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Power Quality Improvement of Grid Connected PV System Using Dynamic Voltage Restorer

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ABSTRACT:- In this paper the detail description of DVR, A DVR is a fast acting custom power device provides effective voltage control to the distribution feeder Every consumer expects a clean and uninterrupted power quality for their sensitive equipment. When there is flow of energy there will be fault and voltage sag, voltage swell, fluctuations and other problems which are most common in power system. Sudden change in loads, motor starting and faults in power system are main causes of voltage sag. Custom power devices are implemented to solar power quality problems. In custom power devices DVR is most effective. Simulation studies have been completed to attest the outcomes. DVR demonstrated and reenacted utilizing the MATLAB/ Simulink and simpower framework tool stash.
Keyword: Dynamic Voltage Restorer, fault and voltage sag, voltage swell, fluctuations, Voltage source

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I. INTRODUCTION

The quality of power closely related to growth of the system operating. Consumers require a sinusoidal waveform for their operation. Power stations expected to produce sinusoidal waveform so that they can provide clean and uninterrupted supply. The increasing utilization of power electronics based devices [4, 5] and due to faults occurring in the system sinusoidal nature of waveform lost. Various power quality problems like voltage sag [3], voltage swell [7], flicker [8] etc. affects the whole system and creates problem in achieving reliable and good constant power supply.

FACTS controllers [11,13] are implemented in the distribution feeder to mitigate power quality problems. These devices come under the category of custom power devices, and these are divided into three categories:-

1. Series connected device
2. Shunt connected device
3. Series and Shunt connected device.

In Custom power devices [16, 19], dynamic voltage restorer (DVR) is most reliable and accurate devices to be connected in between the distribution system and consumer. These devices are implemented to compensate voltage and current fluctuations, improve power quality by injecting the reactive power, and by reducing harmonics generated or absorbed by the user. In the PV grid connected system, major problem is the increase in total harmonic distortion (THD) of the current injected in to the grid [17, 20] during low solar radiation period. The current to be injected into the grid system must be low value of THD, less than 5%

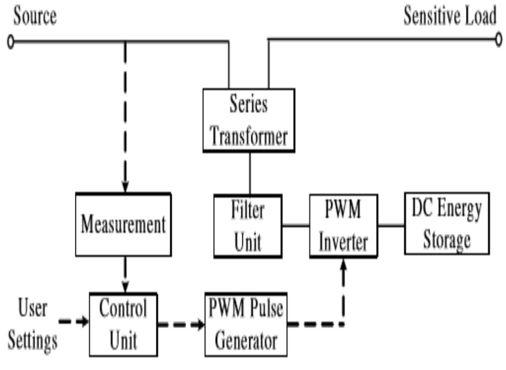

Fig.1.1 Basic block diagram of DVR

Under the condition when there is no sag in the system and operation is going smoothly DVR [22,26,27] remains in the standby mode. Low voltage winding of the booster transformer short circuited. Now booster transformer operates as a short circuited current transformer.

The primary side of the DVR injection transformer is sized to carry full line current. The primary voltage rating is the maximum voltage that the DVR can inject into the line for a given application. The secondary voltage is controlled by voltage source inverter connected to the DC link [24, 28]. The bridge outputs are filtered before being applied to the injection transformer by the harmonic filter and are independently controllable to allow each phase to be compensated individually

To utilize the existing power system in better way the advanced technologies are introduced for the reliable and secure operation of the system. Recent advancement in power electronics innovate the use of FACTS controller [1] in power system. Basically the FACTS devices [2] have the capability of solving the problems of voltage stability [1, 9].

II. POWER QUALITY

Due to low power factor these devices cause power quality issue in the system. There are some points which highlights the factors due to which power quality get affected. Loads at the user end, Industries have very complex network, Semiconductor based switches, Bulky computer networks etc.

Whenever there is deviation from sinusoidal nature occurs the condition is treated as disturbance. There are many factors which affects power quality some of them are Frequent use of power electronic based controllers, Wide area use of programmable logic controllers, Faults in the system, Use of nonlinear loads, Use of arcing furnaces, Large welding machines, Low power factor operating machinery, Switching of large loads, Use of capacitor banks Use of fluorescent lamp Frequent use of complex networks having nonlinear characteristics.

