iSPEC 2019 2019 IEEE Sustainable Power & Energy Conference

Steady-State Security Region Considering Post-Contingency Cascaded DC Commutation Failure

Bo Zhou, Xiaomeng Ai, Jiakun Fang, Chengxiang Yang, et al
Huazhong University of Science & Technology

I. INTRODUCTION

With the increasingly deployed DC transmissions, the conventional AC power system is evolving to the hybrid AC-DC power system. However, the post-contingency cascaded DC commutation failure (CF) may trigger the DC blocking and further cause severe security accidents. Existing control strategies are all prepared for the post-contingency emergencies and can not provide the advice for pre-contingency dispatch decisions. Steady-state security region (SSR) is proposed to depict the scope of dispatch. However, the post-contingency cascaded CF has not been considered in existing SSR methods. This paper proposes the SSR considering the post-contingency cascaded DC-CF to obtain the scope of security-constrained (SC) dispatch decisions for the DC receiving-end power system. The quasi-steady-state voltage reduction at the AC bus of the DC/AC inverter is selected as the CF criterion. The decoupled linearized power flow (DLPF) is introduced to take voltage issues into accounts. The proposed SSR can give a clear scope of the dispatch decisions where the N-1 post-contingency cascaded CF can be inhibited.

II. STEADY-STATE SECURITY REGION

The steady-state security region is the set of operating points where all the operation and security constraints should be satisfied. The commonly-used SSR formulation is based on the DC power flow (DCPF) model and defined in the active power generation space. However, the voltage issues can not be handled. Besides, the N-1 security constraints have not been taken into accounts.

