Mitigation of Voltage Sags in a Hybrid Distribution System by Using Intelligent Technique

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ABSTRACT

Power quality is a very important topic nowadays. Sensitive industrial equipment should be protected against steady-state distortions and temporary transients in the distribution lines. When an induction motor is subjected to voltage sag, the motor still operates but with a lower output until the sag ends. With the increased use of sophisticated electronics, high efficiency variable speed drive, and power electronic controller, power quality has become an increasing concern to utilities and customers. Voltage sags is the most common type of power quality disturbance in the distribution system. It can be caused by fault in the electrical network or by the starting of a large induction motor. Typical disturbances that affect the voltage waveform quality are harmonics, imbalances and sags. This paper presents a solution to protect sensitive loads against voltage disturbances that is based on a series power line conditioner. The goal of the proposed design is that the load does not suffer considerable input voltage variations. To achieve that, Fuzzy Logic Controller based Autotransformer controlled are used, which provides a proper controller operation even with utility grid distribution system. The simulation model & output wave will be evaluate using MATLAB SIMULINK software.

***Keywords** : Power quality, Fuzzy Logic Controller, Autotransformer controlled, MATLAB SIMULINK*

INTRODUCTION

An increasing demand for high quality, reliable electrical power and increasing number of distorting loads may leads to an increased awareness of power quality both by customers and utilities. The most common power quality problems today are voltage sags, harmonic distortion and low power factor. Voltage sags is a short time (10 ms to 1 minute) event during which a reduction in r.m.s voltage magnitude occur. It is often set only by two parameters, depth/magnitude and duration. The voltage sags magnitude is ranged from 10% to 90% of nominal voltage and with duration from half a cycle to 1 min.

Voltage sags is caused by a fault in the utility system, a fault within the customer's facility or a large increase of the load current, like starting a motor or transformer energizing. Voltage sags are one of the most occurring power quality problems. For an industry voltage sags occur more often and cause severe problems and economical losses. Utilities often focus on disturbances from end-user equipment as the main power quality problems.

Harmonic currents in distribution system can cause harmonic distortion, low power factor and additional losses as well as heating in the electrical equipment. It also can cause vibration and noise in machines and malfunction of the sensitive equipment. The development of power electronics devices such as Flexible AC Transmission System (FACTS) and customs power devices have introduced and emerging

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branch of technology providing the power system with versatile new control capabilities. There are different ways to enhance power quality problems in transmission and distribution systems. Among these, the Fuzzy Logic controller based autotransformer controller is one of the most effective devices.

EXISTING SYSTEM

Dynamic Voltage Restorer (DVR) is a custom power device used in power distribution networks to protect consumers from sudden sags and swells in grid voltage. On the basis of recent developments in impedance source (Z-source) inverters the present paper proposes an integration of quasi-Z-source inverter (QZSI) with a built-in high frequency transformer. New type LCCT-Z-Source inverters are presented. Proposed inverters characterize continuous input current, improved relationship between boost coefficient and modulation index and improved EMI performance. Application of four element (Inductor - Capacitor - Capacitor - Transformer) LCCT impedance network provides higher voltage gain than obtained in quasi-Z-source inverter. The advantage of proposed topology over other recently developed Z-source inverters is that two built-in capacitors block DC currents in transformer windings and prevents core saturation. Simulation results are shown to verify the proposed topologies.

POWER QUALITY PROBLEMS

For the purpose of this article, we shall define power quality problems as: Any power problem that results in failure or disoperation of customer equipment, Manifests itself as an economic burden to the user, or produces negative impacts on the environment.' When applied to the container crane industry, the power issues which degrade power quality include:

- Power Factor
- Harmonic Distortion
- Voltage Transients
- Voltage Sags or Dips
- Voltage Swells

Power quality can be improved through:

- Power factor correction,
- Harmonic filtering,
- Special line notch filtering,
- Transient voltage surge suppression,
- Proper earthing systems.

In most cases, the person specifying and/or buying a container crane may not be fully aware of the potential power quality issues. If this article accomplishes nothing else, we would hope to Provide that awareness.

