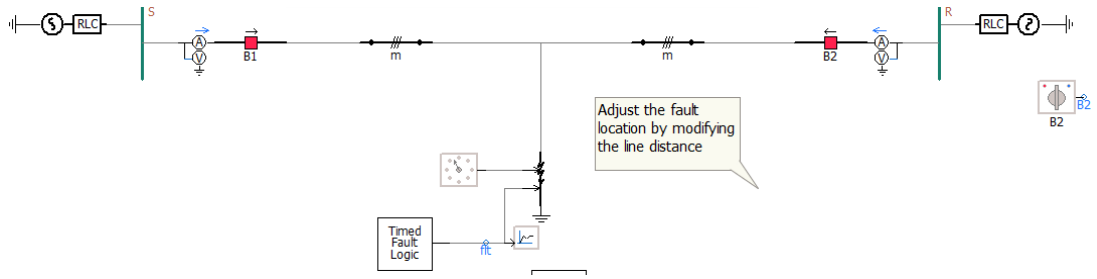

Figure 1 Circuit Simulation Model Diagram

The power supply parameters and circuit parameters are shown in Figure 2 and Figure 3.

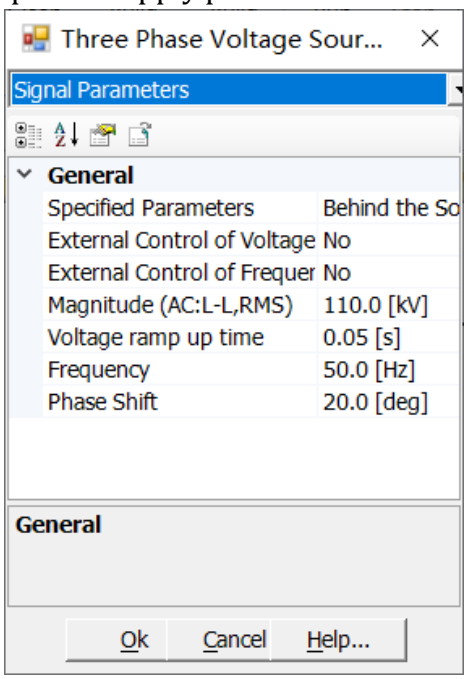

Figure 2 Power parameter settings

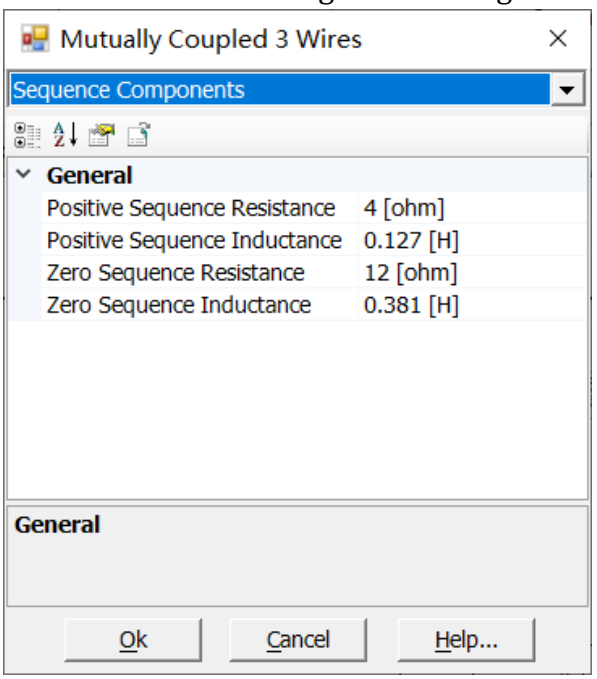

Figure 3 Line parameter setting

3. Accident Cause Analysis

Analysis of the reasons for the malfunction of this operation shows that the logic process of the relay protection device was not considered in the arrangement of the operation sequence, or from the opposite point of view, the protection manufacturer did not consider the above operating conditions when designing the protection program, treat normal operation as an accident situation[8,9].

