Design And Development Of Electronic Control Unit For BLDC Motors

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Abstract— The objective of this project is to design and development of an Electronic Control Unit for BLDC motor using logic functions and the 8-bit microcontroller. The PIC16F15324 is chosen as it is a compact controller with power pack features which helps in controlling the motor and also interacts with multi-board communication. This Circuit is used to control the motor in motor mode as well as generator mode which helps to achieve regenerative braking operation. Project can be extended further wit120h wheel locker systems, Bluetooth control and charger controller system for electric bicycles.

Key Words— Microcontroller, Hall Sensor, Logic functions, BLDC motors.

I. INTRODUCTION

This project describes the design of an Electronic Control Unit for controlling of Brushless DC motors (BLDC) feature high efficiency and excellent controllability motors and has power-saving advantages relative to other motors [1]. Control mechanism consists of logic functions and the 8-bit microcontroller. 8-bit microcontroller is PIC16F15324, which is very compact controller and have 14 pins, used to generate two PWM signals, PWM high and PWM low signal [2]. Further both PWMs perform AND operation with hall sensor input using AND logic and the output is given to gate driver as gate signal input, the gate driver further boost the signal level and driver the gate of power mosfet, which drives the each phase of motor [3]. As BLDC motors do not have brushes it has a long life with less maintenance, low power consumption [10], lower EMI radiation, smooth operation [8].
The Electronic control unit (Fig1) has the following parts: PIC16F15324, Logic Functional block wich receives signals from Hall Sensors, Gate driver, Power MOSFET and the BLDC motor.

II. **Block diagram of Electronic Control Unit**

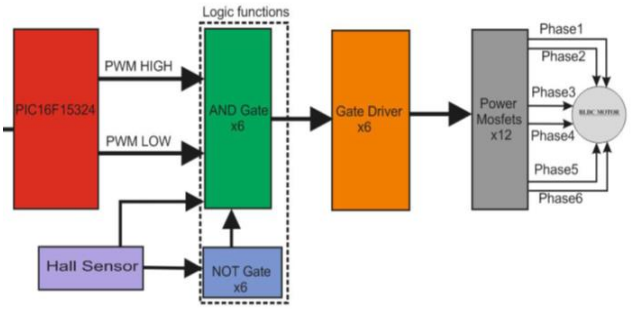

Fig1: Block diagram of Electronic Control Unit

The AND Gate receives an information of rotor positions, via the signals generated by three Hall-Effect sensors placed in the stator. Each phase is driven by the two individual Hall sensors for driving the higher and lower coil, to achieve the motor mode with 120 deg. phase shift. The AND Gate is used as Logic function to impose delay and Schmitt trigger present inside the AND Gate will provide Phase shift for PWM. The BLDC motor is driven with six power MOSFETs arranged in a 3-phase H-bridge configuration.
The Gate driver receive the PWM signals from the
AND Gate and regulate the control voltage and timing of the MOSFET. For the high side MOSFET, the control voltage must be positively offseted with a voltage equal to the voltage in the transistor's source connection. Here the MOSFET with Voltage rating of 100V and Current rating of 180A has been used. Based on the rotor positions the phase sequences will be energized and excited.

III. Motor Mode ANALYSIS

Time sequences Motor Mode																			
Time		0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	##	##	##
Step		1				2				3				4			5		
6 Hall sensors ==> Motor mode																			
Hall 1H		1				1				0				0			0		
Hall 1L		0				0				0				1			1		
Hall 2H		0				0				1				1			0		
Hall 2L		1				0				0				0			0		
Hall 3H		0				0				0				0			1		
Hall 3L		0				1				1				0			0		
PWM H		1				1				1				1			1		
PWM L		PWM				PWM				PWM				PWM			PWM		
Leg 1H And gate out		1				1				0				0			0		
Leg 1L And gate out		0				0				0				PWM			PWM		
Leg 2H And gate out		0				0				1				1			0		
Leg 2L And gate out		PWM				0				0				0			0		
Leg 3H And gate out		0				0				0				0			1		
Leg 3L And gate out		0				PWM				PWM				0			0		
Motor EMF status																			
EMF Pn 1	S1n	+				+				0				-			-		
EMF Pn 2	S2n	-				0				+				+			0		
EMF Pn 3	S3n	0				-				-				0			+		

Fig2: Motor mode analysis with logic function.

The Power drive includes the enhanced controlling of nominal speed of motor and the maximum torque achieved when running into the motor mode, with 120 deg. phase shift

Fig3: The experimental result of motor tested at 1kHZ frequency.

The above three 3 phase output is showing that the individual hall sensor are driving the separate phase without any interference.

