SPEED CONTROL OF BLDC MOTOR USING BOOST CONVERTER

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Abstract: This paper deals with an improvement in power quality and reduction in power consumption of the brushless DC (BLDC) motor targeting low power home appliances. Hall Effect sensors are used to detect the rotor position for electronic commutation of the BLDC motor. The motor is fed through a three phase voltage source inverter (VSI) fed through single phase diode bridge rectifier and a DC- DC converter. Speed of the fan is controlled by varying the DC link voltage at the VSI input. The performance of the proposed drive is simulated in MATLAB/Simulink environment.

IndexTerms: BLDC Motor, Boost Converter, Hall-effect sensor, Voltage source Inverter, MATLAB.

1. INTRODUCTION :

In current scenario, power consumption of the domestic electrical goods has a major role in the power demand for the power supply authority. Brushless DC motors have been under operation in various kinds of industries like transportation, robotics, automobiles and household. Due to availability of various ranges for low and medium power rating motors, along with various application drives, with advantages of high efficiency, flux density per unit volume, low maintenance cost, low electromagnetic interference problems and low noise, have changed the new generation of power sector The permanent magnet brushless DC (PMBLDC) motor consists of three phase windings wound on the stator which is excited by a voltage source inverter and permanent magnets on the rotor inner surface and electronic communication through DC–AC circuit with the position sensors.. BLDC motor has rotor with permanent magnets and stator with stacked steel laminations with windings inserted in slots. The motor has less inertia, therefore easier to start and stop. BLDC motors do not have brushes (hence the name "brushless DC") and must be electronically commutated. BLDC motors are potentially cleaner, faster, more efficient, less noisy and more reliable. Generally a BLDC motor is considered to be a high performance motor i.e. capable of providing large amounts of torque over a vast speed range In the brushless DC motor, polarity reversal is performed by power transistors switching in synchronization with the rotor position. Therefore, BLDC motors often incorporate either internal or external position sensors to sense the actual rotor position or its position can also be detected without sensors.

2. BASIC STRUCTURE OF BOOST CONVERTER

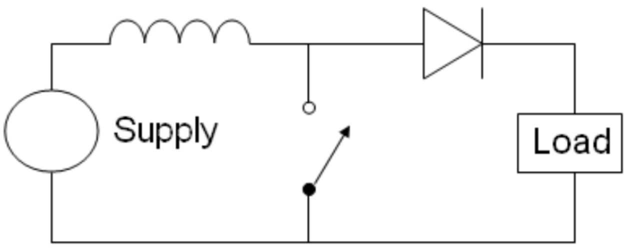

Fig 1: Boost Converter

A boost converter (step-up converter) is a DC-to-DC power converter that steps up voltage (while stepping down current) from its input (supply) to its output (load). It is a class of switched-mode power supply (SMPS) containing at least two semiconductors (a diode and a transistor) and at least one energy storage element: a capacitor, inductor, or the two in combination. To reduce voltage ripple, filters made of capacitors (sometimes in combination with inductors) are normally added to such a converter's output (load-side filter) and input (supply-side filter).

Boost converter Operation

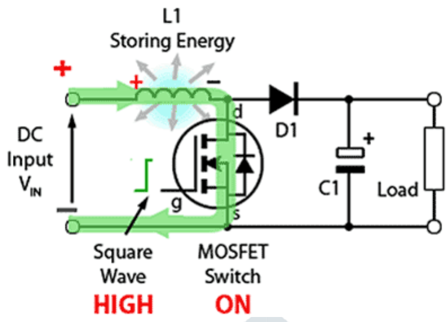

Fig 2 :Boost Converter Operation at Switch On

Fig 2 illustrates the circuit action during the initial high period of the high frequency square wave applied to the MOSFET gate at start up. During this time MOSFET conducts, placing a short circuit from the right hand side of L1 to the negative input supply terminal. Therefore a current flows between the positive and negative supply terminals through L1, which stores energy in its magnetic field. There is virtually no current flowing in the remainder of the circuit as the combination of D1, C1 and the load represent a much higher impedance than the path directly through the heavily conducting MOSFET.

