01 Jan 1983

Bibliography Of Power Systems Operator Training Resources IEEE Committee Report Prepared By The PES Working Group On Operator Training (WG78-4)

Max Darwin Anderson
Missouri University of Science and Technology, mda@mst.edu

82 SM 326-7
January 1983, p. 238

Power System Data Validation and State Calculation by Network Search Techniques

P. Bonanomi
Brown Boveri Research Center, Baden, Switzerland
G. Gramberg
Basle Engineering College, Muttenz, Switzerland

Abstract—A real-time data base for power system monitoring and control must provide an accurate and reliable representation of the system state, based on the available measurements, indications and network parameters. The well-established method for achieving this goal is static state estimation, which calculates a best fit of the measurements onto the network model. A new approach is proposed in this paper, wherein state calculation and data validation are performed by a sequential search through the network graph. It is shown that data validation can be achieved without the usual data fitting. The technique requires modest computing times and features novel properties for bad data identification. The method has been implemented and tested on several standard network models. Once data validation is completed, static state estimation may be performed if a best fit of the measurements is desired.

Introduction

The quality of the real-time data is an important issue in the automatic control and monitoring of technical processes. When instrument failures or other bad data occur, it may be essential to detect and identify them so that appropriate remedial actions may be initiated. Data validation is also important for the plant operator, in particular for his confidence in the centralized monitoring system. Correctness and consistency of the data base can be verified by appropriate algorithms in the process computer.

For the power transmission network, the real-time description of the process consists of the network configuration and parameters, the status of circuit breakers and tap changing transformers, and by a set of measured quantities such as node voltages and active and reactive power flows. A certain measurement redundancy is provided so that bad data may be detected. Before the actual monitoring and control programs can be applied, data conditioning is performed, with two purposes in mind:

a) to detect, locate and identify gross errors in the measurements, parameters and status indications;
b) to calculate a consistent representation of the electrical state such that the available measurements are matched as accurately as possible. This state is defined by the complex voltages at the nodes of the network.

In today's control centers, the major tool for data conditioning is the power system static state estimator, which consists of fitting the set of measurements onto the network model by minimizing an error function such as the Weighted Least Squares (WLS). The method is used for computing a consistent state (task *b* above) and for detecting the presence of bad data (task *a*). In case bad data are detected, additional processing is performed for locating and identifying the bad spots. This task is achieved by analyzing the state estimation residuals and usually requires several runs of the WLS program.

While static state estimation is a good method for computing a consistent state representation from the real-time measurements (task *b*), its performance for handling bad data leaves room for improvement. Better performance would be welcome in several respects, such as computation time, bad data identification, and numerical reliability and convergence in the presence of bad data.

As an attempt to provide an improved tool for power system data validation, a new approach is proposed in this paper. The method is based on a network search procedure and does not involve any data fitting. The algorithm performs basically the following operations:

- it calculates the electrical state and non-measured quantities of the system, using the available measurements and indications.
- it lists the suspicious measurements and network elements in increasing order of confidence.

Basic Features

The data validation and state calculation algorithm is characterized by the following features:

- The complex bus voltages are calculated sequentially, according to a breadth-first search through the network, using Kirchhoff's voltage and current laws when necessary.
- Tolerance margins are calculated for every measured and non-measured quantity.
- Redundant measurements are used to perform consistency checks in which Kirchhoff's laws are verified.
- For each consistency check, all involved network elements are graded according to the outcome of the test.
- Bad data are found by searching among the suspicious data, using appropriate sorting procedures.
- The algorithm is coded in the Pascal language. The network is represented in a 'natural' data structure using records and pointers. The program does not involve any matrices.

Properties

- Computation times are short and linearly proportional to the size of the network.
- The method is non-iterative. Convergence or numerical problems are excluded.
- The algorithm requires a substantial proportion of line flow measurements for adequate observability. The method is not suited for solving load flow problems.
- Nonmeasured quantities are calculated and their accuracy can be judged.
- Error detectability is indicated for every measurement.
- The distinction between line voltage drops and power flows enhances the identification of parameter and topology errors.
- Processing of heavily contaminated networks (with many bad data) is facilitated by the flexibility of the program.
- The deviations between the given measurements and the values obtained from the complex bus voltages can be computed. Once data validation is completed, static state estimation may be performed if the deviations should be minimized.

---

82 SM 336-6
January 1983, p. 233

Bibliography of Power Systems Operator Training Resources

IEEE Committee Report prepared by the PES Working Group on Operator Training (WG78-4)
Max D. Anderson (*Chairman*)
University of Missouri, Rolla, MO

Abstract—This paper provides a current listing of training courses, programs, and resource materials for Power System Operator/Dispatcher training. The training resources are subdivided into five (5) categories:

I. Dispatcher training courses and facilities developed by the Suppliers/Manufacturers
II. University Short Courses
III. Conference Publications
IV. Reference Books
V. Correspondence Courses

A brief description of the offerings of each of the Suppliers/Manufacturers is included.

Summary

The problems of Power System Operator/Dispatcher Training as we know them today are relatively new. They apply to power systems with modern computer-based energy control centers, energy management systems (EMS) and supervisory control and data acquisition (SCADA) systems. Most of the published papers and available training materials have been prepared since 1976.

The Working Group on Operator Training (WG78-4) has been searching out and collecting training material for several years. This has been done by surveys of the utilities and the industries that supply the utilities as well as short courses, publications, and reference materials.

