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Power Quality Control Using Dynamic Voltage Restorer

Anand Chandran[1], Harikrishnan P[2], Timmons Sebastian[3] , Vysakh PS[4]

[12]Affiliation [1]Mar Athanasius College of Engineering, Department of Electrical and Electronics, Kothamangalam, Ernakulam, India

Abstract: **Power quality is one of the major concerns of 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 failure of end use instruments [1]. Two major problems dealt here are the power sags and swells. Sensitive industrial loads and utility distribution networks all suffer from various types of outages and service interruptions which may result in a significant financial loss. To improve power quality custom devices like DVR are used. The dynamic voltage restorer (DVR) is a cost effective solution for the protection of sensitive loads. The DVR, with its excellent dynamic capabilities, when installed between the supply and a critical load feeder, can compensate for voltage sags and swells. The dynamic voltage restorer consists of a voltage source, a voltage source inverter, an injection transformer and a control system. The performance of the DVR depends on control technique involved. The control system involves a PIC microcontroller and discrete PWM pulse generator [3]. The role of DVR to compensate load voltage is investigated during different fault conditions.**

Keywords: **Dynamic Voltage Restorer, Sags, Swells, PIC16F877, Injection Transformer, Batter, Sag Swell Generator**.

I. INTRODUCTION

Voltage sag and swell disturbances are the most frequently occurring Power Quality problems in the distribution system. Power quality phenomenon or power quality disturbance can be defined as the deviation of the voltage and the current from its ideal waveform. Faults at either the transmission or distribution level may cause voltage sag or swell in the entire system or a large part of it. Also, under heavy load conditions, a significant voltage drop may occur in the system. Voltage sag and swell can cause sensitive equipment to fail, shutdown and create a large current unbalance. These effects can incur a lot of expensive from the customer and cause equipment damage [1]. The voltage dip magnitude is ranged from 10% to 90% of nominal voltage and with duration from half a cycle to 1 min and swell is defined as an increase in rms voltage or current at the power frequency for durations from 0.5 cycles to 1 min. Typical magnitudes are between 1.1 and 1.8 p.u[2]. Dynamic Voltage Restorer is normally employed as a solution for mitigation of voltage sag [1]. The proposed system has less number of switching devices and has good compensating capability in comparison with commonly used compensators. The Static Series Compensator (SSC), commercially known as Dynamic Voltage Restorer (DVR), is best suited to protect sensitive loads against such incoming supply disturbances.

II. POWER QUALITY AND ITS RELEVANCE

Voltage deviations, commonly in the form of voltage sag and swell can cause severe process disruptions and result in substantial production loss. Voltage sag and swell can cause loss in production in automated processes since voltage sag can trip a motor or cause its controller to malfunction. Voltage swell is defined as sudden increase in supply between 110 percentages and 180 percentage of the nominal value. Switching of a large inductive load or energizing a large capacitor bank is a typical system event that causes swell. Power quality is crucial for the companies operating in a highly competitive business environment because of its effects on profitability, which is definitely a driving force in industry.

This increasing interest on the improvement of efficiency and the elimination of variations in industry has resulted in more complex instruments. These instruments tend to be more sensitive to voltage disturbances such as voltage sags, voltage swells, outages, harmonics, interruptions and phase shifts. Voltage sags are considered to be the most severe power quality problem since sensitive loads are very susceptible to temporary changes in voltage. A DVR compensates for these voltage excursions provided that the supply grid does not get disconnected entirely through breaker trips.

According to the international standards power quality problems are classified as by duration, type and severity. Common power quality disturbances include surges, spikes, voltage sags, voltage swell and Harmonics on the power line. The typical voltage disturbance is shown in the Fig. 1. The List of categories of power quality issues are:

A. Disturbances:

A disturbance is a sudden deviation from the steady state waveform caused by faults of small duration or by temporary changes in the power system. The disturbances accepted by the International Electro technical Commission (IEC) include voltage dips, voltage increases, small interruptions and impulsive and oscillatory transients. The Institute of Electrical and Electronics Engineers (IEEE) has named voltage dips as sags and voltage increases as swells.

