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A Study of The Geographical Information System (GIS) based Energy Station Identification and Frequency Analysis Using ETA

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ABSTRACT

The energy corporation entity recently pays maximum attention to the environmental and social safe guards associated with its operations. In developing countries mainly suffers to balance the gap between generation and demand for effective operation by the energy utilities. An inadequate transmission capacity, non-uniform location of energy stations may lead to worst consequences when the occurrences of fault and may end up with black out. To overcome the above situation and to improve the stability of such system, In this research proposes a Geographical Information System (GIS) based identification of location of the uncertainty power stations and also a technique called Islanding Scheme to protect the severely affected system by measuring its frequency parameters. The severely disturbed large interconnected power system is divided into number of subsystems with two or more generating buses feeding its nearby loads by disintegrating the tie lines. The sample 50 bus test case system taken from Tamilnadu Electricity Board (TNEB), INDIA to analyze and simulate the results using Electrical Transient Analyzer Program (ETAP) and Geographical Information System (GIS). In this paper, ETAP and GIS effective software tools used for identify the energy station in various locations and analyzing the frequency status of different buses for better operation in electric utilities and thus ensure better management, enhance the improved stability by mapping the data and outage management.

Keywords- Geographical Information System (GIS), Energy Sector; ETAP, Blackout.

I. INTRODUCTION

In INDIA, Southern Region Electricity Board (SREB) consists of Tamilnadu, Kerala, Karnataka and Andhra pradesh Electricity Boards. All the above state electricity boards are interconnected through transmission tie lines. If any Large Disturbances in the energy stations like, generator outage, Sudden increase in load occur in the system, the system will be unstable and the frequency of the system will fall below the nominal frequency, It will leads to complete collapse.

To overcome the above situation and to improve the stability of the system a method called as Islanding scheme. In the Islanding Scheme, severely disturbed large interconnected power system is divided into number of subsystems with two or more generating buses feeding its nearby loads by disintegrating the tie lines. After the fault is cleared or the unit is put into service, the above-subdivided island is tied with each other one by one in a well- coordinated manner without affecting the synchronism of the machines. The geographical identification of the power station is also playing vital role when the occurrence of fault. In this paper, we have taken a sample test case of TNEB system with 10 generating stations, 4 numbers of 765KV substation, 24 numbers of 400KV substation, 12 numbers of very important 230KV substation and neglected the 110KV and radial buses for analysis.

II. GEOGRAPHICAL INFORMATION SYSTEM

Recent days, a computerized grid monitoring of electric utility mainly focus on two-way digital communication for transferring the data among energy utilities. The feature of Information and communication technology helps to bridge the gap between field components and utility operation Centre. The additional futures of Integration of GIS with other effective software

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tools for analyzing the real time can also improve the efficiency of the system performance and operation. Fig. 1 shows the number of power and sub stations considered for the analysis of identification using ArcGIS Geographical Information system software.

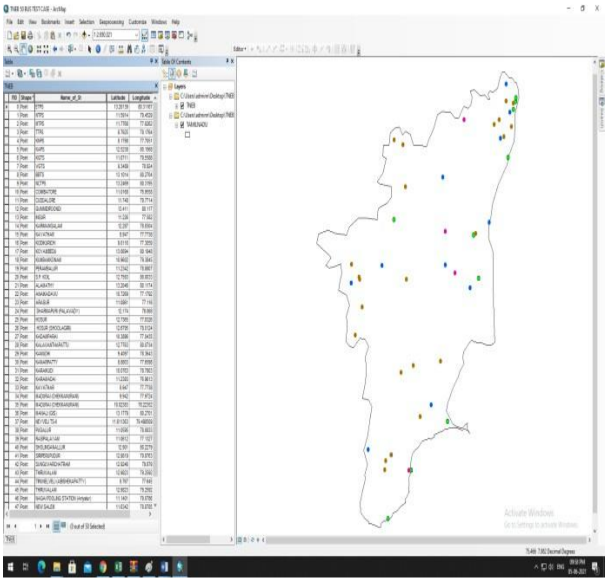

Fig. 1 A sample 50 Bus Test Case System in ArcGIS

In this research work, an ArcGIS software is effectively used to create and compile geographic data of real time sample 50 bus test case system. It is also used to analyzing mapped information of the selected data and to share, discover the geographic information. The analysis also helps to manage geographic information and stored it in a secular database.