III. VOLAGE SAG (Or Dip)

Voltage sag is defined as a decrease in the normal voltage level between 10 and 90% of the nominal rms voltage at the power frequency, for durations of 0. 5 cycle to 1 minute. Voltage sags are mostly caused by connection of heavy loads, start-up of large motors and faults in consumer's installation in large scale industries where induction motors are used for production, voltage sag is frequent problems as starting of large induction motor takes 10 times more current then running motor. The consequences of voltage sag are disconnection and loss of efficiency in electric rotating machines, tripping of electro-magnetic relays and malfunction of information technology equipment namely microprocessor-based control systems.

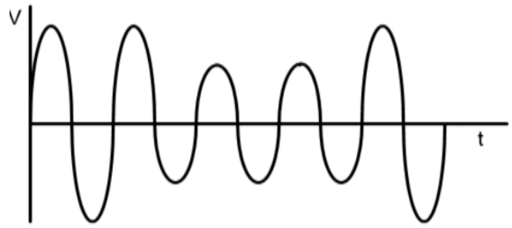

Fig.2. Sag in voltage waveform

IV. VOLTAGE SWELL [14]

Voltage swell is defined as very short hike in the system voltage for the duration of one cycle to few miliseconds.Fig.2 shows the increase in voltage magnitude due to voltage swell. Voltage swell is caused due to line faults, badly dimensioned power sources and also due to false setting or connection in the tap changers in distribution feeders. Various types of faults like three phase short circuit fault, two phase fault, three phase to ground fault, etc. results in short increase in voltage which is termed as voltage swell. Short time heavy increment in healthy phases is also called voltage swell. Main cause of voltage swell is capacitor bank switching, whenever capacitor bank is inserted into the system voltage increases.

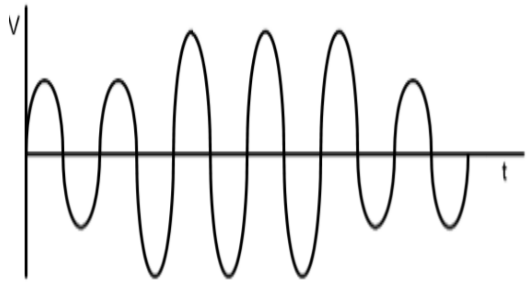

Fig.3. Voltage Swell

V. INTERRUPTION [15]

This is the phenomena in which system voltage decreases up to 10% of its actual value for the time duration not more than 1 minute. Voltage collapses and its magnitude becomes very low. This phenomenon is divided into two categories

a. Very Short Interruption [3]

Very short interruption is defined as total interruption of electrical supply for duration from few milliseconds to one or two seconds. It is shown in fig.4. It is caused due to insulation failure, lightning, system faults, equipment failures and insulator flashover.

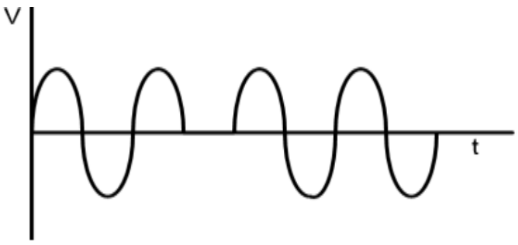

Fig.4. very short interruption in voltage waveform

b. Long Interruptions

Long interruptions are defined as, "it is complete disappearance of power for more than 2 minutes due to faults or other causes" .These are shown in fig.5.These phenomena occur because of faults, birdage, failure of system components, failure of control equipment, etc.

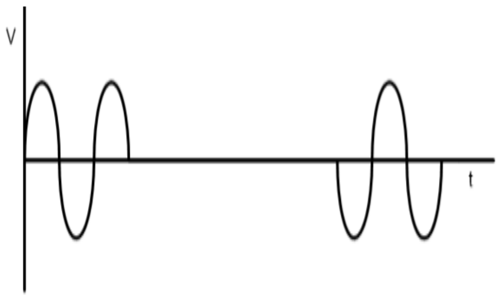

Fig.5. long interruption in voltage waveform

VI. TRANSIENT

Transients in the power system are described as a huge variation in voltage or current waveforms starting from microseconds to fraction of seconds. These are very large variations in the resulting waveforms amplitude of transients may vary from hundreds to thousands. Some common type of transients is given below.

a) Impulsive Transients [1]

It is one of the most famous types of transients which is defined as unidirectional change in waveform of voltage or current as shown in fig.6.

