Power System Stability and Control

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Abstract- The latest power systems have become a highly connected and complex network, consisting of thousands of buses and production stations. In order to provide the required power, it is necessary to expand the power network by adding new production and transmission cables. Due to the economic and environmental constraints of new generator installations and increased demand for load, the flow of transmission lines to existing transmission lines has increased, leading to risks of losing frequency stability and system shutdown. This paper presents a brief overview of the stability of the energy system. A description of the strength of the frequency is presented, along with its terms and conditions. The literature discusses major frequent interruptions in various countries, highlighting the balance of the power system, the relationship of the frequency grid and the control of the power frequency.

I. INTRODUCTION

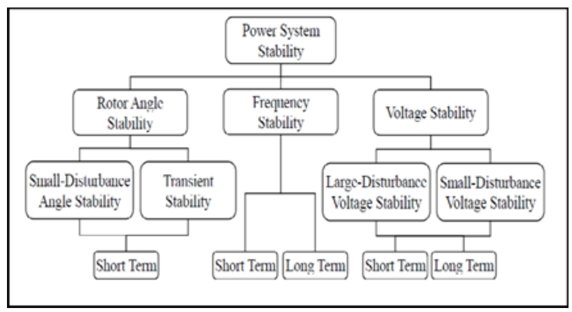
Stabilization of the energy system can be defined according to the IEEE / CIGRE Task Force as, "the ability of the electrical system, in a given initial operating condition, to restore working conditions after experiencing many dynamic physical disturbances of the system. , so that almost the whole system remains the same ". Research into the stability of the energy system has been tested since 1920 onwards. The instability of the power system during that time was due to power plants supplying the load centers with long transmission lines. In the 1930s, the development of AC network analysis provided a possible solution for energy flow analysis, which was seen as an effective tool in the early emergence of large interconnected power systems. In 1950, an analog computer was developed by Reeves to be used to anlyze and mimic the stability problems of a power system. In 1956, the first digital computer software was developed to analyze the stability of the power system; at the same time used to model a system of power systems such as a synchronization machine, ruler, and exciting controls. The power outage in the U.S. Northwest in 1965 attracted energy system researchers and engineers to investigate problems of system stability. The development of energy system networks and performance introduces a new type of energy system stability problems, for example, the impact of renewable energy on the connected energy system. Behavior of low frequency and voltage instability in today's power systems has become more common than past, and most research works focusing on Long-Term Stability, Protection and Performance of Power System and Control. Electrical system stability analysis can be divided into two categories, namely solid stability, or recently termed "flexible stability", which is a function of operating conditions only, and temporary stability, which affects both power system performance and interruptions.

The power system is subject to various interference, and it is never under normal conditions. Minor interruptions are a load change while major interruptions are a type of error, such as the failure of the transmission line to drop generators and the change in loads in electrical systems. The stability of an electrical system depends on both the initial operating condition of the electrical system and the magnitude of the disturbances. In each case of operation, the behavior and durability of the emergency power system will vary. The severity of the emergency depends on the location, type and duration of the error. Typically, the power system is modified so that the operation of the transmission interference condition is different from that of the pre-interruption. Therefore, suppose a power system starts operating in a stable state of mass, in the event of a disruption, there will be a change in the topology of the electrical network. Therefore, when the energy system is stable, the new stable operating environment will be different than before. The degree of severity of the disruption and the probability of occurrence in electrical networks vary. In order to never lose synchronism, the electrical system must be designed and operated to withstand various forms of interaction. If a different combination causes changes in system conditions or load demand for a variety of reasons, this will result in a continuous decrease in the system frequency and voltage profile. Due to the instability of the electrical system, the flexibility and stability of electrical systems are highly dependent on the magnitude of potential disruptions.

