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Research Paper

A SURVEY PAPER ON OVERLOAD MONITORING PARAMETERS AND MODERNISATION IN LOAD SHEDDING APPROACH

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In recent years, there has been an increasing number of major power system blackouts worldwide. This survey provides brief description on parameters that vary during overload condition. Taking that into consideration the objective of this survey is to provide modern load shedding approach and also propose effective and efficient load shedding schemes.

Keywords: Load shedding, Intelligent load shedding, Frequency monitoring, Under frequency relay

INTRODUCTION

A rolling blackout, also referred to as load shedding, is an intentionally engineered electrical power shutdown where electricity delivery is stopped for non-overlapping periods of time over different parts of the distribution region. Rolling blackouts are a last-resort measure used by an electric utility company to avoid a total blackout of the power system.

Rolling blackouts may be localized to a specific part of the electricity network or may be more widespread and affect entire countries and continents. Rolling blackouts generally result from two causes: insufficient generation capacity or inadequate transmission infrastructure to deliver sufficient power to the area where it is needed.

Load shedding is a means of reducing demand usage in a facility and will reducing energy usage by up to 20%. Many times demand charges exceed 50% of the total electric power bill. This makes load shedding a very attractive option to reduce operating costs.

All electricity distributors are required to shed a portion of their load when plant have insufficient generation capacity to meet the demand at that time. This is essential in order to prevent instability of the country's interconnected generation network which

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Figure 1: General Block Diagram

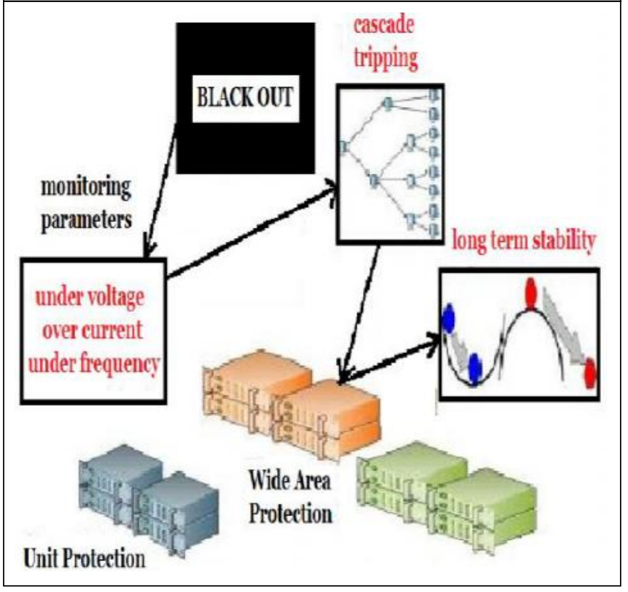
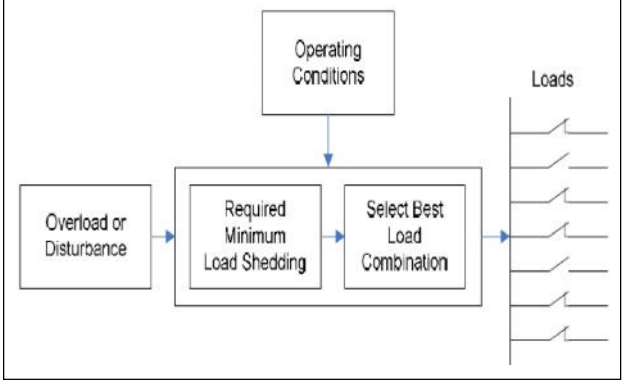


Figure 2: Schematic Diagram of Load Shedding



would result in uncontrolled nation-wide blackouts.

PARAMETERS TO BE MONITORED

The overload may be differentiated by the method that is used to detect and respond to the condition:

- Dispersed frequency monitoring.
- Dispersed voltage monitoring.
- Local equipment overload monitoring.

Analysis of System During an Overload Condition

The more basic analysis covered below includes:

- Watt and VAR transfer limitations of transmission lines.
- Load variations under changing voltage and frequency, including load dropout due to under voltage conditions.

