iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 7 **Issue:** IV **Month of publication:** April 2019

DOI: https://doi.org/10.22214/ijraset.2019.4029

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

FLC based DVR to Mitigate Power Quality Problems

T John Prasanna Kumar[1], T Padmavathi[2]
[1, 2]*EEE Department, GITAM Institute of Technology, GITAM (deemed to be University), Visakhapatnam*

Abstract: Power quality is one of major concerns in the present era. It has become important, especially, with the introduction of sophisticated devices, whose performance is very sensitive to the quality of power supply. Power quality problem is an occurrence manifested as a nonstandard voltage, current or frequency that results in a failure of end use equipment. Dynamic Voltage Restorer (DVR) is a solution to improve voltage quality, which is the most efficient and effective modern custom power device used in power distribution networks. Its appeal includes lower cost, smaller size, and its fast dynamic response to the disturbance. This paper presents modeling, analysis, and simulation of DVR in MATLAB/SIMULINK, which includes PI controller and Fuzzy Controller. The results exhibit clearly the performance of the DVR using Fuzzy Logic Controller mitigates the power quality issues.

Keywords: DVR, Power Quality, Voltage Sag, Voltage swell, PI Controller, Fuzzy logic Controller.

I. INTRODUCTION

Nowadays, modern industrial devices are mostly based on electronic devices such as programmable logic controllers and electronic drives. The electronic devices are very sensitive to disturbances and become less tolerant to power quality problems such as voltage sags, swells and harmonics. Voltage dips are considered to be one of the most severe disturbances to the industrial equipment. Voltage support at a load can be achieved by reactive power injection at the load point of common coupling. The common method for this is to install mechanically switched shunt capacitors in the primary terminal of the distribution transformer. The mechanical switching may be on a schedule, via signals from a supervisory control and data acquisition (SCADA) system, with some timing schedule, or with no switching at all. The disadvantage is that, high speed transients cannot be compensated. Some sag is not corrected within the limited time frame of mechanical switching devices. Transformer taps may be used, but tap changing under load is costly. The family of custom power controllers originally included three basic devices: the Solid-state Breaker (SSB), the Static Compensator (DSTATCOM) and the Dynamic Voltage Restorer (DVR). DVRs are a class of custom power devices for providing reliable distribution power quality. They employ a series of voltage boost technology using solid state switches for compensating voltage sags/swells. The DVR applications are mainly for sensitive loads that may be drastically affected by fluctuations in system voltage. Reliability is expanded to include power quality goals: no power interruptions, tight voltage regulation, low harmonic distortion, and low phase unbalance. But the DVR has plenty of applications in distribution systems aimed to improve the quality and reliability of the power supplied to the end-user. It can be used to prevent non-linear loads from polluting the rest of the distribution system. The rapid response of the DVR makes it possible to provide continuous and dynamic control of the power supply including voltage and reactive power compensation, harmonic mitigation and elimination of voltage sags and swells.

II. DYNAMIC VOLTAGE RESTORER

Custom Power is a concept based on the application of power electronic controllers in distribution systems to supply reliable power. Reliability is expanded to include power quality goals: no power interruptions, tight voltage regulation, low harmonic distortion, and low phase unbalance. The family of custom power controllers originally included three basic devices: the Solid-state Breaker (SSB), the Static Compensator (DSTATCOM) and the Dynamic Voltage Restorer (DVR).But the DVR has plenty of applications in distribution systems aimed to improve the quality and reliability of the power supplied to the end-user. It can be used to prevent non-linear loads from polluting the rest of the distribution system. The rapid response of the DVR makes it possible to provide continuous and dynamic control of the power supply including voltage and reactive power compensation, harmonic mitigation and elimination of voltage sags and swells.

