

# Improved Power Quality on Dynamic Voltage Restorer for Mitigation of Voltage Sag

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**ABSTRACT:** *Power Quality has turned into a noteworthy region of worry in display time because of increment in present day touchy and advanced burdens associated with the conveyance framework. This paper features voltage droop as one of a power quality issue and DVR is utilizing for moderation of voltage hang. One of the significant issues managed here is the voltage hang. To take care of this issue, custom power gadgets are utilized. One of those gadgets is the DVR, which is most productive and compelling present day custom power gadget utilized as a part of energy dissemination systems. This paper presents control quality issues and add up to diagram of DVR and alleviation of voltage list so youthful electrical architects come to think about such a cutting edge custom power gadget for control quality change in future period.*

## 1. INTRODUCTION

Power Quality issues are of indispensable worry in most ventures today, on account of the expansion in the number of burdens delicate to control aggravations. The power quality is a record to qualify of current what's more, voltage accessible to mechanical, business also, family unit shoppers of power. The issue respects both the utilities and clients. For the utilities, to give sufficient power quality is moving goal in view of changes in client hardware and necessities. The power quality is worried about deviations of the voltage from its perfect wave frame (voltage quality) and

deviations of the current from its optimal wave frame (current quality). Such a deviation is known as a "Power quality marvel" or a "power quality unsettling influence". Power quality marvels can be separated in to two sorts, which should be dealt with in an unexpected way.

1. A normal for voltage or current (e.g., recurrence or power factor) is never precisely equivalent to its ostensible or wanted esteem. The little deviations from the ostensible or wanted esteem are called "voltage varieties" or "current varieties". A property of any variety is that it has an incentive at any minute in time.

2. Sporadically the voltage or current veers off altogether from its typical or perfect wave shape. These sudden deviations are called "occasions". This investigation present different power quality issues and essential idea of DVR (Dynamic Voltage Restorer). This ponder manages review of a Dynamic Voltage Restorer (DVR) for moderation of voltage droops. Most normal power quality issues are:

**1. Voltage list (or plunge):** A diminishing of the ordinary voltage level in the vicinity of 10 and 90% of the ostensible rms voltage at the power recurrence, for terms of 0.5cycle to 1 minute. **Causes:** Faults on the transmission or dispersion arrange (the vast majority of the circumstances on parallel feeders). Blames in purchaser's establishment. Association of substantial loads and start-up of extensive engines.

**2. Short Interruptions:** Total interference of electrical supply for span from hardly any milliseconds to maybe a couple seconds.

**Causes:** Mainly because of the opening and programmed reclosure of security gadgets to decommission a flawed segment of the system. The fundamental blame causes are protection disappointment, lightning and cover flashover.

**3. Long interferences:** Total intrusion of electrical supply for term more noteworthy than 1 to 2 seconds. **Causes:** Equipment disappointment in the power framework system, tempests and articles (trees, autos, and so on) striking lines, fire, human error, bad coordination.

**Consequences:** Stoppage of all equipment.

**4. Voltage spike:** Very fast variation of the voltage value for durations from a several microseconds to few milliseconds. These variations may reach thousands of volts, even in low voltage.

**Causes:** Lightning, switching of lines or power factor correction capacitors, disconnection of heavy loads.

**5. Harmonic Distortion:** Voltage or current waveforms assume non-sinusoidal shape. The waveform corresponds to the sum of different sine-waves with different magnitude and phase, having frequencies that are multiplies of power-system frequency.

**Causes:** Classical sources: Electric machines working above the knee of the magnetization curve (magnetic saturation), arc furnaces, welding machines, rectifiers, and DC brush motors.

**Modern sources:** All non-linear loads, such as power electronics equipment including ASDs, switched mode power supplies, data processing equipment, high efficiency lighting.

**6. Voltage fluctuation:** Oscillation of voltage value, amplitude modulated by a signal with frequency of 0 to 30 Hz.

**Causes:** Arc furnaces, frequent start/stop of electric motors (for instance elevators), oscillating loads.

**Consequences:** Most consequences are common to under voltage. The most perceptible

consequence is the Flickering of lighting and screens, giving the impression of unsteadiness of visual perception.

