Renewable Energy Source Based Asymmetrical Half Bridge Fly Back Converter

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Abstract **-The main aim of the project is to analyze the performance of an asymmetrical half bridge fly back converter under variation in wind speed. At low and high wind speeds the wind turbine are operated with the help of permanent magnet synchronous generator. It develops low amount of mechanical stress. As per wind speed the output power is also varied. The switching frequency is maintained as constant as 300Khz.The feedback controller is employed to provide speed control mechanism on permanent magnet brushless dc motor and it tend to achieve an high efficiency rating. The PWM technique is used to provide a gate signal for a 3phase inverter circuit. The BLDC motor speed may vary from 1500rpm to maximum 7000rpm. Simulation work is carried in MATLAB/Simulink model.**

Keywords- Wind turbine, Fly back converter, Permanent magnet synchronous generator, Feedback Controller, Permanent magnet brushless dc motor.

I. INTRODUCTION

The renewable energy sources are the biggest concern in our times. Wind power is good renewable, clean and free source of energy for power production. The Reduce dependence on fossil fuels and imported oils tend to increase use wind energy. It Reduce the emission of greenhouse gas and other pollutant.

One major concern is the noise, Intermittency and variability of the wind. The resonant topologies clearly have good potential on wind power. Power generation from wind has emerged as one of the most successful programs in the renewable energy sector, and has started making meaningful contributions to the overall power requirements of some States. Wind turbines today are up to the task of producing serious amounts of electricity. Turbines vary in size from small 1 kW structures to large machines rated at 2 MW or more.

Therefore, renewable are expected to play a key role in accelerating development and sustainable growth in the second half of the next century, accounting then to 50 to 60% of the total global energy supply. Wind energy production may, however, vary from hour to hour, just as demand from electricity customers will vary from hour to hour. Second to second or minute to minute variations in wind energy production are rarely a problem for installing wind power in a grid [1].

In wind turbine the permanent magnet synchronous generator (PMSG) is preferred because of it simpler design and it doesn’t require any external magnetization. Hence PMSG excitation avoids field current supply or reactive power compensation facilities and the slip rings which are preferred on wound rotor synchronous generator or induction generator. The two mass drive train models are chosen to reduce time consumption problems and it include turbine and shaft model.

The fly back converter has special feature as it can operate at both buck-boost mode with constant switching frequency as 300 KHz and variable duty cycle is possible. The design and test of solid state lamp driver with asymmetrical half bridge fly back converter had been described with large input voltage variations in input with higher efficiency without any harmonics [2] but it has no improvement on output power and it can be applicable for low power applications. The integrated buck-boost converter [3] and has started making meaningful contributions to the overall power requirements of some States. Wind turbines today are up to the task of producing serious amounts of electricity. Turbines vary in size from small 1 kW structures to large machines rated at 2 MW or more. is more efficient as compared with PWM solution but there is the current limiting device at input which increases the circuit complexity.

The buck converter(step down) are used at led replacement lamps since its used for charging the batteries but the current ripples are high [4],it was an transformer less design and provides an surge protection to an equipment connected to it.

The LLC converter [4] can perform both buck and boost mode operation and are most widely used to control the wide range of output power with only narrow variation in operating frequency, but it’s not easy to optimize under large input voltage variations and require an variable frequency control. The steady state analysis of LLC converter [5] had higher transformer turns ratio and there is a semi empirical approach is necessary to perform an analytical function. The series resonant topologies are proposed [6] with led lamp driver hence it requires a high magnetizing inductance which negatively impacts on magnetic component design (relevant number of primary turns, high volume occupation).

At final analysis the asymmetrical half bridge fly back converter is ideal to provide good properties of series resonant topologies with addition of fixed frequency and variable duty cycle. This paper is organized with following section such as fly back design, wind turbine design analysis, feedback technique with PID controller and a three phase inverter with simulation analysis.

