Analysis on the Influence of Different Setting Conditions on the Short Circuit Current Calculation Results of PSD-SCCP

Jianbin Wu¹, Xiaoming Zheng¹, Yi Gao², Haibo Zhao¹, Zhong Wu¹, Peng Wang¹

¹ State Grid Shanxi Economic and Technological Research Institute, Taiyuan, Shanxi, 030001, China
² Auckland University of Technology, Auckland, 1010, New Zealand

Abstract. The result of power system short circuit calculation and verification is important reference for power system relay protection, electrical automatic device setting, transient process research, electrical planning and design and equipment selection. In the process of short circuit calculation, different conditional combination mode may lead to different results. The aggressive conditional combination mode will lead to the decline of power grid security performance, on the contrary, the conservative conditional combination mode will lead to the rapid increase of investment cost, resulting in a certain amount of investment waste. At present, there is no unified short circuit current calculation standard in the industry. Based on the actual power grid calculation example of a province in China, the short circuit current results of six condition combination modes is calculated and analyzed in this paper, expecting to provide an important reference for the setting of short circuit current calculation conditions.

1. Introduction

With the increasing scale of power grid and the increasing voltage level, the problem of exceeding the standard of short circuit current level in some areas becomes increasingly prominent⁴⁻⁵. If the short circuit calculation result is too conservative, it will cause excessive waste of investment, on the contrary, it will lead to the hidden danger of safe and stable operation of power system⁶⁻⁷. PSD-SCCP short circuit current calculation program is developed by China Electric Power Research Institute. It mainly provides efficient and fast calculation methods for the selection of electrical equipment in the power system, the check of switch breaking capacity, the calculation of relay protection setting, the comparison of system wiring modes, etc. The software has been widely used in the power industry⁶⁻⁷. It has friendly human-machine interface, perfect calculation function and convenient analysis results. The program can meet the functional requirements of various power system short circuit current calculation, and provide a set of convenient, efficient and fast short circuit current calculation and analysis means for users. However, in the process of using the software, there are different settings of check items, and different selection methods will lead to great differences in the calculation results. Therefore, it is necessary to compare the calculation results under the commonly used classical short circuit current setting conditions, and then master the influence of specific setting conditions on the trend and amplitude of short circuit current calculation results, so as to provide an important reference for the electrical engineering technicians in short circuit verification and improve the calculation and analysis level of short circuit current in engineering practice.
2. Analysis of PSD-SCCP short circuit current calculation mode

The short circuit current calculation of PSD-SCCP is usually divided into two basic methods based on power flow and grid structure. Due to the complex and variable operation state of power system, the system voltage and system impedance of the short circuit point will change at the same time, which leads to the change factor of the short circuit current is not a single variable, so it is difficult to compare and select the specific power flow distribution that causes the maximum short circuit current. Therefore, this paper does not recommend the short circuit current calculation method based on power flow, although the node voltage is more accurate actual system operating voltage. Compared with the power flow based short-circuit current calculation method, the calculation results of grid based calculation method are basically the same under the same starting mode, grid structure and load level of the generator, so it is convenient to compare and select the influence of different setting conditions on the short circuit current. The optional short circuit current calculation conditions of PSD-SCCP are as follows:

- **Condition 1**: Based on the results of power flow calculation
  - The short circuit calculation is based on the power flow results, and the bus voltage is based on the power flow calculation results.
- **Condition 2**: Consider static load
  - All static loads are treated as constant impedance.
- **Condition 3**: Consider motor load
  - Considering the induction motor model data.
- **Condition 4**: Positive sequence considering parallel reactive power compensation
  - Forming positive sequence admittance matrix to deal with parallel compensation has no effect on zero sequence.
- **Condition 5**: Positive sequence considering line charging power
  - Forming positive sequence admittance array to deal with AC line capacitance, and zero sequence is considered.
- **Condition 6**: Consider line and transformer resistance
  - In addition to reactance, the resistance of transformer and line is also considered.
- **Condition 7**: Full power on mode
  - Short circuit current provided for non output generator.
- **Condition 8**: The transformer adopts standard transformation ratio
  - Set the unit value of transformer transformation ratio to 1: 0, and ignore the non-standard transformation ratio.
- **Condition 9**: During the fault period, all series compensation is bypassed
  - When the short circuit occurs near the series compensation, the action of the protection bypass switch is considered.
- **Condition 10**: Consider flexible DC converter (current source model)
  - Consider the short circuit current provided by the flexible DC converter.
- **Condition 11**: Based on GB/T15544.1-2013 standard
  - When this condition is selected, the bus voltage is the highest voltage of the equipment, otherwise the reference voltage is used.

