Study on Calculation Approach for Setting of Adaptive Three-Section Triad Distance Protection

Jianjun Xu, Qiangnan Du, Lili Bai *

School of Electrical Engineering & Information, Northeast Petroleum University, Daqing 163318, China

Abstract. In order to solute the coordinate questions of three-section distance protection, this article combined with the characteristics of setting approach studies the setting approach in transmission lines distance protection. The protection setting approach of adaptive distance protection II and III section is proposed and is also verified by examples. The value of K_{sen}^{II} in distance protection II is increased from 1.92 to 1.95 and from 0.95 to 1.35 in distance protection III, so the reliability of the line protection is further improved.

Keywords: distance protection; adaptive protection; setting approach; three-section protection.

1. Introduction

Power system transmission lines are usually equipped with distance protection, the protection includes section I of fast moving distance and delayed section II of distance. In other countries, the second section of the distance protection setting adjacent to the shortest line within a certain range[1], then it is used as back-up to protect the adjacent line, the rest of the distance between adjacent lines is under the protection of distance section III.

Since delayed tripped fault line causes the system suffered a severe blow, thus hopefully that section II of distance as backup protection for longer range. However, it must not affect the main protection and under the cooperation of distance II and III section. To solve this problem, this essay combines ask setting calculation features, setting calculation algorithm to study proposed three-stage adaptive distance protection setting calculation algorithm, and the algorithm is verified by an example. It greatly improves the scope of protection of the distance protection.

2. The setting calculation principle of traditional three-section triad distance protection and its shortage

As shown in figure 1, generally according to the principles of escape by the next short-circuit at the exit. Section I distance protection setting value is:

$$Z_{act\cdot 1}^{\mathrm{I}} = (0.8 \sim 0.85) Z_{AB} \tag{1}$$

In the equation: $Z_{act\cdot 1}^{\mathrm{I}}$ --setting value of section I which protects 1; Z_{AB} --Impedance of the line AB.

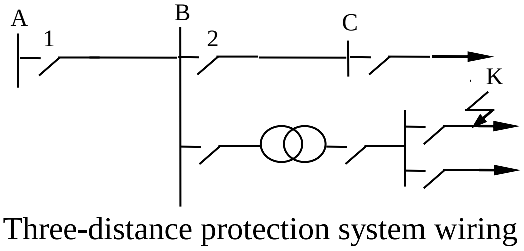

Figure 1 Three-distance protection system wiring diagram

Setting value for which distance protection should be match to adjacent wire, and then consider the influence for branching factor K_{bra} , we can calculate by the following formula.

$$Z_{act\cdot 1}^{\mathrm{II}} = K_{rel}(Z_{AB} + K_{bra} Z_{act\cdot 2}^{\mathrm{I}}) \tag{2}$$

Impedance relay is employed in use for distance protection Ⅲ , consider that the external malfunction has been disconnected, in the condition of the electric generator auto launch, the protection Ⅲ has to command for immediate return, as well to employ the formula:

$$Z_{act\cdot 1}^{\text{III}} = \frac{1}{K_{rel}K_{Ms}K_{re}} Z_{L\cdot\min} \quad (3)$$

In the formula above, the reliability coefficient K_{Ms} , the self start coefficient K_{re} , both are over the value of 1.

There are several factors which can impact the transition resistance, system shock, compensation capacitor in series from protecting the short circuit, to make the effect of conservation imperfect [2], for instance, it only can protect the protection wire and cover 80-85%; it employs complex impedance relay from distant protection, many accessorial relay and each kind of locked equipment, therefore, it has low reliability. In this end, the text provides a way of calculation for three-stage adaptive protection.

3. Calculation approach for setting of adaptive three-section triad distance protection

3.1 Calculation approach for setting of adaptive II section distance protection

As the figure 2 shown, the R_{BK} provides a back-up protection for tuning, Rpri and circuit BCi is major protection Ⅰ, use the method of tuning to protect R_{BK} Ⅱ , the following steps are:

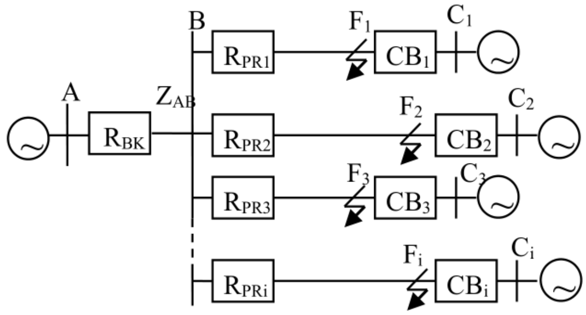

Figure 2 Segment II distance tuning fault point

(1)The pre-operating status in obtaining for electrical system (Topology, Flow distribution). Three short-circuit happened in the end of BCi I of circuit, and Breaker CBi disconnected.

