MODELLING AND SIMULATION FOR VOLTAGE SAGS/SWELLS MITIGATION USING DYNAMIC VOLTAGE RESTORER (DVR)

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ABSTRACT

Quality of supply plays a major role in power system. There are various power quality problems which affects operation of sensitive loads. As technology is improved there are many devices whose performance is sensitive to the power quality of supply. Lower power quality may cause failure or damage to the equipment and also interruption in required working operation. Among such power quality problems voltage sag due to various reasons can in many cases be the most considerable power quality problem. There are various custom power devices are used to overcome such problems of power quality. A Dynamic Voltage Restorer (DVR) is one of those devices, which is used to handle deep voltage sags, swells. The DVR is a series connected voltage compensating device which has excellent dynamic capabilities, which can compensate for voltage sags/ swells. It can provide the better solution to reduction in cases of voltage sag by injecting voltage into the system. In this paper we have presented modeling and simulation of a Dynamic Voltage Restorer (DVR) using MATLAB. The efficiency of the DVR working depends on the performance of the efficiency control technique. In this simulation we have used a PI controller and Discrete PWM pulse generator to compensate voltage sag.

Keywords—DVR, Sags, Swells, Power Quality

INTRODUCTION

An electrical power system is a network of electrical components deployed to supply, transfer, and use electric power. In industry commercial area and homes we have requirements of continue power supply without any sag but we have many big drawbacks and harmonics .whenever the sudden power distribution has stop it will leads to the damage of whole units , system or appliances. We have lot of distortion in a power supply since the power system established. Power quality is the most important for the reliable power system as there are sensitive load connected in power system. The power coming from the source is in sinusoidal form some times with the many distortion in the industrial, commercial as well as household consumers of electricity. As the system is consist of many sensitive load. During the supply there is problem of voltage sag and voltage swell. The sudden increase in voltage than the rated voltage is called as the voltage sag and the sudden decrease in voltage as compared with rated voltage is called as voltage swell. Both the conditions always cause to damage the equipment connect in the system or may be whole system. So to overcome this problem Dynamic voltage restorer is used. Dynamic voltage restorer(DVR) detects and compensate the voltage sag and voltage swell before damage and the system will continue to work without interruption. This study gives the information about the power quality problem and the concept of DVR as well as detail working of dynamic voltage restorer.

Every equipment of the power system is designed for the particular rating. when the power exceeds The rated ratings of that equipments it may cause the damage of equipments the sudden change in power coming from the source can be defined as the deviation of the voltage and current. To detect and compensate the change in voltage the DVR (dynamic voltage restorer) is used.

Voltage swells are not as important as voltage sags, because they are less common in distribution system. voltage sag is considered the most sever cause. Voltage sag may occur from single phase to three phase. As soon as the fault occurs in power system the working of DVR starts. On event of fault which result in voltage sag ,the magnitude reduction is accompanied by phase angle shift and the remaining voltage magnitude with respective phase angle shift is provided by the DVR.

CONSTRUCTION OF DVR

There are two main parts of DVR, first is control circuit which controls injected voltage and second is power circuit. 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. Based on the control signals in the power circuit voltage in injected is get generated with the controlling switches. The basic structure of DVR is described in this section.

There are five main important parts of power circuit

i. An Injection/ Booster transformer
ii. A Harmonic filter
iii. Storage Devices
iv. A Voltage Source Converter (VSC)
v. A Control and Protection system

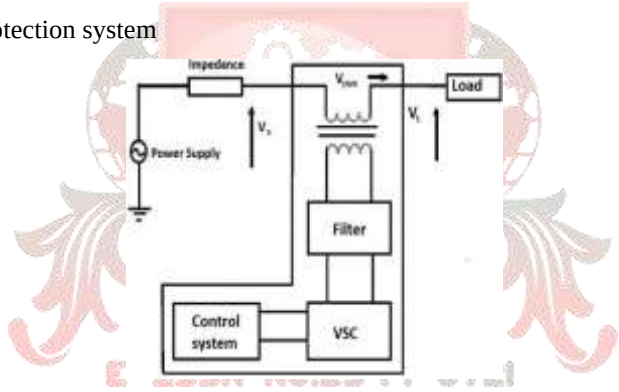

Fig.1: Construction of DVR

Injection/ booster Transformer

Injection transformer is connected in series to the distribution line. And their secondary/LV winding side is connected to the DVR power circuit. Basically it is a step up transformer which is used to increase voltage on the occurrence of sag condition. Having winding ratio of injection transformer to the required voltage at secondary side is important. High winding ratio means high magnitude current on primary side that can causes damaged to other parts of DVR. The HV winding transformers and couplers injects compensating voltage which is generated by a voltage source that is converted in to the incoming supply voltage. The main function of injection/booster transformer is to act as a filter reactance with a line side connected filter. It also balances the rated voltage and variation in voltage. Due to this minimize energy storage capacity and inverter voltage rating.

