

The Influence of Load Model on Transient Stability Limit Removal Time of Power System

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Abstract. In this paper, IEEE10 machine 39 node system as the research object. Load model considering the composition ratio of the induction motor and changes the specific gravity impact on the power system transient stability limit voltage clearing time changes. The results show that the above parameters have an impact on the transient voltage stability of the power system. Considering the change of the composition of the load model can more fully analyze the transient stability. Therefore, the choice of the load model should be careful to avoid adverse consequences such as inaccurate evaluation due to inaccurate load model establishment.

1. Introduction

Before the grid is put into operation, the planning and testing after the input and control are the prerequisites for the safe operation of the grid. Planning, testing and control all need to establish a reasonable model for the load side. In recent years, many cases of transient voltage instability caused by inappropriate selection of load models have occurred in various parts of the world [1-6]. This shows that the selection of the load model will have a more serious impact on the stability and calculation of the power system. Induction motor load is the main component of power system load and also the most important dynamic load, accounting for more than 90% of the industrial load, which is closely related to the transient voltage stability problem [7,8]. Document [9] proposes the concept of transient voltage stability limit removal time for an infinite bus system that contains an induction motor load. Document [10] further studies. Document [11] points out the importance of induction motor modeling in voltage stability. The importance of the load model in analyzing a series of dynamic behaviors of the power system has drawn more and more attention.

Based on the above reasons, this paper studies the effect of the polynomial integrated load model and induction motor model on the transient stability of power system. This article sets the type of circuit fault for the three-phase short circuit, the fault occurred at the beginning of the line. By simulating three different faults, the influence of the different combinations of the polynomial load model and the proportion of the induction motor model in the load model on the transient stability limit removal time of the power system was tested.

2. The load mathematical model

2.1. The polynomial load model



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The static load model of the relation between power and voltage amplitude are represented by polynomial function model. The polynomial model mainly reflects the relationship between voltage and frequency. Because it is composed of constant impedance Z , constant power P , constant current I three kinds of model and linear combination model, It is also called the ZIP model.

2.2. The induction motor load model.

The induction motor model can be generally divided into three categories, one is the five order electromagnetic transient model and rotor electromagnetic transient, if you ignore the transient stator obtained is three order electromechanical transient model, and only consider the first-order mechanical transient model of mechanical transient.

3. The example analysis

3.1. Simulation System

The IEEE10 machine 39 node system structure shown in Figure 1.

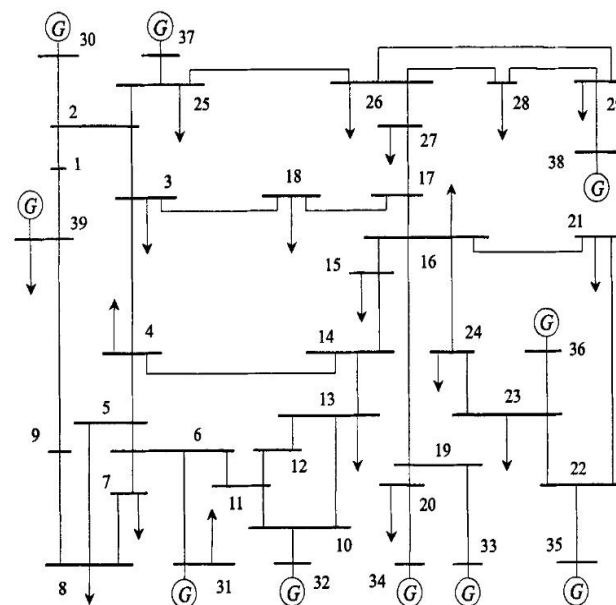


Figure 1. The IEEE 39 node 10 machine system structure.

This article considers the type of fault for three-phase short circuit, the fault occurred at the beginning of the line. By simulating three different faults (3 ~ 4 fault, 13 ~ 14 fault and 23 ~ 24 fault), the influence of the different combinations of the polynomial load model and the proportion of the induction motor model in the load model on the transient stability limit removal time of the power system was tested.

3.2. The result of changing the ratio of polynomial integrated load model.

In the case of three different fault cases, we respectively change the ratio combination of the comprehensive load polynomial model to get the corresponding fault limit removal time. The specific results are shown in Table 1, Table 2 and Table 3.

Table 1. The transient stability limit removal time when the location of the fault point for the branch 3 ~ 4.