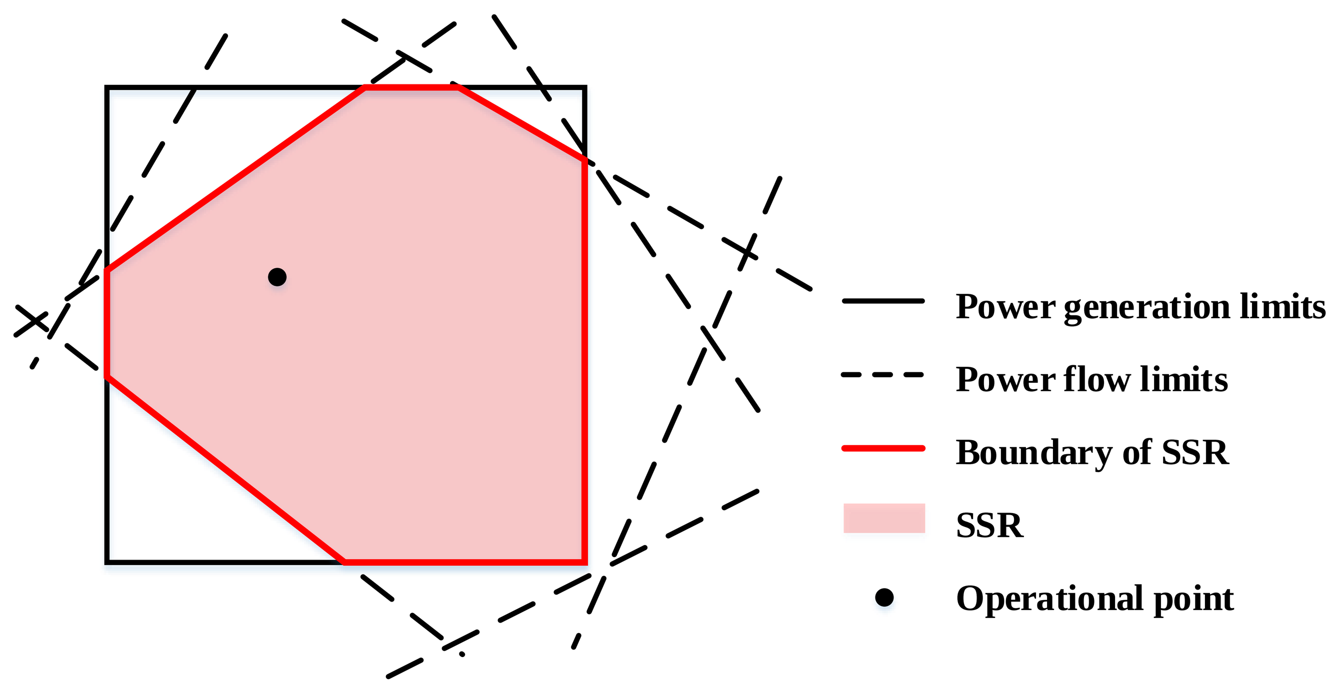

Fig. 1 Schematic diagram of SSR

III. SSR CONSIDERING CASCADED DC-CF

CFs usually occur in the line-commutated converters (LCC) and result from the faults of the DC receiving-end AC power system. From previous studies, CFs is generally triggered when the commutation voltage suddenly drops. So the quasi-steady-state voltage reduction is selected as the CF criterion. It should be noted that the CF criterion is to be used in SSR where the transient response is not the focus so that the quasi-steady-state criterion is reasonable. The critical voltage value adopted in this paper is about 0.9 p.u..

However, the commonly-used DC power flow can not handle voltage issues. In this paper, the DLPF proposed is introduced and the CF criterion can be coupled in SSR formulation. The N-1 contingency of AC transmission lines is also considered. The post-contingency transient process is neglected and the variables at the quasi-steady-state are used for the security criterion. Considering the ramping rate and excitation regulation, the pre- and post-contingency active power generation is assumed the same while the reactive power generation can be different. The security constraints consist of the pre- and post-contingency power generation, power flow, bus voltage, and CF inhibition constraints.

IV. CASE STUDY

The modified IEEE 9-bus system is used for the case study. An inverter station with 100MW-j100Mvar power injection is added at bus 5 and the modified IEEE 9-bus system becomes a DC receiving-end power system. The N-1 transmission line contingency list includes line 4-5, 5-6, 6-7, 7-8, 8-9, and 9-4. The SSR projected on the active power generation plane is shown in Fig. 2. If the operating point is at P1, the post-contingency security constraints will be violated. If the operating point is at P2, the post-contingency cascaded CF may occur. If the operating point is in at P3, the post-contingency cascaded CF can be inhibited. From the above analysis, the effectiveness of the proposed DLPF based SSR with post-contingency cascaded CF considered can be validated.