The first point of the fault print information "PT disconnection" is the signal caused by the TV running without the bus. This information point is easy to understand. However, it is difficult to understand the second point "the distance protection exit of oscillation stage I", because it is unclear whether it is the distance protection exit or the oscillation blocking program is directly wrong. Generally speaking, TV disconnection is mainly used as an auxiliary identification for low-voltage protection. When the TV is disconnected, whether it is a three-phase TV disconnection (symmetric disconnection) or a single-phase or two-phase TV disconnection (asymmetric disconnection)), the secondary side of the voltage transformer measures all low voltages[10]. If there is no blocking protection device at this time, the measured impedance will be less than the set impedance, which will cause the protection element to malfunction. At present, many protection and automatic devices are equipped with low-voltage protection components, such as line distance protection, circuit breaker failure protection, generator-transformer complex voltage overcurrent and impedance protection, low power transformer and motor undervoltage protection, etc., all require low voltage. Components, automatic

ISSN: 2664-9640

devices such as line reclosing, automatic switching of equipment and quick-cutting of factory power also need to be judged without voltage. In the transmission line model of this simulation, the protection device needs to have a TV disconnection check function, but when a TV disconnection is detected, the device will send an alarm signal to block the protection device. Coordinate and protect the safe and stable operation of transmission lines[11].

The current line protection adopts digital protection, which improves the digitalization and intelligence of substation protection at the same time. The method of reclosing has also become very flexible, which can be divided into the methods of detecting no voltage on the busbar, detecting no voltage on the line, and checking the synchronization. Since the bus voltage is required to be considered in the operation modes of no-voltage detection of the bus and synchronous detection, if the recloser is in the operation mode of no-voltage detection of the bus and synchronous detection, the TV disconnection occurs on the bus, and the recloser will detect the TV disconnection at this time. line, the recloser will automatically discharge at this time, which means that the recloser lockout cannot be started, and the recloser task cannot be completed at this time. Under the operation mode of no voltage or no inspection of the busbar with voltage on the detection line, at this time, because the reclosing does not need to detect the voltage of the busbar, only the voltage of the line needs to be detected, and the TV disconnection will not affect the operation mode of the detection line without voltage, the recloser can still work normally.

The simulation model built this time is relatively simple. It only considers the TV disconnection fault of the transmission line, and simulates the blocking protection. In the simulation model, the influence of the reclosing under different operating modes is not considered.

4. Solution

In the simulation model built this time, the distance protection is used, and the distance protection is to judge whether the line has a fault by comparing the measured impedance and the set impedance, and whether the starting distance protection is required. However, when obtaining the voltage, we generally obtain the secondary voltage of the voltage transformer. If the secondary voltage circuit of the voltage transformer is disconnected when the transmission line is in normal operation, the obtained voltage value will change at this time. Impedance relays cannot perform impedance measurements correctly. Examining the protection principle of the impedance device, it can be found that the measured impedance is $Z = \frac{\dot{U}}{\dot{I}}$, but the TV disconnection occurs when the transmission line is in normal operation, $\dot{U}=0$. At this time, the measured impedance measured according to this formula is theoretically zero, no matter what the set impedance value is, Distance protection will malfunction. In order to prevent the protection from malfunctioning, we need to take TV disconnection blocking measures to prevent the malfunction of the distance protection.

The TV disconnection detection technology can detect the TV disconnection fault of the distribution transformer in time, which is a key technology for the comprehensive automation management of the distribution. For a device that only designs a single set of TVs without effectively judging the three-phase TV disconnection (symmetrical disconnection), since the amount of current cannot be introduced, we can use the following methods to improve:

(1) For the air switch of the secondary side voltage circuit in the three-phase linkage mode, we can change the three-phase switch to three single-phase operation air switches or split-phase operation switches, so that grounding or short circuit occurs on the load side. At this time, only the switch of the faulty phase needs to be tripped, which reduces the probability of voltage loss of three phases at the same time. At the same time, since the possibility of true three-phase complete voltage loss in the voltage loop is very small, most of them are caused by human

ISSN: 2664-9640

misoperation. The use of split-phase operation switches can effectively avoid protection and automatic device errors caused by three-phase TV voltage loss. action.

(2) For the quick switching device of factory power, it is generally considered to use a three-phase linkage small switch with auxiliary contacts on the secondary side of the voltage transformer, and then introduce the auxiliary contacts into the blocking circuit of the rapid switching device of factory power. No matter what causes the three-phase linkage air switch to trip, the action is the auxiliary contact at this time, so that the fast switching device of the factory power is blocked.

