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PV-Wind Energy System with Enhanced Efficiency: A Review

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Abstract:-*The integrated system of energy sources as solar photovoltaic and wind energy becomes the common practice to fulfil the demand of the remarkable power. This paper comparesthe work done on Integration of a PV-Wind Energy System (IPVWES) of the wind solar energy by using the grid and rotor-side power converters schemeand Small-Scale Hybrid Standalone Power Generation System (SSHSPGS).The grid and rotor-side power converters scheme (GRSPCS) used for doubly fed induction generator to inoculate PV power into the grid. The system is capable to nourishsignificantly large PV power into the grid compared to an equivalent rating inverter used in the conventional PV-grid system. Thisschemeavoids circulating power throughsub synchronous operation during availability of solar radiation. The recurrent but complementary nature ofwind energy and solar PV sources advances the converter'susefulness. While hybrid standalone power generating system (HSPGS) is based on a wind turbine (WT) and a solar-photovoltaic (PV) array.A squirrel cage induction generator (SCIG) is joined with a WT for electromechanical energy transformation. A battery energy storage system (BESS) is strengthened in the hybrid system to make certain power levelling under wind, solar and load variations. For attaining the maximum power from a solar PV array and to control the output DC voltage, a DC-DC boost converter is regulated using perturbation and observation method. The inclusive performance of the grid- and rotor-side power converters arrangement is batter in term of complication and essential hardware.*

Index Term*: - solar photovoltaic (PV), wind power generation, Battery Energy Storage, Hybrid Standalone Power Generating System, power quality.*

I. Introduction

The industrialization growth and mankind's craving to get more comfort have ensued in a steady rise in the demand for electricity [1]. Diesel Generators are the sources of energy in many rural areas in the world [2].These generators are costly and polluting. To meet this rising requirement, there is drastic increment in the number of conventional power producingstations. It is triggeringmassivepressure on the existing infrastructure.Electricity generation from wind energy and its combination with power grid is a well-founded technique.Efficiency and stability of the hybrid systems are the important matters that have a noteworthy research prospective [1].

In IPVWES and control scheme it gives asophisticatedand cost-effective integration of PV source and DFIG-based wind energy system. The hybrid system provides the following benefits [1]:

1) Improved power transformation efficiency is realized as there is no need to use a dedicated inverter for the PV source. Rotor circuit converters (VSC1 and VSC2) of the DFIG are used by PV-installation.
2) Overall cost is reduced, because of one Voltage Source Inverter(VSI) and its related control circuit (including DSP controller) are removed from the orthodox hybrid system.
3) As compared to the dedicated inverter in the orthodoxinterface, itfacilitates the possible interfacing of higher rating PV source.
4) It gives improved and optimumuse of power converters.
5) In the durationof low speed operation and high solar irradiation,the circulating power flow is decreased. This results in reduction of the losses of the complete system.
6) To extract optimum power from the PV source a maximumpower point tracking (MPPT)is realizedin combination with dc bus of the PV installation. To avoid overloading in case of high wind velocity, the wind turbine system is controlled with the maximum power extraction algorithm in combination with pitch control.
7) Changes in the grid-injected power through out a day arediminished. PV VSIIdle condition is closely eliminated. A basic minimum power conveyance from the hybrid system is retained across the day and throughout the seasons. It can not be obtained by systems fed either by solar PV or wind turbine sources only.
8) Suggested hybrid system givesopportunity to integrate energy storage to enhance power quality and trustworthiness in terms of steadiness and accessibility of the power supply. The whole power inoculation from this hybrid system to the grid is averaged by the recurrent but adulatorycauses of PV and wind.

9) Aimproved PV power control procedurecombined in the control scheme can handle any of the environmental situations in case of either high radiation or wind velocity level happeningconcurrently.