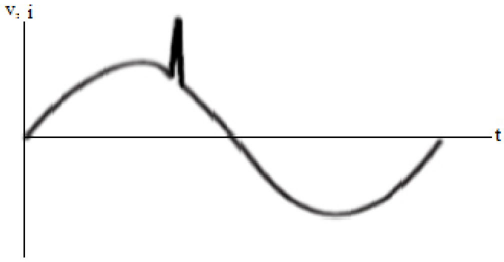

Fig.6. impulsive transients in waveform

b) Oscillatory Transients [17]

This is a bidirectional change in the waveform of voltage or current flowing in the distribution feeder as shown in fig.7.

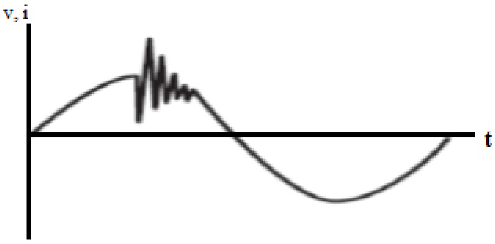

Fig.7. oscillatory transient in the waveform

VII. CUSTOM POWER DEVICE [6][2][3]

The main aim was to provide clean and hassle free power to the consumers. Use of electronic equipment in power system has increased the concern about power quality problems. These devices are the source of power quality issues like, distortions, lower order harmonics, sag, swell, interruption, etc. These devices are also having capability to operate in a complex network. Introduction of these devices in power system has improved the reliability and stability of power system network. These devices also increased the power transfer capability and power quality transferred to the consumer.

VIII. DYNAMIC VOLTAGE RESTORER

Dynamic Voltage Restorer is one of the most accurate and efficient custom power devices in power systems There are mainly three functions of DVR in compensation of power quality problems which are given below;

- Detection of power quality issue.
- Generation of reference voltage for that power quality problem.
- Control and injection of generated voltage in series with the system.

DVR injects three phase voltage into the system when sag comes to the system. These are three distinct single phases which compensates the difference between the voltage after sag and nominal original voltage. The three phase injected voltage is having phase and magnitude in such a way that both can be controlled. In a battery integrated DVR system both active and reactive power can be compensated. This compensation is done through VSC which is operated by PWM technique [14, 16]. The emplacement of DVR for a distribution feeder at (440v) is shown is fig.8 when there is insertion of DVR there is significant increment in the impedance

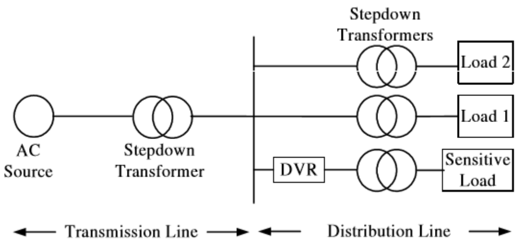

Fig.8. Emplacement of DVR in distribution feeder

IX. VOLTAGE SOURCE INVERTER

A voltage source inverter is energized by a stiff DC voltage supply of low impedance at the input as shown in Figure 9. The output voltage is independent of load current. Voltage source inverters are widely used in low and high power applications such as motor drives, traction, UPS and bi-directional AC-DC converters.

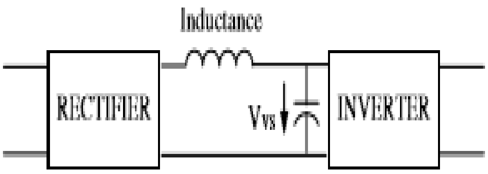

Fig.9. Basic topology of inverter

X. INJECTION TRANSFORMER [33]

Injection transformer is utilized in DVR connected system to isolate the system and also to provide support for converter and other protection equipment like fuses and circuit breakers. These transformers acts as boosting transformer and ensure prevention of transfer of noise and other harmonics and transients to the other side of transformer.

XI. SIMULATION AND RESULT

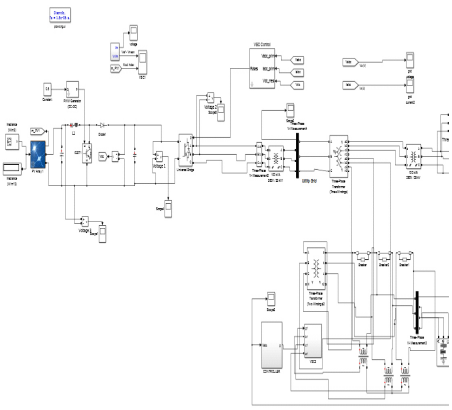

Fig.10. DVR integrated PV grid connected system simulation model

Fig.10. shows the simulation model of grid connected DVR. In first stage of this model PV module is connected as a source to the system.

