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Research paper



Prevention of voltage instability in radial distribution system during fault occurrence

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Abstract

One of the most important fundamentals required for the rapid progress of technology, is stability in power systems. Therefore, with the power systems used for transfering energy over long distances, alongside the exposure of natural phenomena and errors, the stability of voltage protection becomes a necessity for economic and occupational safety reasons. In this paper, the analysis of the level of the voltage of the distribution network was studied by linking the capacitor bank after the network was exposed to error. A study was carried out for the compacted dynamic after connecting the capacitor bank. A PSCAD program was used to simulate a complete electrical distribution system and test results were taken from the same program.

Keywords: *Voltage Stability; Capacitor-Bank; Distribution Network and Power Quality*

1. Introduction

The specifications for the electrical power systems are large and complex, because the process starts with generation and ends with distribution. Ultimately, this ends where energy is transmitted over long distances via transmission lines. The main requirements for the system to be stabled are: to operate at a fixed frequency, to transmit power safely and to have minimal losses. The generator, which is an electric machine, is used to generate electricity at the generating station. These generators must also be able to cope with load changes. As a result of today's rapid technological development, engineers have to be cautious in dealing with energy production in order to obtain continuous energy for the consumer and reduce energy loss.

These days, electrical distribution network is exposed to considerable stress due to the high demand for energy and the large number of investments. In order to maintain a steady and reasonable energy level, we must take into account the integrity of the network. The electrical-grids are required to be utilized successfully. One of the requirements for existing distribution-grids is the ability to be developed without primary investments, while simultaniously not compromising the safety of the power system. The efficient use of distributed network has already caused a state wherein many strength systems are operating with greater frequency and longer closed to voltage stability limits. Energy devices of power systems are stressed by using intensive loading which has a significantly one of a kind reaction to disturbances from that of a non-burdened machine. The capability length and impact of disturbances has also expanded. While a strength machine is operating toward a stability limit, a particularly small disturbance may additionally cause a system upset. Additionally, a large part of the interconnected systems can be distressed by a disturbance. The objective of this study is to obtain stability of the network voltage when a fault occurs on the distribution network by the capacitor-bank. Thus, the main idea of this work is that the demand exceeds the reactive power available in the system. To supply this excess demand of reactive power, we need Capacitor banks, synchronous motors or other methods of compensation.The issue of voltage instability is particularly taken into consideration due to the incapacity of the grid to fulfill the burden call for imposed in terms of inadequate reactive power assist or an active power to be transmitted functionality [1].The stability of the voltage is an important issue in power system due to heavy load, faults and the grids work as a source of reactive power.Inside the grid, in which sufficient reactive electricity era isn't available domestically to alter voltage and preserve the reactive energy stability, there is more susceptibility to voltage instability.

2. Related works:

Following the existing methods summarized as:

Analysis of power system via five varying methods used novel voltage stability suggested by P. GOPI KRISHNA and T. GOWRI MANOHAR [5]. The methods are named as such: (Repeated Optimal Power Flow (ROPF), Repeated Power Flow (RPF), Continuation Power Flow (CPF) in additional to Index of Voltage and finally Radial Basis in Function Neural Network (RBFNN) of intelligent technique respectively. The proposed techniques are required in term of voltage stability due to sensitivity of voltage with any power system and based on many factors. For this reason, the power engineer must observe closely for the voltage stability of the power system, and to be prepared to perform voltage stability analysis, using all the afformentioned methods.

A quick survey on voltage stability that related of Distributed Generated (DG) with presented network considered by Haruna Musa [6]. There are great improvements provided in term of power quality that has a positive impact on the stability of voltage over the network. Thus this study, determines the limitation of maximum capacity taken on as a review for the system in a head of collapse voltage happening by using index of voltage stability. In this review the researcher also focused on the efficiency of the indicators of the

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sensitive line or bus on the voltage collapse rim for recent distribution systems. Line stability factor (LQP) can be defined as the important indicator that index to active and reactive which related to the power received in the end of buses, it can also achieve a better performance with the new distribution systems.
Kumaraswamy and P. Ramanareddy [7] proposed a method for power systems to monitor based on measurements. This method aims to detect instability of the voltage with the use of Kirchoff-Laws.