II. AHB FLYBACK CONVERTER

The operation of fly back converter is briefly reviewed in fig1 it represents the schematic diagram of this paper. Hence input voltage from wind turbine is fed to an uncontrolled rectifier; pitch angle control, two mass drive train models and a permanent magnet synchronous generator are used to afford essential input supply from wind energy.

The flyback converter can be operated at two types of mode as continuous and discontinuous .The continuous mode has drawback as switch is turned on before secondary current falls to zero so there is overlapping occurs in addition the feedback control is so difficult to execute .In order to overcome the drawbacks the discontinuous mode is chosen so the secondary current becomes zero after a time interval Switch is turned on and it has easy implementation of feedback control.

With the design choice, the typical converter waveforms are shown in fig 2.Hence it neglects the short intervals corresponding to the charge and discharge of switch output capacitance, each switching period can be subdivided into up to three modes. There is no need of blocking capacitor because of an single controllable switch S1.the direct current flows at an output side and its easy way to operate an dc motor appliances with reduced harmonic order. The harmonic standard as EN6100-3-2 is chosen on converter to reduce voltage ripples on the dc-link.

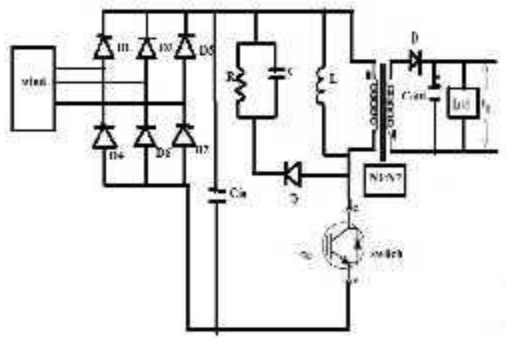


Fig 1.Schematic diagram of proposed circuit

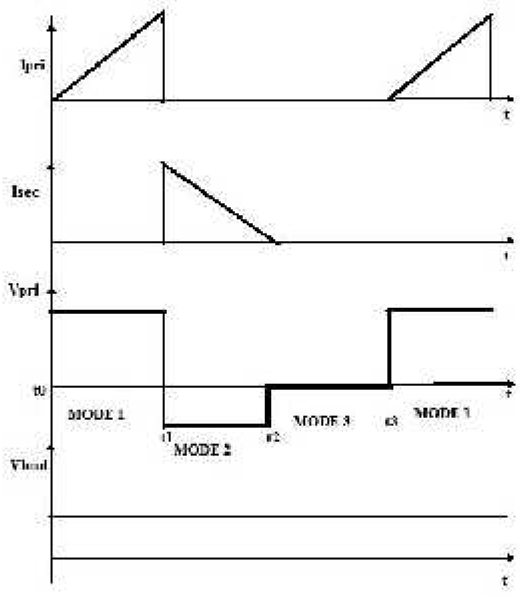


Fig 2. Waveform for modes of operation for a flyback converter

Mode1:

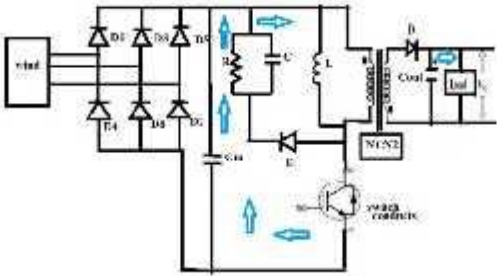


Fig 3. Operating mode 1

During the time interval t0-t1 switch S1 is turned on and the primary winding of transformer get connected to input supply. Diode Dr at output side becomes reverse biased and the primary current rises linearly. Diode at input becomes reverse biased and snubber capacitor becomes charged. The output capacitor discharges the stored energy for continuous regulation of load.

$$V_{in} = L_{Pri} \times \frac{d}{dt} i_{Pri} \qquad (1)$$

At the end of mode 1, the magnetic field energy rises in the primary winding as (1/2) $L_{pri}I^{2}$.And the primary winding voltage and secondary winding voltage are (2) and (3).

