Electrical Power and Energy Systems 33 (2011) 1666–1674

Contents lists available at SciVerse ScienceDirect

Electrical Power and Energy Systems

journal homepage: www.elsevier.com/locate/ijepes

A novel approach to determine transmission reliability margin using parametric bootstrap technique

M.M. Othman *, I. Musirin

Centre for Electrical Power Engineering Studies, Faculty of Electrical Engineering, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia

ARTICLE INFO

Article history:
Received 10 December 2008
Received in revised form 1 July 2011
Accepted 12 August 2011
Available online 17 October 2011

Keywords:
Available transfer capability
Transmission reliability margin
Parametric bootstrap technique
Non-parametric bootstrap technique
Monte Carlo simulation technique
Standard deviation of uncertainty

ABSTRACT

The determination of available transfer capability (ATC) must accommodate a reasonable range of transmission reliability margin (TRM) so that the transmission network is secure from uncertainty that may occur during a power transfer. This paper presents a computationally accurate method in determining the TRM with large amount of uncertainty using the parametric bootstrap technique. The parametric bootstrap technique is used to randomly generate a bootstrap sample of system operating condition with large uncertainty selected at a certain percentage of bootstrap confidence interval. The bootstrap sample is used in the determination of TRM at every time interval. Then, a new value of ATC at the current time interval is calculated by considering the TRM at the same time interval. The effectiveness of the proposed TRM method in providing new ATC value is validated on the Malaysian power system. The results have shown that the proposed method provides accurate estimation of TRM in which it is relatively similar to the TRM result obtained by the standard deviation of uncertainty which is incorporated in the Monte Carlo simulation technique. Further comparisons have been made in terms of accuracy and total time computation in order to verify the robustness of parametric bootstrap in determining the TRM as compared to the non-parametric bootstrap technique.

1. Introduction

In a more competitive electric power market, transmission providers are required to produce commercially viable information of available transfer capability (ATC) so that such information can help power marketers, sellers and buyers in planning, operation and reserving transmission services. ATC is defined as the additional amount of power that may flow across the interface, over and above the base case flows and it indicates as the amount by which interarea power transfers can be increased without jeopardizing system security. The transmission company should determine the optimal split of firm and non-firm (interruptible) ATCs [1]. This information is a great interest to the generating company in order to provide a contract which would transfer a firm or non-firm electric power required by the customers. The optimal split between firm and non-firm ATCs are performed by using the non-sequential Monte Carlo simulation technique incorporating with the DC power flow solution. On the other hand, probabilistic assessment of ATC plays an imperative role in system planning. This information is used by the system planner in determining the best location to add new generations and loads in a system which may assist to the increase of power transfer without violating the system reliability [2]. Silva et al. [2] uses the Monte Carlo simulation technique that takes into account the Linear Programming with DC power flow solution to perform probabilistic assessment of ATC. Mello et al. [3] discussed on a methodology that used to determine simultaneous maximum power transfers (STC) for a large system comprising of many areas. The STC is determined by using the Monte Carlo simulation technique and AC optimal power flow based Interior Point algorithm.

The uncertainties considered in the transfer capability assessment are partly due to the inaccurate network parameters, approximation in transfer capability computation, unforeseen load additions or reductions, changing cost of purchased power, forced unit outages and load changes due to weather, temperature, humidity or economic conditions [4]. Chang et al. [5] and Tsai and Lu [6] utilize the non-parametric bootstrap technique to determine the uncertainty of transfer capability at each hour and it can be used for TRM determination. On the other hand, the parametric bootstrap technique is an alternative approach in estimating the uncertainty and it is utilized when the parametric distribution of the observed data is known [5]. The application of parametric bootstrap technique in the determination of TRM at every time interval in a day has been discussed elaborately in this paper. The parametric bootstrap technique is superior to the non-parametric bootstrap technique in estimating the uncertainty of system operating condition. This is due to the fact that the parametric bootstrap technique

* Corresponding author. Tel.: +60 3 55435037; fax: +60 3 55435077.
E-mail address: mamat505my@yahoo.com (M.M. Othman).

0142-0615/$ - see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.ijepes.2011.08.003