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THE INFLUENCE OF THE FAULT RESISTANCE ON THE ACCURACY OF THE ONE-END DATA FAULT LOCATION ALGORITHMS

BY

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Abstract. For the radial lines of sub-transmission and medium voltage grids, the one-end data fault location algorithms are the only applicable, when it comes to the technical point of view. The merit of such algorithms is that they need data only from one end of the line, thus being economically inexpensive. In the other hand, the fault location accuracy is influenced by many parameters as fault resistance, fault inception angle, location of fault along the line, etc. In the paper are presented some results regarding the influence of the fault resistance on the accuracy of three one-end data fault location algorithms. The simulated faulty voltages and currents were obtained by transposing into ATP a simple sub-transmission test grid.

Key words: fault resistance; one-end data fault location algorithm; error estimation.

1. Introduction

The rapid removal of transmission and sub-transmission lines fault is one of the best measures used to improve the power systems stability and

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implicitly to ensure an adequate reliability of the grid and the continuity into energy transmission.

Taking into account the components from the fault signal that are processed to estimate the fault location, the actual fault location algorithms can be divided in two main categories namely: those who process the power frequency components and those who process the high frequency components (IEEE Standard, 2005).

The power frequency components-based algorithms can be divided in two categories too: one-end and two-end data fault location algorithms.

The one-end data fault location algorithms process the voltages and currents from one end of the line. The merit of the single-terminal data algorithms is that they only need one terminal measuring and data acquisition equipment. There are none real time transmitted data between line's terminals, thus data transmission channels are not necessary. As a consequence of the relatively low implementation, costs, single-end algorithms attract attention and they are superior when it comes to the commercial point of view. In the other hand the accuracy of the fault location depends on many parameters that are not precisely known such as the fault's resistance, fault inception angle, location of fault along the line, etc.

In this paper is analysed the influence of the fault resistance on the accuracy of the fault location algorithms proposed by Takagi (1982), Girgis (1993) and Novosel (1996).

2. Fault Location

In order to observe the influence of the fault resistance in the accuracy of the fault location algorithms for radial lines, in Fig. 1 is depicted a simple test grid, composed by a 110 kV source with the short-circuit power of 1,000 MVA, a sub-transmission line with the length L = 56 km and a consumer connected to the remote-end of the line. In Fig. 1, d represents the per-unit distance from the station to the fault location, R_F is the fault resistance, $\underline{Z}_S$ represents the sources' complex impedance, $\underline{Z}_{\text{cons}}$ is the consumer's complex impedance and $\underline{U}_S$ and $\underline{I}_S$ are the phasors of voltage and current at station's level, respectively.

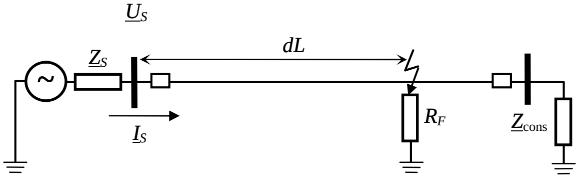

Fig. 1 – One-line diagram of the test grid which experimented a fault.

The test grid presented in Fig. 1 was transposed in Alternative Transients Program (ATP), considering the resistance of the fault, the source's impedance and the consumer's impedance as lumped elements and further more it is considered that the presented sub-transmission line is modelled with ten

"Π" two-ports with lumped parameters, each one modelling a 5.6 km line segment. The fault location algorithms employed in this study use the power frequency phasors of the voltage and current obtained from measurements taken at the station level. To obtain these phasors it is used an adaptive algorithm (Rosolowsky *et al.*, 2001) which starts from the classical Fourier transform and adaptively suppress a decaying DC component.

The fault location algorithms described by Takagi *et al.* (1982), Girgis (1993) and Novosel *et al.* (1996) need the following input data: Takagi's algorithm needs the length of the line, L, the power frequency phasors of the voltage and current, the specific resistance and reactance of the line, R_L and X_L, and the power frequency phasors of the current in the normal regime, $\underline{I}_{\mathrm{LOAD}}$; Girgis's algorithm needs the length of the line, L, the power frequency phasors of the voltage and current and the specific resistance and reactance of the line, R_L and X_L; Novosel's algorithm needs the length of the line, L, the power frequency phasors of the voltage and current, the specific resistance and reactance of the line, R_L and X_L, and the power frequency phasors of the voltage and current in the normal regime, $\underline{U}_{\mathrm{LOAD}}$ and $\underline{I}_{\mathrm{LOAD}}$.

Taking into account the above mentioned requirements, the authors have imagined the fault locator depicted in Fig. 2.

