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# VOLTAGE PROFILE IMPROVEMENT IN A HYBRID WIND ENERGY SYSTEM USING FACTS DEVICES

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**ABSTRACT:** This project deals with the implementation of FACTS devices such as STATCOM and UPFC to enhance the voltage profile in 5-bus hybrid system considering wind energy and solar energy as sources. Also this paper shows the effect of static synchronous compensator (STATCOM) and UPFC on the voltage stability of power system. Main objective of this paper is to improve dynamic voltage control and thus increasing system load ability. The STATCOM is used to regulate voltage in power system by generating or absorbing reactive power. An UPFC whose output is adjusted to exchange capacitive or inductive current so as to maintain or control specific parameters of the electrical power system (typically bus voltage).This paper presents modeling and simulation of STATCOM and UPFC in MATLAB Simulink for dynamic voltage control. The results are then compared and from that the best devices will be suggested.

## 1.INTRODUCTION

There has been a worldwide pattern towards the usage of green or sustainable power source, which owes a lot to the fast utilization of non-inexhaustible power assets. Sustainable power source is commonly gotten from either sunlight based, wind. Upon age, the environmentally friendly power vitality will at that point be circulated to the end-clients by means of the fundamental power matrix or independent disseminated generators that are associated with the primary network. The utilization of efficient power vitality is as yet bound in urban communities where are focused on the improvements and assets. Moreover, there have been utilizations of remote sustainable power source advancements, for example, sunlight based photovoltaic (PV) frameworks, smaller scale hydroelectric frameworks, wind-half breed frameworks in provincial territories in a few nations in Latin America, Africa and South and Southeast Asia[4-6]. The off-network jolt technique is favorable, particularly when the lattice augmentation isn't financially or ecologically reasonable [7-9]. Then again, after the foundation of these environmentally friendly power vitality advancements, the primary issue of concern is the unwavering quality, which is portrayed as the power nature of the provided vitalityWhen such bizarre situations are took place in the machine, bendy alternating present day transmission

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system (FACTS) era opens up a new possibility to improve the voltage profile and controlling the power by way of improving the transmission capacity.The STATCOM is basically a shunt related switching converter type VAR generator. This switching converter can be Voltage source converter or present day supply converter. Generally voltage source converter is getting used but this version makes use of a modern-day source inverter. This machine has the basic block diagram of a STATCOM. An UPFC can constantly provide the reactive energy required to manipulate dynamic voltage oscillation under diverse gadget conditions thereby improve the power gadget transmission and distribution stability.

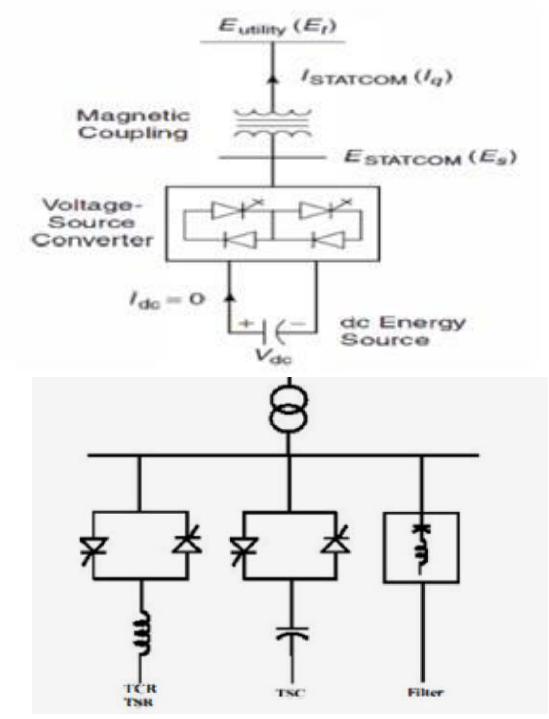


Fig. 1 Block Diagram of STATCOM

The exchanging converter utilizes self-commutating switches like GTO, IGBT. The exchanging converter type have a few points of interest over factor impedance type VAR generators( TCR, TSC) like quicker reaction, requires less space, relocatable and measured. It tends to be interfaced with genuine power sources like battery and so forth. The most significant component is that it can give better execution under low voltage condition as the responsive can be looked after steady.