(2)Use the point Fi to short circuit R_{BK} measured to determine the start impedance of II section distance.

$$Z_{act\cdot 1}^{\text{II}} = Z_{AB} + K_2 \times (Z_A - Z_{AB}) \quad (4)$$

Among them: $Z_{act\cdot 1}^{\text{II}}$ is the setting value protecting R_{BK} section Ⅱ distance; Z_{AB} is an impedance of line AB;K_2 is the percentage protecting adjacent circuit of distance Ⅱ ;Z_A is an apparent impedance protecting R_{BK} measurement; When point Fi shorted, protecting R_{BK} measurements are viewed infinite, thus $Z_{act\cdot 1}^{\text{II}} = 1.2 \times Z_{AB}$.

(3) When the other end of the line I shorted, repeat the above steps (1) and (2).

(4) Select the step (2) to step (3) to calculate the minimum distance II segment setting point.

(5) Calculating at the time to protect the scope of protection of section R_{PRi}I ends apparent impedance faults.

(6) Setting value comparison step (5) protection RBK apparent impedance measurements and step (4) as determined whether the observed protection distance II RBK segment can action.

(7) In step (6), if the protective action, the II segment setting point is reduced to a step (6) 90% determined by the smallest fault impedance.

(8) To determine the setting value of other distance protection section II in the system, repeat step (1) to step (7).

3.2 Section III adaptive distance protection tuning algorithm

(1) Firstly, using the voltage and current sampling values a week before the first use, then calculating the link voltage load current.

(2) Calculating protected installed actual load impedance Z_L .

$$Z_L = \frac{U_L}{\sqrt{3} I_L} \tag{5}$$

(3) Calculating the actual load impedance tuning avoid setting point: $Z_{act\cdot 1}^{\text{III}}$

$$Z_{act\cdot 1}^{\text{III}} = \frac{1}{K_{rel} K_{Ms} K_{re}} Z_L \tag{6}$$

In the equation: K_{rel} --Reliability Coefficient; K_{Ms} --Start coefficient; K_{re} --Return Coefficient.

(4) Calculating $Z_{act\cdot 1}^{\text{III}}$

$$Z_{act\cdot 1}^{\text{III}} = K_{rel}\left(Z_{AB} + K_{bra\cdot \min} Z_{act\cdot 2}^{\text{II}}\right) \tag{7}$$

In the equation: $K_{bra\cdot \min}$ --Branch coefficient minimum; Z_{AB} --impedance of line AB; $Z_{act\cdot 2}^{\text{II}}$ --Setting value of section Ⅱ of adjacent line of AB.

(5) Comparing the setting value in step (3) and step (4), if the value in step (3) is greater than that in the step (4) , then using the value in step (4); conversely, taking the value in step (3).

4. Examples

As shown in Figure 3, a transmission system, which uses a three-phase short circuit for protection. Parameters are: Every minute in line impedance is $Z_1 = 0.45\Omega / km$, maximum load current of line AB, BC is 400A, The power source potential is E=115KV, Fault voltage a week before is $U_L = 112.7KV$, load current is $I_L = 300A$, $K_{rel}^{\text{I}} = 0.8$, $K_{rel}^{\text{II}} = 0.7$, $K_{rel}^{\text{III}} = 1.2$, $K_{Ms} = 1.8$, $K_{re} = 1.3$, $Z_{sA\max} = 10\Omega$, $Z_{sA\min} = 8\Omega$, $Z_{sB\max} = 30\Omega$, $Z_{sB\min} = 15\Omega$.

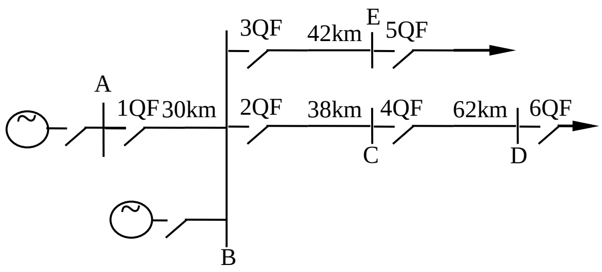

Figure 3 Schematic diagram of a transmission system

Calculate distance protection Ⅱ segment setting value according to the traditional algorithm and adaptive algorithm, the results shown in Table 1.

Table 1 Setting Value of Distance Protection Ⅱ segment(Ω)

	Traditional algorithms	Adaptive Algorithm
$Z_{act\cdot 1}^{\text{II}}$	25.91	26.33

According to the sensitivity of the distance protection section Ⅱ formula (2) can be obtained by comparing the sensitivity of the two methods, as shown in Table 2. Seen from Table 2, the adaptive algorithm improves the sensitivity protection Ⅱ segment, but also expanded the scope of protection.