3. Voltage Instability and Voltage Collapse:[10]

The use of mathematical expressions aid in the definition and clarification of this rea, which is considered ambiguous when there is missing strict expressions. The term of "voltage collapse" refers to non-applicable voltage that magnitude is dropping very fast at the time. In additional to this definition, it refers to huge ambiguity. Disturbance of the system leads to voltage collapse. Which means that when the system is running, there is a stick in time make the voltage be uncontrollable. Actually the voltage becomes unstable first then the collapse may occur later for many reasons such as (load recovery, different phenomena and OLTCs). Many reasons are considered for voltage collapse such as low voltage profiles, density of reactive flow, unsuitable reactive support, and finally difficulty in load system. There are two ways to predict the voltage collapse via signal of low probability and different contingencies. These effects related with voltage collapse require time to restore the system, and time for the customer to leave the supply for periods of time extension [10].

3.Voltage Profile:-

Termination of transmission lines not affected by increasing the impedance, but there is influence represented by the length or line compensation. For this reason the loading will be changed accordingly from less-fraction in Surge Impedance Loading (SIL), which is based on two factors line and length compensation within condition of maximum load. When the line is not affected by increased impedance, that's mean the voltage profile is not flat. There are four load conditions which are: "no load", " short circuit"," surge impedance loading SIL", and finally "full load". These condition can be represented as:[11,12]

- When there is no load that means: $I_{RNL=0}$, and the voltage increased gradually fromV_s to the end of V_{RNL} can be illustrated as $V_{RNL} = \frac{V_S}{Cosh(\partial)}$ ….(1)
- In case of the load with short circuit, $V_{RSC} = 0$ the voltage goes down from V_S and in the other end will be $V_{RSC} = 0$ when receiving and will be

$$V_{RSC} = \sqrt{3}(V_S Cosh(\partial) - I_S Z_C Sinh(\partial)) \quad \text{….(2)}$$

- When SIL the voltage is stable and the equation is

$$V_R = \frac{V_S}{Cosh(\partial)+sinch(\partial)} \quad \text{…(3)}$$

- Last case when full voltage load which is based on properties of the full load current, then the short circuit will be :

$$V_{Rrated} = \sqrt{3}(V_S Cosh(\partial) - I_S Z_C Sinh(\partial)) \quad \text{….(4)}$$

$$I_S = \frac{MVA_{rated}(Cosh(\partial)+JSin(\partial)}{3V_S} \quad \text{….(5)}$$

4. Prevention of Voltage Instability:

Some of the prevention of voltage instability by following **:** (1) Placement of Series and Shunt Capacitors. (2) Installation of Synchronous Condensers. (3) Placement of FACTS Controllers. (4) Coordination of Multiple FACTS Controllers. (5) Under-Voltage Load Shedding. (6) Blocking of Tap-Changer Under Reverse Operation. (7) Generation Rescheduling. [13]

5. The Simulated Model

The network of this simulation system consists of a 5 km long radial feeder, feeding a 2.507 MW of 0.88p.f. lagging. Figure 1 is a single line diagram for the radial feeder, contains 3 laterals and the load (L1- L9) load which are distributed along the feeder**.** Table 1 indicates the value and the p.f of each load of the feeder.

Table 1: Load and P.F of the Feeder Loads

Loads	MVA	Power Factor %
L1	0.568	0.92
L2	0.396	0.88
L3	0.113	0.84
L4	0.247	0.92
L5	0.205	0.90
L6	0.205	0.86
L7	0.238	0.91
L8	0.323	0.85
L9	0.212	0.87

An intensive bank of 350 kvar is connected at the end of the line to correct the power factor.
This research study was carried out on the basis that the network operates in a steady state and an electrical fault had occurred. Note that the capacitor-bank was in operation at that time.The control system (IP) was used to control the switching of the capacitor-bank to the feeder.For investigation, the impact of capacitor-bank on the grid, appropriate simulated model is necessary. In this paper, the model will be built up with reactors, controlled by a parallel fixed capacitor bank. It is connected in shunt with the distributed line which is represented in **Fig 1. Fig 1** also shows the equivalent circuit at which capacitor-bank is modeled. The capacitor-bank can simultaneously absorb and supply the reactive-power at the busbar where it is applied.