## 2.WIND ENERGY SYSTEMS

One of the fast growing power within the international is wind era. Wind is the form of kinetic electricity that transformed to first mechanical with the help of turbine. For generation of electricity from wind, device having PMSG, inverter, Rectifier. In the system wind turbine seize the strength from wind, and generator convert that mechanical power into electrical. With the help of strength electronics apparatus converts the electricity from low to high nice and it manipulate the rotor generator pace. Power generated by wind turbine.

$$P = \frac{1}{2} QAC_p(\lambda)V^3 \quad (1)$$

?=Air density
?= Area of swept out by turbine
?=wind speed
??(?)=power coefficient
?= tip speed ratio

Maximum value of power coefficient theoretically is 0.59. It is depend on two variable ? and pitch angle. Tip speed ratio is given by

$$\lambda = Rn\pi / 30V \quad (2)$$

n=turbine rotor speed in R/min

The power coefficient of the wind turbine

$$C_p(\lambda) = C_1\left(\frac{C_2}{\lambda_1} - C_3\beta - C_4\right)e^{\frac{-C_5}{\lambda_i}} + C_6\lambda$$

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(3)

$$\frac{1}{\lambda_i} = \left[\frac{1}{\lambda+0.089} - \frac{0.035}{\beta^2+1}\right]$$

(4)

When ?= 0 that is the pitch angle then ? = 6.325?? is maximum value

In this project use for generating power from wind use PMSG generator that is permanent magnet synchronous generator. One of the main advantage is that it does not need reactive magnetizing current. In synchronous generator, magnetic field is created by using permanent magnet, or conventional field winding. It can used with any gear box for direct drive application [3]. Application of PMSG in wind turbine Because of their property of self-excitation which allow an operation of high power and high-efficiency. Permanent magnet use typically low power generated application and having low-cost. DC-DC boost converter are used to converter the low power to high.

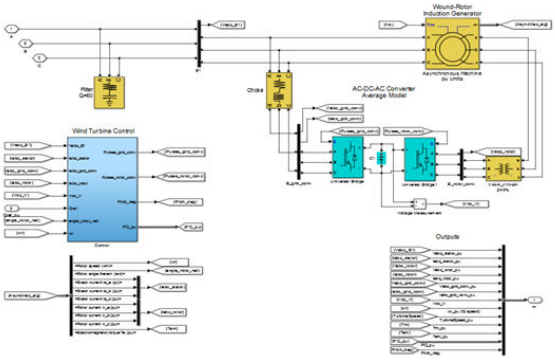

Fig. 2 MATLAB wind model

### 3.PV SOLAR SYSTEM

The solar panel is convert solar electricity into electrical energy with DC-DC converter to step up the voltage of the sun power. In widespread Current supply are connect to parallel to the diode can be represented as a photovoltaic cellular [2]. The equivalent circuit also aggregate of series resistance and shunt resistance represented by Rsh whose value is large and Rs is small. Photovoltaic cellular is the semiconductor device that take in the energy and convert energy of mild into electricity through the impact of sun radiation and temperature. The equal circuit shown below.

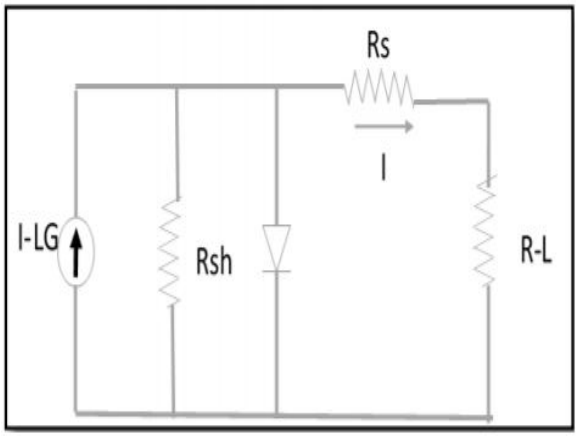


Fig. 3 Equivalent circuit of PV model

The corresponding characteristic of the solar cell is below:

$$I = I_{LG} - I_D - I_{Rsh} \quad (5)$$

$$I = I_{LG} - I_{OS}\{exp^{\frac{q}{AKT}(V+IR_S)]-1\} - \frac{V+IR_S}{R_{sh}} \quad (6)$$

