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The simulation of the closed-loop operation of 10KV power distribution network by PSCAD software

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ABSTRACT

The power distribution network in China's power system usually adopts closed-loop design and open-loop operation for power supply. When the power distribution network needs to be maintained, the closed-loop operation is generally adopted for load "hot inversion". This paper mainly takes the 10KV power distribution network in the 13th five-year plan project of FuZhou city power grid in JiangXi province as an example, and simulates it based on PSCAD/EMTDC. To solve the problem that the relay protection device may misoperation due to the inrush current during the closed-loop operation of the distribution network, and ensure that the phase difference in the both sides of the closed-loop point is minimum, or adjust the transformer connection to reduce the voltage difference between the two sides of the closed-loop point to reduce the current ,reduce the incidence of accidents, improve the security and reliability of 10 kv power distribution network.[1]

Keywords: Pscad/Emtdc, power distribution network loop operation, relay protection, inrush current phenomenon

1. INTRODUCTION

1.1 Development background in foreign countries

The international conference about power distribution networks, held in Belgium in 1983, discussed the design and planning of utility power systems, industrial power grids, power distribution networks, cabling and overhead lines, transformer substation equipment and distribution network management and monitoring systems. This conference puts forward the planning and construction of power distribution network based on the power supply requirements of distribution network to improve the reliability of actual operation of distribution network.

Abroad, the research on power supply of distribution network is generally early, and the knowledge and theoretical system is relatively complete and mature. As early as 1998, the power supply reliability of medium-voltage distribution network in Britain had reached 99.988%, that of other countries, such as 99.984% in America, 99.991% in France, and 99.999% in Tokyo electric power company in Japan.

Developed countries in Europe have perfect power distribution networks with advanced systems and high degree of automation. The remote monitoring of distribution station, circuit breaker and line segment switch has been basically realized. It has basically completed the rules and procedures for the maintenance of distribution network abnormalities and faults. Through the use of distribution GIS system to reasonably deal with distribution network scheduling, power failure complaints, fault treatment and repair, improve the degree of automation of the system. For example, the 20kV medium-voltage distribution network in the distribution network system in France has been basically automated; the Italian ENEL company has more than 80,000 low-voltage switching and closing in the country, it has realized the remote operation of all the distribution networks in the country; the distribution automation system has been built in Berlin, Germany in 2009, reducing the average annual power outage time from 72 minutes in 2008 to 14 minutes in 2009

1.2 Development background in China

Due to the late start and other factors, China's power facilities lag behind the development of foreign countries, and the domestic distribution network and distribution network automation are relatively weak compared with other basic power grid construction.

As early as the end of 2004, the state grid proposed the strategic goal of building a strong smart grid with ultra-high voltage network as the backbone and coordinated development of power grids at all levels. This concept was formally put forward in the 2009 UHV(Ultra High Voltage) power transmission conference, i means China began to plan and carry out the upgrade and transformation of smart grid from 2009.The goal is to have the agreed strong power grid fully operational by 2020.[4]

At present, the 10KV distribution network has been built in some parts of China, however, it is still in the exploratory stage to establish a complete and advanced criterion of closed-loop operation in distribution network. With the developmentÿconstruction and popularization of power grid planning, it is necessary to establish a simulation model for the 10KV power distribution network in order to further improve the reliability of power supply.

WORKING PRINCIPLE OF 10KV NETWORK POPULAR IN CHINA

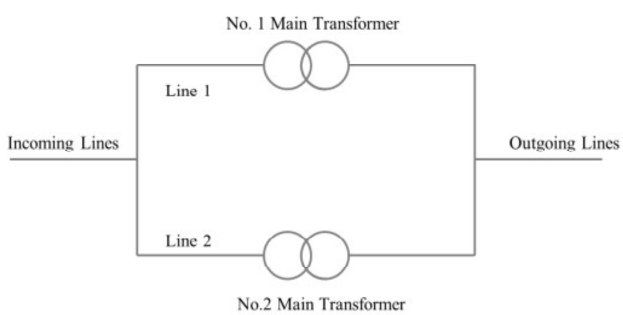

Fig 1 schematic diagram of 10KV ring network working principle

In this paper, two high voltage lines and two transformers constitute a ring power supply network for example: line 1 is connected to the no.1 transformer, line 2 is connected to the no.2 transformer, and the Ring Main Unit is installed to form a ring network power supply line. When the first line or the first transformer needs to be repaired or fails, the power can be supplied by switching the line to the second line and the second transformer. When line 2 or transformer 2 needs to be repaired or fails, power supply can be carried out by switching the line to line 1 and transformer 1 to improve the reliability and continuity of power supply.

