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MITIATION OF VOLTAGE SAG USING DYNAMIC VOLTAGE RESTORER (DVR)

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***Abstract*— Various factors that affect the power quality are voltage unbalance, presence of harmonics, interruptions, the occurrence of faults, and the presence of voltage sag and voltage swell. Out of all the power quality issues, the presence of voltage sags is the critical problem. To address the issues of power quality, special devices are available, which are called flexible alternating current transmission system (FACT) devices.In this paper , various power quality issues are presented. Among all, the occurrence of voltage sag is studied and analyzed. The control circuit to mitigate the voltage sag issues is modeled and simulated. The dynamic voltage restore is used to compensate for the voltages that fall out of the limits. The entire analysis is carried out in MATLAB/SIMULINK. The detailed model for the dynamic voltage restorer is also presented. The circuit topology, control logic, various subsystems, and generation of the voltage sag are important aspects of this paper.**

***Keywords*— power quality ,voltage sag , voltage swell, dynamic voltage restore**

I. INTRODUCTION

Due to the development of semiconductor technology, the era of power electronics is changed drastically. Newer elements and devices with fast response characteristics and with compact size have emerged. Due to the attractive features of those elements/devices, the control of power became easy and flexible. Various applications of the semiconductor elements are shown in the figure below. Most of the commercial, industrial, and domestic loads are designed with these kinds of elements. The entire system is occupied by the semiconductor elements. Despite the advantages of modern semiconductor elements, the major drawback is, they impose nonlinearity into the system. Due to the non-linear property of those elements, a lot of issues are present in electrical power. The issues are not only limited to the electrical distribution system but also extended to the power transmission system. Those issues affect the quality of electrical power. So, they are called power quality issues/problems.

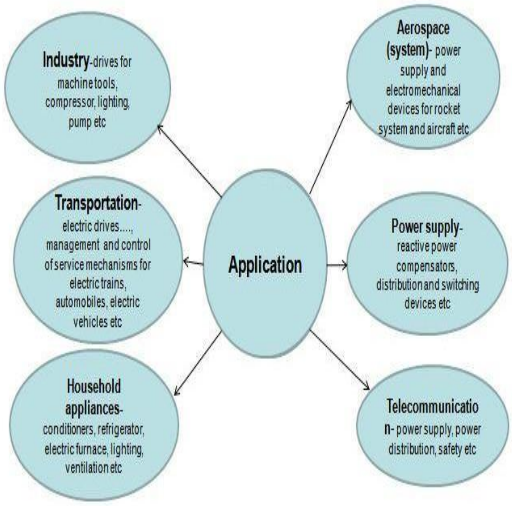


Figure 1 Applications of modern semiconductor devices

The reactive power compensation technique is used in FACTs devices. There are two components of electrical power. The active power and reactive power. The active power is consumed by all loads, whereas loads do not consume reactive power. The disturbances in real or active power can be suppressed using the unused reactive power. This technique is known as reactive power compensation. All the FACTs devices work on the same technique, even though different devices will provide a solution to different problems.

A. *Types in FACTs Devices*

The FACTs devices are classified

based on the connection in the lines. By considering that factor, they are classified as the following types

