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# Implementing Hardware-Based Dynamic Voltage Restorer to Mitigate Voltage Sag and Swell

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**Abstract:**

The most frequent problems with Power Quality in distribution networks are voltage sag disturbances. The main purpose of a dynamic voltage restorer is to lessen voltage sag. In comparison with commonly used compensators, the proposed technique employs fewer switching devices and has better compensatory capabilities. The Dynamic Voltage Restorer (DVR), often referred to as the Static Series Compensator (SSC), is the best device for shielding delicate loads from unexpected supply interruptions. In order to mitigate voltage sag, this project provides the hardware implementation of a single phase dynamic voltage restorer. The distribution feeder and DVR are connected in series at medium voltages. For medium voltage levels, DVR provides an affordable way to safeguard delicate loads. A DVR might not be as economical for low voltage applications as an uninterruptible power supply. Voltage sags can be remedied by injecting power and voltage into the distribution system. To prevent voltage decreases, the DVR has the capacity to generate and absorb both reactive and active power.

**Keywords:**

Static Series Compensator (SSC), Dynamic Voltage Restorer (DVR).

## I. INTRODUCTION:

The most significant problem with power quality is definitely voltage sag. It is described as a brief decrease in voltage magnitude. The main source of voltage sag is a brief rise in current, which typically occurs during breakdowns, transformer energising and the motor starting. Short circuit problems in the gearbox system that occur hundreds of kilometres away can be the source of voltage dips at equipment connections.
Power quality, or PQ, is a crucial component of power systems that indicates the caliber of the energy supplied to users. An increasing number of power systems are using equipment based on power electronics, which might result in voltage aberrations that could harm a distribution grid appliance that is sensitive. In addition, a lot of electrical and electronic equipment in contemporary industrial settings is vulnerable to power supply disruptions.

Temporary power outages and voltage sags are the two most important power quality problems impacting major commercial and industrial users. These PQ problems are typically linked to malfunctions in the systems that supply electricity. Because voltage sags can be linked to failures that occur remotely for the client, they are quite prevalent.

A particular kind of custom power device (CPD) that may guard sensitive equipment from voltage disturbances and enhance power quality in electrical distribution networks is the dynamic voltage restorer (DVR). Numerous CPDs have been created recently in response to industry demands and the development of their essential loads. One of the most promising CPDs for protecting electric appliances from harm is the DVR, which enhances power quality before supplying it to sensitive loads.

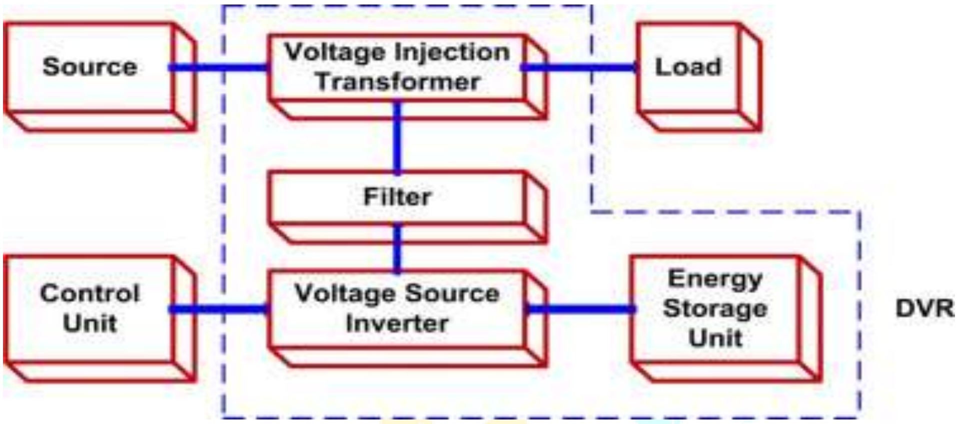
## II. DYNAMIC VOLTAGE RESTORER (DVR):

Dynamic Voltage Restorer (DVR) is a method for stabilizing electrical power distribution voltage. DVR devices can save energy by injecting voltage into the circuit to regulate the voltage and waveform of the power being supplied.

