BULETINUL INSTITUTULUI POLITEHNIC DIN IAŞI
Publicat de
Universitatea Tehnică „Gheorghe Asachi” din Iaşi
Tomul LVII (LXI), Fasc. 3, 2011
Secţia
ELECTROTEHNICĂ. ENERGETICĂ. ELECTRONICĂ

EVALUATION OF TWO-END DATA FAULT LOCATION ALGORITHMS USED IN FAULT LOCATION

BY

MARIAN DRAGOMIR* **and MARCEL ISTRATE**

“Gheorghe Asachi” Technical University of Iaşi,
Faculty of Electrical Engineering, Energetics
and Applied Informatics

Received, June 12, 2011
Accepted for publication: August 16, 2011

Abstract. Accurate results can be achieved if there are employed fault location algorithms which use data from both ends of the line. Some results regarding the fault location errors provided by three fault location algorithms are presented. The results were obtained by transposing into ATP a simple 220 kV grid.

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

1. Introduction

Transmission line faults have to be located quickly and accurately in order to repair the faulted section, restore power delivery and reduce outage time as much as possible.

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; Saha *et al.*, 2010).

The two-end data fault location algorithms employed in this study are those of Chen (2003), Istrate (2009) and Tziouvaras (2001). The first one processes the voltage

* Corresponding author: *e-mail*: dragomir.marian@rocketmail.com

and current synchrophasors from both ends of the line, while the second one processes only the unsynchronized voltages from both ends of the line and the third one processes only the unsynchronized currents from both ends of the line. For estimation of the fault location, the power frequency phasors of the voltage and current are estimated with an adaptive algorithm indicated by Rosolowsky *et al.* (2001).

In modern power grids the trend is to implement Phasor Measurement Unit (PMU) which makes possible the communication between the remote ends of the power grids' lines. Forward, using these PMUs, it can be implemented the Wide Area System (WAS) for monitoring and eventually for protection of the power grid. In these conditions it is possible to use the measurements of the PMUs and thus to implement the two-end data fault location algorithms.

2. Block-Diagram of the Fault Locator

2.1. The Model of the Test Grid

The test grid, depicted in Fig.1, models a part of the real high-voltage ST Bacău 400/220 kV power grid. The length of the 220 kV line of 70 km and at it's delimited by the Stejaru and Gheorghieni power stations.

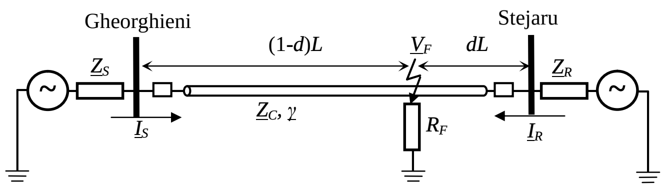

Fig. 1 – One-line diagram of the test grid which experimented a fault.

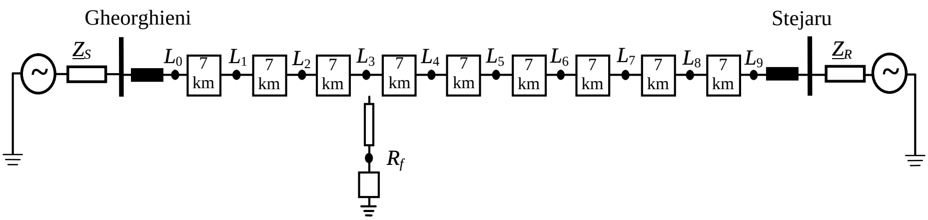

Fig. 2 – ATP model of the test grid.

The test grid was transposed in Alternative Transients Program (ATP). In order to observe the influence of the fault location along the line in the output results of the three algorithms presented by Chen & Liu (2003), Istrate *et al.* (2009), Tziouvaras *et al.* (2001), the presented line was modelled with ten "Π" two-ports with lumped parameters, each one modelling a 7 km line segment. Also, the resistance of fault as well as the sources' impedances were modelled with lumped elements.

Finally, the ATP model of the test grid was imagined as in Fig. 2.

2.2. The Model of the Fault Locator

In order to achieve the fault locator model there have to be indicated the input parameters for the fault location algorithms presented. As a consequence of the fact that all the three fault location algorithms use the power frequency phasors of voltages and currents, the phasor estimation modules represent the common part of the fault locator.

The input data of the fault location algorithms are as follows Chen's algorithm needs to know the length, L, of the line, the magnitude and the phase angle of the positive sequence surge impedance of the line, Z_{c1}, and $j_{Z_{c1}}$, the positive sequence propagation and phase constants of the line, α_1 and β_1, as well as the synchronized phasors of voltage and current from both ends of the line; Istrate's algorithm needs to know the length, L, of the line, the magnitude and the phase angle of the positive sequence surge impedance of the line, Z_{c1} and $j_{Z_{c1}}$, the positive sequence propagation and phase constants of the line, α_1 and β_1, and the sources' impedances, as well as the unsynchronized phasors of the voltage from both ends of the line; Tziouvaras's algorithm needs to know the length, L, of the line, the specific resistance and specific reactance of the line, R_L and X_L, and the sources' impedances, as well as the unsynchronized phasors of the current from both ends of the line.

