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Wind-Photovoltaic Combined Generation with Grid Connection Using Back-to-Back Voltage Source Converters

G.V.K. Murthy[1], Konduiru Yashasvini[2], Racha Nitheesha[3], Juturi Lakshmi Tejaswini[4], Gandla Lakshmi Jahnavi[5], Nekkanti Sai Kiran[6], and K. Sowjan Kumar[7]

[1]Professor, Department of Electrical and Electronics Engineering, PACE Institute of Technology and Sciences, Ongole, Andhra Pradesh, India
[2,3,4,5,6]B.Tech Scholar, Department of Electrical and Electronics Engineering, PACE Institute of Technology and Sciences, Ongole, Andhra Pradesh, India
[7]Assistant Professor in Department of Electrical and Electronics Engineering, PACE Institute of Technology and Sciences, Ongole, Andhra Pradesh, India

ABSTRACT- Here, we introduce a brand - new topology, but easy and efficient, for a grid-linked windphotovoltaic (PV) cogeneration system. A permanent magnet synchronous generator-primarily based totally full - scale wind turbine is interfaced to the utility-grid through back-to-back (Bt-B) voltage-supply converters (VSCs). A PV sun generator is at once linked to the dc-hyperlink capacitor of the B-t-B VSCs. No dc/dc conversion stages are required, and subsequently the system performance is maximized. The proposed topology capabilities an unbiased most strength factor monitoring for each the wind and the PV turbines to maximise the extraction of the renewable energy. The certain small signal fashions for the system additives are evolved to look at the general stability. The effect of the utility-grid faults at the overall performance of the proposed system is likewise evaluated. Nonlinear time-domain simulation consequences below different running situations are supplied to validate the effectiveness of the proposed topology.

KEYWORDS- PV, Voltage, Turbines, Dc Voltage.

I. INTRODUCTION

Renewable Energy sources are becoming very essential now-a-days. The usage of these sources are widely encouraged, since very negligible amounts of pollution will be emitted from them as compared to other conventional (Non – Renewable) energy sources. By comparing the advantages and disadvantages both conventional and non – conventional sources of energy, non – conventional sources are always a step ahead in aspects of saving money, reducing pollution levels, conservation of fuel, requirement of maintenance, easy disposal of used fuel. But, they are intermittent in nature and cannot be available all the time, when they are needed. This aspect wakes up the question to use such kind of sources to fulfil the demand of energy supply.

One of the thoughts to go through this conflict is to use the combination of these sources, and in order to avoid the complexity of connection to the utility grid, here we use only any two of them. So, that the benefits of the available renewable sources will be maximized. Wind and Solar energies are most commonly available renewable energy sources. The techniques of the energy extraction and their conversion into electrical is already available. So, it will be easier to use these two sources to generate electrical energy. In addition to the above conclusions, the cost line of both the energy sources has been saturating very rapidly since the last few days.

Even two of the sources are used, the intermittent characteristics and unregulated quality of both the wind and solar energies, Power – electronic converters needed to be used as interfacing equipment to the load – terminal or the existing grid. This thing leads to the creation of distributed generation units. In general, distributed generation is used for only utilised for only one form of renewable sources.

The combined generation of these two sources will have the following characteristics:

- Overall potential efficiency will be Improved, due to the complementary nature of availability of the wind and solar energies.
- It improves the capital investments by optimizing the usage of land resources.
- Reliability of the system will be increased by having the sources of energy.
- These co – generation systems are dynamically more capable than the static PV generators for the variations in load demand.
- Conservation of Fossil fuels can be done through usage of this kind of Co – generation systems of renewable energy sources.

II. LITERATURE SURVEY

Power-electronic systems for the grid integration of renewable energy sources-a survey

The use of distributed energy resources is increasingly being pursued as a supplement and an alternative to large conventional central power stations[1]. The specification of a power-electronic interface is subject to requirements related not only to the renewable energy source itself but also to its effects on the power-system operation, especially where the intermittent energy source constitutes a significant part of the total system capacity. In this paper, new trends in power electronics[2] for the integration of wind and photovoltaic (PV) power generators are presented. A review of the appropriate storage-system technology used for the integration of intermittent renewable energy sources is also introduced. Discussions about common and future trends in renewable energy systems based on reliability and maturity of each technology are presented[3]

A control methodology and characterization of dynamics for a photovoltaic (PV) system interfaced with a distribution network

