Mitigation of Sag/Swell in Transmission by using DVR

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Abstract

Power quality issue is considered as major concern in industrial sectors and it will occurs due to variation in voltage, current and frequency. The stability of voltage is collapsed by extensive nonlinear load usage. The necessity of FACTS devices is much more needed. It creates a path to power quality and stabilization. With the advancement of Power electronics it is possible to mitigate power quality issues in distribution network. Voltage sag and swell is considered as major disturbance across load which will lead to intrude voltage across sensitive system.To overcome these things, proposed system employs Dynamic voltage restorer (DVR) in order to improve effectiveness of transmission in KVA. Under differential operating conditioning of load which cause severe disturbance in real and reactive power flow at load line. Further in turn makes variation in power factor too. By designing a simulink model incorporating SMES the compensation technique carried out in it is experimentally verified.

Keywords: Sag; Swell; Dynamic Voltage Restorer (DVR); Superconducting Magnetic Energy Storage System (SMES).

I. Introduction

In recent power quality issue is considered as one of the major problem in transmission and distribution sector. Not only it impact electrical utilities enrolled in transmission section but also it would affect sensitive loads which will collect power from that transmission section. The disturbance in power quality is noted by sudden change in voltage, current and frequency [1]. In certain situation, the power electronic devices are handled. It is widely used in improving power quality and strengthens the system to deliver power consistently towards load. Other than industrial sectors, low voltage consuming individual even suffer from power quality issues.Some localized industries such as iron and steel industries, paper milling industries, chemical industries, etc are very sensitive and it would cause distortion. Household electric appliances like air conditioner, motor and several other sensitive loads affected from this more and more. To ensure lifetime of electrical devices, the quality of power intake to do actions is must. Some consistently occurring voltage disturbances are listed below: voltage sag/swell, voltage spikes, short circuit and open circuit fault, harmonics, etc. increase in poor power supply can cause malfunctioning and stops productivity in industries [2].

Among that above mentioned power quality issues, voltage sag and swell repeatedly occurring in transmission path. The possibility of insulation failure during heavy load is connected with line cause sag in addition with short circuit fault. The decreases in RMS value of line voltage tend to be lesser than nominal voltage is called as voltage sag and it stands up to 1 minute (i.e.0.1 to 0.9pu). In opposition to voltage sag, swell is occurred (i.e.1.1 to 1.9pu). Tuning off huge loads, energising

capacitor bank are all the common cause of raise in voltage.From researches and some other analysis, the chance for sag occurrence is high in comparison with swell. Other than that complete shutdown, tripping in circuit breaker and production in higher rate of inrush current also makes way to sag and swell [3]. In 1995, first custom power device is introduced. FACTS devices are more commonly used devices in improving power transfer capability, stability in addition with this power converter might play an important role in ensure power supply. Removal of flicker & harmonics, low phase unbalance, control on under voltage/over voltage is considered as good quality of power supply [11]. A short list on custom power devices is presented below: Battery Energy Storage System (BESS), Dynamic Voltage restorer (DVR), Distribution static synchronous compensator (DSTATCOM)Surge Arrester (SA), Super-conducting Magnetic Energy Storage (SMES), Solid-State Transfer switch (SSTS), Static Var Compensator (SVC), and Uninterruptible Power Supply (UPS), etc [4].

From that DVR is said to be more economical and a better platform to resolve uncertainties. It having some quality factors such as active power flow control, specified energy device to withstand variable condition so called SMES, small in size, less in weight [5]. The key factors are harmonics and try to reach unity power factor. The real and reactive power supply for compensation is performed with consideration of load, supply voltage. In the year of 1996, a first DVR is installed in North America with 12.47 kilo volt. Nearer to half the amount of nominal voltage is injected by DVR. Real power processing and process taken to provide real power is governed by storage system [6].

The overall circuit configuration of proposed method and its compensation techniques is visualized in the form of waveform presenting in section III. Thus section IV concludes how sag is compensated by proposed method and restoration of energy by SMES is justified well.

