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A Review: Power System Stability Improvement using Power System Load Shedding Scheme

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Abstract—*This paper discusses importance of under frequency load shedding and under voltage load shedding to improve instability in power system like voltage instability, frequency instability and phase angle instability. This paper show that root cause of these types of instability is due to deficiency of reactive and active in the power system. Deficiencies of reactive as well as active power are due to of sudden trip generating unit, transmission line losses and overloading conditions. In this paper different load shedding techniques are discussed and also importance of load shedding highlighted for improvement of power system stability. It also discusses design and security issue of load shedding while designing the scheme.*

1. INTRODUCTION

Everything from huge cities, industries, electronic gadgets, communication system etc are all depends on the energy called electricity. Therefore the main objective of utility and distribution system is to satisfy the demand of customer with good power quality continuously round a clock Every year use of electricity is rises therefore more and more generating units are set up to meet the demand of customer or load end. For proper operation of power system it should be necessary that gap between generation and load with losses is equal to zero. Condition for normal operaton is given below:

Total Generation = Total Load + Total Loss

All generating units are connected in parallel and simultaneously supply power to load through transmission line these large groups of generating unit, transmission line and distribution system made power system more prone to faults or stabilities issues. Disturbance in system can be occur by any reason like tripping of generating units, loss of transmission lines, malfunction of relays and circuit breaker etc. In all cases flow active and reactive power in line effected which creates instabilities like frequency instabilities, voltage instabilities, power angle instabilities and dynamic instabilities in power system.

2. TYPES OF POWER SYSTEM INSTABILITIES DURING DISTURBANCES.

2.1 Frequency instability:

In a power system, frequency is a reliable indicator for active power flow between generation end and load end. If consumption of active power by load is more than generation capacities than frequency of the system starts declining or system become unstable. The rate of declining of frequency is depends upon inertia of the generators within the system. In India, electricity generation is on 50 Hz and all equipment within system operates at same frequency. If the load increases on loads end or any generator unit trips at generation end then frequency becomes unstable and starts declining from its normal value. Protection scheme like under frequency load shedding scheme should be used for protection of equipment if declining rate is large otherwise system become unstable and stop working.

2.2 Voltage instability

Voltage is a reliable indicator for reactive power flow between load and reactive power capability of the power system. Reactive power support the flow of active power in system therefore reactive power is necessary for smooth operation of power system and should be maintain at optimum level. Reactive power of system directly reflect towards voltage of the system, if reactive power of system is less, then voltage of the system starts declining and if reactive power is more, than voltage of the system rises . In both cases voltage of system becomes unstable therefore protection scheme like under voltage load shedding scheme , static condenser or synchronous condenser can be used for reactive power control in power system. Relation between voltage and reactive power flow are given below.

$$P_e = \frac{|E_i||E_r|}{X} \sin\alpha$$

$$\alpha = \Theta_i - \Theta_r$$

Where,

E_i = Voltage at local generator.

E_r = Voltage at remote generator

X = Reactive Power between local and remote generator.

θ_i = Voltage angle at local generator.

θ_r = Voltage angle at remote generator.

2.3 Phase angle instability:

These types of instability occur if the voltage phase angle between remote generator and local generator are too large. There are two types of phase angle instability:

- Steady-state instability
- Transient instability

Steady state instabilities occurs if the transmission line to transport power is less in number or if any transmission line trip occurs at load centre then voltage collapse and also steady state phase angle instabilities.

Transient instabilities occur if a fault on transmission system near the generating plant is not cleared rapidly enough to avoid a prolonged unbalance between mechanical and electrical output of the generator. To improve these type of instabilities fast excitation system is needed.

2.4 Dynamic Instabilities:

Dynamic instabilities occur if small low frequency oscillation present in the power system. In these instabilities amplitude of oscillation is small and also their frequency is low. These types of instabilities are occurring due to of amplification of low frequency oscillation by fast acting AVR. To improve these type of instabilities power system stabilizers are used in conjunction with AVR.

Principal of Load Shedding

Load shedding is a protection schemes used in power system to avoid the condition of overloading during large disturbance. Main objective of load shedding is to remove excess load from overloaded system to bring the system back to normal condition. Power system load shedding scheme is useful in improving the stability of power system. Condition of stability and instabilities in power system is given below.

The conditions stable system is

Total Generation (TG) = Total Load (TL) + Losses

Condition for overloading is

Total Generation (TG) < Total Load (TL) + Losses

Overloading or instability can be occurring due to of sudden trip of generating unit or sudden loss of transmission line. In both cases rest of the system take extra load from tripped generator or transmission line and system becomes unstable. To cope the situation of overloading instabilities load shedding protection scheme are used. In this scheme extra load is shed in small steps which help the system to smoothly become stable. For load shedding schemes following point should be considered before designing the scheme.

- Load shedding relay should be able to shed load equal to maximum value of overload.
- Load should be shed in number of stages, rather than in single stage for smooth transition and accurate load shed
- Frequency setting should be done for maximum and minimum setting.
- Each stage should shed enough loads to handle the next, more serious contingencies.
- Time delay should be short for frequency relay.
- Load shedding relay should be spread throughout the interconnected system to avoid unnecessary power loss and undesirable islanding.
- Load priorities should be created for load shedding.

