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FAULT LOCATION CALCULATION BASED ON TWO TERMINAL DATA OF HIGH VOLTAGE TRANSMISSION LINE

ANKAMMA RAO J[1], BIZUAYEHU BOGALE[2],
JEMAL MOHAMMED AMIN[3] & TSEGAYE NEGASH GIZAW[4]

[1]Assistant Professor, Department of Electrical & Computer Engineering, Samara University, Ethiopia

[2]Lecturer, Department of Electrical & Computer Engineering, Samara University, Ethiopia

[3]Assistant Lecturer & Head of the Department, Department of Electrical & Computer Engineering, Samara University, Ethiopia

[4]Assistant Lecturer, Department of Electrical & Computer Engineering, Samara University, Ethiopia

ABSTRACT

Nowadays, power supply has become a business asset. The quality and reliability of power system needs to be maintained in order to obtain optimum performance. Therefore, it is extremely important that transmission line faults from various sources to be identified accurately, reliably and be corrected as soon as possible. This paper presents fault location algorithm based on date measured at both ends of two terminal single high voltage transmission line. MATLAB/ Simulink software was used to implement these algorithms. The simulation results demonstrate the validity of the suitable fault location method in 400KV transmission line.

KEYWORDS: Fault Location, MATLAB, Fault Impedance, Distance Factor, Pure Fault Voltage, Positive Sequence Impedance, Accuracy of Fault Location

INTRODUCTION

Transmission lines are a critical segment of a power system. They sometimes experience. Faults such as short circuits to ground and between phases. This primarily happens due to insulation failure caused by atmospheric disturbances. Therefore, a line protection scheme is essential to any electrical power network. Estimating accurate fault locations in transmission lines has been the utmost subject of interest to utility engineers and researchers for the last several decades. As the majority of faults are of unbalanced nature, negative sequence components of voltages and currents at line ends can be used to estimate fault locations. Many of the algorithms assume data to be available at one terminal of the line. One algorithm based on iterative technique uses the apparent impedance and time domain representation of Prefault and post fault voltage and current measurements [l]. The proposed technique is not a quick fault location estimate. Another approach for estimating the fault location is based on the apparent impedance, voltage and current measurements at the sending end of the line [2]. The fault distance is determined by assuming that the line reactance is proportional to the line length between the sending end and the fault point. Another method based on symmetrical components of the phasors and line impedances is described for locating faults on transmission lines **[3].**

The proposed method is dependent on fault type and applicable **to** short transmission lines only. Other algorithms assume data to be available at both ends of the line. One algorithm uses the apparent line impedances and the post fault fundamental frequency voltage and current measurements to obtain an accurate fault location **[4].** The source impedance, distribution factor and prefault current are not required by the estimation procedure. The proposed algorithm is dependent on fault type. Another technique which uses the post fault steady-state power frequency voltage and current phasors is presented for calculating the fault location ***[5].*** Time synchronization of the measurands at both ends can be achieved by means of a continuous data channel linking each end. The effect of hardware and setting errors on the accuracy is considered. Another technique for fault location estimation which uses post fault data from both ends is presented ***[6].*** The proposed technique produces a synchronization angle which transfers the unsynchronized post fault phasors to the synchronized phasors. The synchronization angle can be calculated and then substituted to estimate the fault location.

The proposed algorithm measures pure voltages of fault network, calculate the distance factor k_v.Based on distance factor, the distance to fault location will be determined.

