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Voltage Sag Compensation by Custom Power Device in Distribution System

T. Divya Sree[1], M .Devi Shankar[2]

PG Student, Dept. of EEE, V R Siddhartha Engineering College, Vijayawada, Andhra Pradesh, India[1]

Associate Professor, Dept. of EEE, V R Siddhartha Engineering College, Vijayawada, Andhra Pradesh, India[2]

ABSTRACT: Fault at transmission or Distribution level cause transient voltage sag in entire system or large part of it. Disturbances such as voltage sag, swell, short duration interruption, transient and harmonic occurs. Fault on 11Kv system or at load point affects voltage profile of other feeders. Unsymmetrical fault effect on distribution line and voltage restoration using DSTATCOM which is a custom power device. This paper deals with two control methods such as PI controller and Fuzzy logic controller implemented for the injection of current. The proposed method is implemented by using MATLAB/SIMULINK.

KEYWORDS: DSTATCOM, Voltage sag, FIS, PI controller, MATLAB SIMULINK

I.INTRODUCTION

The term power quality describes about voltage quality; electric current quality. Power quality defined in IEEE standards as "power quality is concept of powering and grounding sensitive equipment to operate." Power quality problems like voltage sag, swell are major in present era. Voltage sag is also defined as voltage dip. Sag is decrease of rms voltage in between 0.1p.u and 0.9p.u within the duration of 0.5 cycles to 1 minute. Also defined as voltage decrease for the period of short duration ranging from 2ms to couple of minutes [1]. The voltage sag is mainly caused by the faults, starting of large motors or energization of heavy loads.

Faults in power system categorized into short circuit fault and open conductor fault. The common type of short circuit fault is further classified into symmetrical and unsymmetrical fault. Unsymmetrical fault such as LG, LL, and LLG fault occurs on the distribution system. Most frequently occurring fault is LG Fault. Whenever LG Fault occurs the voltage sag occurs in the remaining two phases. Whenever LL fault occurs the voltage sag occurs in the remaining other phase. The way to mitigate voltage dip, swell, interruption in distribution system is by using custom power devices. Custom Power Devices are STATCOM, DVR, UPQC [2].

II. D-STATCOM

The D-STATCOM (Distribution Static Compensator) consists of a Voltage Source Converter (VSC), a dc energy storage device, a coupling transformer connected in shunt to the distribution network through the coupling transformer. Suitable for the adjustment of the phase and magnitude of the D-STATCOM output voltages allows effective control of active and reactive power exchanges between the D-STATCOM and the ac system. Such configuration allows the device to absorb or generate controllable active and reactive power.

The D-STATCOM has been utilized mainly for regulation of voltage, correction of power factor and elimination of current harmonics. It provides a continuous voltage regulation. In this paper, the D-STATCOM is used to regulate the voltage at the point of connection. The control is based on sinusoidal PWM and only requires the measurement of the rms voltage at the load point [3]. The DSTATCOM has the capability of generating continuous variable inductive or capacitive shunt compensation at a level up to its maximum MVA rating [4]. The DSTATCOM has the capability of generating continuous variable inductive or capacitive shunt compensation at a level up to its maximum MVA rating [5].DSTATCOM is represented in figure 1

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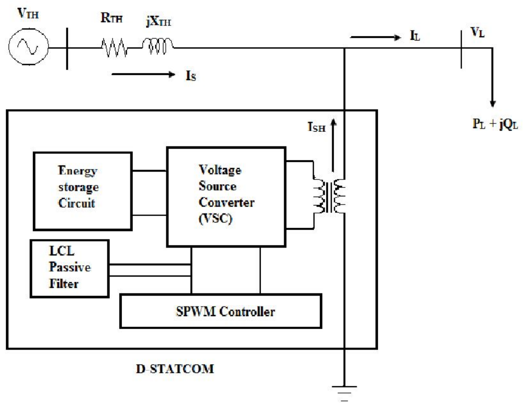

Fig 1: DSTATCOM schematic representation

III. PI CONTROLLER

Proportional-integral controller (PI Controller) is a feedback controller which is the error signal. Error signal is difference between the reference voltage and load voltage. PI controller processes the error signal to zero. [6]

IV. FUZZY LOGIC CONTROLLER

The Fuzzy Logic Controller (FLC) is used as the controller. The Fuzzy Logic tool was introduced by Lotfi Zadeh. It is a mathematical tool for dealing with uncertainty. In fuzzy logic, basic control is determined by a set of linguistic rules which are the user defined system. Fuzzy Logic Controller can be divided into main functional blocks namely knowledge base; fuzzification; Inference mechanism and defuzzification Rule Base.

