A Novel Rectifier Stage Conversion Scheme for Hybrid Wind/PV System Fed Induction Motor Drive Application

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Abstract—Nowadays, world insists conservation of energy due to the impletion of the non-renewable energy sources such as black coal, crude oil, and gas from earth. In India, power devastation plays a vital role since the decrease of the coal in the power plant. This paper provides an invasive solution by using renewable energy such as wind and solar to the power demand. In this paper both are combined to get the desired amount of energy. This design permits the two sources to supply the heap independently or at the same time contingent upon the power request. The innate way of this Cuk-SEPIC intertwined converter, extra info channels are not important to sift through high recurrence music. Consonant substance is inconvenient for the generator life expectancy, warming issues, and proficiency. The combined multi input rectifier arrange additionally permits Maximum Power Point Tracking (MPPT) to be utilized to concentrate most extreme power from the wind and sun when it is accessible. A versatile MPPT calculation will be utilized for the wind framework and a standard bother and watch technique will be utilized for the PV framework. Consequently, expansive voltage spikes over the principle switches are lifted and the effectiveness is moved forward. Here the low voltage push supports the selection of low voltage-evaluated MOSFETs for the decrease of both conduction misfortunes and cost. This demonstrates the proposed framework is likewise financially savvy and proficient. For the case here the framework is considered with the engine stack.

Key Words: Photo Voltaic (PV), MPPT, Wind, DC-DC Converters.

I. INTRODUCTION

The necessity for imperatives in the present day circumstance is perpetual. This is totally substantial if there ought to emerge an event of electrical imperatives, which stays as the greatest one out and out overall essential usage. The enthusiasm for electrical essentially is growing twice as fast as general imperative usage and is most likely going to climb to 76% by 2030 from 12.5% in 2014. This condition can be supervised just with the use of renewable essential sources as wind, tidal, daylight based etc[1]-[3]. Another stress is that in many overpopulated countries like India, there is an over usage of limited power delivering resources and as needs be various urban groups and towns are facing predictable load shedding and power blackouts [4].

The present power period units are not satisfactory to meet the always rising power asks. The wide opening among time and transport territory incite the inefficiency in giving vitality to the commonplace reaches [5]. This can be wiped out just by the use of forefront techniques in power equipment by giving consistent power supply to the customers by giving versatility in source by setting the inverters [6]. Here the general mutt wind/PV structure is as showed up in figure.1.

In this paper, proposed a multi-input rectifier structure is for cross breed wind/sun fueled imperativeness systems. The proposed arrangement is a mix of the Cuk and SEPIC converters. The segments of the proposed topology are: 1) the intrinsic method for these two converters takes out the
necessity for free information channels for PFC [7]-[8]; 2) it can support wander up/down operations for each renewable source (can reinforce wide extents of PV and wind input); 3) MPPT can be recognized for each source; 4) individual and synchronous operation is maintained. The circuit working benchmarks will be discussed in this paper. Reenactment results are outfitted to affirm with the likelihood of the proposed structure.

![Figure 1: Hybrid system with multi-connected boost converter](image1)

II. PROPOSED MULTI-INPUT RECTIFIER STAGE
A framework chart of the proposed rectifier phase of a half breed vitality framework is appeared in Figure 2, where one of the sources of info is associated with the yield of the PV cluster and the other information associated with the yield of a generator. The combination of the two converters is accomplished by reconfiguring the two existing diodes from every converter and the mutual usage of the Cuk yield inductor by the SEPIC converter. This arrangement permits every converter to work typically exclusively if one source is inaccessible. Figure 3 delineates the situation when just the wind source is accessible. For this situation, D1 kills and D2 turns on; the proposed circuit turns into a SEPIC converter and the contribution to yield voltage relationship is given by (1). Then again, if just the PV source is accessible, then D2 kills and D1 will dependably be on and the circuit turns into a Cuk converter as appeared in Figure 4. The contribution to yield voltage relationship is given by (2). In both cases, both converters have venture up/down ability, which give more outline adaptability in the framework if obligation proportion control is used to perform MPPT control.

