DSP based control of Brushless DC (BLDC) motor

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Abstract---Now days, in recently developed technology, motor control becomes very easier as before. There are different control strategies available to speed control of motor. In this paper illustrate the Digital Signal Processor based control of Brushless DC motor. DSP TMS320LF2812 is used to control motor.

Keywords: Introduction, BLDC Motor Operating Principle, Scheme for BLDC Motor Drive, Digital Signal Processor, Simulation and Results, Experimental Setup and Result.

I. INTRODUCTION

In every industry there are processes some form that require adjustment for normal operation. Such adjustments are usually accomplished with variable speed drive and it consists of

1. Controller
2. Power Converter
3. Electric Motor

Controller: The controller generates PWM signal to the converter & hence forms the heart of the Variable speed system. (VSDs)Power Converter: It controls the power flow from an AC supply to the motor by appropriate control of power semiconductor switches (part of power Converter).

Electric Motor: It is connected directly/indirectly to the load.

II. BLDC MOTOR OPERATING PRINCIPLE

To turn DC motor into a brushless design, the windings have to be eliminated on the rotor. This can be achieved by turning the motor inside out. In other words, by making the permanent magnet the rotating part and put the windings on the stator poles as shown in Figure 1. Also there is necessary of reversing the current automatically – a cam-operated reversing switch could be made to do this job.

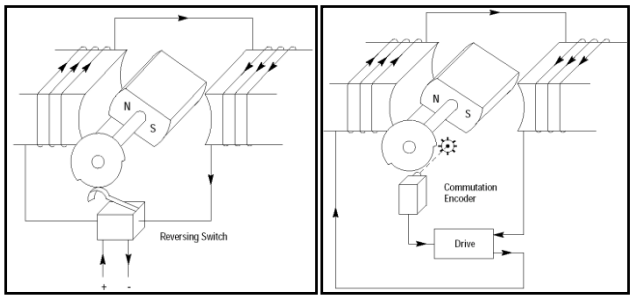

Fig. 1: Operating Principle of BLDC motor.

An electronic amplifier or drive which can also be used to do the commutation in response to low-level signals from an optical or hall-effect sensor.

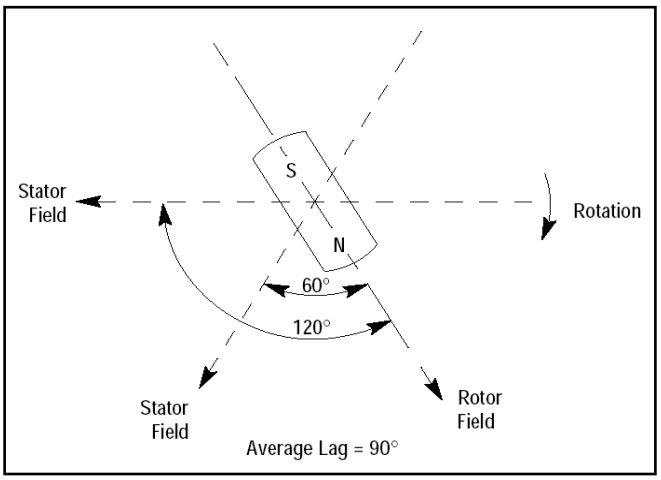

Fig. 2: Angle displacement between sttor and rotor field

The brushless version cannot be driven by simply connecting it to a source of direct current. The current in the external circuit must be reversed at defined rotor positions. Hence, the motor is actually being driven by an alternating current.

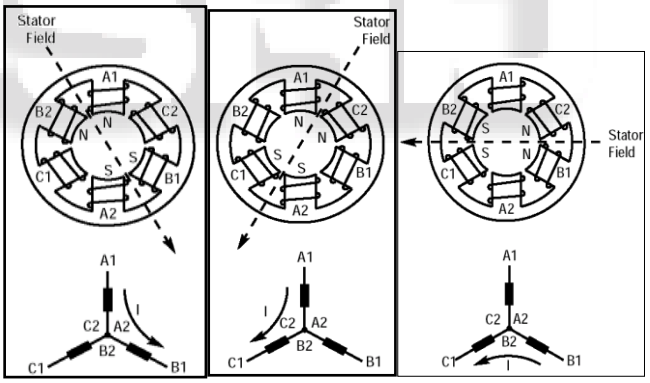

Fig. 3: Direction of flow of current in winding.