**7. Noise:** Superimposing of high frequency signals on the waveform of the power-system frequency.

**Causes:** Electromagnetic interferences provoked by Hertzian waves such as microwaves, television diffusion, and radiation due to welding machines, arc furnaces, and electronic equipment. Improper grounding may also be a cause.

**8. Voltage Unbalance:** A voltage variation in a three-phase system in which the three voltage magnitudes or the phase angle differences between them are not equal.

**Causes:** Large single-phase loads, incorrect distribution of all single phase loads by the three phases of the system.

**2. DVR (Dynamic Voltage Restorer) :** A Dynamic voltage restorer is a power electronic converter based device that has been designed to protect critical loads from all supplyside disturbances other than outages. It is connected in series with a distribution feeder and is capable of generating or absorbing real and reactive power at its ac terminals. DVR developed in the early 1990's, with its excellent dynamic capabilities, when installed between the supply and a critical load feeder, can compensate for voltage sags, restoring line voltage to its nominal value with in a few milliseconds and hence avoiding any power disruption to that load. A power electronic converter based series compensator that can protect critical loads from all supply side disturbances other than outages is called a "Dynamic Voltage Restorer".

### 2.1 Principle And Operation Of DVR:

The basic principle of a DVR is simple by inserting a voltage of required magnitude and frequency, the DVR can restore the load side voltage to the desired amplitude and waveform even when the source voltage is unbalanced or distorted. DVR is connected in between the supply and the load. The main function of the DVR is to boost up the load side voltage so that load is free from any power disruption. Besides voltage sag compensation DVR also carry out other function's such as line voltage harmonic

compensation, reduction of transients in voltage and fault current limitation.

**2.2 Basic Configuration Of DVR:** Among the power quality problems like sag, swell, harmonic, transients etc, voltage sag i.e., sudden voltage dip is the most severe disturbance in power system, generally caused by faults. It last for duration ranging from 3 cycles to 30 cycles. Starting of large induction motors can also result in voltage sag as it draws a large amount of current during starting. In order to mitigate this problem DVR is one of the efficient and effective custom power devices. DVR injects voltage in to the system in order to compensate the voltage dip in the load side and maintains the load voltage at nominal magnitude. Power circuit and the control circuit are the two main parts of the DVR. There are various critical parameters of control signals such as magnitude, phase shift, frequency etc, which are injected by DVR. These parameters are derived by the control circuit. This injected voltage is generated by the switches in the power circuit based on the control signals.

**2.3 DVR Components:** DVR is a solid state power electronic switching device which is connected in series to the power system. It comprises of the following components.

**2.3.1 Energy Storage Device:** The purpose of the energy source is to supply the necessary energy to the VSI which will be converted to alternating quantity and fed to the injection transformer. Batteries are most commonly used and the capacity of the battery determine the duration of the sag which can be compensated by the DVR.

#### **2.3.2 Inverter Circuit:**

The Voltage Source Inverter (VSI) or simply the inverter converts the dc voltage from the energy storage unit (or the dc link) to a controllable three phase ac voltage. The inverter switches are normally fired using a sinusoidal Pulse Width Modulation (PWM) scheme. Since the vast majority of voltage sags seen on utility systems are unbalanced, the VSI will often operate with unbalanced switching functions for the three phases, and must therefore treat each phase independently. Moreover, sag on one phase may result in a swell on another phase, so the VSI must be capable of handling both sags and swells.

#### **2.3.3 Filter Unit:**

Non-linear characteristics of semiconductor devices cause distorted waveforms associated with high frequency harmonics at the inverter output. To overcome this problem and provide high quality energy supply, a harmonic filtering unit is used. These filters can be placed either in the inverter side as or in the line side.

#### **2.3.4 Series Injection Transformer:**

Three single phase injection transformers are used to inject the missing voltage to the system at the load bus. To integrate the injection transformer correctly in to the DVR, the MVA rating, the primary winding voltage and current ratings, the turn-ratio and the short-circuit impedance values of transformers are required. The existence of the transformers allow for the design of the DVR in a lower voltage level, depending upon the stepping up ratio.

