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Comparative Research on Total Transfer Capability Calculation using Load Model

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Abstract

This paper proposes a method calculating total transfer capability(TTC) and critical voltage using static power model based on real-time recording data, traditional power system dispatching calculation doesn't consider load model, which does not agree with the real, this paper compares TTC and critical voltage under different load model and P-V curves, on which load model has a strong influence, so load modeling is necessary based on real-time data and is significant for improving system stability. The simulations show necessity and suitability of the method.

Keywords: *total transfer capability (TTC), critical voltage, power system, load model*

1. Introduction

Since the 1990s, the renewable resource as a distributed power source merged into power netting gradually, with a strong developing tendency and a large–scale, which makes it is difficult to regulate and control power system. Against that background, There is an obvious unbalanced characteristic and uncertainty characteristic in the source network load flow, the border among in the generating electricity, transmitting power, distributing power and electrical power consumption can not be clear or fixed whatever in time and space, the present corresponding innate power system model will face with new challenges, especially power load model, the precision of the whole system model is further aggravated by the innate randomness and uncertainty of load model.

Load modeling is an important work in the power system simulation, the precision of structure and parameter of load model will influence the planning, running and studying of the power system, however the influence on computing TTC and the critical voltage in power system dispatching is more remarkable.

With the restructuring of the electric power industry, transmission capability to gauge the ability of the transmission network to carry through electric power is a major and timely issue. In a liberalized environment, it is important to know how much power can be transferred from a point to point in the future of system operation. The Total Transfer Capability (TTC) is an important indicator to measure security margin of power system. One of the main responsibility of dispatcher is keeping a watch on TTC, and takes effectively steps in case of need to enhance power transfer margin of the weak section.

This paper proposed a new static load model parameters recognition method using real-time recording data, and calculates the total transfer capability and critical voltage consequently.

2. TTC and Critical Voltage Considering Static Load Model

Usually, there are three total transfer capability calculating methods: the first one is based on optimal power flow, the TTC calculated by which tends to represent an ideal operating condition, and is not agree with the actual conditions; the second one is based on continuation

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power flow, it is of good robustness and proper for simulating a predetermined growth pattern of generation of electricity and load, but it only applies to such conditioning way that one part of power section increases generation of electricity and the other part increases, and is not fit for large power grid calculation; the third one is based on repetition power flow, it can apply all kinds of control and regulate means and is easy to treat with all different sorts of stability constraints, but the basic theory needed by which is inadequate at present; therefore, each one of these three approaches has its applying field and limitation. This paper uses the second one because of applying a predetermined load pattern of growth.

Power flow algorithm considering load static characteristic is followed as below equation (1) and (2):

$$\Delta P_i = P_{is0}\left(P_Z\left(\frac{V_i}{V_{is}}\right)^2 + P_I\frac{V_i}{V_{is}} + P_P\right) - V_i\sum_{j\in i}V_j\left(G_{ij}\cos\theta_{ij} + B_{ij}\sin\theta_{ij}\right) \quad (1)$$

$$\Delta Q_i = Q_{is0}\left(Q_Z\left(\frac{V_i}{V_{is}}\right)^2 + Q_I\frac{V_i}{V_{is}} + Q_P\right) - V_i\sum_{j\in i}V_j\left(G_{ij}\sin\theta_{ij} - B_{ij}\cos\theta_{ij}\right) \quad (2)$$

Where Pis0, Qis0 are initial real and reactive power and consider load static characteristic in Equation (1), load model uses ZIP model, here PZ, PI, and PP are coefficients of constant impedance, constant current, and constant power (ZIP coefficients) of real power respectively, and QZ, QI, and QP are coefficients of constant impedance, constant current, and constant power (ZIP coefficients) of reactive power, respectively. In order to represent the influence of load model, Jacobian matrix elements will be changed to Equation (3) and (4) as below:

$$N_{ii} = \frac{\partial\Delta P_i}{\partial V_i}V_i = P_{is0}\left[2A_1\left(\frac{V_i}{V_{is}}\right)^2 + B_1\frac{V_i}{V_{is}}\right] - V_i^2G_{ii} - P_i \quad (3)$$

$$L_{ii} = \frac{\partial\Delta Q_i}{\partial V_i}V_i = Q_{is0}\left[2A_2\left(\frac{V_i}{V_{is}}\right)^2 + B_2\frac{V_i}{V_{is}}\right] + V_i^2B_{ii} - Q_i \quad (4)$$

3. Comparative of the TTC and Critical Voltage under Different Load Model

3.1. Simulation Example 1: 2-node Simple Model

Simple two-node system, system diagram is located as shown in Figure 1, the parameters are shown with the following settings: U0=1, P0=1, Q0=0.5, Z=j0.2, Y=1/Z. Load uses static model(ZIP or exponential function model), active power increasing step is 0.01.