1.3 Safety provisions of closed-loop operation

During the function of 10KV distribution network, when the closing ring is needed, the uninterrupted loop switching technology should be adopted, Through the corresponding switch, the power supply lines are interconnected according to a certain rule or frequency, forming a closed-loop, and realizing the uninterrupted transfer of voltage load. Generally, the closed circuit has the same voltage class, but it contains transformers of various voltage classes, so the voltage class of the closed circuit is different. If closed loop and break loop technology is adopted, the power flow distribution, technical operation and system shall be ensured to meet the rated standard of component load and meet the following safety requirements stipulated by China[2]:

1) during the closed-loop operation, it is necessary to ensure the phase uniformity of the closed-loop point and to determine the specific position of the phase points before and after the closing operation so as to ensure that no phase point changes occur after the system overhaul or the first closing operation.
2) in the electromagnetic ring network, loop closing operation shall be carried out when there is no group difference in the transformer boundary of the ring network.
3) make corresponding predictions for system components to avoid overload during the closed-loop operation.
4) during the operation of electric power system, the voltage difference of busbar between the closed-loop point shall be limited to no more than 9%.
5) ensure that the safety automatic device and relay protection device can be compatible running in the ring network.
6) ensure that the stability of 10KV distribution network meets the requirements during operation.
7) ensure that the frequency difference during grid operation is not more than 0.1Hz.

Before closed-loop operation, the voltage amplitude difference and phase Angle difference on both sides of the closed-loop point should be adjusted to the minimum. For example, the allowable range of amplitude difference of 200KV ring network system is 20% to 30%, the allowable range of load phase Angle difference of 500KV ring network system is 10% to 20%, and the allowable range of load phase Angle difference is not more than 20°.

closed-loop operation must ensure that the phase is the same, and the power flow of each link after loop closing meets the requirements of relay protection, system stability and equipment capacity.

1.4 Common Technical problems about the closed-loop operation

Closed-loop operation will change the original network results, and there are many uncontrollable circumstances, leading to a danger and many uncertain factors to closed-loop operation. Therefore, this paper lists several common improper operation situations:

1) non-synchronous closing: since all 10KV switches in the distribution network are not equipped with corresponding synchronous switches, attention should be paid to this question. and single power supply does not have this problem.
2) phase sequence and phase difference do not meet the requirements, leading to the failure of closed-loop operation, so ensuring phase sequence and phase difference is one of the prerequisites for closed-loop operation.
3) when the closed-loop of voltage vector and the total impedance of ring network does not meet to the requirements. It also means when the equipment is overloaded for closed-loop operation will change the original network structure. After the loop closing operation, the current flowing through the electrical equipment in the line is far greater than the safety current of the equipment, which may cause the electric ring network and the complex electromagnetic ring network, and endanger the life safety.
4) when closing the loop, there will be a huge impact current. When the impact current reaches the action condition of the relay protection device, the corresponding protection action will be triggered. However, too much current change before and after loop closed will lead to failure of ring closing operation or even make closed-loop operation very dangerous.
5) after the closed-loop operation of the distribution network, the network structure and state will change correspondingly, which may lead to the misoperation of the relay protection device, thus making the network structure more complex and chaotic.
6) after the closed-loop operation of the distribution network, due to the change of the short-circuit impedance, there will be short-circuit and other situations, resulting in a huge short-circuit current that will impact the electrical equipment in the line, and too large short-circuit current will damage the electrical equipment and affect the service life.

The main reason for these technical problems in the process of closed-loop operation is that when the non-standard closed-loop operation is carried out, there will be a large impulse current on both sides of the closed-loop point, which will increase the closing loop current. If the closure process fails, the closure current is then analyzed and a mathematical model is established. To analyze the causes of these technical problems. Next, we will analyze the loop current and establish the relative mathematical model. To analyze the causes of these technical problems. During the simulation of power distribution network closed-loop operation, the above improper operations will also be carried out to analyze the simulation results. The short-circuit impedance after closing the loop involves the principle of power flow distribution, which I will also mention below.

2. MATHEMATICAL MODEL OF CLOSED LOOP CURRENT

The calculation of the closing loop current includes the calculation of the impulse current occurring at the moment of operation of the closing loop and the circulating current after the closing loop.

2.1 Calculation of circulating current

We define I as the current on the line before closing the loop, I' as the total circulating current on the line after closing the loop, and I_c as the steady-state circulating current caused by the differential pressure on both sides. Assuming that the pressure difference between two sides does not change in the process of loop closing, according to the superposition theorem, the expression of total circulating current can be obtained as follows.

$$\dot{I}' = \dot{I} + \dot{I}_C \qquad \text{Formula (1)}$$

$\dot{I}$ need to record before closing the loop, the total impedance in the loop network can be calculated, and the voltage vector difference on both sides of the closing point can be divided by the total impedance of the loop network. $\dot{I}_C$ $\dot{U}_{OC}$ Z_{EQ} Z_{EQ} can be obtained by adding the total resistance and total inductance in the ring network, and the expression of, is as follows $\dot{I}_C$ Z_{EQ}.