A. Error Calculation:

The error is calculated as the difference between supply voltage data and the reference voltage data and the error rate is the rate of change of error.

B. Fuzzification*:*

Fuzzification is a process; where the crisp quantities are converted to fuzzy. Fuzzification process involves assigning membership values for the given crisp quantities. This unit transforms the non-fuzzy input variable measurements into the linguistic variable that is a clearly defined boundary. In this simulation study, the error and error rate are defined by linguistic variables such as NB, NM,NS,ZE,PS,PM and PB.

C. Decision Making*:*

Fuzzy process is implemented with Mamdani method. Mamdani inference method easily obtains the relationship between its inputs and output. The decision rules are represented is given in table1

TABLE I FUZZY DECISION RULES

e/Δ e	NB	NM	NS	ZE	PS	PM	PB
NB	NB	NB	NB	NB	NM	NS	ZE
NM	NB	NB	NB	NM	NS	ZE	PS
NS	NB	NB	NM	NS	ZE	PS	PM
ZE	NB	NM	NS	ZE	PS	PM	PB
PS	NM	NS	ZE	PS	PM	PB	PB
PM	NS	ZE	PS	PM	PB	PB	PB
PB	ZE	PS	PM	PB	PB	PB	PB

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D. Defuzzification*:*

It is the process of converting the controller outputs to control signals. Defuzzification means the fuzzy to crisp conversions by using Centroid method [7].

V. RESULT AND DISCUSSION

The entire system can be represented in single line diagram as in figure 2.The system is implemented with PI controller and Fuzzy controller.

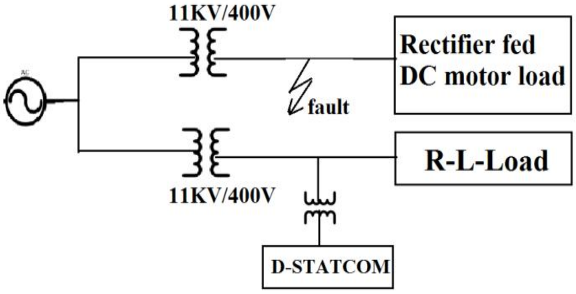

Fig 2: single line diagram

The system parameters are given as below

Source voltage	11KV
Distribution transformer rating	11KV/400V,63KVA
DC Motor rating	50H.P
RL Load	5 KVA (0.8 p.f lag)
DC Link voltage	200V
transformer ratio	1:2
Filter Inductance	6mH
Filter Capacitance	800µF
Carrier frequency	2000HZ
Armature voltage	450V
Excitation Voltage	200V

The system be implemented by using MATLAB Simulink in figure 3 and simulink model of DC motor in figure 4

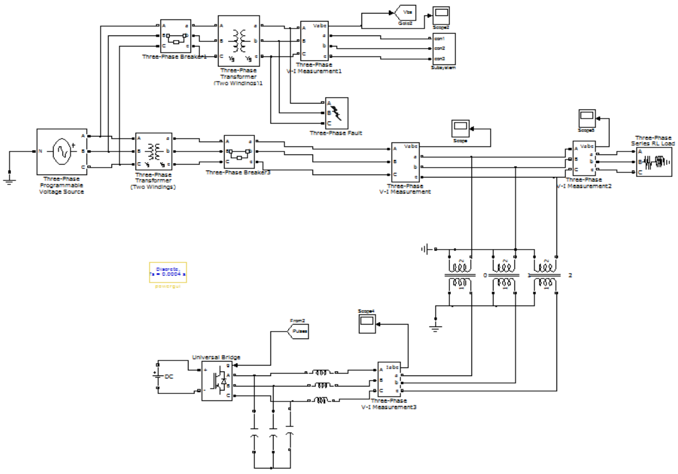

Fig 3 : simulation model for proposed method

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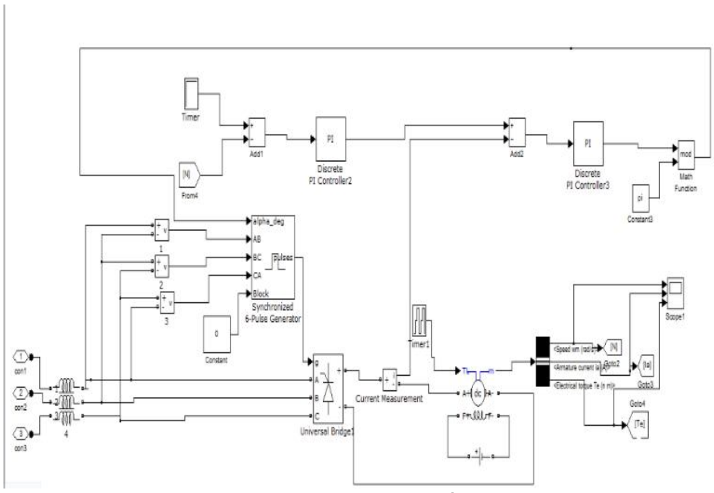