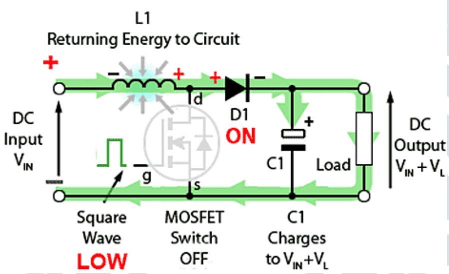

Fig 3: Current Path with MOSFET Off

Fig. 3 shows the current path during the low period of the switching square wave cycle. As the MOSFET is rapidly turned off the sudden drop in current causes L1 to produce a back e.m.f. in the opposite polarity to the voltage across L1 during the on period, to keep current flowing. This results in two voltages, the supply voltage V_{IN} and the back e.m.f.(V_L) across L1 in series with each other.

This higher voltage (V_{IN} +V_L), now that there is no current path through the MOSFET, forward biases D1. The resulting current through D1 charges up C1 to V_{IN} +V_L minus the small forward voltage drop across D1, and also supplies the load.

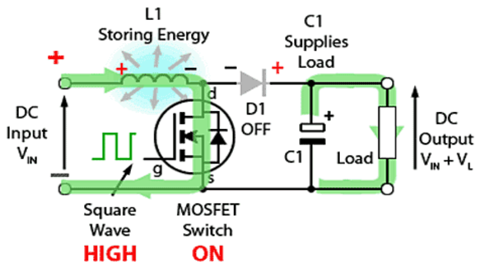

Fig. 4: Current Path with MOSFET On

Fig.4 shows the circuit action during MOSFET on periods after the initial start up. Each time the MOSFET conducts, the cathode of D1 is more positive than its anode, due to the charge on C1. D1 is therefore turned off so the output of the circuit is isolated from the input, however the load continues to be supplied with $V_{IN} + V_L$ from the charge on C1. Although the charge C1 drains away through the load during this period, C1 is recharged each time the MOSFET switches off, so maintaining an almost steady output voltage across the load.

3. EXISTING SYSTEM

A conventional BLDC motor drive consists of a front end diode bridge rectifier and a high value of DC link capacitor , which draws highly distorted peak current. It is rich in harmonics. The existing system does not use any sensors. In the proposed system, the speed of the BLDC Motor is controlled using PI Controller.

4. OPERATION OF PROPOSED SYSTEM

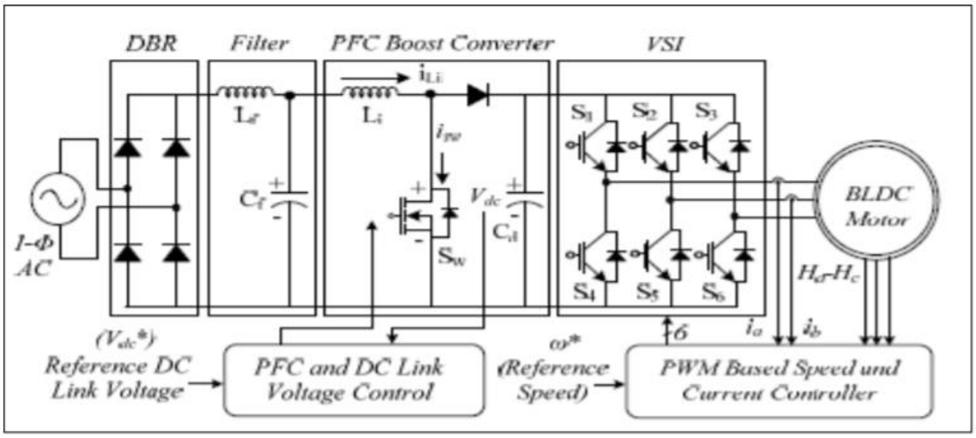

Fig 5: Operation of proposed system

The PMBLDC motor based ceiling fan is fed through a single phase diode bridge rectifier (DBR), followed by DC-DC converter and a voltage source inverter (VSI). A boost converter is used, due to less number of passive components and less cost . Here, a boost converter is used as a front-end converter to control the DC link voltage. Switching pulses for switch of front-end converter is decided in such a way, to ensure sinusoidal input current at unity power factor. Hence, switching frequency of switch should be as high as possible. So in this PFC converter, a MOSFET is used as a switch. The speed of the motor is controlled by DC link voltage. Hall Effect sensors are used to detect the position of the rotor, which decides gate pulses for the VSI

Schematic diagram :

