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Dispatch Security Assessment in Power Systems.

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DISPATCH SECURITY ASSESSMENT IN POWER SYSTEMS.

BY:
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ABSTRACT

Dispatch security assessment is studied to develop a programmable algorithm in this field. The main objectives of the developed securit program are:to incorprate network and enviromental constraints, to provide results which allow the system operator to perform necessary corrective actions into the system dispatch for maintaining secure operation and to provide a fast solution for power flows within the system for any further study. The developed security program provides a solution rapid enough to allow sufficiently frequent repetition to follow changing system conditions and can be used on line or off line for maintaining secure system operation and reliability.

INTRODUCTION

Security analysis of electrical power systems is an important phase of system operation to secure its reliability, continuity and its efficient use of equipment. Security analysis is a must routine which should be performed just after any disturbance or contingency in the system.Results of any security analysis should be obtained as fast as possible to supervise what should be made to keep the system save and reliable.

According to this clear importance of security analysis , the subject has been studied and attacked from different point of views (1-4) . Work is still going on the subject to simplify its implemention, to improve obtained results, to decrease computation time, storage requirement, ...etc.

The paper presents a software based approach for the analysis of security assessment which may be performed to supervise the required adjustments after any outage of generation, transmission or any sudden change in load demand. The developed approach is coded in Fortran IV language and is performed on a sample power network. The developed approach is simple , has a fast response and the obtained results are sufficiently accurate. Implementation of sparsity techniques are recommended for large scale power networks. If such implementation is skillfully coded (5), it will not affect any achievement on this approach.

SECURITY ASSESSMENT PROBLEM

The secure operation of ower system is assured when precautions and arrangements have to keep the system safe from any determinestic or pr changes associated with system operation.

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Security routines must be able to record the system response for credible outages of transmission, generation or loss of loads and the new state is checked in terms of predetermined constraints on the line power flows, reactive sources and voltage magnitudes. When an outage causes constraint violation, supervisory orders should be excuted to perform the appropriate actions.

Security assessment may then be performed through an efficient load flow analysis which may respond to any network change. The load flow problem in a power system is mathimatically defined as:

$$P_i + j\,Q_i = V_i \sum_{j=1}^{n} Y_{ij}^{*} (V_i - V_j)^{*} \qquad i \neq j \qquad (1)$$

The above equation is known as the load flow equation and it is an important relation as it combines all network variables in one experession. Equation 1. represents a set of non-linear simultanious equations. Various approachs have been proposed for its solution in the literature of power system analysis and of numerical techniques.

Newton-Raphson method has been applied successfully to the solution of the load flow problem in low and medium power networks. Decoupled load flow methods are much faster for large power networks.

In this security assessment approach, Newton-Raphson load flow technique has been applied to suit the choosed sample power network.

SECURITY CONSTRAINTS AND CONTINGENCY LIST

Conventional dispatch security constraints are: line power flows, bus voltages and active and reactive power limits. Allowable values of these constraints should be tabulated according to the state of the system and the required operating conditions. So,

$$P_{gimax} \geqslant P_{gi} \geqslant P_{gimin} \qquad i=1,m \qquad (2)$$

$$Q_{gimax} \geqslant Q_{gi} \geqslant Q_{gimin} \qquad i=1,m \qquad (3)$$

$$S \leqslant S_{max} \qquad \text{for all transmission lines} \qquad (4)$$

The voltage mismatch is choosen as 0.01 P.U. therefors,

$$0.99V_i \leqslant V_i \leqslant 1.01\,V_i \qquad (5)$$

Where, P_{gimax}, P_{gimin} are maximum and minimum output of generator i

m	number of generators in the system.
S_{max}	maximum power transmitted through T.L.
V_i	Voltage at busbar i.
n	number of busbars in system considered.

In addition to these constraints, security assessment algorithm must include a contengency list, where the contingencies should be processed in an order that take into account their probability and severity. Generation outage and network changes are the major states which are greatly concerned by a dispatch security assessment program.

PROPOSED ALGORITHM

The proposed algorithm for a sequential analysis of dispatch security assessment is based on Newton-Raphson load flow subroutine to provide a rapid and an accurate solution for the system state after any change in system operating conditions. The main program accepts the order of any change, performs the necessary computations and outputs the new operating state specifying any violation in specified limits which assure the secure operation of the system. Such procedure can be formulated as:

1- Accept the current change, generation, transmission outages, or sudden change in load demand.
2- Test to specify change.
3- Perform necessary load flow studies to investigate the new system state.
4- Print or monitor the necessary adjustments.