II. FREQUENCY STABILITY

According to the IEEE / CIGRE Task Force, frequency stabilization is the ability of the power system to maintain a stable frequency, following severe system irritation, resulting in significant inequality between generation and load ". The stability of the frequency depends on the ability to restore the balance between system production and the need for loading with minimal load losses. Various reasons can lead to losses system frequency stability, such as loss of generation which may cause a sudden imbalance between system production and the need to load. Therefore, frequent instability is due to a lack of power. Significant deviations from both system frequency and voltage, in addition to power flow and other system parameters often lead to server system disruption. Connected power systems can often be associated with systems to divide into islands with different production capacity and specific loads. The reaction of these islands can be seen by focusing on system density rather than relying on machine-related movements. Frequency stability is a major issue for grids on isolated islands where these sub-systems are exposed to a variety of disruptive problems, such as loss of generation or responsibilities. In general, instability is often associated with a number of problems, such as poor coordination of performance control, security features, mechanical reaction impairment and generation retardation. Since the power system is not very in line, segregation has become important to the stability problems of the power system. To understand the problems of instability and to develop solutions to the physical state of instability, the magnitude of the disturbance and the time frame are necessary to deliberately measure. Therefore, according to the IEEE / CIGRE Task Force, the frequency stability can be distinguished by short- and long-term events.

In short-term situations, frequency instability creates islands that produce insufficient and reduced frequency, leading to a deterioration of the system frequency and shutdown of the island by a few seconds. In long-term situations, such as steam turbine over speed control, boiler / reactor protection and control, the response time will range from ten seconds to a few minutes. The instability of the system frequency caused by the imbalance between production and consumption may have a significant impact on energy efficiency, especially in island conditions or in overcrowded conditions leading to a decrease in power capacity. The same situation will lead to a decrease in voltage magnitude. There are other important factors that affect the dynamics of system frequency, such as the structure of the power system. There is an important connection between the electrical network structures and risks within networks. Power system structures involved in the production and transmission of transformer and power limits, load requirements and load conditions have a direct impact on the stability of frequencies in energy systems. The structure of the power system and the function of the grid have implications for controlling and minimizing failures within power networks.



III. MAJOR FREQUENCY DISTURBANCES

Many countries have experienced severe frequency disruptions under various conditions in the past. From the 1970s to the 2000s, many major systems have experienced significant disruption of system frequency (e.g. the following are selected cases of these interference.

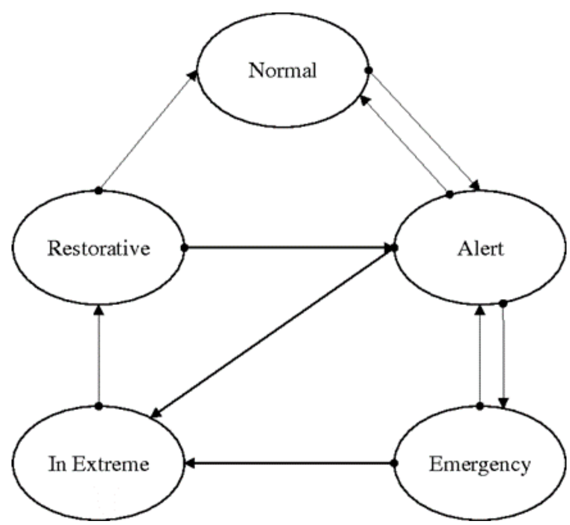
In 1972, an island grid located on an island in East Ontario, Canada led to a significant decrease in system frequency between (58.7 Hz-62.6 Hz), due to poor communication.

In 1977, a power grid located on an island in New York City in the USA led to a decrease in system frequency to 47.5 Hz because the internal power generation capacity was much lower than the city's load.

- In 1981, the state of the Islanding Islands separated the Southwest and the South Coast of England. The power system experienced 47.3 Hz due to the correct clearance of the temporary error in the transmission line.
- In 1985, France's six high-power transmission lines were cut off due to declining faults and a lack of generating power in Europe's energy system. The frequency of the system dropped to 49.6 Hz.
- In 1994, two of the four 380 kv cables ceased to operate between the South and Northern Hemisphere in Italy. The power system has greatly reduced the frequency of the system due to disconnection of transmission lines, which has led to power outages in the South.
- In 1994, the power system in Perth Island, Australia, significantly reduced system frequency by 3.5 Hz / sec. The decrease was significantly due to the disconnection of the power lines, which led to the shutdown of the system.
- In 1996, separate bus safety led to the disconnection of the railways in Brazil. The electrical system had a significant decrease in system frequency between (55.25 Hz-58.0 Hz).
- In 1996, due to high voltage trapped circuit breakers and poor security connections, Malaysia dropped the system frequency to 49.1 Hz. The event resulted in a loss of faults, which is why the loss of 2143 MW due to power generation and power outages.
- On October 28, 2003, in Italy, two 380 kv lines were broken leading to a trip of 220 kv cables, separating Italy and Northern Europe. Due to the lack of integration of production and pad protection equipment, the system frequency dropped to 47.0 Hz and was turned off.
- On November 4, 2006, the European power system was shut down due to power outages and a lack of power generation, splitting the European system into three islands with different frequencies and, as a result, power outages.