The reactive power of Load node is fixed, the active power is growing by fixed step, the TTC and critical voltage under different load model are displayed in Table 1.

Table1. TTC and Critical Voltage under Different Load Model

Load model type	TTC	Critical voltage
4-4-2	2.1635	0.6343
3-3-4	2.1107	0.6338
4-6	2.0823	0.6379
Constant current	2.1529	0.6351
Constant impedance	2.2727	0.6347
Constant impedance (step=0.1)	2.2727	0.6428
Constant power	1.9299	0.6572
Constant power(step=0.1)	1.8999	0.6892

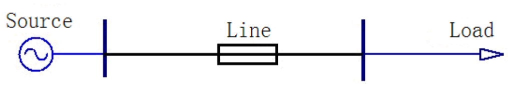

Figure 1. Simple two-node System

Directions: 4-4-2 model is 40% constant impedance, 40% constanr current and 20% constant power; 3-3-4 model is 30% constant impedance, 30% constanr current and 40% constant power; 4-6 model is 40% constant impedance and 20% constant power.

According to table 1: (1) TTC values from 0.8999 to 2.2727, he relative rate of change is 17.76%, thus, load model has a strong influence on TTC; (2) the critical voltage values from 0.6347 to 0.6572, the relative rate of change is 3.42, which is lower than TTC under different load model, but the critical voltage determines system instability points, the value is very useful in evaluating and deciding in power system dispatching; (3) the P-V curve is shown in Figure 2, changing trend of the curve is basically same, however, It was easier to see the differences between these curves; (4) The increasing step of load is 0.01, computing time willed be shorted when increasing step grows, other things, willed be increased, step decreasing can improve accuracy, and It is close for TTC and critical voltage to the actual conditions.

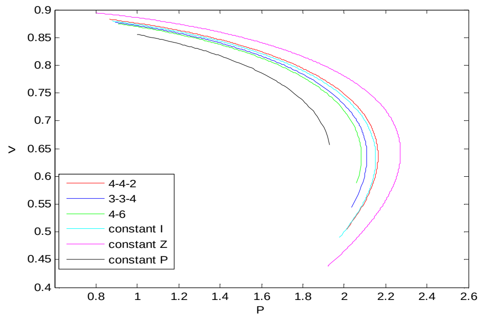

Figure 2. P-V Curves of 2-node System

3.2. Example 2: IEEE-9-node System

The 9-node system has 3 load, as shown in Figure 3, the parameters are shown with the following settings: U_0=0.9956, P_0=-1.25, Q_0=-0.5, load uses static model (ZIP or exponential function model), active power increasing step is 0.05, reactive power is constant.

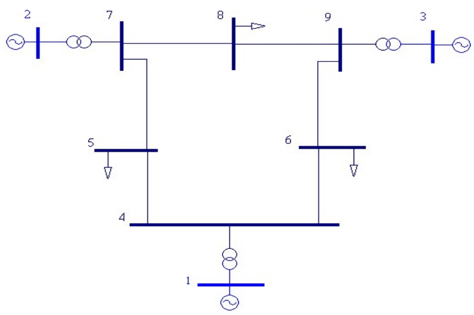

Figure 3. IEEE-9-node System

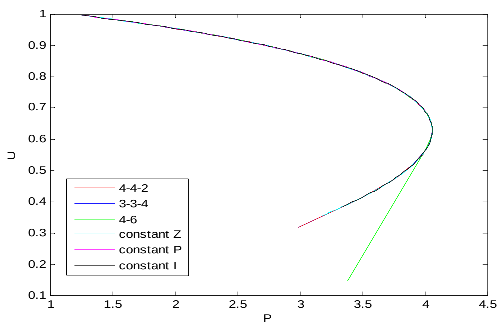

Figure 4.P-V Curve of Mode 1

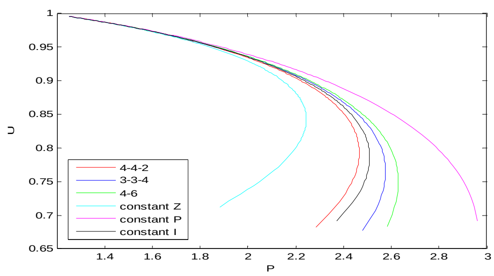

Figure 5.P-V Curve of Mode 2

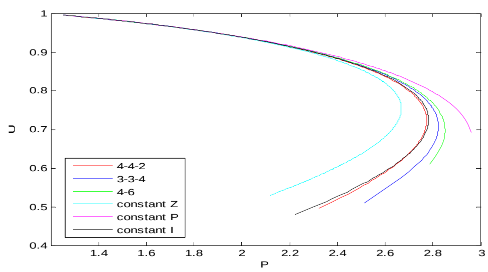

Figure 6. P-V Curve of Mode 3

Operating mode 1: Increasing power of node 5 with other load unchanged, the P-V curve of node 5 is displayed in Figure 4.