Improving the power quality is imperative since sensitive loads in the distribution system are growing daily. With DVR, these delicate loads may be shielded from voltage fluctuations. The DVR is a series-connected solid-state power electronic switching device that applies a voltage to the load and subsequently restores the line voltage to the loads that are sensitive to voltage sag.

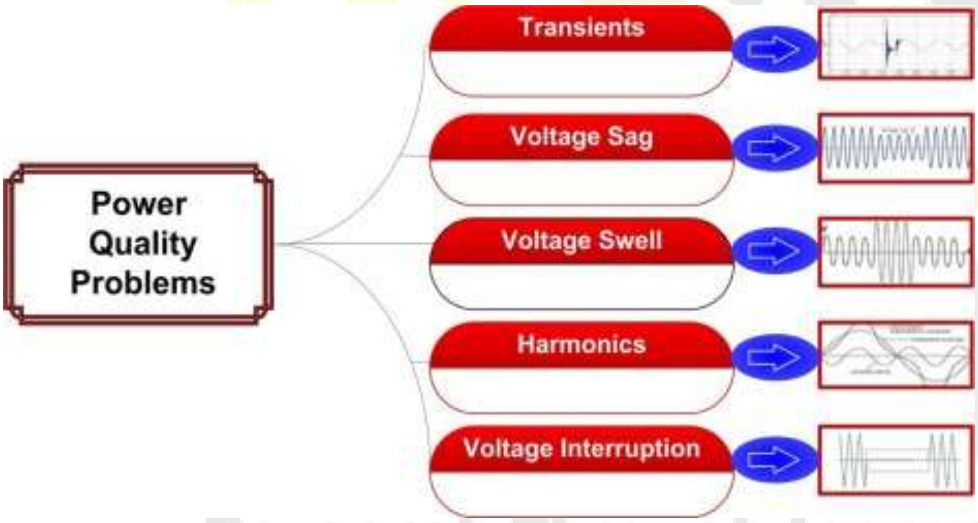
Some key points about DVRs:

- DVRs can inject up to 50% of nominal voltage for a short time (up to 0.1 seconds)
- DVRs can mitigate voltage swells, unbalance, and waveform distortions
- The devices employ gate turn- off thyristors in a pulse-width modulated inverter structure
- The amplitude and phase angle of the injected voltages are variable




Power quality challenges such as voltage sag, voltage swell, voltage transients, voltage interruptions, and harmonics are becoming increasingly serious worldwide.

It has been observed that power quality issues cost US companies over 22 billion dollars in losses in a single year, and in 1991, over 500 customers suffered losses due to equipment failure or damage. Voltage sag is an electrical power distribution network issue that frequently occurs and puts the network's sensitive loads at risk. For stabilisation, we employed solid state transfer switches, uninterruptible power supplies, distribution series capacitors and power factor correctors, static synchronous compensators, and solid state VAR compensators. However, we are now dealing with issues like hard maintenance, expensive services, and a need for a lot of space. The Dynamic Voltage Restorer (DVR) is a valuable solution to reduce the issue of voltage sag.




Voltage sags are the most disruptive of the power quality problems (sag, swell, harmonics). The idea of customized power devices was developed to address these issues. The most effective and efficient bespoke power device utilized in power distribution networks around the globe is the Dynamic Voltage Restorer (DVR).

A DVR is a power electronics converter-based device designed to safeguard essential loads against supply-side voltage disruptions. It is connected in series with the distribution feeder and has the ability to produce or absorb real and reactive power at its ac terminals.

In August of 1996, the first Dynamic Voltage Restorer (DVR) made by Westinghouse for Electric Power Research Institute (EPRI) was installed on the 12.47 kV system of Duke Power Company (North Carolina).

