TEST Engineering & Management

January - February 2020
ISSN: 0193 - 4120 Page No. 3148 - 3152

Design and Implementation of Battery Based Dynamic Voltage Restorer for Power Quality Issues in Domestic Grid

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Article Info
Volume 82
Page Number: 3148 - 3152
Publication Issue:
January-February 2020

Article History
Article Received: *14 March 2019*
Revised: *27 May 2019*
Accepted: *16 October 2019*
Publication: *19 January 2020*

Abstract
Dynamic voltage restorer (DVR) has turned out to be well known as a solution for the protection of sensitive loads from voltage droops. Usage of the DVR have been proposed at both a low voltage (LV) level, just as a medium voltage (MV) level and allowed a opportunity to shield high power sensitive loads from voltage drops. The declared DVR confirms the utilization of a joined feed-forward and feed-back of the controller and it acquires both great transient and steady state reactions. Another control framework is proposed to control the capacitor-maintained DVR. The control of a DVR is appeared with a diminished rating VSC.The proposed circuit of simulation is done in MATLAB/SIMULINK for various faults induced in system and obtained the behavior of DVR in three phase voltage. In real time, the proposed circuit is implemented with a battery and a single phase inverter connected with the grid. The pay of the voltage sag, swell, and harmonics is shown by a decreased rating DVR.

Keywords: *Dynamic Voltage Restorer, Power Quality, Sag, Swell, Harmonics.*

I. INTRODUCTION

The fulfillment of the industrial goals was possible only because the modern industries were able to find innovative technologies that have successfully become technological developments. Continuous production throughout the period is ensured only when the final objective is to optimize production while achieving maximum profits and achieving minimized production costs. The purpose behind requesting top-notch un-interruptible power during creation procedure is essentially a result of the cutting edge assembling and procedure types of gear that work at high productivity require stable and imperfection free power supply for the fruitful task for machines. Machines, sensitive to power supply varieties are to be structured all the more exactly. For instance, some instruments like adjustable speed drives, automation devices, power electronic components etc. fall into the above category.

Cessation to provide the required quality power output may sometimes cause a complete shutdown of the industries which will make a significant financial loss to the industry concerned. However, blame due to degraded quality cannot be simply put on to the hands of the utility itself. It has been observed that in industries, most of the conditions that can disrupt the process are generated within the industry itself. For instance, the greater part of the non-straight loads cause drifters which can influence the unwavering quality of the power supply. Following referenced are some atypical electrical conditions that can upset a procedure caused both at the utility and the client end.

1. Voltage Sags
2. Phase Outages
3. Voltage Interruptions
4. Transients due to Lighting loads, capacitor switching, non-linear loads, etc
5. Harmonics.

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The industries may experience wore out motors, lost information on unstable motion of robotics, redundant downtime, improved conservation costs, burning core time, expanded support expenses and consuming centre materials particularly in plastic ventures, plastic factories and semiconductor plants as a result of the above inconsistencies.

The arrangements set forth as a result of the previously mentioned oddities are called as utility solutions and customer based solutions individually. The best precedents for those two kinds of arrangements are FACTS devices (Flexible AC Transmission Systems) and Custom power device that are are based on solid state power electronic components. FACTS gadgets are constrained by the utility, while the Custom power gadgets are worked, kept up and constrained by the client itself and introduced at the client premises.

II. BLOCK DIAGRAM OF PROPOSED SYSTEM

Figure 1 represents the block diagram of the proposed system. The proposed work minimizes the harmonics generated from conventional control methods for dynamic voltage restorers (DVRs).A capacitor controlled DVR reduces the size and harmonics level. Compensation voltage generated for the voltage sag, swell, and harmonics is demonstrated using a reduced-rating DVR.

Battery, which delivers the output as dc is connected to DVR to deliver compensation voltage in grid line. Grid tie inverter is controlled by a controller by generating six PWM pulses for six switches of the inverter from its digital outputs. The generated output waveform was read by using its analogue input and Total Harmonic Distortion was calculated (THD).

