SENSORLESS BLDC MOTOR DRIVE WITH COMMUTATION CORRECTION

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ABSTRACT:

This paper deals with the problem faced by commutation in sensorless BLDC motor and their correction. Thus the commutation error caused by the several non-ideal factor like control loop, internal power factor is corrected using phase lock loop. The main function of this phase lock loop is to put down IPF angle to reference value. The function of phase discriminator in PLL used to detect the IPF angle, LPF and auto phase regulator(APR). Thus this paper is wind-up with simulation and experimental result for correction commutation error caused by sensorless BLDC motor.

keywords- Sensorless BLDC motor, phase lock loop.

I. INTRODUCTION

In recent years, due to the requirement of energy conversion and emission reduction, electrical machines technology has gained rapid development. The key technique about the design of different kinds of electrical machines, the corresponding control technique, the modeling and testing, and the fault diagnosis technique have been widely investigated in the past few years. In many applications the Brushless dc motor drives have become increasingly popular, following recent developments in rare-earth permanent-magnet materials and the semiconductor devices used to control the stator input power and to sense the rotor position. They are now frequently used in applications such as flight control systems and robot actuators, and for drives which require high reliability, long life, little maintenance and a high torque-to-weight ratio. One of the most important control parameters is the rotor position signal .In a traditional BLDC motor drive, six discrete rotor position signals are needed and detected through three hall sensors; however, for a high-speed BLDC motor drive, traditional position sensors may degrade the rotor dynamic performance and increase the extra ventilation loss at too high-speed rotation. Therefore, sensor less control is essential for the high-speed BLDC motor drive. Several kinds of sensor less control methods for the BLDC motor have been widely investigated in the past. Rotor position of the BLDC motor can be detected through a zero-crossing point (ZCP) of the back electromotive force (EMF), PM flux linkage, the third harmonic of the back EMF, or other characteristic signals. No matter which kind of sensorless scheme is adopted, a detection error cannot be avoided.

For the BLDC motor drive a position detection error will cause a serious commutation error especially at high speed, which degrades the system operating performance significantly.

a. Due to commutation error " torque per ampere" and load capacity of the sensorless BLDC motor became degraded.

b. Energy efficiency also became poor with respect to copper loss increases.

c. Large commutation error causes dangerous to large torque ripple and current peak in BLDC drive.

Therefore sensorless BLDC motor drive, correcting the commutation point is focused in this paper. Here a novel commutation correction method is proposed to compensate the commutation error caused by a non-ideal current wave. The core idea of this method is to detect the phase error between phase current and phase back EMF and regulate this error to zero by a PI regulator. The simulation results verify its effectiveness. This kind of phase error is defined as an internal power factor (IPF) angle the real position signal determines the phase of the back EMF, the estimated position signal determines the phase of current. That means the total position error is equivalent to the IPF angle. In other words, if the IPF angle of the high-speed BLDC motor is corrected to zero, the commutation error is actually compensated totally. Finally this paper verify the validity and superiority of the proposed strategy by both simulation and experiment.

II. PROPOSED METHOD

According to the pervious literature some testing result that the sensorless BLDC motor always possesses a sinusoidal PM flux linkage and phase back EMF. The sinusoidal back EMF is due to lower iron loss and manufacturing cost in BLDC motor. Therefore in this paper, a sensorless BLDC motor is selected as a research object. In addition buck converter cascaded with voltage-source inverter is usually selected as the power circuit is shown in fig.1