©IJRASET: All Rights are Reserved

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

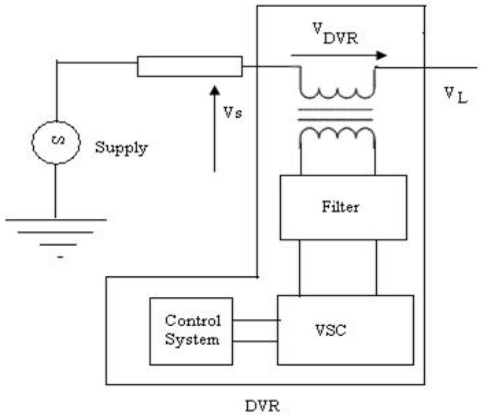


Fig. 1 Schematic Diagram of DVR

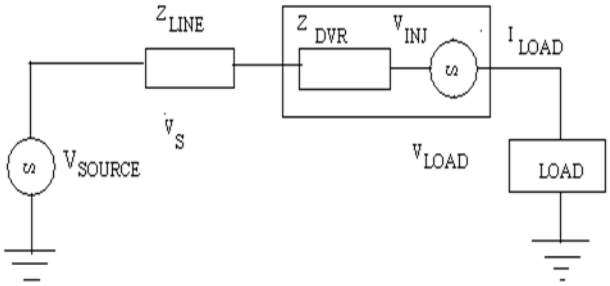


Fig. 2 Equivalent Diagram of DVR

A. The components of DVR

1) Injection Transformer: The Injection/Booster transformer is a specially designed transformer that attempts to limit the coupling of noise and transient energy from the primary side to the secondary side. Its main tasks are: connects the DVR to the distribution network via the HV-windings and transforms and couples the injected compensating voltages generated by the voltage source converters to the incoming supply voltage. In addition, the Injection/ Booster transformer serves the purpose of isolating the load from the system. It is one unit three phase construction.

2) Harmonic Filter: The main task of harmonic filter is to keep the harmonic voltage content generated by the voltage source converters to the permissible level. It has a small rating approximately 2% of the load MVA connected to delta-connected tertiary winding of the injection transformer.

3) Voltage Source Converter: A VSC is a power electronic system consists of a storage device and switching devices, which can generate a sinusoidal voltage at any required frequency, magnitude, and phase angle. In the DVR application, the VSC is used to temporarily replace the supply voltage or to generate the part of the supply voltage which is missing.

4) Storage Devices: The purpose is to supply the necessary energy to the VSC via a dc link for the generation of injected voltages. The different kinds of energy storage devices are superconductive magnetic energy storage (SMES), batteries, and capacitance.

5) Capacitor: DVR consists of a capacitor having large rating. In addition, it is used for stiff DC voltage for the input of an inverter.

B. DVR Working

1) Protection Mode: If the over current on the load side exceeds a permissible limit due to short circuit on the load or large inrush current, the DVR will be isolated from the systems by using the bypass switches and supplying another path for current.

2) Standby Mode (Voltage Injected by DVR is Zero): In the standby mode the booster transformer's low voltage winding is shorted through the converter. No switching of semiconductors occurs in this mode of operation and the full load current will pass through the primary.

3) Injection/Boost Mode: In the Injection/Boost mode the DVR is injecting a compensating voltage through the booster transformer due to the detection of a disturbance in the supply voltage.

©IJRASET: All Rights are Reserved

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 6.887
Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

III. MODELLING OF DVR

A. PI Controller

It is an error signal obtained from the reference voltage and the RMS value of the terminal voltage measured. PI Controller is a feedback controller which ensures the plant to be controlled with a weighted sum of the error and the integral of that value. The proportional response will be adjusted by multiplying the error by constant KP, called proportional gain. The contribution from integral term is proportional to both the magnitude of error and duration of error. First error will be multiplied by the integral Gain, Ki and integrated to give an accumulated offset that have been corrected previously.

B. Fuzzy Logic Controller

Fuzzy logic (FL) controller is the heart of fuzzy set theory. The major features are the use of linguistic variables rather than numerical variables. This control technique relies on human capability to understand the systems behavior and is based on quality control rules. Fuzzy Logic provides a easy way in providing definite conclusion based upon vague, noisy, imprecise, ambiguous or missing given information.

1) The Fuzzyfication interface converts the given input to linguistic definitions.
2) The Knowledge Base consisting of a data base and a rule base.
3) A Decision Making unit, simulating a human decision process, and interface the fuzzy control action from the knowledge of the control rules and the linguistic variable definitions.
4) Defuzzification interface yields a non-fuzzy control action from an inferred fuzzy control action.