II. Structure of DVR

DVR is also called as series voltage booster and it is enrolled with solid state power electronic components; those are in series connection with distribution line. It comprised of injecting transformer, harmonic filter, voltage source converter, etc. the generalised structure of DVVR is represented in fig. 1. Initial state is to maximise the voltage across load if any disturbance faced at load.

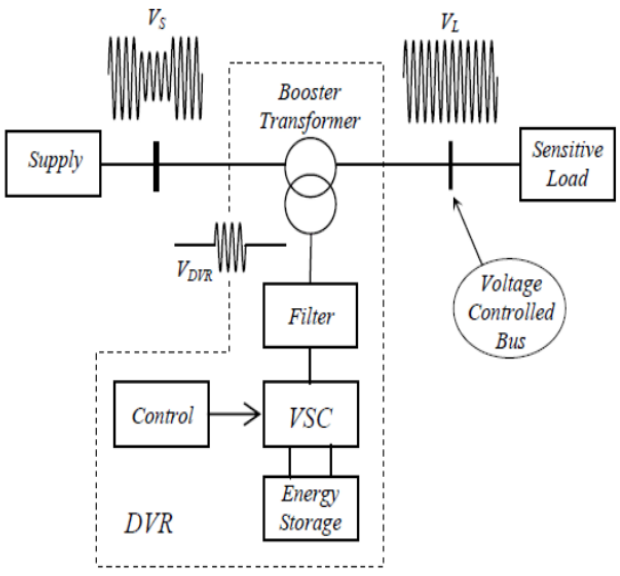

Fig.1. Basic principle behind DVR

The first and foremost case is to identify voltage sag/swell occurrence in line and inject (or) absorb reactive power to make it equivalent to nominal voltage [7]. The following elements present in DVR based voltage mitigation is explained in a step by step manner.

A. Injection/step-up transformer

The purpose of it to reduce coupling noise and delivers power towards secondary from primary winding. Through HVV-winding holding in it helps to tie up DVR with distribution network. Also it couples injected compensation voltage with inlet. It can prevent load from system.

B. Storage device

It is the major thing in voltage sag compensation; because it can supply required quantity of real power. Normally lead-acid battery, SMES, fly wheels and super capacitor are used as storage system. The maximum capability of compensating DVR by supplying active power is totally depends upon storage devices. In proposed work, SMES is chosen due to its higher performance and to maintain a steady state power flow.

C. Superconducting magnetic energy storage system (SMES)

The structure of SMES used in Simulink model is visualized in Fig.2.It replaced need of dc link capacitor. The flow of dc current through superconducting coil stores energy in the form of magnetic field. Whenever the system is connected, it quickly delivers the charge hold within it. To perform AC-DC for charging and DC-AC for discharging a power maintaining system is connected with the load.

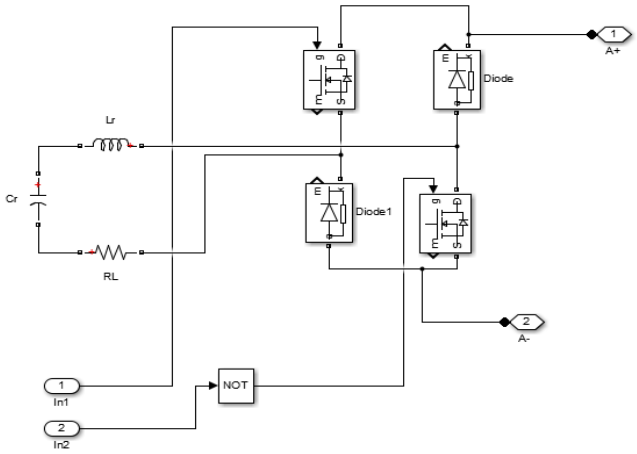

Fig.2. Structure of SMESpresented in mathematical modelling

D. Voltage source inverter (VSI)

Its role is to convert dc voltage gained from storage system into ac. It couples injection transformer with main system. VSI with low voltage rating is enough.