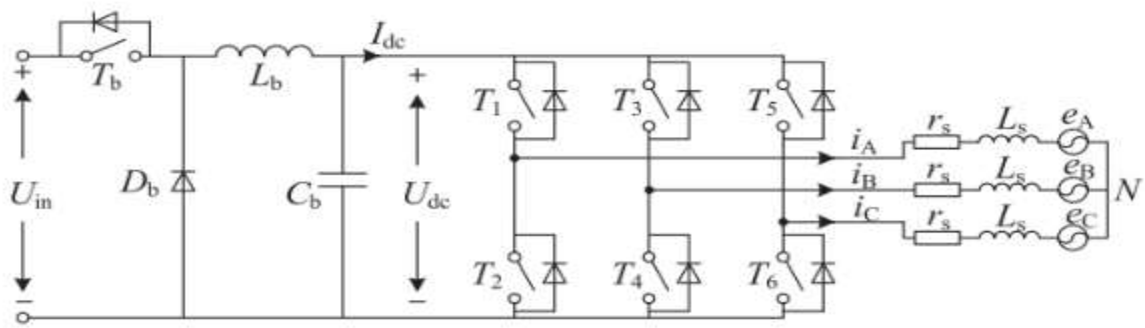

Fig.1.BLDC motor drive with buck converter

A buck converter (step-down converter) is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load).With switching circuit the back emf and phase current will like the given below figure2.

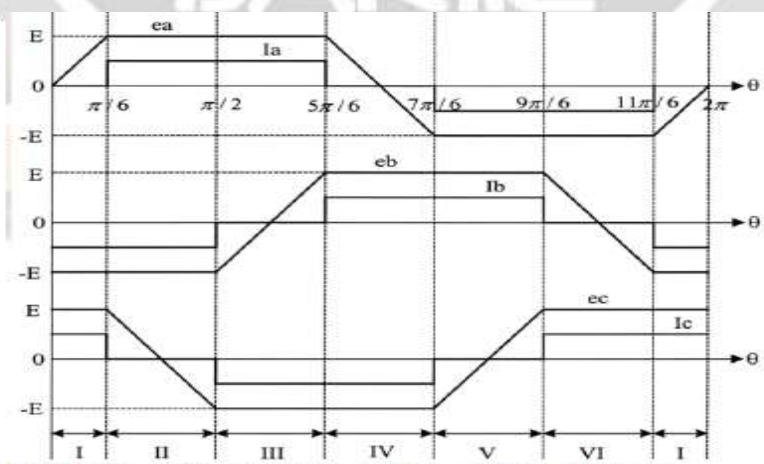

FIGURE (2): BACK EMF AND PHASE CURRENTS WAVEFORMS OF BLDC

Sensorless Drive in PM Flux linkage: The mathematical model of sensorless BLDC motor is built up first. The phase voltage equations can be represented as

$$\begin{bmatrix} u_A \\ u_B \\ u_C \end{bmatrix} = r_s \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} + \frac{d}{dt} \begin{bmatrix} \Psi_A \\ \Psi_B \\ \Psi_C \end{bmatrix} + \begin{bmatrix} u_N \\ u_N \\ u_N \end{bmatrix} \qquad (1)$$

where u_x is the phase voltage, r_s is the phase equivalent resistance, ix is the phase current, ΨX is the phase flux linkage, and u_N is the voltage of a neutral point. The subscript "X" denotes phase A, B, or C. Ψ_X consists of a flux linkage established by the stator current and PM, and equations can be presented as

$$\begin{bmatrix} \Psi_A \\ \Psi_B \\ \Psi_C \end{bmatrix} = \begin{bmatrix} L_s & 0 & 0 \\ 0 & L_s & 0 \\ 0 & 0 & L_s \end{bmatrix} \begin{bmatrix} i_A \\ i_B \\ i_C \end{bmatrix} + \begin{bmatrix} \Psi_{\text{PM\_}A}(\theta_r) \\ \Psi_{\text{PM\_}B}(\theta_r) \\ \Psi_{\text{PM\_}C}(\theta_r) \end{bmatrix}. \qquad (2)$$

From (2), it can be seen that rotor position θr can be derived from Ψ_{PM_X}, and Ψ_{PM_X} can be observed through (1) and (2). For a high-speed BLDC, stator resistance r_s is too small and can be neglected, so the u-i model based Ψ_{PM_X} observer can be simplified as

$$\Psi_{\text{PM\_}X}(\theta_r) \approx \int [u_x - u_N] dt - L_s i_x. \qquad (3)$$