Numerous topologies and control methods are there in the literaturefor effective and safe incorporation of RESs into remote areas [3-8]. A provision of wind and solar energy has been determined by means of an optimization procedure for remote area is given in [3]. The stability of hybrid solar PV power generation united with a battery system has been analysed [4]. There is suggestion of hybrid wind-PV and battery connected stand-alone power producing system to remove the necessity of added dump load to stabilize the system when surplus power is generated [5]. This technique is complex in control and needs bulky constituents. Frequently, the voltage and frequency are controlled using suitable switching of the interfacing inverter in hybrid stand-alone power generation systems. Usually, the droop control approach is frequently chosen in attaining frequency control [6, 7]. The droop control aches with a number of shortcomings, such as necessity of complex internal multi-loop feedback control, the AC bus voltage and frequency differ beneath the loss of one or more RES [8]. In SSHSPGS, a wind-PV HSPGS using a squirrel cage induction generator (SCIG) is suggested for rural regions. A BESS is usedto engross power recurrence of wind speed and solar-irradiance variations. To control AC bus voltage and frequency at load terminals and to improve the power quality at the PCC a three-leg self-commutated switch based VSC is employed. A DC-DC boost converter connects solar PV array terminals and DC bus of a VSC for extraction of solar dependent power and to attain maximum power point tracking (MPPT) from PV array underneath the change in solar radiations.

The main aids of SSHSPGS are as follows:

• The suggested topology is using only a three-phase VSC and a DC-DC boost converter for wind and solar energy based HSPGS.It is simple and cost efficient.

• The topology suggested in this paper also incorporates BESS at DC bus of VSC to facilitate functions of power levelling underneath wind and solar power harvest and load perturbations.

• Control procedure is suggested for switching of VSC to attain harmonics compensation at PCC to diminish SCIG de-rating, to regulate voltage and frequency at load bus and to give insufficient reactive power demand of SCIG under wind speed changes.

• DC-DC boost converter control algorithm make sure MPPT at solar-PV array terminals under variation in solar-irradiance.

• Test in real time the performance of the suggested topology and its established control procedures.

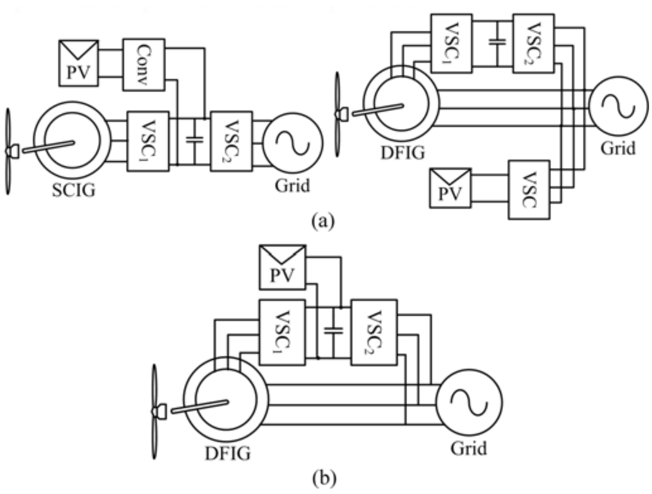

Fig1. (a) Block diagram of the conventional PV-wind hybrid systems.(b) Block diagram of Integration of a PV-Wind Energy System (IPVWES).

II. Integration of a PV-Wind Energy System

Grid connected PV-Wind hybrid system model has following modelling and control aspects:

A. GRID CONNECTED HYBRID SYSTEM

A 1 MW capacity of wind DFIG system is taken in this model along with a solar- PV generation of comparable rating. In this model, the rotor-side converter (VSC1) is rated for 250 kVA, while the grid-side converter is rated at 340 kVA is used .To connect the stator circuit of DFIG with the grid the circuit breaker s_2 is used.[9]

