*Proceedings of **BITCON-2015** Innovations For National Development*
National Conference on : Leading Edge Technologies in Electrical and Electronics Engineering

Research Paper

VOLTAGE SAG MITIGATION USING FUZZY LOGIC CONTROLLER IN ARC FURNACE

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ABSTRACT

Power quality has always been an issue that is continuously increasing its importance in modern industrial and commercial applications. Voltage disturbances; for example the voltage sag , swell, noise etc. are the common power quality problems that appears due to increased use of a large numbers of sophisticated and sensitive electronic equipment in industrial systems. To overcome this problem, custom power devices are used. One of the most common device used to improve the quality of supply is the D-STATCOM which is the most efficient and effective modern custom power device used in power distribution networks. It is connected in parallel with the power electronic based device so that they can quickly improve the voltage sag problem in the system and restore the load voltage to the pre-fault value. The primary advantage of the D-STATCOM is keeping the users always on-line with high quality constant voltage maintaining the continuity of production. In this dissertation, a fuzzy logic controller method for D -STATCOM that protects a sensitive load, to counter voltage sag under non-linear loading condition is presented. D-STATCOM along with other parts of the distribution system are simulated using MATLAB/ SIMULINK.

1. INTRODUCTION

The quality and reliability of power in distribution systems have been increasingly attracting the interest of the user in modern times and have become an area of concern for modern industrial and commercial applications. The increasing use of sophisticated manufacturing systems, industrial drives, precision electronic equipment in modern times results in the greater demand of power quality and reliability in distribution networks than ever before. Power quality problems encompass a wide range of phenomena. Voltage sag/swell, flicker, harmonics distortion, impulse transients and interruptions are a prominent few. These disturbances are responsible for problems ranging from error in one area of plant such as shut down to another one resulting in loss manufacturing capability. Voltage sags/swells can occur more frequently than any other power quality phenomenon. These sag/ swells are the most important power quality problems in the power distribution system.

2. ARC FURNACE

2.1 Arc Furnace

The industrial application of arc furnace is melting and refining. It is used to produce steel principally by using iron. The arc furnace are used to apply bulk power by the application of high current. Arc furnace is used as load because it is that the main source of electrical power quality problems. Therefore it is necessary to develop an accurate and easy to use ac arc furnace model.

In this dissertation, the dynamic model of Arc Furnace is constructed in two steps -:

- Using Chaotic current
- Using V-I characteristic of Arc Furnace

A low frequency chaotic signal is modulated with arc voltage. The proposed model is connected to the system as controlled voltage source.

2.2 Arc Furnace Operation

The Schematic of electric arc furnace is shown below:

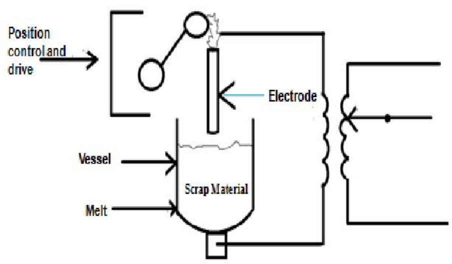


Figure 2.1. : Industrial Installation Of Arc Furnace

The operation of arc furnace consist of three different stages. These are

- The 1st is the one in which electric arc struck. This is accompanied by the lowering of supply electrode into the vessel charge.
- The 2nd stage is the melting stage in which the arc applies heat to the surface of the charge and the current path in the vessel charge supplies i^2r heating. In this stage the current may be quiet high and the current wave shape may be quiet erratic due to rapid changes in the current path.
- The 3rd is the refining stage in which the contents are heated to a very high temperature and surplus contents are either taken from bottom or from the top of the furnace or either vaporized. The heating is due to i^2r heating or due to current in the charge.

3. POWER QUALITY & CUSTOM POWER CONCEPT

POWER QUALITY

3.1(a) Introduction

Electrical utilities and end users of electric power are becoming increasingly concern about the quality of electric power. There are economic impact on utilities, their customers and suppliers of load equipment. It has been a great emphasis on revitalizing industry with more automation and more modern equipment. Electronically controlled energy efficient equipment is sensitive to deviation in the supply voltage than in electromechanical. Today, electrical utilities are no longer independently operated entities. They are a part of a large network of utilities tied together in a complex grid. The combinations of these factors have created the electrical systems requiring power quality. Thus power quality is defined as

“Any power problem manifested in voltage, current, or frequency deviations that result in failure or misoperation of customer equipment

3.2(a) Power Quality Parameters

Parameters of power quality are as follows:

- Voltage magnitude variation
- Even or Odd harmonics in the waveform for AC power
- Transient voltages and currents.
- Continuity of service.

Power systems are complex in nature these days. The major concerns for the customers are the reliability and quality of power supply at the load centres since hundreds of generating stations and load centres are interconnected. Well developed countries shows reliable power generation but not the quality of supply. Uninterrupted supply of energy must be provided to all the customers .

