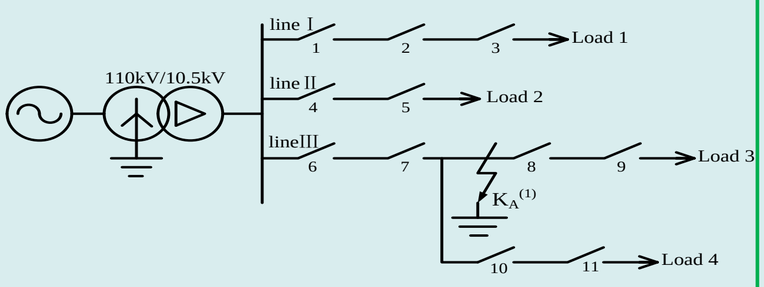
Single Phase Grounding Fault Location Method based on the Change of the Zero Sequence Current along with Compensation Degree

Qingpu Xiao Shandong University

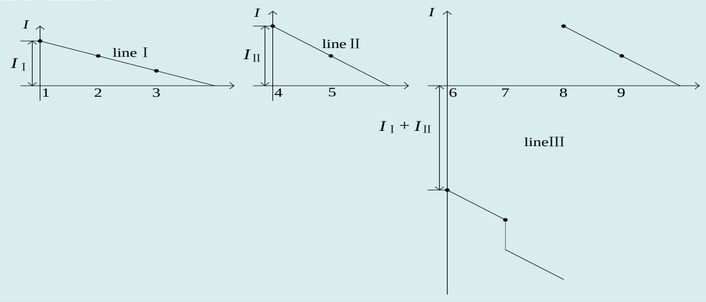
Abstract

This paper proposes a single phase grounding fault location method based on the change of steady state zero sequence current along with the compensation degree. Firstly, the distribution law of zero sequence current along the line for the single phase grounding fault in ungrounded system is analyzed. The correlation of the zero sequence current change with the compensation degree is also analyzed. Then the method of distinguishing grounding fault and disconnection fault is obtained. Finally, the fault location process is summarized.

Distribution law of zero sequence current along the line



The zero sequence current of fault path increases with the decrease of distance to fault point, and the direction of capacitive current is from line to bus. The zero sequence current on the non fault path decreases with the decrease of the distance to the end of the line, and the capacitive current flows from the bus to the line .

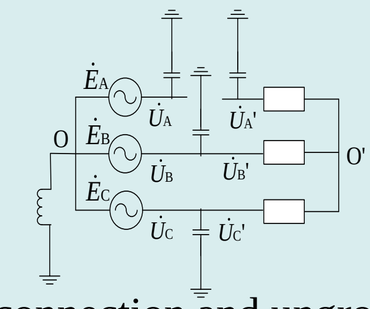


Influence of changing compensation degree on zero sequence current

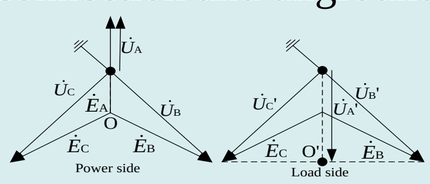
$$\begin{cases} \Delta I_1 = I_1' \cdot \dfrac{U_0}{U_0'} - I_1 = U_0' \cdot \mathrm{j}\omega C_1 \cdot \dfrac{U_0}{U_0'} - U_0 \cdot \mathrm{j}\omega C_1 = 0 \\ \Delta I_6 = I_6' \cdot \dfrac{U_0}{U_0'} - I_6 \\ \quad = U_0' \cdot [\dfrac{1}{3\omega L'} - \omega(C_\Sigma - C_6)] \cdot \dfrac{U_0}{U_0'} - U_0 \cdot [\dfrac{1}{3\omega L} - \omega(C_\Sigma - C_6)] \\ \quad = U_0 \cdot (\dfrac{1}{3\omega L'} - \dfrac{1}{3\omega L}) \end{cases}$$

If the zero sequence current before and after the change are converted under the same voltage, the zero sequence current on the non fault path is unchanged and the zero sequence current on the fault path is changed.

