

## **STUDY DIFFERENT TYPES OF POWER QUALITY**

# **PROBLEMS IN POWER SYSTEM AND CUSTOM POWER DEVICE DYNAMIC VOLTAGE RESTORER (DVR) FOR POWER QUALITY IMPROVEMENT**

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### **ABSTRACT**

*In this scheme described the various power quality problems occur in distribution system like voltage sag, voltage swell, flicker, transient, harmonics, inrush current, distortion etc. And Dynamic voltage restorer (DVR) is a modern power device used to mitigate various power quality problems like voltage sags, voltage swell etc. In this scheme study of power circuit and working principle of dynamic voltage restorer for various power quality problems mitigation and various controlling scheme used for controlling the DVR are discussed in brief.*

**Keywords:** *Custom Power Device, Control Theory, DVR, Power Quality Problems,*

### **I. INTRODUCTION**

Power quality defines in various ways as per the Institute of Electrical and Electronic Engineers (IEEE) Standard IEEE1100 defines power quality as “the concept of powering and grounding sensitive electronic equipment in a manner suitable for the equipment.” And second power quality defines as “Power quality is a set of electrical boundaries that allows a piece of equipment to function in its intended manner without significant loss of performance or life expectancy”[1].

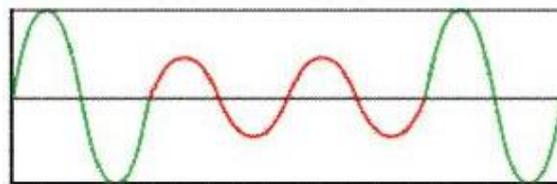
Nowadays many power electronic or nonlinear loads are increasing and these loads are more responsible for poor power quality and also during fault and different switching methods power quality is not maintained for improvement or to maintain power quality many FACTS devices and custom power devices are developed. Power quality problems (sags, swells, harmonics...) voltage sags are the most sensitive disturbances which are compensated by FACTS controllers. FACTS controllers are divided into four categories like series FACTS controllers, shunt FACTS controllers, combined series series FACTS controllers, combined series shunt FACTS controllers,[2,3]. In order to overcome these problems the concept of custom power devices is introduced. The compensating devices either compensate a load, i.e., correct its power factor, unbalance etc. or improve the quality of the supplied voltage. These devices are either connected in shunt or in series or combination of both. The devices include,

- Active Power Filters
- Dynamic Voltage Restorer (DVR)
- Unified Power Quality Conditioner (UPQC).

These devices improve the power quality and dynamic voltage restorer (DVR) is one of the most important custom power device for improvement of power quality, DVR solve many power quality related problems. This paper include the various types of power quality problems created in distribution system and which types of compensating devices used for mitigation these types of power quality problems and also include the custom power device DVR power circuit and working principle during compensating the abnormal conditions. And indicate the different theory or method used for DVR control.

## II. POWER QUALITY PROBLEMS

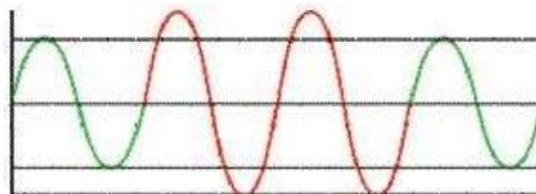
Various types of power quality problems are generated in power system like voltage sag, voltage swell, transient, notch, harmonics etc. Voltage sag defined as rms reduction in the AC voltage at power frequency from half of a cycle to a few seconds duration this voltage sag is due to the heavy lagging load like induction motor starting load furnace etc.



**Fig.1 Voltage sag**

Sag also generated when power transfer from generating station to the load sag are most sensitive to some load used invarious purpose[1].

Voltage swell is opposite of voltage sag and according to IEEE 1159 increase in RMS voltage level to 110%-180% of nominal, at the power frequency for duration of half cycle to one minute or Voltage Swell is defined as an increase in rms voltage or current at a power frequency for duration from 0.5 cycles to 1min or RMS increase in AC voltage at power frequency from half of a cycle to a few seconds' duration.

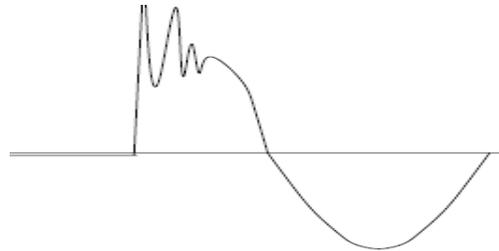


**Fig.2 Voltage swell**

Swell which is a momentary increase in voltage, happens when heavy load turns off in power system. Voltage swell also caused by large capacitor bank on and also when single line to ground fault occur then voltage increase on other healthy phases. Due to voltage swell sensitive equipment can damage.[1]

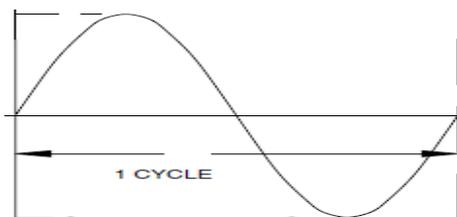
Flicker may be define as the Variation of input voltage sufficient in duration to allow visual observation of a change in electric light source intensity. Flicker due to the load take large initial current like elevator arc welder etc.