This paper proposes a control strategy for a single-stage, three-phase, photovoltaic (PV) system that is connected to a distribution network.[4] The control is based on an inner current-control loop and an outer DC-link voltage regulator. The current-control mechanism decouples the PV system dynamics from those of the network and the loads. The DC-link voltage-control scheme enables control and maximization of the real power output. Proper feedforward actions are proposed for the current-control loop to make its dynamics independent of those of the rest of the system[5]. Further, a feedforward compensation mechanism is proposed for the DC-link voltage-control loop, to make the PV system dynamics immune to the PV array nonlinear characteristic. This, in turn, permits the design and optimization of the [6]PV system controllers for a wide range of operating conditions. A modal/sensitivity analysis is also conducted on a linearized model of the overall system[7], to characterize dynamic properties of the system, to evaluate robustness of the controllers, and to identify the nature of interactions between the PV system and the network/loads. The results[8] of the modal analysis confirm that under the proposed control strategy, dynamics of the PV system are decoupled from those of the distribution network and, therefore, the PV system does not destabilize the distribution network. It is also shown that the PV system dynamics are not influenced by those of the network (i.e., the PV system maintains its stability and dynamic properties despite major variations in the line length, line X / R ratio, load type, and load distance from the PV system)

Stability of a variable-speed permanent magnet wind generator with weak ac grids

The operation of high-power wind generators with weakened ac grids has historically been difficult because of stability and power quality issues. This paper presents an analytical stability study of a variable-speed directly-driven permanently-excited 2-MW wind generator connected to ac grids of widely varying strength and very weak grids. The generator includes two back-to-back full-scale vector controlled 3-level neutral-point-clamped (NPC) voltage-source-converters (VSC). A 47th order small-signal analytical wind generator model is developed within MatLab, and a summary[9] of the model structure and controls is given. Model verification is demonstrated for fast and slow system variables employing detailed simulation software PSCAD/EMTDC. An eigenvalue stability study for weak ac networks is presented, and qualitative conclusions about inherent system dynamics and stability characteristics are given. These insights are employed to study the design of an ac voltage controller for weak ac networks. Two alternative controller designs are studied for their potential to enhance system robustness to changes in ac grid strength. Testing on the detailed simulator PSCAD/EMTDC is employed throughout to confirm conclusions from analytical studies.[10]

Offshore wind integration to a weak grid by VSC-HVDC links using power-synchronization control - a case study

In this paper, the application of a recently invented power-synchronization control is proposed for integrating a doubly fed induction generator[11] (DFIG)-based offshore wind farm to a weak ac grid through a voltage-source converter (VSC)-based high-voltage dc link. The control strategy, along with the antiwindup techniques and the bumpless[12] transfer between two different control modes, is elaborately discussed. Two different fault cases, namely[13], onshore and offshore faults are considered and the fault-ride through techniques are presented. In case of the onshore fault, both with-chopper and without-chopper solutions are investigated.[14] For an offshore fault, a coordinated fault-ridethrough scheme is proposed when the offshore HVDC converter [16]and the wind farm are in voltage-control modes. The entire study is carried out in a real-time digital simulator (RTDS) platform.

III. PROPOSED SYSTEM AND CONTROL DESIGN

A. Modeling and Control of the Proposed Wind Photovoltaic Cogeneration System

As appeared in Fig. 1, the proposed framework comprises of a VSR to interface the breeze generator, and a VSI to associate the cogeneration framework into the utility-network. The PV generator is legitimately associated with the dc-connect capacitor of the BtB VSCs by means of a dc link [27]. The VSR and VSI are two-level converters comprising of six cells; each contains a protected entryway bipolar transistor (IGBT) in corresponding with a diode. In the accompanying subsections, the total displaying and control of the proposed framework is given.

B. Wind Generator

A full-scale wind turbine (FSWT) using a perpetual magnet simultaneous generator (PMSG) is chosen for its low support and low operational expense [2]. The breeze turbine model is spoken to as following,

$$Pm=\frac{1}{2}\,Cp(\beta,\lambda)\rho\pi \boldsymbol{R^2 v_{wind}^3},$$

$$\lambda=\frac{\boldsymbol{R}\omega\mathbf{r}}{\boldsymbol{v_{wind}}}$$

where Pm is the mechanical force caught by the breeze turbine sharp edges; Cp is the rotor coefficient which is a non-straight capacity of the edge pitch point (ϐ) and the tip-speed proportion (λ); ρ is the air thickness; R is the range of the breeze turbine edge; νwind is the breeze speed; ωr and is the mechanical speed of the rotor. In this paper, ϐ is set to focus in the ordinary working conditions to augment the breeze power age [13]. The PMSG is displayed as following,

$$\bar{v}_s = R_s\bar{\imath}_s + L_s\frac{d\bar{\imath}_s}{dt} + j\mathrm{P}\omega_r(\psi + L_s\bar{\imath}_s)$$

$$J\frac{d}{dt}\omega_r + \beta\omega_r = \frac{3}{2}\mathrm{P}\psi I_{sq} - T_m$$

