

# Hardware Implementation to Mitigate Voltage Sag and Swell by Using DVR

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**Abstract**—The most important aspect of electrical engineering is power quality in recent year. Power quality problem is occur by abnormal voltage, frequency and current. The major problem are occur here are voltage sag or swell. Now a day there are many custom power devices which are used to mitigate the power quality problems. Such as dynamic voltage restorer can be used to compensate voltage sag or swell in the system. Dynamic Voltage Restorer is connected in series between source and load. It is a custom power electronics based device that can mitigate the power quality issues and restore the load voltage to a pre-fault value. The component of Dynamic voltage restorer consists of voltage source inverter (VSI), injection transformer, filter and energy storage device.

**Keywords**— Dynamic voltage restorer (DVR), Voltage sag or swell, Power quality, Voltage Source Inverter (VSI).

## I. INTRODUCTION

Voltage sags and swells in the industrial distribution system are the most severe disturbance at electrical grid because of the sufficient clearing time of the faults which create voltage sag and propagation of sags from the transmission and distribution system to the low voltage loads. Voltage sags are decrease of the normal voltage level between 10 to 90% of rms voltage, for durations of 0.5cycle to 1 min. Voltage swells are increase of the voltage beyond the normal voltage level with duration of more than 3cycles.

There are many types of methods are used to compensate the power quality issues mostly voltage sags and swells are active power filters, battery energy storage systems, Distribution static synchronous compensators, distribution series capacitors, surge arresters, super conducting magnetic energy systems, static electronic tap changers, solid stat transfer switches, solid state fault current limiter, static VAR compensators, Thyristor switched capacitor, Uninterruptable power supply (UPS) and Dynamic Voltage Restorer (DVR).One of them is the use of FACTS for the transmission system which improves just power transfer capability and stability compensating the sags and Swells is low because of the tap changing under load goes to very costly. The most frequently used way to improve power quality issue is to install DVR on the sensitive load side which provide both voltage compensation and fault current limiting Functions.

## II. PRINCIPLE OF DVR

The Basic operating principle of a DVR Is to insert a voltage of required magnitude and phase in series with a distribution feeder to maintain the desired Amplitude and waveform for the load voltage Moreover, The compensation capability is sensitive to the load level, and is independent of the system short circuit capacity and the installation position. To improve the compensation capability of DVR, Such as the large amplitude or long duration voltage fluctuation, the energy storage unit is essential to supply the power transfer during the voltage compensation.

Loads connected downstream of the DVR are thus Protected from any power quality problems due to faults occur on the network. The location of DVR, in terms of the connection arrangement of upstream injection transformers and type of protection is to propose to potentially sensitive loads, is a major factor when determining the type of the inverter control requisite. The DVR is located downstream of a delta-star distribution transformer.

The conventional DVR basically consists of:

1. Booster transformer
2. Harmonic filter
3. Storage Devices
4. A Voltage Source Converter (VSC)
5. DC charging circuit
6. A Control and Protection system.

### 2.1 Booster Transformer

The Injection transformer is a specially designed transformer that attempts to limit the coupling of noise and transient energy from the primary side to the secondary side. Injection transformer is nothing but booster transfer which used to boost up the remaining voltage to the rated voltage magnitude. it is used as a step up transformer which can step up the voltage which is required.

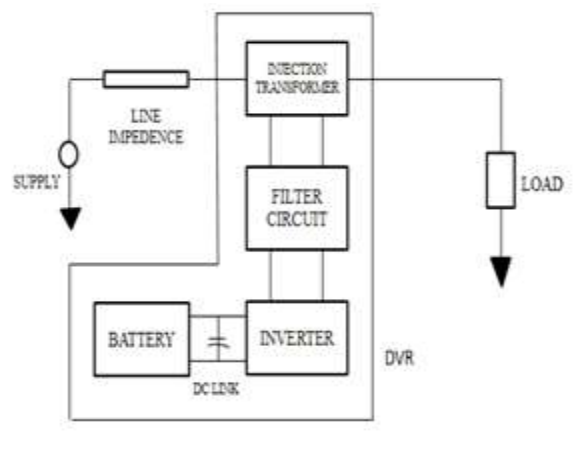


Fig.1 Block diagram of DVR

### 2.2 Storage Device

A DC-link voltage is used by the VSC to produce an AC voltage into the grid and during a majority of voltage sags active power injection is required to restore the supply voltages.

### 2.3 Harmonic Filter

The harmonic filter is inserted to reduce the switching harmonics; common sources of harmonics are electronic loads. Due to these sources of harmonics, harmonic currents generate harmonic voltage as they pass through the system impedance. These harmonic equipment can cause input voltage fluctuations, additional heating, over voltages in power system.