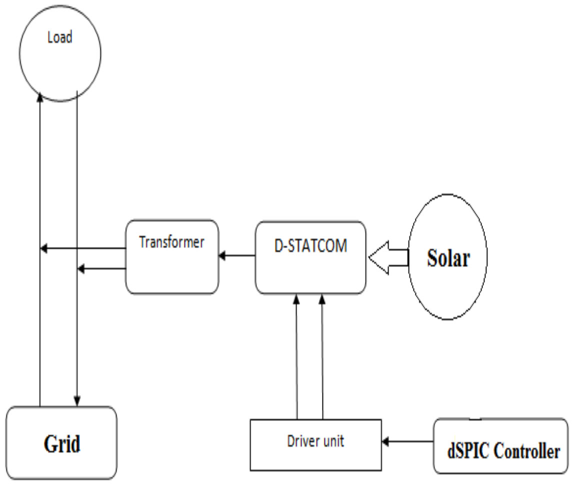

Figure 1. Block Diagram of Proposed System

It consists of the dSPIC controller, driver unit, battery, dynamic voltage restorer and transformer. The dSPIC controller is connected to the driver unit block and then to the dynamic voltage restorer. The dynamic voltage restorer is connected to the grid through the transformer.

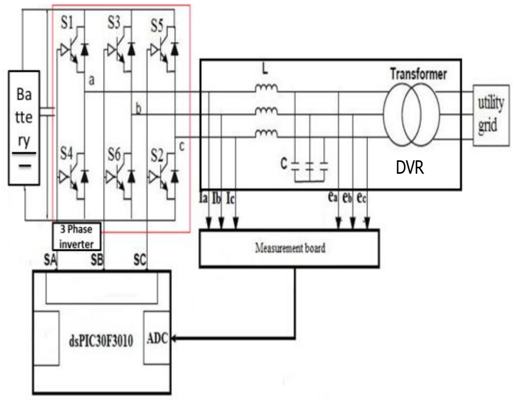

Figure 2. Circuit Diagram of Proposed System

Figure 2 shows the circuit diagram of the proposed system. The utility grid is connected to the DVR. The three phases of the supply are connected to one of the three legs of the three-phase inverter. The three-phase inverter is connected to the battery. The measurement board measures the voltages and whenever it detects sag or swell, the dSPIC controller generates the gating pulses to the three-phase inverter. The controller triggers the switches according to the voltage required. The three-phase inverter converts the dc voltage from the battery according to the voltage requirement to ac and is fed to the grid. The

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simulation model of the DVR with dSPIC controller is shown in figure 3.The proposed system is tested for sag and swell by applying three-phase fault and also for harmonics. The fault induced voltage and current waveforms are shown in figure 4.The output voltage of DVR and injected voltage by DVR are shown in figure 5.The DVR mitigates both voltage sag and swell conditions in the proposed system. The harmonics level is also reduced