The torque characteristic indicates that maximum torque is produced when the rotor and stator fields are at 90° to each other. Therefore, to generate constant torque we would need to keep the stator field a constant 90° ahead of the rotor. Limiting the number of phases to three means that we can only advance the stator field in increments of 60°. This means we must keep the stator field in the same place during 60° of shaft rotation. So we can't maintain a constant 90° torque angle, but we can maintain an average of 90° by working between 60° and 120° is illustrate in Figure 2 and Figure 3.

III. SCHEME OF CONTROL OF BLDC MOTOR

The general scheme to control BLDC motor is shown in Figure 4. BLDC motor control is obtained by proper commutating inverter circuit. This action is done using controller which will generate necessary PWM signals.

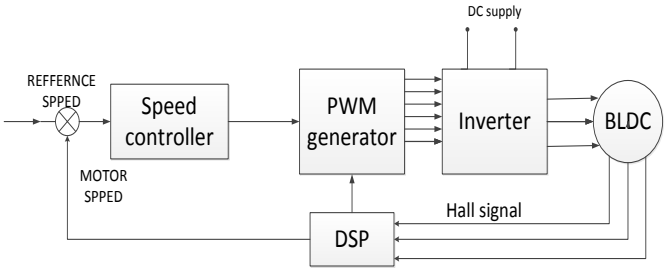

Fig. 4: Scheme of Control of BLDC motor.

There are different types of controller are used to control speed of BLDC motor Drive.

1) PI Controller
2) DSP Controller
3) Programmable Logic Controller
4) Microcontroller
5) Fuzzy Controller

Fuzzy and PI controller are used for control speed but they consume more time to give output so it not used for real time application.

To increase the reliability and reduce hardware and maintenance costs, it is desirable to use a DSP controller.

IV. THE TMS320 DSP FAMILY [11]

There are different types of DSP families available now days. According to application we use Digital signal processor. Classification of different DSP according to application shown in Figure 5.

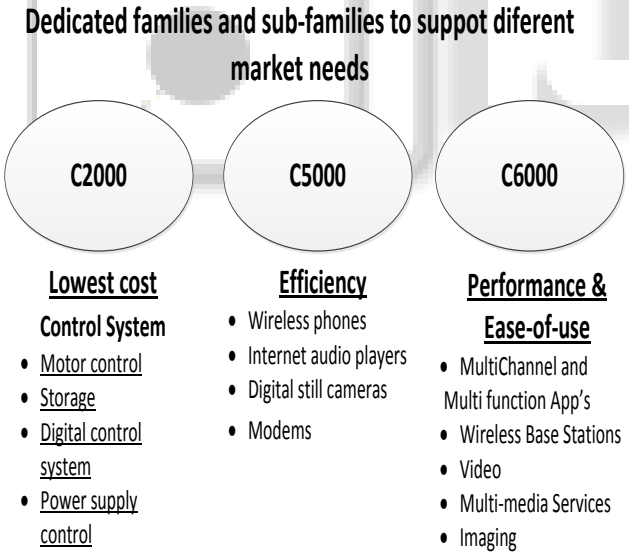

Fig. 5: Classification of DSP Family.

A. FEATURES OF TMS320LF2812

- TMS320F2812 Fixed Point Digital Signal processor
- 150MIPS operating speed
- 18K words on chip RAM
- Event Managers A and B (EVA and EVB)
- 128K words on-chip Flash memory
- 64K words off-chip SRAM memory
- 30MHz. Clock rate
- SPI,SCI,CAN are available
- 2 expansion connectors (analog and I/O)
- On board IEEE 1149.1 JTAG Connector
- 5-volt only operation with supplied AC adapter
- TI F28xx code composer studio tools driver

B. HOW TO WORK ON DSP?

Mainly two ways to work with DSP

1) Stand-alone mode

DSP has its own assembly language.
SPDT switch to upward position.
And connect the keyboard to the PS/2KBD connector.

