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# Transmission Line Based on The Voltage Stability Control

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**ABSTRACT:** This paper focuses on discussing, the transmission line networks need to be browbeaten ever more completely. The more efficient use of the transmission network has already led to a situation where many power systems are operated more often and longer close to voltage stability limits. A power system stressed. The transfer capacity of an existing transmission line network needs to be increased without central reserves and without compromising the power scheme's security. For voltage, stability can cause a system to collapse. At any point in time, the condition that operates a power system should be stable. There are various operational criteria that the system has to meet in order to function as required.

Environmental and economic constraints make it possible for power systems to operate nearer to their stability limits. It is, therefore, both critical and challenging to maintain a system that is secure and stable. In recent years, planners and researchers of power systems have concentrated much of their attention on systems' voltage stability.

**KEYWORDS:** Power system; transformer line; Control system; voltage stability; networks.

## 1 INTRODUCTION

The term voltage stability is used in power systems to refer to a system's ability to maintain voltage under acceptable profiles when subjected to different load changes and system topologies [1]. A system can be unstable because of the transportation of reactive power over long distances. This implies that a power system with reactive power resources can have few problems relating to voltage stability. A power system is said to be stable if, at normal operating conditions, the voltage and a disturbance are very close [1]. The opposite condition is when the voltages get out of control and decrease because of the weakening of voltage control, increment of load, and equipment outage. These phenomena usually occur when reactive power is forced to travel over long distances [2]. This causes instability. Therefore, it is recommended to do a regular assessment of power systems for voltage stability as this is paramount for the planning and operation of electrical networks [1]. A system is a voltage unstable if for at least one bus in the system bus voltage magnitude decreases as the reactive power injection at the same bus is increased. The problem with voltage stability is usually concerned with the entirety of power systems; however, it is just one critical area where the problem is involved [2].

A power system does not have the ability to transfer electrical power to the loads infinitely [1]. The main reason that leads to voltage instability is the failure of a power system to meet the requirements of reactive power, especially in a case where the power system is heavily stressed [2].

Power systems might be subjected to a sudden increase of reactive power demands causing a partial or total system breakdown. The extra reactive power demands must be met by the generator and reactive power compensator reserves to prevent such incidents.

Voltage stability, instability and collapse are well- defined in [4] and these issues have been the focus of a great deal of research recently. Dynamic analysis has been used to conduct voltage stability since voltage instability is a dynamic phenomenon.

Nevertheless, static voltage stability analysis is widely used in voltage stability research, as the static analysis is not overly complicated, and requires low calculation time. The static analysis provides an accurate analysis method for handling mostly short disturbances, while dynamic analysis analyzes massive load disturbances.

Managing power systems is increasingly becoming difficult because of various reasons that relate to the current power systems. Firstly, operations of power systems require little or no supervision due to the increase in the need to transfer power over long distances [1]. Secondly, these power systems operate under limits close to security, while thirdly, there are environmental constraints that make it hard for transmission networks to be expanded [2]. From a layman's point of view, the numerous cases of blackouts reported daily are primarily caused by the voltage instability of power systems [1]. For this reason, voltage instability has become a significant point of concern among engineers and power system researchers [2].

Voltage instability can also be contributed to by other factors. They include a voltage control action, the nature and characteristics of the device that compensates reactive power, load characteristics, and generator reactive power limits [2]. Therefore, the power systems cannot transfer power over a long distance because there is a large amount of reactive power required at an absolute value of distance. Simultaneously, because there is too much loss of reactive power, it becomes difficult for reactive power to be transferred [1]. The high loss of reactive power is mainly due to the need to produce voltage control in the control area [2].

There are reasons which researchers have identified to make it harder for the management of power systems. Different power systems compete for profits and producing services at a lower cost. This competition leads to a long duration that the systems must operate close to stability limits and security.

As earlier identified, environmental constraints is also a major reason for preventing further expansion of the transmission networks [2]. They severely limit transmission networks from expanding. Near the load centers, environmental constraints prevent transmission networks from expanding. This is argued to have a negative influence on the stability of the power systems [1].

The underlying reason for this negative influence is the increasing distance between a load and a generator. When the distance increases, the voltage support is reduced. In a market marked with deregulation, there is a need to have a new power flow control and a new type of voltage. However, the currently used power systems are not designed for [2] in Fig.1 shown the transmission line [6].