The characteristics of this PV module are very much important for the system behaviour so the power voltage and current voltage characteristics are also shown in fig.11 and fig.12.

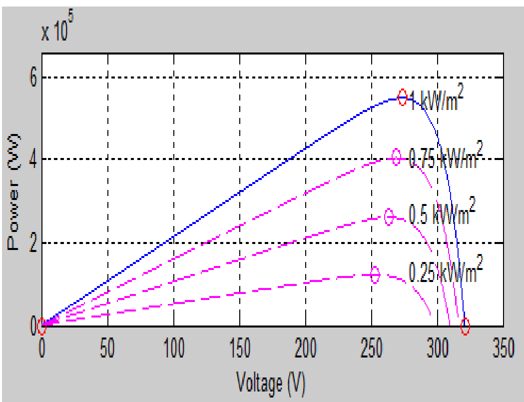

Fig.11. P-V curve of solar module

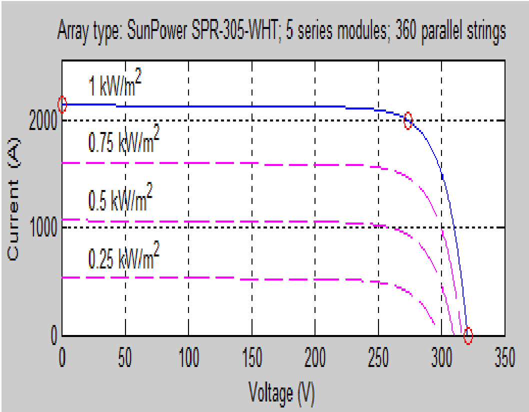

Fig.12. P-V curve of solar module

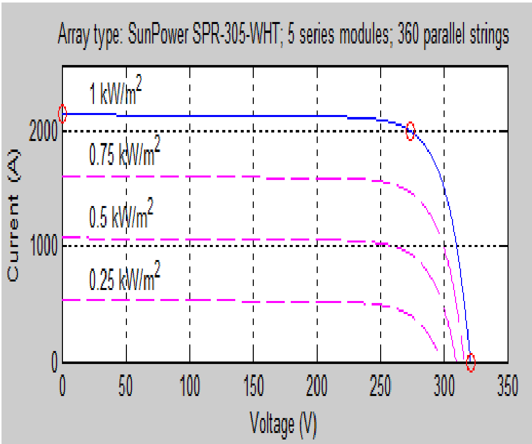

Fig.13. Current voltage characteristics of PV module

Simulink Model of DVR

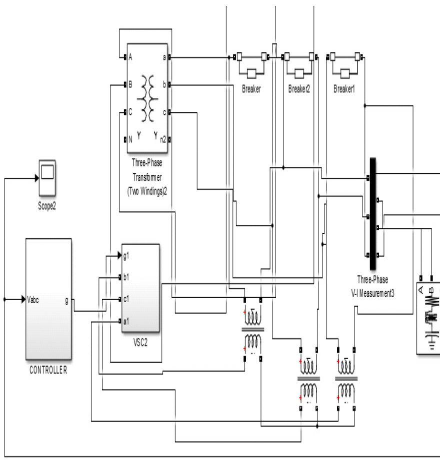

Fig. 14. Simulink model of DVR

Results before Compensation

In this work total system is analysed on a three phase fault occurred in the transmission line near grid. Whenever fault occurs in the system voltage of the grid collapses and decreases up to 0.2 p.u. and grid current increases very sharply. Voltage and current waveform when there is fault in the system are shown in fig.15 and fig.16

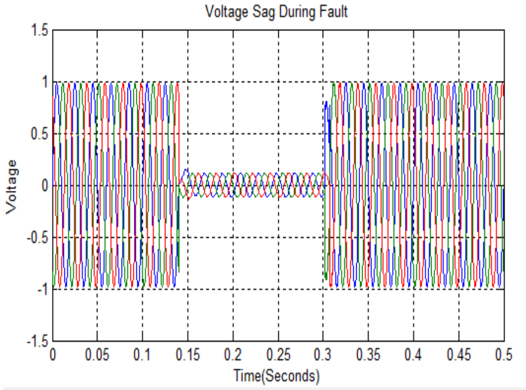

Fig. 15. Voltage sag during fault

During fault grid voltage decreases and in p.u. value it decreases up to 0.2 p.u. injected voltage during fault is shown in figure.5.15