Ψ_{PM_X} is 90 electrical degrees lag behind e_X of the BLDC motor, where e_X is the phase back EMF of the BLDC motor. Therefore, the ZCP of Ψ_{PM_X} is just the commutation point. The control diagram of a PM flux linkage based high-speed BLDC motor sensorless drive is shown in Fig. 3. The switching table in Fig. 3 shows the commutation sequence of the high-speed BLDC drive, and it is presented in Table I. The relation between rotor sector signal N and drive signals of the VSI is shown in Table I.

The circuit diagram for proposed system is shown in fig.8.

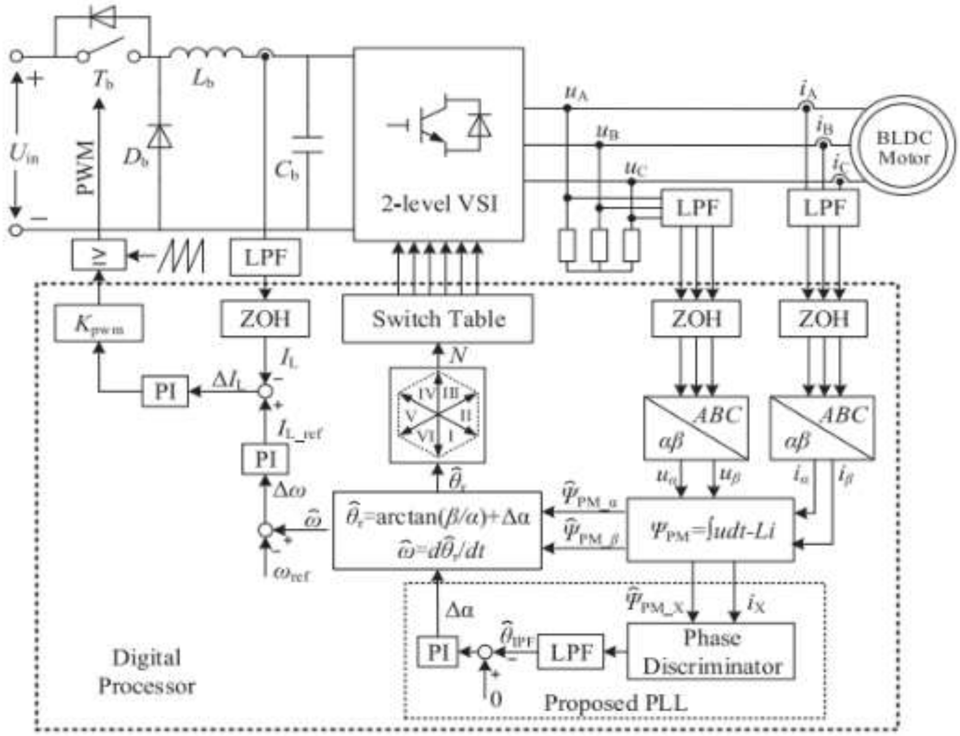

Fig.3.Sensorless BLDC motor used for the correction of commutation error.

TABLE 1

SWITCHING TABLE

quadrature	A+	A-	B+	B-	C+	C-	On phase	
I	1	0	0	0	0	1	T1	T6
II	0	0	1	0	0	1	T3	T6
III	0	1	1	0	0	0	T3	T2
IV	0	1	0	0	1	0	T5	T2
V	0	0	0	1	1	0	T5	T4
VI	1	0	0	1	0	0	T1	T4

Note: ”1”mean the power switch is ON and “0” means it is OFF.