?: Cell output current (A)

?: cell output voltage

?$_{??}$ : Photon current (A)

?$_{??}$ : PV cell's reverse saturation current (A)

?: Boltzmann's constant. (1.38 ∗ 10 −23 J/°K)

?: Electron charge. (1.6 ∗ 10 − 19 C)

?, ?: Ideality constant, between 1 and 2

?$_{?h}$ : PV cell parallel resistance. (Ω)

?$_{?}$ : PV cell series resistance. (Ω)

Under short circuit and open circuit condition mathematical model of PV cell has been created.

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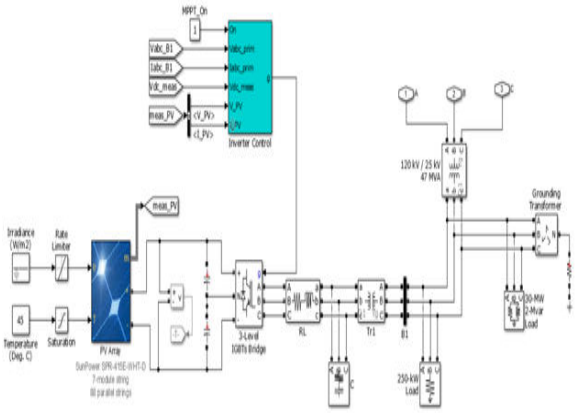

Fig. 4 MATLAB PV model

## 4.CONTROL SYSTEM BLOCK DIAGRAM OF STATCOM AND UPFC

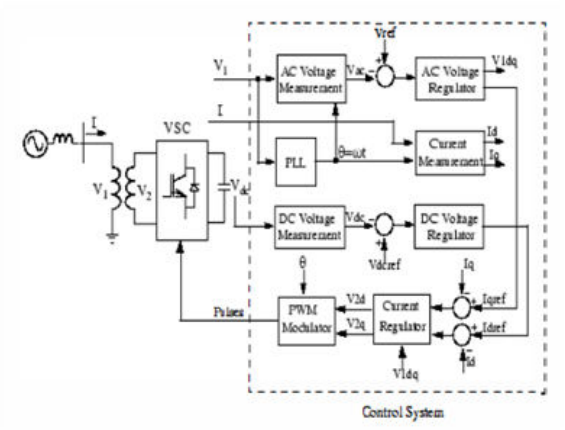


Fig.5. Control Block Diagram of STATCOM

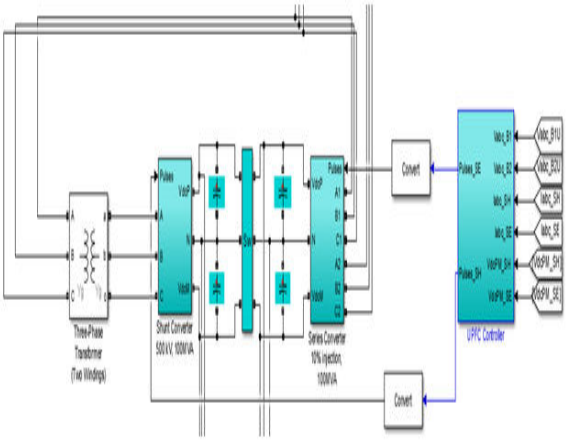

Fig. 6. Control System Block Diagram of UPFC

The control system consist of

1) Phase lock loop-PLL synchronize positive sequence component of the three phase primary voltage VI. The output of the PLL (angle Θ=wt) is used to compute direct axis and quadrature axis components of AC 3ϕ voltage and current ($V_d$, $V_q$, & $I_d$, $I_q$).

2) The AC and DC measurement system measures the d &q components of AC positive sequence voltage and current as well as DC voltage $V_{dc}$ to be controlled

3) The outer regulation loop consists of AC voltage regulator and DC voltage regulator. The output of AC voltage regulator is the reference current $I_{qref}$ and is given to current regulator. Where Iq is the current in quadrature with voltage which control reactive power flow. The output of DC voltage regulator is reference $I_{dref}$ and is given to current regulator. $I_d$ is the current in phase with voltage which control active power flow.