$$Z_{eq} = R + j\omega L \qquad \text{Formula (2)}$$

$$\dot{I}_C = \frac{\dot{U}_{OC}}{\dot{Z}_{EQ}} \qquad \text{Formula (3)}$$

$\dot{U}_{OC}$ is the voltage vector difference on both sides of the closing ring point;

$Z_{EQ}$is the total impedance of ring network;

2.2 Calculation of impulse current

Because the power system is symmetrical in three phases, the analysis with either phase will not affect the final results. As an example of A phase instantaneous impulse current generated by the analysis of closed loop operation, closed-loop operation from transient to steady state, this process is A process of oscillation damping, and the network is the presence of inductive components, impact current itself with periodic and aperiodic component, so you can establish time-domain differential equation to solve closed loop in the process of impulse current.

$$\dot{U}_{OC} = E_m \sin（\omega t + \alpha） = R i_t + L\frac{di_t}{dt}$$

Formula (4)

E_m is the amplitude of the $\dot{U}_{OC}$ equivalent potential;

ω is the rated angular frequency of the system;

α is the initial phase Angle which is the phase Angle when$t = 0$ÿ

$i_t$is the instantaneous value of current at the moment of closing loop;

t is the time after closing the loop;

$L\frac{di_t}{dt}$ Voltage applied to the inductor element;

The general and special solutions of the nonhomogeneous differential equation are obtained by solving the upper differential equations.

The general solution of the equation is the aperiodic component of the closed loop current

$$i_{dc}（t） = e^{-（R/L）t}\left\{\frac{-E_m}{\sqrt{R^2+\omega^2L^2}}sin[\alpha - \phi]\right\} \quad \text{Formula (5)}$$

The particular solution of the equation is the periodic component of the closed loop current

$$i_{ac}（t） = \frac{E_m}{\sqrt{R^2+\omega^2L^2}}sin(\omega t + \alpha - \phi) \quad \text{Formula (6)}$$

E_m is the amplitude of the $\dot{U}_{OC}$ equivalent potential;

ω is the rated angular frequency of the system;

ϕ is the set factor Angle of impedance power which can be obtained by using formula(6) and $\phi = \tan^{-1}\left(\frac{\omega L}{R}\right)$;

The specific value can be obtained according to time by inserting the factor Angle of impedance power into the above equation. t According to the above equation, it can be known that the amplitude of the intermediate component of the closed loop current is

$$I_m = \frac{E_m}{\sqrt{R^2+\omega^2L^2}} \qquad \text{Formula (7)}$$

The impulse current is expressed as follows

$$i_t = i_{dc}(t) + i_{ac}(t) \qquad \text{Formula (8)}$$

$$i_t = -I_m e^{-(R/L)t}\sin[\alpha - \phi] + I_m \sin[\omega t + \alpha - \phi]$$

Formula (9)

It can be seen from the formula that the magnitude of the impulse current is affected by the amplitude difference and the phase Angle difference of the voltage. It can be seen that the effect of voltage phase Angle difference is greater. The purpose of the following simulation is to proceed from these two aspects. By reducing the phase difference of the voltage on both sides of the closed loop, the impulse current can be suppressed. When, is any number, the aperiodic component is zero, that is to say, the component that keeps the current from changing is zero, and the closed-loop circuit is about to enter the steady state. $\alpha - \phi = \kappa\pi$ Then, the impulse current reaches its maximum value. $\alpha - \phi = \frac{\pi}{2}$.

Therefore, the maximum instantaneous impulse current will occur at the second half of the operation period

$$i_{M=}I_M \bullet K_M = I_M\left(1 + e^{-0.01/\tau}\right)$$

Formula (10)

$\tau = \frac{L}{R}$ is the decay time constant of the aperiodic component of the closed loop current;

$K_M = \left(1 + e^{\frac{-0.01}{\tau}}\right)$ is the impact coefficient;

Since there may be a calculation error, we will introduce an error coefficient,, then the following expression for the maximum instantaneous impulse currentK_S, $K_S = 1.05$

$$i_{M=}K_S \bullet I_M \bullet K_M \qquad \text{Formula (11)}$$

$$K_S = 1.05 \qquad \text{Formula (12)}$$

K_S is error coefficient;

Finally, the effective value of the maximum instantaneous impulse current is

$$I_M = \frac{I_m}{\sqrt{2}}\left[1 + 2(K_S K_M - 1)^2\right]^{\frac{1}{2}} \qquad \text{Formula (13)}$$

The effective value of instantaneous impulse current can be obtained from the above formula, and the setting value of quick break protection in current protection can be set by using the effective value. In order to prevent the large moment impulse current caused by the current protection misoperation and affect the success of closed-loop operation