IV. POWER SYSTEM OPERATING STATES

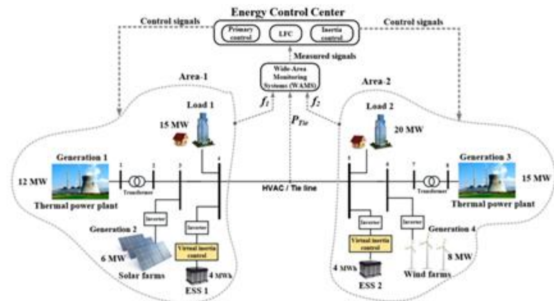
According to, the state of operation of the energy system can be divided into five regions, normal, vigilant, emergency, extreme and rehabilitative. Figure.2 shows these operating conditions. Under normal circumstances, the system can operate in a secure way. The system goes into a state of alert if a variable falls below certain limits but is still within acceptable range. An emergency occurs when the system becomes weak enough to withstand any conditions due to overcrowding. When the severity of the disturbance increases the system enters an emergency (or very urgent) emergency. Finally the restore mode represents the state in which the control action is used to reconnect all resources and restore system loads. concept in AC power systems. Power measurement can be considered as a flywheel that rotates with a certain frequency.



Frequency of the grid system, depends on the power system (eg 60 Hz in North America and 50 Hz in Europe and Malaysia). The flywheel is continuously accelerated by several generators connected within the electrical system to power the flywheel. At the same time, the flywheel is lowered with loads that release energy from the flywheel. The wheel will continue to rotate as long as the accelerated and reduced force is close to zero. Whenever there is a discrepancy between the power produced and the load, the acceleration and deceleration forces do not cancel. The frequency of rotation in this case will change. During a particular event, the rate of change of frequency is actually equal to the inertia of the wheel. This inertia is represented within the AC power system by the total inertia of all rotating weights (eg generators and motors) connected to the power system using equipment.

V. POWER SYSTEM BALANCE AND GRID FREQUENCY

In any power system, most of the electricity is generated by a compatible generator and supplied with an electric grid. With rotating machines, the frequency of the electrical grid system is created and continuous. Power generation and electricity consumption must always be kept in a balanced state, while the power of the electrical system can handle minor interruptions. As long as this balance continues, the frequency of the power grid system will remain in normal condition. However, the disruption of the impact balance between power generation and load demand will be compensated for by the kinetic energy stored in the surrounding equipment. Sufficient power is maintained to keep the grid cycles up to seconds (depending on the number of equations). Thus, the frequency of a system or grid will be deducted from its fixed point value. Too much productivity causes the system frequency to increase, while the loss of productivity causes the system frequency to decrease. Frequency deviations should be kept within certain limits to avoid power outages or damage to equipment. To ensure this, a number of control strategies need to be incorporated into the power system In any power system, most of the electricity is generated by a compatible generator and supplied with an electric grid. With rotating machines, the frequency of the electrical grid system is created and continuous. Power generation and electricity consumption must always be kept in a balanced state, while the power of the electrical system can handle minor interruptions. As long as this balance continues, the frequency of the power grid system will remain in normal condition. However, the disruption of the impact balance between power generation and load demand will be compensated for by the kinetic energy stored in the surrounding equipment. Sufficient power is maintained to keep the grid cycles up to seconds (depending on the number of equations). Thus, the frequency of a system or grid will be deducted from its fixed point value. Too much productivity causes the system frequency to increase, while the loss of productivity causes the system frequency to decrease. Frequency deviations should be kept within certain limits to avoid power outages or damage to equipment. To ensure this, a number of control strategies need to be incorporated into the power system shows the balance system frequency, number of generator poles and rotational speed of compatible equipment. In fact, controlling the generator speed can control the frequency of the power system. The generator is usually fitted with a controller to monitor and feel the speed constantly. In a single power system with a single generator unit, when the load increases, the additional power supply is initially provided by the inertia of the power generator. As a result, the generator speed will decrease, so the system frequency decreases.