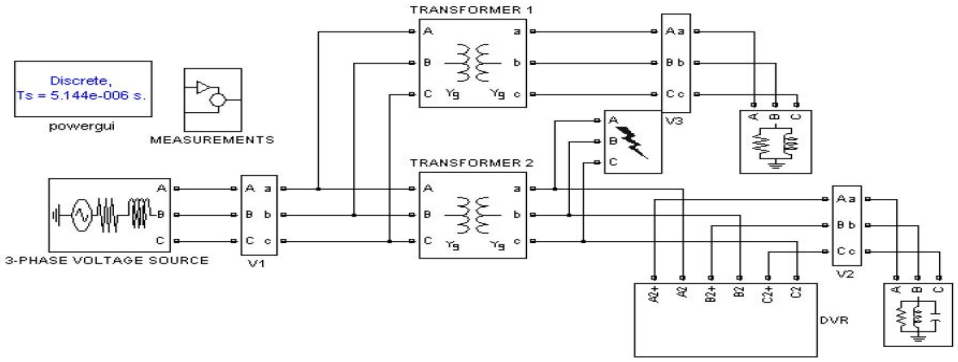


Fig. 3 Simulation Diagram of distribution system considered with DVR

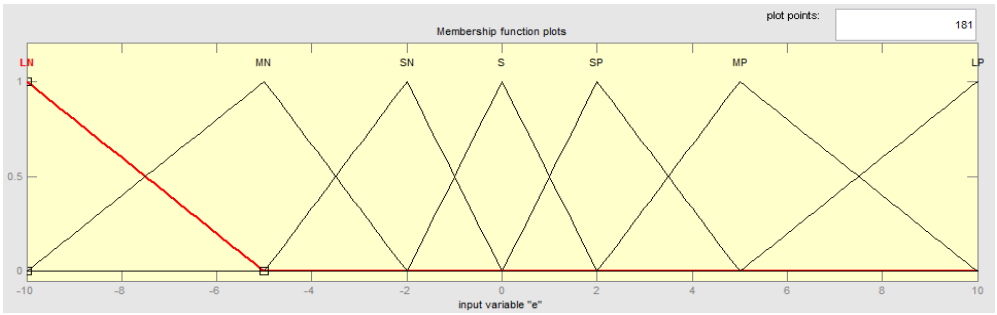


Fig. 4 Membership Function for Input Variable Error

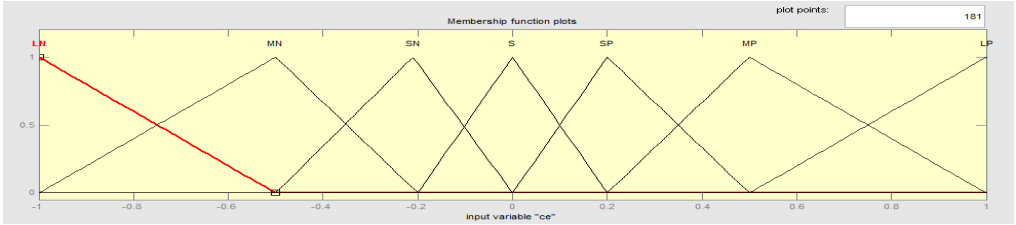


Fig .5 Membership Function for Input Variable Change in Error

©IJRASET: All Rights are Reserved

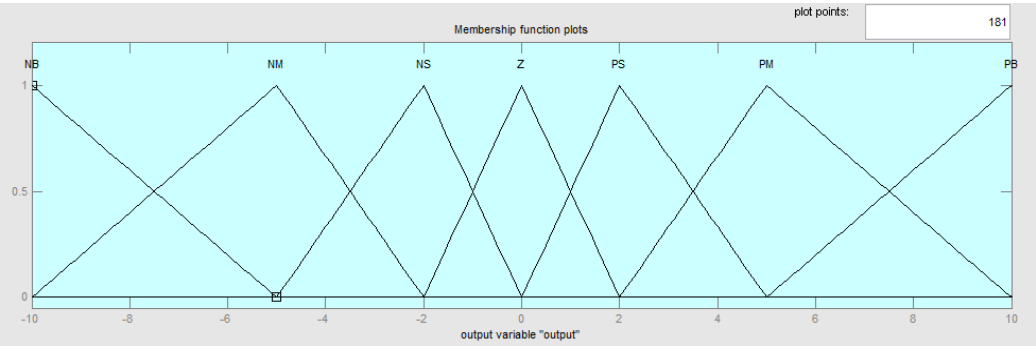


Fig. 6 Membership Function for output Variable

ER / E	LP	MP	SP	S	SN	MN	LN
LP	PB	PB	PB	PM	PM	PS	Z
MP	PB	PB	PM	PM	PS	Z	NS
SP	PB	PM	PM	PS	Z	NS	NM
S	PM	PM	PS	Z	NS	NM	NM
SN	PM	PS	Z	NS	NM	NM	NB
MN	PS	Z	NS	NM	NM	NB	NB
LN	Z	NS	NM	NM	NB	NB	NB

Fig. 7 The set of fuzzy control rules

IV. RESULTS AND DISCUSSIONS

Single line diagram of the system considered without and with DVR is shown respectively comprised by a 13KV, 50HZ source supplies to bus where a load is connected.

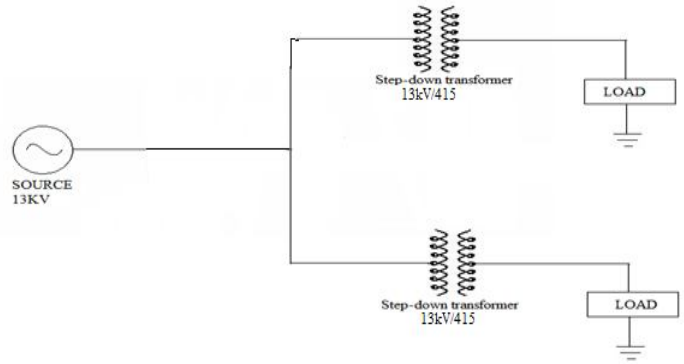