A power quality problem is defined as any manifested problem in voltage or current of leading to frequency deviations that result in failure or mis-operation of customer equipment. Power quality has serious implications for the consumers. In power system, especially the distribution system, has numerous non-linear loads which significantly affect the quality of power supply. These loads may distort the supply waveform. Some system events also contribute power quality problems like capacitor switching, starting of motors and faults. The consequence of power quality problems includes a large economic loss.

3.3(a) POWER QUALITY PROBLEMS:

3.3.1 (a) Voltage sag : A decrease of the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0.5 cycles to 1 minute

3.3.2(a)Very short interruptions: Total interruption of electrical supply for duration from few milliseconds to one or two seconds.

3.3.3(a)Long interruptions: Total interruption of electrical supply for duration greater than 1 to 2 seconds

3.3.4(a)Voltage spike: Very fast variation of the voltage value for durations from a several microseconds to few milliseconds. These variations may reach thousands of volts, even in low voltage

3.3.5(a)Voltage swell: Momentary increase of the voltage, at the power frequency, outside the normal tolerances, with duration of more than one cycle and typically less than a few seconds.

3.3.6(a)Harmonic distortion: Voltage or current waveforms assume non-sinusoidal shape. The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiples of power-system frequency.

3.3.7(a)Voltage fluctuation: Description: Oscillation of voltage value, amplitude modulated by a signal with frequency of 0 to 30 Hz

3.3.8(a) Noise: Superimposing of high frequency signals on the waveform of the power-system frequency.

3.3.9(a)Voltage Unbalance:

A voltage variation in a three-phase system in which the three voltage magnitudes or the phase-angle differences between them are not equal.

CUSTOM POWER

Custom Power is a concept based on the use of power electronic controllers in the distribution system to supply value-added, reliable, high quality power to its customers. For many customers, this is a preferred alternative to the customer improvising utility power by their own means, mostly in a band aid manner with numerous uninterruptible power supplies. Many utilities are moving in the direction of value-added custom Power service to their large customers.

Custom Power means that the customer receives specified power quality from a utility or a service provider or at the fence equipment installed by the customer in coordination with the utility, which includes an acceptable combination of the following features:

- No power interruptions.
- Magnitude and duration of voltage reductions within specified limits.
- Magnitude and duration of over voltages within specified limits.
- Low harmonic voltage.
- Low phase unbalance.
- Acceptance of fluctuating, nonlinear and low power factor loads without significant effect on the terminal voltage.

This can be done on the basis of an individual, large customer, industrial or a supply for a high tech community on a wide area basis.

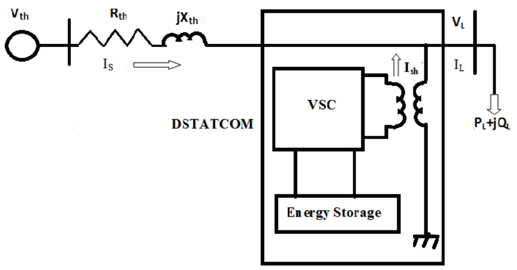
D-STATCOM

D-STATCOM is one of the most important controller for distribution networks. It regulates system voltage, improves voltage profile, reduce voltage harmonics, reduce transient voltage disturbances and load compensation. DSTATCOM uses power electronic converter to synthesise the reactive power output.A DSTATCOM converter is controlled using PWM or other voltage/current shaping techniques. It operates on low rated power thus controlling carrier frequency much higher than FACTS controller.

The DSTATCOM is the solid – state based power converter version of the SVC. Operating as a shunt – connected SVC, its capacitive or inductive output currents can be controlled independently from its connected AC bus voltage. Because of the fast-switching characteristic of power converters, the DSTATCOM provides much faster response as compare to SVC. DSTATCOM is a shunt connected, reactive compensation equipment, which is capable of generating and or absorbing reactive power whose output can be varied so as to maintain control of specific parameters of the electric power system.

DSTATCOM provides operating characteristics similar to a rotating synchronous compensator without mechanical inertia, due to the DSTATCOM employ solid state power switching devices it provides rapid controllability of the three phase voltages, both in magnitude and phase angle.

In addition, in the event of a rapid change in system voltage, the capacitor voltage does not change instantaneously; therefore the DSTATCOM reacts for the desired responses. For example, if the system voltage drops for any reason, there is a tendency for the DSTATCOM to inject the capacitive power to support the dipped voltages.



4. METHODOLOGY

4.1 Fuzzy Logic System

FL is a problem solving control system methodology that lends itself to implementation in systems ranging from simple, small, embedded micro-controllers to large, networked, multi-channel PC or work station-based data acquisition and control systems. It can be implemented in hardware, software, or a combination of both. FL provides a simple way to arrive at a definite conclusion based stage, in order to provide missing input information.

In fuzzy logic, basic control is determined by a set of linguistic rules which are determined by the system. Since numerical variables are converted into linguistic variables, mathematical modelling of the system is not required. The fuzzy logic control is being proposed for controlling the inverter action. The fuzzy logic controller has two real time inputs measured at every sample time, named error and error rate and one output named actuating signal for each phase. The input signals are fuzzified and represented in fuzzy set notations as membership functions. The defined ‘If … Then …’ rules produce output (actuating) signal and these signals are defuzzified to analog control signals for comparing with a carrier signal to control PWM inverter.