3. MODEL CONSTRUCTING AND RUNNING BASED ON PSCAD/EMTDC

3.1 Overview of the Development of 10KV distribution network in FuZhou city, JiangXi province

During the 13th Five-Year Plan period, FuZhou will invest 4.373 billion yuan to build its power facilities. According to the plan, Fuzhou will build a modern smart power grid with 1000KV as the support, 500KV as the backbone, 220KV as the main grid frame and 110KV and below as the distribution network. In 2020, the 220KV substation will be fully covered, the power supply capacity will be doubled, the supporting capacity of the power grid will be comprehensively improved, and the power supply guarantee level of the industrial park will be improved. Basically solve the long-term "low voltage" problem, effectively meet the economic and social development and the increasing demand for electricity. And according to the national planning direction, can make the power resources constitute more environmental protection and health, vigorously develop the wind power facilities in JiangXi province. "The old urban area is the urban center of Fuzhou urban area. After a period of development, this part has reached a good and stable level. Because the 12th Five Year Plan and transformation, in addition to remote areas, is still a rare single line formÿ lines and switching stations have been built to connect lines at the same time, basically give priority to with double loop network connection mode, for economic development to a certain level, gradually formed double loop network, ring network and two for the power supply. Fuhe River as the boundary in Shangdundu town ÿline is a single radiation line, the reliability is not high. During the 12th Five-Year plan period, the power supply through the substation will gradually form the double-loop network hand-in-hand connection mode to meet the reliability requirements. Fubei district is mainly used for industrial electricity. There are two industrial parks here. The current situation is single radiation connection. Because the load in this area is very large increase, and the wiring is also relatively simple, the single radiation wiring is still adopted.

3.2 Liaison diagram and closing system diagram of JinChao 10KV ring network

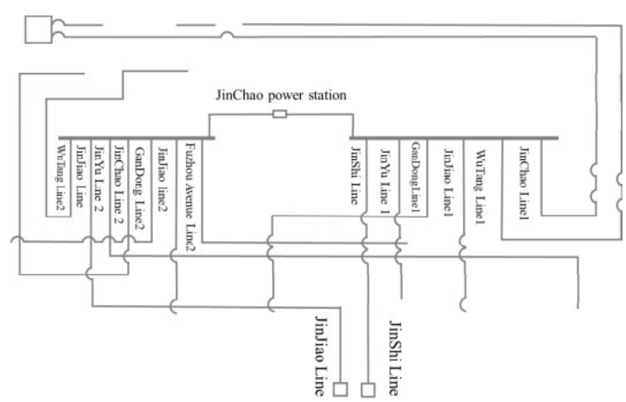

Fig. 2 contact diagram of ring network

Figure 2 is the electrical wiring diagram of 10KV loop network of JinChao power station.From JinChao get two power cord access platinum Shuian switching station JinChao line, WuTong first and second line access to platinum Shuian, JinChao substation and platinum Shuian erected by these few lines formed by switching station , once the JinChao first and WuTong first and second line need repair or malfunction, only need to remove the line of failure point , through platinum JinChao power station appears from the other side of the power supply to ensure the other except fault point load power supply, improve the reliability of power supply. radiation in the horizontal plane.

3.3 The simulation model based on the PSCAD / EMTDC software

3.3.1 Modeling

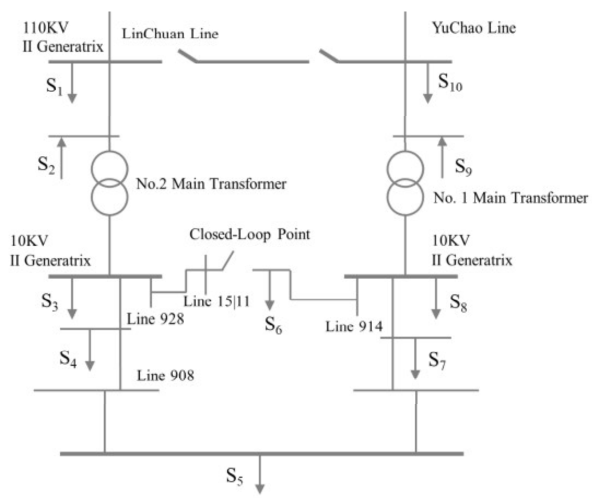

Fig.3 Power flow diagram of distribution network

According to figure 3, We used PSCAD / EMTDC software and relevant parameters such as the load power and bus voltages before closed-loop to build a simulation model of 10kV distribution network system, the change of current and other related parameters during the closed-loop operation of 10kV distribution network was simulated on the basis of the simulation model.

The line is often used as medium short distances of transmission line and short distances of underground cable for power supply. We used pi equivalent circuit to equivalent line and We chose coupled pi section instead of nominal pi section. Because the coupled PI section is closer to the actual use of JinChao 10KV Loop network in Fuzhou City in Jiangxi Province than nominal pi section and It can make the simulation result is closer to the real value. The couple pi section can provide the appropriate fundamental impedance, but it is not suitable to simulate other frequencies except the fundamental frequency. There will not affect the simulation experiment results in this paper.

