Performance Optimization for Brushless DC Motor Using DRV8312 Evaluation Board

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Abstract - *Brushless DC motors (BLDC) evolution is a continuous process. For example, BLDC motors have long been used in industrial applications such as feed drives for CNC machines, actuators, industrial robots, and electric vehicles have begun to use high-performance BLDC. There are specific BLCD motor control evaluation boards for analyzing these parameters and performance. One of the best-used evaluation boards is DRV8312-EVM from Texas instruments. Which contains C2000 real-time microcontroller. In this paper, the performance variation plots are superimposed with the rated parameter results to clearly understand the sensitivity and performance analysis of a BLDC motor through DRV8312 hardware. This provides a great way to learn and experiment with digital control of medium voltage brushless motors to increase the efficiency of operation for BLDC motors.*

***Key Words*: BLDC, DRV8312-EVM, C2000 real-time microcontroller, Texas instruments**

1. INTRODUCTION

In modern days, due to the rising popularity and demand for electric vehicles, these BLDC motors have gained a new platform to showcase their features. The popularity of Brushless DC motor (BLDC) is rapidly increasing due to their various advantageous features which include high density of torque, high density of power, high efficiency, good saliency ratio, flux weakening capabilities, and speed control operations over a wide range, etc [12]. However, the main challenge that occurs in the development of BLDC motor controllers always begins with the high complexity of the electronic commutation system that must be used because BLDC motors don't have the commutator and brush compared to other DC motors [5,11]. So, it's called a Brushless DC motor. There are many types of controllers that are commercialized at a lower price, one of them is DRV8312-EVM. This BLDC motor Controller has some features like torque control, speed control, etc., with a wider range of variables, and position control [1,2].

The addition of, magnetic sensors, encoder sensors, current sensors, temperature sensors, voltage sensors, and signal amplifiers are the main component of this motor controller. Of course, this type of motor controller cannot be used for more complex high-power Industrial applications. Along with these needs, motor controllers with more complete features have a more expensive commercial price. This paper showcases the simulation results of Hall sensors sequence matching concerning the speed of the BLDC Phase voltage sequence of the motor with load and no-load conditions. Hall effect sensors are the most commonly used method of detecting rotor position in BLDC motors, due to the low cost and as it is easy to use with the permanent magnets which are present in the rotor [3]. And the commutation happens every 60-degree increment, increasing the high-resolution sensing also, this DRV8312 hardware contains a low-side current sensing technique that is connected to the current sense element between the load and ground of the board. The major problem is to detect load short to ground and some system ground disturbance in the shunt resistor.

1.1 Motor specification

Every motor controller is built and driven based on the parameters of the motor which is used. So, the motor which is used here is a 24V BLDC motor with a maximum RPM of 3000. The output power of the motor concerning the maximum speed is 50W. And this motor is of 8 poles with the phase resistance of 0.7 Ohms and the maximum torque for this motor is 1.5Kg-cm.

2. THEORY OF OPERATION

DRV8312-C2 consists of a control CARD-based motherboard evaluation module. The DRV8312-C is a motor controller evaluation board for spinning a three-phase brushless DC motor (BLDC) often referred to as a permanent magnet synchronous motor (PMSM) [7,8]. The DRV8312-C is a high-performance, power-efficient, cost-effective sensorless field-oriented control (FOC) and sensored or sensorless trapezoidal EMF commutation platform that speed test performance development for a quicker time to market through closed-loop proportional and integral error control of the motor [9,10].

This DRV8312 has a three-phase inverter board with an interface to accept the control card and is integrated with a power module board which is supporting up to 50V and 3A continuous. The control card is pre-flashed with the insta-spin BLDC to spin a BLDC motor using the graphical user provided by DRV8312 [6].