![Figure 2: Proposed rectifier stage for a Hybrid wind/PV system.](image2)

![Figure 3: Only wind source is operational (SEPIC).](image3)

![Figure 4: Only PV source is operation (Cuk)](image4)

Figure 5 shows the different exchanging conditions of the proposed converter. On the off chance that the turn on term of M1 is longer than M2, then the exchanging states will be state I, II, IV. Also, the exchanging states will be state I, III, IV if the switch conduction periods are the other way around. To give a superior clarification, the inductor current waveforms of each exchanging state are given as takes after accepting that \(d_2 > d_1\); subsequently just states I, III, IV are talked about in this illustration. In the accompanying, \(I_{PV}\) is the normal information current from the PV source; \(I_{W}\) is the RMS input current after the rectifier (wind case); and \(I_{dc}\) is the normal framework yield current. The key

\[
\frac{V_{dc}}{V_{w}} = \frac{d_2}{1 - d_2} \tag{1}
\]

\[
\frac{V_{dc}}{V_{pv}} = \frac{d_1}{1 - d_1} \tag{2}
\]
waveforms that represent the exchanging states in this illustration are appeared in Figure 6. The numerical expression that relates the aggregate yield voltage and the two information sources will be represented in the following segment.

III. MPPT CONTROL OF PROPOSED CIRCUIT

A typical characteristic disadvantage of wind and PV frameworks is the discontinuous way of their vitality sources. Wind vitality is fit for providing a lot of force yet
its nearness is exceedingly flighty as it can be here one minute and gone in another. Sun powered vitality is available for the duration of the day, yet the sun based illumination levels differ because of sun force and capricious shadows cast by mists, winged animals, trees, and so forth. These disadvantages tend to make these renewable frameworks wasteful. Be that as it may, by consolidating most extreme power point following (MPPT) calculations, the frameworks' energy exchange proficiency can be enhanced essentially.

To portray a wind turbines control trademark, condition (3) depicts the mechanical power that is created by the wind [6].

\[ P_m = 0.5 \rho A C_p (\lambda, \beta) v_w^3 \] (3)

The power coefficient \( (C_p) \) is a nonlinear capacity that speaks to the proficiency of the twist turbine to change over twist vitality into mechanical vitality. It is reliant on two factors, the tip speed proportion (TSR) and the pitch point. The TSR, \( \lambda \), alludes to a proportion of the turbine rakish speed over the wind speed. The scientific portrayal of the TSR is given by (4) [10]. The pitch point, \( \beta \), alludes to the edge in which the turbine cutting edges are adjusted to regard to its longitudinal hub.

\[ \lambda = \frac{R}{\omega_b} \] (4)

Where

\( R = \) turbine radius,
\( \omega_b = \) angular rotational speed

Figure 7 and 8 are delineations of a power coefficient bend and power bend for a common settled pitch (\( \beta=0 \)) even hub wind turbine. It can be seen from figure 7 and 8 that the power bends for each wind speed has a shape like that of the power coefficient bend. Since the TSR is a proportion between the turbine rotational speed and the wind speed, it takes after that each wind speed would have a unique comparing ideal rotational speed that gives the ideal TSR. For every turbine there is an ideal TSR esteem that relates to a most extreme estimation of the power coefficient \( (C_p,\text{max}) \) and along these lines the greatest power. In this way by controlling rotational speed, (by methods for conforming the electrical stacking of the turbine generator) greatest power can be acquired for various wind speeds.

\[ I = I_{ph} - I_D \] (5)

\[ I = I_{ph} - I_0 \left[ \exp \left( \frac{q(V + R_s I)}{A k_B T} \right) - 1 \right] \frac{V + R_s I}{R_{ph}} \] (6)

Where

\( I_{ph} = \) photocurrent
\( I_D = \) Diodecurrent
\( I_0 = \) saturationcurrent
\( A = \) idealityfactor
\( q = \) electronic charge \( \text{e}.1.6*10^{-9} \).
\( k_B = \) Boltzmann's constant \( \text{e}1.38*10^{-23} \)
\( T = \) celltemperatur
\( R_s = \) seriesresistance
\( R_{ph} = \) shuntresistance
\( I = \) cellcurrent
\( V = \) cellvoltage
Commonly, the shunt resistance ($R_{sh}$) is extensive and the arrangement resistance ($R_s$) is little [5]. In this manner, it is normal to disregard these resistances keeping in mind the end goal to rearrange the sunlight based cell display. The resultant perfect voltage-current normal for a photovoltaic cell is given by (7) and delineated by Figure 10. [5]

$$I = I_{ph} - I_0 \left( \exp \left( \frac{qV}{kT} \right) - 1 \right)$$

(7)

