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Design of Dynamic Voltage Restorer for three phase network as steady state device in the Distribution System

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Abstract
This paper proposes a dynamic voltage restorer for three phase network as steady state device. In this work, a compensator has been explored for dynamic voltage restorer to correct the quality power. Using the proposed design, the voltage compensation has been verified for non-linear load. The simulation has been done using MATLAB/Simulink. The proposed method provides better results for steady state analysis in response to the balanced applied input voltage. Hence, dynamic voltage restorer has been studied, designed and analyzed to improve the power quality at ac power supply.

Keywords: *Dynamic voltage restorer, proportional-differential controller, RLC load, steady state response, three phase network.*

Introduction

Power quality is the one of the most important and sensitive issue to determines the failure or success of operation in an equipment [1]. This is the only parameter that states the condition of electrical tolerance of a load. Any change in supply power in terms of voltage, current or frequency causes power disturbances or poor power variation [2-4]. During power variations, the load either undergoes voltage sag or produces a spike voltage during its operation. If the supply quality gets decreased, sensitive equipment might trip, and any load connected on the system may get come to a standstill [5]. Voltages drop are one of the most harmful power quality disturbances for sensitive end user. Equipment used in modern industrial plants becoming more sensitive to voltage sags as the complexity of the equipment increases [6]. Enormous resources are lost every year due to industrial equipment malfunction as consequences of voltage sags. Under voltage is generally a chronic problem aggravated by a number of factors beyond the end user's control [7]. This gives rise to the development of different compensating devices like, Dynamic Voltage restorer (DVR), Unified Power Quality Conditioner (UPQC), Battery energy Storage System (BESS) and many more controllers [8]. To maintain the supply voltage to the operational load within prescribed limits, the dynamic voltage restorer injects the differential voltage [9] [10]. The Dynamic Voltage Restorer (DVR) operates in standby mode in normal conditions whereas in case of disturbances variation in the output voltage occurs [11] [12]. Inspite of voltage sags and swells compensation, DVR can also be implemented for other features like: line voltage harmonics compensation, reduction of transients in voltage and fault current limitations [12]. DVR consists of rectifier, energy storage device, PWM inverter, filter, and injection transformer [13]. The block diagram of DVR is shown in Fig. 1.

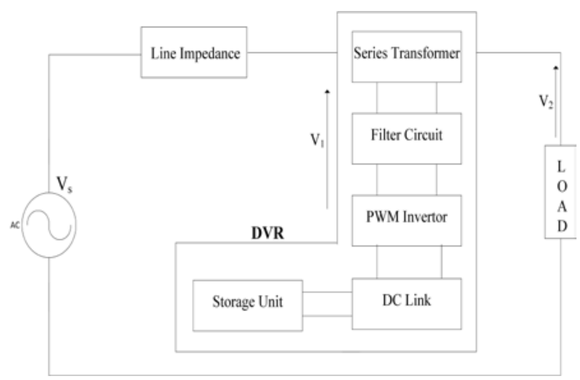

Fig 1 Block diagram of DVR

Voltage injection or compensation methods by means of a DVR depend upon the limiting factors such as; DVR power ratings, various conditions of load, and different types of voltage sags. Some loads are sensitive towards phase angel jump and some are sensitive towards change in magnitude and others are tolerant to these [13]. Therefore the control strategies depend upon the type of load characteristics.

In this paper, dynamic voltage restorer has been studied to stabilize the output voltage and current across non linear load. The paper is organized as follows. Section II presents the methodology for the propose design while the results are discussed in Section III. The conclusion is presented in Section IV.

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Methodology

The DVR is modeled and simulated using the MATLAB and its Simulink. The block diagram of the proposed DVR connected system is shown in Fig. 2. An AC voltage source has been act as input to the circuit. RC snubber circuit has been installed with the ac source.

Thereafter, MOSFET and internal diode in parallel with a series RC snubber circuit is applied. When a gate signal is applied, the MOSFET conducts and acts as a resistance (R_{on}) in both directions. If the gate signal falls to zero when current is negative, current
is transferred to the anti parallel diode.