Fig 4 :simulink model of motor

PARK’S TRANSFORMATION**:**

DSTATCOM control employs a-b-c to d-q-0 transformation. During the abnormal conditions, the voltage change. After comparing d-voltage and q-voltage with the desired voltage error, d and q are generated. This error component is converted into a-b-c component using d-q-0 to a-b-c transformation.

CONTROL CIRCUIT:

The reference voltage and the load voltage is converted from three phase quantity to two phase quantity using parks transformation and from the difference error is calculated. Error rate and error is given as input to fuzzy controller to get the actuating signal. The actuating signal is converted from two phase to three phase quantity as a sinusoidal waveform. Sinusoidal waveform is compared with triangular carrier signal. When the control signal is greater than the carrier signal, three switches of the six are turned on and the counter switches are turned off with the triggering pulses.

DSTATCOM WITH PI CONTROLLER:

A.LG FAULT:

When LG fault occurs on feeder which feeds DC motor load the voltage sag occurs on the RL load. As RL load is connected to same finite source. voltage restoration is done by using DSTATCOM Current; DSTATCOM injects three phase current. Thus the voltage is restored by using DSTATCOM. DC Motor is a non-linear load.

The voltage sag occurs in voltage waveform from 0.1 to 0.2 duration represented in figure 5.the DSTATCOM current is shown in figure 6 and the restored voltage be given in figure 7.

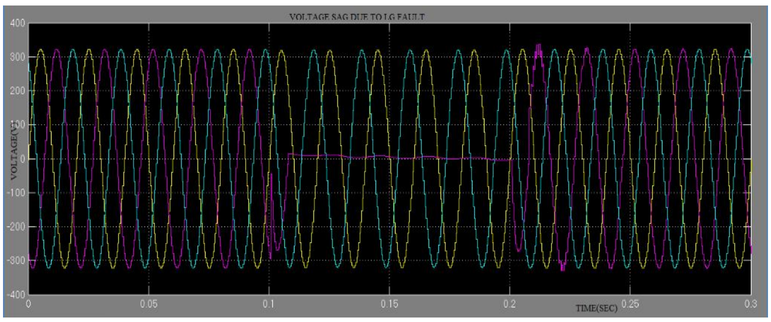

Fig 5: voltage sag due to LG fault

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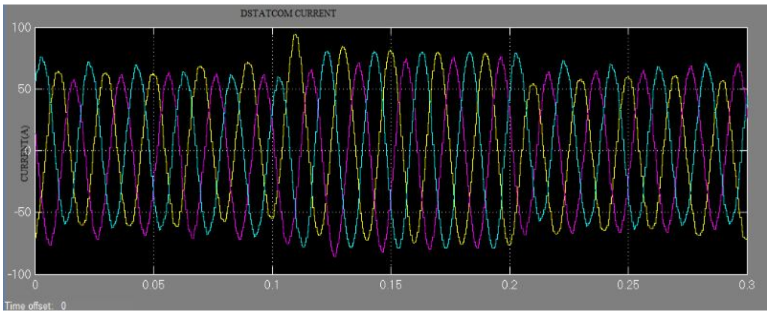

Fig: 6DSTATCOM CURRENT

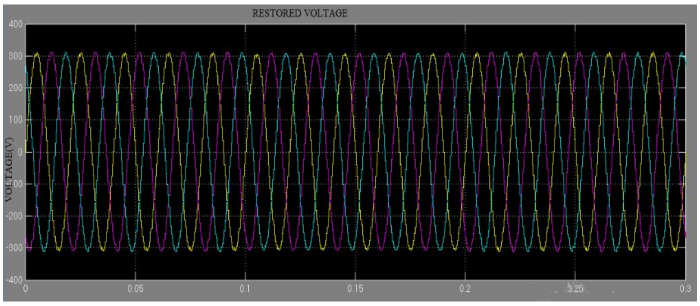

Fig 7: Restored voltage

LL FAULT:

Whenever LL fault occurs on the DC Motor load feeder the voltage on the RL load affects. As the RL load is connected to same finite source. DSTATCOM induces three phase current for the voltage restoration. DC Motor is a non-linear load.