FL requires some numerical parameters in order to operate such as error and significant rate of change of error, but exact values of these numbers are usually not critical. For example, a simple temperature control system could use a single temperature feedback sensor whose data is subtracted from the command signal to compute "error" and then time differentiated to yield the error slope or rate of change of error, hereafter called "error-dot". The values produced by the controller don't have to be symmetrical and can be "tweaked" once the system is operating in order to optimize performance. Generally, FL is so forgiving that the system will probably work the first time without any tweaking

4.2 Basic Structure of FLC

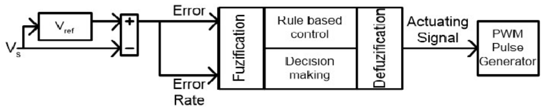


Figure4.1

MEMBERSHIP FUNCTION: DESIGNER

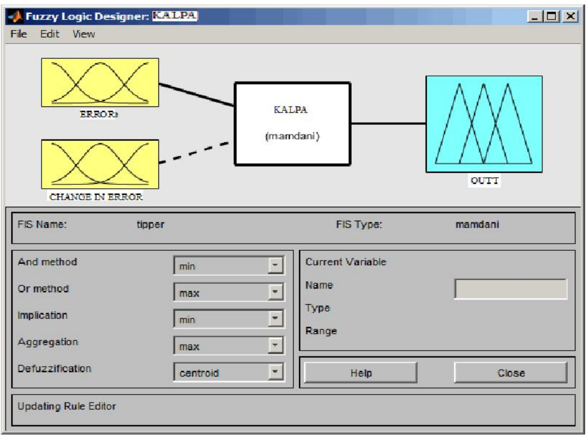


Figure 4.2 :Membership Function of MFC in MATLAB

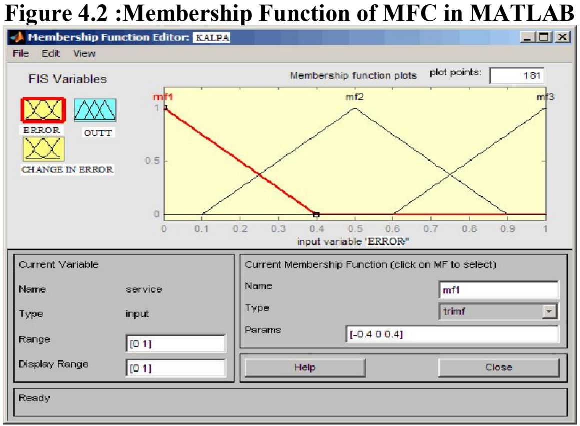


Figure 4.3:Membership Function for input 2 in MATLAB

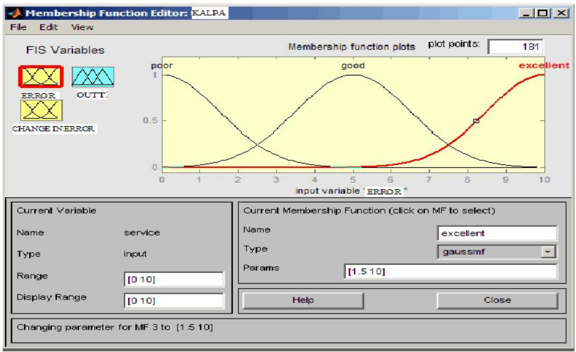
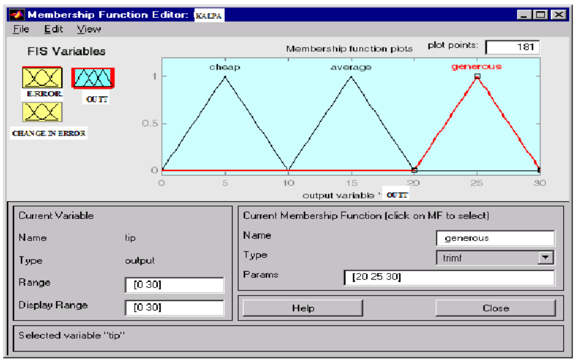


Figure 4.4 :Membership Function for output in MATLAB



A. Control System With SFC

4.4 Fuzzy Rules

A simple if-then rule is defined as follows: If error is Z and error rate is Z then output is Z

Table 4.1: Fuzzy rules

Ce/e	NB	NM	NS	Z	PS	PM	PB
NB	NB	NB	NB	NM	NM	NS	Z
NM	NB	NB	NM	NM	NS	Z	PS
NS	NB	NM	NM	NS	Z	PS	PM
Z	NM	NM	NS	Z	PS	PM	PM
PS	NM	NS	Z	PS	PM	PM	PB
PM	NS	Z	PS	PM	PM	PB	PB
PB	Z	PS	PM	PM	PB	PB	PB

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Note: This Paper/Article is scrutinised and reviewed by Scientific Committee, BITCON-2015, BIT, Durg, CG, India