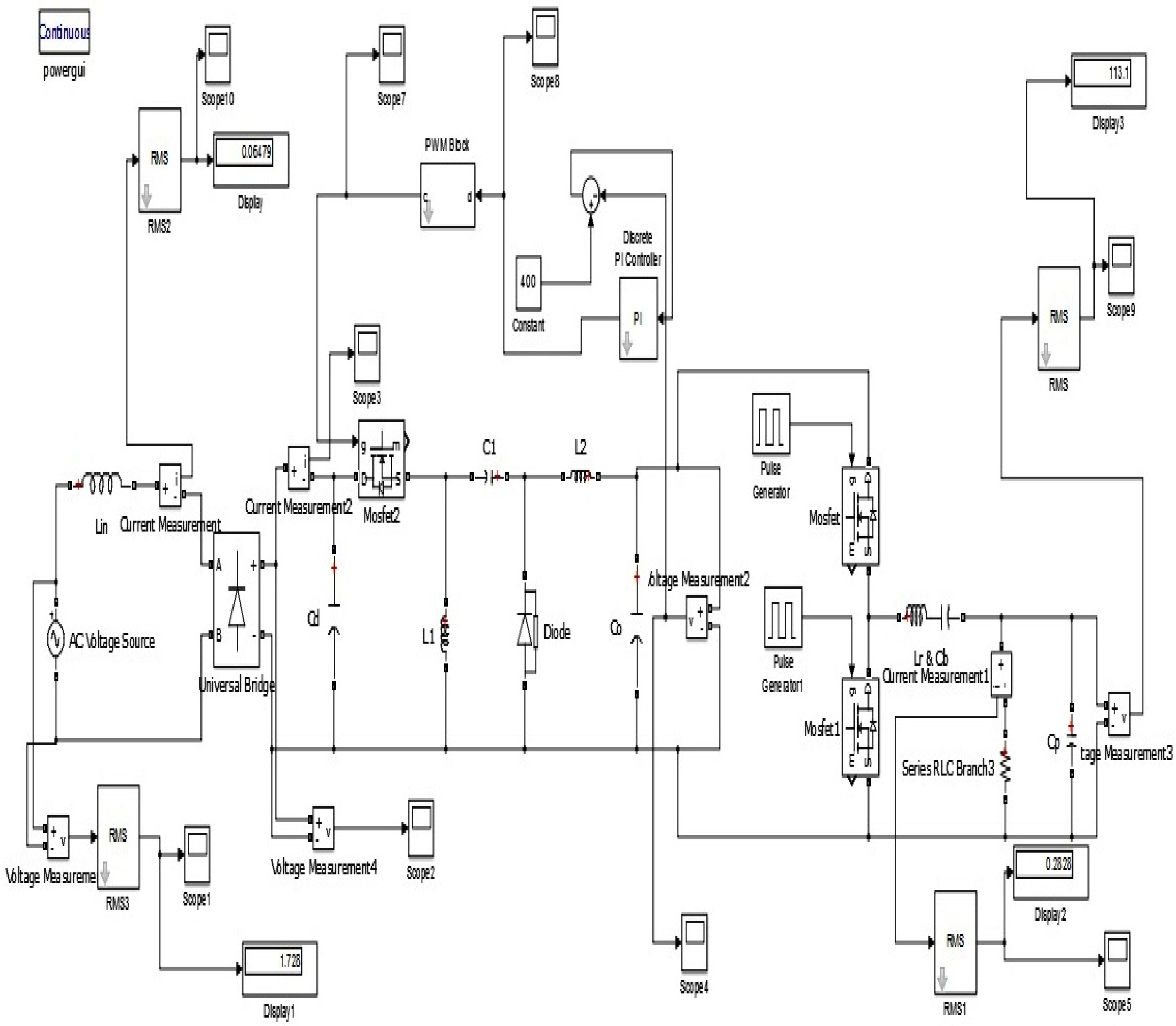

Fig 2 Block diagram of the proposed DVR connected system

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A diode in parallel with a series RC snubber circuit has also been implemented. In on-state, the diode model has an internal resistance (R_{on}) and inductance (L_{on}). For most applications the internal inductance should be set to zero. The Diode impedance is infinite in off-state mode. A pulse width modulation (PWM) along with discrete partial-integrator (PI) controller is used over the reference and sensed load voltages to generate gate signals for the MOSFET of the power circuit. 80 KHz switching frequency has been used in PWM controller.

Results and Discussions

A three phase ac source of 100 MVA, 270 V, 50 Hz is applied to a non-linear load of the diodes having (R=40Ω, L=1mH and C=1μF) is considered. The simulation has been performed for a balanced source supplying to non linear load. The line voltage is shown in Fig. 3.

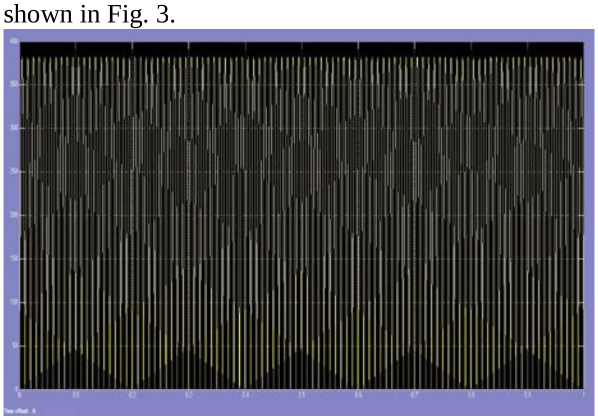

Fig 3 Line Voltage

Fig. 4 shows the terminal voltage across MOSFET fed RLC snubber circuit. Similarly, figure 5 shows the line current diagram obtained after simulation from the output of universal bridge.

