A BLDCM Control System Based on CAN Communications Applied to E. V.

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***Abstract*— This paper describes the process carried out to design and manufacture the hardware and software of a control system for brushless direct current motors based on CAN communications applied to electric vehicles. The proposed control system consists of a brushless motor controller and software C library based on a microcontroller ATmega64M1. With this controller, software and a digital battery management system, a prototype of a control system for 3-phase brushless motors is developed.**

Keywords*— *brushless direct current motor (BLDCM), controller area network (CAN), microcontroller ATmega64M1 , BLDC motor control C library, BLDC control system, electric vehicle.

I. Introduction

In recent years, the automotive industry has begun to focus its efforts on the research and development of electric vehicles. This type of vehicle has some advantages over traditional internal combustion vehicles, such as the cost savings in fuel consumption and zero emissions of polluting gases. For this reason the use of these vehicles, despite having less autonomy than internal combustion vehicles, may increase in the near future.

Due to electric vehicles require high efficiency to achieve the best performance, it is required to use BLDC motors (Brushless Direct Current Motors). These motors have excellent torque characteristics, high performance, and a very wide range of speeds, plus a lifetime. They have no brushes switching, so the need for periodic maintenance is reduced. However, the use of a complex control system based on a microcontroller that manages the switching of the motor coils is necessary.

II. The BLDCM Controller

The BLDCM controller design is based on μC ATmega64M1 [1], which, by its characteristics is suitable for the control of this type of motors. The main feature of this μC that is required for this project is a 12-bit high speed PSC (Power Stage Controller) module. This module controls the power stage and the switching of the BLDC motor coil signals by the technique of PWM (Pulse Width Modulation) [2][3].

A. Controller Design

The main stages in the design of the controller are three: the control stage, the communication stage and the power stage. At the control stage the configurations of the inputs and outputs of the μC are performed. In the communication stage, it is located the electronics used to interconnect the μC with the PC. This stage allows using either RS-232 or CAN (Controller Area Network) protocols. Finally, in the power stage, they are located the drivers that raise the output voltage of the PSC module of the μC to get the right voltage for activating the MOSFET transistors. These transistors excite the motor coils with the correct voltage. Fig. 1 shows the different modules of the controller's design.

B. Design and Manufacture of the PCB

The PCB controller was designed using the Altium Designer software. This is a design of 2-layer with the component mounting in the top layer. Fig. 2 shows a 3D view of the final design of the prototype, developed under the simple Eurocard format.

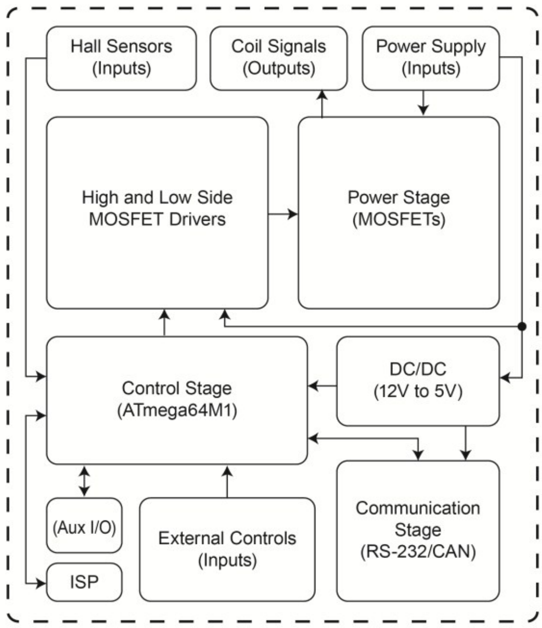

Fig. 1. Diagram of the parts of BLDCM controller

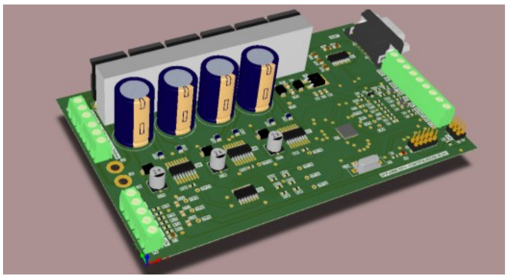

Fig. 2. 3D view of the BLDC controller

III. THE MOTOR CONTROL SOFTWARE LIBRARY

The development of the function library for controlling BLDC motors is based on the open-loop control with speed adjustment technique [4]. Fig. 3 shows the most important components of the µC ATmega64M1 for this application.