More attention has been paid to DVRs and dynamic sag correctors than to other power quality compensators because they provide an affordable way to deal with voltage sags, which are the most frequent and severe voltage disturbances. A drop in the RMS ac voltage (10–90% of the nominal voltage) with a power frequency of 0.5 cycles to one minute is referred to as a voltage sag. Voltage sag is typically induced by short circuit failures, such as a single-line to ground fault in a power system, the start-up of large-rated induction motors, and the presence of heavy load connections. The simplest and flexible method is to use power electronic devices as compensators. These compensators comprise series-parallel compensators, which are also known as custom power devices. Series compensators, such as Static Series Compensator (SCC), Dynamic Voltage Compensator (DVC), and Dynamic Voltage Restorer (DVR), are regarded as the most cost-effective methods for voltage compensation in distribution systems.

**BLOCK DIAGRAM OF DVR:**

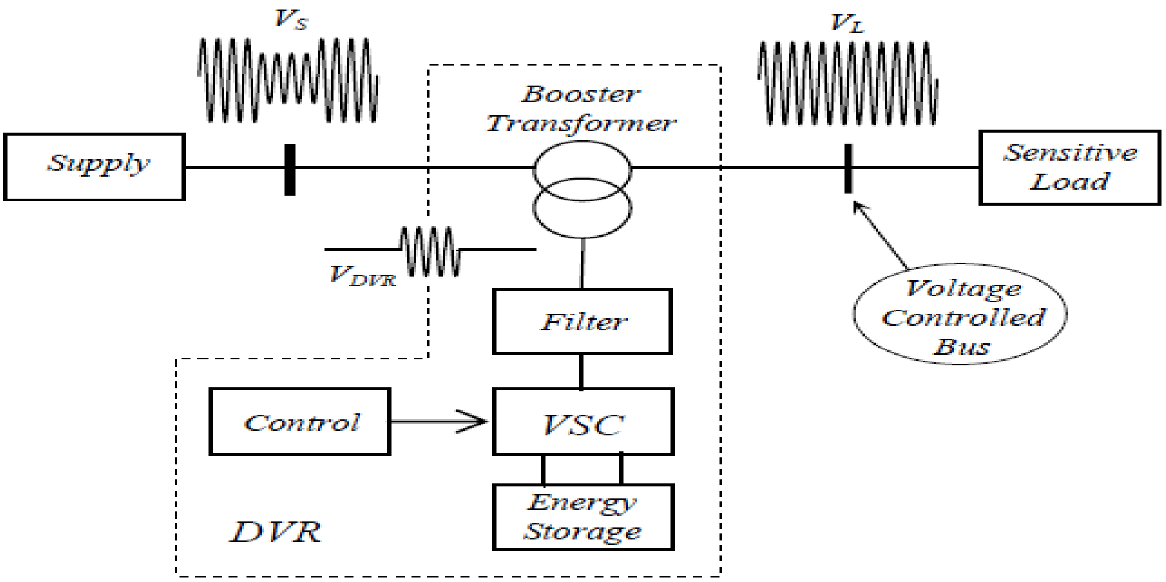



Fig. 1 displays a schematic representation of the DVR integrated into a distribution network. The line current is I, the source voltage is Vs, and the DVR's series injected voltage is VDVR. Usually, an injection transformer with its secondary winding linked in series with the distribution line makes up the DVR. In order to respond to a voltage disturbance upstream, a VDVR has to receive both real and reactive power from the DVR.

