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COMPENSATION OF VOLTAGE FLUCTUATIONS LIKE SAG USING MODIFIED DVR

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ABSTRACT: Today, there is a demand for short term energy storage devices like flywheel energy storage, photovoltaic modules, battery energy storage and super capacitors. Since they are having less power and energy rating, they cannot be used for high power applications. With the increase in application of wind power variety of new topologies are coming into picture. Among the different form of variable speed fixed frequency topologies DFIG is most popular form due to its efficiency and ability to allow wide range of speed variation at reduced converter size. In this paper work when grid voltage variation occurs, the dc link voltage also varies, ultimately rotor input voltage varies. This causes abnormal input of reactive power to rotor circuit this is noticed when a simulation model is simulated using MATLAB The compensation of voltage sag is done by a custom power device, known as Dynamic Voltage Restorer (DVR).The model is subjected to fast load change and correctively the voltage sag is maintained power quality with harmonic distortion were improved.
KEYWORDS: Downstream fault; DVR; Power Quality; Voltage Fluctuations

I. INTRODUCTION

Presently a days, current mechanical hardware's are for the most part dependent on electronic gadgets, for example, programmable rationale controllers. These electronic gadgets are extremely delicate to control changes and become less tolerant to control quality issues, for example, voltage swells, lists and sounds. Voltage lists are viewed as one of the most serious unsettling influence to the mechanical gadgets. Voltage pay at a heap can be accomplished by appropriate receptive power infusion at the heap purpose of regular coupling. Shunt capacitors can be utilized in the essential side of the appropriation transformer for the remuneration of responsive power and in this way for voltage pay. Utilizing SCADA the mechanical exchanging should be possible with some planning timetable, or with no exchanging by any stretch of the imagination. The hindrance is rapid homeless people can't be redressed. A few hangs are not revised inside the restricted time .Transformer taps can be utilized, however its exorbitant when utilizing on load. Another arrangement existing to the voltage guideline is the utilization of a unique voltage restorer (DVR)[17] The working standard of a DVR is to infuse a voltage of required greatness and stage in arrangement with a feeder to keep up the ideal plentifulness and waveform for the heap voltage to be redressed. Notwithstanding that, the remuneration ability is touchy to the heap level, and is free of the framework impede and the establishment position [1].It utilize a progression of voltage help innovation utilizing strong state switches for repaying voltage hangs/swells. The DVR are for the most part utilized for touchy burdens that might be genuinely influenced by changes in framework voltage. Voltage hangs are turning into the most significant power quality worry to electric utility clients with delicate burdens. Voltage extent between 0.1 to 0.9 Pu are said to be lists. Hangs are dominatingly brought about by deficiencies that are unavoidable on the dissemination frameworks because of the interconnectivity of the utility frameworks. The dispersion class dynamic voltage restorer (DVR) is an arrangement associated control hardware gadget which can make up for circulation framework hangs and swell [21].Dynamic Voltage Restorer (DVR) is a custom gadget utilized in control appropriation systems to take care of the issues of voltage lists and swells and its extreme effect on touchy burdens. DVR is an arrangement associated strong state gadget that infuses fitting voltage into the framework so as to remunerate the heap voltage changes. Its essential capacity is to quickly lift up the heap side voltage on account of an aggravation so as to maintain a strategic distance from any power disturbance to that heap [7]. Because of the normal for high vitality thickness and snappy reaction, a superconducting magnet is chosen as the vitality stockpiling unit to improve the remuneration ability of DVR [1][3]. A Superconducting Magnetic Energy Storage gadget comprises control electronic converters that quickly infuses or potentially ingests genuine as well as receptive power and along these lines controls power stream in a distribuition/transmission framework. [2][5][7]

Superconducting Magnetic Energy Storage (SMES), described by its profoundly proficient vitality stockpiling, speedy reaction, and power controllability, is relied upon to add to excellent intensity of the power frameworks. SMES can be used in two proficient manners. One is using it as an UPS or associate SMES parallel. The subsequent technique controls the framework voltage in a roundabout way through directing the infusing current of SMES. The remuneration ability is impacted by the framework cut off and the area of SMES. To improve the pay capacity of DVR, for example, a long term voltage vacillation, the vitality stockpiling unit is fundamental to supply the power move during the voltage remuneration [1]. In this paper, a superconducting magnet is presented as the vitality stockpiling unit of the DVR. Right off the bat, the activity guideline of the SMES based DVR is investigated. At that point, the dynamic reaction of the SMES based DVR is assessed utilizing MATLAB reproduction.

