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On impedance matching and maximum power transfer

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ABSTRACT

This paper investigates the relationship between the impedance matching and the maximum power transfer problems, and presents a predictor–corrector framework for fast estimation of the maximum power transfer limit for the load increase pattern with a common scaling factor. First, a network equivalent technique is presented and a "decoupled" equivalent network is obtained for every load bus. Second, a special form of impedance matching condition is derived for the maximum power transfer problem with an unlimited load variation pattern. Though this is an unrealistic case in power systems, it might have a profound physical mechanism and lead to an interesting explanation and application for the presented equivalent technique. Third, this paper discusses the relationship between the impedance matching and the maximum power transfer problem for the load increase pattern with a common scaling factor. Finally, a predictor–corrector framework is introduced for fast estimation of the maximum power transfer limit for the load increase pattern with a common scaling factor.

1. Introduction

Due to economic, technical and environmental concerns, today's power systems are being forced to operate closer to their loadability limits. As a result, the power transfer capability of an interconnected power system has been becoming an important concern of both system planners and operators. Therefore, how to determine the maximum power transfer limit of an interconnected power system has become an increasingly important issue in power system planning and operation.

In modern power systems, the increasing penetration of renewable energy sources is putting power system security in a challenge because of large uncertainties. Excessive power injections of renewable sources could cause an undue risk of system overloads, voltage collapse, or even blackouts due to deficient power transfer capabilities. Therefore, accurate evaluation of transfer capability is essential to maximize utilization of existing transmission grids while maintaining system security.

In general, the power transfer of an interconnected power system may be limited by the physical and electrical characteristics of the systems including any one or more of thermal, voltage and stability limits [1]. When the dynamic or transient stability constraints are considered, it will be very difficult to determine the maximum power transfer limit for online applications [2–4]. Therefore, in the last decades, considerable attentions were mainly paid to the calculation of the maximum power transfer limit with static security constraints [5–8], and the conventional P–V and Q–V curves are widely used as a tool for off-line application in utility industries [9,10].

In recent years, due to the fast development of synchronized phasor measurement technologies, the measurement-based methods have received considerable attentions for online estimation of the maximum power transfer limit [11–18]. In essence, this type of method is based on the well-known impedance matching principle. The measured data are used to obtain the Thevenin equivalent of the system, as seen from the load bus under study, and the apparent impedance of the load. When the Thevenin impedance matches the load impedance in magnitude, the maximum power transfer is reached.

The purpose of this paper is to discuss the relationship between impedance matching and maximum power transfer, and thus propose a predictor–corrector framework for fast estimation of the maximum power transfer limit for the load increase pattern with a common scaling factor. First, a network equivalent technique is presented. In Section 2, a special form of impedance matching condition is derived for the maximum power transfer problem with the unlimited load variation pattern. Section 4 discusses the maximum power transfer problem for the limited load increase pattern. In Section 5, a predictor–corrector framework is introduced for fast estimation of the maximum power transfer limit for the load

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