In many cases, those involved with specification and procurement of container cranes may not be cognizant of such issues, do not pay the utility billings, or consider it someone else's concern. As a result, container crane specifications may not include definitive power quality criteria such as power factor correction and/or harmonic filtering. Also, many of those specifications which do require power quality equipment do not properly define the criteria. Early in the process of preparing the crane specification:

- Consult with the utility company to determine regulatory or contract requirements that must be satisfied, if any.
- Consult with the electrical drive suppliers and determine the power quality profiles that can be expected based on the drive sizes and

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technologies proposed for the specific project.

- Evaluate the economics of power quality correction not only on the present situation, but consider the impact of future utility deregulation and the future development plans for the terminal

VOLTAGE SAG

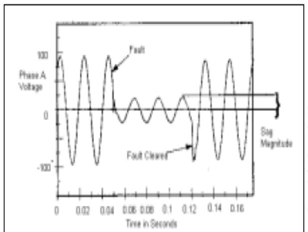

Fig 1 Typical Voltage Sag

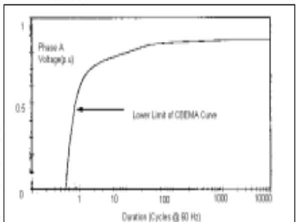

Fig 2 The Susceptibility Curve

Voltage sags and momentary power interruptions are probably the most important PQ problem affecting industrial and large commercial customers. These events are usually associated with a fault at some location in the supplying power system. Interruptions occur when the fault is on the circuit supplying the customer. But voltage sags occur even if the faults happen to be far away from the customer's site. Voltage sags lasting only 4-5 cycles can cause a wide range of sensitive customer equipment to drop out. To industrial customers, voltage sag and a momentary interruption are equivalent if both shut their process down. A typical example of voltage sag is shown in fig 1. The susceptibility of utilization equipment to voltage sag is dependent upon duration and magnitude of voltage sags.

Voltage-Sag Analysis- Methodology

The methodology is outlined in chapter9 (proposed) of IEEE Gold book (IEEE standard 493, Recommended practice for the design of reliable industrial and commercial power system) The methodology basically consists of the following four steps:

Load Flow:

A load flow representing the existing or modified system is required with an accurate zero- sequence representation. The machine reactance Xd" or Xd ' is also required. The reactance used is dependent upon the post fault time frame of interest. The machine and zero-sequence reactance are not required to calculate the voltage sag magnitude.

Voltage Sag Calculation:

Sliding faults which include line-line, line to ground, line to line- to ground and three phase are applied to all the lines in the load flow. Each line is divided into equal sections and each section is faulted

Voltage Sag Occurrence Calculation:

Based upon the utilities reliability data (the number of times each line section will experience a fault) and the results of load flow and voltage sag calculations, the number of voltage sags at the customer site due to remote faults can be calculated. Depending upon the equipment connection, the voltage sag occurrence rate may be calculated in terms of either phase or line voltages dependent upon the load connection. For some facilities, both line and phase voltages may be required. The data thus obtained from load flow, Voltage sag calculation, and voltage sag occurrence calculation can be sorted and tabulated by sag magnitude, fault type, location of fault and nominal system voltage at the fault location

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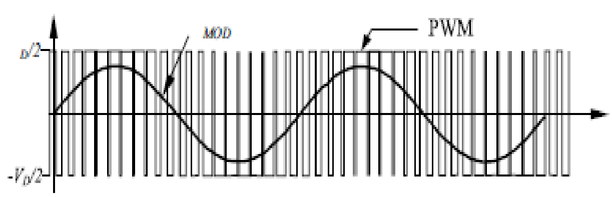
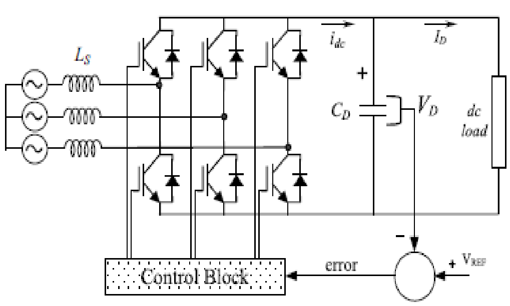
VOLTAGE SOURCE CONVERTERS (VSC)