In addition to improving the device itself, another important consideration is the criterion of TV disconnection. The main criterion for identifying TV disconnection is whether the low-voltage components can be properly blocked when the three-phase TV is disconnected. The single-phase or two-phase unbalanced TV disconnection will not affect the low-voltage criterion, because the low-voltage criterion of the general device uses the line voltage. cause a malfunction. Therefore, the blocking circuit of some protection and automatic devices is very effective for asymmetrical disconnection such as single-phase disconnection and two-phase disconnection, but it has no effect on the complete three-phase disconnection on the secondary side of the TV, which cannot be effectively prevented. mishap occurs. Generally, when the starting element does not act, it only needs to meet one of the following conditions, the TV is disconnected and blocked:

(1) The three-phase voltage phasor and amplitude are greater than 8V, that is,

$$\left|\dot{U}_a+\dot{U}_b+\dot{U}_c\right|>8V \tag{1}$$

(2) The algebraic sum of the three-phase voltage amplitudes is less than 24V, that is,

$$\left|\dot{U}_a\right|+\left|\dot{U}_b\right|+\left|\dot{U}_c\right|<24V \tag{2}$$

The average delay time is 1.25s to send an abnormal signal of TV disconnection. Among them, equation (1) reflects the asymmetrical disconnection of the voltage circuit, that is, single-phase or two-phase TV disconnection; equation (2) reflects the voltage The circuit is symmetrically disconnected, that is, the three-phase TV is disconnected. At the same time as the voltage disconnection signal is issued, the protection that will malfunction when the voltage circuit is disconnected is blocked, and the disconnection overcurrent protection is activated. After the three-phase voltage is normal, the TV disconnection signal will be reset after a delay.

5. Simulation

The protection of the transmission line adopts the distance protection, and the judgment logic after adding the criterion of the TV disconnection blocking logic is shown in Figure 4.

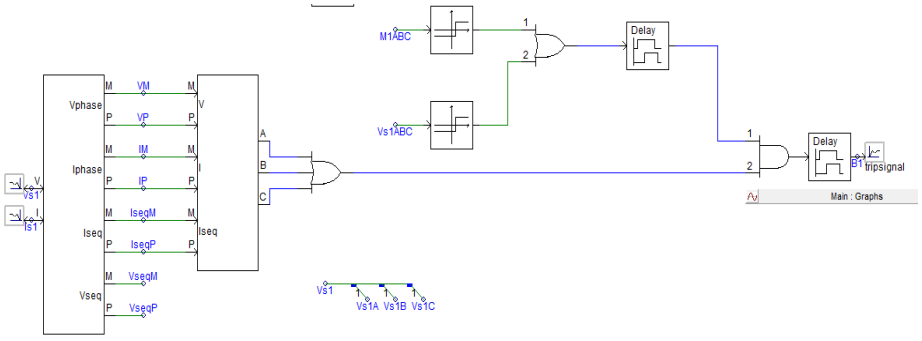

Figure 4 Distance protection and TV disconnection blocking judgment logic

Among them, M1ABC is the algebraic sum of the three-phase voltage amplitudes, and its input comparator settings are shown in Figure 5; vs1ABC is the three-phase voltage sum amplitude, and its input comparator settings are shown in Figure 6.

ISSN: 2664-9640

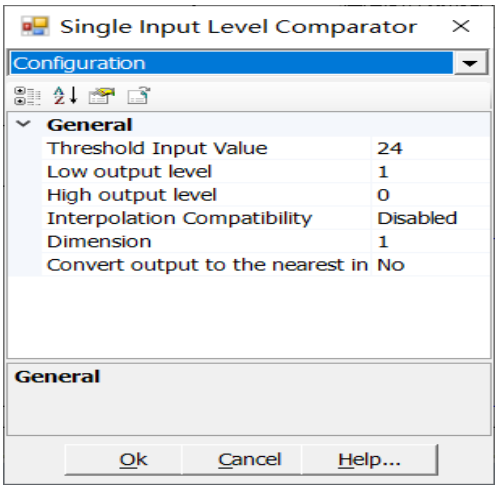

Figure 5 M1ABC Input Comparator Parameter Setting

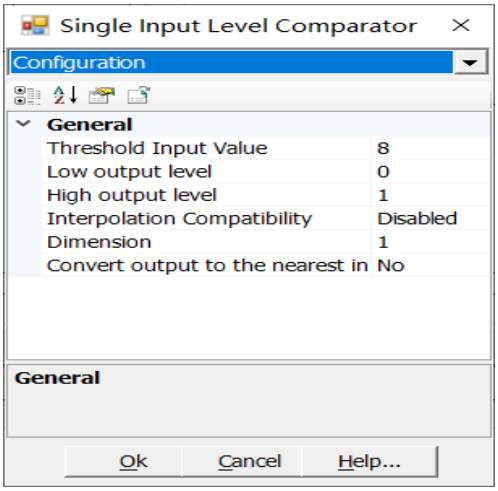

Figure 6 vs1ABC input comparator parameter settings

First, simulate the action curve of the circuit breaker when the transmission line has an A-phase grounding fault and the TV is not disconnected. At this time, the simulation model of the transmission line is shown in Figure 7, B_1 is shown in Figure 8, and the impedance circle and the measured impedance are shown in the Figure 9 shown.