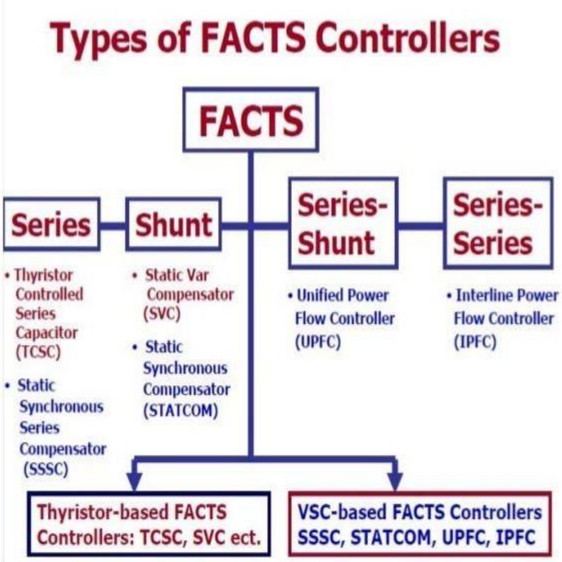


Figure 2 FACTS classification

B. *Compensation by FACTs*

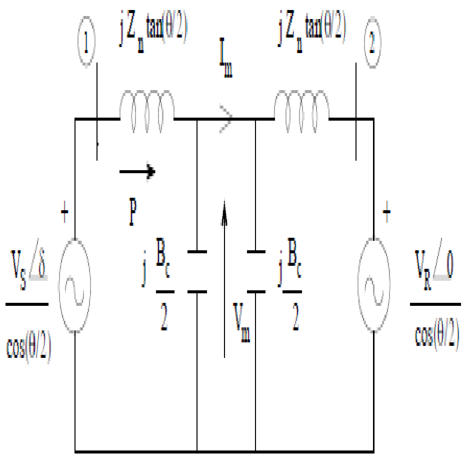


Figure 3 Equivalent circuit of shunt compensation

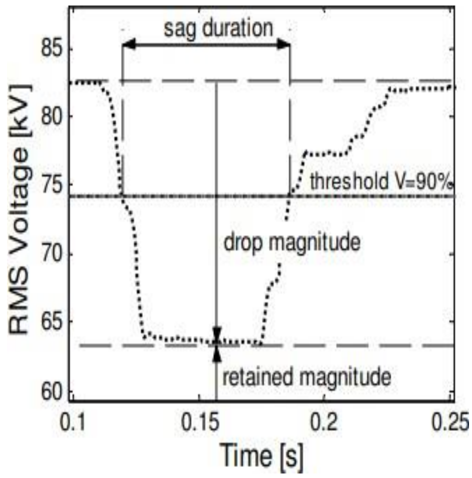
The above circuit shows the equivalent circuit of the shunt compensation in lines. Two capacitors connected across the line are used as the reactive power sources in shunt compensation. Half of the capacitance is near the first end, and the remaining half is placed near the second end. Usually, the first end is the source end or sending end. The second end is load end or receiving end.

II. VOLTAGE SAG ANALYSIS

A. *Duration and Magnitude*

The magnitude and duration are the most important characteristics of voltage sag. These parameters are defined as follows

- The amplitude of the voltage drop in the system is called the sag magnitude
- The time for which the magnitude is lower than the actual system voltage is called the duration of the sag



Type of Sag	Duration	Magnitude
Instantaneous	0.5 - 30 cycles	0.1 - 0.9 pu
Momentary	30 cycles - 3 s	0.1 - 0.9 pu
Temporary	3 s - 1 min	0.1 - 0.9 pu

Figure 4 sag properties

Table 1 Classification of sag according to IEEE 1159

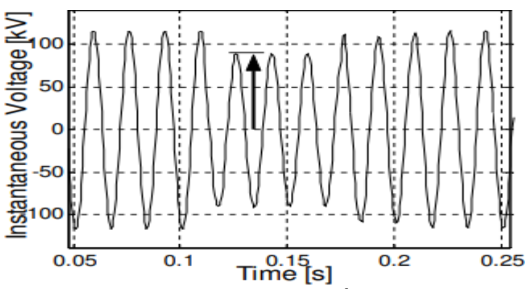


Figure 5 Sag waveform

III. DYNAMIC VOLTAGE RESTORER (DVR)

The dynamic voltage restoration process is presented using the dynamic voltage restorer device. The configuration of the DVR is shown in the figure below.

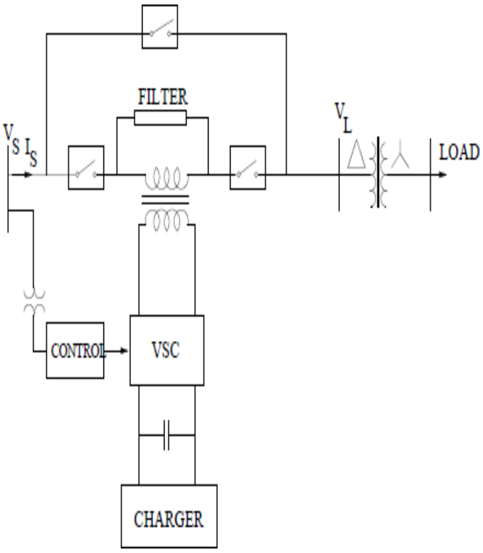


Figure 6 Structure of DVR

A. Operation

The DVR can be operated as a series compensating device. It can be operated in combination with a voltage source converter to get the best results in improving the power quality issues. DVR has the following operating modes

- Standby mode
- Boosting mode

During the first mode of operation, it will not inject any voltage into the system. Only it will be in standby mode. Whereas, in the second mode, the DVR injects the voltage into the system for voltage compensation.

The DVR requires the continuous operation of following the following subsystems

- Boost transformers
- Passive filtering equipment
- Energy storage device
- Control circuit

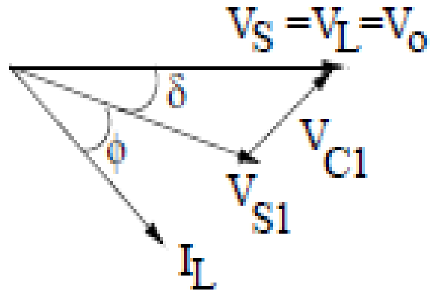


Figure 7 DVR injected voltage

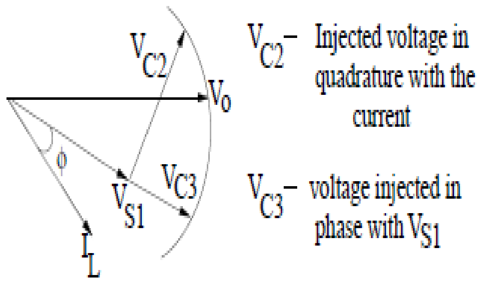


Figure8 Alternate control logic

B. Protection and control

While mitigating the voltage sags and the other voltage compensation, it has to consider the following things.