$$V_{pri} = V_{in} \qquad (2)$$

$$V_{sec} = V_{in} \times \left(N_2 / N_1\right) \qquad (3)$$

Mode2:

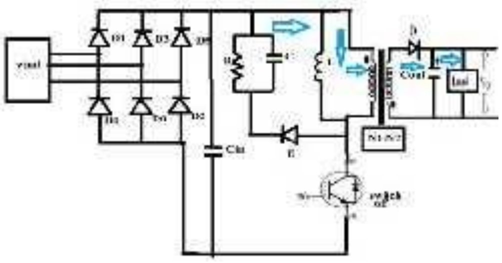


Fig 4.Operating mode 2

During t1-t2 time interval the switch S1 is turned off and the voltage polarities across the primary winding becomes reversed. Diode D becomes forward biased and snubber capacitor starts to dissipate at slow rate because of parallel connection of snubber resistor. Diode Dr at output side is forward biased and the supply current to load, the output capacitor C0 gets charged. At the end of this mode the complete transfer of magnetic field to the output is done and the secondary winding emf as well the current falls to zero .The diode Dr Stops conducting. At the end of mode 2 the primary winding and secondary winding voltage are (4) and (5).

$$V_{Pri} = V_0 \times \left(N_1 / N_2\right) \qquad (4)\ (5)$$

$$V_{sec} = V_0$$

Mode3**:**

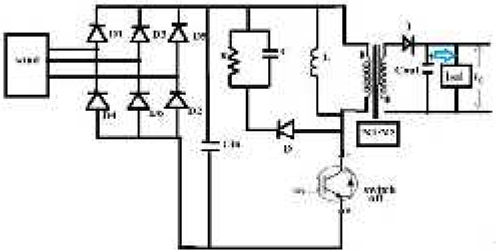


Fig 5.Operating mode 3

During the time interval t2-t3 the switch S1 still at turned off condition and the diode Dr is also at zero conducting state. The output capacitor however discharges the energy to supply uninterrupted voltage at the load. This method then again follows the 1st mode.

III. FLYBACK DESIGN PROCEDURE

The typical specification of an asymmetrical half bridge fly back converter with BLDC motor as shown in Table 1.The switching frequency of an soft switch IGBT is set to 300 kHz .the proper design of snubber result in high reliability, high efficiency and low EMI .The switching stresses are high because of parasitic inductance. To suppress the peak voltage the typical RC snubber is attached and the snubber capacitor must be small enough as 50uf in order to keep a power dissipation of the resistor to a minimum

TABLE I. CONVERTER SPECIFICATIONS

Input voltage range from wind energy, Vin	240V-270V
Permanent magnet BLDC motor speed	1500-7000 rpm
Output power	>100 watts
Output current, Io	3A
Efficiency	>90%

A. *Transformer Design*

In designing the isolation transformer for the fly back converter, one need to consider the worst condition as mode 3.The minimum input voltage and maximum duty cycle (d_{max}) is taken with an assumptions of voltage balance across magnetizing inductance(L_m), it gives the following expressions:

$$V_m(t) = \frac{(1-d_{max})V_{in,min}}{1+\lambda} d_{max} T_s - \frac{V_0}{n_{21}}(1-d_{max})T_s = 0 \quad (6)\ (7)$$

$$M_{max} = \frac{V_0}{V_{in,min}} = \frac{n_{21}}{1+\lambda} d_{max}$$

The magnetizing current peak and valley values are expressed as

$$I_{pk} = i_m + \frac{V_0}{2n_{21}L_m f_s}(1-d_{max}) = n_{21} I_0\left(1 + \frac{1-d_{max}}{\gamma}\right) \quad (8)$$

$$I_{vl} = i_m - \frac{V_0}{2n_{21}L_m f_s}(1-d_{max}) = n_{21} I_0\left(1 - \frac{1-d_{max}}{\gamma}\right) \quad (9)$$

Where = $2\frac{L_m f_s}{R_0} n_{21}^2$ is dimensional parameter,n_{21} is the transformer ratio and T_s as sampling time period.