3. METHODS OF LOAD SHEDDING

There are several methods of load shedding are used to improve the stability of power system, some of them are given below with advantage and disadvantages.

3.1 Interlocking Scheme

It is a pre-planned scheme, in which load breaker are connected or interlocked with main breaker through wire. If any generator breaker or utility grid tripped then automatically a trip signal is sent to load breaker to shed load connected with load breaker. It is simplest and fast acting scheme than any other load shedding scheme. Unnecessary load shedding is present in this scheme which highlighted drawback of interlocking scheme of load shedding.

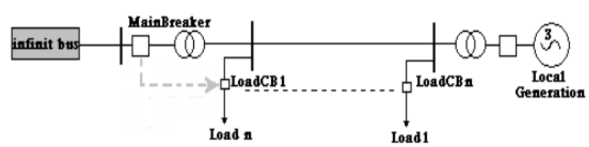

Fig. 1: Frequency at different loads [8]

3.2 Under Frequency Relay Scheme

In this load shedding scheme frequency relay is used to detect any change in system frequency. This scheme is divided in number of stages and there are some delays in each stage so that unnecessary load shedding can be minimized. Each state has some threshold value whenever contingency occur and frequency starts decline then frequency relay wait for threshold for a predetermined time. If frequency reaches minimum threshold value then a trip signal is sent by frequency relay to load breaker. After first stage if the frequency still declines the frequency relay again send trip signal to another load breaker and this process is continue until frequency reaches to normal value. In this load shedding unnecessary load shedding is minimized as compared to interlocking scheme.

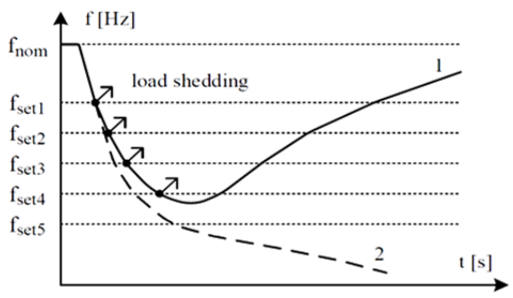

Fig. 2 Frequency at different loads [9]

3.3 Under voltage load shedding

This scheme is similar to under frequency load shedding scheme, in this voltage relay is used to monitor the voltage of the system and trip signal is sent to load breaker if the voltage reaches the threshold value. There is two basic under voltage load shedding scheme used for decentralized or distributed system and centralized system. In decentralized scheme relays has relays installed at the loads to be shed. If voltage begins to collapse in these locations then trip signal is sent to load by relays connected with these loads. In centralized scheme under voltage relays are installed at key system buses within the area and trip signal is sent to shed load at different location.

3.4 Programmable Logic Controller scheme

After the development of microcontroller in 1970, it boosts the automation market in the world. This raises an industrial controller programmable logic controller (often called PLC) which can work in difficult and hazardous environment. The application of PLC in industrial power system and load shedding scheme are started after 1980. PLC automation is more accurate, more fast and easy to programme then relay based automation. In this scheme all load circuit breaker get trip signal from PLC. PLC monitors frequency and rate change of frequency and send trip signal to load according to programme which is stored in its memory by operator. PLC based load shedding scheme is more reliable than frequency load shedding scheme.

3.5 Intelligent Load Shedding Scheme

All existing load shedding methods needs improvement in their response time, accuracy, fast detection, optimizatition and reliability in load shedding decision. To improve these parameters in load shedding scheme an intelligent load shedding scheme is needed. Intelligent load shedding scheme contains knowledge base system, computation system, monitoring system, distributed control and network models. In system knowledge base in which pre - trained data using selected input output data bases from offline studies and simulation are stored. Knowledge base system periodically send requests to the ILS computation engine to update the load shedding tables and ensuring that optimum load will be shed when contingency occur. These load shedding table are downloaded to remote distributed control PLC located to near to shed able load. When any contingency occur fast and accurate load shedding can be taken.

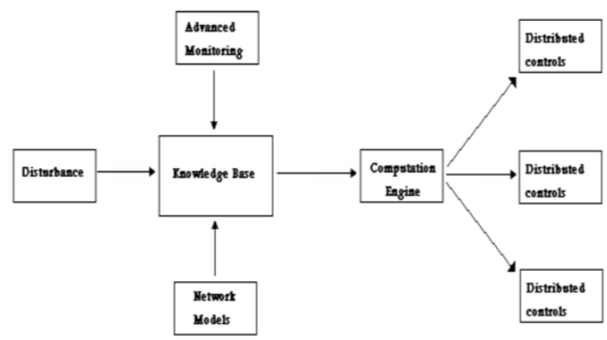

Fig. 3: Frequency at different loads [8]

4. CONCLUSION

In this paper different load shedding scheme are study to improve the stability of the power system. Different load shedding scheme can be used for improvement of stability of a system during disturbance (mostly in case of large disturbance). Out of above mentioned load shedding scheme ILS (Intelligent load shedding) are more accurate, fast response time and more reliable to shed load than any other methods.

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