### 2.4 DC Charging Circuit

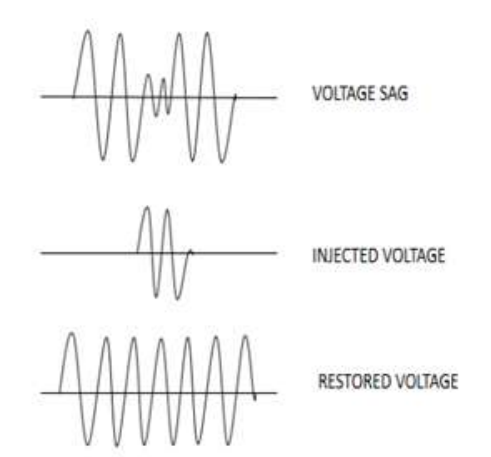
It has two main tasks: The first task is to charge the energy source after a sag compensation event. The second task is to continue dc link voltage at the supposed dc link voltage.

### 2.5 Voltage Source Converter

The converter is most likely a Voltage Source Converter (VSC), which Pulse Width modulates (PWM) the DC from the DC-link/storage to AC voltages injected into the system. A VSC is a power electronic device consists of a storage device and switching devices, which can generate an AC voltage at any essential frequency, magnitude, and phase angle. In the DVR

application, the VSC is used to provisionally replace the reference voltage or to generate the part of the supply voltage which is missing.

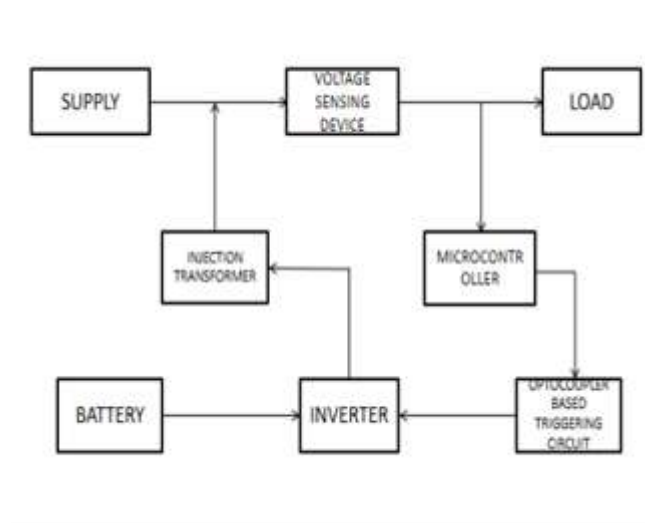
### 2.6 Waveform:-



**Fig.2 Waveform**

### III. WORKING

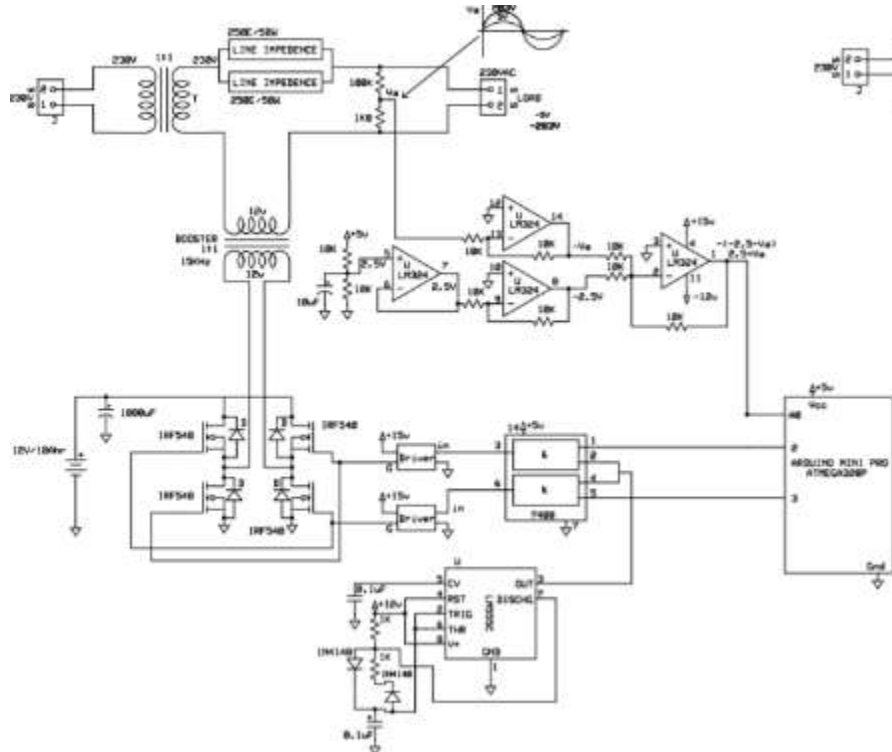
This is the hardware implementation of Dynamic Voltage Restorer (DVR) designed for mitigation of voltage sags.