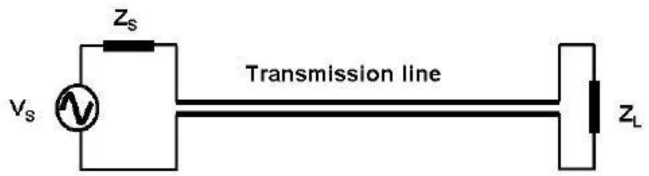


***Fig. 1. Transmission line***

## 2 TYPES OF TRANSMISSION LINES

The different types of transmission lines include the following in Fig2.

### OPEN WIRE TRANSMISSION LINE

The two-wire transmission lines are straightforward, low cost, and easy to maintain over short distances. It consists of a pair of parallel conducting wires separated by a uniform length. Another name of an open-wire transmission line is a parallel wire transmission line.

### COAXIAL TRANSMISSION LINE

The two conductors are placed coaxially and filled with dielectric materials such as air, gas, or concrete. These cables are used in CC systems, digital systems, computer network connections, internet connections, and Fiber cables.

#### OPTIC FIBER TRANSMISSION LINE

long distance which is used to send signals over a long distance with little loss in signal. The optic fiber cables are used as light guides used for data transmission and applications.

#### WAVE GUIDES

Most of the electromagnetic energy moves from one pace to another; their types of waveguides are dielectric waveguides and optical fiber communication.

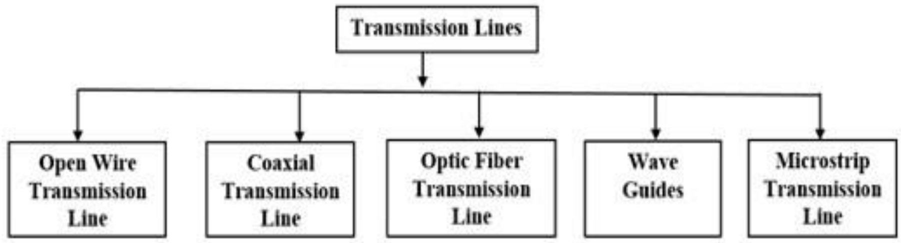


***Fig. 2. Types of Transmission lines***

This chapter seeks to review the different techniques, both traditional and current, which are applied to mitigate the voltage stability issues. The chapter also looks the various types of voltage stability. There are two main classifications of voltage instability: short term instability and long-term instability [3].

Voltage stability can cause a system to collapse. At any point in time, the condition that operates a power system should be stable. There are various operational criteria that the system has to meet in order to function as required [1]. Environmental and economic constraints make it possible to for power systems to operate nearer to their stability limits. It is therefore both important and challenging to maintain a system that is secure and stable. In recent years, planners and researchers of power system have concentrated much of their attention on voltage stability of systems [1].

The corresponding dynamics of these two categories are referred to as short term and long dynamics, respectively. Within the transient or short-term scale, various dynamics fall under it [2]. They include the governor dynamics, turbines, excitation systems, and automatic voltage regulators. When we talk about the transient or short term, it implies a few seconds of transmission. Additionally, HDVC interconnections, electronically operated loads, and induction motors are also included in the short-term category [1]. When voltage instability occurs during the short-term time frame, it usually results from loss synchronism or rotor angle imbalance.

For long term time frames, the main components which operate under this time scale include boilers, limiters, and transformer tap changers. Ideally, the long-term time frame usually lasts between a few minutes up to ten minutes [2]. Voltage stability does occur in the long-term time frame. And the primary cause for this is the large electrical distance that is created between the load and the generator. However, this depends on the power system's detailed topology [3].

This is in the presence of a distributed generation. The chapter will investigate both induction machine and synchronized machine distributed generation. As a result, there will be a clear presentation of voltage instability that is caused by:

- Long term large disturbance
- Transient voltage instability,
- Finally, the chapter will present the impact of the distributed generations and their possible modes of operation [2].
- Long term small disturbance

The previous chapter also looked at the transient voltage instability and showed that it appears in different forms which are caused by various mechanisms. This therefore implies that investigation of voltage stability is important for one to comprehensively develop an understanding of the impact of induction machine and synchronous machine distributed generation on voltage stability [3]. Similarly, investigating voltage stability is important to further understand the impact on long term large disturbance, long term small disturbance, and transient voltage stabilities. Researchers have also argued for the need to further evaluate the operational impact of induction machine distributed generation and synchronous machine distributed generation on the various mechanisms of voltage instability. Before presenting the small case study, it would be best to first understand the dynamic characteristics of a distributed generation [3].