The System is simulated with PI controller and LL fault on the DC motor load which causes sag from the duration of 0.1 to 0.2 on the RL load is represented in figure 8.the induced DSTATCOM current is in figure 9 and restored voltage in figure 10.

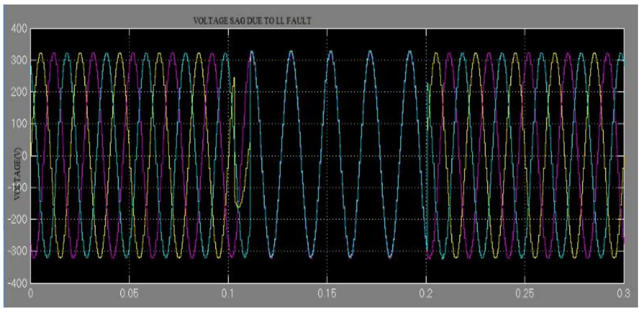

Fig 8: voltage sag

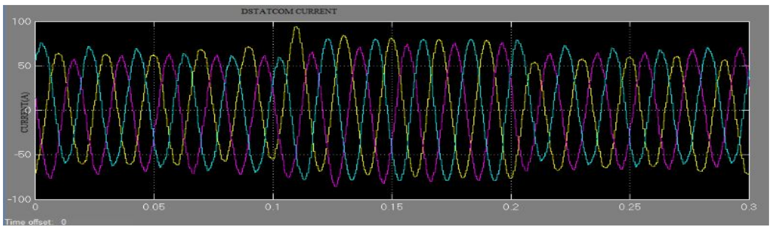

Fig 9: DSTATCOM current

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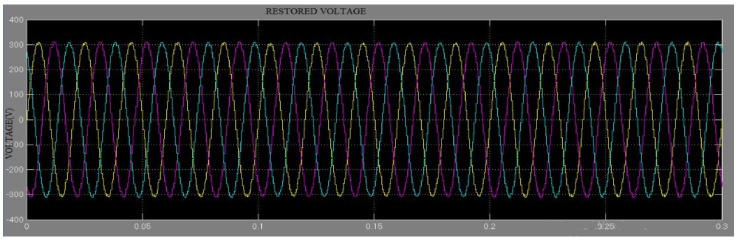

Fig 10: restored voltage

DSTATCOM WITH FUZZY CONTROLLER:

LG FAULT:

When LG fault occurs on feeder which feeds DC motor load the voltage sag occurs on the RL load. As RL load is connected to same finite source. voltage restoration is done by using DSTATCOM Current; DSTATCOM injects three phase current. Thus the voltage is restored by using DSTATCOM.

The voltage sag occurs in voltage waveform from 0.1 to 0.2 duration represented in figure 11.the DSTATCOM current is shown in figure 12 and the restored voltage be given in figure 13. input membership for error is given in figure 14 and error rate in figure 15

