DIGITAL SHORT CIRCUIT SOLUTION OF POWER SYSTEM NETWORKS

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By

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S U M M A R Y

This thesis presents a study of the digital short circuit solution of power system networks. The work described here has been directed primarily towards providing general short circuit programs.

The thesis consists mainly of six chapters and they are as follows;

The first chapter contains an introduction for the short circuit analysis of electrical networks and the previous work done by others in this field.

The second chapter contains the methods of formation of the network bus impedance matrix, which is used in the short circuit analysis, since the formation of the network matrix is the major part of a digital computer program for short circuit solution of power system problems. A comparison between the different methods, in order to choose the best one from the point of view of computational time, storage required, and modification of the network bus impedance matrix, is included. It is found that the formation of the network bus impedance matrix by Algorithm is the best

method to satisfy all these requirements. Also, a modification is introduced to the proposed method when taking the effect of mutual inductance between two transmission lines into consideration.

Chapter three includes the use of mathematical simulation techniques on digital computer, d.c. and A.C. network analysers. They are applied to a sample network which is taken from the 220 kV network of the unified power system (U.P.S.). It is concluded that the d.c. analyser can be used for three phase short circuit analysis with an error not exceeding 3-5% compared to that using a digital technique. Also, a general digital computer program is developed using the method of Algorithm with its new modification for the 3-phase short circuit solution of power system networks.

In chapter four, the general digital computer program is applied to the U.P.S. of northern Egypt. The program output results are; total $MVA_{s.c.}$, total short circuit current for each bus, current and voltage distributions for different elements. Also, a curve between values of perunit $MVA_{s.c.}$ against the equivalent perunit positive sequence reactance for each bus is drawn. From which it can be seen that the $MVA_{s.c.}$ for all buses of the unified power system are less than that of the rupture capacity of circuit breakers in service. Also, it can be seen from this curve that the values of the perunit positive sequence reactances for 220 kV buses of northern part of U.P.S. is ranging between 1.1 and 2.82, and these values for 66 kV buses is ranging between 3.4 and 37.6 and for 33 kV buses is ranging between 8.4 and 25.7. It is also seen that the $MVA_{s.c.}$ for any bus of the unified power system can be obtained from this curve provided that its short circuit positive sequence reactance is known. Also, the three phase short circuit program is used to show the effect of shunt elements of the 500 kV transmission system on the short circuit level at 220 kV busbar of Cairo-500 kV substation. It is concluded that, the shunt capacitances increase the value of the equivalent reactance at the fault busbar, so decreasing the short circuit level. The shunt reactors compensate the effect of capacitance i.e. decrease the value of equivalent short circuit reactance. A study was made on the present situation of the reactors in the 500 kV transmission system and a relation is developed between the ratio of equivalent reactances with and without shunt elements against percentage reactor reactance. From which it can be seen that the neglection of the shunt capacitance in the 500 kV transmission line leads to an error of 7% in the equivalent positive sequence reactance at 220 kV busbar of Cairo-500 substation which gives in pessimistic short circuit results. Therefore, it is necessary to represent the 500 kV transmission line as regorous as possible to avoid this high value of error and to demonstrate the lower share of the High-Dam power station in the short circuit mega-volt-ampere at the 220 kV northern part of the U.P.S. Also, due to variation of the operating condition of the U.P.S., the percentage reactor reactance will be subjected to variation thus secureing the optimum reactive power distribution. However variation will lead to partial compensation of the capacitive reactance of the 500 kV transmission lines. Moreover these compensation is more sensitive with low values of reactor reactance. Therefore, it is preferable from the short circuit level point of view to operate with reactor reactance values ranging from 70% to 150% of value corresponding to the normal operating condition.

In chapter five, a general single line to ground computer program is built up using the modified Algorithm method taking into consideration the mutual inductance between two transmission lines. Then the program is applied to the northern part of the U.P.S. of Egypt. The program output results are, total single phase zero sequence component current in KA, the equivalent zero and positive sequence reactances in ohm referred to 220 kV, the residual zero sequence voltages at all the buses other than the faulted one and the zero sequence current distribution in all elements connected to the fault nodes. Also relations between the different phase fault currents and voltages and ratios of equivalent zero sequence reactance to positive sequence reactance are drawn. From which it can be seen that the values of the ratio of the equivalent zero sequence reactance to the positive sequence reactances is ranging between 0.33 and 5.7. Also the phase currents and voltages for any kind of fault for any bus in the northern part of U.P.S. can be obtained, provided that the ratio of equivalent zero sequence reactance to positive sequence reactance is known for that specified bus. Also the values of equivalent positive and zero sequence reactances for all buses of the northern part of U.P.S. are given.

It is known that the protection engineer requires that, the zero sequence current in any system elements to be equal to or more than a certain percentage. Therefore a trial is made to clearly interpert the bulky results obtained with single line to ground faults at the different busbars of the U.P.S. by dividing the whole system into zones consisting of elements carrying zero sequence currents of values equal to or greater than the specified value.

Also, it is found that the calculation of zero sequence current can be carried out neglecting the mutual effect between elements with an error of 3% in the total value of the zero sequence current such neglection of the mutual elements allows to avoid the processes of matrix inversion since the matrices become of diagonal form.

Chapter six includes the conclusions of the results mentioned in the previous chapters.

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