Watt and VAR Transfer Limitations

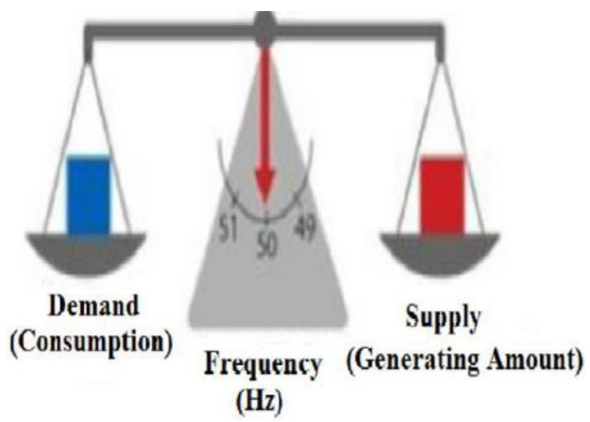
When a high load is applied, a high current is drawn. This, in turn, forces a voltage loss in the line reactance, which, in turn, means less voltage at the load. Depending on the load characteristics, this results in a point of diminishing returns. One finds that, for any line, there is a maximum Watt and VAR transfer rate. Beyond this maximum transfer rate is found that as an attempt is made to increase loading by reducing load resistance, the net system loading actually falls. Normally the maximum Watt and VAR transfer rate is well beyond the levels at which one would operate a system, so it does not become a consideration in normal operating practices. It only shows up for serious overload conditions.

Frequency Monitoring

Under-Frequency Relay Load Shedding

Frequency monitoring is a high speed means of detecting a major system upset, but it must by its nature wait for serious conditions to exist, including islanding and/or generation already slowing down, before it acts. Once frequency has strayed far enough from nominal that it can be assured a system upset has occurred, there may be only fractions of seconds to may be tens of seconds for the necessary load to be shed before the system totally collapses.

Figure 3: Relationship Between Frequency and Power (Demand / Supply)



After a disturbance in a power system there may be local frequency swings as generation swings back and forth with respect to the balance of the network. These swings occur independently of whether there has been a system islanding condition even if average frequency stays at the system nominal frequency. If these frequency swings are severe, they can lead to the momentarily picking up of an under frequency relay.

Current and / or Power Monitoring

Current (and/or power) monitoring is basically monitoring for overheating of specific equipment using an I^2R approach. If current rises above the full load amps for an extended period there is indication of a damaging overheating. Over current load shedding is not typically thought of as a load shedding function, since it is usually protecting a specific piece of equipment against faults rather than protecting a power system as a whole. It removes equipment from service rather than removing the load that caused the overloading condition. As typically applied, over current relaying only loosely fits into the definition of load shedding.

Ignoring the role of over current protective relays for now, the extent to which over current or power relays are installed specifically for load shedding is fairly low. One reason is that due to the short term overload capability of most equipment, the relays may serve best as alarms to operators rather than as automatic load shedding devices.

Another reason is that the load that is the eventual source of the overload of a given piece of equipment may be quite remote from the relay, and manual load transfer to another source may be a better solution than shedding the load.

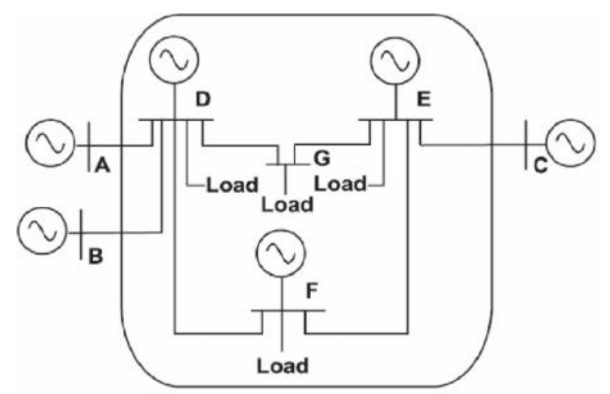
Under-Voltage Based Approach

For the purposes of this section consider voltage based load shedding as a system with a dedicated relay that sheds local load when the relay sees three phase voltage depressed for an extended period (2 seconds to maybe a minute, depending on what non-load factors could cause voltage depression). This is indicative of an overload. Voltage based load shedding cannot be set to operate as fast as frequency based load shedding because by nature under voltage can be fooled by the voltage dip caused by faults and load energization.

Over current relays may have a role in supervising other load shedding relays. For instance, in some situations it may be advisable to supervise an under voltage load shedding relay with an over current relay to give added security that the under voltage condition is due to an overload condition or to only trip a line when power flow is in a given direction.

The following example is an attempt to show the various aspects of an overload condition and the protection practices that could be used to detect and respond to the condition. Imagine the following scenario in the adjoining that shows several chances for a load shed system to prevent a system collapse and shows some aspects of how an apparently stable system may actually be slowly progressing toward a system collapse. At first it appears that buses D, E, F, and G are too well tied to the system grid (represented by A, B and C) for an islanding condition to occur. Suppose that buses D, E, F, and G are drawing power from the rest of the world and that loading overall is quite heavy at this time. Now suppose lines A-D and B-D are on a common transmission tower right of way and for some reason a single event (e.g., a tower failure) took both lines out of service. To some extent this is almost a triple contingency situation: It assumes the loss of two lines at a time of heavy system loading. But it is a possible scenario that is not beyond the realm of possibility. Suppose that line C-E is now overloaded, and that voltage in the system has decayed. This relieves loading to some extent. Suppose generator E is small in relation to the local loading and that generator E tries to support voltage and its field began to supply VARs beyond its long-term capacity.