B. . *Pwm Design Of Three Phase Inverter*

For higher switching frequency, the pwm inverter is considered as the voltage source inverter. SPWM are applied to inverter in order to obtain Sinusoidal output voltage with reduced harmonics. The three-phase switching state functions S_a, S_b, S_c of the inverter are used to calculate the line output voltage of PWM inverter.

$$[U_{AB}\ U_{BC}\ U_{CA}]^T = [T_{AV}\ T_{BV}\ T_{CV}]^T U_{dc} \quad (10)$$

Where,

$$\begin{bmatrix} T_{AV} \\ T_{BV} \\ T_{CV} \end{bmatrix} = \frac{1}{2}\begin{bmatrix} 1 & -1 & 0 \\ 0 & 1 & -1 \\ -1 & 0 & 1 \end{bmatrix}\begin{bmatrix} S_a \\ S_b \\ S_c \end{bmatrix} \quad (11)$$

These are the switching values for the gate pulses of three phase inverter.

IV. CONTROL STRATEGY

The speed control mechanism of BLDC motor is achieved by the closed loop method .in closed loop technique we prefer a feedback type to achieve an high efficiency rate with reduced distortion rate. The PID controller is used for fast response, high stability and zero steady state error. The transfer function of PID controller as expressed

$$\mathrm{PID}(s) = K_p + \frac{K_i}{s} + sK_d \quad (12)$$

From the PID controller the comparator is used to calculate the pulse signal for an soft switch. The values of PID controller as

$$K_p = 0.1$$

$$K_d = 0$$

$$K_i = 0.001$$

V. SIMULATION RESULTS

The AHB flyback converter is analyzed and experimental results are obtained through a matlab tool.

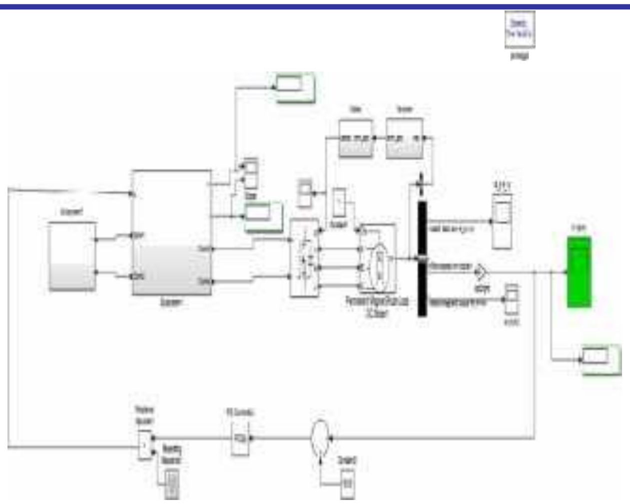
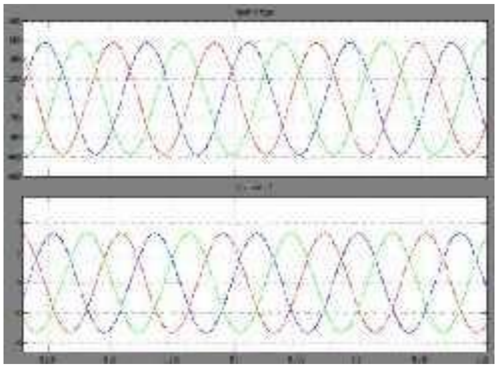


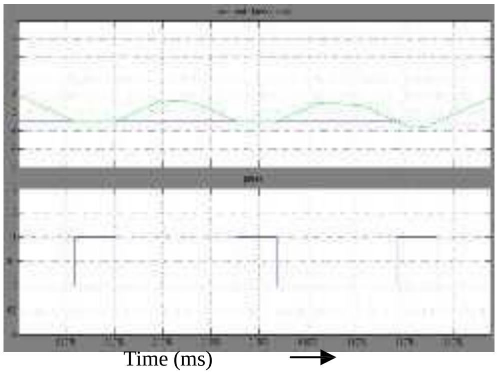
Fig 6 .Overall simulation of proposed circuit.