A transient event is short-lived burst of energy in a system brief discontinuity of the waveform and transient due to the when heavy load switch on or switching capacitor bank for power factor correction this effect mitigation also important for devices.

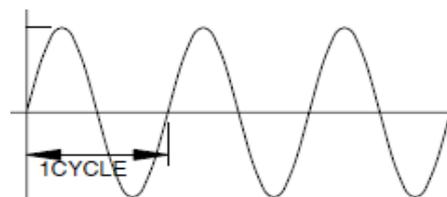


**Fig3: Transient due to fault current brake**

Harmonic is the frequency that is an integral multiple of the fundamental frequency. If we are considering the fundamental frequency is 50 Hz, then the second harmonic has a frequency  $2*f = 2*50$  sinusoidal wave of 100 Hz, and third harmonics has  $3*50 = 150$ Hz and so on.



**Fig.4 Fundamental wave form**

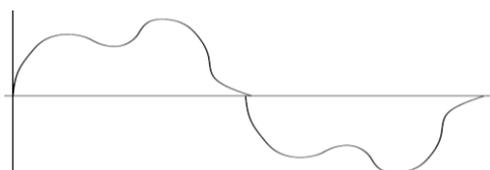


**Fig.5 3<sup>rd</sup> harmonics wave form**

Non linear load or power electronics load are responsible for harmonics due to the harmonics heating produce in the electrical equipment and mal function create in realy and protective systems and also.

Inrush current mean when start a large load at that time large current flow in the initial stage in the system due to this possibility of damage the equipment so devices must be protected from the inrush current.

Deviation of wave from fundamental pure sine wave its called distortion due to the power electronics devices and during faulty condition main wave form is distorted and it can also caused change the phase shift. Below wave form is distorted from pure sine wave or fundamental wave. Interruption defined as the Complete loss of voltage or current for a time period[1].



**Fig.6 Distorted wave form**



**Fig.7 Distorted wave form**

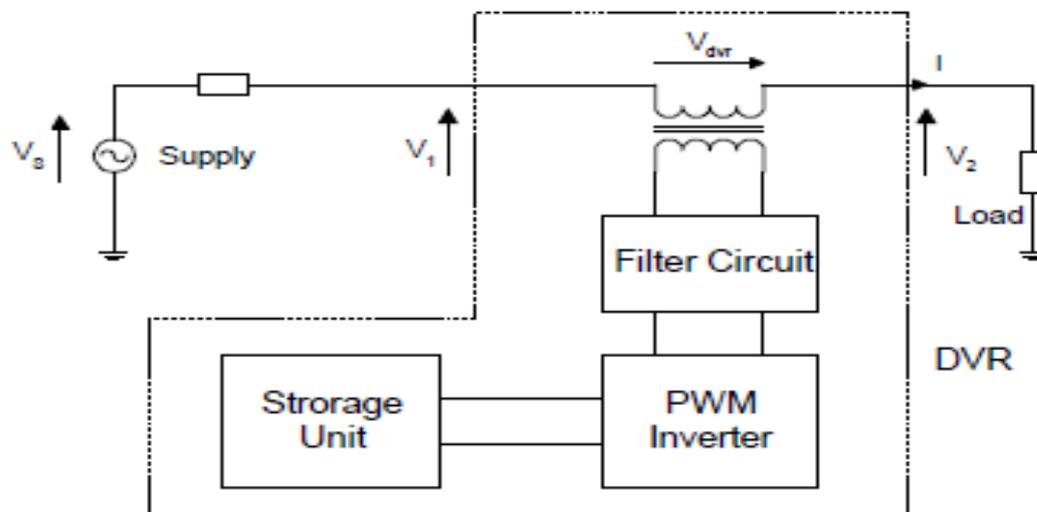


Fig.8 DVR basic block diagram

DVR power circuit made of a various components like DC energy storage device, inverter circuit, filter circuit series injecting transformer and sometimes bypass switches. Energy Storage used to provide active power to the load during deep voltage sags. Lead-acid batteries, flywheel can be used for energy storage [4]. The DVR is a custom power device that is connected between the supply voltage and the load in the distribution system there are various circuit connections and control schemes that can be used to implement a DVR. Main purpose of DVR is to compensate voltage sags and swells. DVR introduce other features like line voltage harmonics compensation, reduce transients in voltage in the system and fault current maintain. The DVR injects a voltage in series with the help of series injecting transformer terminal so the load voltage ( $V_2$ ) is always constant in magnitude.