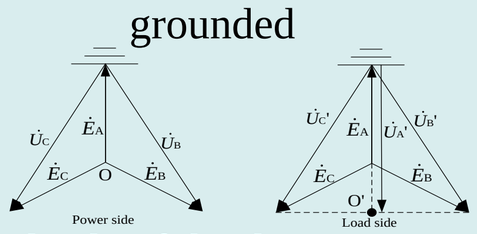
Distinction between grounding and disconnection



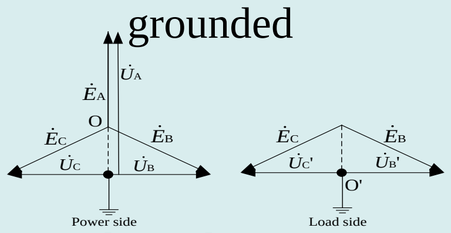
Disconnection and ungrounded



The power side of the disconnection is grounded



The load side of the disconnection is grounded



When one phase disconnection fault occurs in resonant grounding system, no matter whether it is grounded or not and which side is grounded, the zero sequence voltages on the power side and load side of the disconnection point are different.

Grounding fault location process

(1) When the zero sequence voltage $U_0 > 100\mathrm{V}$ and the zero sequence voltage U_i of all feeder terminals meet $0.95U_0 < U_i < 1.05U_0$, it is regarded as single phase grounding fault.

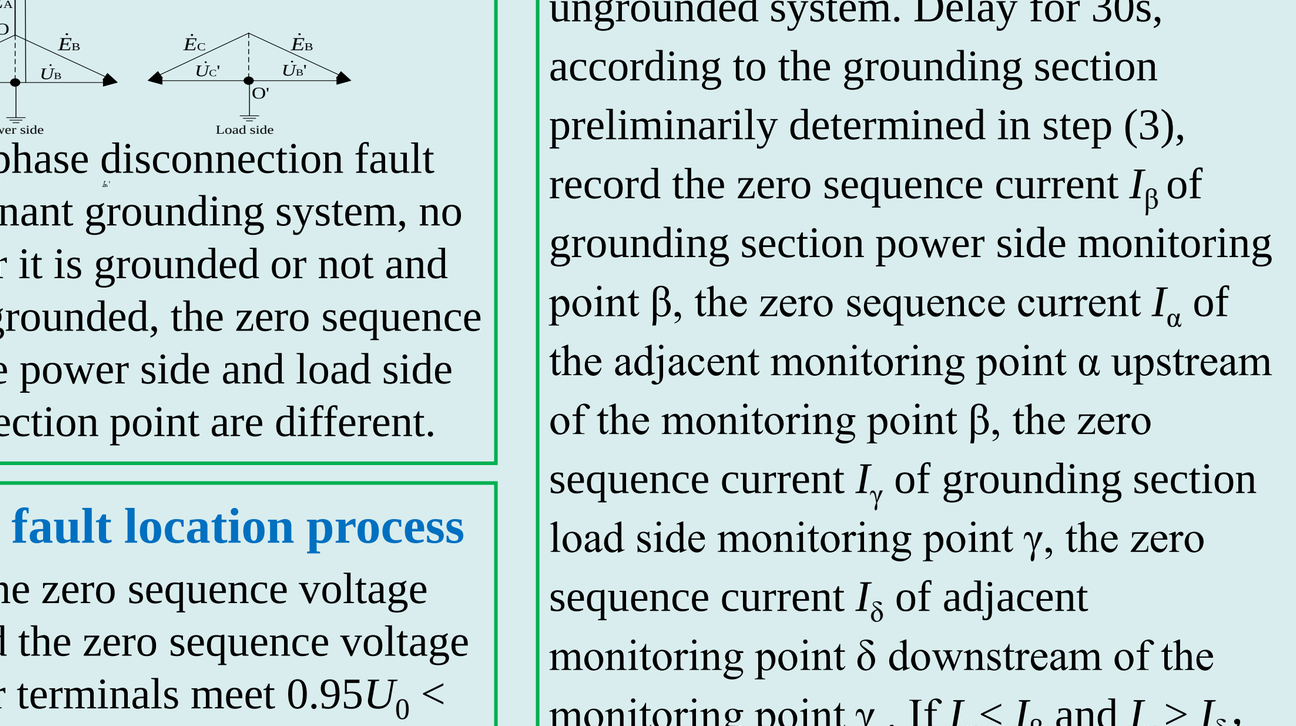
(2) Record the neutral point voltage U_0 and the zero sequence currents I_n (n =1-11) of each monitoring point at this time. Then adjust the arc suppression coil inductance from L to L'.