II. MODELLING OF DVR

Power quality concern is expanding now a days. Significant power quality issues are voltage hang, voltage swells, sounds, glinting and so forth. Voltage hang is the serious issue that evolvs among the purchasers. Custom power gadgets are presented from the previous days as a viable answer for this. DVR is the fundamental custom power gadget for this voltage droop mitigation.Other than voltage lists and swells remuneration, DVR can likewise make up for line voltage harmonics,reduction of homeless people in voltage and deficiency current impediments.

A. Basic Configuration of DVR

The main components of the DVR consists of:

- Energy storage unit
- Filter unit
- Inverter circuit
- Series injection transformer

Energy storage unit

During a voltage sag, the DVR injects a voltage to restore the load supply voltages. The DVR needs a source for this energy. Two types of system are considered, one using stored energy to supply the delivered power and the other having no internal energy, where energy is taken from the incoming supply through a shunt converter. Fig 1 descibes the major components of DVR.

Inverter circuit

The voltage source inverter converters the dc voltage from the vitality stockpiling unit to a controllable three stage air conditioning voltage. The inverter switches are regularly terminated utilizing a sinusoidal heartbeat width balance plot. Since by far most of voltage droops are seen on utility frameworks are unequal, the VSI will frequently work with uneven exchanging capacities for the three stage, and should thusly treat each stage freely. Also a hang on one stage may bring about swell on another stage.

Filter unit

The non straight attributes of semiconductor gadgets cause mutilated waveforms related with high recurrence sounds at the inverter yield. To defeat this issue and give top notch vitality supply, a symphonious separating unit is utilized. These channels can be set in either side of the inverter.

Series injection transformer

Three single stage infusion transformers are utilized to infuse the missing voltage to the framework at the heap transport. To incorporate the infusion transformer accurately into the DVR, the MVA rating, the essential winding voltage and current evaluations, the turns proportion and the short out impedance estimations of transformers are required. The presence of the transformers take into consideration the structure of the DVR in a lower voltage level.

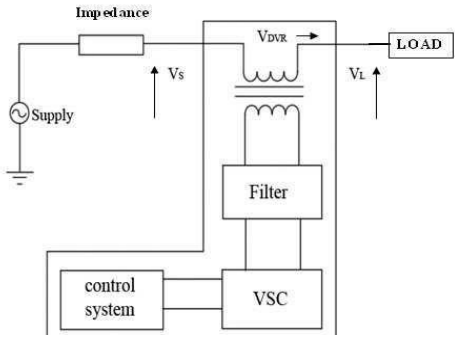

Fig. 1 Components of DVR

B. Mathematical model of DVR

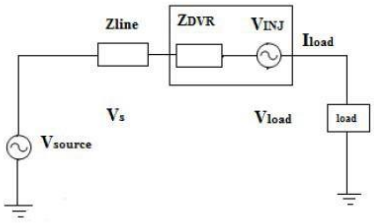

Fig. 2 Equivalent Circuit of DVR

The system impedance depends on the fault level of the load bus. When the system voltage drops, the DVR injects a series voltage through the injection transformer so that the desired load voltage magnitude can be maintained. Fig 2 shows the equivalent circuit of DVR.The series injected voltage of the DVR can be written as

$$V_{DVR} = V_L + Z_{TH} I_L - V_{TH} \quad (1)$$

$$V_{DVR} \angle \delta = V_L \angle 0 + Z_{TH} \angle (\beta - \theta) - V_{TH} \angle \delta \quad (2)$$

The complex power injection of the DVR can be written as,

$$S_{DVR} = V_{DVR} I_L \quad (3)$$

$$\theta = \tan^{-1}\left(\frac{Q_L}{P_L}\right) \quad (4)$$

The load current IL is given by,

$$I_L = \frac{[P_L + jQ_L]}{V} \quad (5)$$

III. PROPOSED CONTROL CIRCUIT

In typical DVR based remuneration, downstream shortcoming current was not considered or the DVR was circumvent during that deficiency. However, here alongside voltage list remuneration downstream deficiency current moderation was additionally considered. The control plot for the moderation of downstream deficiency current is given beneath.