Fig. 8 Basic configuration of system without DVR

A. Parameters for System Considered Without DVR

Source Voltage	13KV
Line resistance and inductance of feeder 1	0.0002 Ω, 0.001 H
Line resistance and inductance of feeder 2	0.0002 Ω, 0.001 H
Step-down transformer on feeder 1	13KV/415V
Step-down transformer on feeder 2	13KV/415V
Load	R=0.1 Ω and L=0.1926H

©IJRASET: All Rights are Reserved

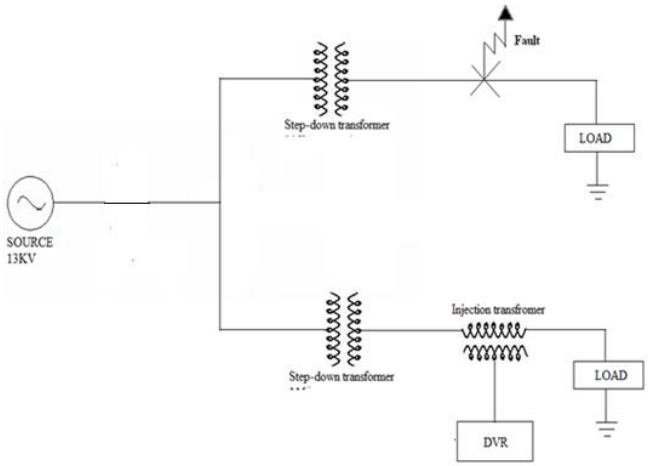


Fig. 9 Basic system configuration with DVR

B. Parameters for System Considered With DVR

DC voltage	200V
Capacitance	750µs
Inverter Specifications	IGBT based 3 Arms, 6 pulse, Carrier frequency=10kHz, Sample time = 5µs
Injection transformer	100/1000V

1) Case 1: Voltage sag

To analyze the working of DVR for voltage sag compensation a fault is applied to the system for time duration of 200ms.The DVR is simulated to be in operation only for the duration of fault.