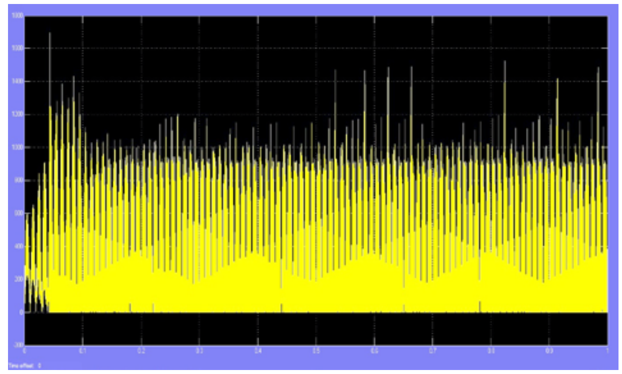

Fig 4 Terminal Voltage across MOSFET

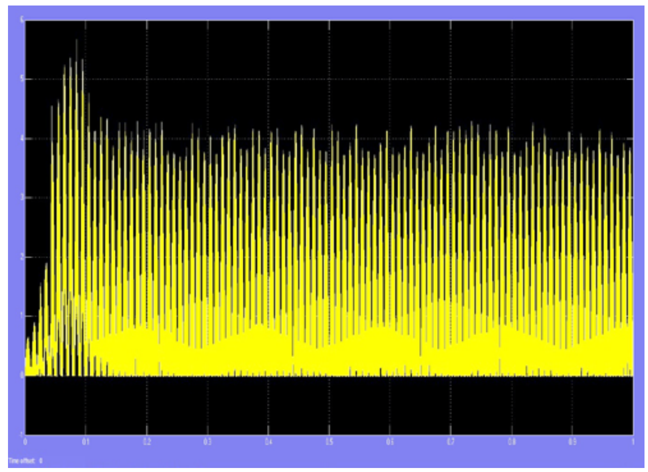

Fig 5 Line Current diagram

Fig. 6 shows the voltage after voltage compensation using pwm based partial integral controller circuitry. The controller gives better results on load side which is shown in Fig. 6. From Fig. 6, one can understand that the controller does not produce output properly due to sampling period under considered for calculating the power.

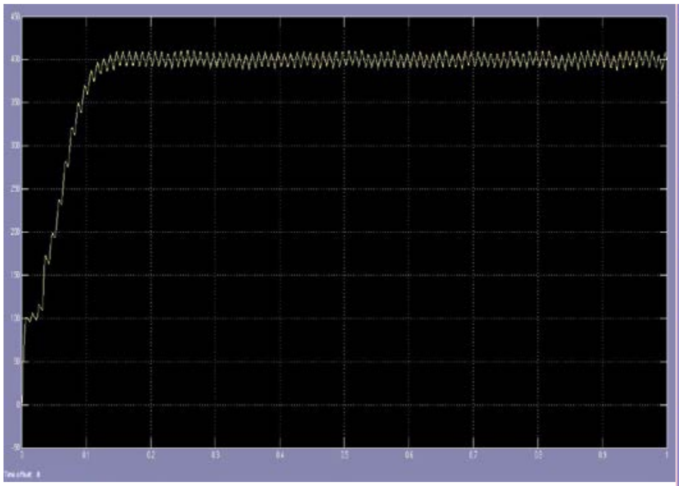

Fig 6 Voltage after voltage compensation using pwm based partial integral controller circuitry.

Fig. 7 represents the line current measured after compensation across RLC circuit using power control analysis.

Similarly, Fig. 8 represents the output voltage measured after compensation across RLC circuit using power control analysis.

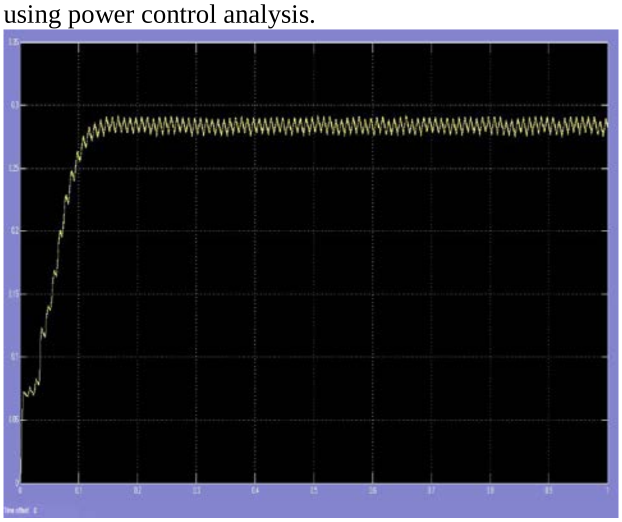

Fig 7 Line current measured after compensation across RLC circuit using power control analysis.