A voltage-source converter is a power electronic device, which can generate a sinusoidal voltage with any required magnitude, frequency and phase angle. Voltage source converters are widely used in adjustable-speed drives, but can also be used to mitigate voltage dips. The VSC is used to either completely replace the voltage or to inject the 'missing voltage'. The 'missing voltage' is the difference between the nominal voltage and the actual. The converter is normally based on some kind of energy storage, which will supply the converter with a DC voltage. The solid-state electronics in the converter is then switched to get the desired output voltage. Normally the VSC is not only used for voltage dip mitigation, but also for other power quality issues, e.g. flicker and harmonics.





LCL Passive filter

The line-filter between the converter and the grid can be reduced by using an LCL-filter instead of an L-filter. The main drawback with this is that the LCL-filter will introduce a resonance frequency into the system. Harmonic components in the output voltage can lead to resonance oscillations and instability problems unless they are properly handled. One way of reducing the resonance current is by adding a passive damping circuit to the filter. This damping circuit can be purely resistive, causing relatively high losses, or a more complex solutions consisting of a combination of resistors, capacitors and inductors. A more attractive option is the use of active damping where the output voltage from the converter is used to damp out the resonance oscillations. Several methods for active damping have been presented in the literature, but most of these are utilizing sensors for measuring the either the capacitor voltages or currents, only a few methods based on sensorless control have been presented. The focus in this paper is on sensorless control and how to realize active damping without measuring anything but the output current from the converter and the dc bus voltage.

The Virtual Flux Concept

A typical LCL-filter is shown in Figure 1 where V1 is the grid side voltage, Vc is the voltage across the filter capacitor and V2 is the converter output voltage.

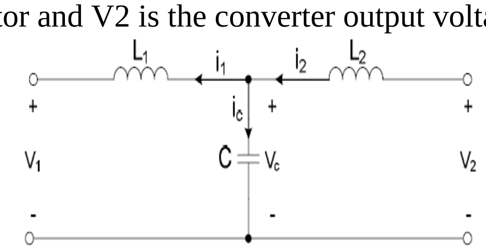


Figure 1: LCL-filter

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The capacitor voltage, Vc, can be expressed by equation (1) whereas the grid side voltage,V1, can be expressed by equation (2).

$$\underline{V_c} = \underline{V_2} - L_2 \frac{d\underline{i_2}}{dt} \qquad (1)$$

$$\underline{V_1} = \underline{V_c} - L_1 \frac{d\underline{i_1}}{dt} = \underline{V_c} - L_1 \frac{d}{dt}\left(\underline{i_2} - C\frac{d\underline{V_2}}{dt} + CL_2\frac{d^2\underline{i_2}}{dt^2}\right) \qquad (2)$$

The main problem with equation (2) is that it depends on the third derivative of the converter output current, a fast changing quantity containing a relatively large amount of ripple in addition to measurement and discretization noise. It is therefore desirable to express the equations in an Alternative way. One such way is to use the virtual flux concept introduced by for the VOC and later by for the DPC. The converter side flux is given by equation (3) whereas the capacitor and grid side virtual flux is given by equation (4) and (5). Drift compensation of the virtual flux is done using the method described by Niemela.

$$\underline{\psi_2} = \int \underline{V_2} dt$$

$$\underline{\psi_c} = \int \underline{V_c} dt = \underline{\psi_2} - L_2 \underline{i_2}$$

$$\underline{\psi_1} = \int \underline{V_1} dt = \underline{\psi_c} - L_1 \underline{i_2} + L_1 C \frac{d^2}{dt^2} \underline{\psi_c}$$

The capacitor current can be estimated using equation (6).

$$\underline{i_c} = C\frac{d}{dt}\underline{V_c} = C\frac{d^2}{dt^2}\underline{\psi_c} \qquad (6)$$