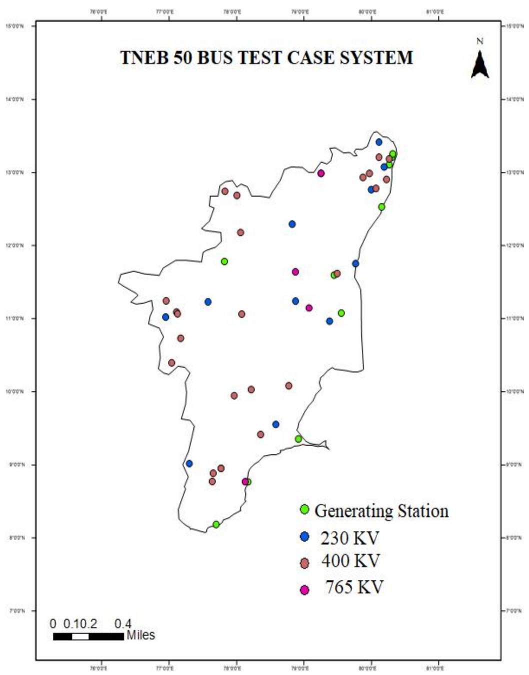

Fig. 2 Location and Identification Mapping of Test Case

The sample test case of TNEB system with 10 generating stations, 4 numbers of 765KV substation, 24 numbers of 400KV substation, 12 numbers of very important 230KV substation is located and identified in Fig. 2. The Green color representing the location of generating station considered and the remaining colors represented the substation in different voltage levels as shown in the above system.

III. ELECTRICAL TRANSIENT ANALYZER PROGRAM

Nowadays, ETAP is playing vital role in the energy sector application for analyzing various studies. It is an effective user friendly software and also easy to use for many applications for calculating the data in a trusted manner. The complexity analysis of power system studies can be performed with a help of ETAP and to make the effective decision by the energy utility operators. Fig. 3 shows the single line diagram of 50 bus test case system in ETAP for analyzing the frequency of the system. operate to separation using any of the following three different methods

1. Under frequency
2. Over frequency
3. Rate of raise of frequency

In general, frequency will vary with respect to demand connected to the system and the power balance equation. The recent frequency relays are having multiple setting levels for coordinating different load shedding schemes. All the load shedding schemes will typically expand and tripping the load with increasing frequency deviation. In India, generally a deviation of ±5% frequency is considered as a disturbance in the system and to be taken care of preventive measures.

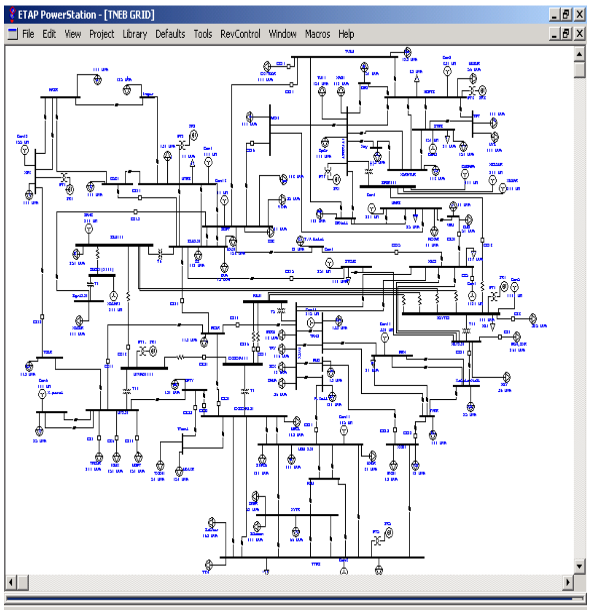

Fig. 3 Single Line Diagram of 50 bus in ETAP

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IV. ISLANDING SCHEME AND FREQUENCY ANALYSIS

A. *Effect of Large Disturbances*

In a normal system, the torques (Power) applied to the shaft of each generator are balanced.