The DVR is customarily circumvent during a downstream flaw to avert potential unfavorable effects on the shortcoming and to secure the DVR parts against the issue current. An actually detailed way to deal with increasingly productive use of the DVR is to outfit it with extra controls and empower it additionally to constrain or intrude on the downstream flaw ebbs and flows. A control way to deal with empower a DVR to fill in as a deficiency current limiter is

proposed before . The fundamental downside of this methodology is that the dc-interface voltage of the DVR increments because of genuine power ingestion during issue current-restricting activity and requires a change to sidestep the DVR when the defensive transfers, contingent upon the shortcoming conditions, don't quickly clear the flaw.
The proposed DVR is a multifunctional DVR that is it can alleviate for both voltage list and downstream flaw current . Therefore, the common impacts of these modes on one another must be assessed. At 15 ms, the framework is exposed to a stage A to stage B issue with the obstruction of 0.8 ohm at 90% of the line length from source side. The shortcoming causes 87% voltage list at the PCC. At 55 ms, another issue with the opposition of 0.3 on stage An at 10% length of the link at burden side. The upstream deficiency is cleared by transfers at 93 ms.

IV. SIMULINK MODEL AND RESULTS

4.1 SIMULATION BLOCK REPRESENTATION MODEL

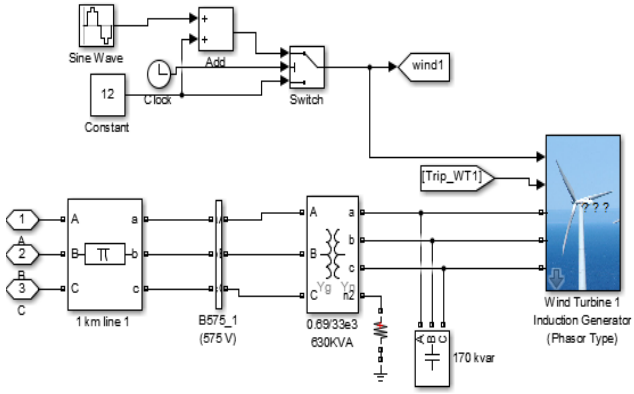

Fig 7.1.1. simulation block model

PARAMTERS OF MODELLING

4.1.1 DFIG PARAMETERS

SL NO	PARAMETER NAME	RATING
1.	Rated Power	2.00 MVA
2.	Rated Voltage	690 V
3.	Rated Current	2.00 KA
4.	Rated Frequency	50 Hz
5.	Pole Numbers	4no
6.	Stator Resistance	0.34 p.u.
7.	Rotor Resistance	0.009p.u.
8.	Stator Leakage Inductance	0.105 p.u.
9.	Rotor Leakage Inductance	0.111 p.u.
10.	Magnetic Inductance	3.34 p.u.
11.	Magnetic Resistance	47.61 p.u.
12.	Angular Moment Of Inertia	3.825 p.u.
13	Mechanical Damping	0.01 p.u.

4.1.2 WIND TURBINE PARAMETERS

SL NO	PARAMETER NAME	RATING
1.	Turbine Rotor Speed Range	9-19 RPM
2.	Rated Rotor Speed	1500 RPM
3.	Rated Wind Speed	13 m/s
4.	Turbine Tower Height	80 m
5.	Rotor Diameter	80 m
7.	Gear Box Ratio	1:100