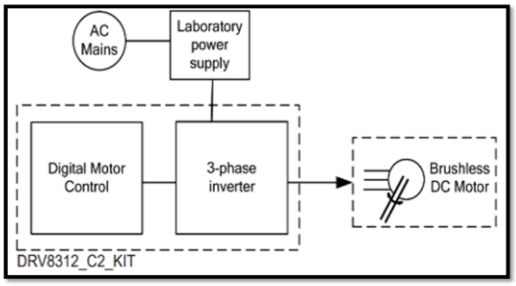

Fig -1: Block diagram for a typical motor drive system

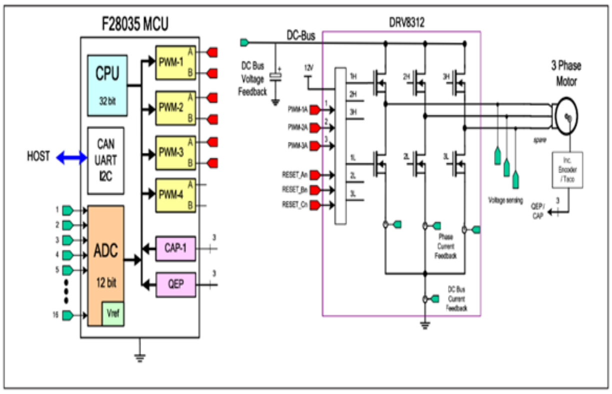

Fig -2: DRV8312 Functional Diagram

Fig -4 below illustrates the position of these macroblocks on the DRV8312 - C2 board. The use of a macroblock is, for enabling the different power stages and easy to debug and testing of one stage at a time. The Banana jack connectors can be used to interconnect the power line of these power stages or blocks to construct and test a complete system. All the Pulse width modulation and analog to digital converters convert signals which are the actuation and sensing signals or output signals have designated test points (TP) DRV8312 on the board, which makes it easy for an application developer to try out new algorithms and strategies for different applications [4].

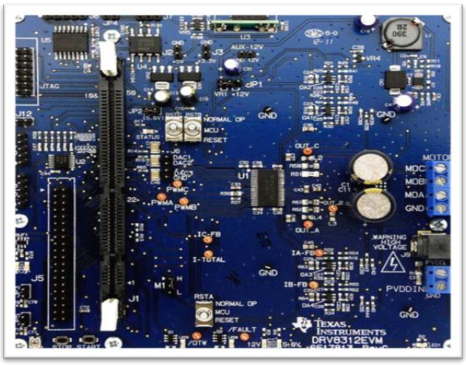

Fig -3: C2000™ Real-Time microcontrollers

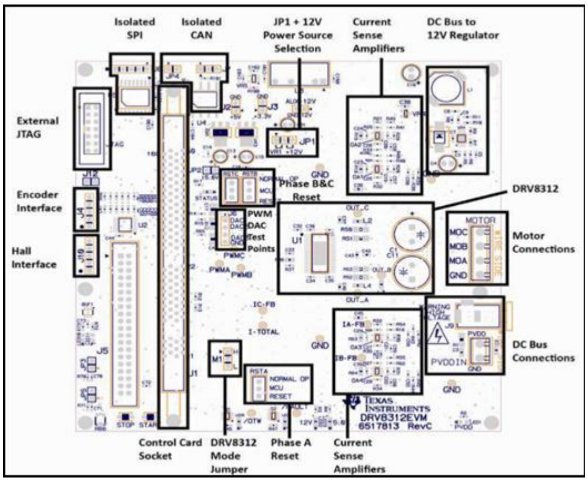

Fig -4: DRV8312-EVM Board Macros

3. HALL-SENSOR SYNCHRONIZATION

In the below table-1 and fig-4, we will come to know that for the three-phase motor for 60-degree rotation, two phases will be fixed and one phase will be varying and frequency doesn't change. And how digital hall sensor signals are synchronized with respect to phase voltage.

Table -1: Hall sensor sequence

Hall Sensor Signal		
S1	S2	S3
1	1	0
0	1	0
0	1	1
0	0	1
1	0	1
1	0	0

Basically, a Brushless DC motor will have three Hall Effect Sensors fitted on the rotor or the stator according to the motor specification proposed to the system. These Hall effect sensors are placed 120 degrees apart from each other, giving 0 to the 360-degree angle position [14].