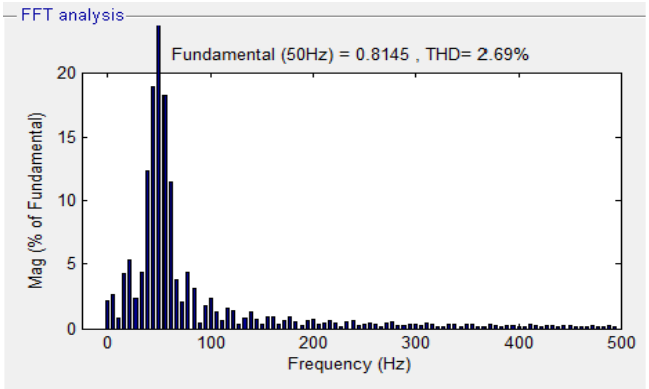


Fig. 10 FFT analysis for Source Voltage without DVR

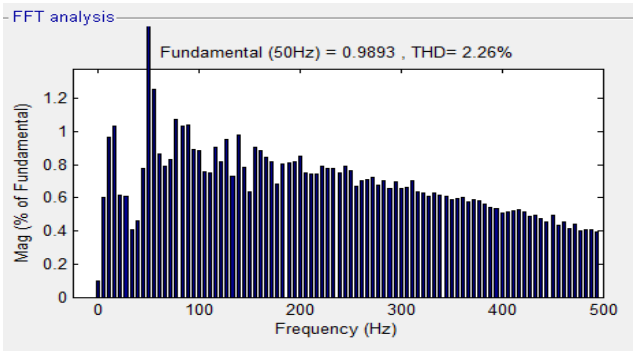


Fig. 11 FFT analysis for Load Voltage with DVR using PI controller

©IJRASET: All Rights are Reserved

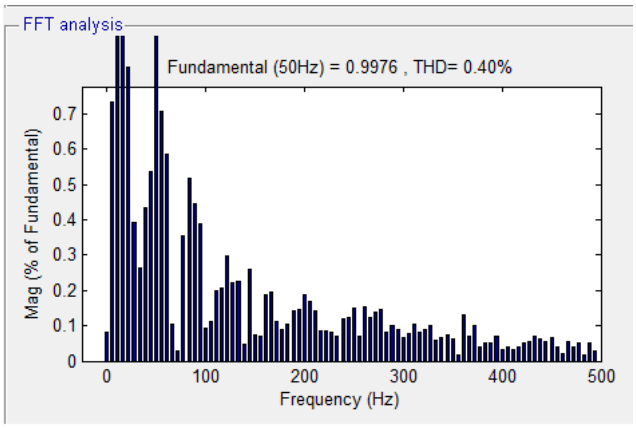


Fig. 12 FFT analysis for Load Voltage with DVR using Fuzzy Logic Controller

So, from the above comparison it is clear that by using Fuzzy Logic Controllers we can achieve the more efficient Total Harmonic distortion (THD).

2) Case 2: Voltage swell

To analyze the working of DVR for voltage swell compensation a fault is applied to the system for time duration of 200ms.The DVR is simulated to be in operation only for the duration of fault.