The fundamental idea of a dynamic voltage restorer is to, in the event that the source voltage is distorted or unbalanced, inject a voltage of the proper magnitude and frequency to restore the load side voltage to the necessary amplitude and waveform. In order to make up for voltage dips in the grid line caused by faults, the Dynamic Voltage Restorer (DVR) is a voltage source converter connected in series with the grid. In fact, it rectifies the voltage at the electrical load terminals by producing a series voltage

**HARDWARE DESIGN:**

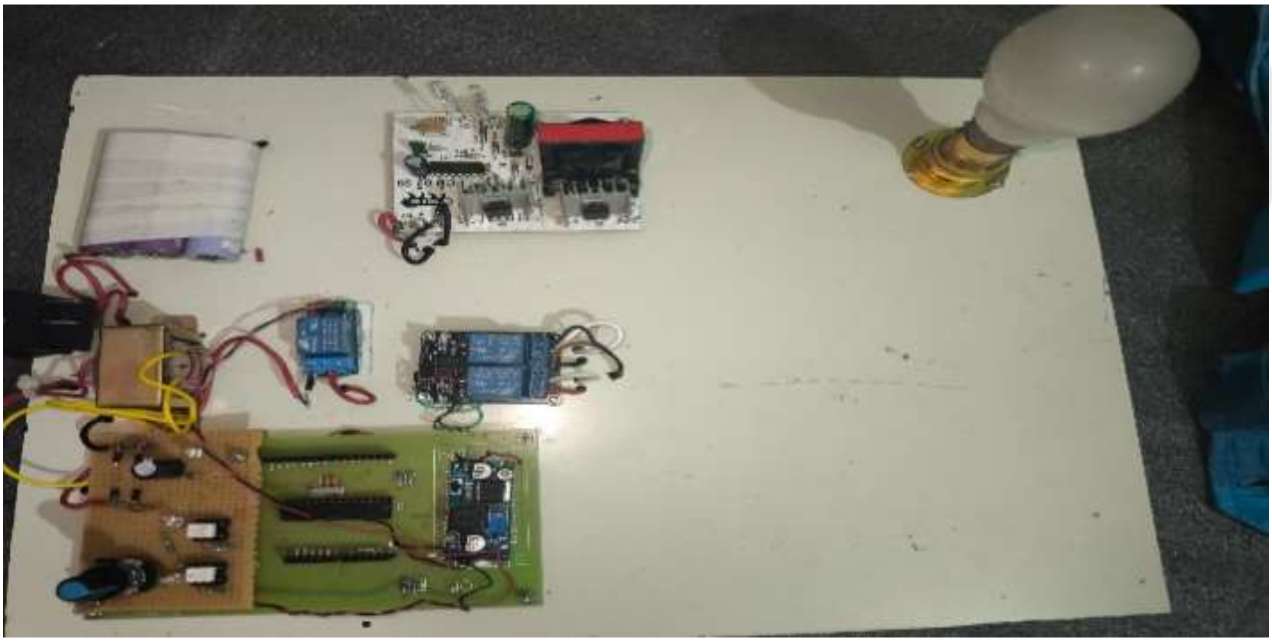


**Fig 2 Hardware of DVR**

**Components of DVR Hardware**

1. **Inverter Circuit**

Dynamic Voltage Restorers (DVR) are complicated static devices that add the 'missing' voltage during a voltage sag. Basically, the device injects power into the system to restore the voltage to the level required by the load.

2. **Opto coupler**

An optocoupler can separate two circuits electrically from one another and pass an electrical signal between them. Typically, they have a silicon photo detector at the output, a light-emitting part at the input, and an infrared LED.

3. **Microcontroller**

An Atmega-328P microprocessor is included in this dynamic voltage restorer's circuitry. This particular kind of microcontroller has three ports in addition to 28 pins. Port B, Port C, and Port D are the names of the three ports. An analog port with six pins overall is called port C. Digital ports B and D each contain 7 pins.

4. **Coupling network**

The voltage source inverter, coupling transformer, and interfacing filter work together to provide the voltage waveform needed to reduce voltage fluctuations in the load circuit. In order to prevent the transformer winding from causing a voltage drop across the load, the coupling transformer has to transport energy from the voltage source inverter to the load and offer low impedence on the load side.

**Conclusion**

The DVR hardware idea is explained in this article. The proposed technique maintains the load voltage magnitude at the appropriate value, which may help both identify and reduce voltage sags. The suggested device's performance is found to be appropriate based on theoretical studies.

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