$T_e = T_{mech}$ (1)

Where T_e = Electrical Torque N-m T_{mech} = Mechanical Torque N-m

The rotor of each generator rotates at the speed of $W = W_O$. The emf , voltage and current will very with the same frequency $f_o = W_O / 2$□. During the operating condition a torque imbalance $\Delta T = T_{mech} - T_e$ appeared in each generator which leads to a change in speed $\Delta W = W - W_O = d\delta/dt$ and the corresponding change in the instantaneous frequency $\Delta F = f - f_O$. In this operating condition when a large disturbance like , 3 phase fault, large capacity generator outage, Sudden increase in load occur in the system, the system will be unstable and the frequency of the system will fall below the nominal frequency, It will leads to complete collapse.

B. *Frequency Relays*

When the system being subjected to severe disturbances, the frequency falls below the threshold value then the system enters in to island condition. The generator unable to satisfy the load connected in the system during this conditions. Hence, it is necessary to safe guard our system from damage as quickly as possible without damaging the apparatus and equipment's. At this condition, the frequency relay should If the loads are higher than its generation i.e electrical energy demand is higher than mechanical energy input, then the generator will tend to slow speed and causing an under frequency mode. The under frequency relays are incorporated to sense the under frequency during the above said conditions. If the generations are higher than its load demand i.e mechanical energy input is higher than the electrical energy demand, the system will enter in to over frequency mode of operation. It is a rare case of occurrence of developing countries energy systems. This over frequency will sense by over frequency relay. In the balanced conditions, generation should be equal to load demand. In some rare scenario, the prime mover speed will be slightly changing in respect of island sub divided system frequency.

C. *Controlled segregation*

The tripping of energy system elements to be controlled one at the time of disturbance occurs in the system. The tripping is mainly depending on the occurrence of severity of faults incurred in the system. The controlled tripping's are relatively balanced with respect to composition of generation and load demand. The preventive measures to be taken immediately in the terms of cascading, load shedding and to enable the proper appropriate restoration.

D. *Restoration of the System*

After an islanding scheme adopted, an effective, rapid and prompt restoration of the power system is very much essential to minimize the down time and to save the costs of energy utility. After the fault is cleared, the subdivided islands to be synchronized depending upon the parameters like voltage and frequency. When a disturbance occurs in the system, the entire system is divided into two islands with some generating stations and nearby loads, using the under frequency relays.

At this islanding moment of operation, there could be a following possible scenarios i.e either the system will enter into under frequency mode or over frequency mode.

a. When the connected loads from the 50 bus sample test case system are larger than its connected generation, the generators of the test case system will tend to slow speed and thereby causing under-frequency status.
b. When the generating stations supply from the 50 bus sample test case system are larger than its connected load demand, the generators of the test case system will tend to high speed and thereby causing over-frequency status.

V. CASE STUDIES AND DISCUSSION

In the case study, we have carried out load flow studies for the 50-bus system using ETAP and then we have simulated the islanding scheme by induced the following disturbances.

1. Outage of generator
2. Sudden Increase in Load

The entire system divided into two islands when its being subjected to disturbances. The first one consist of TTPS and it has been segregated with the nearby generating stations and loads. The second island consists of MTPS and with the segregation of nearby generation and loads.