The control system based on the voltage oriented control (VOC) and virtual flux is shown in Figure 2

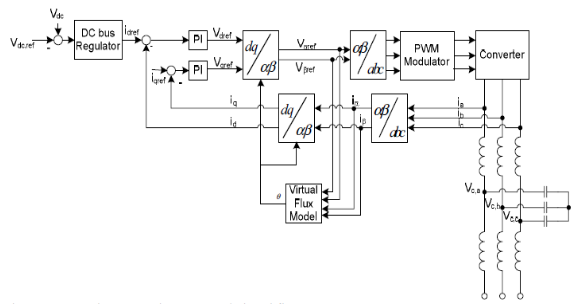


Figure 2: Control system using VOC and virtual flux

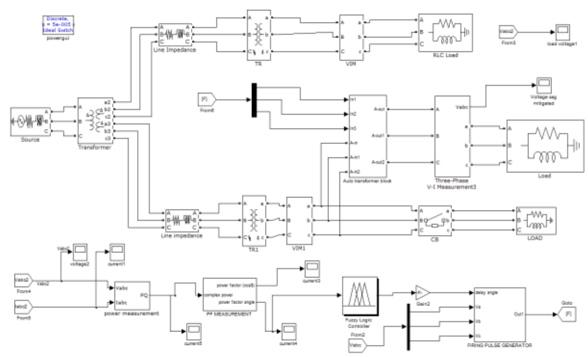
WHAT DO YOU MEAN *FUZZY* ??!!

Before illustrating the mechanisms which make fuzzy logic machines work, it is important to realize what fuzzy logic actually is. Fuzzy logic is a superset of conventional(Boolean) logic that has been extended to handle the concept of partial truth-truth values between "completely true" and "completely false". As its name suggests, it is the logic underlying modes of reasoning which are approximate rather than exact. The importance of fuzzy logic derives from the fact that most modes of human reasoning and especially common sense reasoning are approximate in nature. The essential characteristics of fuzzy logic as founded by Zader Lotfi are as follows.

- In fuzzy logic, exact reasoning is viewed as a limiting case of approximate reasoning.
- In fuzzy logic everything is a matter of degree.
- Any logical system can be fuzzified
- In fuzzy logic, knowledge is interpreted as a collection of elastic or, equivalently , fuzzy constraint on a collection of variables .
- Inference is viewed as a process of propagation of elastic constraints

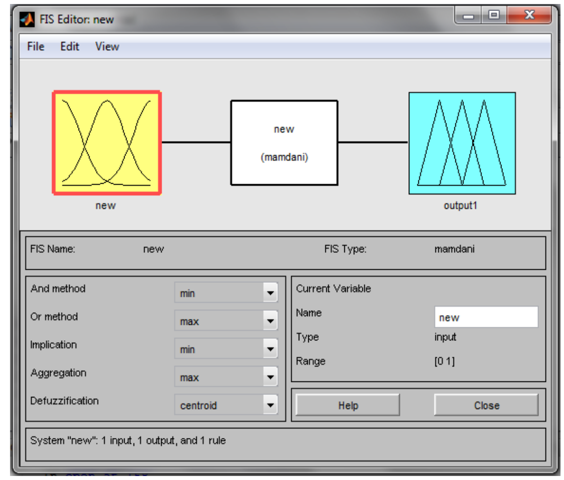
PROGRAMMING THE FUZZY LOGIC

"Fuzzy logic allows a generalization of conventional logic". It provides for terms between "true" and "false" like "almost true" or "partially false". Therefore, fuzzy logic cannot be directly processed on computers but must be emulated by special code. Fuzzy tech provides

