Performance Evaluation of the Generalized Control Tuning Procedure for MMC-VSC Systems

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***Abstract*—The proper selection of PI-controller parameters of MMC-VSC systems is a challenging task. At present, the industry practice is to use the trial and error approach that consumes a great amount of time. This paper analyses the performance of the generalized control tuning technique that can be used to simultaneously tune PI-controllers of practical MMC-VSC systems. The performance evaluation is done in-terms of the average time taken to determine suitable PI-controller parameters that satisfy the predefined performance requirements. It is showed that the proposed method is simple and fast.**

I. Introduction

Stability and control of MMC-VSC systems is a popular research topic at present. Tuning of VSC control loops is a challenging task as it consists of cascaded PI-control loops. The control tuning techniques based on simplified transfer functions are not suitable as the control system is not completely decoupled and also the converters interact through the dc system [1], [2]. Optimization enabled EMT simulation technique is used to tune VSC controllers in [1] and [3]. However to reduce the computational burden, the time-domain objective functions consider only the outer-loop controllers. In addition, the author of [1] has indicated that the simultaneous tuning of converters in a dc grid considering multiple operating conditions is not practical. Even with a use of a 60 core specially designed computer, the parallel optimization method proposed in [3] takes 20 hours to tune the converters of a point-to-point VSC system. Due to these reasons, the practical VSC systems are tuned by means of the trial and error approach.

II. Generalized Control Tuning Technique

A generalized frequency-domain technique to simultaneously tune converters in a practical MMC-VSC system is proposed by the authors in [2]. The gain tuning problem is formulated as an optimization problem that seeks for required damping of all oscillatory modes and required negative values for all decaying modes. The frequency-domain stability attributes are calculated using a validated small-signal stability model that includes the dynamics of ac system, dc system, MMCs (arm inductor and average converter losses), and control system (control-loops, PLLs, and measurement filters). In addition, the tuning method considers multiple operating conditions to cover the practical operating regions of the MMC-VSC system.

TABLE I
Average Computational Time

Short circuit ratio (SCR)	Average time taken to tune controllers
5.0	less than a minute
3.0	∼2 minutes
2.0	∼5 minutes
1.5	∼30 minutes

III. Results and Discussion

The performance of the control tuning algorithm is evaluated by calculating the average time taken to simultaneously tune all PI-controllers in the point-to-point MMC-VSC system described in [2]. Different ac system strengths ranging from very-weak to strong systems are considered and the performance requirements are set as the same. For each ac system, the average time taken to tune controllers on a general purpose computer (4 core) are given in Table I. It can be observed that the proposed control tuning technique takes only a few minutes to simultaneously tune all PI-controllers of the MMC-VSC system connected to ac systems with SCR values higher than 2.0. From the results provided in in Table I, it is clear that the control tuning method proposed by the authors is more suitable to simultaneously tune converters in a dc grid compared to the time-domain simulation based optimization techniques proposed in [1] and [3].

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References

[1] Z. J. Zhou, “Co-ordination of Converter Controls and An Analysis of Converter Operating Limits in VSC-HVDC Grids,” Ph.D. dissertation, Dept. Elect. & Comput. Eng., Univ. Manitoba, Canada, 2013.

[2] S. Arunprasanth, U. D. Annakkage, C. Karawita, and R. Kuffel, “Generalized Frequency-Domain Control Tuning Procedure for MMC-VSC Systems,” *IEEE Trans. Power Del.*, in press.

[3] A. Y. Goharrizi, R. Singh, A. M. Gole, S. Filizadeh, J. C. Muller, and R. P. Jayasinghe, “A Parallel Multimodal Optimization Algorithm for Simulation-Based Design of Power Systems,” *IEEE Trans. Power Del.*, vol. 30, no. 5, pp. 2128–2137, 2015.