VI. ETAP SIMULATED RESULTS FOR LOSS OF GENERATION

The simulation was carried out by creating a generator outage of at 0.2 seconds. The Fig.4 shows the sudden loss of generation at 0.2 seconds.

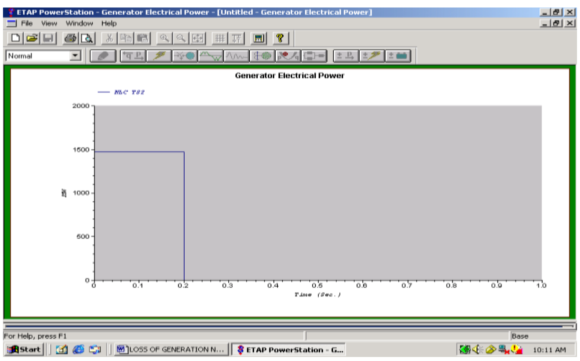

Fig. 4 Real power generation at 0.2 sec

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The deviation in frequency of buses is shown in Fig. 5. After the outage of generator, the frequency of the system falls from the nominal value. The case model has been analyzed if the frequency falls below the critical level of 47.6 Hz then the system will be collapsed.

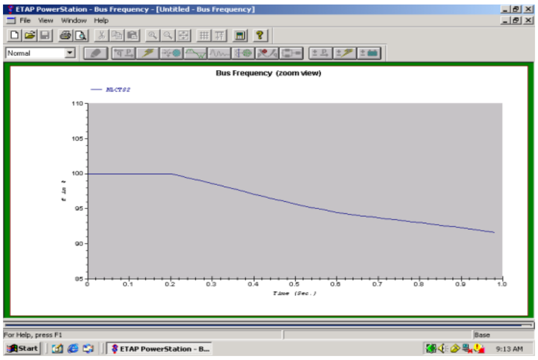

Fig. 5 Bus Frequency of the system

The Fig.6 shows the bus voltage angle with respect to time when it is being subjected to disturbance.

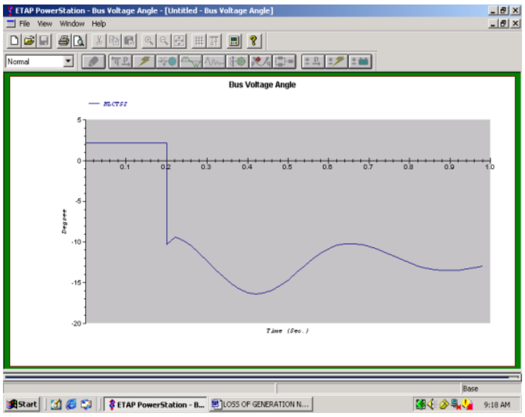

Fig.6 Bus Voltage Angle

The simulation has been carried out by creating a sudden increasing load at at 0.2 seconds. The Fig.7 shows the sudden increase in load at 0.2 seconds at real power loading. After the sudden increase in load, the frequency of the system falls from the nominal value. If the frequency falls below the critical level of 47.6 Hz the system will collapse.

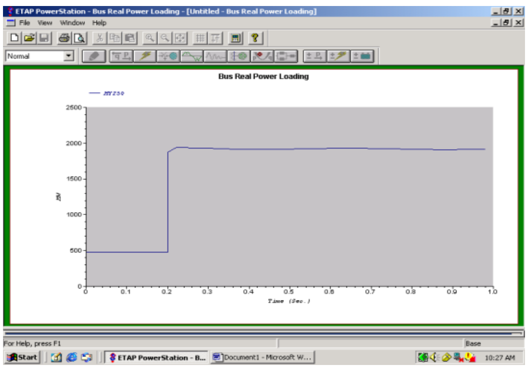

Fig.7 Sudden Increase in load

VII. RESULTS AND DISCUSSION

The stability can be achieved by the frequency parameters of the power system while it is being subjected to disturbances. In this paper, frequency parameters are obtained from the ETAP and the data is converted into geo- spatial database using GIS. The spatial database is integrated with the parameters to create a vector layer in Arc GIS. Spatial query and analysis can be done on this vector layer, which facilitates the decision maker to take effective controlling measures. The locations and the status of frequency of the system is shown in Fig. 8.

