"A Study of MPPT of PV-Wind of Grid Connected Hybrid System"

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Abstract:

The rising requirement for electrical energy at the pace of a period, to meet the expansion in the utilization of numerous elective energy like solar energy and wind. The accessibility solar and wind energy won't ever run out and solar energy can likewise be utilized as an elective energy that can switch over completely to electrical energy. Solar and wind energy has a fluctuating nature where there is dependably an adjustment of how much energy after some time. By expanding the use of solar board energy can be accomplished by the presence of strategies like MPPT (Maximum Power Point Tracking). P&O and INC is a calculation that can be utilized as a MPPT, where it will gain proficiency with each illumination change that happens and get maximum power.

Keywords: Hybrid Wind Solar System (HWSS), Doubly Fed Induction Generator (DFIG), Solar Photovoltaic (SPV) Array, MPPT.

1. Introduction

A plan, control and assessment of an Autonomous Hybrid Wind Solar System (AHWSS) energy framework taking care of into three-stage, four-line loads and a variety of batteries. Wind Energy Conversion System Connected to the Grid (WECS) contains Doubly Fed Induction Generator (DFIG) and two PWM voltage source converters for example Lattice Side Converter (GSC) and Rotor Side Converter (RSC) associated consecutive at DC-interface and are furnished with a calculation for Maximum Power Point Tracking (MPPT). The framework voltage-situated control calculation is utilized to keep a consistent DC transport voltage for the GSC and to adjust the receptive power at the power lattice even the dissimilarity in recurrence and voltage can be managed with this original methodology. The stator voltage-orientated vector control is carried out in the RSC control procedure, conveying successful controlling of dynamic and responsive power at the stator, and furthermore a MPPT is accomplished through controlling the Tip Speed Ratio. The photovoltaic (PV) framework alongside the lift converter is taken care of to the DC connect. A Perturb and Observe technique is utilized for tracking maximum power in a solar PV framework. The model is executed in MATLAB's Sim-power-framework tool stash with ode3 solver and is introduced in various situations, e.g., solar illumination, contrasting wind speed, dynamic, and uneven nonlinear burdens.

2. Literature review

(Lei et al., 2022) [1] presents a dispersed age framework (DG) that joins arrangement of a wind turbine (WT) and photovoltaic (PV) utilizing a brought together power quality conditioner (UPQC). Alongside giving dynamic power (AP) to the utility lattice, Wind-PV-UPQC further develops PQ pointers, for instance, voltage drops/floods, sounds of matrix voltages, and PF. Since Wind-PV-UPQC relies upon double pay plot, the equal converter fills in as a sinusoidal voltage source, while the series converter functions as a sinusoidal current source.

(Grgić et al., 2020) [3] presents a battery-helped semi Z-source inverter (qZSI) powered by a wind-solar mixture age framework for independent burden supply. The thought about wind energy transformation framework (WECS) uses a self-energized enlistment generator (SEIG) for power age. Maximum power point tracking calculations (MPPTs) are executed to catch the maximum accessible power from both the WECS and the photovoltaic (PV) framework. The batteries make up for the motions in the accessible wind and solar power to guarantee persistent activity of the framework. Furthermore, the used qZSI, being a solitary stage inverter with buck/support capacity, disposes of the necessity for an extra transformer or dc help converter.

(El-Raouf et al., 2018) [4] proposes Maximum power point tracking (MPPT) of PV-wind-FC half breed framework taking care of another local area in Egypt-New El-Farafra Oasis as a Case Study. The proposed framework incorporates PV framework, super durable magnet simultaneous generator-based wind turbine and power device with an energy stockpiling framework. These converters are likewise used to increment and bind together the result voltage of the three sources after MPPT method proposed to a typical DC transport. DC/AC inverter is used to associate the half breed power framework into AC heaps of proposed local area. The three proselytes and the inverter are constrained by PI regulator tuned by Particle Swarm Optimization (PSO).