E. Passive filters

The conversion of PWM pulse into sinusoidal waveform. The structure of filtering unit is designed with single inductor and capacitor. Depending upon the need, the position of placing filtering circuit is judged; either it may be injecting transformer's low voltage side or high voltage.

The harmonic elimination processed in this way only. Additional advantage is reduction in stress across injecting transformer. The equivalent circuit of DVR is represented in below Fig. 3.

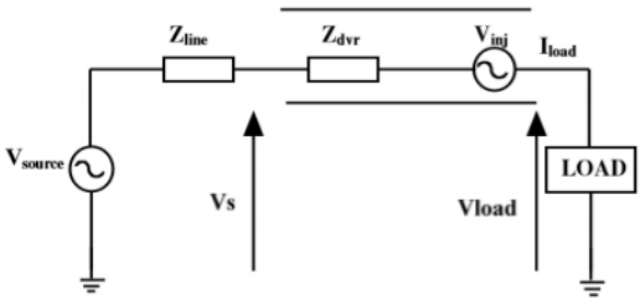

Fig.3. Equivalent circuit of DVR

III. RESULT AND DISCUSSION

To validate the proposed technique for implementation of SMES based DVR a MATLAB simulation is carried out. A MATLAB simulation is done carried by step-by-step process and it is mentioned below:

Step1. Generation of voltage sag due fault in the transmission line without SMES based DVR.

1. Triple line to ground fault.
2. Line to ground fault.
    - Instantaneous
    - Momentary
    - Temporary

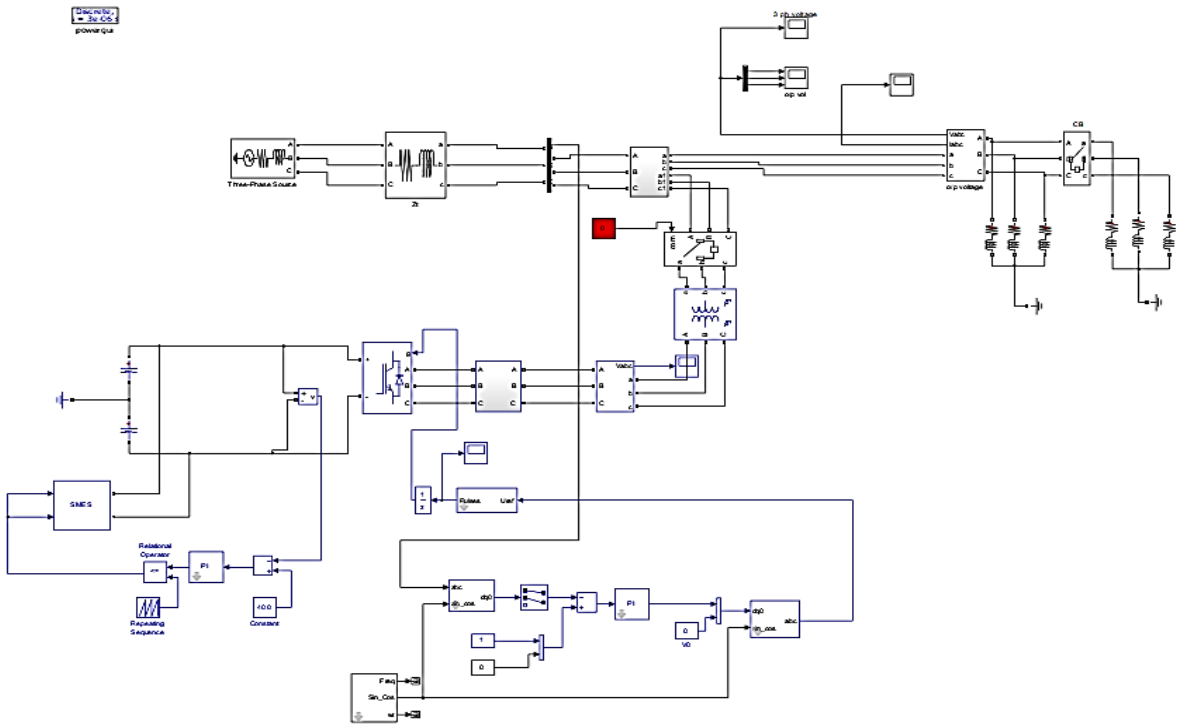

Fig.4. Simulink blocks showing proposed methodology

Step2. Implementation of SMES based DVR.
Step3. Compensation of voltage sag for type of fault using SMES based technology.