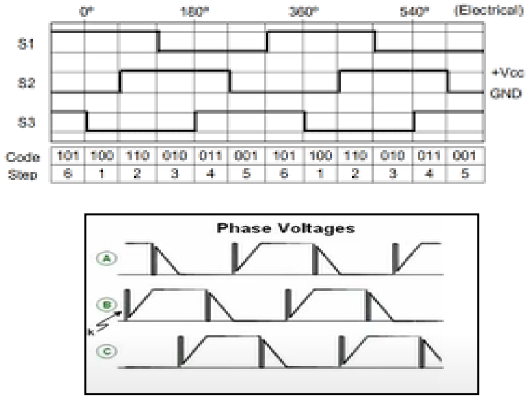

Fig -5: Hall-sensor sequence synchronization with phase voltage

4. SIMULATIONS AND RESULTS

After completing the logic operation table and hall sensor synchronization concerning phase voltages with load and no-load conditions. In the evaluation process, we got to know that the Hall sensor frequency increases with respect to speed, and frequency doesn't change with respect to torque and load [13].

Fig -6: Hall-sensor sequence perfectly matches the Table-1

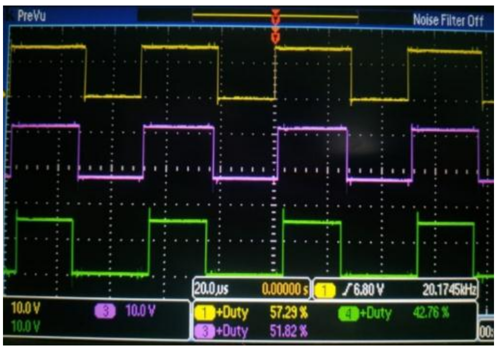

Fig -7: Phase voltage PWM for 500 rpm without applying any load perfectly matches the Fig-5

Fig -8: Phase voltage PWM for 1000 rpm without applying any load perfectly matches the Fig-5

When the load is applied to the motor respect to it the duty cycle changes and frequency remains constant.

