Computational Model for Transient Stability Analysis of Power System in Nigeria

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ABSTRACT

A programme for handing and improving the transient stability of the Nigeria power grid electrical network was developed. The idea was demonstrated by applying it to the outages of the main generating units. The methodology was built upon a state of increasing power transfer through the health portion of the network during disturbances. There were there parts concerned; the first part was the developing of the load flow programme using fast decoupled method and transient stability programme using modified Euler's method in the step by step solution, the second part was the engagement between the two programs, the third part was the application of the new programme on the Nigeria power grid network (330KV). And finally a recommendation was given with the aim of achieving efficient power flow stability

Keywords: *Power flow, transient stability, simulation, modified Euler's method*

INTRODUCTION

Due to increased power transactions between various power systems and due to continuing postponement of transmission reinforcements, power systems are being operated closer to their lower secure limits. This has exacerbated the traditional conflict between the two major objectives of power system operation, economics and security (Saadat, 1999). Several methods for off line transient stability analysis are under research and development. They contain efficient step-by-step integration of the differential expiations, direct method of stability analysis, pattern recognition techniques, expert systems, and neural networks. In multi-machine stability studies, the only method that gives satisfactory results is step-by-step integration method, the step-by-step time simulation is a conventional method, which is the most reliable one. It gives an accurate result and can handle the complicated system models.

The step-by-step integration method has the advantages that voltages, currents and apparent powers at various buses could be monitored as a function of time during the disturbances. Among many stability analysis methods, the modified Euler's method is gaining more popularity because of its simplicity and high accuracy. Modified Euler's method is a method that is able to determine stability with explicitly integration differential equations describing the post fault system. The fast decoupled load flow solution requires more iterations than the Newton - Raphson method, but needs considerably less time per iteration and a load flow solution is obtained very rapidly. The storage requirements are about fifty percent less than that of Newton - Raphson. This technique is very useful in contingency analysis where numerous outages are to be simulated or a load flow solution is required (Saadat, 1999, Gupta, 1996; Sauer et al, 1998). The fast-decoupled had flow method is getting more popularity as a result of its simplicity, high speed and low memory requirement. Therefore, it is the concerned of this research work.

MODELING OF THE LOAD FLOW AND THE TRANSIENT STABILITY PROGRAMMES

The Load Flow Programme: The most important mathematical operation in power system analysis is the careful analysis and investigation of load-flow study, which is concerned with the determination of state (variables voltage, current, power and power factor) at various point of power network. Load flow studies are essential for all power system problems and it is not a simple task. No direct solution can be found to a load flow because of the nature of the equations and ever increasing complexity of power systems (Humpage, 1998). There are many powerful methods for load flow study, but the fast decoupled load flow method has been accepted in recent years by utility industry as the best approach to obtain the power flow solutions. This method is used in system planning, operational planning and operation control due to its low memory requirements, speed and very good convergence characteristics for practical problems. In this work, a load flow programme was developed using the fast decoupled method as shown in Fig. 1.

The Transient Stability Programme: The simplest model used in the transient stability studies is commonly referred to as classical model. The classical model is used to study the transient stability for power system for a period of time during which the dynamic behavior of the system is dependent largely on the stored energy in the rotating inertias. It's the simplest model and requires a minimum amount of data (Pai, 1981, 1979, Kirshnaparandhama, 1980, Claymont, 1986). Hence, a modified Euler's method is used. The flow chart of the programme is shown in fig. 2

The Programme Integration (Fast decoupled load flow & Modified Euler's Method): The cost of losing synchronous operation through a transient instability is extremely high in modern power systems. Consequently, combining the load flow programme with a transient stability programme is necessary in order to avoid the problem. The common key between the two programmes is the number of bus-bars. The flow chart of the combination process is shown in Fig. 3. This programme performs the task of transient stability study when machines are represented in classical model. The flow chart shown represents the main programme which calls different sub-routines; such a structure which permits the removal and addition of system components. The transient stability programme operates when a fault occurs on the system. If the system is unstable, it gives hint to the load flow programme to the load flow programme to redistribute the power, i.e., increase the electrical power for generating units in steps chosen. The programme will start by reading the data file, converting the transformers to their -equivalent, forming the Y-matrix and starting the iterations solving algorithm using fast decoupled method. When the programme reaches to a solution the output information will be fed to the transient stability programme again to examine the situation of the network, if the system is stable then the programme will be ended and the output files of the transient stability programme will be printed if not, the programme will raise the generation unit power into the other step and so on until the system reaches the stability situation. All the three programmes were written in MATLAB language using the matlab package version 7 for the load flow programme the number of iteration (8) with 0.0001 tolerances. For the stability programme the unit step was 0.005 and fault clearing time is equal to 0.1 second and total solution time is 1.5 second. The execution time for the last programme (the combination between the two programmes) was 1 minute.