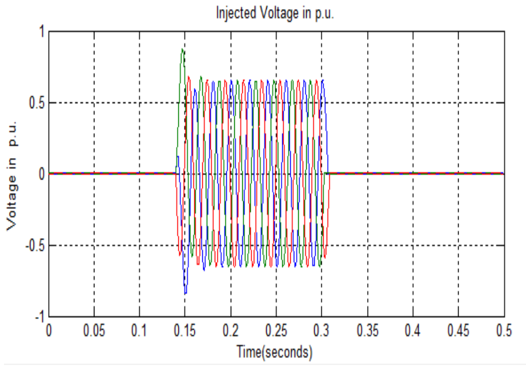

Fig. 16. Injected Voltage during fault

Voltage sag during fault is compensated by DVR by injecting voltage in series. Compensated voltage is shown by fig.17.

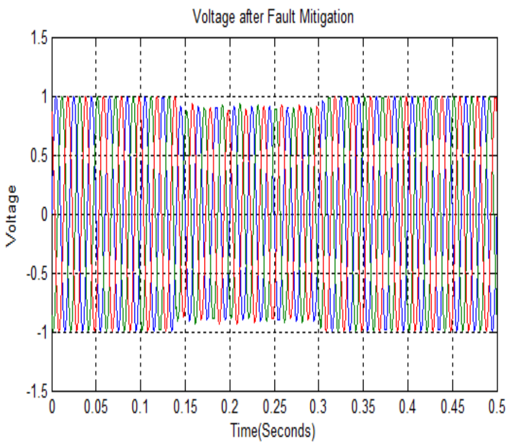

Fig. 17. voltage waveform after fault mitigation

CONCLUSION

Global requirement of electrical energy is constantly increasing. In recent years renewable energy sources such as solar, wind have been concerned on a growing environmental realization to pollution. The idea of utilizing non-conventional energy resources is born from the requirement to search for the new sources of energy, among various renewable energy sources PV sources have no availability problems and are assumed to become the largest contributors to energy (electrical) generation. The use of renewable sources has decreased the dependency on fossil fuels and also helped in reduction of greenhouse gases emissions.

The rapid degradation of conventional energy resources and increasing various environmental issues have risen the importance of various renewable energy resources like solar energy (Photovoltaic)[1], wind energy, tidal energy etc.

In solar energy conversion system first stage it to generate DC voltage with the help of PV module, in next stage a DC-DC converter is applied to boost up the voltage and it requires a three phase (6pulse) voltage source converter (VSC) for DC-AC conversion. In a grid connected PV system three phase VSC is applied which is essential for enhancing the power injected to the system. Main power quality issues in a grid connected system are, voltage sag, voltage sag and interruptions due to fault, to resolve these issues various custom power devices are used in which DVR is most efficient and effective.

A grid is an interconnected network consists of generation unit that supplies power through transmission lines to distant substations that circulates the power through distribution lines to users. Grid connected system is the best way to generate power but this system may also affected by fault occurrence, even system is perfectly designed but when there is flow of energy there will be fault occurrence and

System will become unstable, if fault occurs in the system the whole system will be affected as PV system[1] is connected in series with the system. Low DC value at the input as compare to required value leads to fault condition and the output current of the system become irregular in shape. This thesis work has presented a PV grid integrated system in which voltage sag compensation technique is used through DVR. Boost converter is utilized to get a high level DC output. Three level (6 pulse) inverter converts boosted DC into AC and a 2MW grid is connected through 14km feeder line. Three phase fault analysis is done. Voltage is compensated with new technique and DVR working is efficient. Voltage compensated by DVR is up to 0.95 p.u. Total harmonic distortion is only 0.37 percent in compensated voltage. This thesis work shows the effects of fault inside the grid connected PV system and a fault mitigation technique using DVR. The whole system is designed using MATLAB/Simulink software. The simulation results thus show that proposed system works efficiently and voltage compensation technique of DVR is accurate and precise

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