B. Voltage Sags:

According to the IEEE defined standard, IEEE Std. 1159, 1995 Voltage Sag is defined as a decrease in RMS voltage up to 10% - 90% of nominal value, for a duration of 0.5 cycles to 1 minute or decrease in the RMS value of the voltage ranging from a half cycle to a few seconds.

C. Voltage Swells:

Voltage Swell is defined by IEEE 1159 as the increase in the RMS voltage level up to 110% - 180% of nominal value, at the power frequency for small durations of 0.5 cycles to 1 minute or increase in the RMS value of the voltage ranging from a half cycle to a few seconds.

D. Distortion:

Distortion in the voltage or current waveform that occurs when nonlinear loads are connected to the electrical system is termed as unbalance. The current drawn by nonlinear loads are non-sinusoidal though the supply voltage is sinusoidal.

E. Unbalance:

Unbalance in a three-phase system is a situation in which either the three-phase voltages are not equal in magnitude or the phases differences between the voltages are are not 120° or both

F. Voltage fluctuations:

Continuous and sudden changes in the nominal value of the supply voltage are known as voltage fluctuations

G. Flicker:

Flicker is defined as the impression of unsteadiness of visual sensation induced by a light stimulus whose luminescence or spectral distribution fluctuates with time (IEEE 1995).

H. Noise:

Noise is the unwanted voltage or current superimposed on the power system voltage or current waveform respectively

I. Harmonics:

Harmonics are as considered steady state events, where the 50 Hz waveform of voltage and /or current contains distortions. Harmonics are not normally caused by the utility system. They are the result of non-linear loads . These loads inject harmonic currents into the utility system and in severel cases can cause problems for surrounding customers. Harmonics levels are increasing in the power systems due to proliferation of power converter circuits which are based on switched mode topologies [2].

J. Surges:

Surges are transient over voltages that usually last less than a few milliseconds. They are normally the result of lightning and equipment switching.

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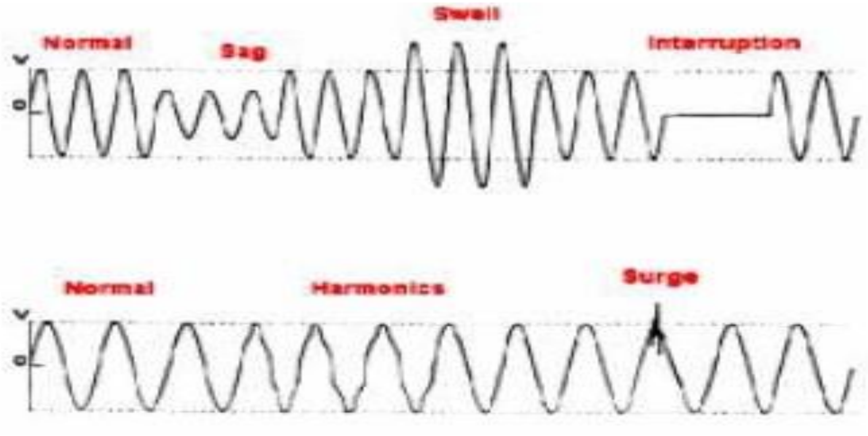

Figure 1: Typical voltage Disturbances

III. DYNAMIC VOLTAGE RESTORER

A schematic diagram of the DVR incorporated into a distribution network is shown in Fig. 2 Vs are the source voltage, V1 is the incoming supply voltage before compensation, V2 is the load voltage after compensation, DVR is the series injected voltage of the DVR, and I is the line current. The DVR typically consists of an injection transformer, the secondary winding of which is connected in series with the distribution line. The injection of an appropriate DVR in the face of an upstream voltage disturbance requires a certain amount of real and reactive power supply from the DVR [1]. The DVR consists of 4 major parts:-

1. Voltage Source Inverter (VSI):

These inverters have low voltage ratings and high current ratings as step up transformers are used to boost up the injected voltage.