(Chaudhary et al., 2019) [5] examined that because of climb in cost of regular wellspring of energy we mindful toward non-customary wellspring of energy. This paper with present of a half breed solar-wind energy framework with brace associated. Mixture solar-wind framework comprise wind, solar source and ac loads. In solar dc yield framework is raised by support converter. MPPT procedure is utilized to augment the result of solar framework.

(Kordestani et al., 2018) [6] examined that Photovoltaic (PV) as a sustainable wellspring of energy assumes a critical part in producing power's in the business and circulated buyers. The result power of the PV gadget is exceptionally nonlinear which is reliant upon I-P and V-P attributes of the gadget and furthermore light circumstances. In this way, many examination works have been performed to improve the exhibition and acquire maximum power from the PV boards.

(Mohod et al., 2017) [7] introduced a sustainable power crossover power framework in view of photovoltaic (PV) and wind, and furnished with Cuk DC converter, three stage inverter and LC channel. The wind and PV energy are reasonable for mixture framework since they are harmless to the ecosystem and generally accessible in India. Notwithstanding, the mixture power framework that exclusively relies upon the irregular environmentally friendly power sources creates a fluctuating result voltage that prompts harm to the machines working on a steady stockpile. The displaying of the half and half framework with Cuk converter, three stage inverter and LC channel are finished utilizing MATLAB Simulink.

(Kabalci et al., 2018) [8] introduced both a half breed microgrid framework plan with environmentally friendly power and their control strategies, investigation result. This environmentally friendly power assets (RES) comprise of 33kW PVs, 100kW energy unit stack and a 50kW wind turbine with extremely durable magnet coordinated generator (PMSG). PV plant incorporates the PV clusters and DC help converter. Energy component plant incorporates the power module stacks and DC support converter. The wind energy plant contains the wind turbine, PMSG, uncontrolled rectifier and DC help converter. The lift converter associated with PV plant has been constrained by utilizing steady conductance maximum power point tracking calculation (IC-MPPT A). Both the lift converters of the wind energy framework and power module framework have been worked with PI regulators.

(Hassan et al., 2016) [9] populated with various Maximum Power Point Tracking (MPPT) techniques for Photovoltaic (PV) framework to get maximum power from it. This piece of work gives a man-made reasoning based fluffy rationale MPPT demonstrating and control of PV framework in a lattice associated mixture power framework under various weather conditions. The proposed procedure utilizes seven fluffy sets with seven semantic factors applied to a DC converter. Besides, a battery module is added as an energy stockpiling framework during excess power or potentially reinforcement gadget during load interest.

(Tang et al., 2017) [10] proposed an original crossover maximum power point tracking (MPPT) technique under somewhat concealed conditions (PSC) is proposed. The obligation pattern of the dc converter is controlled from little to enormous with fixed stretches to examine the P-V qualities bend under to some degree concealed conditions, and afterward figure out the maximum power esteem, which is called obligation clear (DS) calculation in this postulation. With the proposed control calculation, when the DS interaction is done, the annoyance and perception (P&O) strategy promptly begins in order to follow the genuine MPP under PSC.

3. Photo Voltaic (PV) System

In this chapter the modeling and design of overall system such as PV system, boost converter, load and MPPT controller has been presented.

3.1 Equivalent circuit and Mathematical Model

A current source type PV model is discussed in this section. The equivalent circuit is also shown.

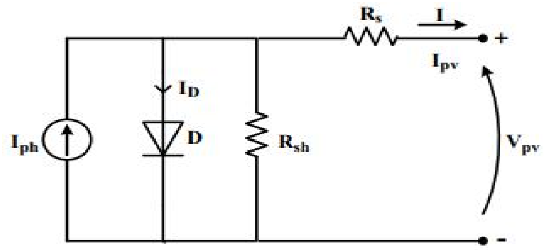

Fig1: The equivalent circuit of a PV array.