The resource material is presented in five (5) categories:

I. Suppliers/Manufacturers—This category consists of training resources designed and fabricated by industry specifically for the electric utilities for their Dispatcher training needs.

II. Universities—These are short courses offered periodically which are specifically for Dispatcher Training.

III. Conference Publications—These are recent publicatins currently available. Some of these papers have been prepared by the working group for two (2) COPS sessions and two (2) invited paper sessions presented at the PES Summer & Winter meetings.

IV. Reference Books—These are suggested reference books that are basic to Power Systems Operator Training.

V. Correspondence Courses—These are a sample of courses available by correspondence which can provide the trainee with some background for Dispatcher Training.

Contributing authors include but are not limited to Robert P. Schulte (Bonneville Power Administration), John M. Thorson, Jr. (Control Data Corporation), Don Ewart (General Electric), R. A. Bednarik (Con Edison) and Max D. Anderson (University of Missouri, Rolla).

---

82 SM 406-7
January 1983, p. 256

Improved Structure Avoiding Local Field Intensification on Spacers in SF_6 Gas

K. Itaka and T. Hara
Sumitomo Electric Industries, Ltd., Osaka, Japan
T. Misaki, Member IEEE and H. Tsuboi
Okayama University, Okayama, Japan

Breakdown performance of SF_6 gas is apt to be influenced by local electric field intensification, so spacers used in SF_6-gas-insulated apparatus should be designed to avoid local field intensification in the SF_6 gas region. Spacers made of cast epoxy are usually used, so the difference of dielectric constant between epoxy and gas causes field intensification in the vicinity of the gas-epoxy-electrode interface. Reduction of such field intensification is important in practical insulation design. In this report, cone-type spacers which have no inserts and are fitted between flanges in SF_6-gas-insulated apparatus are investigated.

The fundamental structure of cone-type spacers studied is shown in Fig. 1. This spacer is designed as a full-size model for gas-insulated equipment. The flashover characteristics of the spacer shown in Fig. 1 are sometimes reduced under the influences of the local field intensification at the spacer-flange interface.

It is difficult to obtain the degree of such field intensification correctly by field calculations since the field intensification is limited within a small region. Therefore, the reduction of the local field intensification is troublesome in the design of practical apparatus.

The most common means of reduction is shielding the field by using inserts. However, methods other than using inserts become preferable from the point of view of cost, etc. if they can avoid the occurrence of flashover initiated by the field intensification. In this paper, only the methods without inserts are studied.

Fig. 2 shows the field distribution on the surface of the flange without spacer. The interface between rounded surface and flat surface (point P) has greater electric stress, and the electric stress is reduced steeply away from the interface (point Q). In the conventional structure of spacer fitting, the spacer makes contact with the flange at point P where the electric stress is increased, so the field intensification becomes greater. In addition, the conventional structure has a wedge-shaped gas gap between spacer and flange near point P, creating singularity of field distribution and resulting in the occurrence of local field intensification.

The authors thought it important to avoid these two factors and proposed a different structure as shown in Fig. 3. The structure seemed to be effective for the reduction of local field intensification for the following reasons:

(1) The spacer makes contact with the flange at point Q where the electric stress is reduced compared with that at point P.
(2) The right angle between spacer and flange avoids the singularity of field distribution.

The effectiveness of the proposed structure was made clear by field calculations and experiments.

Since these results can be applied for the design of not only cone-type spacers but also disc-type spacers, they are significant for the insulation design of practical gas-insulated apparatus.

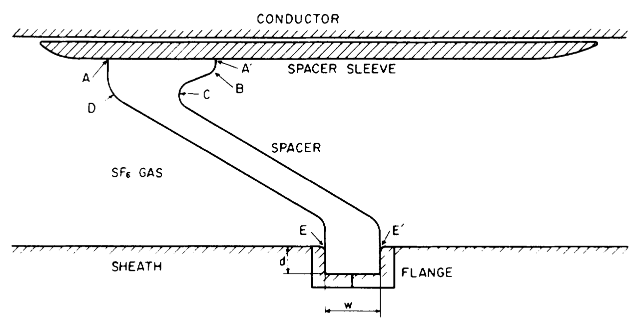

Fig. 1. Basic structure of conventional cone-type spacer.

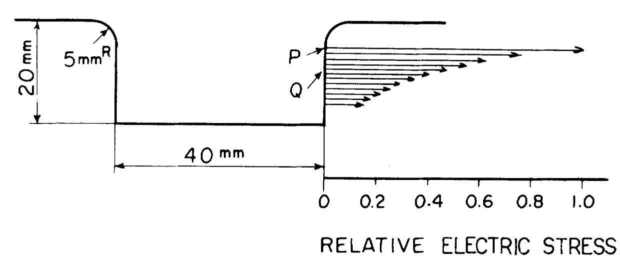

Fig. 2. Field distribution at surface of flange.

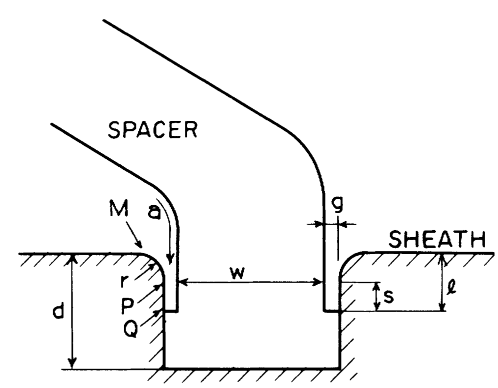

Fig. 3. Improved structure for reduction of local field intensification.