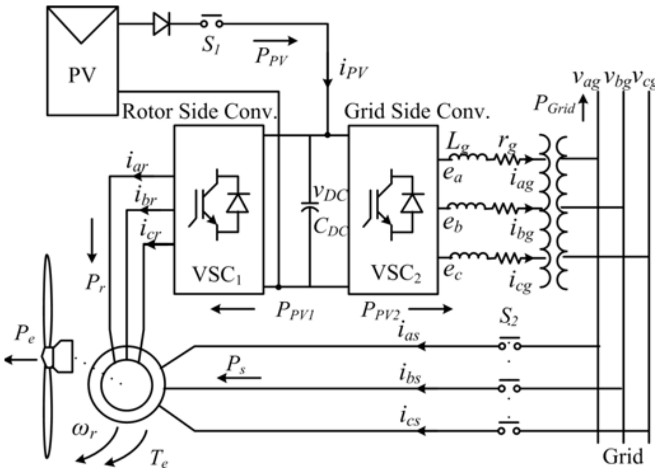

Fig. 2.solar PV-wind with DFIG system.

The block diagram of the solar PV-wind DFIG system is shown in Fig. 2. To operate over wide range of speed the rotor side convertertechnique is used in the above model. Pitch control technique is used to make sure optimal energy extraction. This technique also protects against unwarrantedwind turmoil and overloading [10].

An anti-blocking diode and dc breaker S_1 is used to protect the PV source whose operation is integrated into overall control strategy.

To protect $VSC_2$from overloading algorithm is integrated to control dc-bus voltage control(rather than only MPPT control)[11].

B. DFIG Control

DFIG is coupled with rotor current parameters and it is a nonlinear model.[12], [13]. Voltage of rotor terminal is controlled by $VSC_1$by means of modulation indices.For both VSC_1 and VSC_2 we use a technique that is sinusoidal pulse width Modulation.To control the rotor circuit current components PI controller that is invoked by decoupling and feed-forward compensation. Itis a better choice for first order plant transfer function to achieve maximum power yield the wind turbine –driven DFIG can be controlled over a range of speed. With the understanding and using PI compensator phenomena to improve line voltage profileor for reactive power support we can also use DFIGcontrol. It is an additional function.The control scheme proposed in this paper, for the grid-sideconverter, differs from the conventional control schemes in thebelow aspect:
1) In the suggested scheme, the control method given for grid-side converter has been combined with a special (modified) PV power control procedure and not just a orthodox MPPT control.

2) Extra control loop has been combined in the suggested system to challenge the “poorest case” environmental effect (i.e., high solar irradiation and high wind velocity occurring at the same time) by automatically adjusting VSC2 loading.

3) The PV and the wind systems operate at MPPin most of the duration. But, in the days of high solar irradiation and heavy wind conditions happening concurrently, the PV functioning point shifts from MPP to avoid overloading of VSC2.

III. HYBRID STAND ALONE POWER GENERATION SYSTEM

In figure.3 block diagram of SSHSPGS is shown.It consists of following component such as a PCC connected WT driven fixed speed three-phase squirrel cage induction generator (SCIG).At SCIG terminals athere is a three-phase star-connected excitationcapacitor bank that is used to supply reactive power to generate electricity. To control voltage and frequency of load bus terminal a three-leg VSC circuit is used. To connect the AC terminals of VSC to PCC A set of interfacing inductors are used.The output terminals of boost DC-DC converter is connected to the DC bus of VSC.

Output terminal of a solar PV array is connected for supply to the boost converter.There is a battery at DC bus for power balance in case of change in solar PV array power and consumer load demand situation. The BESS is used to supports the DC bus of VSC. The BESS store surplusrenewable energy during high power generation by system and less load demand by consumer.

In the time period of less renewable power generation It discharges through the load for the compensation of shortageof load demands.

To maintain the stability of this system in the long duration of excess power generation and less load supplies requirement ,which may fill-up the BESS,a dump load ($\mathbf{R_d}$) to discharge access power is connected to DC bus by means of a switch.

The operation of dump load is controlled using a solidstateself-commutated switch (Sd)' three phase linear and nonlinear loads are supplied from the PCC through a threephasestar-delta transformer with transformation ratio1:1. The transformer is used to electrically isolate loads from PCC and create neutral terminals for a three-phase four-wire system [15].

