Development of Power System Fault Locating Method using Voltage Sag Data
– Development of Prototype Tool for Fault Location and Evaluation using Practical Power System Data –

Background

In recent years, an electric power company is required to specify the position and influence of a fault on transmission networks, and to analyze the influence of voltage sag and to give clear information to consumers. There are fault-locating devices (known as FL) on power transmission lines. In order to identify a fault location, fault locators (FLs) have been installed on power transmission lines. They are installed mainly on high voltage and long distance transmission lines, but not on all lines due to cost limitation. Consequently it takes huge time and effort to specify fault points on transmission lines where an FL is not installed. Moreover, a replacement cost should be an important issue because existing FLs are rapidly becoming aged. Therefore, an accurate fault location technique that is applicable to wide power system networks with low cost is required.

Objectives

To develop a new fault location scheme using measurements of voltage sag recorded at substations and to evaluate fault location error with practical fault data on a real power system of a Japanese electric power company;

Principal Results

1. Construction technique for fault location

A construction technique for fault location on power systems with the following features was developed.

(1) The developed new scheme of fault location derives the faulted point by comparing actual measurements of voltage sag recorded by oscillograph etc. at substations and calculated voltage sag of corresponding buses by CRIEPI's fault analysis tool [*1]. (Fig.1)

(2) To improve the accuracy of fault location, the standard deviation of difference between the measured values and the calculated values is employed as an evaluation function to identify fault impedance and location. (Fig.2)

2. Evaluation of fault location accuracy with practical fault data on a real power system

The fault location accuracy of the developed method was verified using past practical fault data obtained in joint research with the Kyushu Electric Power Co., Inc.

(1) As seen from hatched cells in Table 1 "Base-case," 11 of 19 cases show good results that mean the location error is less than 2.0km or 1.2 miles, which is the error level as the FL.

(2) The effect of small generators near a fault point for fault location accuracy should not be ignored because an actual generator model (a voltage-source model) can maintain voltage rather than a static load model because of an internal voltage source. As seen in Fig.3 (a) and Table 1 "Advanced (a)," a small generator as actual generator model with internal voltage source obtains good results the same as FL error level.

(3) A scheme to sort out measured points with uncertain values using standard deviation is also proposed as shown in Fig.3 (b). The results after modeling the small generators and sorting measured points with measurement errors in order to raise fault location accuracy are shown in Table 1 "Advanced (a&b)". The accuracy is almost comparable as existing FL (error is less than 2.0km) in 15 of 19 cases.

Future Developments

The prototype tool will be further developed to improve the accuracy, and also a field test will be performed.

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Reference

Yo Suetsugu, et.al., 2007, "Development of Power System Fault Locating method using Voltage Sag Data - Development of Prototype Tool for Fault Location and Evaluation using Practical Power System Data -", CRIEPI Report R06008 (in Japanese)

＊1：K-method : This is a high speed and accurate calculation tool of voltage sag analysis for a double circuit transmission line.

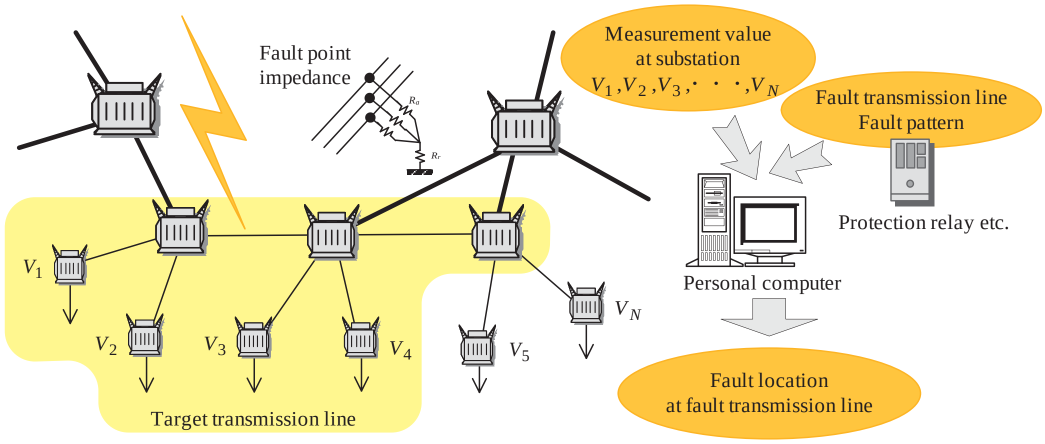
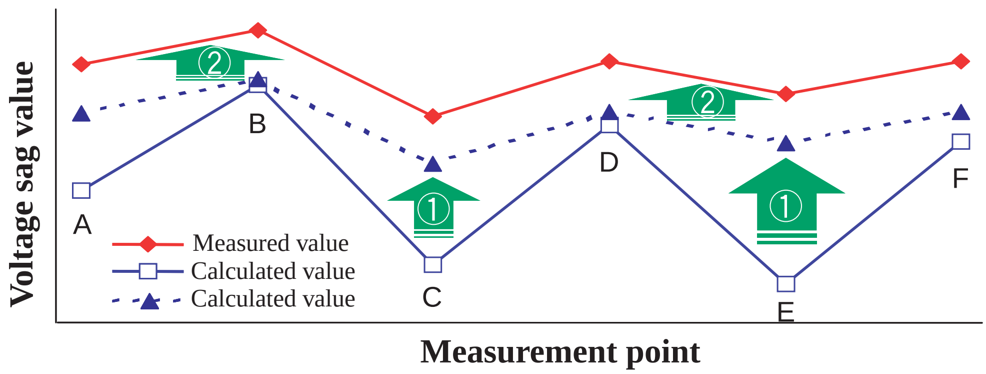