The ruler's job is to open the turbine gate to increase the speed of the turbine. Increasing turbine speed will increase system frequency. The systemic frequency in this case recovers within an acceptable range [46]. In connected power systems, frequency control is used as a control mechanism to restore system frequency during emergencies. Figure 4 shows the various control actions required to restore system frequency to prevent power system shutdown. It can be seen that in the event of a power outage, the main controller will respond to reset the balance between power generation and load requirement. The set point is usually 50 Hz in this control action. The main controls for all other generators within the power system will respond in a matter of seconds (period from 0 to 10 seconds). Almost, any deviation from this fixed point occurs [46]. The controller adjusts the output power of the generator unit until the balance between output power and demand is reached. If the frequency of the system is from the nominal frequency of 50 Hz in the synchronization area, it may cause a difference between normal time and sync time. This offset serves as the performance indicator for the basic, secondary and maximum control power and should not exceed 30 seconds [49]. Fig.5 shows the timing of the various (slightly spaced) steps of the primary, secondary and tertiary controls.

IMPORTANCE OF FREQUENCY STABILITY- There are a few factors that need to be considered in order to maintain system frequency in the power system in a small band. The performance of generators in conventional power stations is highly dependent on the performance of all auxiliary electric drives. These services bring air and fuel to the boiler, oil bearings and cooling services across all systems. If low speed occurs due to low frequency, it will greatly affect these resources. Outputs to power stations will decrease, and this will lead to more closure of power stations Frequencies below 47 Hz will result in damage to steam engines, while hydroelectric power plants and thermal units are much stronger. Frequencies of up to 45 Hz, may be the worst possible result, which is termination. Power converters are sensitive to variance of the system frequency and can be overloaded if the frequency is from the normal value. To ensure that AC electric motors operate at a constant speed, a fixed speed is required. In a few consumer applications, the AC engine is used to drive equipment at a relatively limited price. The main frequency may be used in electrical systems as a basis for timing various processes.

CONCLUSION

This paper introduces the energy system stability manual and describes the operating system operating conditions. The definition and principle of stability of the energy system frequency is also presented. Major international disruptions as presented in this paper indicate that the risk of a power failure of the energy system collapses still exists. In addition, these distractions add to the knowledge of common during complex distributed situations. This paper introduces a determination of the power system frequency that includes descriptions of the normal operating frequency of the world, the importance of the soft power balance, the power system frequency grid and the frequency control to improve system frequency during a disruption.

REFERENCES

[1] P. Kundur, J. Paserba, V. Ajjarapu, G. Andersson, A. Bose, C. Canizares, N. Hatziargyriou, D. Hill, A. Stankovic, C. Taylor, T. Cutsem and V. Vittal, 'Definition and Classification of Power System Stability', IEEE transaction on power systems, vol. 19, no. 2, 2004.

[2] C. Steinmetz, 'Power Control and Stability of Electric Generating Stations', AIEE Transaction, vol., no., p. 1125, 1920.

[3] R. Evans and R. Bergvall, 'Experimental analysis of stability and power limitations', AIEE Transaction, p. 39, 1924.

[4] R. Wilkins, 'Practical aspects of system stability', AIEE Transaction, p. 41, 1926.

[5] R. Farmer, 'power system dynamics and stability', the electric power engineering handbook, Arizona State University, Ed.LL. Grigsby. 2001.

[6] H. Zheng, 'High frequency AC power systems', Doctoral dissertation, University of South Carolina Columbia, Scholar Commons, 2014.

[7] M. Kothari, 'Power System Dynamics', Department of Electrical Engineering, IIT Delhi. 2010.

[8] G. Vassell, 'Northeast blackout of 1965', IEEE Power Engineering Review, vol. 11, no. 1, pp. 4-8, 1991.

[9] S. Dahal, N. Mithulananthan and T. Saha, 'Investigation of small signal stability of a renewable energy-based electricity distribution system', Proc. 2010 IEEE Power and Energy Society General