In(2),$\overline{v_s}$ and $\overline{\imath_s}$ are the stator voltage and current in the unpredictable vectors portrayal, separately, where a perplexing vector $\bar{x}$=Xd+jXq with the end goal that Xd and Xq are the direct (d −) and quadrature (q −) segments of $\bar{x}$ in the pivoting reference outline; Rs and Ls are the stator-winding opposition and inductance, individually; j is the fanciful unit number; ψ is the transition linkage of the rotor magnets; Ƥ is the quantity of posts sets; Tm is the mechanical force; while j and β are the engine idleness, and gooey grating, separately.

C. Machine-Side Voltage Source Rectifier (VSR)

Fig. 2 shows the connection between the mechanical rotor speed and the produced breeze turbine power at various breeze speeds. At any wind speed, there is an ideal estimation of the mechanical rotor speed that relates to the age of the most extreme breeze power. The extraction of the most extreme breeze power is accomplished by the VSR in Fig. 1. The MPPT calculation for the breeze generator (MPPTw) utilizes the breeze speed (νw) to create the ideal estimation of the rotor speed (ω_r^*) following the mechanical attributes in Fig. 2 , .

As appeared in (4), a PI speed regulator (Gs(s)=gps+gis/s) is actualized to control the rotor speed (ωr) to the ideal worth (ω_r^*) and directs the q-segment of stator current reference (I_{sq}^*), though the d-segment of stator current reference (I_{sd}^*) is set to zero to work at the most extreme created force [19].

I_{sq}^*=($\omega_r^* -$ ωr)Gs(s)

I_{sd}^*=0

where s speaks to the differential administrator.

Explaining (3) and (4), expecting Isq ≈ I_{sq}^* inside the transmission capacity of the speed regulator (Gs(s)), and setting gis/gps the shut circle move capacity of the speed regulator becomes;

$$\omega_r/\omega_r^* = \left(\tfrac{3}{2}\mathrm{P}\psi g_{ps}/J\right)/\left(s + \left(\tfrac{3}{2}\mathrm{P}\psi g_{ps}/J\right)\right),$$

where the transmission capacity is $\frac{3}{2}P\omega_r^0$Ls$\overline{\iota_s}$ [rad/s], and is chosen to be around 10% of the transfer speed of the inward current regulator [discussed in the accompanying paragraph]. The speed regulator boundaries, i.e.,gps and gis, can be tuned likewise.

$$\bar{v}_s = (\bar{\iota}_s^* - \bar{\iota}_s)G_i(s) + j\mathrm{P}\mathring{\omega}_r L_s \bar{\iota}_s + j\mathrm{P}\psi H\omega_r$$

As appeared in Fig. 1 and (5), a PI current regulator (Gi(s)=gps+gii/s) is utilized so the created stator flows of the PMSG follow the relating references in (4).

where $j\mathrm{P}\mathring{\omega}_r L_s \bar{\iota}_s$ are the decoupling circles;H is an addition; though the superscript "°" signify the consistent state estimation of the variable. The current regulator in (5) is planned by fathoming (2) and (5). By setting gii/gpi=Rs/Ls, the shut circle move capacity of the current regulator becomes; $I_{sd}/I_{sd}^* = 1/(\tau_i s + 1)$, where the transfer speed of the current regulator is 1/τi=gpi/Ls [rad/s], and is chosen to associate with 10-20% of the exchanging recurrence of the VSR.