Table 2 Distance of section Ⅱ protection sensitivity

	Traditional algorithms	Adaptive Algorithm
K_{sen}^{II}	1.92	1.95

After completing the distance protection Ⅱ tuning segment, according to the traditional algorithm and adaptive algorithm to calculate the distance protection Ⅲ segment setpoint, the results shown in Table 3, the setting value can not be seen from the advantages of the adaptive algorithm.

Table 3 The distance protection Ⅲ segment setting value(Ω)

	Traditional algorithms		Adaptive Algorithm	
	543	47.43	77.78	47.43
$Z_{act\cdot 1}^{\text{II}}$	47.43		47.43	

Sensitivity backup protection from near and far to test the sensitivity of backup protection for both methods.

When as a near backup,

$$K_{sen}^{III} = \frac{Z_{act\cdot 1}^{III}}{Z_{AB}} \tag{8}$$

When as a far backup,

$$K_{sen}^{III} = \frac{Z_{act\cdot 1}^{III}}{Z_{AB} + K_{bra\cdot\max} Z_{BC}} \tag{9}$$

In the equation: $K_{bra\cdot\max}$ --Maximum branching factor; Z_{BC} --BC adjacent line impedance.

According to equation (8), it has been their near backup protection sensitivity, as shown in Table 4; according to the equation (9), got their sensitivity remote backup protection, as shown in Table 5. As the near back-up protection to meet the requirements of sensitivity, as the BC line remote backup protection, but can not meet the requirements of sensitivity, so the setting value of the two methods should be re-selected, as shown in Table 6. According to the new setting value, according to equation (9) revalidate remote backup sensitivity, as shown in Table 7.

Table 4 The distance protection of Ⅲ near backup protection sensitivity

	Traditional algorithms	Adaptive Algorithm
K_{sen}^{III}	3.51	3.51

Table 5 The distance protection of Ⅲ far backup protection sensitivity

	Traditional algorithms	Adaptive Algorithm
K_{sen}^{III}	0.83	0.83

Table 6 The distance protection of section Ⅲ of the new setting value(Ω)

	Traditional algorithms	Adaptive Algorithm
$Z_{act\cdot 1}^{III}$	543	77.78

Table 7 Distance Protection of New Ⅲ remote backup protection sensitivity

	Traditional algorithms	Adaptive Algorithm
K_{sen}^{III}	0.95	1.35

As can be seen from Table 7, remote backup protection, the adaptive algorithm has been greatly improved sensitivity allows to meet the requirements.

5. Conclusion

Adaptive distance protection algorithm is which when the power system changes (including operating mode, topology, fault type and line load changes, etc.), the protection device/system automatically modified online protection setting value, to get the best protection adaptive performance. The main advantages are:

(1) distance Ⅱ adaptive tuning algorithm does not require segment and the adjacent line segments with Ⅰ tuning, in addition, it increases the sensitivity of the protection Ⅱ segment, but also expanded the scope of protection.

(2) Section Ⅲ adaptive distance communication channel tuning algorithm does not require, but also improves the sensitivity protection Ⅲ segment, but also expanded the scope of protection.

(3) Adaptive distance protection algorithm greatly improves the scope of protection, the line to protect the reliability has been further improved. In support reliable communication system, a wide range of applied in engineering practice is possible.

ACKNOWLEDGEMENT

This work was supported by Youth Science Foundation of Northeast Petroleum University (NO: NEPUQN 2014-04).

Reference

[1] Xu Jianjun, Yan Limei. Brittleness Simulation of Electric Power Systems Based on Chart Theory[J], Dynamics of continuous discrete and impulsive systems-series A-mathematical analysis, 2007.7:2348-2351

[2] Yan Limei, Zhu Yusong, Xu Jianjun, et.al. Transmission Lines Modeling Method Based on Fractional Order Calculus Theory[J]. TRANSACTIONS OF CHINA ELECTROTECHNICAL SOCIETY, 2014 ,Vol.29,No. 9:260-268 (In Chinese)

[3] YAN Li-mei, CUI Jia, XU Jian-jun, et.al. Power system state estimation of quadrature Kalman filter based on PMU/SCADA measurements. Electric Machines and Control. Vol.18 No.6, June 2014: 78-84. (In Chinese)

[4] YAN Limei, XIE Yibing, XU Jianjun, et.al. Improved Forward and Backward Substitution in Calculation of Power Distribution Network with Distributed Generation[J]. JOURNAL OF XI’AN JIAOTONG UNIVERSITY, Vol.47, No.6, p117-123, Jun.2013 (In Chinese)