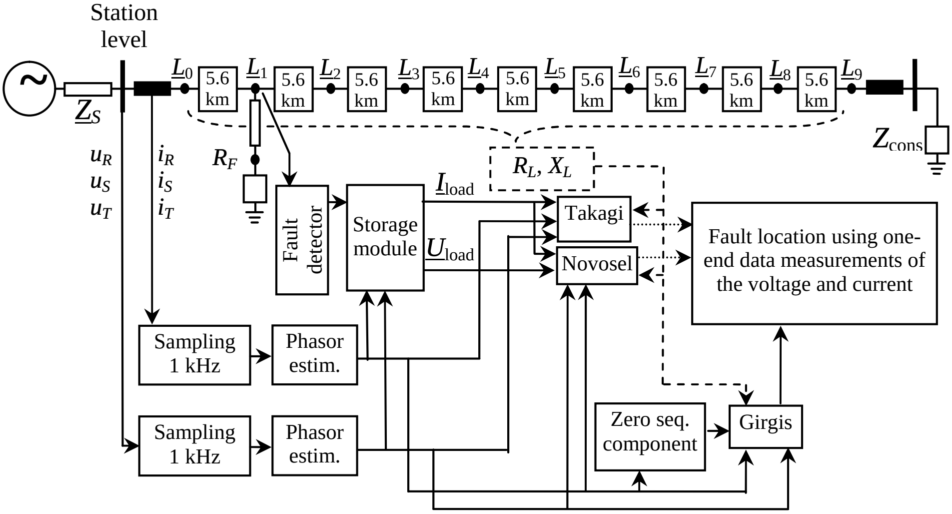

Fig. 2 – ATP model of the fault locator.

From Fig. 2 it can be seen that the sampling and the phasor estimation modules represent the common parts of the algorithms employed in this study.

3. Results and Comments

In order to obtain the simulated results it is necessary to be carried out additional specifications as follow: the nominal voltage of the grid is 110 kV; the nominal frequency is 50 Hz; the short-circuit power on the station is 1.000

MVA; the specific resistance and specific reactance are, respectively, R_L= 0.063 Ω/km and X_L = 0.446 Ω/km and the reactance of the source is X_S = 12.1 Ω.

Taking as parameter the resistance of the fault, R_F, [Ω], some simulation results are those shown in Table 1. There were simulated single-phased faults, 1F, double-phased faults, 2F, and three-phased faults, 3F. The errors computation were made after the first, second and third cycle of the fault inception, denoted by “I”, “II” and “III” and in the stabilized fault regime, denoted by “stab”.

Table 1

R_f Ω	No. of cycles	Takagi			Girgis			Novosel		
		1F	2F	3F	1F	2F	3F	1F	2F	3F
1	I	15.63	0.94	1.03	5.93	0.91	0.97	4.93	1.05	1.01
	II	15.21	0.91	0.69	5.41	0.92	0.65	5.08	0.98	0.67
	III	15.58	0.89	0.49	5.46	0.68	0.46	5.1	0.85	0.48
	stab	15.75	0.84	0.51	5.46	0.71	0.71	5.12	0.85	0.52
10	I	15.84	1.26	1.3	6.00	0.93	0.98	5.74	1.66	1.64
	II	15.42	1.23	0.96	5.48	0.94	0.66	5.89	1.59	1.3
	III	15.79	1.21	0.76	5.53	0.7	0.47	5.61	1.46	1.11
	stab	15.96	1.16	0.78	5.53	0.73	0.72	5.53	1.46	1.15
50	I	16.24	1.42	0.6	5.99	0.94	0.96	5.89	2.28	2.14
	II	15.82	1.39	0.91	5.47	0.95	0.64	5.81	2.21	1.8
	III	16.19	1.37	0.73	5.52	0.71	0.45	5.7	2.08	1.61
	stab	16.36	1.32	0.58	5.52	0.74	0.7	5.72	2.08	1.65

Considering the fault location along the line as another parameter, some graphic results for single-phased faults are shown in Figs. 3,…,5.

As it results from Table 1 and from Fig. 3, Takagi’s algorithm provide large errors in the case of single-phased faults. The influence of the fault resistance is not so important, the error introduced by a value of R_F = 50 Ω being greater with 0.7% compared with the one introduced by a value of R_F = 1 Ω. The Girgis’s algorithm is practically unaffected by the value of the fault resistance, the error intoduced by a value of R_F = 50 Ω being greater with 0.06% compared with the one introduced by a value of R_F = 1 Ω.