2) Serial monitor mode

DSP also provide work with c/c++ with help of serial monitor.
SPDT switch to downward.
Connect pc serial port to DSP port using RS232 serial cable.
The programme can be assembled in two methods.

- Text editor method.
- Code composer studio.

C. How to Load Program in DSP?

(1) Make simulation of BLDC motor in MATLAB. Generate code in Simulink. This will generate Code in '.c file '
(2) Load this code in Code Composer Studio using Emulator.
(3) CCS will generate .out file .This .out file is downloaded in VI DSP Downloader.
(4) Using downloader will generate .asc file which will be further loaded in DSP TMS320LF2812.

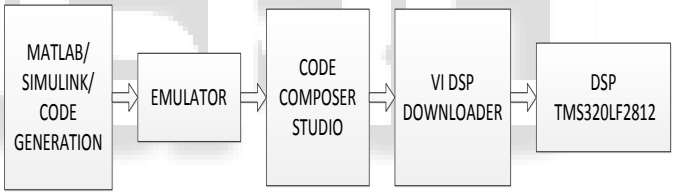

Fig. 6: Load program in DSP

V. SIMULATION AND RESULT OF BLDC MOTOR

To control BLDC motor , first need to calculate the rotor position using hall effect sensor .There are three hall effect sensor used in this simulation. Figure 7 shows the decoder block. This will decodes the Hall Effect sensor signal into emf signals. The decoding of this signal is done in sequence shown in Table 1.

ha	hb	hc	emf_a	emf_b	emf_c
0	0	0	0	0	0
0	0	1	0	-1	+1
0	1	0	-1	+1	0
0	1	1	-1	0	+1
1	0	0	+1	0	-1
1	0	1	+1	-1	0
1	1	0	0	+1	-1
1	1	1	0	0	0

Table. 1: DECODER Block

The generated emf signals further fed to the Gate block. According to given table, this block will generate six signals to operate inverter. This signal sent to gate port of universal bridge. Figure 8 shows the GATE signal generating block.

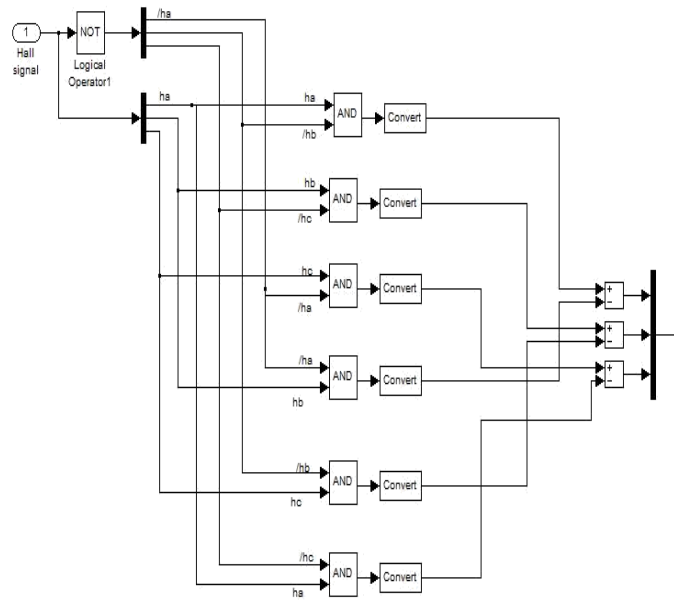

Fig. 7: Decoder Block

emf_ a	emf_ b	emf_ c	T1	T2	T3	T4	T5	T6
0	0	0	0	0	0	0	0	0
0	-1	+1	0	0	0	1	1	0
-1	+1	0	0	1	1	0	0	0
-1	0	+1	0	1	0	0	0	0
+1	0	-1	1	0	0	0	0	1
+1	-1	0	1	0	0	1	0	0
0	+1	-1	0	0	1	0	0	1
0	0	0	0	0	0	0	0	0