THE APPLICATION OF THE NEW PROGRAMME ON THE NIGERIAN NATIONAL GRID NETWORK

The Nigeria National grid network with all its bus bars and transmission lines continue to operate normally, without good efficiency till now, electrical power system at its levels; the generation, the transmission and the distribution. This led to a large reduction in the power production of the electrical power. Despite the stations/generating units do not operate in isolations unit, but are interconnected to the national grid with central control center at Oshogbo in Osun State, there seems to be instability of the system.

Table 1: System stability and critical clearing times for case (a)

The Unit	The System Stability	Tcr (sec)
Benin-Onitsha	(Case a)	
Sapele	unstable	0.000781
Kanji	stable	0.684473
Afam	stable	0.310434
Onitsha-Alaoji (System Stability for case (b) Table 2.		
Afam	unstable/***	0.000781***
Sapele	stable	* * *
Kanji	stable	* * *
Alaoji-New Heaven		
Afam	stable	0.34541
Kanji	unstable	0.000781
Sapele	unstable	0.000781

Source: Fieldwork simulated results, 2011

The network under consideration represents the National grid network which consists of 27 bus-bar and 7 generating systems. To apply the new programme on the network, the National Grid was analyzed using the transient stability programme which was developed in this work to assign the most dangers regions. For this study the total solution time was 1.5 second, the integration step length was 0.005 and the fault clearing time was 0.1 second depending on the time of the first zone of the distance protection used in the National electrical network protection system. Two types of faults are considered these are:

Case study (a): A three phase short circuit near the bus bar which follows the transformer of the generator. This fault will cause the bus bar voltage to be zero. To ensure getting rid of the severe condition, the faulted line is not returned to the system as shown on table 1.

Case study (b): A line stretching fault. In this type, fault does not include nay short current fault, that is to say, it only signifies that the current breakers of the line removed the line from the system as shown on table 2. The mark (* * *) shows that the system stability not affected by restoring the line.

Enhancement of the transient stability of the National Grid Network: Stability is an important constraint in power system operation. A new methodology that reduces the consuming time of the operator to determine a transient secure operating point is presented. From the obtained results, it is obviously, that the network is suffering from serious problems. The outage of the generating bus bars at Kanji and Sapele, will lead Afam bus to swing away from the stability region and will cause the instability of the whole system. While the outages of the rest of the generating buses not affect the stability of the system. A programme for handling and improving transient stability of the National Grid Network was developed and applied to the outages of the main generating units. The method is built upon a state of the increasing power transfer through the healthy portion of network during disturbances, which flows a machine to swing through a large angle from its original position before it reaches the critical clearing angle. In case 'a' by using the new programme, the generating power of the generating units was increased in steps (50MW in each step) and at each step, the transient stability of the system was calculated. After three steps, the whole system reaches the stability situation in both cases.

CONCLUSION

This study was presented to ensure that transient stability can be maintained by searching an operating point that respects appropriate stability limits. Such as search using power generation increment has to be investigated. From the obtained results one realizes that there are two regions drastically affected in the network under consideration, these are Sapele and Afam generating unit. Rising the generation of the generated bus bar in steps (50MW in each step) affects the stability of the network. From results obtained, by a new programme it was clear that after the 3rd steps of increasing the generating power led to the stability of the network in all the situations. The new modeling programme has the ability to analyze the system by transient stability analysis and then uses the load flow analysis to solve any problem that may arise in the network by increasing the generating power of the generation units. It seems obvious, from the modeling and analyses that this new programme greatly improves the ability to monitor system stability. It also reveals that the combination between load flow and transient stability programmes is suitable for automated computation and helps the operator to take a quick decision to analyze a severe fault in the grid and give a solution of the problem.