The source current and source voltage are shown in fig 8.the source voltage is rectified by an uncontrolled diode bridge rectifier to obtain an direct current and it's supplied to an fly back converter circuit. The gate pulses are generated thrown a feedback control mechanism for an converter switch. The gate pulse generation is shown in fig 7.



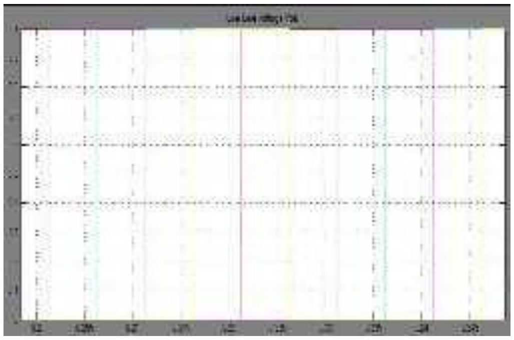
Time (ms) →

Fig 7.The source voltage and source current from the wind energy.



Time (ms) →

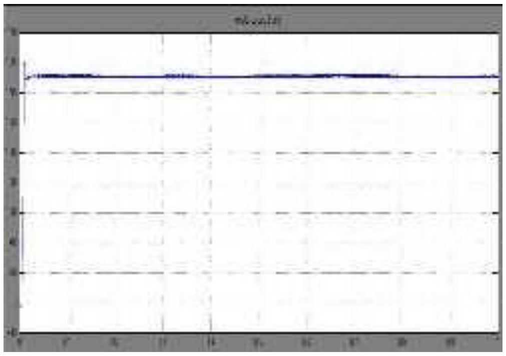
Fig 8. Gate pulse for converter switch



Time (ms) →

Fig 9. Pulses of three phase inverter by an SPWM technique

The speed of permanent magnet BLDC motor obtained from fly back converter is shown in fig 7.for a constant 1500 the speed rate as 1495-1505 rpm is achieved. The torque has been calculated with an stator emf current from the BLDC Motor

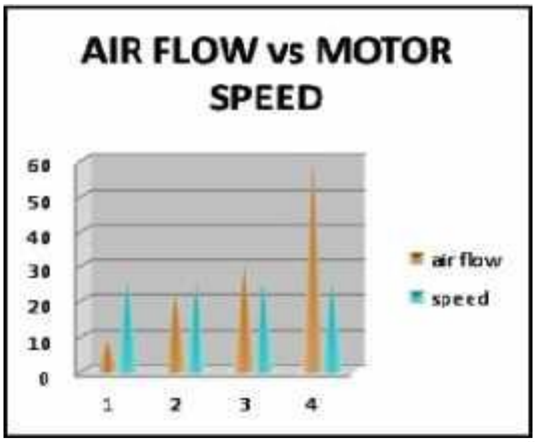


Time (ms) →

Fig 10.The speed of BLDC motor that ranges from 1495-1510 rpm

Finally converter efficiency is calculated based on the input and output power relation. It's nearly above 90%.

A. Comparison of Airflow Versus Motor speed



Air flow	Motor speed(rps)
10	25.2
22	25.13
30	25.11
60	25.15

Fig 11.Comparison of wind flow and BLDC motor speed

VI. CONCLUSION

This paper presented the analysis of the Asymmetrical Half Bridge (AHB) fly back converter as a wind energy power for high speed BLDC motor. The speed variation from 1500rpm to 8000rpm is achieved at wide variation of wind flow. The advantages of discontinuous conduction mode on converter produce a continuous power flow at output side. In feedback loop the PID controller is used to maintain maximum efficiency as greater than

95%.The three phase PWM inverter get regular pulse intervals as stator current feedback operation. The eminent results with the help of MATLAB/Simulink tool the efficient operation of the proposed circuit.

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