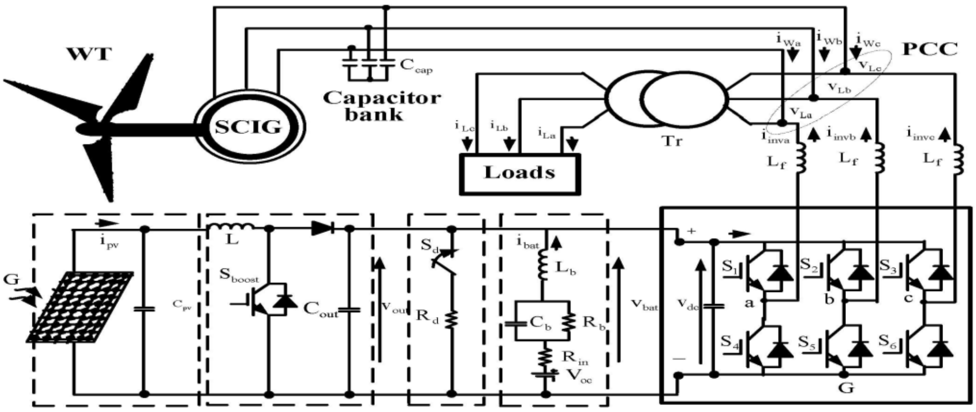

Fig.3 Block diagram of Small-Scale HybridStandalone Power Generation (SSHSPGS).

Thehybridsystemwithconventional distributed generation havingindividual source converters.

IV.RESULT ANALYSIS

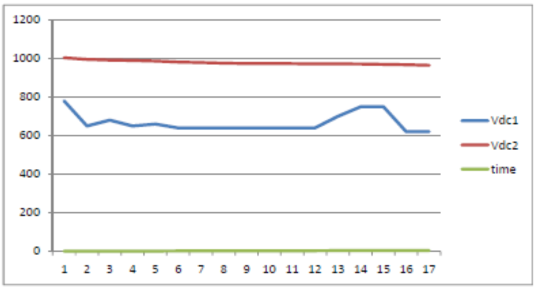

Fig.4 DC link voltages V_{dc1} andV_{dc2} with respect to time in PVWES and SSHSPGSrespectively.

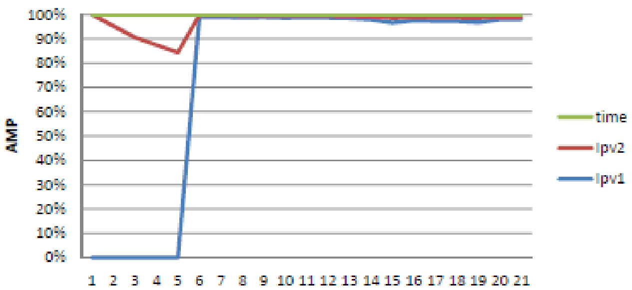

Fig.5 Output PV currents $I_{pv1}$and I_{pv2} with respect to time in IPVWES and SSHSPGS respectively.

V. CONCLUSION

Doubly fed induction machine which is used inIPVWESis more competent than squirrel cage induction machine in SSHSPGS.An extra feature that is grid side and rotor side convertor is used in IPVWES. PV installation utilizes rotor circuit converter (VSC_1 and VSC_2) of the DFIG. In SSHSPGS a control algorithm is proposed for switching of VSC to achieve harmonics compensation at PCC .This algorithm is also use to reduce de rating of SCIG, regulate voltage and frequency at load bus. It also provides deficit reactive power demand of SCIG under wind speed variation. In conventional interface it requires dedicated inverter. While in IPVWES provide facility of interfacing with all possible high rating PV-source. However SSHSPGS also used dedicated inverter.In IPVWES it reduces the circulating power flow under DFIG system during low speed operation and high solar irradiation.It cuts down the losses of overall system .It results in increased and optimal utilization of power converters.

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