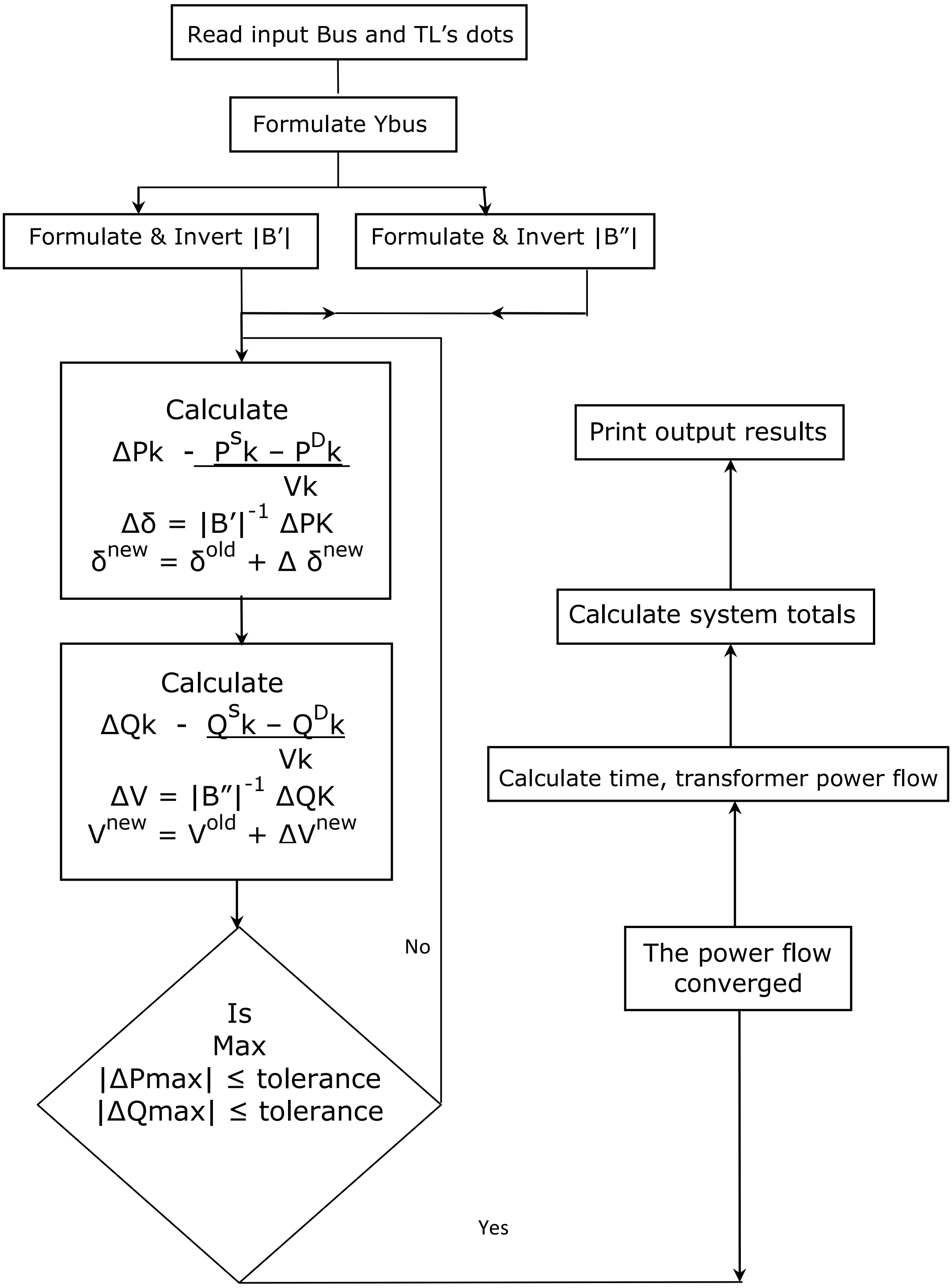

Fig 1: The flow chart for a fast decoupled power flow programme

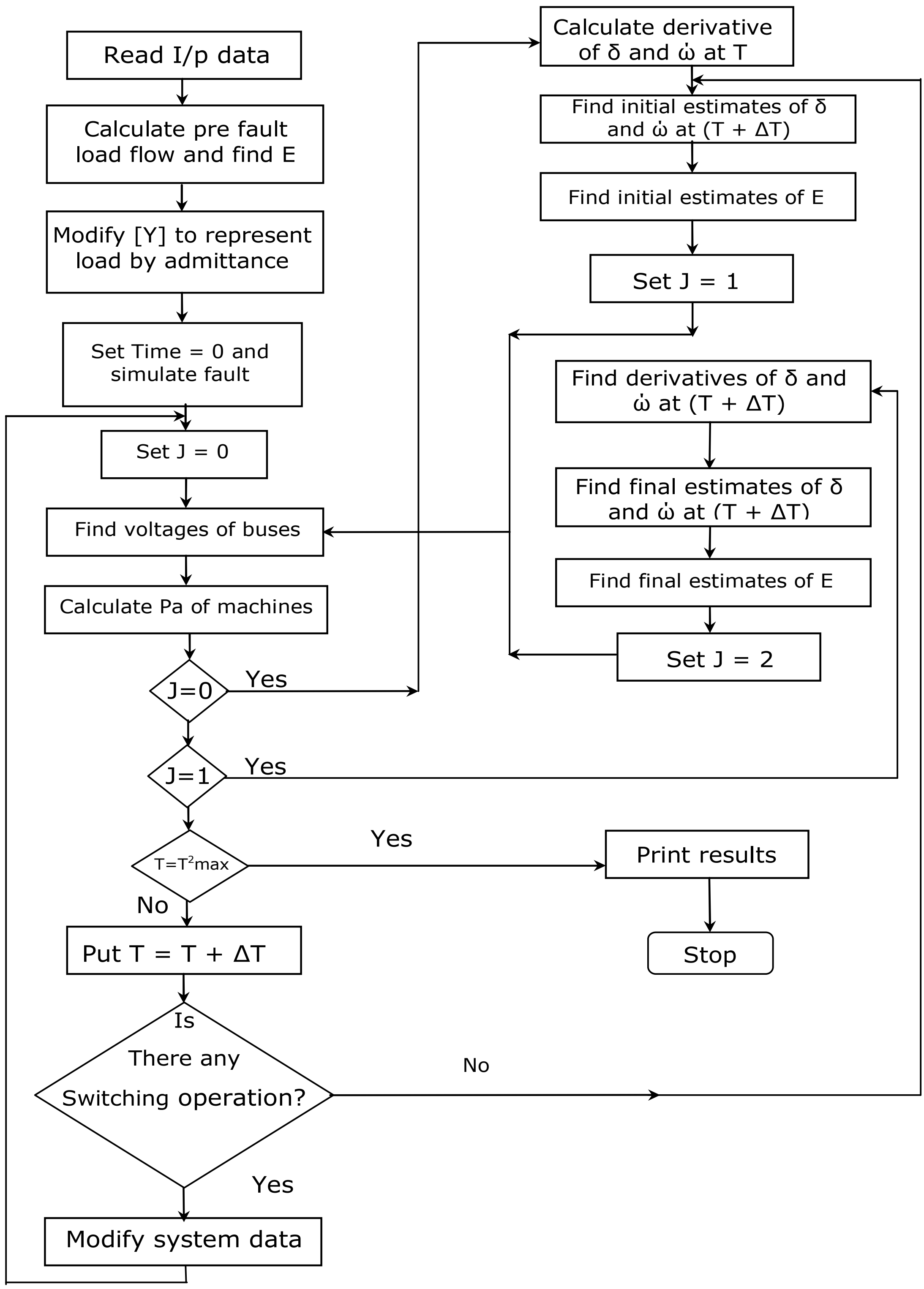

Fig 2: Flow chart of transient stability