Based on the above different setting conditions and according to the actual situation of the power grid in a province of China, six calculation combination models are designed to analyze the influence of different calculation conditions on the calculation results of short circuit current. The calculation results are shown in Table 1.

| Mode 1                  | Condition 1 | Condition 2 | Condition 3 | Condition 4 | Condition 5 | Condition 6 | Condition 7 | Condition 8 | Condition 9 | Condition 10 | Condition 11 |
|-------------------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|-------------|---------------|-------------|
| Condition 1             | ×           |             |             |             |             |             |             |             |             |               |             |
| Condition 5             | ×           | ×           |             |             |             |             |             |             |             |               |             |
| Condition 9             | √           | ×           |             |             |             |             |             |             |             |               | √           |

### Table 1. Calculation condition settings of 6 modes
It can be seen from the above table that, compared with mode 1, other modes only change one condition at a time (marked in red in the paper), so that the change of short-circuit current caused by the change of setting conditions can be accurately analyzed, the change trend and amplitude can be mastered, and the reference of condition combination can be provided for engineers and technicians in short-circuit analysis.

3. Analysis of calculation results of different models

Based on the calculation data of power grid planning in a province of China in 2021, the 1 phase and 3 phase short circuit currents of 220kV bus are calculated respectively for six different calculation modes, and the calculation results are shown in Table 2.