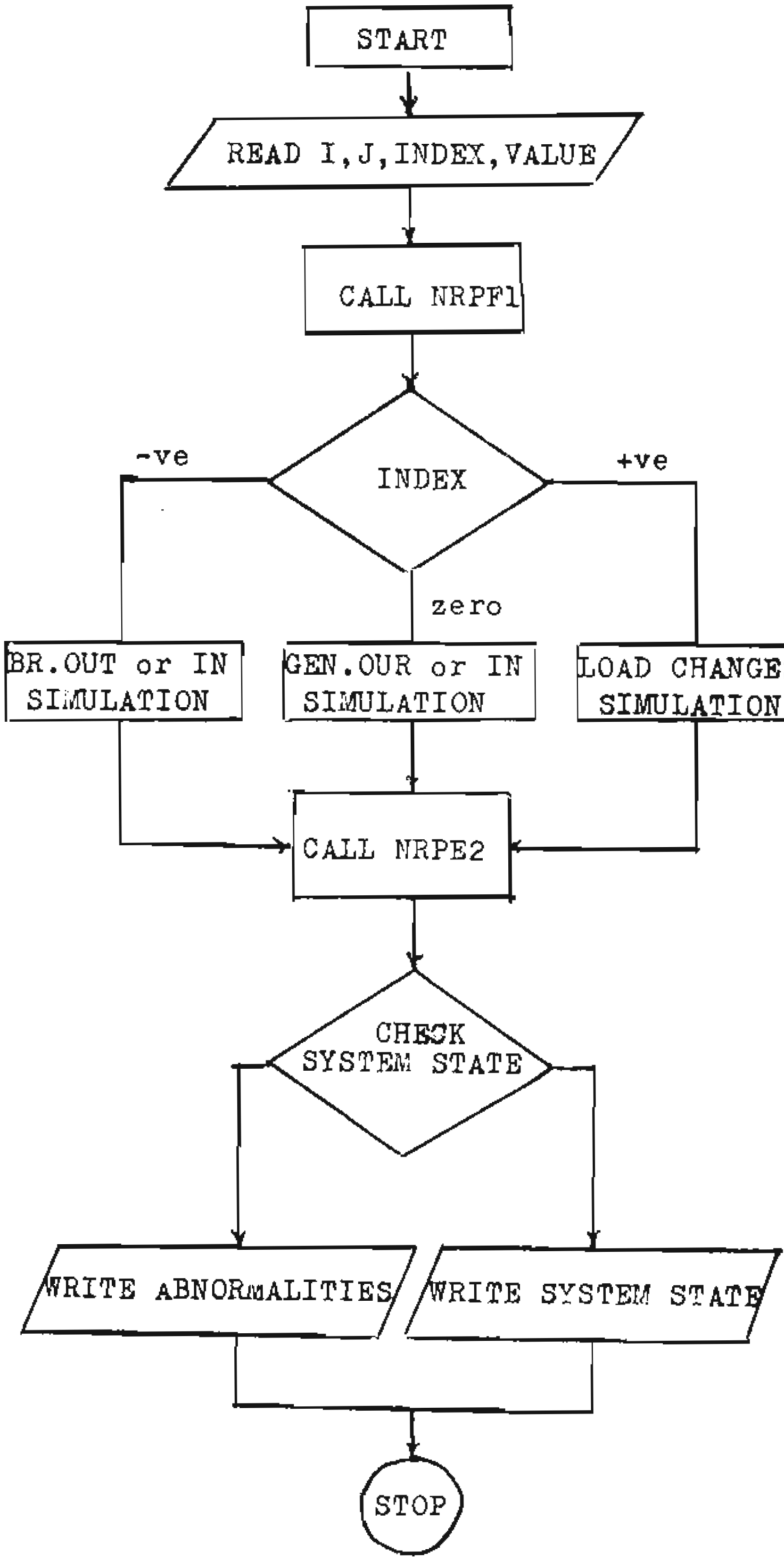
The Newton-Raphson load flow program is divided into two subroutines NRPE1 and NRPF2, the first of which is responsible for data initialization and preparation while the second is responsible for computations and results of the analysis.

Fig.1.shows the flow chart of the proposed idea,in which the read statement provides the new system state,I and J are the indecies of the required nodes or node, INDEX may be punched with any value(+ve, -ve or zero) to identify one of the following three different cases:branch out or in, generation out or in and load changes

SIMULATION STUDIES ON A SAMPLE NETWORK

To investigate the applicability of the developed algorithm for dispatch security assessment, simulation studies have been carried out on the sample power system(6) shown in fig.2.The following study cases have been performed on the network:

Case study 1 : System state as given in the original reference.
Case study 2 : Branch outage simulation between nodes 2 and 3 and generation partial loss at node 2.
Case study 3 : Branch outage simulation between nodes 2 and 3 and generation adding at node 4.