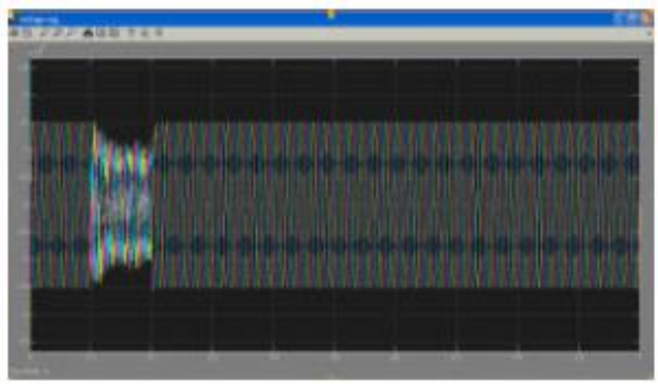


you with all the tools to design and test a fuzzy logic system**.** Once designed, fuzzy tech stores your work as an FTL format file. FTL stands for "Fuzzy Technology Language", and can be considered "the programming language of fuzzy logic". Fuzzy Tech provides an all-graphical user interface fuzzy Tech converts this FTL description to code that can be used on your target hardware that is, the hardware where your fuzzy logic solution finally shall run on.

SIMULINK MODELFUZZY INFERENCE SYSTEM BLOCK



SIMULATION WAVEFORMS OF LOAD SIDE VOLTAGE SAG



CONCLUSION

In this paper, the modeling and simulation of auto transformer controlled by with fuzzy logic controller has been developed using matlab/simulink. For the controller, the simulation result shows that the au compensates the sag quickly (50µs) and provides excellent voltage regulation. Auto transformer handles different fault condition like normal system, single line to ground fault, double line to ground fault, three phase fault, voltage sag, balanced and unbalanced fault without any difficulties and injects the appropriate voltage component to correct any fault situation occurred in the supply voltage to keep the load voltage balanced and constant at the nominal value. In this paper, the auto transformer has shown the ability to compensate for voltage sags at the grid side, this can be proved through simulation. The efficiency and the Effectiveness in voltage sags compensation showed by the auto transformer makes it an interesting power quality device compared to other custom power devices. Therefore, when it comes to implementation, it is crucial to consider these factors, so that the performance of auto transformer is optimized

REFFERENCES

[1] A.E. Hammad, Comparing the Voltage source capability of Present and future Var Compensation Techniques in Transmission System, IEEE Trans, on Power Delivery. volume 1. No.1 Jan 1995.

[2] G.Yalienkaya, M.H.J Bollen, P.A. Crossley, “Characterization of Voltage Sags in Industrial Distribution System”, IEEE transactions on industry applications, volume 34, No. 4, July/August, PP.682-688, 1999

[3] Haque, M.H., “Compensation Of Distribution Systems Voltage sags by DVR and D STATCOM”, Power Tech Proceedings, 2001 IEEE Porto, Volume 1, PP.10-13, September 2001.

[4] Anaya-Lara O, Acha E., “Modeling and Analysis Of Custom Power Systems by PSCAD/EMTDC”, IEEE Transactions on Power Delivery, Volume 17, Issue: 2002, Pages: 266 272.

[5] Bollen, M.H.J.,”Voltage sags in Three Phase Systems”, Power Engineering Review , IEEE, Volume 21, Issue :9, September 2001, PP: 11-15.

[6] M.Madrigal, E.Acha., “Modelling OF Custom Power Equipment Using Harmonics Domain Twchniques”,IEEE 2000

[7] R.Meinski, R.Pawelek and I.Wasiak, “Shunt Compensation For Power Quality Improvement Using a STATCOM controller Modelling and Simulation”, IEEE Proce, Volume 151, No.March 2004.

[8] J.Nastran , R. Cajhen, M. Seliger, and P.Jereb,”Active Power Filters for Nonlinear AC loads, IEEE Trans.on Power Electronics Volume 9, No.1, PP: 92-96, Jan 2004.

[9] C S Chang, Y.S. Ho, P.C. Lo “Voltage Quality Enhancement with Power Electronics Based Devices.

[10] Glanny M Ch Mangindaan, M Ashari Mauridhi HP “Control of Dynamic Voltage Restorer For Voltage Sag Mitigation” ICTS 2008 available from http://ieeexplore.ieee.org/ebooks/5270869/5271123.pdf