| Bus name | Type | Mode 1 | Mode 2 | Mode 3 | Mode 4 | Mode 5 | Mode 6 |
|----------|------|--------|--------|--------|--------|--------|--------|
| SX-LL    | 1 phase | 45.89  | 49.29  | 45.89  | 46.69  | 45.96  | 44.95  |
| SX-LL    | 3 phase | 56.47  | 63.69  | 56.46  | 57.21  | 56.60  | 54.58  |
| SX-YB    | 1 phase | 50.04  | 54.14  | 50.04  | 49.93  | 50.05  | 48.84  |
| SX-YB    | 3 phase | 52.96  | 59.09  | 52.95  | 52.97  | 52.97  | 51.33  |
| SX-XR    | 1 phase | 39.71  | 43.03  | 39.39  | 39.15  | 39.71  | 38.69  |
| SX-XR    | 3 phase | 42.55  | 45.95  | 42.16  | 42.30  | 42.55  | 41.31  |
| SX-LF    | 1 phase | 51.84  | 59.52  | 51.84  | 52.14  | 51.91  | 50.79  |
| SX-LF    | 3 phase | 53.83  | 64.74  | 53.83  | 54.17  | 53.92  | 52.40  |
| SX-FR    | 1 phase | 55.78  | 60.55  | 55.77  | 55.39  | 55.79  | 54.11  |
| SX-FR    | 3 phase | 69.35  | 79.60  | 69.35  | 68.98  | 69.37  | 66.79  |
| SX-XX    | 1 phase | 41.80  | 47.76  | 41.80  | 41.80  | 41.97  | 40.76  |
| SX-HH    | 1 phase | 40.09  | 47.69  | 40.09  | 40.13  | 40.29  | 38.69  |
| SX-HC    | 3 phase | 50.65  | 56.30  | 50.65  | 50.43  | 50.66  | 49.42  |
| SX-HC    | 1 phase | 60.87  | 73.05  | 60.86  | 60.75  | 60.88  | 59.20  |
| SX-HE    | 3 phase | 44.42  | 48.56  | 44.42  | 44.24  | 44.46  | 43.28  |
| SX-HE    | 1 phase | 43.29  | 48.83  | 43.29  | 43.14  | 43.33  | 41.85  |
| SX-JC    | 3 phase | 43.77  | 53.09  | 43.77  | 43.72  | 43.98  | 42.72  |
| SX-JC    | 1 phase | 44.23  | 57.82  | 44.23  | 44.27  | 44.51  | 42.81  |
| Location | Phase | 1 | 2 | 3 | 4 | 5 |
|----------|-------|---|---|---|---|---|
| SX-JZ    | 3     | 48.39 | 52.33 | 48.39 | 47.47 | 48.41 | 47.38 |
| SX-JZ    | 1     | 63.68 | 73.73 | 63.68 | 62.6  | 63.71 | 62.16 |
| SX-JD    | 3     | 36.48 | 39.77 | 36.48 | 36.51 | 36.49 | 35.85 |
| SX-JD    | 1     | 36.91 | 40.83 | 36.91 | 37.14 | 36.91 | 35.98 |
| SX-JA    | 3     | 45.99 | 52.87 | 45.99 | 45.77 | 46.22 | 44.64 |
| SX-JA    | 1     | 47.07 | 56.28 | 47.06 | 47.01 | 47.35 | 45.21 |
| SX-LX    | 1     | 34.85 | 37.79 | 34.85 | 34.79 | 34.86 | 34.00 |
| SX-LX    | 3     | 34.36 | 38.24 | 34.36 | 34.37 | 34.38 | 33.25 |
| SX-LC    | 1     | 62.50 | 69.99 | 62.50 | 62.18 | 62.52 | 61.32 |
| SX-LC    | 3     | 68.62 | 81.77 | 68.62 | 68.31 | 68.65 | 66.92 |
| SX-LA    | 1     | 46.01 | 52.96 | 46.01 | 45.66 | 46.23 | 44.44 |
| SX-LA    | 3     | 45.26 | 53.88 | 45.26 | 45.00 | 45.52 | 43.33 |
| SX-PC    | 1     | 41.03 | 44.38 | 41.03 | 41.01 | 41.03 | 39.96 |
| SX-PC    | 3     | 45.67 | 48.96 | 45.52 | 46.33 | 45.67 | 44.28 |
| SX-SZ    | 1     | 49.15 | 51.82 | 49.15 | 49.84 | 49.15 | 47.79 |
| SX-SZ    | 3     | 53.32 | 55.97 | 53.19 | 53.66 | 53.32 | 51.61 |
| SX-TX    | 1     | 40.08 | 45.38 | 40.08 | 40.10 | 40.11 | 39.25 |
| SX-TX    | 3     | 41.05 | 47.68 | 41.05 | 41.21 | 41.09 | 39.88 |
| SX-WZ    | 1     | 43.49 | 45.87 | 43.37 | 43.27 | 43.49 | 42.01 |
| SX-WZ    | 3     | 43.97 | 46.67 | 43.83 | 43.95 | 43.97 | 42.09 |
| SX-XZ    | 1     | 44.85 | 49.01 | 44.81 | 44.78 | 44.85 | 43.73 |
| SX-XZ    | 3     | 48.42 | 53.13 | 48.39 | 48.80 | 48.42 | 46.78 |
| SX-YT    | 1     | 49.80 | 54.69 | 49.59 | 48.25 | 49.81 | 48.06 |
| SX-YT    | 3     | 59.23 | 65.44 | 58.96 | 58.15 | 59.23 | 56.90 |
| SX-YQ    | 1     | 43.11 | 46.81 | 43.11 | 43.32 | 43.12 | 42.26 |
| SX-YQ    | 3     | 50.34 | 56.47 | 50.34 | 50.80 | 50.34 | 48.82 |
| SX-YD    | 1     | 46.03 | 49.60 | 46.02 | 46.41 | 46.03 | 45.20 |
| SX-YD    | 3     | 48.59 | 53.02 | 48.58 | 49.05 | 48.60 | 47.44 |
| SX-YC    | 1     | 48.09 | 57.37 | 48.09 | 47.74 | 48.11 | 46.65 |
| SX-YC    | 3     | 50.50 | 62.68 | 50.50 | 50.42 | 50.53 | 48.37 |
| SX-JS    | 1     | 52.69 | 62.63 | 52.69 | 52.45 | 52.73 | 51.30 |
| SX-JS    | 3     | 54.11 | 67.91 | 54.11 | 54.05 | 54.15 | 52.08 |

The calculation results are analyzed, and other models are compared with model 1. The results are as follows:

Mode 2: The three-phase short circuit current of 16 stations exceeds the standard, and 4 additional stations compared to mode 1. The single-phase short circuit current of 12 stations exceeds the standard, and 6 additional stations compared to mode 1. Compared with mode 1, the average ratio of short circuit current increases by 9.21%. The maximum increase is 30.73%, which is the three-phase short circuit current of SX-JC. The minimum increase is 1.68%, which is the single-phase short circuit current of SX-XX.