According to figure 3, We selected two generator transformers are three-phase two-winding transformers with the same model and parameters of data plate, to promote the symmetry of distribution network operation. First, we chose the ideal transformer of three-phase two-winding transformers as the reference group referred to the corresponding component library of PSCAD/ EMTDC. The current was 120A after the simulation of closed-loop. Then We selected Nonideal transformer of three-phase two-winding transformers in the component library of PSCAD/EMTDC to simulate the real transformer in the closed-loop operation and We measured the current was 119A after the closed-loop operation. The error caused by the transformer is about 0.83%, which can be ignored. However, we still chose the nonideal transformer to eliminate instead of the ideal transformer which ignores Magnetized branch and only reserves equivalent series leakage reactance of transformer. We used PQ decomposition method to get the preliminary simulation results and use the modified equation to rearrange and simplify formula.

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}H & N\\ J & L\end{bmatrix}\begin{bmatrix}\Delta\delta\\ \Delta U/U\end{bmatrix} \qquad \text{Formula (14)}$$

Strong coupling between the reactive power and the voltage also between the active power and the frequency, so We neglected N and j in formula(14),and then simplified formula.

$$\begin{bmatrix}\Delta P\\ \Delta Q\end{bmatrix} = \begin{bmatrix}H & 0\\ 0 & L\end{bmatrix}\begin{bmatrix}\Delta\delta\\ \Delta U/U\end{bmatrix} \qquad \text{Formula (15)}$$

According to formula (15), We cloud calculate the power flow distribution of the line.

3.3.2 the simulation of closed-loop

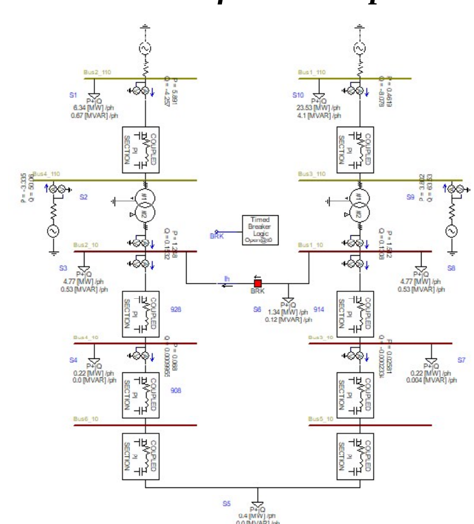

Fig.4 The building simulation model on PSCAD \ EMTDC software

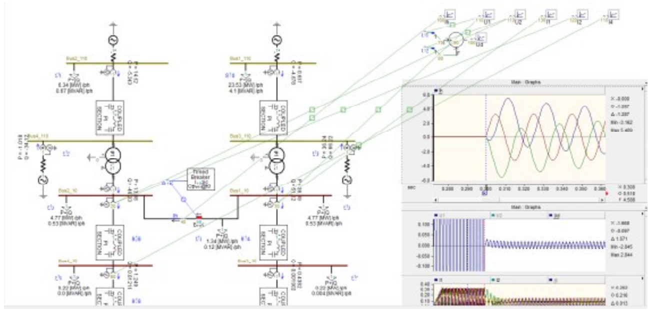

Fig.5 Multimeters in the simulation model for corresponding Parameters.

At two sides of the closed-loop, U1 and U2 are the voltage, U_d is the voltage difference, I1and I2 are the current. I_h is the closed-loop current.

According to figure 3, We built the simulation model which is shown in Figure 4 based on Power flow distribution. Rated voltages are 10KV of the generator transformer 1# and the generator transformer 2# . We referred datum to get the load flow distribution before closed-loop, as shown in table 1.

Table.1 the load flow distribution before closed-loop

P+jQ(MW,MVar)	P+jQ(MW,MVar)
S1:19.03+j2.01	S6:4.03+j0.36
S2:2.65+j4.13	S7:0.65+j0.012
S3:14.31+j1.6:	S8:14.31+j1.6
S4:0.65+j0.011	S9:2.65+j4.13
S5:0.12+j0.003	S10:70.6+j12.3

We simulated the operation of closed-loop in the 10KV looped network simulation model, the time of closed-loop was preset at 0.3s. We got the limp was 165A during the simulation and then the loop current was gradually stabilized at 120A. The error between 120A which loop current had shown as simulation and 119A which current is actual value was about 0.83%, so we thought the simulation model is reliable model.

The time of limp is very short for the purpose at hand. But it maybe cause malfunction of power System Relay Protection Equipment. We can use suitable time-delay relays and digital relays to prevent this kind of problems.