THEORY OF IMPEDANCE BASED FAULT LOCATION ALGORITHM

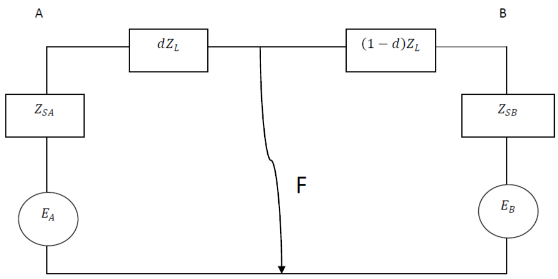

Figure 1: Fault Network Diagram

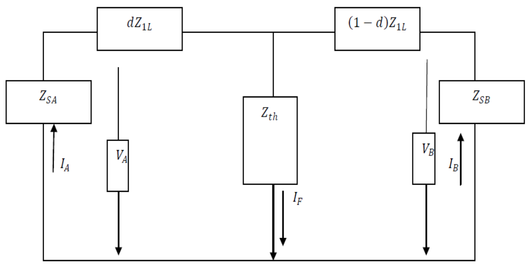

Figure 2: Pure Fault Circuit of Positive Sequence Thevenin's Equivalent Circuit

NOMENCLATURE

d Estimated distance to the fault (units: p.u)

V_A, V_B Protective distance relay voltage at the line end A & B.

I_A, I_B Protective distance relay current at the line end A & B.

I_F Total fault current

Z_L Total line impedance

V_F Fault voltage

Z_{SA}, Z_{SB} Source impedances at terminals A and B respectively

E_A, E_B Source voltages at terminals A and B respectively

Z_{1L} Total positive sequence line impedance

A.FAULT LOCATION ALGORITHM

To derive the Fault location algorithm, first we determine the thevenin's Equivalent impedance of the positive sequence network in the pure fault condition and the expression for thevenin's Equivalent impedance is

$$Z_{th} = \frac{(Z_{SA} + dZ_{1L})(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} \quad (1)$$

The expression for pure fault voltages of positive sequence at each end of the line is

$$V_A = dZ_{1L}I_A - Z_{th}I_F \quad (2)$$

$$V_B = (1-d)Z_{1L}I_B - Z_{th}I_F \quad (3)$$

And the line currents

$$I_A = \frac{(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} I_F \quad (4)$$

$$I_B = \frac{(Z_{SA} + dZ_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} I_F \quad (5)$$

Substituting the expressions for currents in the pure fault voltage expressions

$$V_A = dZ_{1L}\frac{(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} I_F - \frac{(Z_{SA} + dZ_{1L})(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} I_F \quad (6)$$

$$V_A = \left(dZ_{1L}\frac{(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} - \frac{(Z_{SA} + dZ_{1L})(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} \right) I_F \quad (7)$$

$$V_B = (1-d)Z_{1L}\frac{(Z_{SA} + dZ_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} I_F - \frac{(Z_{SA} + dZ_{1L})(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} I_F \quad (8)$$

$$V_B = \left((1-d)Z_{1L}\frac{(Z_{SA} + dZ_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} - \frac{(Z_{SA} + dZ_{1L})(Z_{SB} + (1-d)Z_{1L})}{Z_{SA} + Z_{SB} + Z_{1L}} \right) I_F \quad (9)$$

Now we define the distance factor

$$K_v = \frac{V_A}{V_B} \tag{10}$$

Substituting the expressions of V_A and V_B in the distance factor expression

$$K_v = \frac{V_A}{V_B} = \frac{\left(dZ_{1L}\frac{(Z_{SB}+(1-d)Z_{1L})}{Z_{SA}+Z_{SB}+Z_{1L}} - \frac{(Z_{SA}+dZ_{1L})(Z_{SB}+(1-d)Z_{1L})}{Z_{SA}+Z_{SB}+Z_{1L}}\right)I_F}{\left((1-d)Z_{1L}\frac{(Z_{SA}+dZ_{1L})}{Z_{SA}+Z_{SB}+Z_{1L}} - \frac{(Z_{SA}+dZ_{1L})(Z_{SB}+(1-d)Z_{1L})}{Z_{SA}+Z_{SB}+Z_{1L}}\right)I_F} \tag{11}$$

$$K_v = \frac{\left(dZ_{1L}(Z_{SB}+(1-d)Z_{1L}) - (Z_{SA}+dZ_{1L})(Z_{SB}+(1-d)Z_{1L})\right)}{\left((1-d)Z_{1L}(Z_{SA}+dZ_{1L}) - (Z_{SA}+dZ_{1L})(Z_{SB}+(1-d)Z_{1L})\right)} \tag{12}$$