Table. 2: GATE BLOCK

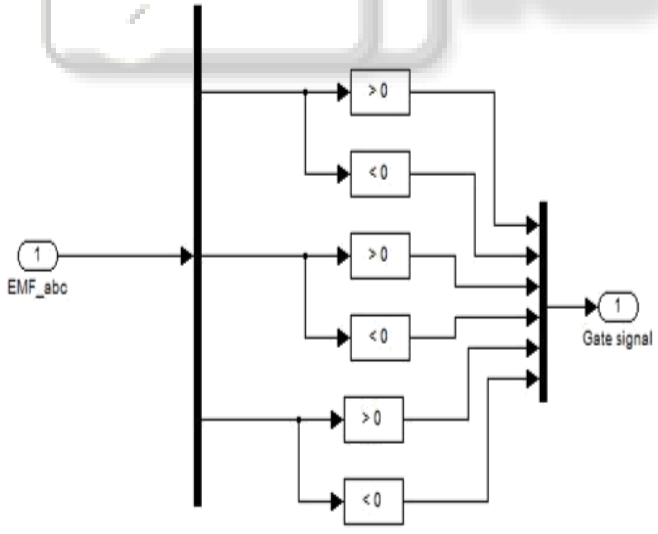

Fig. 8: Gate Block

The complete Simulation BLDC motor is shown Figure 9 and Figure 10. There are two different simulation of Open Loop and Close Loop control shown in figure. There is feedback is used in the Close loop control. This feedback is given to summing point .This summing point will generate error signal, which will fed to the PI control Block. The output waveform of open loop and close loop speed is shown in Figure 11 and Figure 12 respectively.