Figure 4: Power System



System operators might see the event where lines A-D and B-D were lost and, from their remote location, think the system was surviving the event but with moderately depressed voltage. However, one minute after the event, tap changers throughout the system start to correct for low voltage and the system load starts to rise. Two minutes after the event the field excitation limiter at generator D forces the field to back down and voltage at the loads falls again. Then one minute later tap changers start to raise load voltage again and load again rises. Operators might see the heavy loading on line C-E and become concerned but decide to accept the condition.

If they could monitor the generation and realize that the excitation limiters had kicked in, they might even be more concerned. Prior to voltage collapse, another unforeseen event occurs. The protective relaying on the heavily overloaded line C-E trips due to load encroachment that looks like a zone 3 distance fault. The system consisting of buses D, E, F, and G has islanded with insufficient generation to support its load, several minutes after the initial event. At this point frequency based load shedding may be the only method that can stop the imminent collapse of the island.

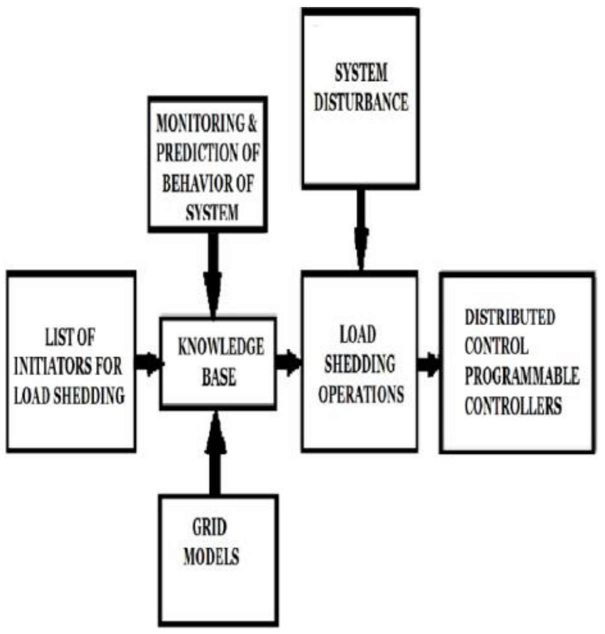
This process shows the means of load shedding that could have been used in the process:

- The last resort, under frequency relaying, was the final defense against island collapse once the island was created. The condition could have been caught earlier.
- Under voltage relaying could feasibly have detected a condition and shed load.

INTELLIGENT LOAD SHEDDING APPROACH

An intelligent load shedding approach requires a comprehensive understanding of power system dynamics and process constraints, combined with knowledge of system disturbances.

Figure 5: Functional Block Diagram of Intelligent Load Shedding



In recent years, modern system analysis software programs have been designed as a component of a larger power management system in order to perform system analysis using real-time data. In addition, techniques such as Neural Network (NN), Generic Algorithms (GA), Simulated Annealing (SA), Fuzzy Logic (FL), Expert Systems (ES), etc., have emerged in the field of power systems offering more effective problem solving, knowledge representation and reasoning, search, planning and action, for some highly non-linear problems, which often cannot be solved using conventional techniques.

PROPOSED METHODOLOGY

Automatic Load Shedding

This is a protection scheme initiating the automatic isolation of additional parts of the national grid, to protect the entire grid from cascading to a total blackout. Automatic load shedding always occurs on the transmission system level, with the result being large amounts of electricity and large blocks of customers taken off supply in a very short time.

Selective Load Shedding

This is done where time is available (typically up to 30 mins) to make selective choices on what customers are shed. Each feeder is then assigned a priority based on their overall customer mix. These feeders are then ranked against each other, the lowest priority feeders being targeted for load shedding first, the highest priority feeders last to be shed and typically first to have supply restored.

Rotational Load Shedding

This will occur on the low priority feeders if the load shedding duration extends for several hours.

CONCLUSION

The detailed study of the parameters needed to be monitored during an overload condition has been done. From the survey the importance of a timely applied load-shedding action has been reconfirmed. Finally we can say that there is a need of improvement in the existing schemes and a smart way should be adopted for reliable and efficient operation.

An intelligent load shedding schemes for the reliable operation has been proposed and hence the objective of this survey has been achieved.

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