2. Injection Transformers:

Three single phase injection transformers are connected in delta/open winding to the distribution line. These transformers can be also connected in star/open winding. The star/open winding allows injection of positive, negative and zero sequence voltages whereas delta/open winding only allows positive and negative sequence voltage injection.

3. Energy storage:

Batteries, flywheels or SMEs can be used to provide real power for compensation. Compensation using real power is essential when large voltage sag occurs.

4. Control System:

The control system consists of a PIC16F877 microcontroller. It senses the disturbances in voltages and generates necessary PWM trigger pulses to the inverter according to the necessary voltage to be injected.

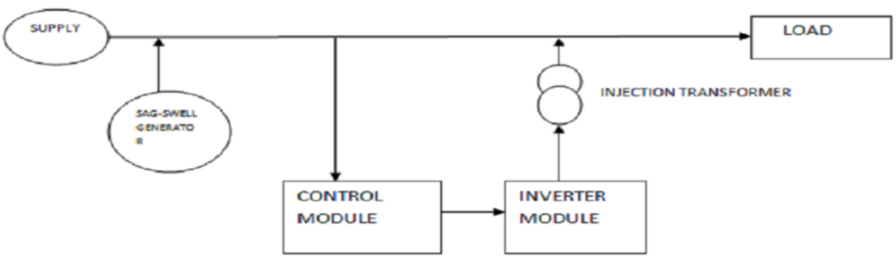

Fig: 2. Block Diagram

A. Operating principle:

The DVR is designed to inject the missing voltage into the distribution line. Its basic idea is to dynamically inject a voltage uc (t) as shown in Fig. 3 & Fig. 4. The upper part of Figure shows a simplified single-phase equivalent circuit of a distribution feeder with a DVR, where the supply voltage us(t), the DVR injection voltage uc(t) and the load voltage uL(t) are in series. So, the DVR is considered to be an external voltage source where the amplitude, the frequency and the phase shift of uc(t) can be controlled. The purpose is to maintain the amplitude of the load voltage fixed and prevent phase jumps in countries to undergo restructuring with the hope of achieving efficiency in these companies. [5]

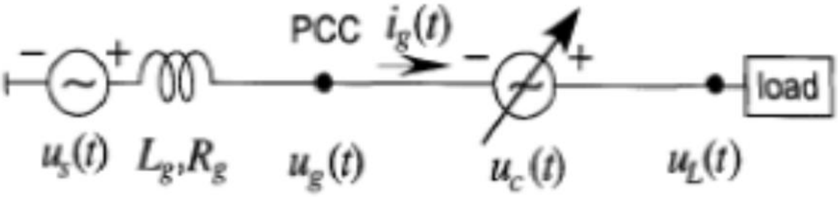

Fig 3. Equivalent circuit of DVR

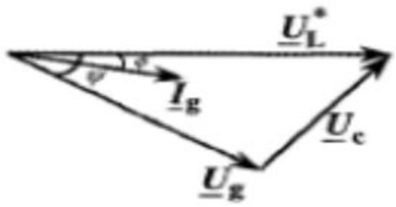

Fig 4. Phasor diagram of voltage restoring operation

B. Circuit Diagram:

The circuit consists of a control system, inverter and a sag swell generator. The heart of the DVR is two PIC 16F877 microcontrollers. Two isolation transformers are used to inject the required voltage to the supply.

1. Control System:

The control system, shown in Fig. 5, consists of a PIC16F877 microcontroller. It detects the amplitude of the supply voltage at each instant using the ADC pin in the PIC. The input voltage is rectified and given to the PIC. Twenty five samples from each period is taken and the value at each instant is compared with the ADC value which is preset with that of a perfect sine wave. The microcontroller triggers a square pulse when it detects a sag or swell in the main supply. The sag and swell is simulated by using two switches in the circuit [6]. When the switch that detects sag is turned ON, the LCD will display "SAG DETECTED" and a synchronizing pulse will be generated by the microcontroller. A pulse width modulated wave according to the sag or swell voltage is obtained from the PWM pin of the PIC microcontroller. This turns the AND gate ON which will eventually trigger the inverter module according to the required voltage.