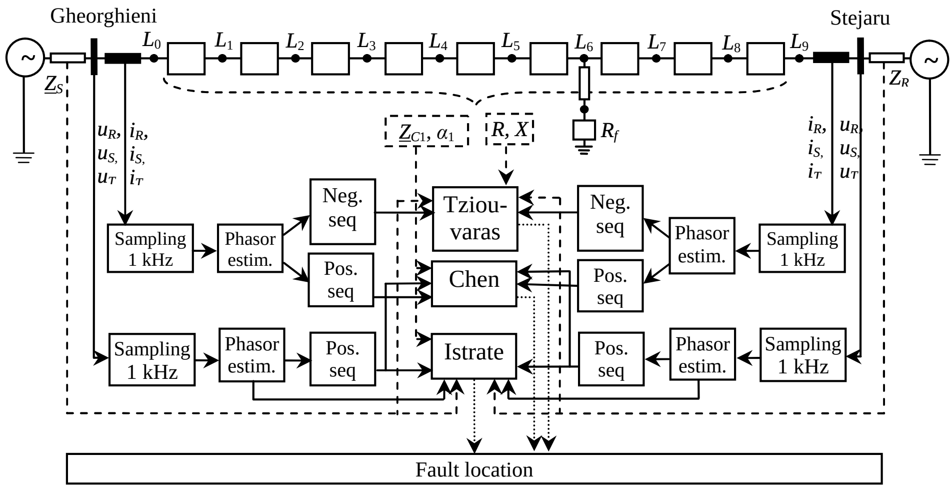

Fig. 3 – Block-diagram of the fault locator.

Taking into account the above specified requirements and the ATP model of the test grid, the imagined block-diagram of the fault locator results like in Fig. 3. two-end data fault location algorithms.

3. Results and Comments

In order to obtain the simulated results, there need to be carried out additional specifications as follows the nominal voltage of the grid is 220 kV; the nominal frequency is 50 Hz; the short-circuit power on the Gheorghieni power station is 900 MVA and that on the Stejaru power station is 800 MVA; the magnitude and the phase angle of the positive sequence surge impedance are Z_{c1} = 386.6 Ω and $j_{Z_{c1}} = -4.6^{\circ}$, the specific resistance and specific reactance are R_L = 0.066 Ω/km and X_L = 0.409 Ω/km, respectively, the reactance of the Gheorghieni source is X_S = 66.89 Ω and the one of the Stejaru source is X_S = 56.94 Ω. Also there was supposed that the fault resistance is R_f = 10 Ω.

Taking as parameter the location of the fault along the line, *d*, [%], 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 and third cycle of the fault inception, denoted “I” and “III” and in the stabilized fault regime, denoted “stab”. Also, in Figs. 4 and 5 there were indicated some graphic representations.

Table 1

d %	Fault type	Chen			Istrate			Tziouvaras		
		I	III	stab	I	III	stab	I	III	stab
20	1F	1.81	1.87	1.85	1.26	2.07	2.05	2.21	2.32	2.26
	2F	2.13	2.29	2.22	1.24	2.53	2.29	2.52	2.48	2.47
	3F	2.91	2.02	2.16	2.53	2.24	2.15	2.61	2.39	2.34
40	1F	1.12	1.26	1.24	1.42	1.51	1.44	1.91	1.72	1.46
	2F	1.99	2.04	2.16	2.02	2.14	2.21	1.42	2.21	2.14
	3F	2.54	2.31	2.22	1.83	2.15	2.04	2.52	2.11	2.31
60	1F	1.14	1.13	1.15	1.83	1.09	1.28	1.35	1.31	1.16
	2F	2.04	2.19	2.15	1.85	2.07	2.14	2.28	2.21	2.34
	3F	2.03	2.01	2.07	2.04	2.12	2.01	1.88	2.35	2.44
80	1F	1.12	1.26	1.25	1.33	1.28	1.14	1.25	1.26	1.29
	2F	2.13	2.08	2.15	2.11	2.06	2.04	2.01	2.42	2.53
	3F	2.04	2.3	2.31	2.11	1.81	1.95	2.48	2.58	2.72

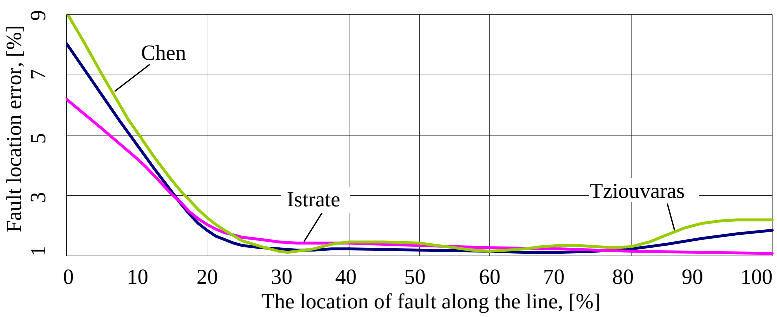

Fig. 4 – Fault location errors for single-phased faults.