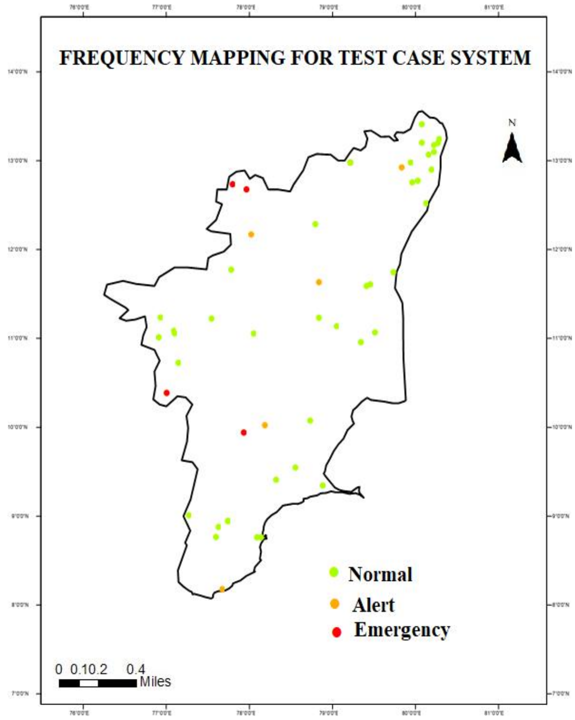

Fig.8 Frequency Mapping of Test Case in GIS

The simulation for the islanding scheme was carried out by creating a generator outage of bus at 0.2 seconds. The resultant output obtained by dividing the entire system in to two islands when the system frequency falls below than 47.6 Hz is shown in Fig.9.

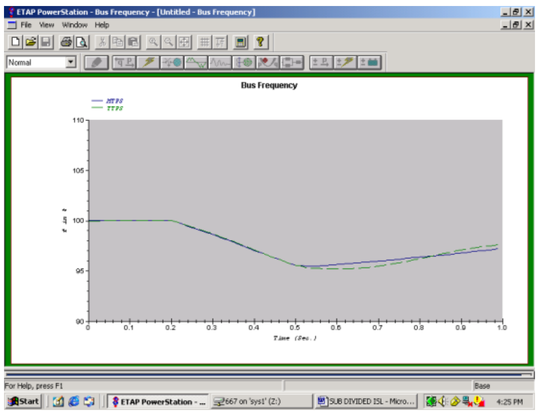

Fig.9 Two Subdivided Islands

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The X-axis denotes the simulation time in seconds and the Y-axis represents the bus frequency in percentage. The scale 47.6 Hz corresponds to 97.2%. When the system reaches 47.6 Hz, immediately under frequency relay operates and the system is divided in to two islands. The first Island comprising of TTPS and nearby generators and loads are shown by green color. The second Island comprising of MTPS and nearby generators and loads are shown by blue color.

VIII. CONCLUSION

The proposed Geographical Information System (GIS) based Energy Station Identification and Frequency Analysis Using ETAP system consists of sample case real time test TNEB data with 50 buses including generating stations, and other higher voltage levels of substation. The power system needs to operate without any disturbances to satisfy the consumer demand. The frequency of the system to be monitored regularly to prevent the system from complete collapse i.e black out. To maintain the system in a stable manner, in this paper the frequency analysis done using ETAP and the entire system will be divided into two islands when its being subjected to disturbances and the frequency falls below 47.6 Hz. In this paper also proposes a GIS based identification of location of the uncertainty power stations and frequency mapping to ensure the better quality of performance and provide uninterrupted service to the consumers by the energy control entities.

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