4) From $I_{dref}$ and $I_{qref}$ reference current produced respectively by DC voltage regulator and AC voltage regulator given to current regulator at control magnitude and phase of voltage generated by PWM converter ($V_{2d}$, $V_{2q}$) and gives the proper gate pulse to $V_{se}$ for further operation of voltage regulator.

5) UPFC control system consists shunt converter and series converter and the UPFC controller.

6) The controlling is used for the shunt and series converter for the generating of the gate pulses to the converter.

7) The output of the UPFC can be controlled through the gate pulse controlling the output at the sag, swell and other conditions.

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## 5.SIMULATION MODEL

STATCOM and UPFC are connected approximately middle point of the transmission line. In that test model two generators are connected both end side. After creating a fault the disturbances in transmission line can be compensated by STATCOM and SVC.

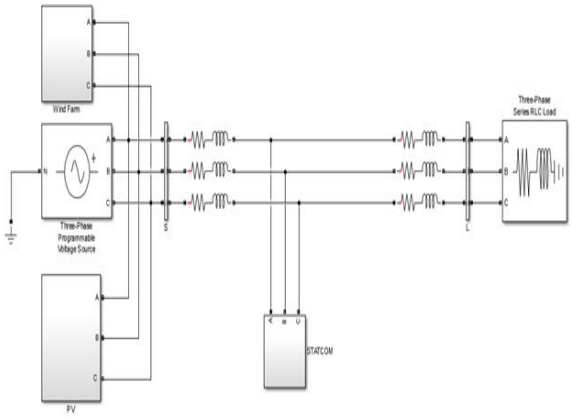

Fig. 7. STATCOM on Transmission Line

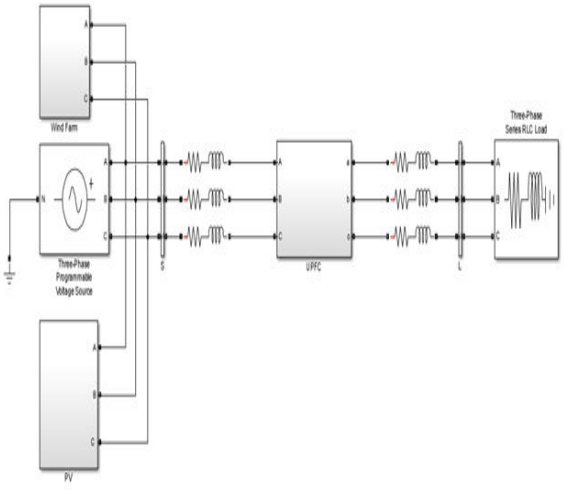

Fig. 8.UPFC on a Transmission Line

Above figure shows the MATLAB simulation model of transmission line with STATCOM, UPFC whose output graphs are displayed on common display of voltage scopes to compare the performance of simple transmission line with STATCOM and SVC.

## SIMULATION RESULTS

Faults at either the transmission or distribution level may cause voltage sag or voltage swell in the entire system or a large part of it. Also, under heavy load conditions, a significant voltage drop may occur in the system. These effects can be very expensive for the customers ranging from minor quality variations to productions downtime and equipment damage.

Voltage swell, which is momentary increase in voltage, happens when a heavy load turns off in a power system. A voltage droop or a voltage plunge is a brief length decrease in RMS voltage which can be brought about by short out, over-burden or turning over of electric engines. Voltage list happens when the RMS voltage diminishes somewhere in the range of 10 and 90 percent of ostensible voltage for one-half cycle to one moment. The proposed control plan is reproduced utilizing SIMULINK in power frameworks square set. The framework execution of proposed framework under the dynamic condition are appeared in the accompanying figures.

The compensation of the voltage at the conditions of the sag and swell with STATCOM is shown in fig.9 where the compensation for UPFC is shown in fig.10.