COMPLETE CIRCUIT GRID CONVERTER CONTROL MODEL

Figure below shows the matlab/Simulink diagram of DVR compensated network

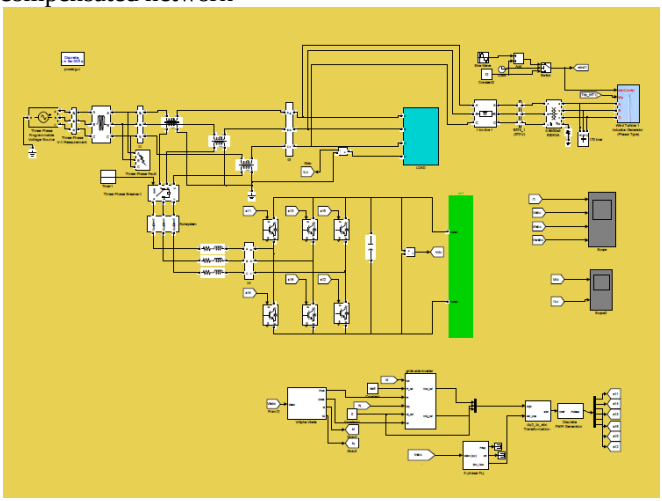

Fig 7.1.2. simulation MATLAB complete circuit model

Fig 5.1.2 shows an open loop control output of a VSI converter. This shows that in open loop system, dc link voltage fluctuation is very large. To achieve minimum fluctuation, we have to increase the DC link capacitor size, which will be difficult to implement in practical case. So we adopt an advance control scheme for GSC such as vector control scheme.

4.3 PROPOSED CONTROL METHOD OF DVR

DVR can be controlled by controlling its inverter. The control unit gives information on required voltage to be inserted and its duration during sag. Inverter is the core component of DVR. The control strategy of inverter will directly affect the performance of the DVR.
Since numerical variables are changed over into phonetic variables, scientific demonstrating of the framework is not required.

4.3.1 MODEL OF DVR

MATLAB simulink programming is utilized for reenactment and results. Simulink is a product bundle for displaying, reproducing and dissecting dynamic frameworks. It bolsters straight and non-direct frameworks displayed in consistent time, tested time or a half and half of the two Simulink

incorporates a complete square library of sinks, sources, direct and non-direct segments and connectors. It has a broad control library that permits simple usage of any control calculation, including direct control, fluffy rationale, neural systems and others. The DVR utilizes self-commutating IGBT strong state power electronic changes to moderate voltage hangs in the framework. The voltage controlled three single-stage full scaffold PWM inverters are utilized to create remunerating voltage. The exchanging recurrence of the inverters is 3 kHz. Three of single-phase inverters are connected to the common DC voltage source. The DC voltage source is an external source supplying DC voltage to the inverter for AC voltage generation. The three 600/10000 V (rms) single-phase injection transformers boost the output waveform of the inverter unit and supplies voltage to load side , where the voltage is further stepped down to 0.4 kv for sensitive load (load to be protected).The circuit breakers are placed in the circuit with the injection transformers allowing the protection of the DVR.

4.3.2 Proposed DVR Configuration

The DVR uses self-commutating IGBT solid-state power electronic switches to mitigate voltage sags in the system. The voltage controlled three single-phase full bridge PWM inverters are used to produce compensating voltage. The switching frequency of the inverters is 3 kHz. Three of single-phase inverters are connected to the common DC voltage source. The DC voltage source is an external source supplying DC voltage to the inverter for AC voltage generation. The three 600/10000 V (rms) single-phase injection transformers boost the output waveform of the inverter unit and supplies voltage to load side , where the voltage is further stepped down to 0.4 kv for sensitive load (load to be protected).The circuit breakers are placed in the circuit with the injection transformers allowing the protection of the DVR.

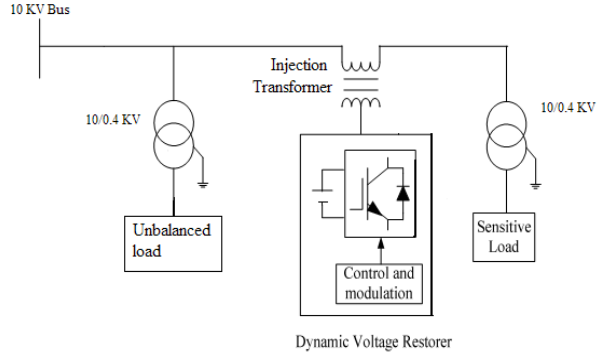

Fig 7.3.1Single line diagram of system

Simulink Model of DVR connected to a distribution network (voltage sag produced through load) The power circuit of DVR systems can be represented as a three-phase equivalent circuit as shown in Fig