DVR is connected between sensitive load feeder and source. SMES based DVR is to initiate fast dynamic response during fault condition. It helps to protect consumers from grid voltage transients and also it restores the power. The main reason to choose SMES among various energy storage systems is said to be time delay during charging and discharging is too short.

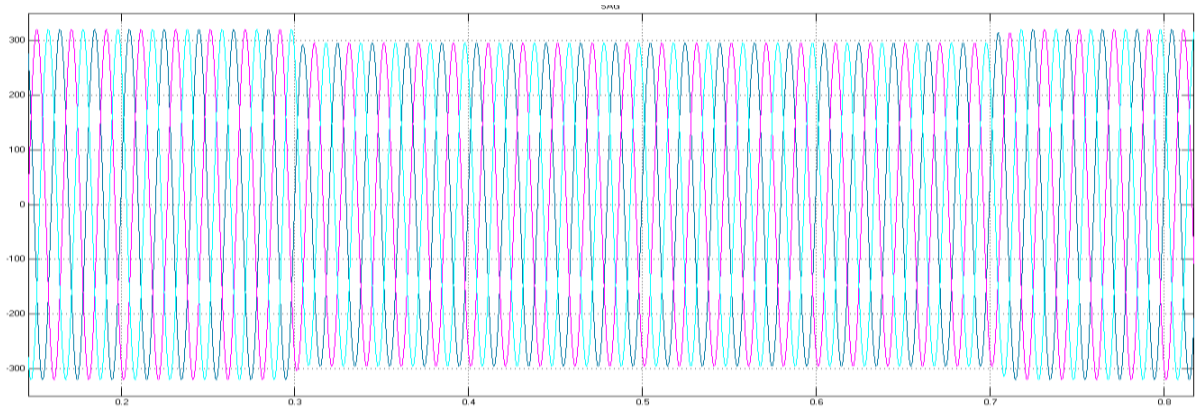

Fig.5. Representing voltage sag

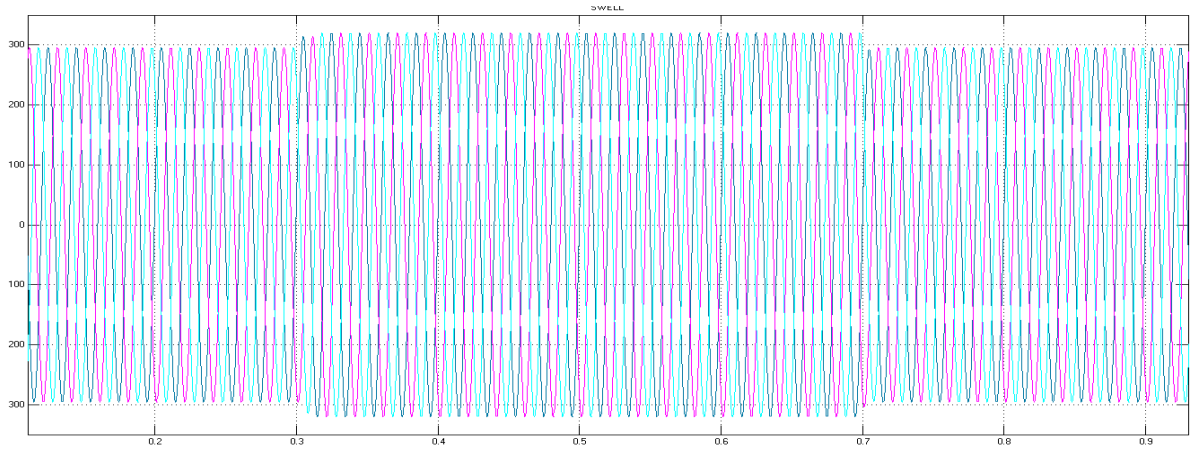

Fig.6. Representing voltage swell

From fig 5 and 6, the appearance of sag and swell is represented graphically. Thus rise and fall in voltage should damage an appliance which operates with this supply voltage. So that special care is needed to resolve this.The processes carry over in mathematical modelling of designing PI controller is shown below.