3.4 Parameter-Settings and analysis of simulation results

In the process of closed-loop simulation, the bus waveform and data was measured as follows:

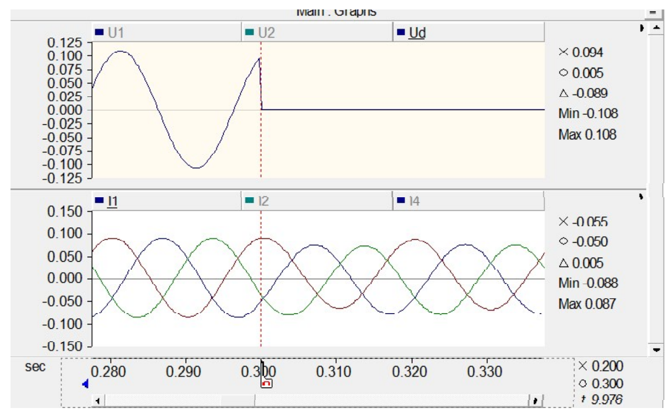

Fig.6 The current at two sides of closing point

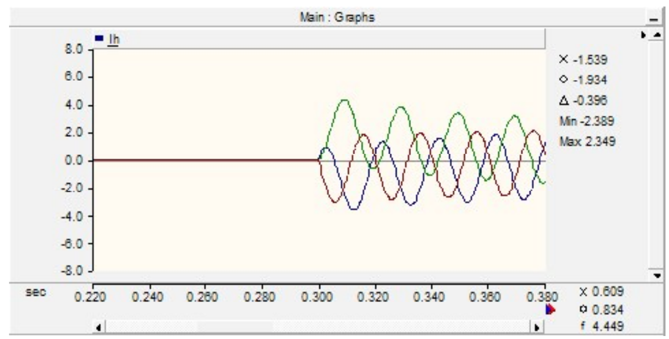

Fig.7 the waveform of closed-loop's current

Figure6's annotation: the time unit of abscissa is second, and the ordinate is the measured current.

We set the time of distribution network simulation model is 1s and made closed-loop occur in 0.3s. Then We measured the stable closed-loop's current was 87A. The symbols X and 0 separately represented the ordinates before and after closed-loop and the symbol ^{3}% is the difference between two moments. The Min was minimum current during the operation of closed-loop, instead, the Max was the maximum value of the current, namely limp, their unit two were KA.

As shown in Figure 6, the waveform of I1 and I2 were coincident, I1 and I2 separately represented section II bus current and sectiona!bus current of 10kV distribution network.

According to figure 7, The initial value of the current was 0, the current rised sharply from 0 to 2349A after 0.3s. It was consistent with the closed-loop occurred in 0.3s. Only after closed-loop can there be current in the line.

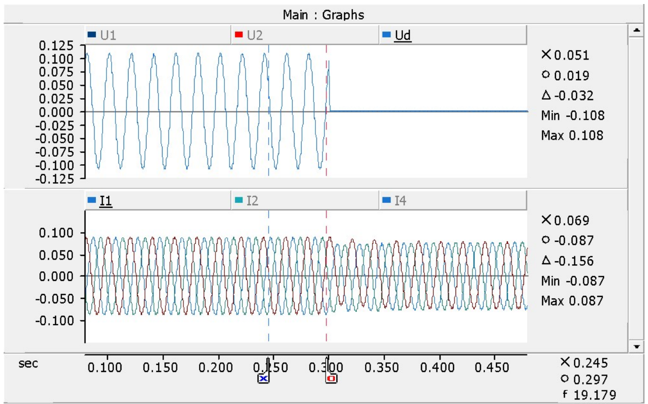

Fig.8 the waveform voltage difference and current of 914 line after closed-loop

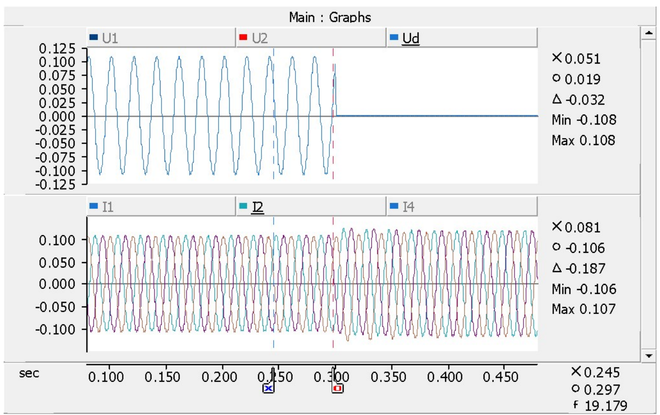

Fig.9 the waveform voltage difference and current of 928 line after closed-loop

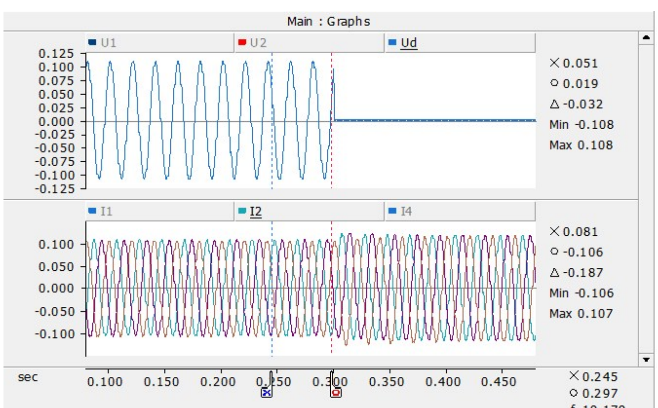

Fig.10 the waveform voltage difference and current of 908 line after closed-loop

According to figure 8, The current of the line 914 decreased from 87A to 69A compared with that before closed-loop, the voltage difference on two sides had changed to 0V since 0.3s, because of closed-loop.

