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Hardware Implementation of Dynamic Voltage Restorer to Reduce Voltage Sag/Swell

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Abstract:
Voltage sag disturbances are the most common Power Quality issues in distribution systems. Dynamic Voltage Restorer is usually used as a way to reduce voltage sag. The suggested method requires fewer switching devices and has superior compensating capabilities compared to frequently utilised compensators. The Static Series Compensator (SSC), also known as Dynamic Voltage Restorer (DVR), is ideal for protecting sensitive loads from incoming supply disruptions. This project presents the hardware implementation of single phase Dynamic voltage restorer in mitigating voltage sag. The DVR is linked in series to the distribution feeder at medium voltages. DVR offers a cost-effective solution for protecting sensitive loads at medium voltage levels. For low voltage applications, a DVR may be less cost- effective than an uninterruptible power supply. Voltage and power injections into the distribution system can be used to overcome voltage sags. The DVR has the ability to both produce and absorb reactive and active power in order to guard against drops in voltage.

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

1. 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.

2. DYNAMIC VOLTAGE RESTORER (DVR):

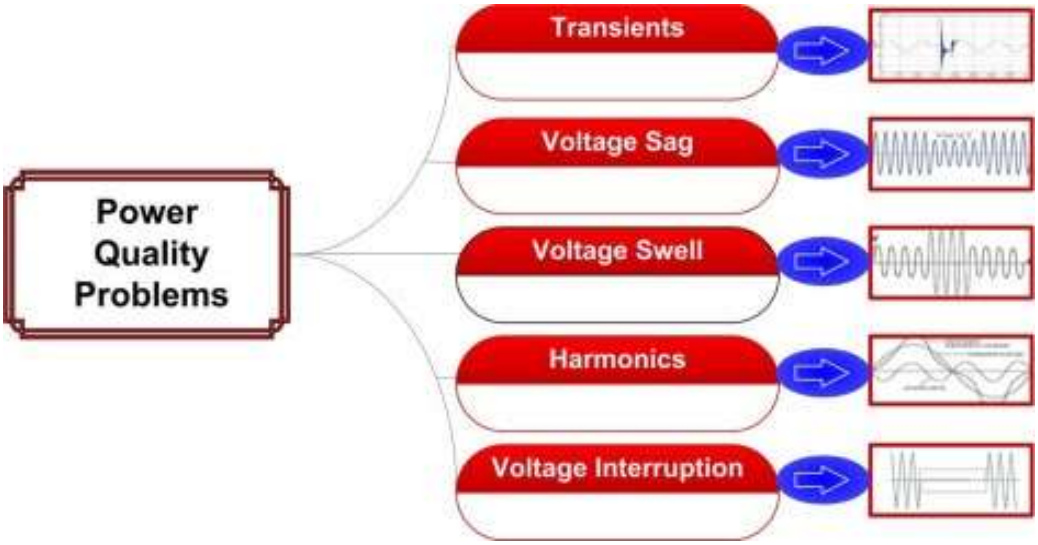
Dynamic Voltage Restorer (DVR) is a method for stabilizing electrical power distribution voltage. DVR devices can save energy by injecting voltage into the circuit to regulate the voltage and waveform of the power being supplied

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.



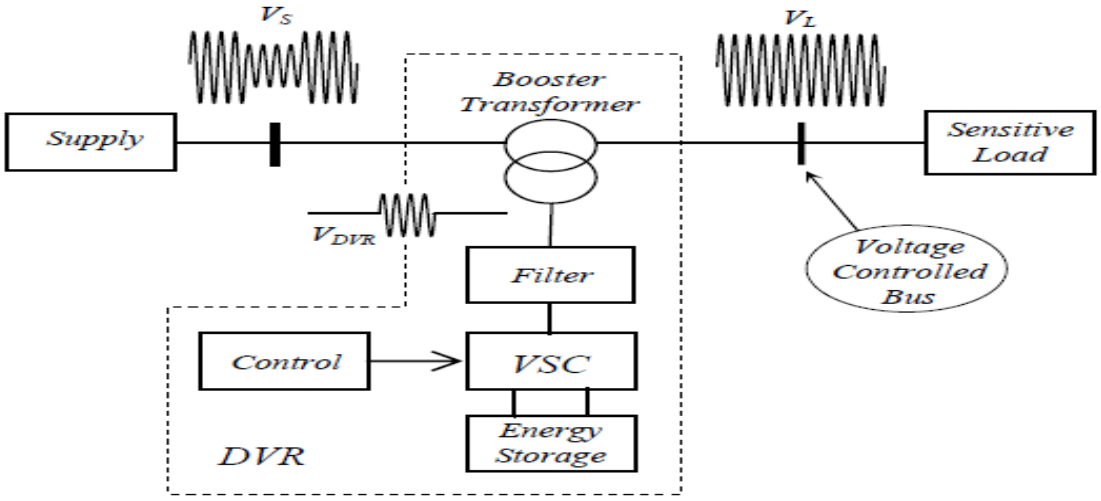
The most severe disruptions among the power quality issues (sag, swell, harmonics) are voltage sags. To overcome these problems the concept of custom power devices. Dynamic Voltage Restorer (DVR) is the most efficient and effective custom power device used in power distribution networks worldwide.