**3. Compensation Strategies:** Three compensation strategies are normally used for sag compensation.

#### **A. Pre-sag Compensation:**

The DVR injects the difference voltage between during-sag and pre-sag voltages to the system, the DVR must compensate for both magnitude and angle. It is the best solution to obtain the same load voltage as the pre-fault voltage and is best suited for loads sensitive to phase angle jumps like angle-triggered thyristor controlled loads. The method gives nearly undisturbed load voltage, but can often exhaust the rating of the DVR.

#### **B. In-phase Compensation:**

The generated DVR voltage is always in phase with the measured supply voltage regardless of the load current and pre-sag voltage. The phase angles of the pre-sag and load voltage are unique yet the most imperative criteria for control quality that is the consistent extent of load voltage is fulfilled. In this arrangement, the DVR is intended to remunerate the voltage extent as it were. This strategy is appropriate for loads that can withstand stage edge bounces.

**C. Least (improved) Energy Injection:** The third technique is the base vitality infusion, which relies upon boosting the dynamic power provided by the system by limiting the dynamic power provided by the compensator. This remuneration is to completely use the vitality

stockpiling; data about the heap current is utilized to limit the consumption of the vitality stockpiling.

#### **4. Hang Detection Techniques:**

A voltage hang identification system distinguishes the event of the hang, the begin point, the end point, hang profundity and stage move. Normal voltage hang identification systems are as per the following. A. Pinnacle esteem technique: The least complex technique for observing the supply is to screen the pinnacle, or abundancy, of the supply voltage, at that point contrasting it and a reference. A controller could be set to perceive if there is a distinction more noteworthy than a predefined esteem and switch in the inverter.

##### **B. Root Mean Square (rms) technique:**

The begin time of the list can be characterized as the principal purpose of  $V_{rms}$  when dips under  $0.9pu$ . To discover the end time of the droop, look for an interim where  $V_{rms}$  dips under  $0.9pu$  for at minimum a large portion of a cycle. The recuperation time is at that point picked as the primary point in this interim.

##### **C. Fourier Transform (FT):**

The FT is accomplished through orthogonal decay of energy framework flag. All in all, a trigonometrically orthogonal capacity set or exponential orthogonal capacity set is used. By applying FT to each supply stage, it is conceivable to acquire the size and period of each of the recurrence segments of the supply waveform. For functional advanced usage Windowed Quick Fourier Transform (WFFT) is utilized, which can without much of a stretch be actualized progressively control framework. The main disadvantage of this strategy is that it takes one cycle to restore the exact data about the list profundity and its stage, since FT utilizes an averaging system.

##### **D. Space Vector Method:**

The three stage voltages  $V_{abc}$  are changed into a two measurement voltage  $V_{dq}$ , which thus can be moved into greatness what's more, point. Any deviation in any amount uncovers the event of an occasion. Looking at these amounts with reference ones will evaluate the unsettling influence in the dq-outline, which must be changed back to the abc outline. This strategy

has no time delay, yet requires complex controller.

##### **5. Moderation of voltage droop:**

At the point when a specific client or establishment experiences voltage lists, various moderation techniques are accessible. These can be assembled as takes after:

1. Lessening the quantity of occasions.
2. Changes in the power framework.
3. Relief at the interface amongst framework and stack.

##### **4. Enhancing end-utilize hardware.**

Lessening the quantity of flaws handles the issue at the source. It won't just decrease the number of voltage lists at the same time, particularly for dissemination frameworks, additionally the quantity of interferences and furthermore expenses could be high. Enhancing the power framework does not diminish the number of voltage lists, however it makes it serious. Another fairly new arrangement is the quick medium-voltage exchange switch. At the point when a voltage hang happens in the supply, the heap is changed to the substitute supply. Utilizing thyristors will give a exchange time short of what one cycle where as utilizing vacuum switches will take maybe a couple cycles for the exchange. The exchange switch can't relieve lists that start in the transmission framework.