Fig/1 : Dispatch Security Assessment.

Obtained results from these case studies are summerized in tables 1 and 2 for line power flows and node voltages respectively . All results have been checked with stored system constraints and obtained after three iterations.

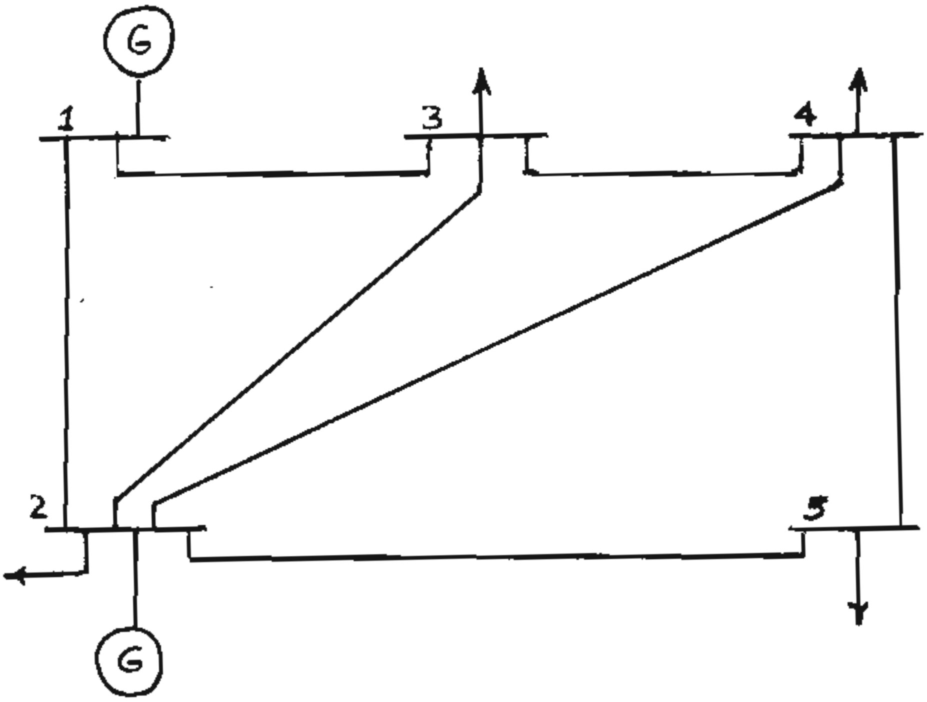


Fig.2: Sample power network.

Table 1: Line power flows

Bus code	Case study 1. Real po power P MW	Case study 1. Reactive power Q MVAR	Case study 2. Real Power P MW	Case study 2. Rractive Power Q MVAR	Case study 3. Real Power P MW	Case study 3. Reactive Power Q MVAR
1 2	88.847	-2.832	89.789	5.695	76.779	-3.587
1 3	40.776	3.684	50.811	8.613	42.258	2.542
2 3	24.429	4.786	Out of the network.			
2 4	27.685	4.408	37.883	6.989	29.867	1.868
2 5	54.149	11.793	59.329	13.426	55.263	10.532
3 4	19.093	-3.463	4.474	-5.645	-3.115	-8.650
4 5	6.283	0.548	1.361	-0.315	5.245	1.808

Table 2 : Bus voltage magnitudes.

Bus No	2	3	4	5
Case study 1	1.05246	1.02893	1.02819	1.01968
Case study 2	1.04758	1.01321	1.01547	1.01185
Case study 3	1.04751	1.02338	1.02645	1.01494

CONCLUSIONS

Dispatch security assessment in power systems is based on an efficient, accurate load flow subprogram. For low and medium scale power systems load flow subprograms are coded using Newton-Raphson iterative technique. For large scale power system, decoupled methods and sparsity implementation techniques should be used to insure minimum computer storage requirements and computation time.

The main program which performs the sequential analysis of dispatch security assessment contains tables of system constraints, contingency list and allowable rated parameters of varies equipments of the system. The only change in the main program is in the data card which contains the new state in system operation

Obtained results for different operating conditions of generation partial loss and addition and branch outage of loads at different buses of a 5-node sample power network showed fast convergence in all cases. Some values of obtained results are compared with the corresponding predetermined values. The comparison assured the accuracy of the obtained results.

Dispatch security assessment simulation on large scale networks using sparsity techniques and decoupled load flow methods is the next step of this paper.

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