The percentage of constant	The percentage of constant current (%)	The percentage of constant power (%)	Transient stability limit removal time (s)
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impedance (%)			
100	0	0	1.2641
0	100	0	1.235
0	0	100	1.185
80	20	0	1.2641
80	10	10	1.2641
70	30	0	1.2641
0	4	96	1.185
0	5	95	1.195

Table 2. The transient stability limit removal time when the location of the fault point for the branch13 ~ 14.

The percentage of constant impedance (%)	The percentage of constant current (%)	The percentage of constant power (%)	Transient stability limit removal time (s)
100	0	0	1.2741
0	100	0	1.3040
0	0	100	1.2340
10	90	0	1.3040
12	88	0	1.3040
20	80	0	1.285
0	10	90	1.2541

Table 3. The transient stability limit removal time when the location of the fault point for the branch23 ~ 24.

The percentage of constant impedance (%)	The percentage of constant current (%)	The percentage of constant power (%)	Transient stability limit removal time (s)
100	0	0	1.235
0	100	0	1.235
0	0	100	1.175
90	10	0	1.235
80	20	0	1.235
70	30	0	1.235
0	2	98	1.175
0	4	96	1.185

Through the data in the table we can observe some phenomena and laws.

(1) Under the three kinds of fault conditions, the fault limit cut-off time corresponding to pure constant power load model is the smallest.

(2) There are two cases (3 ~ 4 and 23 ~ 24 failures), the maximum cutting time is the limit when the load model is constant impedance.

It can be seen that when the proportion of constant impedance reaches a certain value (in this case, 70%), the constant impedance model plays a leading role in the fault cut-off time. The proportional change of constant current and constant power basically has no effect on the fault cut-off time. When the ratio of the constant impedance is greater than this value, the fault limit resection time is no longer sensitive to the change of the ratio of the constant impedance. In this case, when the ratio of the constant impedance is greater than 70%, the fault limit resection time is the largest and remains

unchanged. However, when the proportion of constant impedance is very small, the model of constant current and constant power plays a leading role in the fault removal time, and the fault removal time is very sensitive to the ratio of constant current and constant power. One percent change will cause the fault cut-off time to change.

(3) When the 13 ~ 14 branch failures, the constant current load model fault removal time limit the maximum. Similarly, the percentage change of constant current has a greater impact on the fault cut-off time.

3.3. The result of changing the induction motor ratio in the load model.

In the case of three different fault cases, the proportion of induction motor load models were changed respectively, and the corresponding results of the fault limit resection are shown in Table 4.

Table 4. The fault limit cut-off time when the proportion of induction motors in the load model is different (The generator considers the damping mode with no damping and constant potential respectively).

Induction motor load ratio		Fault line		
		3~4	13~14	23~24
25%	No damping	0.334	0.174	0.214
	Damping	0.354	0.214	0.224
50%	No damping	0.304	0.104	0.154
	Damping	0.324	0.144	0.164
75%	No damping	0.184	0.074	0.094
	Damping	0.194	0.114	0.104
100%	No damping	0.054	0.034	0.074
	Damping	0.074	0.074	0.894

We can see from the above table the following conclusions.

(1) When the same fault and the proportion of induction motor model are the same, the fault limit removal time without damping must be smaller than when there is damping.

This shows that the impact of generator with or without damping and induction motor load model has nothing to do.

(2) Whether the generator considers the damping or not, as the proportion of the induction motor model increases, the fault cut-off time decreases.

This is because the power system transient stability calculation is the analysis of electromechanical transient process. It mainly reflects the unbalanced relationship between the mechanical power and the electromagnetic power of rotating electrical components in the system. Induction motor load model describes the motor rotor equation of motion, which directly reflects the imbalance between mechanical power and electromagnetic power. The greater the proportion of induction motors in the load model, the greater the component of the relationship between mechanical power and electromagnetic power, so the greater the effect on the fault cut-off time.

4. Conclusion

The proportional combination of the polynomial integrated load model and the proportion of the induction motor model have different effects on the power system fault removal time. Using different

load models will directly affect the results of the transient stability calculation, thus affecting the power system planning, design, operation and other decisions based on this.

The contents of this paper have some reference value for further research on load dynamic modeling and transient voltage stability.

Because this paper mainly analyzes the influence of power system load model on transient voltage stability, the paper does not consider the impact of certain factors such as generator excitation of the head-end power system.

5. References

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