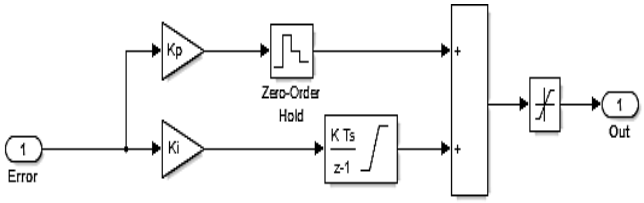

Fig.7.PI controller

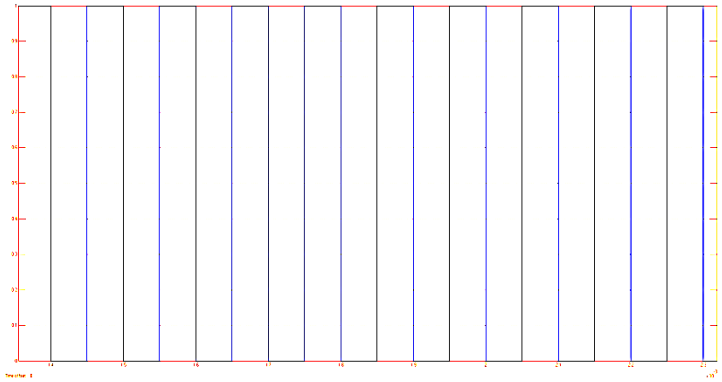

Fig.8. Gating signal

The gate signal delivered to switches present in SMES is visualized in above waveform. This waveform explains about how much amount of voltage compensated after the occurrence swell and sag in a system.

Fig.8.Compensated voltage

The voltage rating represented in fig.8 will be the exact range to operate electric appliances and other appliances in safe zone. Finally a nominal voltage rating of 300V is transmitted without loss.

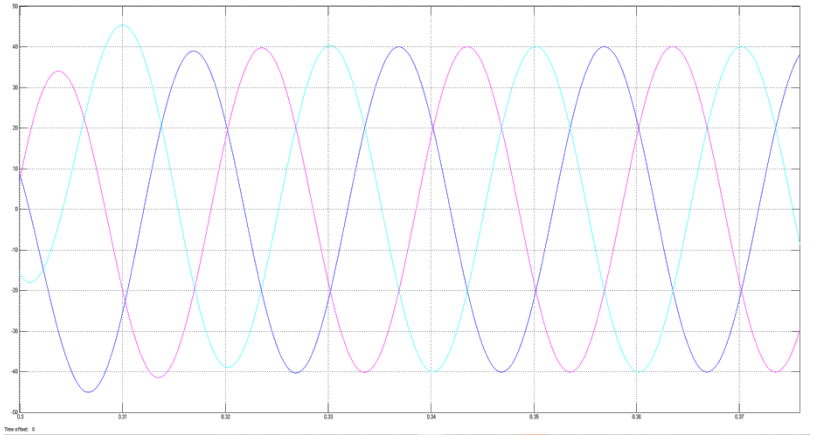

Fig.9.Current

IV. Conclusion

The experimental analysis of proposed voltage compensation technique is studied through simulation study. It is robust, convenient to functioning under steady state. In concentration with essentiality of control logic, the simplest PI controller is presented in addition with proposed method should recover disturbance caused in transmitting huge power. Thus DVR is the most effective custom power device among various FACTS controllers; andsucha way to operates load under balanced and unbalanced condition.

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