Where, R_S is the array series resistance in Ohm, R_P is the array parallel resistance in Ohm,
I and V are the output current and voltage of the array in Ampere and Volt.

$$I = N_p \times I_{ph} - N_s \times I_{rs}\left[e^{\left(\frac{q\times V}{A\times K\times T}\right)-1} - \left(\frac{V + I \times R_s}{R_{sh}}\right)\right] \quad (1)$$

Where, I_{ph} is photo current in Amp,
I_{rs} is saturation current in Amp,
N_S and N_p are the number of series and parallel modules respectively,
q is charge on electron in coulomb,
A is diode ideality factor,
T is cell Temperature with change in irradiation in degree kelvin.

Now,

$$I_{ph} = I_{scr} + K_i \times (T - T_r) \times S \quad (2)$$

$$I_{rs} = I_{rr} \times \left(\frac{T}{T_r}\right)^3 \times e^{\left(\frac{q\times E_g}{K\times A}\times\left(\frac{1}{T_r}-\frac{1}{T}\right)\right)} \quad (3)$$

Were,
I_{scr} is Short circuit current at reference Temperature in Amp,
I_{rr} is reverse saturation current in Amp,
T_r is reference temperature in Kelvin,
S is solar irradiance in mW/Sq. cm,
K_i is S.C. current Temp. coefficient in (Amp/Kelvin),
K is Boltzmann's constant,
E_g is band gap energy of semiconductor used cell in joules, also,

$$E_g = E_{g0} - \left(\frac{\alpha\times T^2}{T+\beta}\right) \times q \quad (4)$$

Where, E_{go} = band gap at 0k and,

4. Wind Turbine

Under constant acceleration a, the kinetic energy E of an object having mass m and velocity v is equal to the work done W in displacing that object from rest to a distance under a force F, i.e E = W = F.s, According to the Newton's second law of motion.

$$F = m * a \quad (5)$$

thus, the kinetic energy becomes

$$E = m * a * s \quad (6)$$

From kinematics of solid motion $v^2 = u^2 + 2as$ where u is the initial velocity of the object. This implies that $a = v^2 - u^2/2s$. Assuming the initial velocity of the object is zero, we have that $a = v^2/2s$. Hence from equation (2) we have that

$$E = \frac{1}{2} * mv^2 \quad (7)$$

This kinetic energy formulation is based on the fact that the mass of the solid is a constant. However, if we consider wind (air in motion) as a fluid, both density and velocity can change and hence no constant mass. Hence the kinetic energy (in joules) in air of mass m moving with velocity Vw(wind) can be calculated from equation (3) above. The power P in the wind is given by the rate of change of kinetic energy, i.e.

$$P = \frac{DE}{dt}$$
$$= \frac{1}{2} * \left(\frac{\mathrm{dm}}{\mathrm{dt}}\right) * \mathrm{Vw}^2 \quad (8)$$

But mass flow rate dm/dt is given by dm/dt = $\rho A v_w$ where A is the area through which the wind in this case is flowing and ρ is the density of air. With this expression, equation (4) becomes

$$P = \frac{1}{2} * \rho * A * v_w^3 \qquad (9)$$

The actual mechanical power P_w extracted by the rotor blades in watts is the difference between the upstream and the downstream wind powers.

$$P = \frac{1}{2} * \rho * A * v_w \ (v_u^2 - v_d^2) \qquad (10)$$

where v_u is the upstream wind velocity at the entrance of the rotor blades in m/s and v_d is the downstream wind velocity at the exit of the rotor blades in m/s. We shall see later that these two velocities give rise to the blade tip speed ratio. Now from the mass flow rate, we may write

$$\rho * A * v_w = \rho * A(v_u + v_d) \qquad (11)$$

v_w being the average of the velocities at the entry and exit of rotor blades of turbine. With this expression, equation (6) becomes