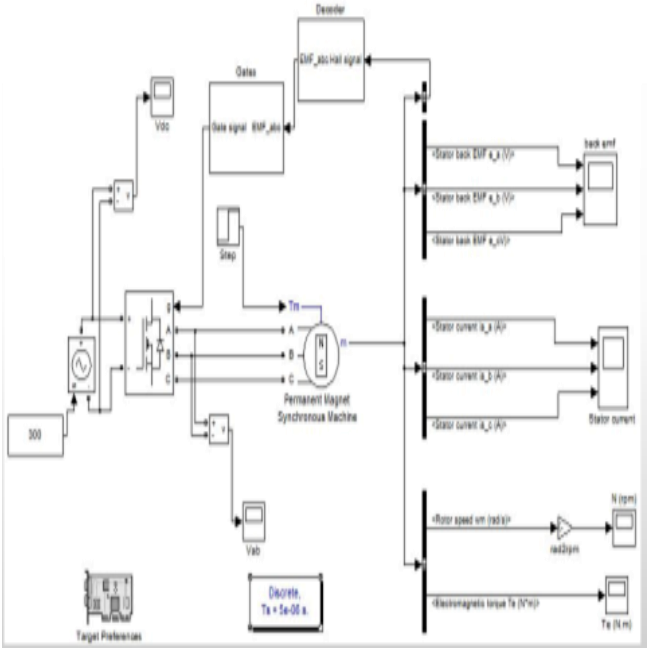

Fig. 9: OPEN LOOP SIMULATION

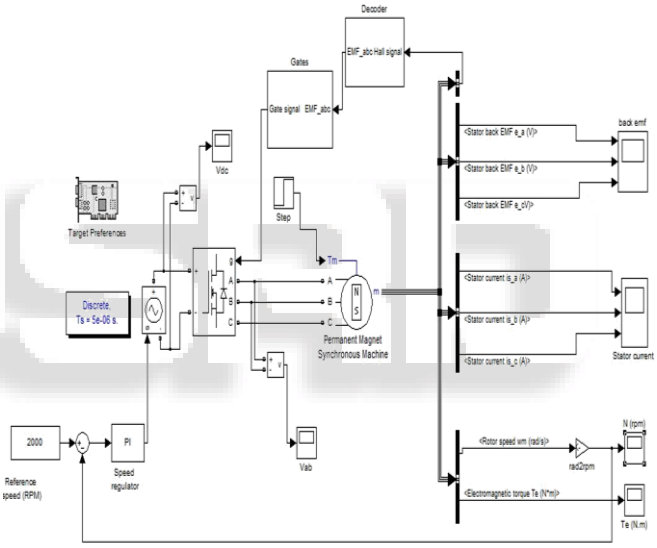

Fig. 10: CLOSE LOOP SIMULATION

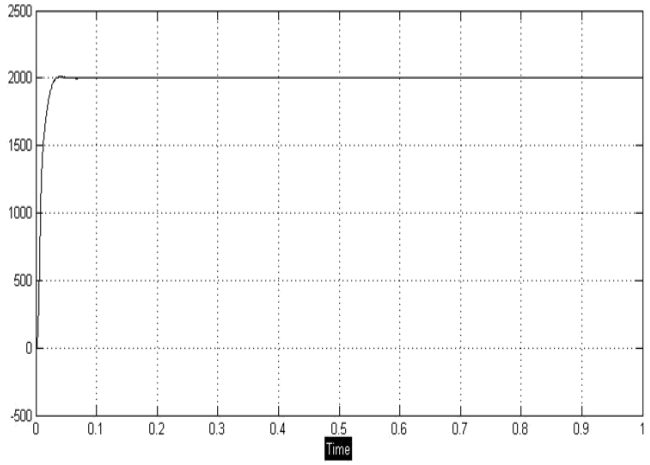

Fig. 11: Open loop simulation result of speed

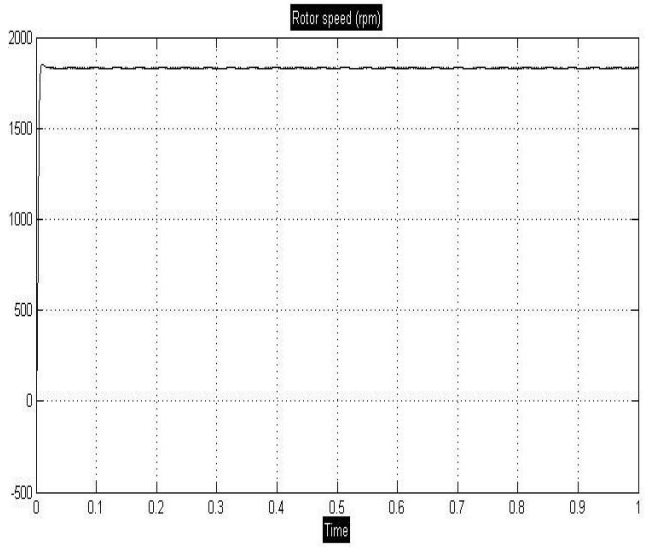

Fig. 12: Close Loop Simulation Result of Speed

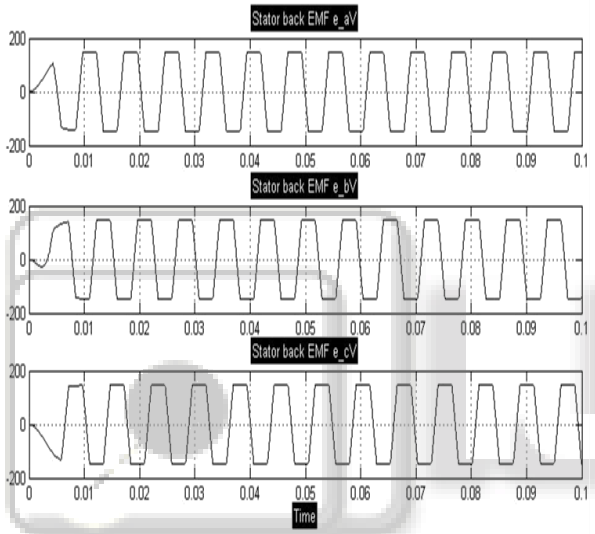

Fig. 13: Induced back EMF of BLDC motor.