**Fig.3 Block diagram of hardware implementation**

In the block diagram, the 230V, 50 HZ supply is isolated by means of a 1:1 (230/230), 150VA isolation transformer. This isolated voltage is treated as the line voltage, which supplies power to the load, through simulated line impedance. The simulated line impedance is simply a wire wound resistor. To have maximum effect of voltage drop = across the line impedance, the resistance value considered is of very high value, 120 Ohms. After this simulated line impedance, a switch is connected, through which the load can be connected or disconnected. In the return path, the DVR output is connected, by means of the output winding of the coupling transformer developed. This output from the DVR is connected in series with the load, and mitigates the line impedance effects, i.e. in this case the voltage drop caused by it. The DVR circuit has to check the load voltage and need to be connected to the micro controller circuit and correct the voltage if there is any shortage or excess when compared to a Reference voltage, by injecting appropriate voltage into the micro controller can't read voltages more than 5V. As the  $230\sqrt{2}$  V

of positive and negative peak voltage cannot be directly fed to the micro controller circuit, this voltage is attenuated to 2.5V at peak points by means of a potential divider. The potential divider is basically a resistor divider network, with resistors R1 and R2 as shown in the figure. One of these resistor values is arbitrarily chosen and the other value is calculated, as explained below. Initially, the R2 value is assumed and is 1.8KΩ. The supply peak voltage, output voltage, R1 and R2 values are related by the following equation.  $(R2 \div (R1+R2)) \times 230\sqrt{2} = 2.2 \text{ V}$  Here, the R1 value is calculated and is 2.6k The output voltage is considered to be 2.2V, instead of 5V that can be accepted by the micro controller circuit. The micro controller has to sense both positive and negative = voltages, and the range it can accept is only 0 to 5V. Thus, for positive and negative peaks if 2.5 V is generated as the output, = then if 2.5 V is added then the output remains in the range of 0 to 5V. But, the input supply.



**Fig.3 Circuit diagram of DVR hardware implement**

Voltage can have a value more than 230V rms. In order to accommodate the excess voltages, instead of 2.5 V for peak voltages 2.2V is generated. Thus, another 0.3 V is there to meet the higher voltages. If the lamp load is not connected, the output of the isolation transformer does not have any drop, and the full voltage appears across the sensing circuit, and there is no need of any correction by the DVR circuit. When the load is connected, the lamp glows and current flows through the simulated line impedance, and there is an appreciable voltage drop across the line impedance, and this drop in voltage need to be injected by the DVR circuit.

### 3.1 Dynamic Voltage Restorer:

The functioning and designing of different blocks of dynamic voltage restorer is discussed herewith.

#### 3.1.1 Single phase voltage source bridge inverter

The voltage source inverter used in the DVR circuit makes the induction of required voltage with required phase possible. This inverter uses dc capacitors as the supply and can switch at a high frequency to generate a signal which will mitigate the voltage sags and swells across the load.

### 3.1.2 Micro controller circuit

The microcontroller circuit is the heart of the system, and is responsible for generating the reference voltage waveform from the voltage waveform that is sampled from the sensing network, which it has obtained from the reference voltage sensing circuit. This reference voltage waveform is generated keeping the zero crossing as the reference to maintain the phase relationship of the load and correcting voltage. As the voltage induced through the coupling transformer, generated by the bridge inverter, the resulted voltage across the load will be a pure sinusoid of required voltage.

### 3.1.3 Opto coupler and driver circuits

Opto couplers are capable of transferring an electrical signal between two circuits while electrically isolating the circuits from each other. They generally consist of an infrared LED, light emitting section at the input and a silicon photo detector at the output. The input for opto couplers can be either AC or DC, which can drive the LED.

### 3.1.4 Coupling network

The voltage waveform for mitigating the voltage variations in the load circuit is achieved with the voltage source inverter, coupling transformer and an interfacing filter. The coupling transformer needs to transfer energy from the voltage source inverter to the load and at the same time need to provide low impedance on the load side, so that the transformer winding itself does not provide a voltage drop across the load.

### 3.1.5 Inverter driving circuitry

In order to trigger the IGBTs, it is required to apply a +12V pulse to make it turn „ON“ and -12V pulse to turn it „OFF“ to the gate with respect to its emitter. Thus, in order to provide triggering pulses to each and every MOSFET, it is required to have four isolated power supplies of  $\pm 12V$  which can be used to apply trigger pulses to the respective MOSFETs. This inverter provides the required outputs, which can be used to drive the opto-coupler secondary side, which is meant for driving the IGBT gate.

### 3.1.6 Isolated power supplies for filter elements

Three different power supplies are required, to provide power to various blocks of the over-all DVR circuit. The micro controller requires basically a 5-V supply. But, the op-amp circuit associated with the potential divider circuit requires a  $\pm 12$  volts supply. This supply is generated from a step-down transformer connected to the mains. The DVR inverter requires a separate power supply, and this is generated from another step-down transformer and another 12-V supply is generated using another step-down transformer, which is mainly to power the isolated power generator circuit.

## IV. FUTURE SCOPE

Study and control of power quality issues for deregulated power system.

## V. CONCLUSION

In this paper, hardware protocol model of DVR is setup. The proposed technique could identify the voltage sag and is capable of mitigating the sag by maintaining the load voltage magnitude at desired voltage and THD within limits. The proposed technique is simple and uses only one switching per phase. Hence the system is simple, economical and does not require energy storage device as compared to commonly used DVR or STATCOM. Performance of the proposed device is verified by theoretical results and is found to be satisfactory. Best control strategy for sensitive loads which can't withstand for phase angle jumps is pre-sag compensation. For minimum voltage injection, in- phase injection compensation is the best. For minimum energy injection by the DVR, phase advance compensation is best but requires more voltage injection.

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