A DVR is a power-electronics converter-based device developed for protection from supply-side voltage interruptions for critical loads. It may generate or absorb real and reactive power at its ac terminals and is linked in series with the distribution feeder.

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

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:



A schematic diagram of the DVR incorporated into a distribution network is shown in Fig. 1. Vs is the source voltage, V_{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. To inject a VDVR in response to an upstream voltage disturbance, the DVR must offer both actual and reactive power.

The dynamic voltage restorer's main premise is to inject a voltage of the appropriate magnitude and frequency to restore the load side voltage to the required amplitude and waveform, even if the source voltage is imbalanced or distorted. The Dynamic Voltage Restorer (DVR) is a voltage source converter linked in series with the grid to compensate for voltage dips in the grid line during faults. Indeed, it creates a series voltage to rectify the voltage at the terminals of electrical loads.

HARDWARE DESIGN:

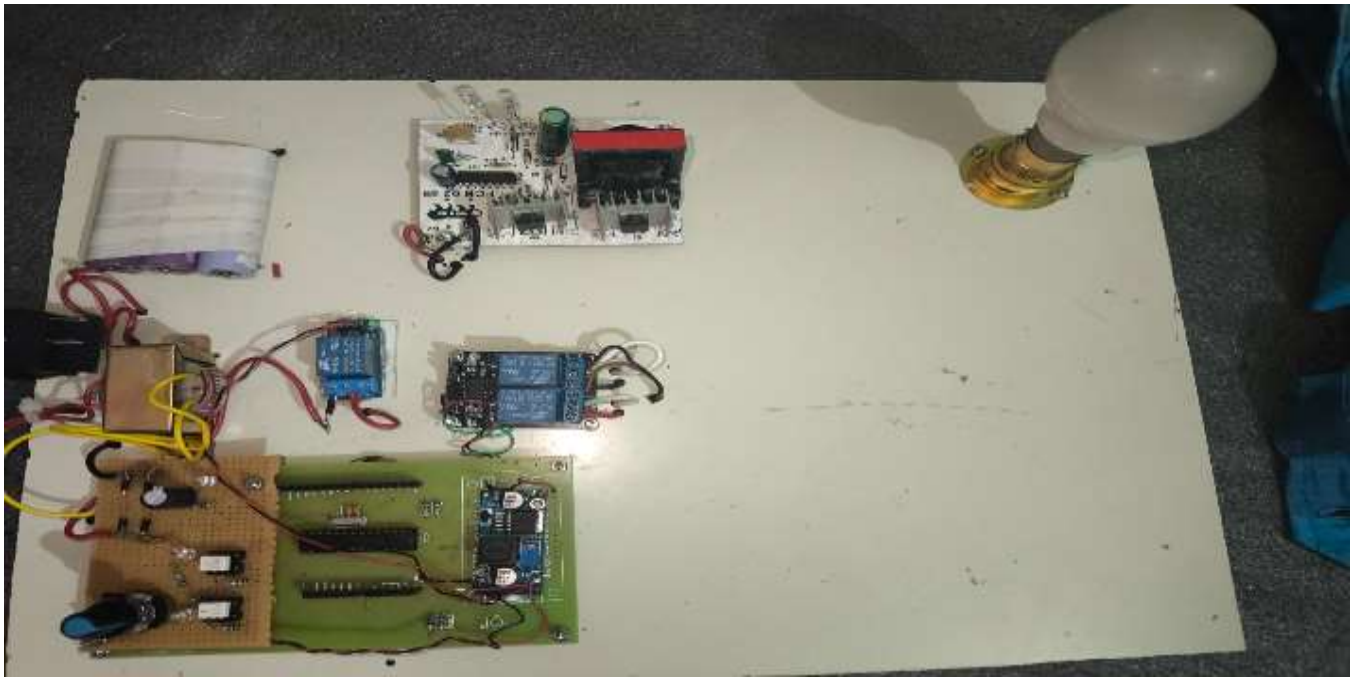


Fig 2 Hardware of DVR

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

This article sets out the DVR hardware concept. The suggested method may both detect voltage sags and mitigate them by keeping the load voltage magnitude at the intended value. Theoretical findings validate the performance of the proposed device, which is determined to be adequate.

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