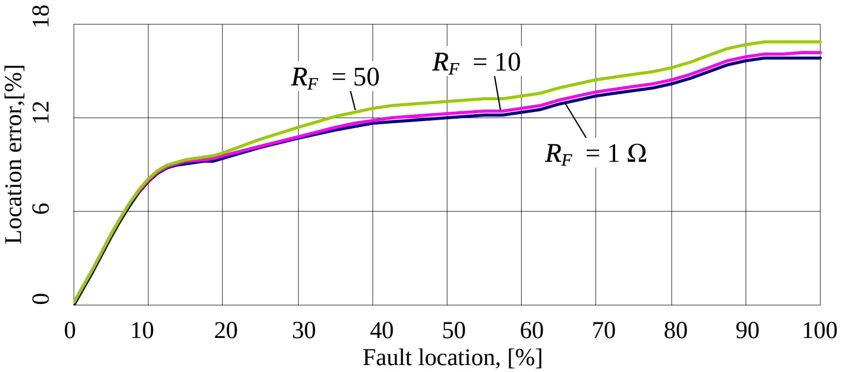

Fig. 3 – Location errors computed by Takagi’s algorithm.

The Novosel's algorithm is sensibile at the value of the fault resistance, the error intoduced by a value of R_F = 50 Ω being greater with 1.3 percent compared with the one introduced by a value of R_F = 1 Ω.

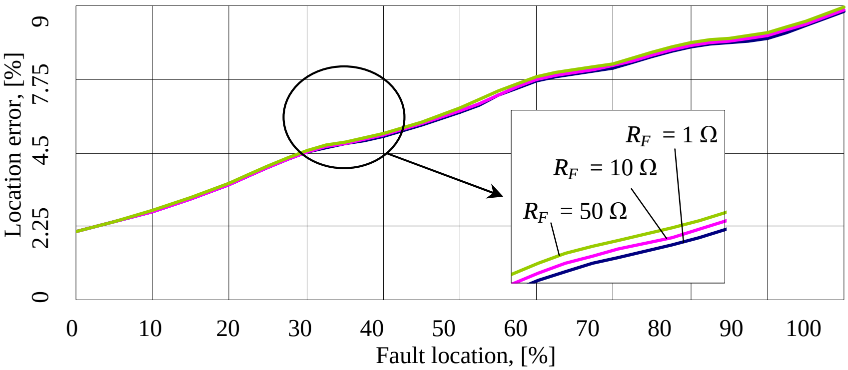

Fig. 4 – Location errors computed with Girgis's algorithm.

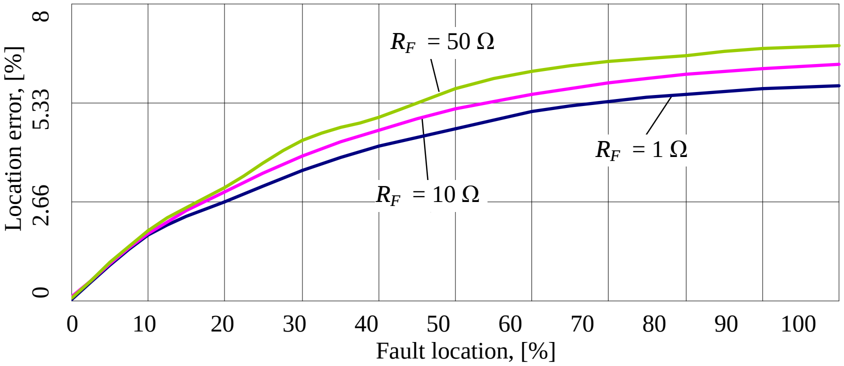

Fig. 5 – Location errors computed with Novosel's algorithm.

4. Conclusions

In this paper there were presented some simulation results regarding the estimation accuracy of three one-end data fault location algorithms. The simulation results show that for the single-phased faults the algorithms of Girgis and Novosel provide better results when compared to those provided by Tagaki's algorithm. For polyphased faults the errors are comparable. Also, from the simulation results it can be observed that the Novosel's algorithm is sensible with respect to the value of the fault resistance.

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INFLUENŢA REZISTENŢEI DEFECTULUI ASUPRA PRECIZIEI ALGORITMILOR CE FOLOSESC MĂSURĂTORI DE LA O SINGURĂ EXTREMITATE A LINIEI

(Rezumat)

Din punct de vedere tehnic, în reţelele radiale de 110 kV precum şi în cele de medie tensiune, algoritmii de localizare ce folosesc măsurători de la o singură extremitate a liniei sunt singurii care pot fi implemnetaţi. Principalul avantaj al acestor algoritmi este că nu necesită echipament auxiliar, fiind astfel economici. În lucrare este analizată influenţa rezistenţei defectului asupra preciziei a trei algoritmi ce folosesc măsurători de la o extremitate a liniei. Tensiunile şi curenţii în regim de defect au fost obţinuţi prin transpunerea în ATP a unei reţele test de 110 kV.