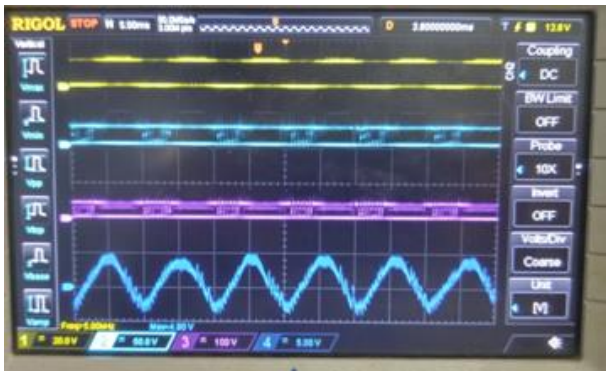

Fig4: The experimental result of motor tested at 5 kHZ frequency

IV. Generator Mode ANALYSIS

Time sequences Generator Mode ==> from motor to generator = reverse Hall sensors																							
Time		0	15	30	45	60	75	90	105	120	135	150	165	180	195	210	##	##	##	##	##	##	315	##	##
Step		1				2				3				4				5					6		
6 Hall sensors ==> Gene mode																									
Hall 1H = not(Hall 1H motor)		1				1				0				0				0					0		
Hall 1L		0				0				0				1				1					0		
Hall 2H		0				0				1				1				0					0		
Hall 2L		1				0				0				0				0					1		
Hall 3H		0				0				0				0				1					1		
Hall 3L		0				1				1				0				0					0		
PWM H		PWM				PWM				PWM				PWM				PWM					PWM		
PWM L		PWM				PWM				PWM				PWM				PWM					PWM		
Leg 1H And gate out		0				0				0				PWM				PWM					0		
Leg 1L And gate out		PWM				PWM				0				0				0					0		
Leg 2H And gate out		PWM				0				0				0				0					PWM		
Leg 2L And gate out		0				0				PWM				PWM				0					0		
Leg 3H And gate out		0				PWM				PWM				0				0					0		
Leg 3L And gate out		0				0				0				0				PWM					PWM		
Gene EMF status																									
EMF Pn 1	S1n	-				-				0				+				+					0		
EMF Pn 2	S2n	+				0				-				-				0					+		
EMF Pn 3	S3n	0				+				+				0				-					-		

Fig5: Generator mode analysis with logic function.

The Power drive includes the enhanced charging of the battery and achieved the regenerative mode for current controlled mechanism for motor, when running into the generator mode, with 180 deg. phase shift for each time sequence.

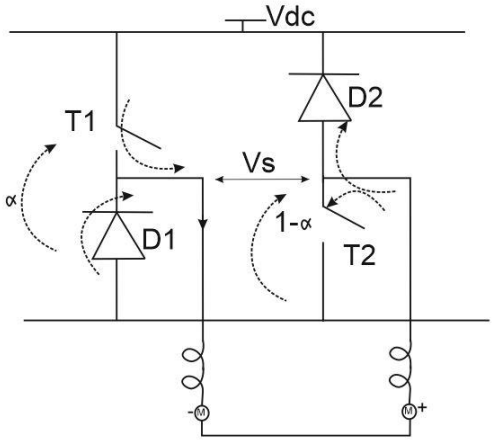

Fig6: Antisymmetric Chopper for Generator mode.

Where α is firing Angle, the value of alpha must lie between 0< α<0.5.
If 0.5< α<1, then it causes the reverse current and the controller can burn the motor.

V. SOFTWARE Used For SIMULATION

Vissim- This graphic software of application design/simulation/control will accompany you from the beginning to the end of your developping knowledge of the system with microcontrollers or DSPs, with industrial PC computers, configured in administration automation of inputs/outputs for process control. The product studies are complex, and so a powerful software is needed to help with the design: VisSim will be indispensable all throughout your development. VisSim is a modeling software whose principle is the use of functional blocks. The user should set these blocks and organise them in order to simulate the desired system or phenomenon.

Functional blocks categories available in Vissim simulation
- Annotation blocks (Signal Producer)
- Generator blocks
- Consumer blocks (consumer signal)
- Arithmetic blocks (Arithmetic)
- Boolean blocks / Dynamic blocks (Integration)
- Matrix operation blocks
- Linary System blocks

• Nonlinary blocks
• Fixed point
• Optimization
• Random generator

V. CONCLUSION

The BLDC motors runs successfully with the proposed Electronic Control Unit using the programmed Vissim software. It takes 4.80A for the 5kHz with low power consumption. This control technology provides a smooth running with less cost effective Control board using the Logic gates.

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