$$K_v = \frac{(Z_{SB}+(1-d)Z_{1L})(dZ_{1L}-(Z_{SA}+dZ_{1L}))}{(Z_{SA}+dZ_{1L})((1-d)Z_{1L}-(Z_{SB}+(1-d)Z_{1L}))} \tag{13}$$

$$K_v = \frac{(Z_{SB}+(1-d)Z_{1L})(-Z_{SA})}{(Z_{SA}+d\,Z_{1L})(-Z_{SB})} \tag{14}$$

Let $Z_{SA} = Z_{SB}$ **(15)**

$$K_v = \frac{(Z_{SB}+(1-d)Z_{1L})}{(Z_{SA}+d\,Z_{1L})} \tag{16}$$

$$K_v(Z_{SA}+dZ_{1L}) = (Z_{SB}+(1-d)Z_{1L}) \tag{17}$$

$$d(K_v+1)Z_{1L} = (Z_{SB}-K_vZ_{SA}+Z_{1L}) \tag{18}$$

The expression for distance to fault location is

$$d = \frac{(Z_{SB}-K_vZ_{SA}+Z_{1L})}{(K_v+1)Z_{1L}} \tag{19}$$

POWER SYSTEM MODEL

The Sim Power System which is an extension to the simulink of MATLAB software was used to simulate the double end fed power system. The 100 km, 400 kV transmission line was modeled using distributed parameter model as shown in Figure 3.

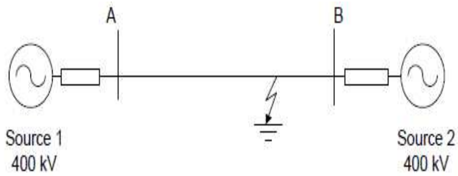

Figure 3: Power System Model

The transmission line parameters are as follows:

Positive Sequence Resistance, R_1 : 0.0275 Ω / km

Zero Sequence Resistance, R_0 : 0. 275 Ω/km

Zero Sequence Mutual Resistance, R_{0m} : 0.21 Ω/km

Positive Sequence Inductance, L_1 : 0.00102 H/km

Zero Sequence Inductance, L_0 : 0.003268 H/km

Positive Sequence Capacitance, C_1 : 13 $e^{-0.009}$ F/km

SIMULATION RESULTS

The simulation is carried out for these algorithm by varying various fault parameters like fault inception angle, fault resistance, fault type, fault location. The various measurements processed for various types of faults during implementation of algorithm.. The accuracy of fault location of these three algorithms are compared and shown in Table.1.

The fault location error is calculated as

$$Error(\%) = \frac{|Calculated\ Fault\ Location - Actual\ Fault\ Location|}{Total\ Line\ Length} * 100 \quad (20)$$

CONCLUSIONS

In this paper, fault location is calculated using pure fault voltages at both terminals of high voltage transmission line using Matlab Simulink and programing. The accuracy of fault location of the algorithm are observed by varying various fault parameters like fault inception angle, fault type, fault location, fault resistance. The simulation results show that all ten types of faults are correctly located with fault location error less than 1%.

Table 1: Various Fault Location Results

S.No	Fault Type	(in º)	R_g (Ω)	D (km)	Calculated Output (km)	Error (%)
1	ACG	36	45	33	32.7652	0.23
2	BCG	90	66	54	54.226	0.22
3	ABG	72	33	76	76.0240	0.02
4	CG	0	56	35	34.9906	0.01
5	AG	54	22	12	11.972	0.02
6	BG	18	45	20	19.9912	0.01
7	BC	72	8	78	78.6379	0.63

8	AB	90	10	68	68.1142	0.11
9	AC	36	12	83	83.1437	0.14
10	ABC	54	7	91	91.6308	0.63

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