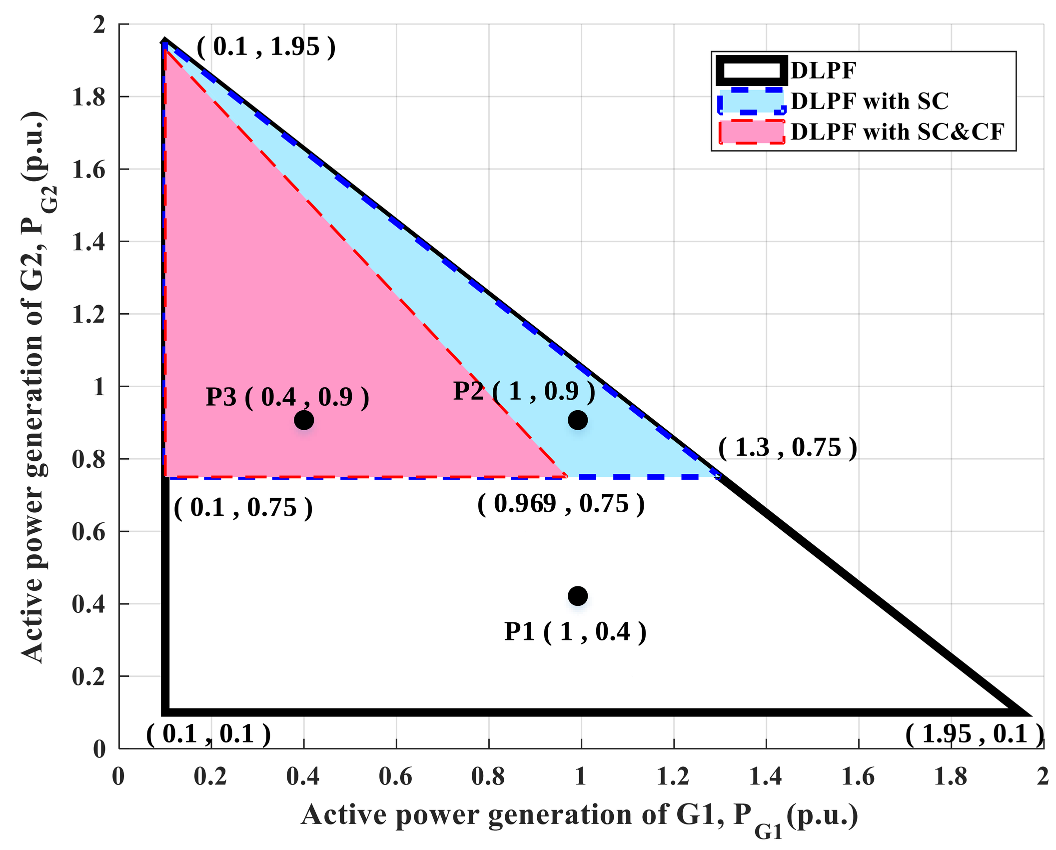

Fig. 2 DLPF based SSR with different security constraints

The modified IEEE 30-bus test system is also used for the case study. An inverter station with 100MW-j100Mvar power injection is added at bus 3. The contingency list includes all lines except line 9-11, 12-13, and 25-26. The projections on the active power generation space of SSR are shown in Fig. 3. With the post-contingency CF inhibition constraints considered, SSR using DLPF with SC is cut and narrowed. The results validate the effectiveness of the proposed SSR.

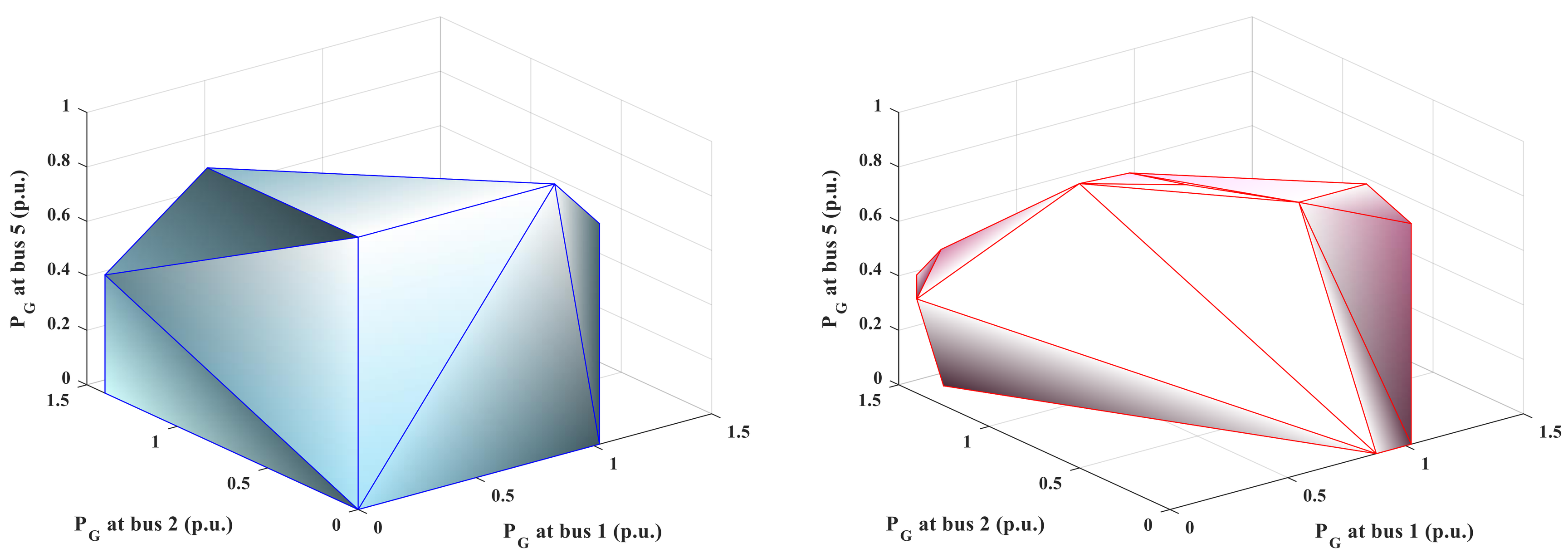

Fig. 3 SSR for modified IEEE 30-bus system.
(a) Only security constraints, (b) With CF inhibition considered

V. CONCLUSION

This paper proposes the method to build the steady-state security region with the post-contingency cascaded DC commutation failure considered. The quasi-steady-state voltage reduction is adopted as the DC commutation failure criterion. The decoupled linearized power flow is introduced to handle the voltage issues. The proposed SSR can give comprehensive support for the power system operators to avoid the post-contingency cascaded commutation failure so that the N-1 security can be guaranteed. The case studies in modified IEEE 9- and 30-bus test system validate the effectiveness of the proposed method.

Tel: +8618202739441
E-Mail: zhoubo563@foxmail.com

Paper Number:201907120000107