According to figure 9, The current of the line 928 increased from 81A to 126A compared with that before closed-loop, the voltage difference on two sides had changed to 0V since 0.3s, because of closed-loop.

the horizontal plane and the direct radiation in the horizontal plane are obtained. By comparing with the query data, we can see that the model can accurately reflect the actual situation.

We measured the limp is about 107A in a series of simulation, so we thought the simulation model is built reasonably.

3.4.1 The analysis of voltage

We used PSCAD \ EMTDC to build the closed-loop operation model and found that the voltage difference before closed-loop in keeping with the rule, the voltage difference on two sides had changed to 0V since closed-loop, The circulating current at the point of closed-loop was mainly caused by the cycle power.

3.4.2 The analysis of current

The Magnitude of the limp and the steady-state current at the moment of closed-loop exceed the threshold value of current quick-break protection, and then automatic reclosing was switched after the instantaneous overcurrent protection. Because the amplitude difference and phase difference of the voltage on two sides of the closed-loop still existed, the current of the line 1511 could not decrease. According to figure 8, the current had exceeded the threshold of circuit two-stage protection which delay action after little time such as 0.5s. However, the current of point 6 in the line 1511 rapidly increased caused the line trippingÿit made circuit two-stage protection cannot be switched. According to figure 9, the current of the line 908 was smaller than the threshold of current quick-break protection. If the current quick-break protection was not switched immediately when the flashy flow occurred in the line 914, it maybe cause accidents. Finally, we thought when the voltage difference at two sides of closed-loop exceed the corresponding threshold, then the circulating current become the flashy flow cause of the switching of relay protection equipment, it maybe damage to electric accessories and affect the safety and reliability of the power grid working. When we hoped the current of closed-loop operation was reasonable, we needed to take action to reduce the voltage difference of the bus line and the branching line.

4. THE ANALSIS OF IMPACT FACTORS ON CLOSED-LOOP CURRENT

4.1 The influence of voltage difference on two sides of closed-loop on current

The amplitude of the circulating current is related to the voltage difference. We built the closed-loop model based on PASCAD\EMTDC investigate the influence of various voltage difference on closed-loop current. We set up the voltage difference more than 20% in the simulation, then we measured the voltage difference at two side of closed-loop was 10.5KV and 15KV, the current in the line was 3797A which is the Max as shown in the figureÿbecause the value of current was too high to keep electric accessories working. According to the rule, we should not to make the voltage different more than 20%, and then we can operate in safe environment. So it is important to ensure the voltage difference up to specification which can effectively limit current for the purpose at hand.

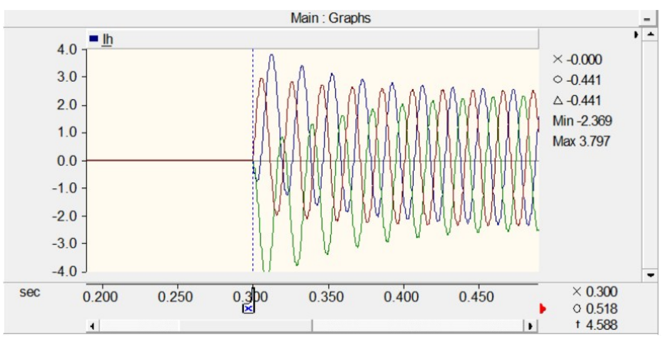

Fig.11 the voltage difference at two sides of closed-loop

If we changed the value of the voltage difference at two sides of closed-loop to 10.5KV, the circulating current was small and stable, it would the safety and reliability of closed-loop operation. it was thus clear that the closer the value of the voltage difference and the safer the operation of closed-loop.

4.2 The influence of the frequency difference on two sides of closed-loop current

There are always the frequency difference and the voltage difference at two sides of closed-loop for the purpose at hand. We built the model to simulate the frequency difference to investigate the influence of various frequency difference and phase-angle difference on closed-loop current.