$$P_w = \frac{1}{2} * \rho * A * (v_u^2 - v_d^2) * (v_u + v_d)\frac{1}{2} \qquad (12)$$

$$P_w = \frac{1}{2}[\rho * A * (v_u^3) * \left\{\frac{\left(1 - \left(\frac{v_d}{v_u}\right)^2 + \left(\frac{v_d}{v_u}\right) - \left(\frac{v_d}{v_u}\right)^3\right)}{2}\right\}] \qquad (13)$$

$$Cp = \frac{\left(1 - \left(\frac{v_d}{v_u}\right)^2 + \left(\frac{v_d}{v_u}\right) - \left(\frac{v_d}{v_u}\right)^3\right)}{2} \qquad (14)$$

$$P_w = \frac{1}{2}[\rho * A * (v_u^3) * Cp \quad (15)$$

The expression for Cp in equation (10) is the fraction of upstream wind power captured by the rotor blades. Other names for this quantity are the power coefficient of the rotor or rotor efficiency. The power coefficient is not a static value. It varies with tip speed ratio of the wind turbine.

Let λ represent the ratio of wind speed v_d downstream to wind speed v_u upstream of the turbine, i.e.

$$\lambda = \frac{v_d}{v_u} \qquad (16)$$

$$\lambda = \frac{\textit{Blade tip speed}}{\textit{Wind speed}} \qquad (17)$$

λ is called the tip speed ratio of the wind turbine.

5. Resul

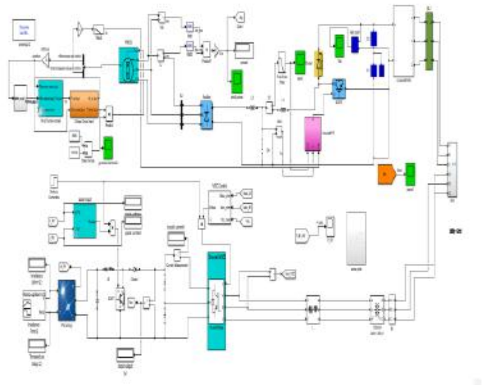

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Fig: simulation model of hybrid system

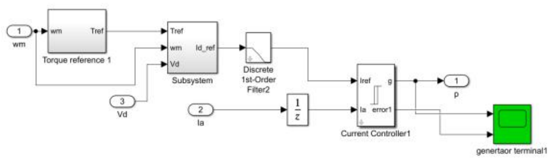

Fig : MPPT for Wind Generator

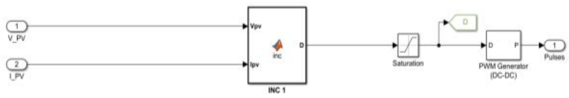

Fig : MPPT for solar PV

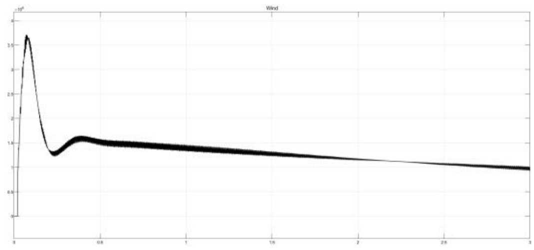

Fig: Output of wind system

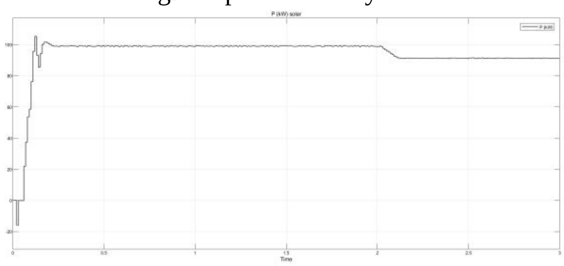

Fig: Output of Solar PV system

6. Conclusion:

The work is focused in designing a hybrid model for grid connected wind-PV to varying condition. The model is successfully designed and implemented in Matlab software.

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