From previous chapters it is clear that the when the transmission loading is increased, the power system is brought closer to voltage instability. When power is generated locally from a distributed generation, it increases the load ability of the system of distribution [2]. Using PV curves, one can show how the reactive power support in a system of distribution helps to increase the capabilities of power transfer. Reactive power has to be provided locally because it is difficult to transmit it over long distances [3].

Hence the presence of distributed generation that produces reactive power helps to increase the capability of power transfer from a transmission network to a system of distribution [2]. At the same time, the presence of distributed generation that absorbs reactive power has the capacity to decrease the capabilities of power transfer. The evidence of this has been shown in numerous studies where induction machine distributed generation decreased load ability but the presence of synchronous machine distributed generation increases load ability [2].

A distributed generation can either be induction or synchronous. The figure below helps to illustrate how both disturbed generations are structured.

Synchronous distributed generation has the ability to remain stable even when a grid faults [3]. This ability is attributed to the stability of rotor angle. The rotor angle stability is determined using the critical area method or what is commonly known as the equal area criterion [3].

Synchronous distributed generation affects voltage stability thereby making a matter of interest for this paper and particularly this chapter.

Thus, in order to get a glimpse of how synchronous distributed generation has a dynamic performance, one can consider a HV bus which has a three phased fault. The terminal voltage of a generator is significantly reduced due to the fault that occurs in the grid. The generator will keep on supplying reactive power as the faults continues. This keeps the terminal voltage of the distributed generation at a higher level than that at the faulted point as the fault continues [3]. When the terminal voltage of a distributed generation reduces, the capability of the distributed generation to deliver power is decreased [3]. A generator cannot return to its state prior the fault if there is an increase in the rotor angle to the extent that it passes the critical angle. These are the phenomena that explain the dynamic performance of a synchronous distribution generation [3]. In Fig3. Shown the voltage Stability

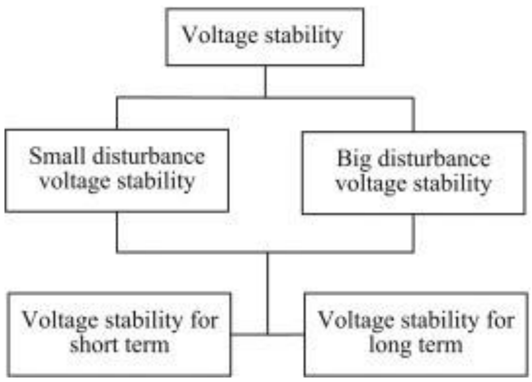


*Fig. 3. Voltage Stability*

From this analysis, it is clear that the synchronous distribution generation provides support for voltage during a system fault. It does this by supplying reactive power as the fault occurs. From this point of view, it can be argued that synchronous distributed generation helps to reduce problems relating to transient voltage instability. Induced machine distributed generation has been explained in the previous section of this chapter. It has been discussed that induced distributed generation has the ability to remain stable even when a fault occurs in a grid as a result of voltage stability. In order to further understand and explain the dynamic operation of an induced distribution generation, we will consider the same examples used to describe the dynamic performance of a synchronous distributed generation. In the example, there is a system with a HV bus in which a three phased fault occurs. The first fault last for about 0.4 seconds but the generator still remains stable. The second fault lasts for 65 seconds but the induced generator becomes unstable [2].

To explain the performance of the induced generator, the following points are noticed [2]. The generator terminal voltage will be significantly reduced as a result of the grid fault. The generator unit is caused to accelerate as a result of a reduction in the delivered active power [2]. Even after clearance of the fault, there is a significantly high speed of the generating unit. The speed is very high compared to that prior the occurrence of the fault [2]. Because of the high speed, there is increased consumption of reactive power in the induced generator. Hence, due to the increase in consumption of reactive power, the terminal voltage of the generator is decreased. But if the speed continues to increase thereby passing the critical speed, it will be hard for the generator to go back to its state before the fault occurred [2].