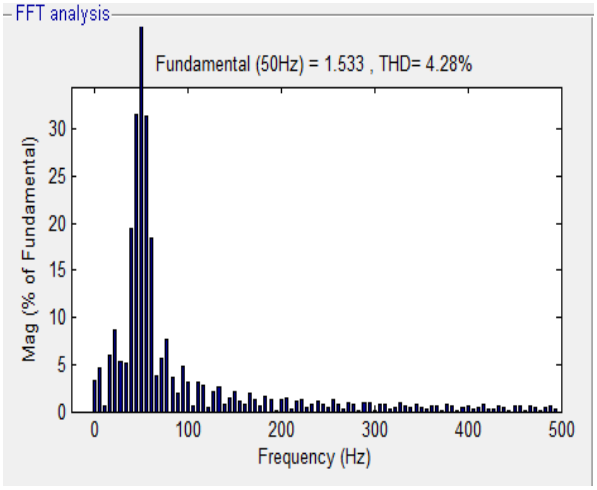


Fig. 13 FFT analysis for Source voltage without DVR

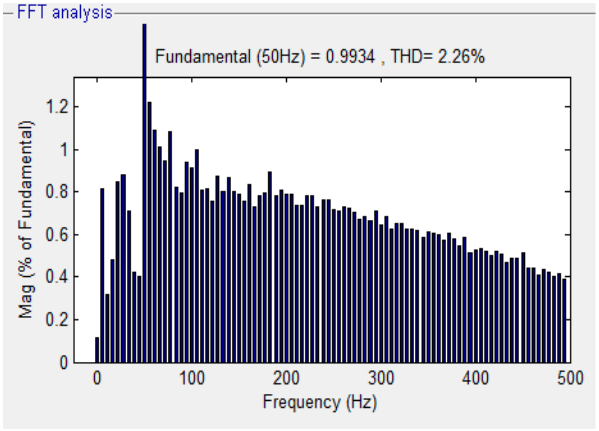


Fig. 14 FFT analysis for Load Voltage with DVR using PI controller

©IJRASET: All Rights are Reserved

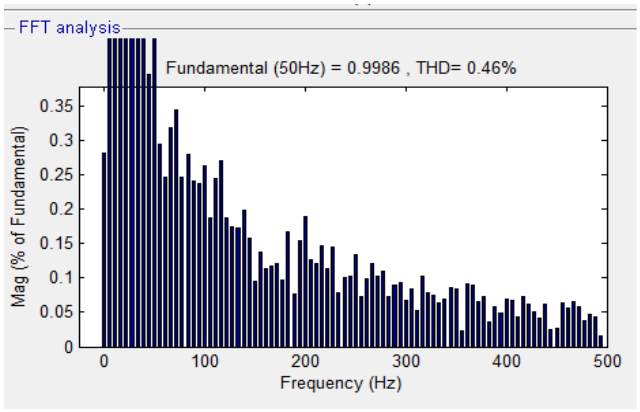


Fig. 15 FFT analysis for Load voltage with DVR using Fuzzy Logic Controller

So, from this case we conclude that the Total harmonic distortion using the Fuzzy Logic controller is more efficient than the PI Controller.