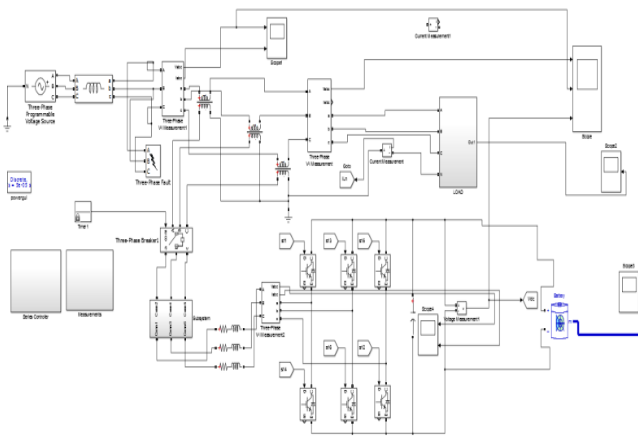

Figure 3. Simulink Model of DVR with dSPIC Controller

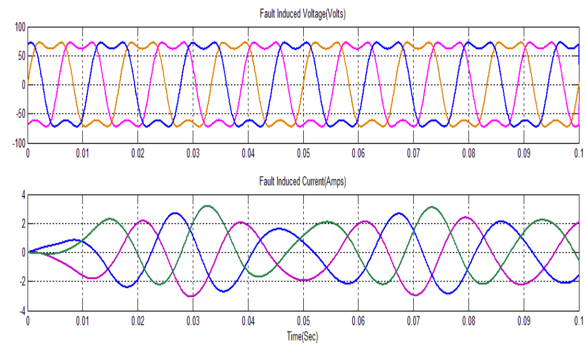

Figure 4. Waveforms of the Fault Generation

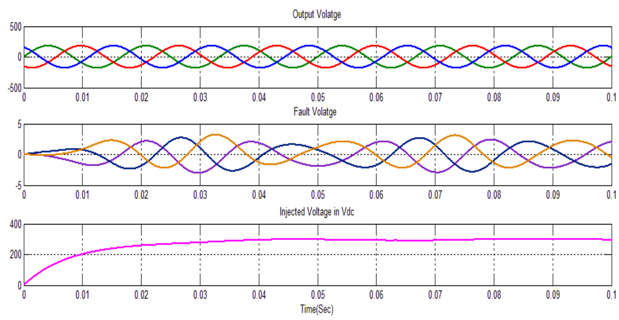

Figure 5. Waveform of Output Voltage Obtained

The THD value for the conventional system is 36.27%. When the control strategy is incorporated to compensate, the source voltage THD falls to 18.12% as shown in figure 6.

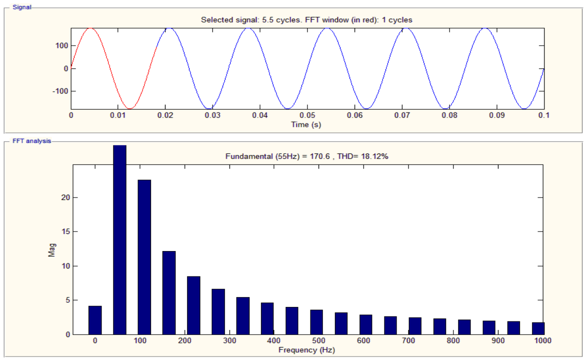

Figure 6.THD analysis through FFT for the proposed system

IiI. experimental setup

The hardware setup of the proposed system in a single phase is shown in figure 7. Since the implementation of the proposed system in three phases is highly complex, a prototype is made in a single phase. The hardware part consists of a step-down transformer, rectifier, dSPIC controller, PWM isolator, LC Filter, Grid tie inverter. The single phase supply is given to the step-down transformer.

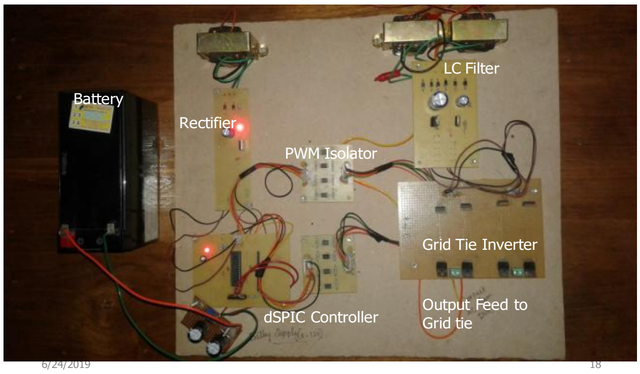

Figure 7. Hardware setup of Proposed System

The step-down transformer is connected to the rectifier. The rectifier is fed to the dSPIC controller. The dSPIC controller is connected to the PWM isolator and then to the grid inverter. The output of the inverter is fed to the line through the LC filter.

The single phase supply of 230V is given to the step-down transformer. The step-down

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transformer steps down the voltage. This voltage is then rectified through a rectifier and is fed to the controller. According to the voltage requirement, the controller generates the gating pulses to the three-phase inverter of the DVR. Thus the inverter converts the dc voltage in the battery according to the requirement to ac voltage and fed to the line.

IV. EXPERIMENTAL RESULTS

The following results show the experimental results of the implementation of a supercapacitor based DVR system which consists of a capacitor as an energy storage device with battery. Figure 10 shows the compensated voltage when DVR is activated, where DVR injects 120V into the system so that the voltage is compensated back to the normal voltage of 220V.Figure 8 shows the switching sequence of DVR.The first pulse shows the applied voltage to the power electronic device. The second pulse shows the PWM generated output. The third pulse is the complete signal. These pulses are given to the inverter. The inverter switches according to the voltage requirement and converts the voltage from the battery to ac and fed to the grid.