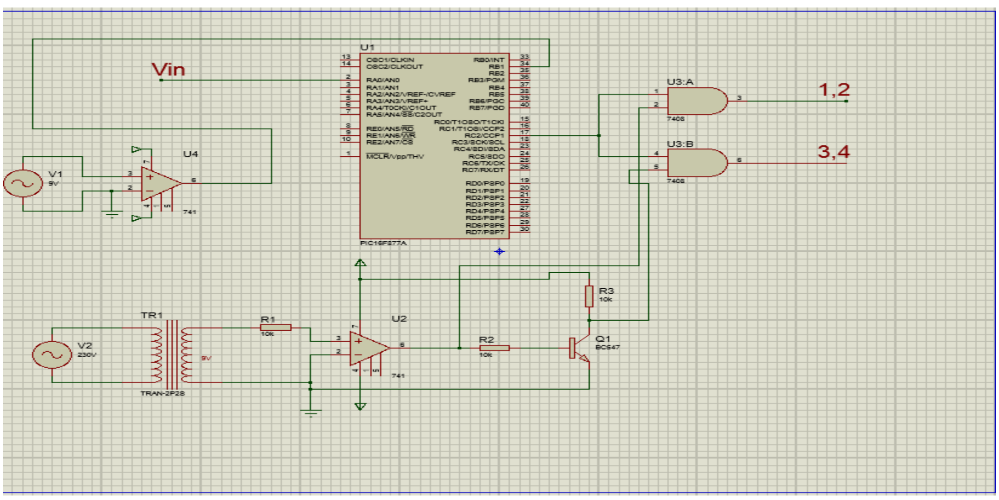

Fig: 5. Control circuit

2. Inverter Module:

It is a PWM based inverter circuit which supplies the required compensating square pulse as shown in Fig. 6 and this pulse generated is then added with the supply voltage. If the switch that detects swell is turned ON, the LCD will display "SWELL DETECTED". The operation is similar to that in case of swell up to the output of the inverter module. The microcontroller generates an extra pulse in case of swell to trigger the relay and invert the output of the inverter at the primary of the injection transformer [4]. This voltage is then added with the main supply and the voltage will then decrease back to its normal value. Thus a compensating voltage, either in phase (for sag) or out of phase (for swell) is given in series with the main circuit so that power quality of the system is improved.