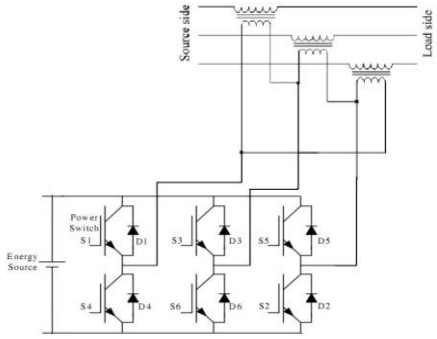

Fig 7.3.2 Equivalent three phase circuit diagram for DVR

The general principle of DVR is that whenever the system detects a voltage sag/swell, the DVR should react as fast as possible and inject an ac voltage into the grid. It can be implemented using the synchronous reference frame (SRF) technique based on the instantaneous values of the supply voltage. The control algorithm produces a three-phase reference voltage to the PWM inverter that tries to maintain the load voltage at its reference value. The voltage sag/swell is detected by measuring the error between the supply voltage and the reference value. The reference component is set to a rated voltage.The SRF method can be used to compensate all types of voltage disturbances, voltage sag/swell, voltage unbalance, and harmonic voltage.

The difference between the reference voltage and the supply voltage is applied to the ZSI to produce the load rated voltage, with the help of pulse width modulation (PWM) through the

PI controller:

$$V_d = \frac{2}{3}\left[V_a \times \sin(\omega t) + V_b \times \sin\left(\omega t - \frac{2\phi}{3}\right) + V_c \times \sin\left(\omega t + \frac{2\phi}{3}\right)\right]$$

$$V_q = \frac{2}{3}\left[V_a \times \cos(\omega t) + V_b \times \cos\left(\omega t - \frac{2\phi}{3}\right) + V_c \times \cos\left(\omega t + \frac{2\phi}{3}\right)\right] \quad (7)$$

$$V_0 = \frac{1}{3}\left[V_a + V_b + V_c\right],$$

where ω = rotation speed (rad/s) of the rotating frame. We have

$$V_a = \left[V_d \times \sin(\omega t) + V_q \times \cos(\omega t) + V_0\right]$$

$$V_b = \left[V_d \times \sin\left(\omega t - \frac{2\phi}{3}\right) + V_q \times \cos\left(\omega t - \frac{2\phi}{3}\right) + V_0\right]$$

$$V_c = \left[V_d \times \sin\left(\omega t + \frac{2\phi}{3}\right) + V_q \times \cos\left(\omega t + \frac{2\phi}{3}\right) + V_0\right]. \quad (8)$$

4.4 CALCULATION OF DC LINK VOLTAGE

RMS value of grid line voltage V_g= 690 V

Grid phase voltage RMS value is = 690/√ = 398.37

Peak value of grid phase voltage V_{gm}= √ * 398.37 = 563.392

For SVPWM technique, Vdc = √ * V_{gm}
Hence DC link voltage Vdc = √ * V_{gm}= 975.8
So reference value of V_{dc} i.e. Vdc* must be greater than calculated Vdc so 1000 V can be selected as a reference value.

4.5 SIMULATIONS AND RESULTS

The system runs at 50 Hz frequency and total simulation time is chosen to be 0.35 seconds in each case. The scope connected to the V-I measurements at supply side as shown in fig 7.5.1

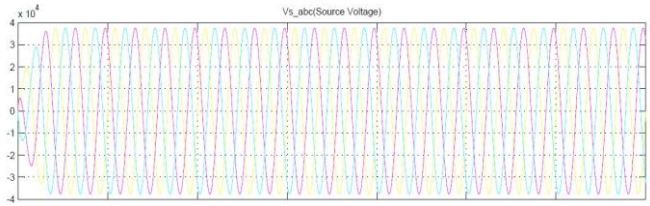

Fig 7.5.1. Voltage Sag due to DFIG/disturbances

load side gives the simulations of supply voltage having sag and the voltage across load. We have taken DFIG and three phase programmable sources. The disadvantage of DFIG as a source is that it creates voltage misbalance in the system due to which sag is produced. In Fig 7.5.2 it is observed that initially there is no voltage injection and power flow from DVR to the system. As no voltage sag is sensed. As soon as the load becomes unbalanced the voltage sag occurs.