Mode 3: The three-phase short circuit current of 12 stations exceeds the standard, and 0 additional stations compared to mode 1. The single-phase short circuit current of 6 stations exceeds the standard, and 0 additional stations compared to mode 1. Compared with mode 1, the average ratio of short circuit current decreases by 0.17%. The calculation results of the two models are basically the same.

Mode 4: The three-phase short circuit current of 12 stations exceeds the standard, and 0 additional stations compared to mode 1. The single-phase short circuit current of 5 stations exceeds the standard, and 1 reduced stations compared to mode 1. Compared with mode 1, the average ratio of short circuit current increases by 0.16%. The calculation results of the two models are basically the same.

Mode 5: The three-phase short circuit current of 12 stations exceeds the standard, and 0 additional stations compared to mode 1. The single-phase short circuit current of 6 stations exceeds the standard, and 0 additional stations compared to mode 1. Compared with mode 1, the average ratio of short circuit current increases by 0.25%. The calculation results of the two models are basically the same.
Mode 6: The three-phase short circuit current of 10 stations exceeds the standard, and 2 reduced stations compared to mode 1. The single-phase short circuit current of 4 stations exceeds the standard, and 2 reduced stations compared to mode 1. Compared with mode 1, the average ratio of short circuit current increases by 2.78%. The maximum reduction is 4.28%, which is the three-phase short circuit current of SX-WZ. The minimum increase is 0.78%, which is the single-phase short circuit current of SX-XX.

The short circuit current difference between mode 2 to mode 6 compared mode 1 is shown in Figure 1:

![Figure 1. The short circuit current difference between mode 2 to mode 6 compared mode 1](image)

4. Conclusion
In this paper, 6 calculation modes are designed based on 11 different setting conditions of short circuit current calculation software PSD-SCCP, and short circuit current calculation is carried out based on the actual grid structure of a province in China. According to the calculation results, the following conclusions can be obtained:

(1) In mode 2, considering the motor load, the impedance of parallel branch increases, the short-circuit impedance decreases, and the calculation result of short circuit current increases obviously compared mode 1.

(2) In mode 6, the impedance correction coefficients of generator and transformer are considered, and the calculation results are conservative.

(3) Compared with mode 1, the calculation results of mode 3 to mode 5 have little difference.

Acknowledgments
It is grateful that the Fundamental Research Funds for the Central Universities of China(2017MS095) and National Natural Science Foundation of China(51407077) provides guidance and support in writing.

References
[1] Ruan Qiantu. (2005) Present situation of short-circuit current control in Shanghai power grid and countermeasures. Power System Technology, 29(2): 78-83.
[2] Yuan Juan, Liu Wenying, Dong Mingqi, et al. (2007) Application of measures limiting short circuit currents in Northwest China Power Grid. Power System Technology, 31(10): 42-45.

[3] Yao Zhiqing, Yu Fei, Zhao Qian, et al. (2013) Simulation research on large-scale PV grid-connected systems based on MMC. Proceedings of the CSEE, 33(36): 27-33.

[4] Zhang Yong, Wang Yunhui, Shen Jiantao, et al. (2007) Research of short-circuit current calculation in transmission network. Power System Technology, 31(1): 40-42.

[5] Tian Hua, Wang Qing, Zhu Feng, et al. (2010) Comparative study of short-circuit current calculation results based on PSASP software. Power System Protection and Control, 38(1): 56-60.

[6] Zhang Yongkang, Cai Zexiang, Li Aimin, et al. (2009) An optimization algorithm for short-circuit current limitation of 500 kV power grid by adjusting power grid configuration. Automation of Electric Power Systems, 33(22): 34-39.

[7] Li Yong, Yao Wenfeng, Yang Liu, et al. (2013) Analysis on the problems of thermal stability and standard-exceed short circuit current in the CSG main grid. Southern Power System Technology, 7(2): 21-25.