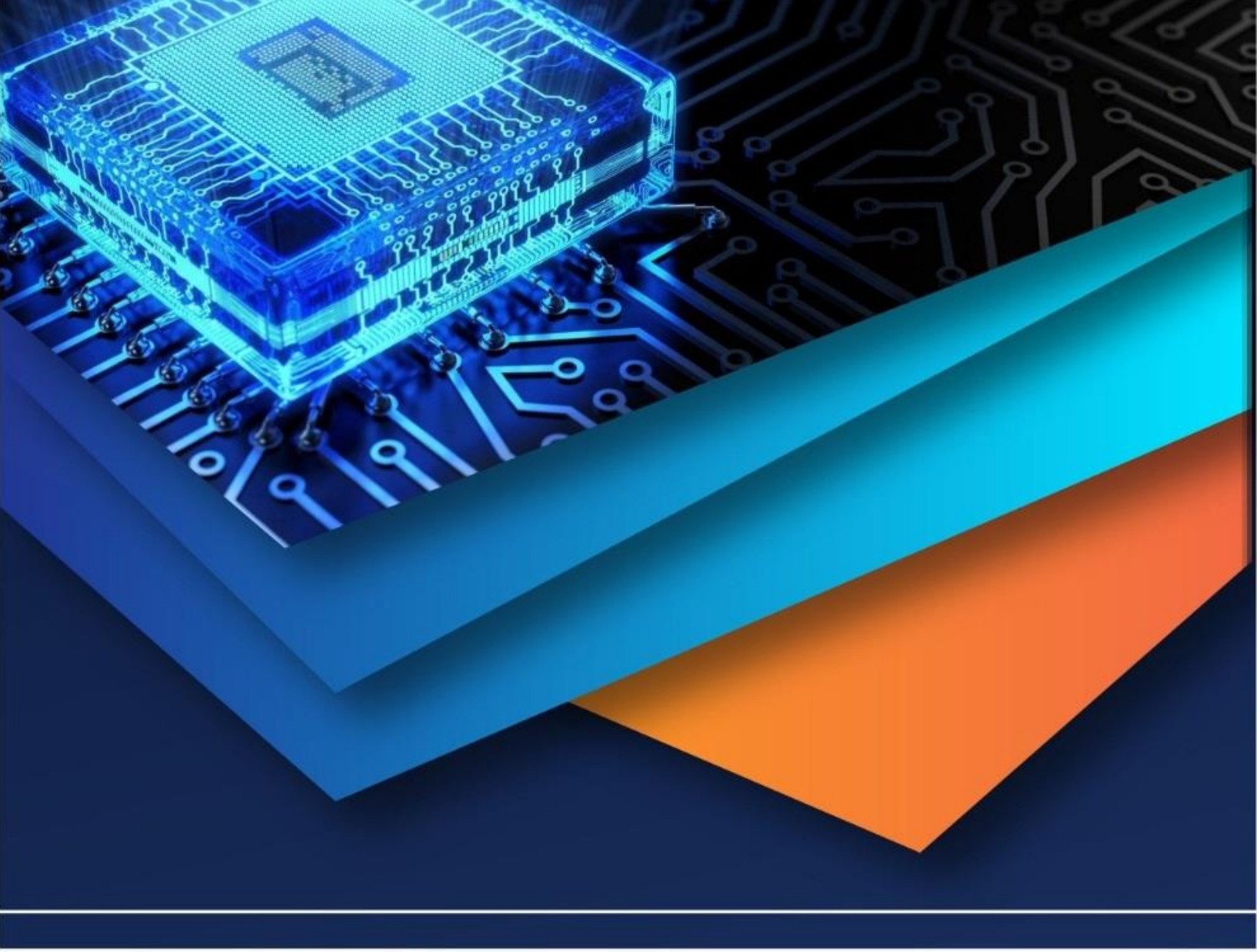
V. CONCLUSIONS

The most effective custom power device for mitigating the power quality problems in the electrical distribution system is DVR. The above results show that dvr mitigates the sag very fast and provide the excellent regulation of voltage. The balanced and unbalanced faults are handled by the dvr without any difficulties and inject the voltage to correct the fault situation. The dvr keeps the load voltage balanced and maintains the constant nominal value. The above simulation based FFT results clearly shows that fuzzy logic controller exhibited a better performance in improving the load voltage to the normal condition.

REFERENCES

[1] S. H. Hingorani “Introducing custom power” IEEE spectrum, vol.32 no.6 June 1995 p 41- 48
[2] Benachaiba Chellali, FERDI Brahim, “Voltage Quality Improvement
[3] Using DVR,” Electrical Power Quality and Utilizations, Journal Vol. XIV, No. 1, 2008
[4] M. Bollen. “Understanding Power Quality Problems, voltage sags and Interruptions.” IEEE press, 1999
[5] Ming Fang, Mister I. Gardiner, Andrew MacDougall, Granta A. Matheson, A novel series dynamic voltage restorer for distribution system, IEEE 1998
[6] C. Fitzer, M. Barnes and P. Green, “Voltage Sag Detection Technique for a Dynamic Voltage Restorer”, IEEE Trans. Industry Applications, Vol. 40(1), Jan.2004, pp. 203 – 212
[7] Power Quality Enhancement Using Custom Power Devices by A. Ghosh and G. Ledwich. 2002. Kluwer Academic Publishers
S. Choi, J. Li and M. Vilathgamuwa, “A Generalized Voltage Compensation Strategy for Mitigating the Impacts of Voltage Sags/Swells”, IEEE Trans. Power Delivery, Vol. 20(3)
[8] Mattavelli, P. Rossetto, L. Spiazzi, G. Tenti, P. “General- Purpose Fuzzy Controller for DC-DC Converter” IEEE Transactions on Power Electronics, Vol. 12, No. 1, January 1997.

©IJRASET: All Rights are Reserved



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)