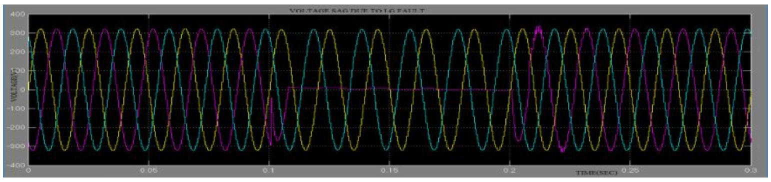

Fig 11: voltage sag due to LG fault

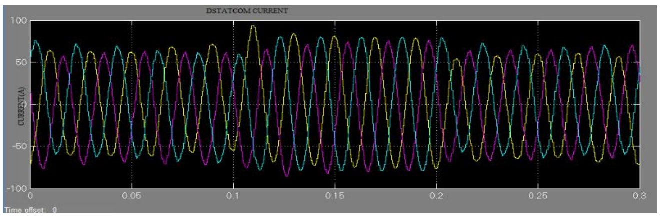

Fig: 12:DSTATCOM CURRENT

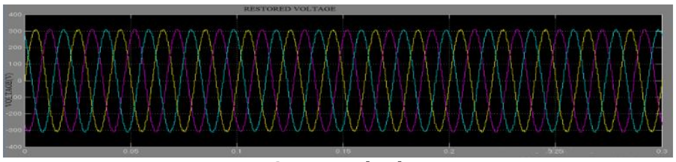

Fig 13: Restored voltage

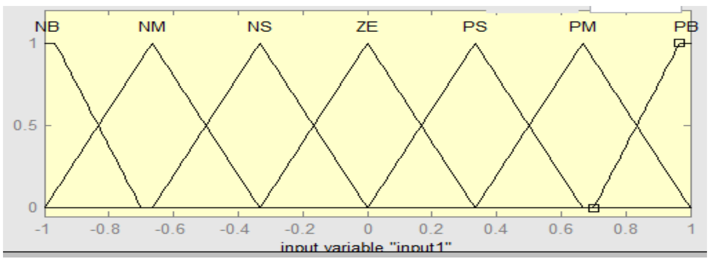

Fig 14:input membership function for error

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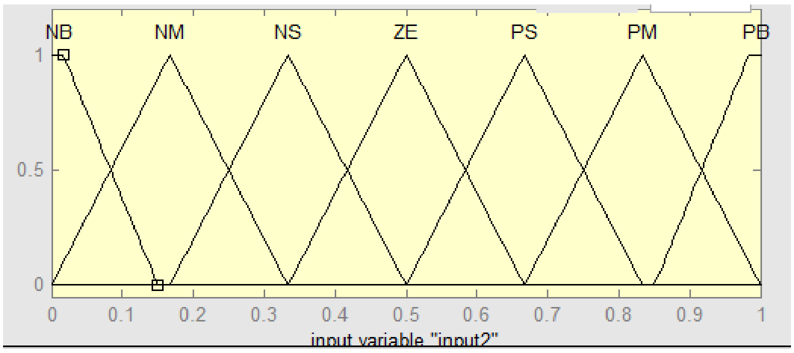

Fig 15:input membership function for error rate

LL FAULT:

Whenever LL fault occurs on the DC Motor load feeder the voltage on the RL load affects. As the RL load is connected to same finite source. DSTATCOM induces three phase current for the voltage restoration.

The System is simulated with fuzzy logic controller and LL fault on the DC motor load which causes sag from the duration of 0.1 to 0.2 on the RL load is represented in figure 16.the induced DSTATCOM current is in figure 17 and restored voltage in figure 18.

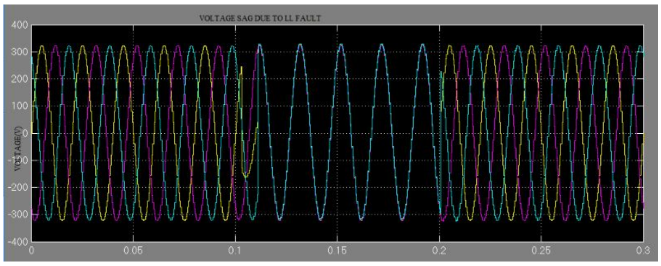
Fig 16: voltage sag

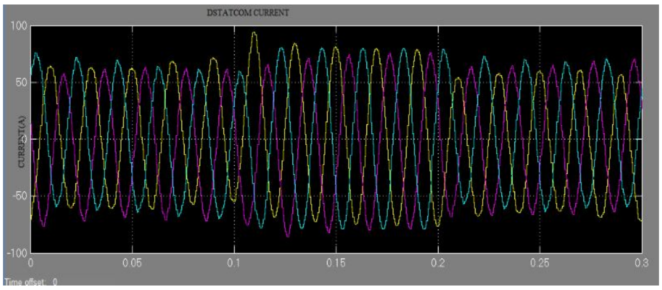
Fig 17: DSTATCOM current

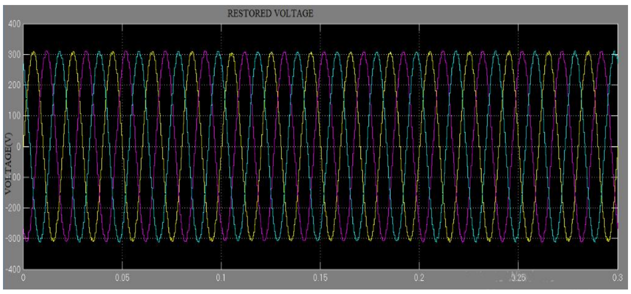
Fig 18: restored voltage

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VI. CONCLUSION

DSTATCOM using two control methods namely Fuzzy Inference System and PI controller applied for the voltage sag compensation. D-STATCOM corrects all the voltage magnitudes, phase deviations and harmonics at the desired load point with FUZZY LOGIC CONTROLLER and PI controller. The simulation results clearly indicates that D-STATCOM provide excellent voltage compensation capability. Therefore the fuzzy logic controller provides much better result, faster and smoother response than the conventional PI controller.

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BIOGRAPHY

T.Divya Sree, PG Student in V.R.Siddhartha Engineering College. Areas of interest are Power System, Power Electronics.

M. Devi Shankar working as Associate Professor. He has 14 years of teaching experience. He has published many papers in national and international conferences and journals.