All three phases of the injected voltages are of compensated amplitude and phase. voltage source converter (VSC) with a dc capacitor is used. The inductor in series ( $L_f$ ) and the parallel capacitor ( $C_f$ ) with the VSC are used for reducing the ripple in the injected voltage. sometimes used with bypass switches it protect inverter circuit during faulty condition.

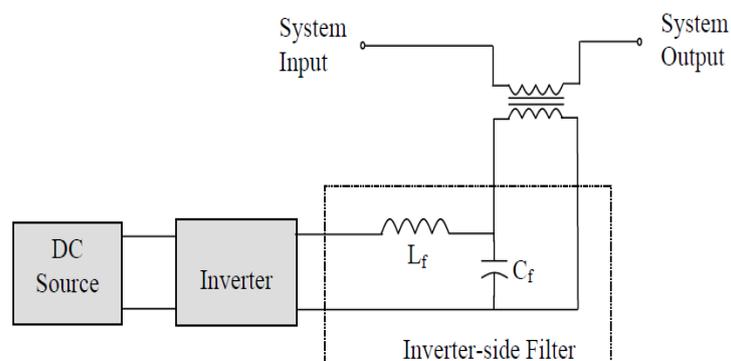


Fig. 9 Series inductor and parallel capacitor

The DVR has three modes of operation which are protection mode, standby mode and boost mode.

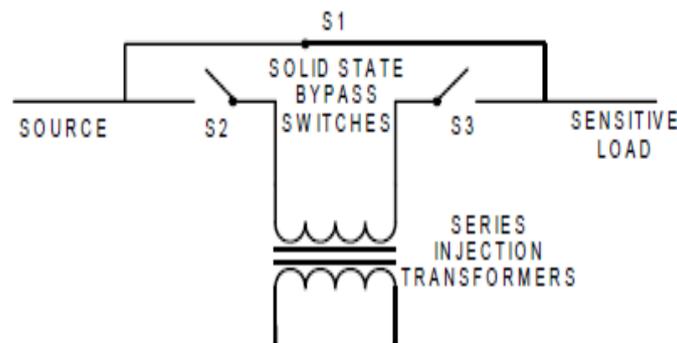


Fig.10 DVR protection mode

Protection Mode the DVR is protected from the over current in the load side due to short circuit on the load and current change its direction. S1 switch closed and protect DVR circuit as shown in above figure.[5,6]

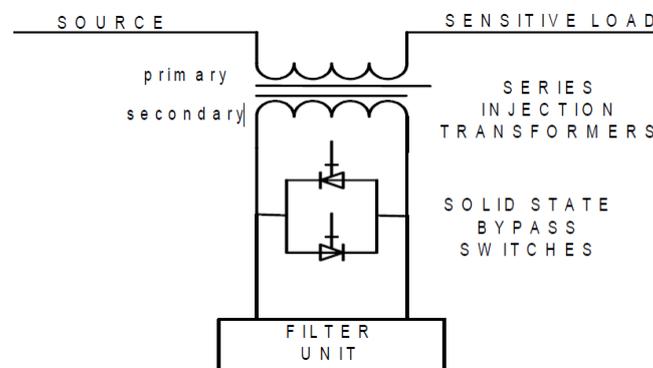


Fig.11 DVR standby mode

The DVR is most of the time in standby mode at that time  $V_{DVR} = 0$ , when not any disturbance detect by DVR in this mode the low voltage winding of the booster transformer is shorted through the converter. No switching of the semiconductor occurs in this mode of the transformer. The DVR is most of the time in this mode this mode shown in above figure.

In third mode of the DVR is the boost mode, in this mode  $V_{DVR} > 0$ , in this mode the DVR inject a compensation voltage through the booster transformer due to the detection of the supply voltage disturbance and DVR take action on these detection.[5,6]

#### IV. CONTROL STRATEGIES USED FOR DVR

There are various control strategies used for control the DVR and reference signal generation and power quality improvement like, The synchronous reference frame (SRF) theory, dqo transformation or Park's transformation [5] Instantaneous power (p-q) theory, PID Controller Method Fuzzy Logic control etc[ 8,9]

The dqo transformation or Park's transformation is widely used method for generation of reference signal used to control of DVR. The dqo method gives the sag depth and swll information and also phase shift information with start and end times. The quantities are expressed as the instantaneous space vectors. First convert the voltage from a-b-c reference frame to d-q-o reference.[5,3,7]

## V. CONCLUSION

From the above information various types of power quality problems are created in power system due to the different types of load and others reasons and many Facts and custom power devices are used to solve these, DVR is one of the custom power devices which inject voltage in series during some abnormal condition created in power system and operate at different modes of operation and various theory and method used for controlling the DVR.

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