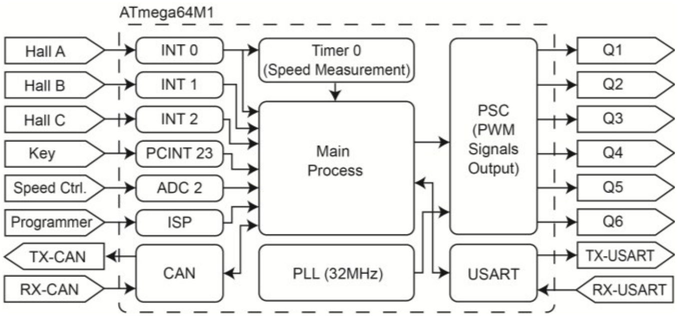

Fig. 3. Diagram of the parts of the µC used in the BLDCM controller

The Hall sensor signals (A, B and C) from the motor enter in the µC through the ports that have priority external interrupts. These interrupts act on the main system process activating the switching of the Q1 to Q6 outputs of the PSC (Power Stage Controller) module in the correct order. The interrupt of the A Hall sensor carries out the measurement of motor speed by the timer 0.

The input signal "Key" starts or stops the motor. In the main process, it disables or enables the PSC module. This module generates the 6 PWM (Pulse Width Modulation) signals, from the Q1 to the Q6, which attack the drivers of MOSFETs transistors.

The motor speed adjustment is performed by a digitized analog signal through one of the ADC (Analog to Digital Converter) channels. This digitalized signal establishes the duty cycle of the PWM signal. This PWM signal of 16 kHz is generated from the clock signal of the PLL (Phase-Locked Loop) inside the µC, set at 32 MHz.

Moreover, there are both the CAN (Controller Area Network) and the UART (Universal Asynchronous Receiver and Transmitter serial) communication modules with their respective transmit and receive data signals.

IV. THE CAN PROTOCOL

Table I shows the proposed CAN message priority levels for interconnection of the complete BLDCM control system (BLDCM controller, BMS and PC).

TABLE I: CAN MESSAGE PRIORITY LEVELS

Initial Node	Final Node	ID	Message
PC	Controller	0x530	Start/Stop motor
PC	Controller	0x531	Change motor rotation
BMS	PC	0x532	Min. battery voltage value
PC	Controller	0x533	New motor speed value
Controller	PC	0x534	Actual motor speed value
BMS	PC	0x535	Battery voltage value

V. THE BLDCM PROTOTYPE

The prototype of the BLDCM control system is designed and manufactured in order to check the correct operation of the BLDCM controller and the C library developed. Moreover, has been incorporated a digital BMS developed in another project [5] along with a battery pack of 5 li-ion cells (Fig. 4).

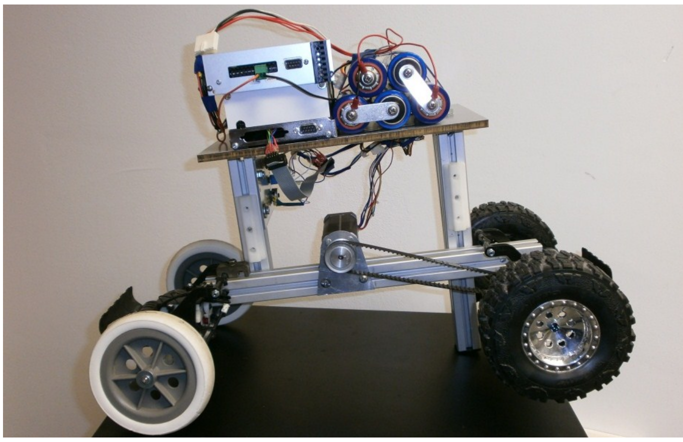

Fig. 4. View of the manufactured BLDCM control system prototype

CONCLUSIONS

With the development of the prototype and its testing has demonstrated the correct operation of both the controller and the C library developed as a complete system with BMS. This development presents a starting point for future extensions of this project or new applications related to BLDC motors.

REFERENCES

[1] Atmel ATmega16/32/64M1 microcontroller's family: http://www.atmel.com/devices/ATMEGA64M1.aspx, Last accessed 2014, May.

[2] Alphonsa Roslin Paul, and Prof. Mary George, "Brushless DC motor control using digital PWM techniques", Proceedings of 2011 International Conference on Signal Processing, Communication, Computing and Networking Technologies (ICSCCN 2011), ISBN 978-1-61284-653-8, pp: 733 – 738, 2011.

[3] K. R. Rajagopal, and Ajay Nair, "Design and development of a TMS320F2812 DSP controller based PM BLDC motor drive", International Conference on Electrical Machines and Systems (ICEMS), ISBN 978-1-4244-7720-3, pp: 776 – 780, 2010.

[4] Wang Dongmei, Guo Haiyan, and Yu Jing, "Modeling and simulation research of brushless DC motor open-loop speed-adjustment system", The 2nd International Conference on Intelligent Control and Information Processing, ISBN 978-1-4577-0816-9, pp: 394 – 398, 2011.

[5] H. Garrido, J. M. Cabrera and V. Déniz, "Diseño de un sistema de gestión de baterías Li-Ion", PFC, University of Las Palmas de Gran Canaria, January 2014.