Fig -9: Phase voltage PWM for 1000 rpm with applying load

4.1 The main loop of the proposed DRV8312-C2 motor controller

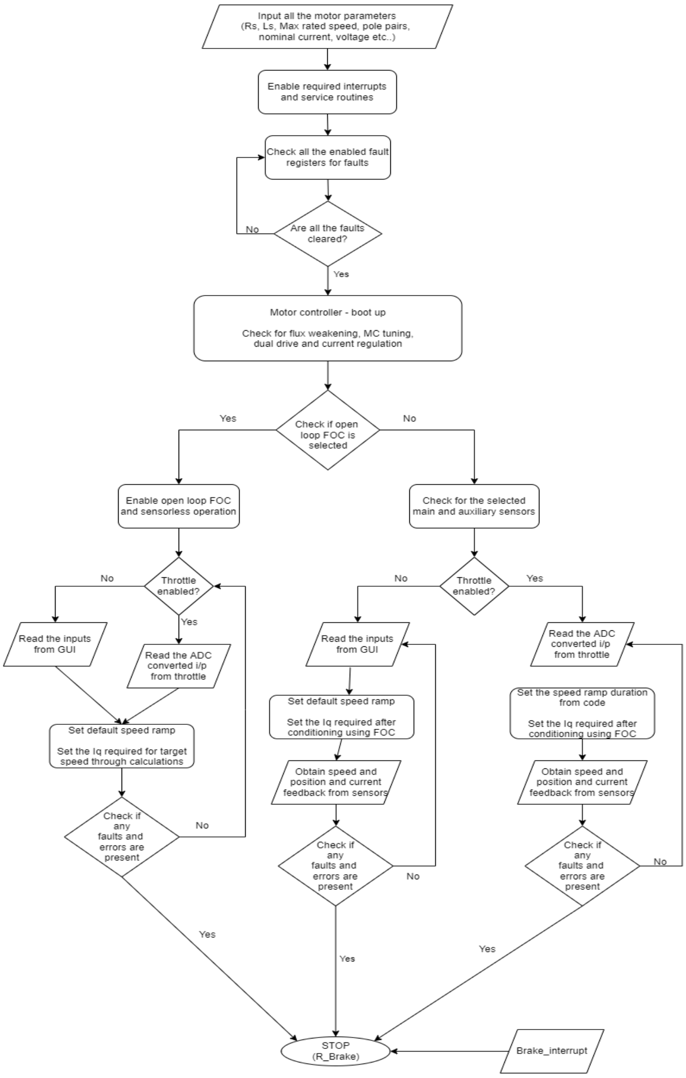

Fig -10: Flow chart of the proposed motor controller

4.2 Image of the simulation process

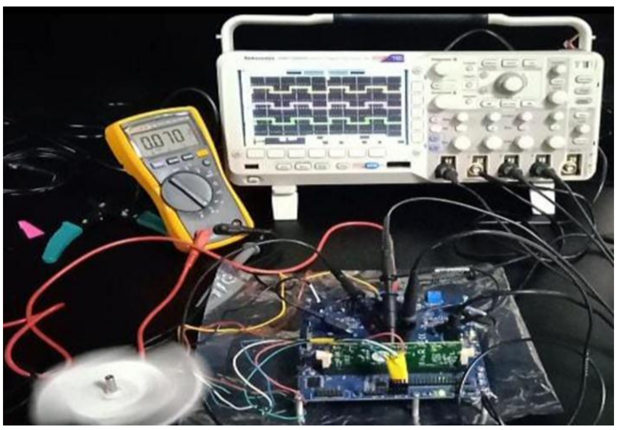

Fig -11: Image of the testing process

5. CONCLUSIONS

This paper attempted to analyze the performance variation plots superimposed with the rated parameter results to clearly understand the sensitivity and performance analysis of a Brushless DC motor through DRV8312 hardware. The desired speed is further processed based on a predefined tuned value. Accordingly, the proposed system can solve the high overshoot in transient response. This study will contribute to the application of the Brushless DC motor in the electric vehicle industry.

REFERENCES

[1] Texas Instruments, "DRV8301 Three-Phase Gate Driver with Dual Current Shunt Amplifiers and Buck Regulator," 2015.

[2] Texas Instruments, "Three Phase BLDC Motor Kit with DRV8312 and Piccolo MCU"

[3] D. C. Hanselman, "Brushless Permanent-Magnet Motor Design", University of Maine, McGraw-Hill Inc., 1994.

[4] A. R. Krishnan, "Electric Motor Drives: Modeling, Analysis, and Control", 1st ed., Pearson, 2001.

[5] J. Karthikeyan, R. Dhana Sekaran, "Current Control of Brushless DC Motor Based on a Common DC Signal for Space Operated Vehicles," in Electrical Power and Energy Systems, volume 33, pp. 1721-1727, August 2011.

[6] A. Mukhlisin, "Perancangan Modular Controller 3 Phase Brushless Direct Current (BLDC) Motor Menggunakan ARM 32-Bit Cortex M-4 MCU," p. 92, 2015, [Online]. Available: http://repository.its.ac.id/51990/.

[7] K. Vasudevan, P. Damodharan, "Sensorless brushless DC motor drive based on the zero-crossing detection of back electromotive force (EMF) from the line voltage difference", IEEE Transaction on Energy Conversion, vol. 25, no. 3, 2010, pp. 661-668.

[8] K. Gadekar, S. Joshi and H. Mehta, "Performance Improvement in BLDC Motor Drive Using Self-Tuning PID Controller," 2020 Second International Conference on Inventive Research in Computing Applications (ICIRCA), Coimbatore, India, 2020, pp. 1162-1166.

[9] R. Arulmozhiyal and R. Kandiban, "An intelligent speed controller for Brushless DC motor," 2012 7th IEEE Conference on Industrial Electronics and Applications (ICIEA), Singapore, 2012, pp. 16-21.

[10] Community and SimpleFOC, "No Title," 2021. https://simplefoc.com/.

[11] D. Choi, "Development of Open-Source Motor Controller Framework for Robotic Applications," IEEE Access, vol. 8, pp. 14134–14145, 2020, doi: 10.1109/ACCESS.2020.2965977.

[12] Aghili F.Ripple suppression of BLDC motors with finite driver/amplifier bandwidth at high velocity. IEEE Transactions on Control Systems Technology.2011; 19(2): 391-397.

[13] M. Bhuiya, N. Sakib, M. Uddin, K. M. Salim, "Experimental Results of a locally developed BLDC Motor Controller for electric tricycle.". 10.1109/ICASERT.2019, pp. 1-4.

[14] K. Tabarraee, J. Iyer, S. Chiniforoosh and J. Jatskevich, "Comparison of brushless DC motors with trapezoidal and sinusoidal back-EMF," 2011 24th Canadian Conference on Electrical and Computer Engineering(CCECE), Niagara Falls, ON, 2011, pp. 000803-000806.