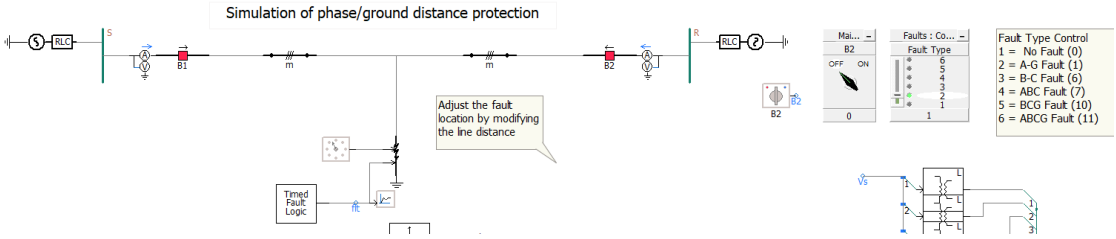

Figure 7 Model diagram of transmission line when phase A is grounded and TV is not disconnected

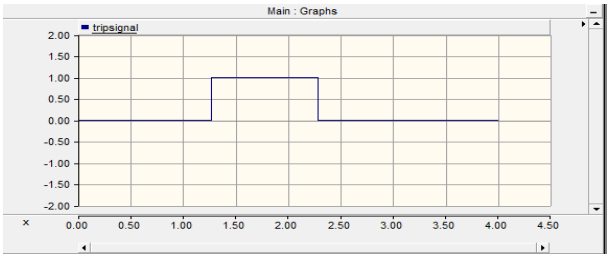

Figure 8 B1 Action Curve

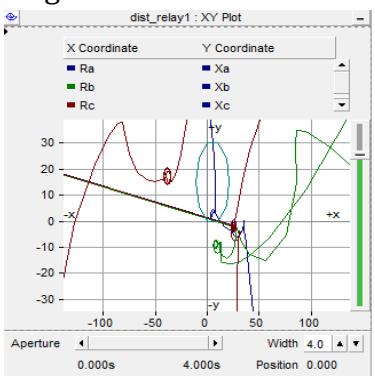

Figure 9 A-phase ground impedance circle and measured impedance diagram

Then simulate that there is no fault in the transmission line, and the TV single-phase disconnection (A phase). The simulation model of the transmission line is shown in Figure 10,

ISSN: 2664-9640

the action curve of is shown in Figure 11, and the impedance circle and measured impedance are shown in Figure 12.

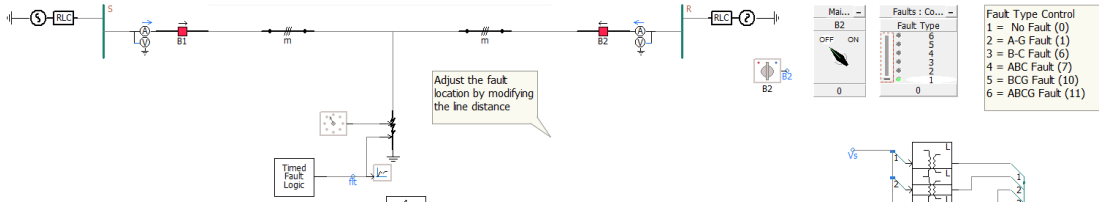

Figure 10 No fault, transmission model diagram of TV single-phase (A-phase) disconnection

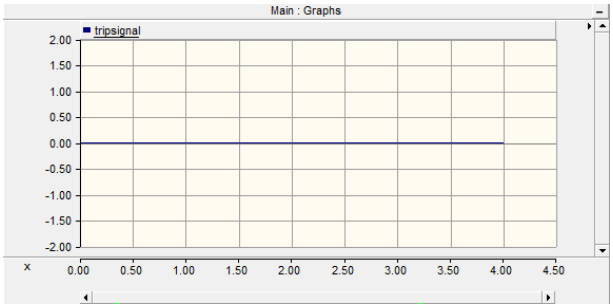

Figure 11 Action curve diagram of B1

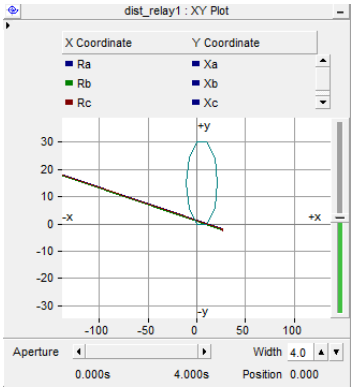

Figure 12 TV single-phase broken line impedance circle and measurement impedance diagram

Finally, there is no fault in the simulated transmission line, and the three-phase TV is disconnected. The action curve of is shown in Figure 13, and the impedance circle and measured impedance are shown in Figure 14.