VI. EXPERIMENTAL SETUP

Following Figure14 shows the Experimental setup of BLDC motor. This will contains the instruments Host PC, IPM Module, DSO, DSP TMS320LF2812, BLDC motor, Power Supply, and Hall Effect Encoder.

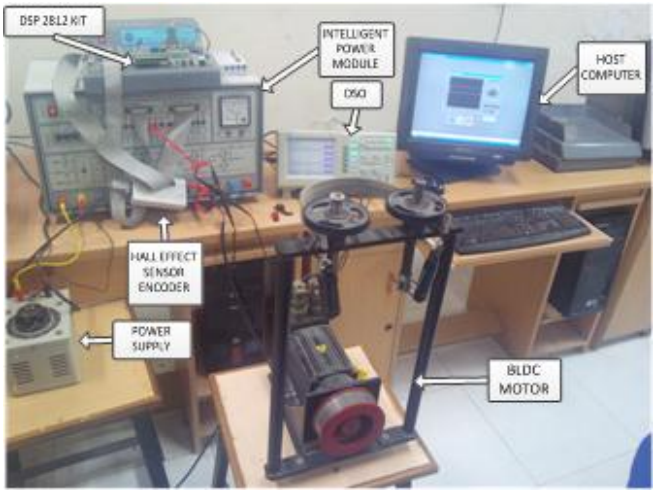

Fig. 14: Experimental Setup

Host PC contains VI DSP Downloader, MATLAB and CCS 3.3 software. IPM module contains inverter converter circuits and input and output signal ports. Input and output signal can be stored using Digital Signal Oscillator. Power supply used 230 V AC single phase .The PWM and Hall Effect sensor result caught by DSO is shown in Figure 15.The speed control by DSP is shown in Figure 16 and Figure 17 for open loop control and closed loop control respectively.

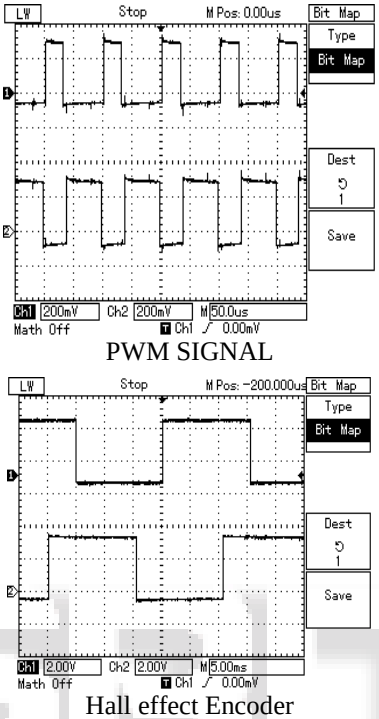

Fig. 15: Results of PWM signal and Hall Effect encoder signal from DSO at 500 rpm.

Fig. 16: Open Loop Speed

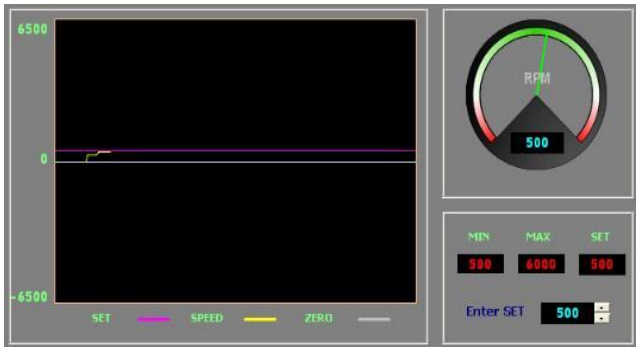

Fig. 17: Open loop speed

VII. CONCLUSION

This paper describes the control of BLDC motor using DSP. The simulation of motor open loop and close loop control obtained. The DSP based control of BLDC motor also obtained. The speed control obtained using this DSP with no load in simulation and Experimental setup.

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