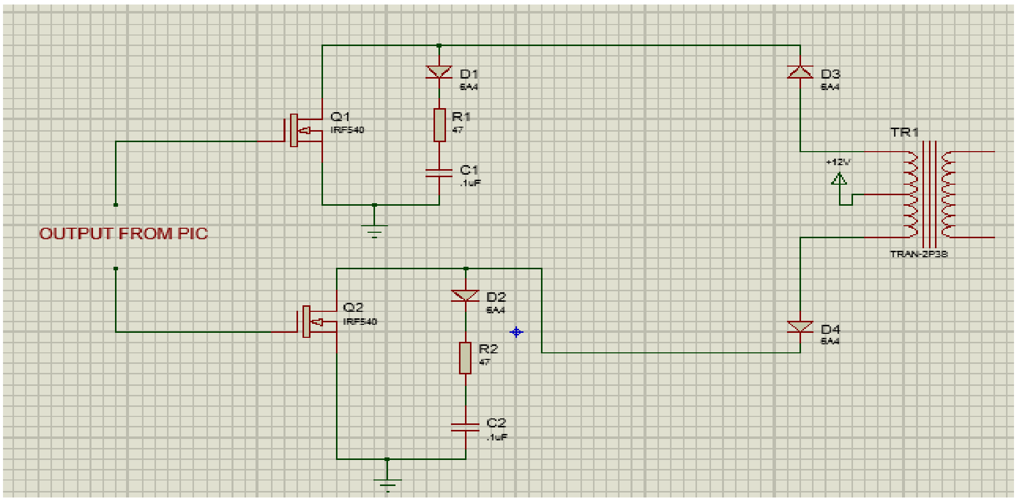

Fig 6. Inverter Circuit

3. Sag Swell Generator:

A different sag-swell generator for the test of custom power devices is described in [3]. Voltage sag, voltage swell, outage, harmonic distortion, notches, and voltage unbalance can be generated. Fig. 7 shows this single-phase sag swell generator using an auto transformer, series transformer, and SCR thyristors. In Fig. 7, the source voltage is constant. To produce a disturbed voltage, a series transformer *is* inserted between the negative grids of the source voltage and the output terminal. The secondary voltage of the transformer is determined by multiplying the turn ratio of the transformer and the secondary voltage of the auto transformer. The outage is also generated by adjusting the magnitude of the voltage sag to 100% of the source voltage. The controller triggers S1 and S2 to connect or disconnect one of the tap winding sections into the circuit. The anti parallel thyristors S*B*1 and S*B*2 are used as bypass switches that connect the auto transform output to the load unless the fault condition is presented [3].

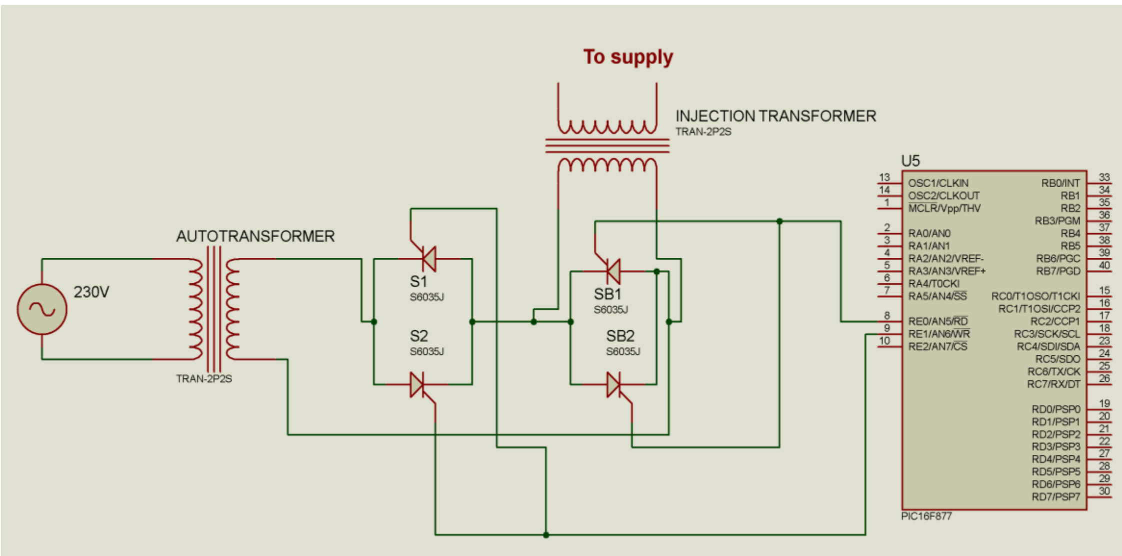

Fig 7. Sag Swell Generator

IV. FLOW CHART

The programming of PIC16F877A is done using MPLAB software and burned into the PIC using PIC kit2 software. The flow chart of the program is shown below in Fig. 8.