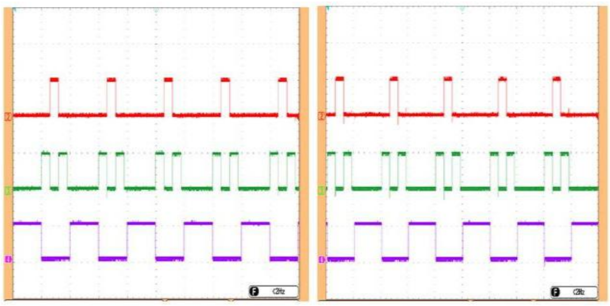

Figure 8. Switching Sequence of DVR

This shows the gate pulse generated by the driver circuit which is fed to one of the MOSFETs of the ZSI. In a similar fashion gate pulse for the other five MOSFETs are also generated and fed to the inverter.Figure 9 shows the battery voltage waveform and the inverter output voltage. This is the voltage required to mitigate the missing voltage.

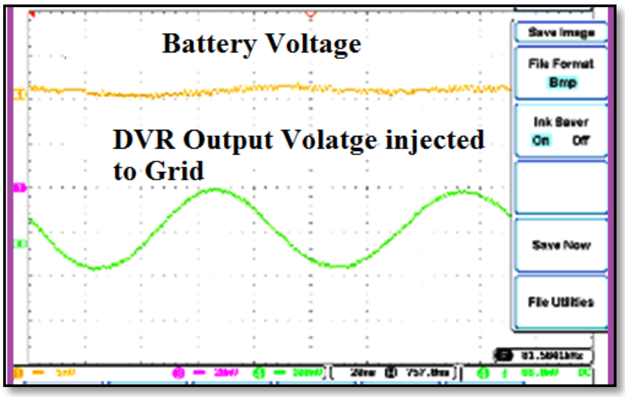

Figure 9.Battery Voltage and Output Inverter Voltage

Figure 10 shows the battery voltage and the compensated voltage fed to the grid. The control strategy along with ZSI is incorporated in the power system reduces the harmonics within the IEEE standards (<20%) for diode rectifier non-linear load as shown in figure 11.

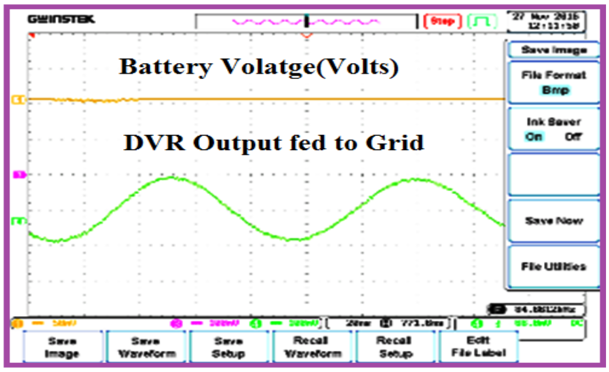

Figure 10.Battery Voltage and Compensated Voltages Fed to Grid

Figure 11.THD of Source Voltage Using DVR

This method uses an LC filter which further reduces the THD values and thereby reducing the distortions greatly. So the power factor is improved, thereby significantly improving the power quality.

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V. CONCLUSION

The research project is aimed at designing and implementing a battery based dynamic voltage restorer for power quality issues in domestic grid. In this undertaking,

DVR checks the utilization of a consolidated feed-forward and input strategy of the controller and it gets both great transient and unfaltering state reactions. Another control method is proposed to control the capacitor-bolstered DVR. The control of a DVR is shown with a diminished rating VSC.The proposed works minimize harmonics generated from conventional control methods for dynamic voltage restorers (DVRs).A capacitor controlled DVR reduces the size and harmonics level. DVR Compensation voltage is generated for the voltage sag, swell, and harmonics is demonstrated using a reduced-rating DVR. The total harmonic distortion value of the conventional system is 36.27 %.This value gets reduced to 18.12% in the proposed system. The advantage of using dSPIC microcontroller is that it has fast processing speed compared conventional controller. It has enhanced flash program memory and less cost compared to conventional controllers. Proposed work implemented in MATLAB/ SIMULINK with test voltage sags was created using real fault conditions. The utilization of a consolidated feed-forward and feed-back control framework has been confirmed for the medium voltage framework and has been appeared to have generally excellent transient and consistent state capacities. The prototype model is developed in real to verify DVR system using grid tie inverter using a battery source to fed single phase grid as a DVR system. Further, harmonics level is reduced with better efficiency of DVR for grid interface.

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