#### CASE STUDY

The following diagram represents voltage stability in the presence of a distributed generated system under study. With a synchronous machine, it was possible to operate at a constant voltage [2]. The changes in the demand of load do not affect the output of the reactive power. There is a local supply of reactive power except when the system of distribution has reactive power in excess due to the shunt capacitor [2]. According to these conditions provided, three synchronous machine distributed generation are examined [2]. The first one operates a unity pf case the second one operates at a lagging pf case, while the final one operates at a constant voltage case [2]. In all the three cases, one general assumption is made; that the synchronous distributed generation operates continuously at a power output of 4 MW [2].

The case is also examined using an induced machine distributed generation. In this case we compensate the induced machine with a shunt capacitor. The capacitor is switched off at various steps. The process of switching on and off the shunt capacitor in the induced machine distributed generation is not usually based on the loading that occurs in the distribution system. This therefore implies that the size of the capacitor will be limited because of overvoltage on minimum load. As previously explained, an induction machine distributed generation causes both over and under voltage in the distribution system.

A maximum distributed generation and a maximum load will cause under voltage to occur. In such cases, voltage at feeder ends and the capacitor compensation will suffer under voltage. Based on the conditions provided, there are operations for the distributed generation which are investigated. They include: an induction distributed generation with a normal capacitor (normal c), with a large capacitor (larger c), and with a larger capacitor plus STATCOM (larger c plus STATCOM). In Fig4. Shown the type of the voltage stability

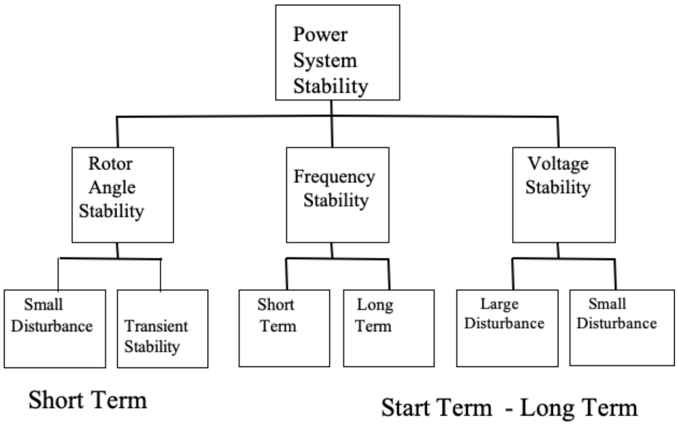


***Fig. 4. Type of voltage stability***

## 3 RESULTS OF THE CASE STUDY AND PROPOSED SOLUTIONS

In order to investigate the stability of transient voltage, a bolted three phased fault is applied [2].

The clearing time for the fault is set differently for different distributed generation. In order to analyze the stability of long-term large disturbance voltage, a single phased fault is applied at both lines. And lastly, in order to examine the voltage stability of long-term small disturbance, the load at bus 3 is increased [2].

### IMPACT ON THE STABILITY OF TRANSIENT VOLTAGE

Using the synchronous machine, the response was as expected. The machine managed to improve the stability of transient voltage within the system of distribution. The primary reason for this is because the machine helps to increase voltage within the system of distribution as the fault continued to occur. As a result, this ensures that the voltage recovers quickly after the fault occurs. Transient voltage instability and showed that it appears in different forms which are caused by various mechanisms [2]. This therefore implies that investigation of voltage stability is important for one to comprehensively develop an understanding of the impact of induction machine and synchronous machine distributed generation on voltage stability [2].

The improvement is not only concentrated in the particular system of distribution connected to the distributed generation but it is also evident in the neighboring systems of distribution. This also means that when one distribution system experiences either a voltage collapse or a voltage recovery, the nearby distribution systems will also experience the same [2].

Using an induction machine distributed generation a lot of reactive power is absorbed immediately after clearance of the fault. The generator terminal voltage is seen to significantly reduce as a result of the grid fault [2]. The generator unit is made to accelerate as a result of a reduction in the delivered active power [2]. Even after clearance of the fault, there is a significantly high speed of the generating unit [2]. The speed is very high compared to that prior the occurrence of the fault. Because of the high speed, there is increased consumption of reactive power in the induced generator. Hence, due to the increase in consumption of reactive power, the terminal voltage of the generator is decreased [4]. But if the speed continues to increase thereby passing the critical speed, it will be hard for the generator to go back to its state before the fault occurred. Managing power systems is increasingly becoming difficult because of various reasons that relates to the current power systems. Firstly, operations of power systems require little or no supervision due to the increase of the need to transfer power over long distances [1]. Secondly, these power systems operate under limits which are close to security while thirdly there are environmental constraints that make it hard for transmission networks to be expanded [2]. From a layman's point of view, the numerous cases of blackouts which are being reported on daily basis are primarily caused by the voltage instability of power systems [1]. For this reason, voltage instability has become a major point of concern among engineers and power system researchers [2].