#### **6. PROPOSED CONTROLLER FOR DVR:**

DVR control technique depends on inphase remuneration technique, as it will be much more straightforward and henceforth, the controller and subsequently the reaction time will be speedier. It is worth saying that, in spite of the fact that the proposed DVR does not adjust for the stage edges, it tracks them. A basic bolster forward controller procures its voltage esteems from the source, with no criticism from the heap, going for straightforward and quick reaction.

##### **A. Droop Detector:**

In this investigation, the FT system is utilized. It requires no less than one working cycle to recognize the droop begin/end occasions. The DVR won't work on little voltage variety

occasions to keep the operational misfortunes to a base. The yield of the comparator decides the voltage required to be infused by the DVR, and is known as the blunder flag.

### B. Age of the Compensating Voltage:

In the proposed DVR, a sinusoidal PWM plan will be utilized. The inverter utilized as a part of this think about is a six-beat inverter, the transporter waveform is a triangular wave with high recurrence. The essential of PWM is to analyze a sinusoidal control flag of ordinary 50 Hz recurrence with tweaking triangular beats of higher recurrence.

### C. Infusion of the repaying voltage:

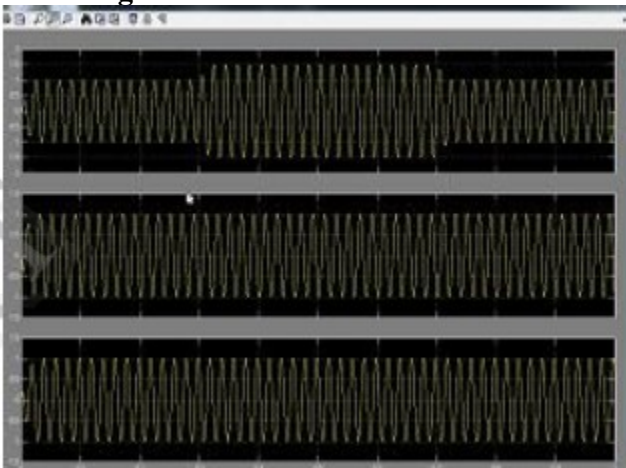
Once the mistake flag greatness surpasses the resilience for dynamic voltage variety, the circuit breakers near associate the DVR in to the circuit by means of the infusing arrangement transformers. In this think about, a 10% over-pay is presented by the controller to neutralize any drops.

## 7. Results

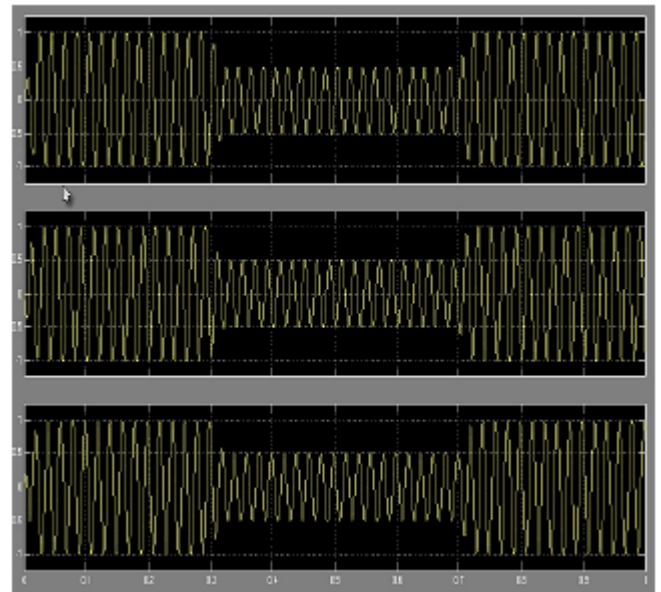
### 7.1 Voltage sag



### 7.2 Voltage swell



### 7.3 Three phase fault of voltage sag



## Conclusion

The reproduction comes about unmistakably demonstrated the execution of the DVR in moderating the voltage droop because of various blame conditions in dissemination framework effectively. DVR is one of the quick and compelling custom power gadgets which has higher effectiveness on voltage list remuneration .Hence this makes the DVR to be a fascinating force quality change gadget.

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