Because of the consistency of the state of the wind and PV exhibit control bends, partnered most extreme power point following plan known as the slope climb look (HCS) procedure is frequently connected to these vitality sources to concentrate greatest power. The HCS methodology annoys the working purpose of the framework and watches the yield. In the event that the course of the uproar (e.g an ascent or fall in the yield voltage of a PV cluster) brings about a positive change in the yield control, then the control calculation will proceed toward the past bother. On the other hand, if a negative change in the yield power is watched, then the control calculation will invert the heading of the pervious bother step. For the situation that the adjustment in power is near zero (inside a predetermined range) then the calculation will summon no progressions to the framework working point since it compares to the most extreme power point (the peak of the power curves).
The MPPT scheme employed in this paper is a version of the HCS strategy. Figure 12 is the flow chart that illustrates the implemented MPPT scheme.

IV. DYNAMIC MODELLING OF INDUCTION MOTOR

In an ordinary four post enlistment engine, there are two arrangements of indistinguishable voltage profile windings will be available in the aggregate stage winding. These two windings are associated in arrangement as appeared in fig. 13(a). For the proposed inverter these two indistinguishable voltage profile winding loops are disengaged, and the accessible four terminals are taken out, as appeared in the fig.13 (b). Since these two windings are isolated similarly, stator resistance, Stator spillage inductance and the charging inductance of each indistinguishable voltage profile windings are equivalent to the half of the ordinary enlistment engine appeared in fig.13 (a). The voltage equitation for the stator winding is given by normal dc connect.

\[ V_{a1} - V_{a2} = \left( \frac{3}{2} \right) i_{a1} + \left( \frac{L_{m}}{2} \right) \times i_{a2} - \left( \frac{1}{2} \right) \left( \frac{L_{m}}{2} \right) \times i_{b3} \]

\[ V_{a3} - V_{a4} = \frac{3}{2} i_{a3} + \frac{L_{m}}{2} \times i_{a4} - \left( \frac{1}{2} \right) \left( \frac{L_{m}}{2} \right) \times i_{b3} \]

Voltage equations in dq0 frame can be solved from the basic equations of induction motor.

Flux linkages are as follows

\[ \lambda_{q} = L_{ss} \times i_{q} + L_{m} \times i_{r} \]
\[ \lambda_{d} = L_{ss} \times i_{d} + L_{M} \times i_{dr} \]
\[ \lambda_{ds} = L_{1s} \times i_{ds} \]
\[ \lambda_{qr} = L_{1r} \times i_{qr} \]
\[ \lambda_{dx} = L_{1x} \times i_{dx} \]

(11)

The expression for the electromagnetic torque in terms of dq0 axis currents is

\[ T_{e} = \left( \frac{3}{2} \right) \left( \frac{P}{2} \right) L_{M} \left( i_{qr} \times i_{dr} + i_{ds} \times i_{q} \right) \]

(12)

Rotor speed in terms of Torque is

\[ \frac{d}{dt} \omega_{e} = \left( \frac{P}{2} \times J \right) \left( T_{e} - T_{L} \right) \]

(15)

V. MATLAB/SIMULATION RESULTS

![Simulink model of Individual operation with only PV source](Cuk operation)

![Output power](Fig.15. Output power)

![Switch currents (M1 and M2)](Fig.16. Switch currents (M1 and M2))
Fig. 17. Load currents

Fig. 18. Simulink model of Individual operation with only wind source (SEPIC operation)

Fig. 19. The injected three phase generator current

Fig. 20. Output power

Fig. 21. Switch currents ($M_1$ and $M_2$)

Fig. 22. Output Voltage (V)

Fig. 23. Simulink model of Simultaneous operation with both wind and PV source (Fusion mode with Cuk and SEPIC)

Fig. 24. The injected three phase generator current

Fig. 25. Output power

Fig. 26. Switch currents ($M_1$ and $M_2$)
VI. CONCLUSION

The hybrid solar and wind power generation can be used to generate huge amount of power at approximately all times of a day. This can be an alternative cause of energy to the non-renewable resources. This can be enforced instead of a single source, to gain more power most of the times. The generation of hybrid wind and solar power has been simulated using Mat lab software and output waveform for voltage, current and power have been obtained which provide the extensive and effective knowledge about the same system in simulation. This may be extended as implementing the model in real time and making it suitable for 3 phase applications with suitable modifications by the use of phase transformer or with the use of three phase inverter.

REFERENCES