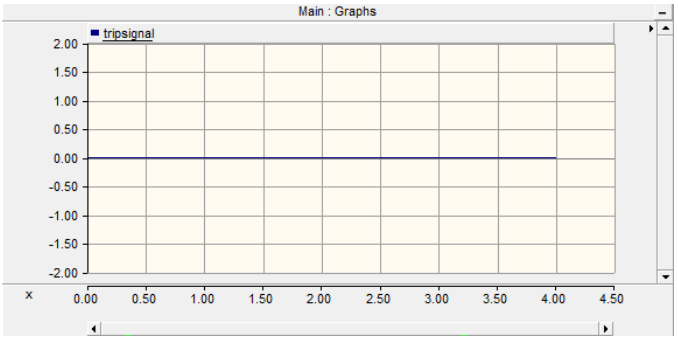

Figure 13 Action curve diagram of B1

ISSN: 2664-9640

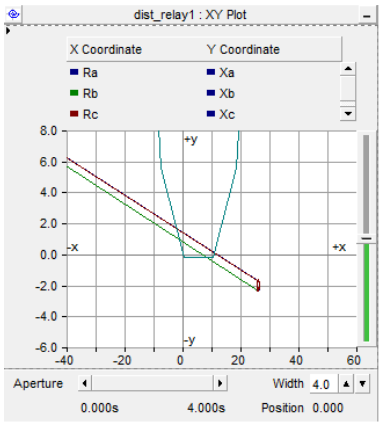

Figure 14 TV three-phase broken line impedance circle and measurement impedance diagram

According to the simulation results, when the secondary side wiring of the voltage transformer is normal and the transmission line fails, the distance protection and the TV disconnection blocking logic cooperate. At this time, the measured impedance passes through the impedance circle, and the protection device B_1 can operate correctly. In the event of a fault, whether the TV three-phase disconnection or the TV single-phase disconnection, when the measured impedance passes through the impedance circle, and after the logic operation of the blocking logic and the distance protection, the protection device B_1 does not operate reliably, which verifies the reliable anti-maloperation of the blocking logic.

6. Conclusion

This paper analyzes the cause of the accident by analyzing the accident caused by the TV disconnection and not blocking the automatic protection device during the power transmission operation of the 110kV substation, and then takes relevant solutions, not only to improve the device itself, but also to consider the TV Criteria for disconnection, etc. Finally, the logic criterion model of the coordinated action of TV disconnection and distance protection is built in PSCAD/EMTDC simulation software, which verifies the reliability of the solution.

References

[1] Han Xiao. Power System Relay Protection [M]. Beijing: Machinery Industry Press, 2005.

[2] Guo Angxiao. Analysis of PT disconnection problem of 220 kV busbar and reconstruction of secondary circuit[J]. Electrical Technology, 2020(18):108-109+111.

[3] Shen Jun, Zhang Hongxi, Wang Zhong, et al. A case of distance protection malfunction and solutions [J]. Electric Power Engineering Technology, 2017, 36(03): 100-104.

[4] Xue Feng, Yin Wei, Pan Qi, et al. Coping strategy for TV disconnection and faulty action when distance protection starts first and then TV disconnection when fault outside the zone[J]. Electrical Application,2016,35(24):63-65+85 .

[5] Ge Junshan, Wang Yonghui. Research on the influence of voltage transformer disconnection on distance protection and countermeasures [J]. Electrical Measurement and Instrumentation, 2016, 53(21):106-109.

[6] She Qingju. Talking about the influence of TV disconnection on relay protection and countermeasures [J]. Science and Technology Wind, 2014(24):43.

[7] Huang Shu, Ma Kai, Tan Shufeng. Malfunction analysis and solution of distance protection for a certain line mutation[J]. Power Grid and Clean Energy, 2013,29(03):30-32+38.

[8] Xing Ruijiang. Cause analysis of a special TV disconnection and misoperation event[J]. Electrical Technology, 2008(09):67-68.

ISSN: 2664-9640

[9] Liang Guangyu.PT disconnection and oscillation blocking[J]. Power System Protection and Control, 2008(15):82-84.

[10] Wei Wenxiang, Huang Yuan, Zhang Min. Analysis and application of TV disconnection based on the principle of voltage amplitude comparison [J]. Electrical Application, 2008(11):71-73.

[11] Xu Jian'an.Analysis of PT secondary disconnection and blocking [J]. Water Conservancy Science and Technology, 2008(01):58-59+61.