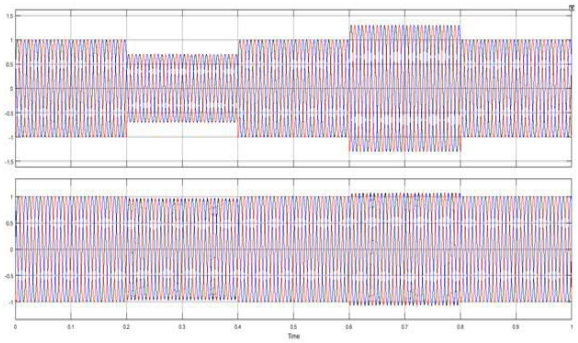

Fig.9. Variations of source and load voltage for STATCOM

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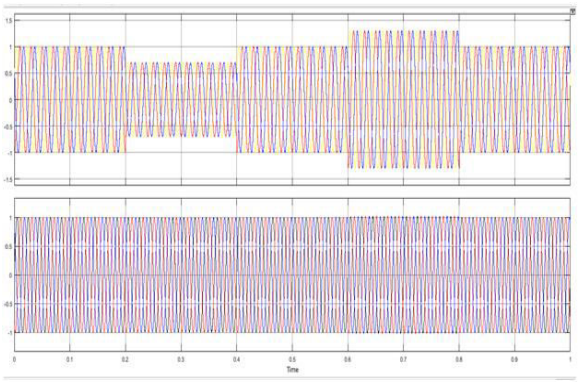

Fig. 10. Variations of source and load voltage for UPFC

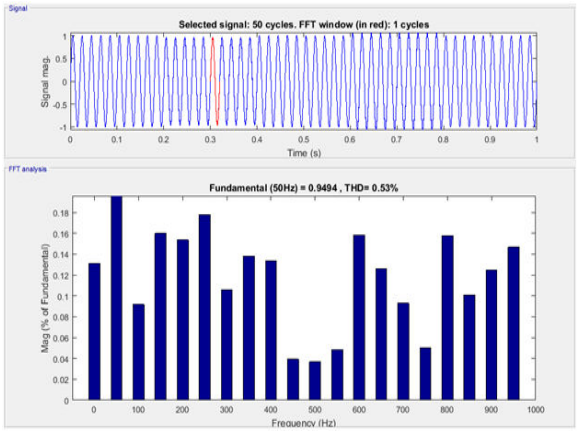


Fig. 11.THD values of source voltage for STATCOM

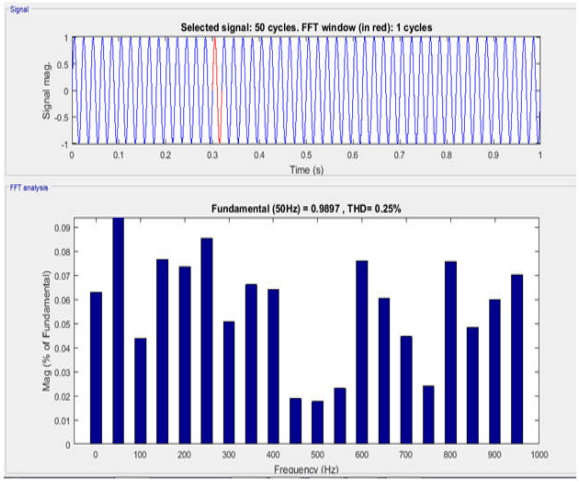


Fig.12. THD values of voltage for UPFC

The comparison of the performance of the STATCOM and UPFC can be analyzed by the THD analysis for the voltage . The THD values for both STATCOM and UPFC are shown in fig.11 and fig.12. From this it is clear that the UPFC gives the better performance compared to the STATCOM.

## CONCLUSION

In this paper the STATCOM and UPFC models are analyzed with MATLAB/SIMULINK tool considering the wind and solar system as the sources. it is shown that how STATCOM has successfully been applied to power system for effectively regulating system voltage. When system voltage is low the STATCOM generates reactive power (STATCOM capacitive). When system voltage is high it absorbs reactive power (STATCOM inductive). The usefulness of UPFC has been studied in improving the transient stability of the above model. The THD comparison is performed for the STATCOM and UPFC and it can be concluded that the performance of power system improved by using UPFC .

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