Harmonic Filter

Because of non-linear characteristics of semiconductor devices (like UPS, VRD inverter) distorted waveforms associated with high frequency harmonics at inverter output get generated. To reduce such harmonics and get good power quality power supply filters are used As we knows parameters of non- linear semiconductor devices get varied with respect to current and voltage. Basically filter is used to avoid unwanted tripping of load and also to filter the harmonics in injection voltage. Harmonics can causes voltage drop in the system and also phase

shift in a fundamental components of the inverter output. Basically our filter is placed at the two sides, one is the high voltage side (line side filter) and another one is a low voltage side (inverter side filter).

Storage Unit

During the voltage sag, DVR injects a voltage to restore the load supply voltage. DVR exchange active and reactive power. If active power is supplied to the load then it will need a source for this energy and its units are KW and MW. Also reactive power is the power which flows back and forth which means it moves in both the direction in a circuit or reacts upon itself and its unit is KVAR and MVAR. DVR takes energy from incoming supply. The shunt converter connected to the supply side and load side. Storage unit selection is depends upon the installation of load MVA, load power factor, sag depth, sag duration, frequency of sag occurrence. In storage unit of DVR there are two types of systems, first is storage energy and another one is internal energy. Storage energy system contains battery; capacitors, flywheels and internal energy system there are superconducting magnetic energy storage. We can also use the hybrid

Voltage Source Converter

VSC is a power electronic system which consists storage device and switching devices. It can generate a sinusoidal

Voltage at any required frequency, magnitude, and phase angle. There are two main purpose of VSC in DVR; one is to temporarily replace the supply voltage or to generate the part of the supply voltage which is missing. Metal Oxide Semiconductor Field Effect Transistors (MOSFET), Gate

Turn-Off thyristors (GTO), Insulated Gate Bipolar Transistors (IGBT), and Integrated Gate Commutated Thyristors (IGCT) are the four main types of switching devices.Among these four devices IGBT is the most suitable switching device. It can be place to reduce conduction losses. It has low cost and high gate drive speed. For real power absorption from utility additional rectifiers are required. With the use of IGBT, need of battery charging unit can be reduced.

WORKING OPERATION OF DVR:

When sag occurs on distribution system, then DVR compares between reference voltage and sag voltage. To boost up to the required voltage of load, energy stored in storage unit transferred to a converter. Then converter converts dc voltage to AC. Output of converter may contain some harmonics, to reduce those harmonics we use filter. This filtered output is passed through bypass switch to an injection transformer. Then injection transformer injects

the required amount of voltage in distribution line. Basically DVR is the series connected power electronic device used. To inject voltage hand required magnitude and frequency. Rated voltage is compared with voltage variation and the voltage difference between these two us injected by DVR. DVR is an inverter and DC required for the capacitor is given by this energy storage like PV system or fuel cell. Then the inverter converts DC into AC during the period of sag. There are three mode of operation of DVR

i. Protection mode
ii. Standby mode
iii. Injection/ boost mode

1) Protection mode:

If over current on the load side exceeds a a permissible limit due to short circuit on the load on large inrush current DVR will be isolated from the systems with the help of the bypass switches and supplying another path for current.

2) Standby mode:

In the standby mode the booster transformer low voltage winding is shorted through the converter. No switch of semiconductors occurs in this mode of operation and full load current will pass through the primary.

3) Injection mode/ Boost mode:

Injection or boost transformer is specially designed transformer that attempt to limit coupling of noise and transient energy from the primary side to the secondary side. It's one more purpose is to isolate load from the system.