- The energy storage system is ON during standby mode so that DVR will operate in self-charging mode.
- During sag/swells, it has to inject the voltage into the system; in that injected voltage, the presence of zero sequences is not required.
- It should have appropriate protection equipment to protect from sudden short circuits. So the breakers and other protection equipment need to be used.

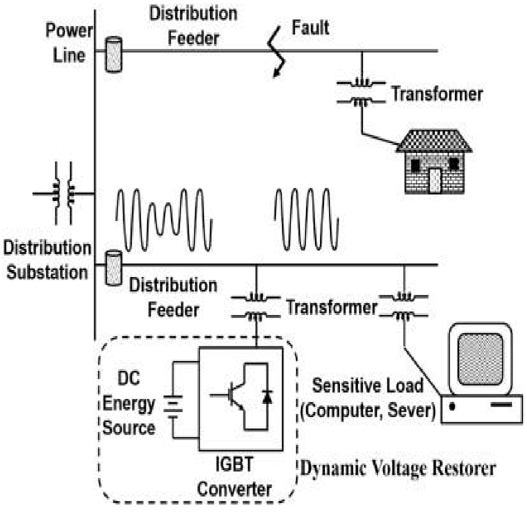


Figure 9 Installation of DVR

IV. SIMULATION RESULTS

the simulation results obtained for the dynamic voltage restorer for suppression of voltage sag is presented. Entire simulations are carried out in MATLAB/SIMULINK. The results are shown for the single-phase and three-phase systems.

A. *Sytem Specification*

The following are the system specification. The system considered here is the single- phase system; it consists of the following specification.

- A fault occurs at 0.015s to 0.27s, during this the voltage sag occurs
- A fault occurs at 0.37s to 0.43s, during this the voltage swell occurs
- The supply voltage is 230 V RMS.
- The inductive load is used in the simulation
- The step size used in the simulation is 1e-5.

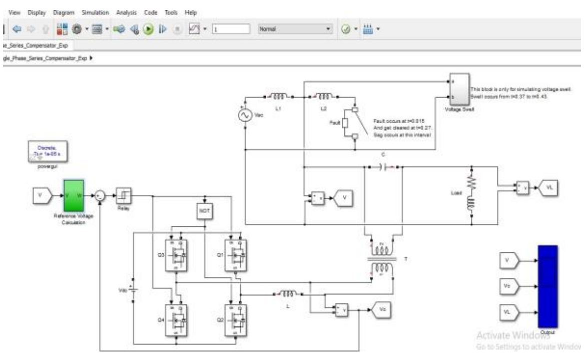


Figure 10 Single-phase DVR for mitigation of Voltage sags and Swells

B. *Output waveforms of Single phase*

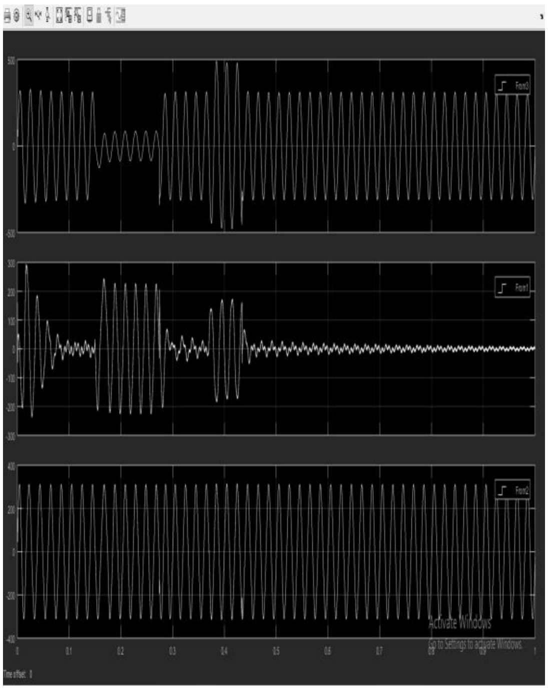


Figure 11 Supply voltage, reference voltage, and the output voltage of DVR

In the above figure, the first waveform shows supply voltage, in which voltage sag and swell are present.

- The second figure shows the reference voltage generated by DVR, which is injected into the system; only during voltage sag and swell, the magnitude of the reference voltage is maximum; otherwise, it is minimum.
- The third waveform shows the output voltage at the load terminals, irrespective of the presence of voltage sags and swells; the output is like a pure sinusoidal waveform.
- From the sinusoidal voltage, it can be stated that the presence of dynamic voltage restorer suppresses the voltage sags and swells.

V. CONCLUSION

Following are the conclusions of the present work carried out in this report

- DVR is the best device to mitigate the voltage sags and swells in the lines
- The sags that occur in transformer are not possible to suppress
- The sag and swell generation mechanism is different
- The DVR response for voltage sags and swells in equal.

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