There are reasons which researchers have identified to make it harder for the management of power systems. Different power systems compete for profits and producing services at a lower cost [5]. This competition leads to a long duration that the systems are required to operate close to stability limits and to security. As earlier identified, environmental constraints is also a major reason for preventing further expansion of the transmission networks [2]. They severely limit transmission networks from expanding. Near the load centers, environmental constraints prevent transmission networks from expanding. This is argued to have a negative influence on the stability of the power systems [1]. The underlying reason for this negative influence is the increasing distance between a load and a generator. When the distance increases, the voltage support is reduced. In a market marked with deregulation, there is need to have new power flow control and new type of voltage [2]. However, the currently used power systems are not designed for [2].

## 4 IMPACT ON THE STABILITY OF LONG-TERM LARGE DISTURBANCE VOLTAGE

The presence of synchronous distributed generation reduces the number of OLTC. This is due to the disturbance that occurs in the process. The presence of the synchronous distributed generation on various modes of operation is seen to successfully restoring the voltages on the secondary bus substations. It is also clear that this restoration is impossible without the presence of the distributed generation.

From this explanation, one can draw that the presence of synchronous distributed generation helps to increase the margin of voltage stability of long-term large disturbance. But the optimal improvement is only realized at a constant voltage that the distributed generation will operate on.

Using the induction machine, there will be a collapse of voltage at a time of three seconds if there is no immediate disconnection of the induction distributed generation. There will also be an increase in the speed of the distributed generation because the induction machine normally does not have enough torque to decelerate the speed even after clearance of the fault.

## 5 IMPACT ON VOLTAGE STABILITY OF LONG-TERM SMALL DISTURBANCE

With synchronous distributed generation there will always be an increase in the margin of stability. However, the increase in margin becomes higher when the synchronous machine operates under a mode where the voltage is controlled. But for an induction machine distributed generation, the margin of stability is reduced in all the three cases (normal C, larger C, and larger C plus STATCOM) except for the third case of larger C plus STATCOM. In order to explain how these two phenomena, occur, the transmission and generation of reactive and active power is used.

With a synchronous distributed generation, there is decrease in transmission of active and reactive power because of the generation of both reactive and active power. For an induction distributed generation, there is also a decrease in transmission of reactive power. But since the machine also absorbs reactive power, there is increase in reactive power. In the information systems (IS) literary works, technology (IT) has been identified as a business ability that can lead to competitive benefits and companies' performance of Electrical [1]. The field has evolved in significant ways during the past three decades. For implementation to research methods. They include the importance of the analysis, practicality, precision, attention, detachment and values. Clear idea about mentioning help a specialist considers the method besides technique toward usage and evaluate what they have concerning the objectives defined in their guidelines. This creates a company basis, then shapes sureness. Over the prospect of back monitoring after this venture takes absent ongoing is abridge [8].

## 6 Conclusion

In addition, this chapter gives a conclusion based on the analysis of the case study. In addition is summarizes the other chapters within the paper.

From the discussion presented it is clear that the problem with voltage stability is usually concerned with the entirety of power systems but in essence, it is just one critical area where the problem is involved. The term voltage stability is used in power systems to refer to the ability of a system to maintain voltage under acceptable profiles when subjected to different load changes and system topologies. A system can be unstable because of the transportation of reactive power over long distances.

This implies that a power system which has reactive power resources can have little problems relating to voltage stability. A power system is said to be stable if at normal operating condition, the voltage and a disturbance are very close. The opposite condition is when the voltages get out of control and decrease because of weakening of voltage control, increment of load, and outage of equipment. These phenomena usually occur when reactive power is forced to travel over long distances.

This causes instability. It is therefore recommended to do regular assessment of power systems for voltage stability as this is paramount for planning and operation of electrical networks. A system is voltage unstable if for at least one bus in the system bus voltage magnitude decreases as the reactive power injection at the same bus is increased.

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