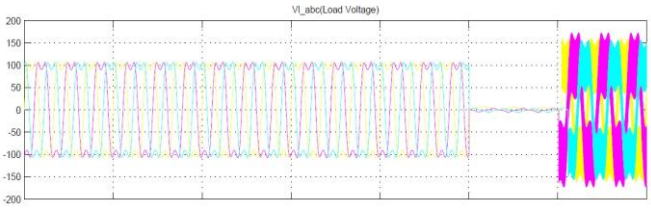

Fig 7.5.2 . Voltage Sag due to DFIG/disturbances

After the occurrence of Voltage Sag DVR comes into action and injects voltage which somewhat lessen the sag. Thus the system becomes more stable.as shown in fig 7.5.3 and 7.5.4.the sensing of DFIG disturbances by the DVR results in a rectified output voltage profile in which the voltage sag is compensated. the proposed methodology proves very unique that rectified the critical load changes disturbance problem.

The primary task of DVR is providing the high quality voltage to the critical loads. DVR enable the proposed system for providing a good power and voltage quality to the critical load. The controller output signals stabilize when all the phase voltages of the load attain the desired value. DVR gives high performance in injecting the more in-phase voltage with proper polarity and phase angle.

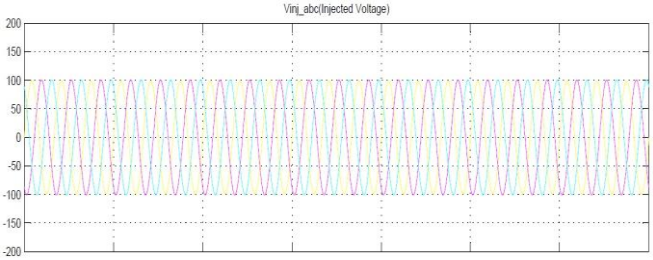

Fig 7.5.3. Injected Voltage due to DVR

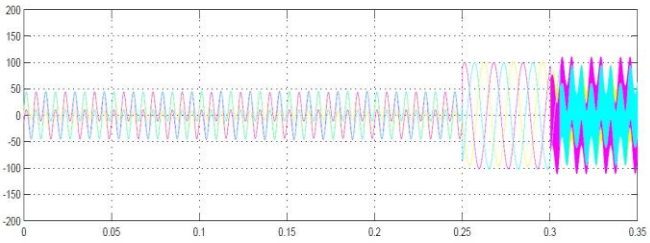

Fig7.5.4. Final rectified voltage by DVR

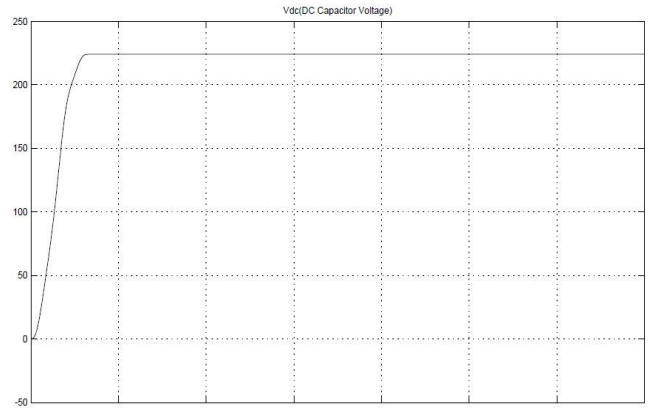

Fig 7.5.5. capacitor voltage output

The Fig 7.5.5. illustrates how quickly the DVR responds for sudden changes to keep the sensitive load voltages at reference value. The calculated injection voltages exactly compensate the sag because the controller exactly calculates the missing voltage. Also the exponential rising curve of energy storage device above depicts that the sensing done by DVR for voltage sag and response given by capacitor storage resolves the problem, the single-phase PWM inverters managed by the control system generate the three distinct series inverter output voltages to compensate the source voltages at different sag level.

V. CONCLUSION

Because of the normal for high vitality thickness and fast reaction, a superconducting magnet is chosen as the vitality stockpiling unit to improve the pay ability of DVR. Notwithstanding that, a helper control methodology for the interference of downstream flaw current in transmission line is presented. The remuneration ability of DVR can be further be improved by utilizing fluffy controller as criticism controller.

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