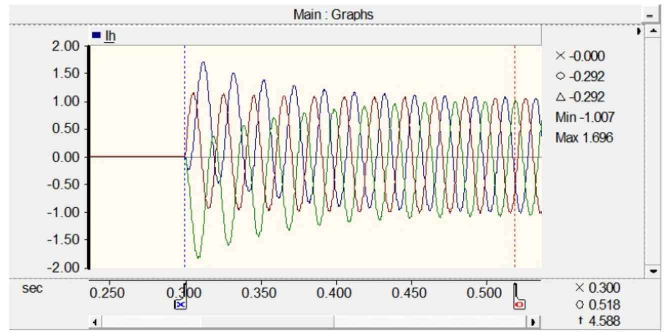

Fig.12 The simulation of the frequency difference at two sides of the close-loop

We changed the frequency difference at two sides of the close-loop though changed the frequency of the AC power. When we set up the frequency at two sides of the AC power was 50Hz and 49.9Hz. According to figure 12, the limp was 1697 A. Even if the frequency difference was only 0.1Hz, it was very harmful to the whole system. So we should not ensure the frequency difference more than 0.1Hz to operate the close-loop.

If the phase difference is too large, it will generate a large current. It is very dangerous to operate in this in this case. The phase angle difference between the two sides of the closed-loop is affected by the parameters of the system and the distribution of the power flow. In this paper, we used good modified equations to reduce the phase angle difference between closed-loop in the 10KV closed-loop simulation model. The phase difference was reasonable in the simulation every time. So we thought the simulation model is reliable model.

4.3 The influence of electric accessories on two sides of closed-loop current

The transformers as two sides of closed-loop will operate in parallel for a short time, so we should select transformers that meet the requirements:

1) The transformer unit should be as same as the another.
2) The impedance potential difference of transformers between closed-loop should less than 10%
3) The ratio of the maximum capacity to the minimum capacity of transformers should less than one third.
4) The turns ratio of transformers should be as the same as the another.

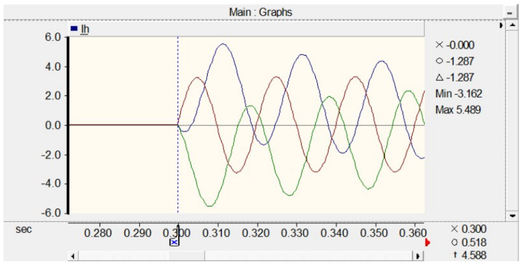

Fig.13 The simulation of 50% turns ratio of transformers at two sides of the close-loop

We verified the ideas above through the 10KV closed-loop simulation model and We changed the parameters to investigate the influence of various the turns ratio of transformers on closed-loop current. We changed the turns ratio of transformers to reduce 50%, the current increased rapidly and exceed the threshold, the maximum current was 5489A and the minimum current was 3162A during the simulation. In this case, even if the voltage difference and the frequency difference was reasonable, the large current would damage electric accessories even personal safety.

To summarize, we need check the phase sequence and the phase between the closed-loop, we need ensure the frequency and the amplitude of the power as the same as the another power before operation of the closed-loop.

For the purpose at hand, the working personnel make the phase A0B and C work separately through the phasing adjustment. When electric accessories saults or overhaul and maintenance, the working personnel should check the phase between the loop switch to ensure the phase is the same when they adjust voltage in the operation closed-loop.

Finally, we think the simulation model of 10KV closed-loop operation is an instructive experience for the purpose at hand.

CONCLUSION

We built the simulation of 10KV distribution network in Fuzhou City, Jiangxi Province based on PSCAD/ EMTDC. Then we measured the current 0voltage0 power of the closed-loop and so on, we needed judge if safety of the operation of the closed-loop according to parameters and waveform of the bus and line. It always occurs the flashy flow when the circulating current more than the threshold of relay protections. In this paper, We investigated the influence of the voltage difference0the frequency difference0the phase difference on the close-loop current, we presented the conclusion and recommendations about limit the current through changing the transformer tap which can reduce the voltage difference of the close-loop, we also needed ensure the frequency difference and the phase difference was reasonable. we think the simulation model of 10KV closed-loop operation is an instructive experience for the 10KV distribution network.

For the purpose at hand, we can effectively and safely guide 10kV closed-loop operation when we observe the procedures. It can not only reduce the outage frequency, but also improve the stability and continuity of the power supply. In fact, it can ensure that the load for level ‘!and a! will not power supply failure or interruption. And it can improve the convenience of residents’ lives as the load for level b! to improve the economy of power supply. We take Zhongshan City as an example, according to yearbooks, there are more than 1200 times of mesh ring switching power supply have been carried out since 2010. It is mean that outage time of each line reduce 15 minutes. The average load of each line usually is 3MW, so we can calculate that it produces 90000 KW/h electrical energy. According to 1KW/h electrical energy could be equivalent to the gross output value of industry about 22.14 yuan, and the socioeconomic performance was 6.35 in 2010 year. It could bring the benefit equivalent of the gross output value of industry and the gross output value of industry was 1.99 million yuan and 570 thousand yuan. So it is very important to be able to make mesh ring switching power supply efficiently and safely.

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