SIMULATION AND RESULT

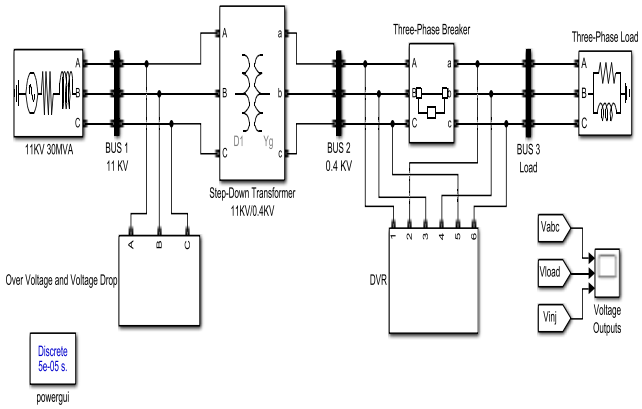

Fig.2:System with overvoltage and voltage drop and DVR

Fig.3: Voltage output for overvoltage and voltage drop

In this simulation external block for overvoltage and voltage drop effect is provided in between source and step down transformer.

Overvoltage and voltage drop is created with the help of stair generator. Overvoltage drop and voltage drop is applied at different period of time on supply voltage (i.e. source voltage). As a effect voltage disturbance is occurred at load point.

When this condition is occurs then DVR gets activated and injects voltage as per required by load, to provide continuous supply to load end without any disturbances.

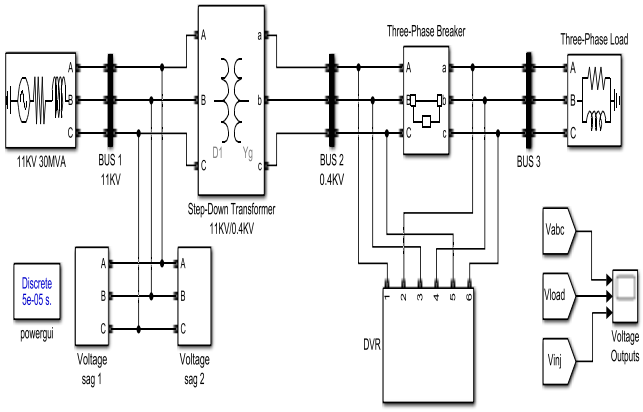

Fig.4: System with Voltage sag and DVR

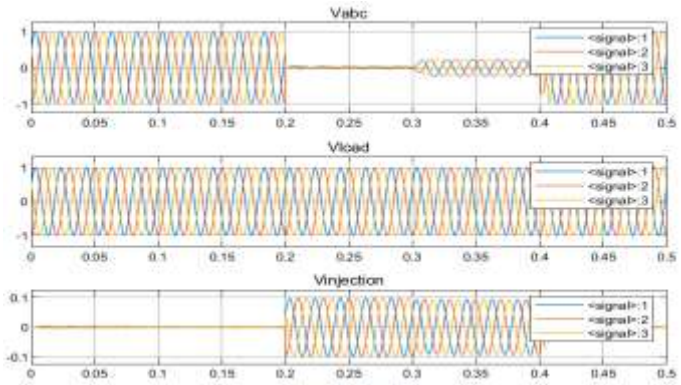

Fig.5: Voltage output for voltage sag

In this part of simulation external voltage sag is provided using stair generator blocks. This external sag is connected in between 11 KV, 1MVA source and step down transformer in order to create condition for short circuit,

External short circuit is provided for 0.2 to 0.4 sec. Hence because of this short circuit condition, voltage sag occurs in supply voltage.

To reduce this voltage sag DVR get ON at 0.2 to 0.4 sec. and injects voltage in supply voltage, which results as distortion free supply towards load.

CONCLUSION

To show working and operation of DVR in mitigation of voltage sags, simple distribution network is simulated using MATLAB 2018a. A DVR is connected to a system in series to compensate the voltage sag. In this simulation In-phase voltage sag compensation method is used.

DVR can handles both balanced and unbalanced (i.e. normal and abnormal) situations without any difficulties and injects the appropriate voltage component to correct rapidly any deviation in the supply voltage to keep the load voltage constant at the nominal value.

The DRV has main advantages of fast response to the faulty condition.It has simple control system.Also the cost required for the DVR is low.In DVR we are using the discrete PWM control scheme and PI controller which it is very efficient to provide the voltage sag compensation.

The above characteristic makes it ideally suitable for low voltage power applications.

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