study wing and modified Euler's method

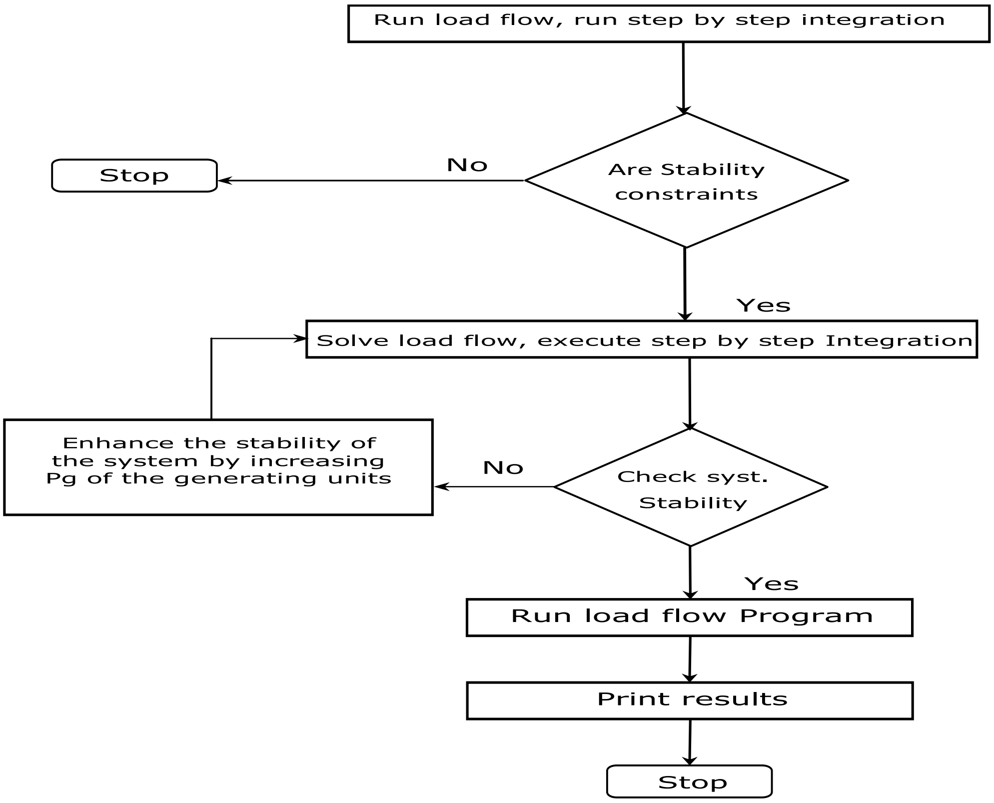

Fig 3: Flow chart of the New Integrative Programme

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