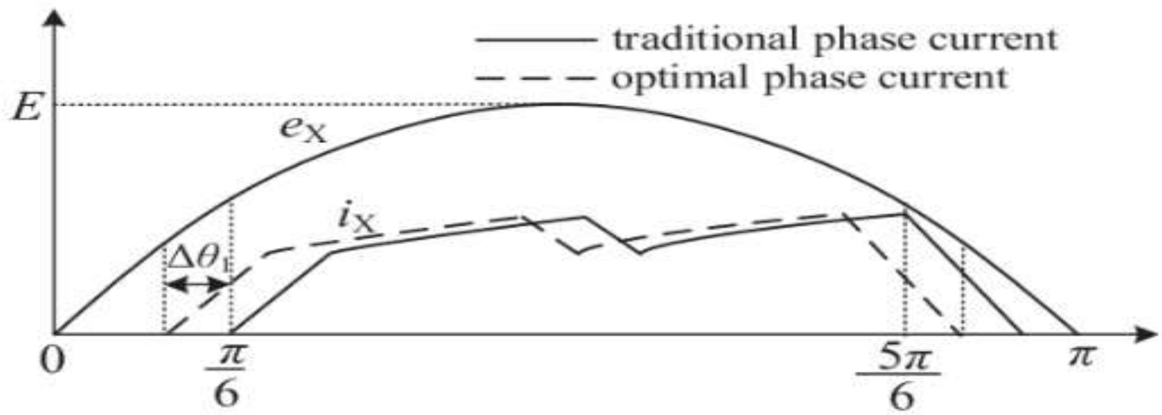

Fig.4.Commutation error $\Delta\theta_1$ caused by a non-ideal current wave.

In this paper a proposed sensorless BLDC motor for correcting commutation error by PLL is proposed. The function of the proposed PLL is to lock the phase relation of the back EMF and stator current. Phase discriminator, LPF, and APR are designed and the improved control diagram is given. Finally this paper is to point out robustness and high frequency application and for better performance.

The block diagram of our proposed system is given below:

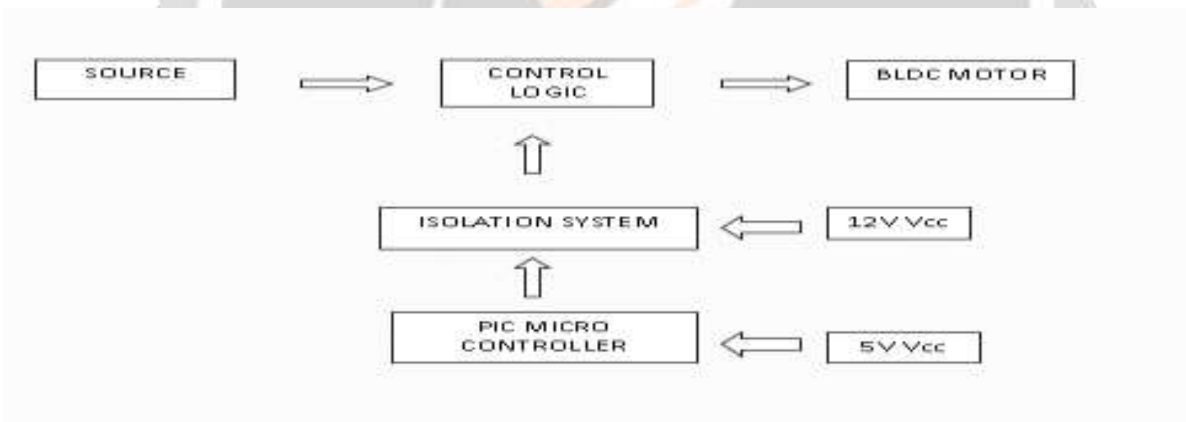

Fig.7.Block diagram of proposed system

PIC Microcontroller:

PIC microcontroller was used in this paper to obtain the gate signal of the inverter switches using SPWM. PIC 16F877A was used to generate the Modified Sine Wave gate signals and PIC 16F887 was used to generate Sine Wave gate signals. Both have 40 pins with different functions. Two PICs were programmed in order to drive switches for Modified Sine Wave and Sine Wave inverter. Program MATLAB was used to write the PICs codes.