As it results from Table 1 as well as from the graphical representations made in Figs. 4 and 5, it can be said that the two-end data fault location algorithms provide good results when the fault takes place at a distance, ***d***, greater than 20%...25% from line's length measured from the power station. Algorithms of Chen and Tziouvaras provide good results with less than 1.5% errors in the case of single-phased faults and less than 2.2% errors in the case of polyphased faults if the fault takes place between 25% and 80% from line's length. Algorithm of Istrate, which uses only the unsynchronized phasors of the voltage from both ends of line, provide estimation errors comparable with those provided by Chen's algorithm, which decreases continuously from 0 to 100% from line's length.

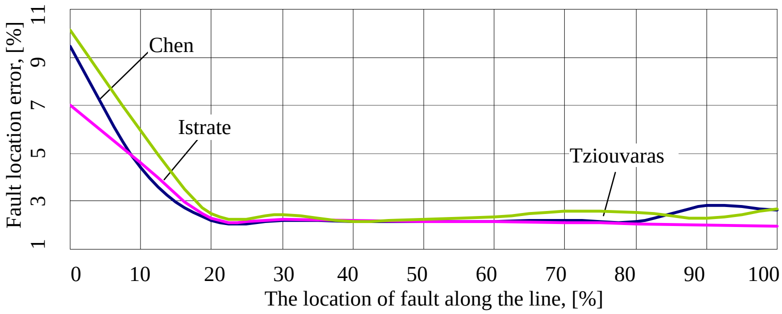

Fig. 5 – Fault location errors for double-phased faults.

4. Conclusions

In this paper there were presented some simulation results regarding the estimation accuracy of three fault location algorithms. In order to obtain the simulated faulty voltages and currents the authors modeled and then transposed into ATP a part of a real high voltage grid. The estimation errors provide by the above mentioned algorithms can reach 1.5% in the case of single-phased faults and 2.2% in the case of polyphased faults, when distance to fault takes values from 25% to 80% from line's length.

Overall, it can be said that the algorithm of Istrate provides the best results when compared with those of Chen and Tziouvaras.

REFERENCES

Chen C.S., Liu C.W., *Fast and Accurate Fault Detection/Location Algorithms for Double-Circuit/Three-Terminal Lines Using Phasor Measurements Units*. J. of the Chinese Inst. of Eng., **26**, *3*, 289-299 (2003).

Istrate M., Miron A., Istrate C., Guşă M., Machidon D., *Single-Phased Fault Location on Transmission Lines Using Unsynchronized Voltages*. Adv. in Electr. a. Comp. Engng., **9**, *3*, 51-56 (2009).

Rosolowski E., Izykowski J., Kasztenny B., *Adaptive Measuring Algorithm Suppressing a Decaying DC Component for Digital Protective Relays*. Electric Power Syst. Res., **60**, *2*, 99-105 (2001).
Saha M.M., Izykowski J., Rosolowsky E., *Fault Location on Power Networks*. Springer-Verlag, London, 2010.
Tziouvaras D.A., Roberts J.B., Benmouyal G., *New Multi-Ended Fault Location Design for Two or Three-Terminal Lines*. IEE 7th Internat. Conf. on Develop. in Power Syst. Prot., Amsterdam, 2001, 395–398.
* * * *IEEE Guide for Determining Fault Location on AC Transmission and Distribution Lines*. IEEE Standard *C37.114*, 2005.

EVALUAREA ALGORITMILOR DE LOCALIZARE A DEFECTELOR CE FOLOSESC DATE DE LA AMBELE EXTREMITĂŢI ALE LINIEI

(Rezumat)

Defectele din reţelele electrice trebuie localizate rapid şi precis în vederea menţinerii stabilităţii reţelei şi a minimizării timpului de ieşire din funcţionare a liniei cu defect. Rezultate precise se pot obţine dacă se utilizează algoritmi de localizare a defectelor ce folosesc date de la ambele extremităţi ale liniei. Se prezintă câteva rezultate ce permit evaluarea algoritmilor propuşi în funcţie de erorile introduse. Rezultatele au fost obţinute cu ajutorul transpunerii în ATP a unei reţele de 220 kV.