Fig.1 Outline of developed fault location scheme



①: The shape of the measured value and the calculated values is fitted by minimizing standard deviation.
②: The distance between the measured value and the calculated value is contracted by minimizing average of differences.

Fig.2 Evaluation function to identity fault location

Table 1 Result of fault location

Fault data		Fault locatio error(km)※		
Voltage level	Fault pattern	Base-case	Advanced (a)	Advanced (a&b)
220kV	2L:1φG	3.7	-	-
220kV	2L:1φG	11.5	14.0	0.0
66kV	1L:2φS	0.9	-	-
220kV	2L:2φ G	2.3	1.2	1.2
500kV	1L:1φG 2L:2φG	20.3	12.2	8.1
220kV	2L:1φG	1.0	1.0	-
220kV	1L:1φG	1.3	0.0	0.0
220kV	2L:2φG	2.6	1.3	-
220kV	2L:2φG	4.6	2.3	-
66kV	2L:2φS	0.6	-	-
66kV	2L:2φS	1.0	-	-
66kV	2L:2φS	0.6	-	-
66kV	2L:3φG	7.0	-	-
66kV	1L:2φG 2L:3φG	0.3	0.3	-
66kV	1L:3φG 2L:3φG	0.2	0.2	-
66kV	2L:3φG	1.7	-	-
66kV	1L:2φS	0.3	1.9	-
66kV	1L:3φG	7.0	1.0	-
66kV	1L:2φS	0.3	0.2	-

* Hatched cells means error is less than 2.0km and "-" means without advanced method.

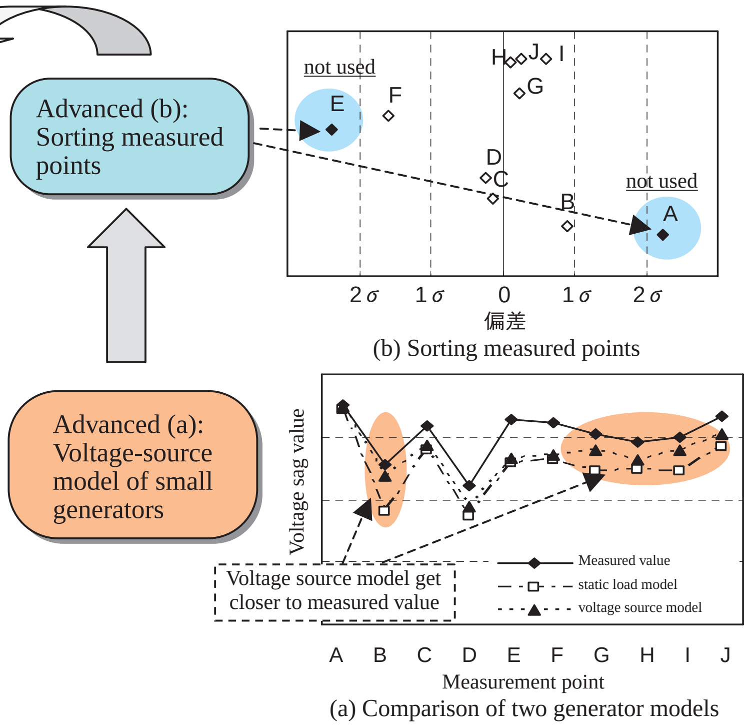


Fig.3 Advanced method improving accuracy