ISOLATION SYSTEM:

The 12V power supply is given to the isolation system after giving input to the isolation system they are given to the control logic.

CONTROL LOGIC:

Control logic is a key part of a software program that controls the operations of the program. The control logic responds to commands from the user, and it also acts on its own to perform automated tasks that have been structured into the program.

BLDC motor:

Brushless DC electric motor also known as electronically commutated motors, or synchronous DC motors, are synchronous motors powered by DC electricity via an inverter or switching power supply which produces an AC electric current to drive each phase of the motor via a closed loop controller.

The simulation analysis for the proposed system is shown below, were the experimental anaylsis for the sensorless BLDC motor with their commutation correction is proposed here in this paper with current voltage waveform using MATLAB.

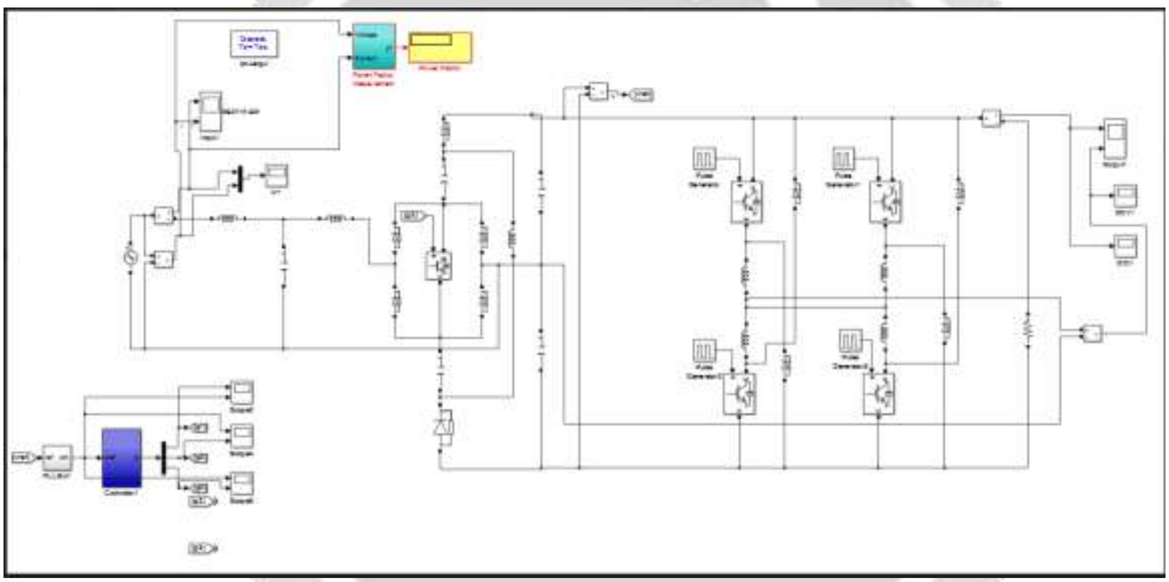

Fig.8.a.Stimulation circuit for proposed method

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III. RESULT AND DISCUSSION

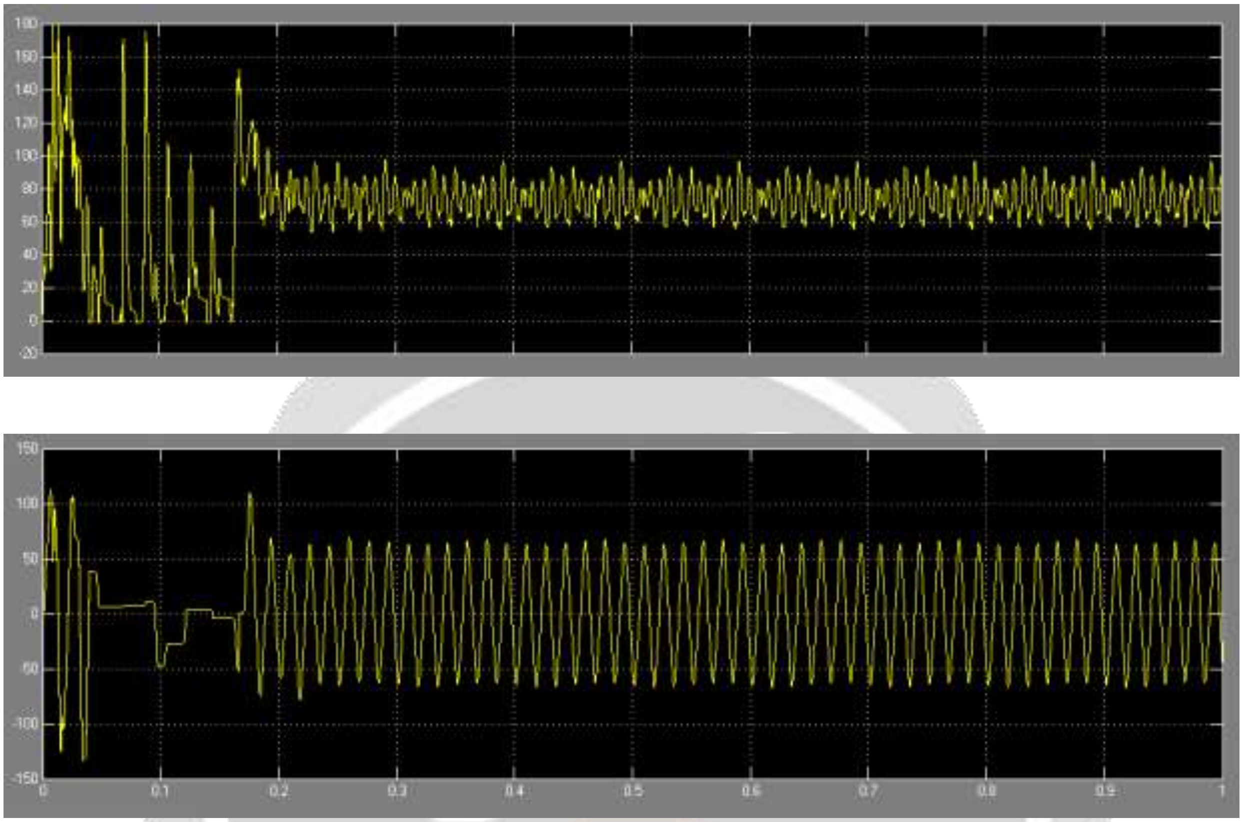

Fig.8.b .Output for sensorless BLDC motor for voltage and current source

The above graph shows the output voltages and output current of sensorless BLDC motor commutation error correction. The input source voltage and current is given to the buck converter, it is a DC-to-DC power converter which steps down voltage (while stepping up current) from its input (supply) to its output (load) a 230v. On other hand AC supply is given to the rectifier where 230v is step down to 12V using regulator for regulating 5V in order to operate the delay switch in different phase we are in need of regulator, here a MOSFET switch used. A crystal oscillator is used to fed clock pulse to the MOSFET switch. The output of the circuit is taken as sine wave.

IV. Conclusion:

The sensorless BLDC motor for commutation error correction caused by several non-ideal factor is corrected using the IPF angle to zero. A novel commutation correction method is proposed to compensate the commutation error caused by a non- ideal current wave. The core idea of this method is to detect the phase error between phase current and phase back EMF and regulate this error to zero by a PI regulator. The simulation results verify its effectiveness. This kind of phase error is defined as an internal power factor (IPF) angle the real position signal determines the phase of the back EMF, the estimated position signal determines the phase of current. That means the total position error is equivalent to the IPF angle. In other words, if the IPF angle of the high-speed BLDC motor is corrected to zero, the commutation error is actually compensated totally. Thus simulation result is observed and simulated. This paper using sensorless BLDC motor give better performance , robust and high frequency application.

V. REFERENCES:

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