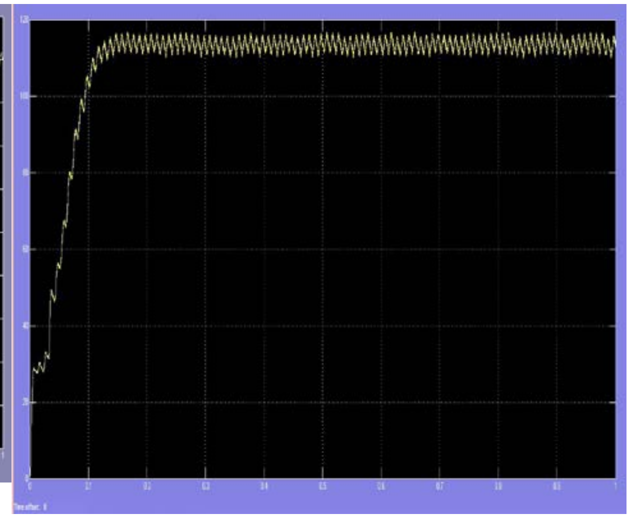

Fig. 8 Output voltage measured after compensation across RLC circuit using power control analysis.

The results showed that the PWM controller is providing proper results measured across RLC load.

Conclusions

In this paper, we analyzed a model for DVR using a PWM based PI controller system. The controller used has the capability to produce fast reference compensation voltage signal that has been presented and analyzed across RLC load. The results showed that the output voltage and current perform better and showed steady state values. The simulation results shows excellent performance under three phase balanced source applied to non-linear load. The proposed controller is efficient to compensate the input voltage at the load terminals.

References

[1] Gosh, A. and G. Ledwich, "Compensation of distribution system voltage using DVR". IEEE Trans. Power Deliv., 17, no 46880, 2002

[2] Carl N.M.Ho, Henery and S.H. Chaung, "Fast Dynamic Control Scheme for Capacitor-Supported Dynamic Voltage Restorer: Design Issues, Implementation and Analysis. IEEE, 2007.

[3] Fitzer C, Barnes M, Green P, "Voltage Sag Detection Technique for a Dynamic Voltage Restorer" IEEE Transactions on Industry Applications, 2004, pp. 203–212.

[4] Saleh S A, Rahman M A, "Wavelet-based dynamic voltage restorer for power quality improvement" IEEE 35th Annual Power Electronics Specialists Conference, 2004, pp. 3152–3156.

[5] Meyer C, Doncker R W, Li Y W, Blaabjerg F, "Optimized control strategy for a medium voltage

DVR - Theoretical investigations and experimental results”, Power Electronics, IEEE Transactions, 2008, pp. 2746-2754.

[6] Muni, B P, Venkateshwarlu S, Makthal H V, “Review of dynamic voltage restorer for power quality improvement”, IEEE Industrial Electronics Society, 2004, pp.749-754.

[7] Lee S J, Kim H, Sul S K, "A novel control algorithm for static series compensators by use of PQR instantaneous power theory”, IEEE Trans on Power Electronics, 2004, pp.814-827.

[8] G. Venkataramanan and B. Johnson, “A pulse width modulated power line conditioner for sensitive load centers,” IEEE Trans. Power Delivery, vol. 12, pp. 844–849, Apr. 1997.

[9] D. M. Vilathgamuwa, A.A.D.R. Perera, S.S. Choi, Voltage sag compensation with energy optimized dynamic voltage restorer, IEEE Trans. Power Deliver.18(3) (2003) 928-936.

[10] IEEE Standards Board (1995), “IEEE Std. 1159-1995”, IEEE Recommended Practice for Monitoring Electric Power Quality”. IEEE Inc. New York.

[11] Vilathgamuwa, M., A.A.D. Ranjith Pcrcra and S.S. Choi, 2002. Performance improvement of the dynamic voltage restorer with closed-loop load voltage and current-mode control. IEEE Trans. Power Elect., 17: 824-834. DOI: 10.1109/TPEL.2002.802189

[12] R. Madhusudan and G. R. Rao, (2012), Modeling and simulation of a Dynamic Voltage Restorer (DVR) for power quality problems voltage sags and swells, in Proc. International Conference on Advances in Engineering, Science and Management (ICAESM), 442-447.

[13] J. W. Liu, S. S. Choi, S. Chen, (2003), Design of Step Dynamic Voltage Regulator for Power Quality Enhancement, IEEE Transactions on Power Delivery, 18, 1403-1409.