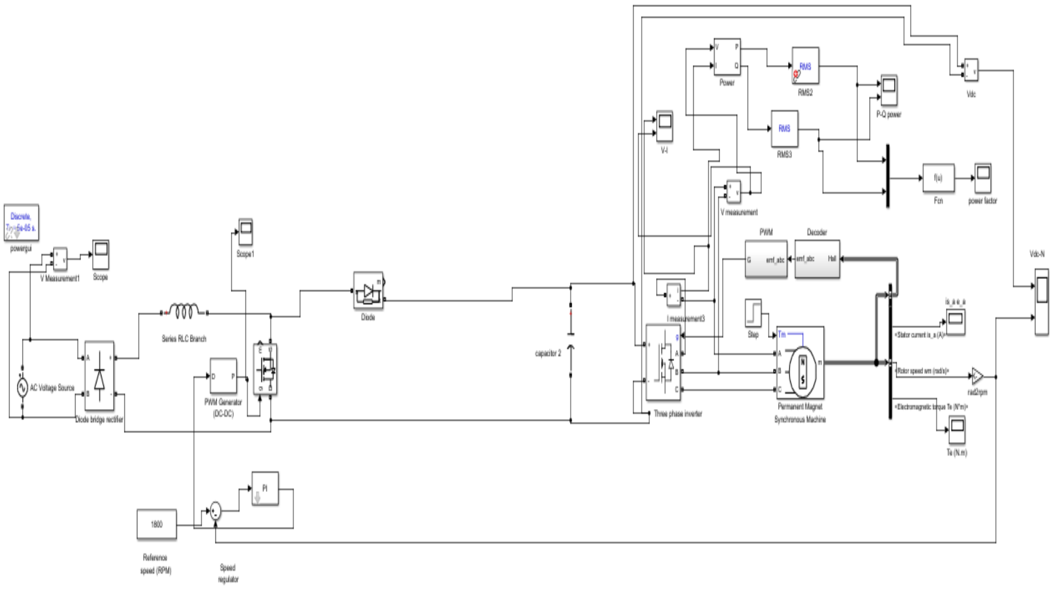

Fig 6 :Speed control of BLDC Motor with PI Controller

The power from the AC mains is stepped down to circuit operating range with a transformer which is rectified using a rectifier . The Rectifier Converts AC to DC and feeds the power to a boost Converter. A Boost converter is a DC-to-DC power converter which is used to drive the Inverter. The Switching of Inverter is controlled by a Control unit. The Inverter, which drives the brushless DC motor is switched in a predefined sequence to perform the so called electronic commutation. The switching sequence of the inverter is decided by the pulse generator. The feedback signal from BLDC motor is compared with the reference speed signal in the PI Controller to drive the inverter.

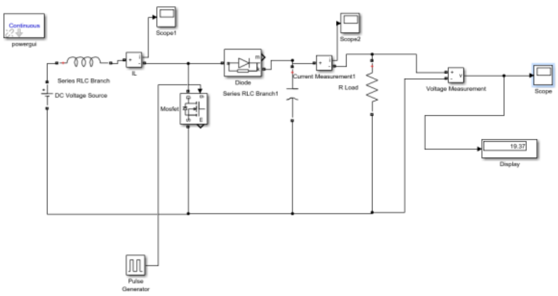

Fig 7 : Simulation of Boost Converter

In the Fig 7 , a boost converter is simulated for input voltage of 12V. The above simulation circuit of a boost converter consists of a inductor, MOSFET, diode, resistor. The voltage is measured across the resistor using the voltage measurement block.