Operating mode 2: Increasing all the power of load, and only considering load static characteristic of 5-node load, the P-V curve of node 5 under different load model is displayed in Figure 5.

Operating mode 3: Increasing all the power of load and considering all load static characteristic, the P-V curve of node 5 is displayed in Figure 6.

The change of TTC and critical voltage is different a large under different load model, the contrasted outcome is shown in Ttable 2.

Table 2. The Comparative Outcome under Different Mode and Different Load Model

System type	Load increasin g mode	TTC		Critical voltage		Increasing step
		Change	Percentage Change	Change	Percentage Change	
2-node system	1	0.3428	17.76%	0.0225	3.42%	0.01
9-node system	1	0.0589	1.47%	0.0701	11.3%	0.05
9-node system	2	0.7175	24.21%	0.1504	21.73%	0.01
9-node system	3	0.2945	9.94%	0.0606	8.76%	0.01

Conclusions can be reached based on the result of simulation: (1) When single load is increasing with other load remaining constant, the TTC and critical voltage are most conservative under constant power load model; (2)When all load are increasing, whatever loads consider static load characteristic, the TTC and critical voltage are the most optimistic under constant power load model. (3) TTC and critical voltage not only have relations with pattern of growth of power system, but also have very big concern with Load model, opposite conclusion can even be come to under special circumstances, therefore, only the load model based on real-time recording data is the most factual model.

3.3. The TTC and Critical Voltage under Real-time Load Model

In view of the facts that a more accurate calculating method should be used based on real-time load model, the P-V curve is displayed in Figure 7 using real-time load model, it can be seen the outcome is of high accuracy and practical.

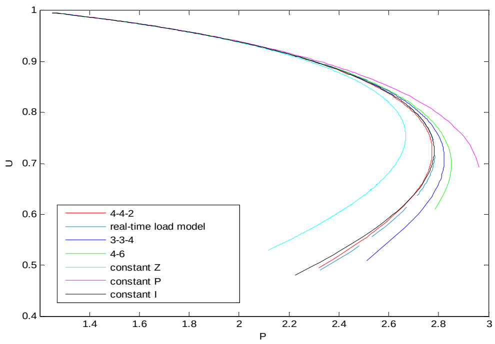

Figure 7: P-V Curve of 9-node System with Real-time Load Model

4. Conclusion

This paper proposes static load model based on real-time recording data is the most factual through comparing P-V curve under different load model, and calculates TTC and critical voltage in power system using the real-time model, Simulated calculation results demonstrate TTC and critical voltage change a great deal under different load model, it is obvious load model based on real-time data has higher accuracy, the outcome computed by which is consistent with the practice.

References

[1] Ding Ping, Zhou Xiao-xin, Yan Jian-feng, et al. *Calculation of Online Total Transfer Capability in Bulk Interconnected Grid Integrating Rationality and Security Principle*. Proceedings of the CSEE. 2010; 30(22): 1-6.

[2] JIANG Weiyong, ZHANG Boming, WU Wenchuan, et al. *A Total Transfer Capability Calculation Method for Power System Operation and Decision Automation of Electric Power Systems.* 2008; 32(10): 12-17.

[3] Shi Jinghai, He Renmu. *Load time-variantion in dynamic load modeling.* Proceedings of the CSEE. 2004; 24(4): 85-90.

[4] Li Defeng, Ju Ping. A study on the identifiability of electric load models. *Automation of Electric Power Systems*. 1997; 21(7): 10-14.

[5] Ai Qian, Chen Chen, Shen Shande, Gu Danzhen, Zhou Yuguang. *Research on parameter identification of load models by using linear BP networks*. Proceedings of the CSEE. 2005; 25(5): 21-27.

[6] Cheng Ying, Ju Ping, Wu Feng. PS algorithm in load parameter identification and its comparison with genetic algorithm. *Automation of Electric Power Systems.* 2003; 27(11): 25-29.

[7] Ju Ping, Ma Daqiang. *Power system load modeling*. China: Electric Power Press, 2008.