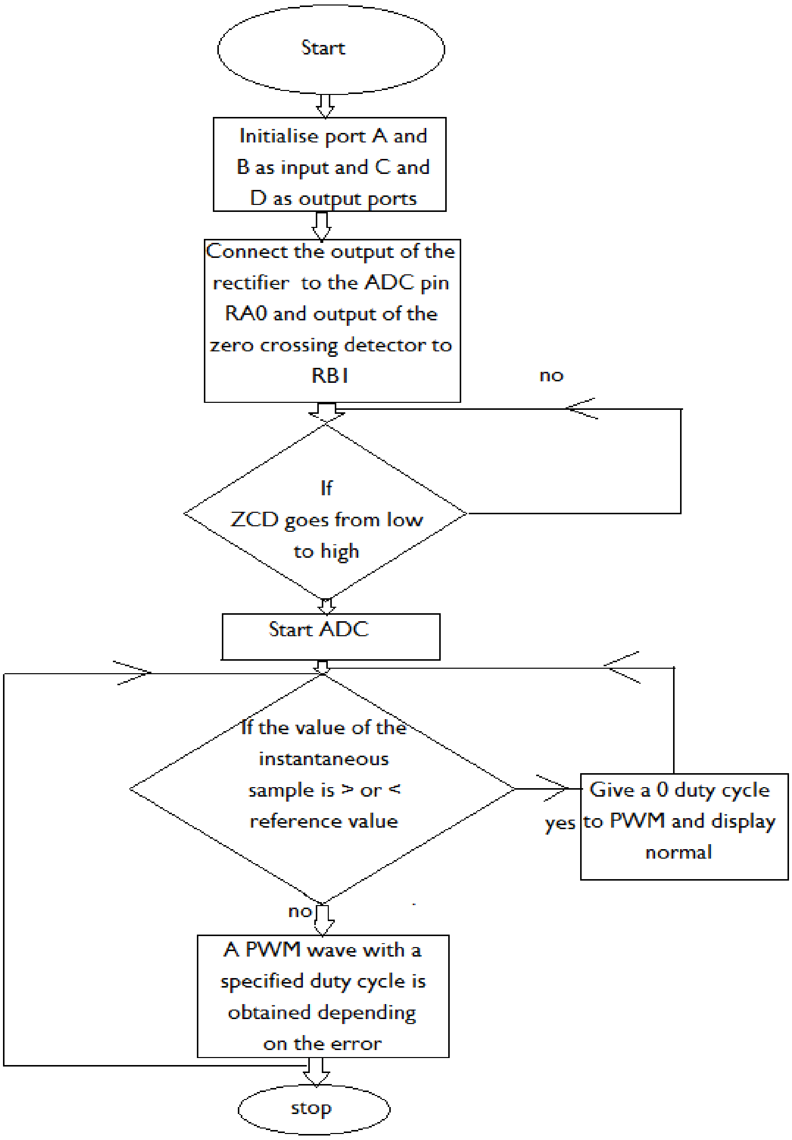

Fig: 8. Flow Chart

V. CONCLUSION

This paper presents the simulation of a DVR. The DVR handles the situation without any difficulties and injection or absorption of the appropriate voltage component to rapidly correct any changes in the supply voltage thereby keeping the load voltage balanced and constant at the nominal value. During simulation, the DVR has shown the ability to compensate for voltage sag and swell.

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REFERENCES

[1] Subhro Paul, SujaySarkar, SurojitSarkar, Pradip Kumar Saha, Gautam Kumar Panda, "Dynamic Voltage Restorer for Power Quality Improvement", International Journal Of Engineering And Computer Science ,Vol. 2, Issue1, pp. 234-239 ,Jan 2013

[2] Vicente Feliu and Aurelio Garca-Cerrada, "A Versatile Control Scheme for a Dynamic Voltage Restorer for Power-Quality Improvement", IEEE transactions on power delivery, vol. 24, no. 1, pp. 202-247 May 2013.

[3] J.Mangalanathan, "Hardware implementation of single phase dynamic voltage restorer in mitigating voltage sag and swell", International Journal of Innovative Science, Engineering and Technology, Vol. 1 Issue 3,pp.187-193 May 2014.

[4] N V Sarath Babu , A.Naveen kumar ,Shaik Ansar, "Power quality improvement using 5-level flying capacitor multilevel converter based dynamic voltage restorer for various faults", International Journal Of Engineering And Computer Science , Vol. 2, Issue 5, pp. 1606-1613 May, 2013.

[5] Al-Mathnani,. A.O, Shareef, H, Mohamed A, Ali M.A.M, "Power quality improvement using DVR with two fast vector control", Power Engineering and Optimization Conference (PEOCO) 2010 4th International, pp .23-24 ,June 2010.

[6] Ahmet TEKE, Mehmet Emin MERAL, Mehmet TUMAY, Mehmet Ugras CUMA, "A practical disturbance generator to test performan Of various spower quality Mitigation devices" Turkish Journal of Electrical Engineering & Computer Sciences, Vol.1, Issue 3 pp 38-54, January 2013.