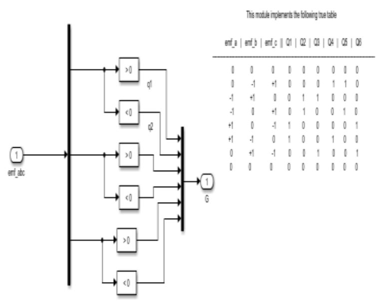

Fig 9: Pulses given to gate of Universal Bridge

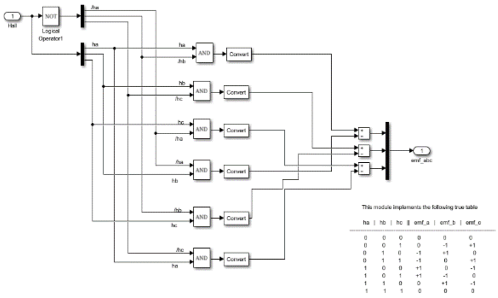

Fig 10 : Decoder Simulation module from hall sensor

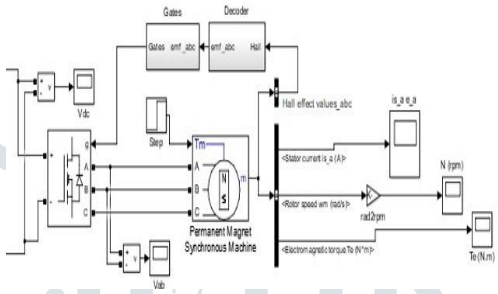

Fig 11 : Simulation of Speed control of BLDC Scope N rpm is used to measure speed.

5. RESULTS

The Simulation waveforms are observed in the scope of MATLAB. Fig 12 shows a Boost converter output waveform. It is observed that the closed loop speed control has wide range of speed control and is more efficient than open loop control. The closed loop speed control of BLDC Motor exhibits better torque characteristics than open loop control of BLDC Motor.

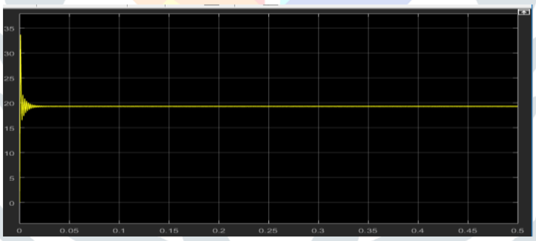

Fig 12 : Boost converter output voltage waveform

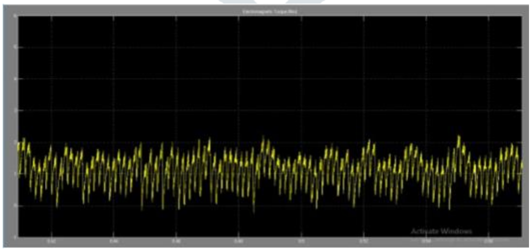

Fig 13 : Electromagnetic Torque using open-loop system

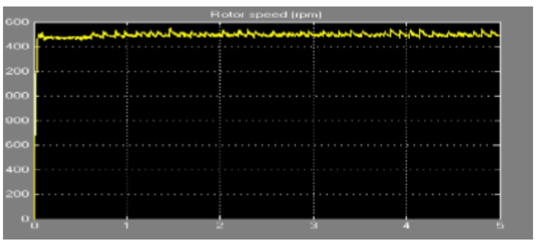

Fig 14 : Speed achieved from closed loop system

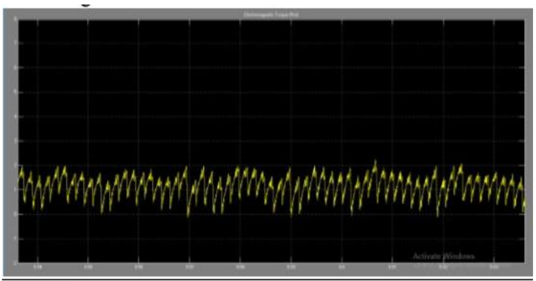

Fig 15 : Electromagnetic Torque closed loop system

6. CONCLUSION

A simple, efficient and economical method for speed control of BLDC motor has been simulated . In this project, a system which utilizes the combined benefits of BLDC motor and Controller is employed to achieve precise control and constant torque of BLDC motor. BLDC motor can drive the loads such as Fan, Water Pump, etc.. With minor modifications, this system could be employed to operate other load types used in medical, automotive, industrial and robotic applications. The proposed system is also suitable for applications where continuous running motor over longer period is required.

In the proposed system Electronic Commutation is employed. Electronic Commutation eliminates wear and tear, sparks. It ensures the proper rotor rotation of the BLDC motor, while the motor speed only depends on the amplitude of the applied voltage. The amplitude of the applied voltage is adjusted using the PWM technique. The required speed is controlled by a speed controller. Employing an Controller adds very little cost to the control system, yet offers the user much greater control over the motor to ensure it runs with optimum efficiency, in addition to offering more precise positional, speed, or torque-output.

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