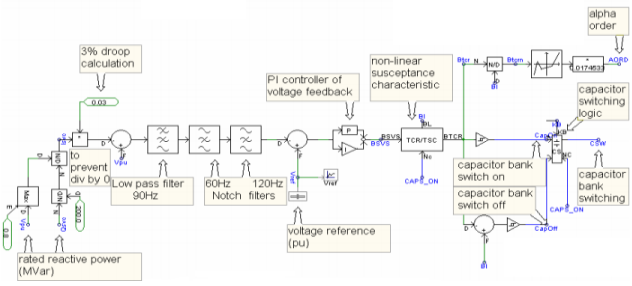


Fig. 1: Simulated Model

6. Dynamic-Response of the System

Figure 2 shows the voltage profile of the feeder before the fault.

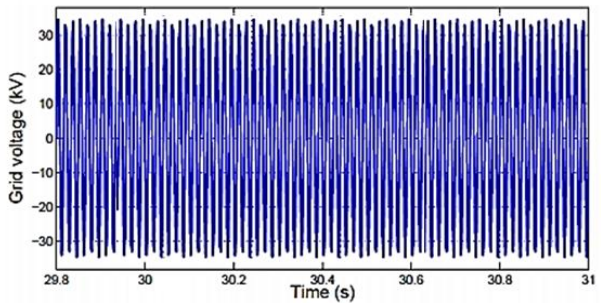


Fig. 2: Steady State Voltage of the System

The decrease in feeder voltage is due to a temporary error on the feeder. To prove the ability of the model to re-produce the dynamics of the capacitor-bank, a test was conducted. The system was working under a line to ground fault. The dip on the voltage of the network was simulated, and observing the response of the voltage profile of the system. In fact, this is a test for a dynamic response and not the implementation of the "low-voltage". The voltage of the network declines from 1.0 p.u. to 0.4 p.u. and the dip continues for 18 cycles or for 0.3s. The aim of the test is to indicate that the simulated model was really responsive to the events occuring in the dynamic time-scale. In reality, it is the actual response of the network-voltage. The test results in **Fig. 3a** shows that the model actually did respond to the event of the network as predicted. The voltage of the network back stable and constant to the normal level for the demand of the current of the converter as appeared in **Fig 3b**.

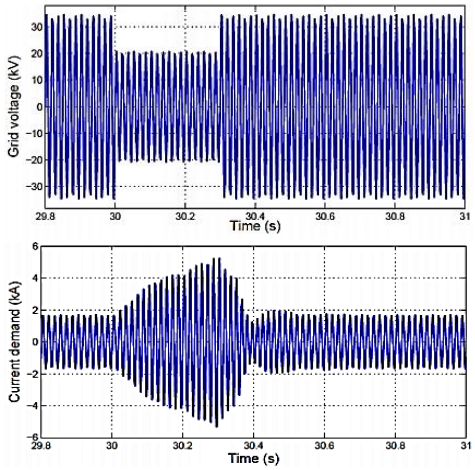
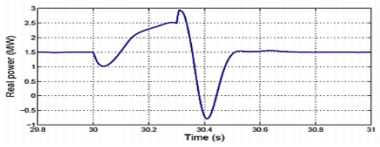


Fig 3: (a) Voltage Grid of the Simulation **(b)** Current Demand of the Grid

It is clear from **Fig. 5a and Fig. 5b** that power output displays a severe increase when the incident faults happen. This is because of the capacitor-bank of the network trying to keep real-power output at 2 MW despite of the occurring of voltage-drop. Basically, the capacitor-bank increases the demand of the current from the generator, which appears as a hop in power. According to the results, the behavior of the model is predictable, and in reality the declarations of the response can be presented. All transients' conditions when the voltage dip takes place and when the dip finishes are also obvious.



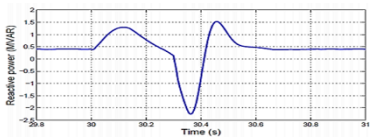


Fig 5: (a) Real Power for the Simulated System **(b)** Reactive Power of the Simulated System

7. Conclusion

The levels of the voltage of the transmission and distribution network depend directly on the type of load as well as the fault. Therefore, the consumer must be provided with a stable voltage. The method presented in this study, achives a stable voltage level for a short time on the distribution network during the occurance of the sudden fault. This stabilization of voltage happened after the network was equipped with a bank of capacitors.

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