(3) Delay for 30s, record the neutral point voltage U_0' and the zero sequence currents I_n' (n =1-11) of each monitoring point again. Calculate $\Delta I_n = I_n' \cdot \dfrac{U_0}{U_0'} - I_n$ (n =1-11). If $|\Delta I_n| < 0.05\mathrm{A}$, it shows that the monitoring point is on the non fault path. If $|\Delta I_n| > 0.05\mathrm{A}$, it shows that the monitoring point is on the fault path. If $100\mathrm{V} < U_0 < 1000\mathrm{V}$, high impedance grounding fault occurs, which needs to be verified, and go to step (4).

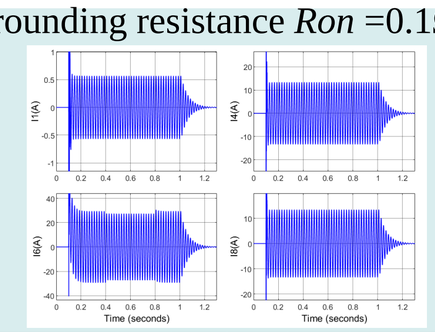
(4) The system becomes a neutral ungrounded system. Delay for 30s, according to the grounding section preliminarily determined in step (3), record the zero sequence current I_β of grounding section power side monitoring point β, the zero sequence current I_α of the adjacent monitoring point α upstream of the monitoring point β, the zero sequence current I_γ of grounding section load side monitoring point γ, the zero sequence current I_δ of adjacent monitoring point δ downstream of the monitoring point γ . If $I_\alpha < I_\beta$ and $I_\gamma > I_\delta$, the verification is correct.

Simulation

The original over compensation degree is 6%. 0.1s, phase A between monitoring point 7 and monitoring point 8 is grounded. 0.4s, the system over compensation degree becomes 1%. 0.8s, the over compensation degree becomes 6%. 1s, the grounding fault disappears.



Grounding resistance Ron =0.1Ω



	1	2	3	4	5	6	7	8	9	10	11
I_n(A)	0.4	0.27	0.13	9.37	4.69	20.61	15.99	9.42	4.71	0.27	0.13
I_n'(A)	0.4	0.27	0.13	9.38	4.69	19.21	14.59	9.43	4.72	0.27	0.13
ΔI_n(A)	0	0	0	0	-0.01	-1.42	-1.42	0	0	0	0

Grounding resistance Ron =5000Ω

	1	2	3	4	5	6	7	8	9	10	11
I_n(A)	0.04	0.03	0.01	0.94	0.47	2.07	1.61	0.95	0.47	0.03	0.01
I_n'(A)	0.04	0.03	0.01	1.05	0.52	2.14	1.63	1.05	0.53	0.03	0.01
ΔI_n(A)	0	0	0	0.01	0	-0.14	-0.14	0	0.01	0	0

Grounding resistance Ron =5000Ω in neutral ungrounded system

	1	2	3	4	5	6	7	8	9	10	11
I_n(A)	0.03	0.02	0.01	0.71	0.35	0.74	1.09	0.71	0.35	0.02	0.01