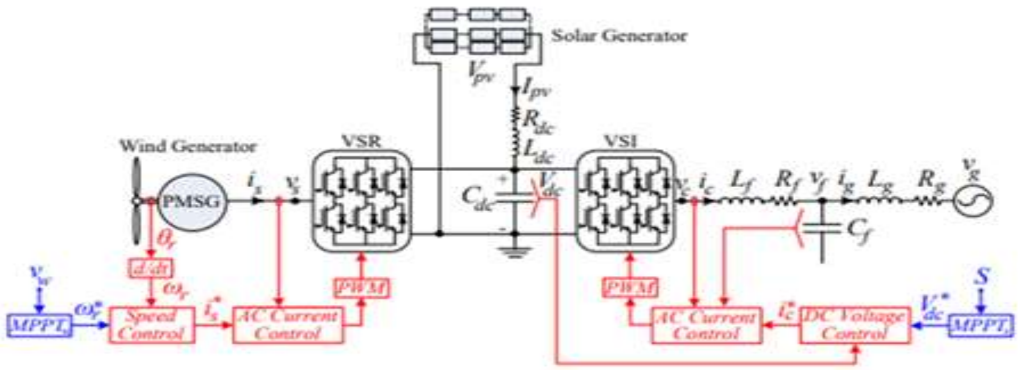


Figure 1: Proposed Wind PV Cogeneration system

D. Photo Voltaic Generator

In this, a PV cluster of a model "PV-UD190MF5" has been considered. The PV model is profoundly nonlinear yet mirrors no unique presentation on the transient security of the framework. The model of the PV generator is given in Appendix A while the dc link elements in Fig. 1 are demonstrated as following;

Vpv=Vdc+RdcIpv+Ldc $\frac{dI_{pv}}{dt}$

The Ipv-Vpv qualities of the PV exhibit are appeared in Fig. 3. At any sun based irradiance level, there is an ideal working point ($\mathring{I}_{pv}$,$\mathring{V}_{pv}$) comparing to the most extreme created PV power. As appeared in Fig. 1, the MPPT calculation of the PV cluster (MPPTs) utilizes the sun oriented irradiance level (S) to decide the ideal estimation of the dc-connect voltage (V_{dc}^*) [from Fig. 3] that relates to the age of the greatest PV power.

Alluding to Fig. 1, the ostensible voltage for PV exhibits is planned at 1457V. With these days enhancements in the incorporated force converters, PV clusters can be straightforwardly associated with a dc-connect with ostensible dc voltage up to 1500V at 2.0 MVA.

E. Grid-Side Voltage Source Inverter (VSI)

As appeared in Fig. 1, the air conditioner side of the VSI is ended by an inductive channel (Lf) with an inward obstruction (Rf) and a shunt capacitor (Cf). The root-mean-square (rms) estimation of the three-stage terminal voltage and flows of the VSI are vc and ic, individually. The utility-network impedance contains an inductive part (Lg) in arrangement with the comparable opposition of the line (Rg); vg and ig are the utility-framework three-stage rms voltage and flows, individually.

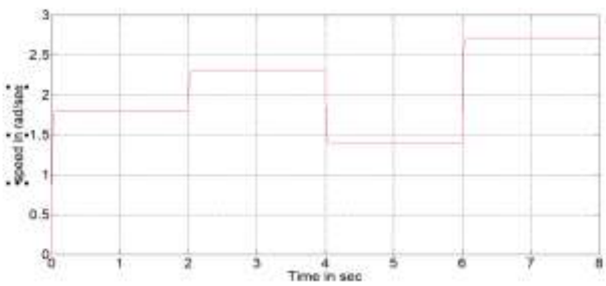
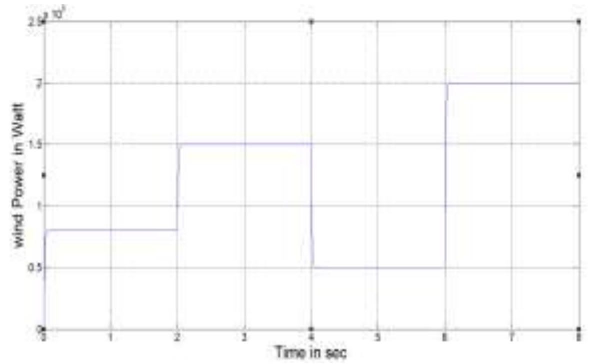
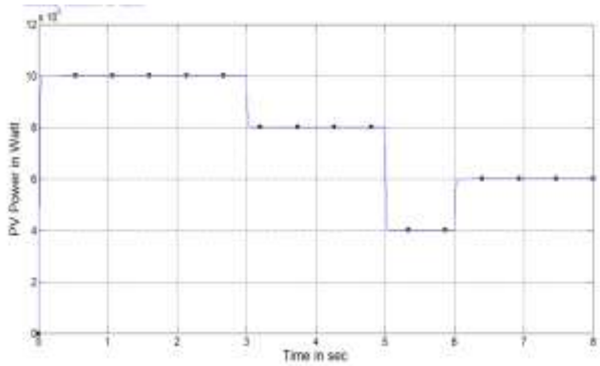


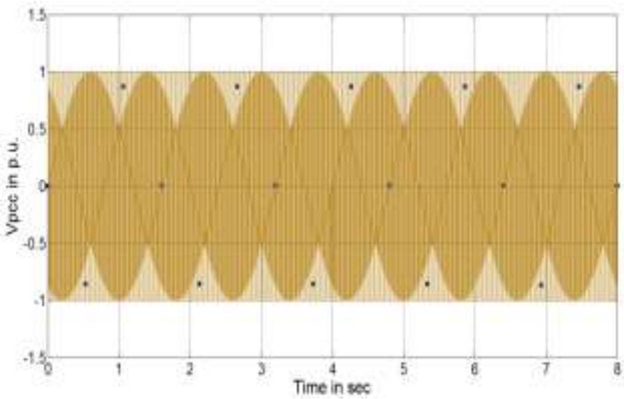
Figure 2: Pulse waves calculated in time period



(a)



(b)



(c)

Figure 3 (a)(b)(c): Time in sec of Voltage variations

Figure 3 is showing the time in sec of Voltage variations between the dc levels.

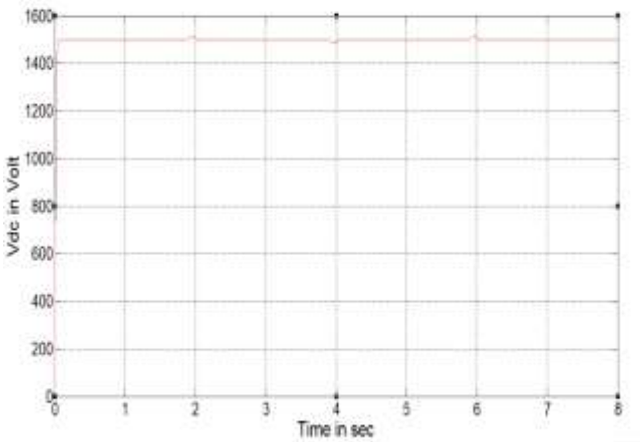


Figure 4: Voltage dropping levels

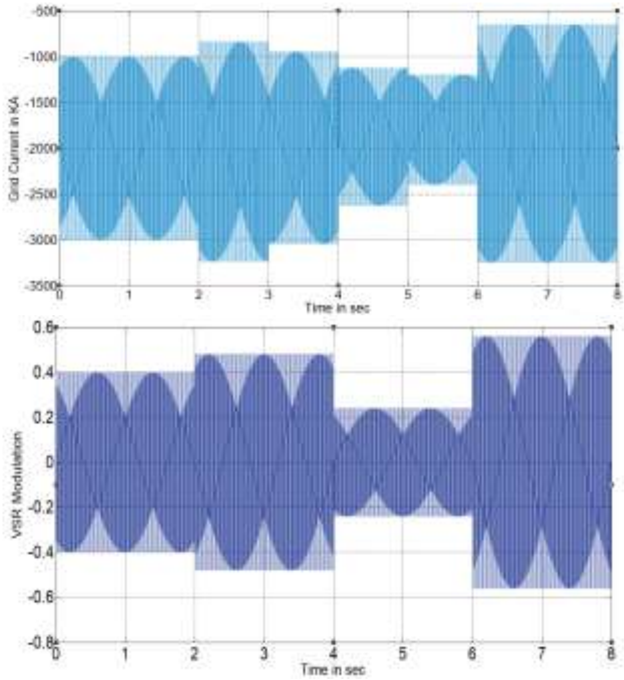


Figure 5: Variation between the two levels of dc

IV. CONCLUSION

Wind-PV Co-generation system connected to the grid are increasing both in the number of installations and also in the rated power of each plant and will cover a significant percentage of the electric generation mix. In this article, a comprehensive overview of grid- connected wind PV co-generation systems is presented. Different control techniques for proposed system such as PV MPPT, WECS MPPT control. And Inverter control and its performance is validated through the MATLAB Simulink version 2017a.Grid side converter control is done to grid synchronization with power (active and reactive) control.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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