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BLDC Motor Control for SVF Extraction though CAN communication

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Abstract

SVF is known to be able to differentiate into various cells and treat damaged human tissues and intractable diseases. The digestion of adipose tissue with collagenase is divided into SVF, oil and mature adipocyte, and the two parts are separated by density difference with time. BLDC(blushless dc) motors have many advantages compared to induction motors as well as conventional DC motors. High reliability, large output torque, high power density, high efficiency, low inertia, fast response, maintenance-free flatbed, excellent torque and speed characteristics. BLDC motors have some disadvantages. The motor field is not easily controlled and the maximum available size of the permanent magnet limits the power rating, requires a rotor position sensor and requires a power semiconductor switching circuit. Since these devices require high-speed rotation, as in the above comparison, BLDC type is suitable, Hall sensor or encoder is built in, and PWM or CAN communication method is effective to maintain stable rotation speed.

Keywords: Stromal vascular fraction(SVF), blushless dc(BLDC) motor, CAN (Controller Area Network), stm32f MCU

INTRODUCTION

Stem cell therapy offers potential treatments in areas that could not be solved by conventional therapies. Types of stem cells include Mesenchymal Stem/Stromal Cells(MSC), Hematopoietic Stem Cells(HSC), Stromal Vascular Fraction(SVF), Neural Stem Cells (NSC), Embryonic Stem Cell (ESC). SVF is a fraction obtained by dissociation, centrifugation and washing of cells using digestive enzymes or physical methods from adipose tissue collected from a patient, and various kinds of stem cells such as mesenchymal stem cells are relatively easily obtained And is attracting attention as a source of stem cells. SVF is obtained by dissociation, centrifugation and washing of cells through digestive enzymes and physical methods from adipose tissue taken from the patient. SVF is attracting attention as a stem cell source that can easily obtain various kinds of stem cells. In order to extract such svf, it is necessary to use a centrifugal separation method, so that high-speed motor control is essential.

A brushless dc motor is a rotating self-synchronous machine with a permanent magnet and with known rotor shaft positions for electronic commutation. Permanent magnet motor shape can be divided into Surface Permanent Magnet (SPM) and Interior Permanent Magnet (IPM).

SPM is a simple motor control algorithm and requires Can to prevent magnet displacement during high speed operation. Therefore, a loss due to an eddy current is generated. On the other hand, the IPM method has high motor torque and high motor efficiency at the same current. Although it is advantageous for high-speed operation, the motor control algorithm is complicated. The stator of the BLDC motor is made of laminated steel laminations with windings on the inner circumference of the slot. Normally the stator is similar to an induction motor. However, the windings are distributed in different ways. Most BLDC motors have three stator windings connected in a star shape. Each of these windings consists of a plurality of coils interconnected to form a winding. One or more coils are interconnected to form windings distributed in the periphery of the stator so as to be disposed in the slots and to form even poles. Depending on the type of connection, BLDC motors are identified as trapezoidal back electromotive force or sinusoidal back electromotive force motors. When the interconnections of the coils in the stator winding generate traction in the trapezoidal manner, this is called a trapezoidal back electromotive force BLDC motor. On the other hand, when the generated back EMF is sinusoidal, it is called a sine wave back electromotive force BLDC motor. As the name implies, the trapezoidal motor provides trapezoidal power in a trapezoidal manner and the sine wave motor's back electromotive force is sinusoidal. In addition to counter-electromotive force, phase currents have trapezoidal and sinusoidal variations in each type of motor. Therefore, sinusoidal motors produce smoother output torque than trapezoidal motors. The rotor consists of permanent magnets. Based on the magnetic field density required in the rotor, a suitable magnetic material is selected for the rotor. Ferrite magnets are usually used to make permanent magnets. As technology advances, rare-earth alloy magnets become popular. Generally, surface mount rotor topologies are adopted for PMBLDC motors. The rectification of the BLDC motor is electronically controlled, unlike the brush type DC motor. To rotate the BLDC motor, the stator windings must be activated in the proper sequence with the aid of the rotor position signal. The rotor position is detected using the hall effect sensor built into the stator. Most BLDC motors have three Hall sensors built into the stator of the non-drive end of the motor. Each time the rotor stimulus passes near the hall sensor, the signal indicating that the N or S pole is passing near the sensor is high or low. The combination of these three Hall sensor signals determines the exact order of the rectification.

In this study, we will use a Hall position sensor to create a speed-closed-loop BLDC driver. We implement the BLDC motor (BG65Sx25, dunkermotoren Inc.) control system design using a stm32f4 microcontroller.

MATERIALS AND METHODS

stm32f407 microcontroller

The control program of stm32f MCU used here is software driven. Direct register access can make the source code smaller and more efficient than the software driven method. However, in order to use the register direct method, it is necessary to have deep knowledge about the interaction between the register and the bit field of the processor, and the operation order required for proper operation of the peripheral device. The software-driven method creates a program using functions or structure variables that are provided to the library to control peripheral devices. Using the supplied functions or structure variables, you can control the behavior of peripheral devices, so you can write the entire program without having to access the hardware directly. The software running method may be slower than the register direct access method, but it is implemented by a software driven method because the speed of the processor of the stm32f MCU is fast enough. The stm32f MCU is suited for digital signal controllers (DSCs) that require high computational performance and DSP instructions for demanding applications such as advanced motor control and medical devices through single-cycle DSP instructions. Currently, the system can be implemented with one stm32f MCU that includes this high-performance digital signal controller for MCU and DSP in one system.

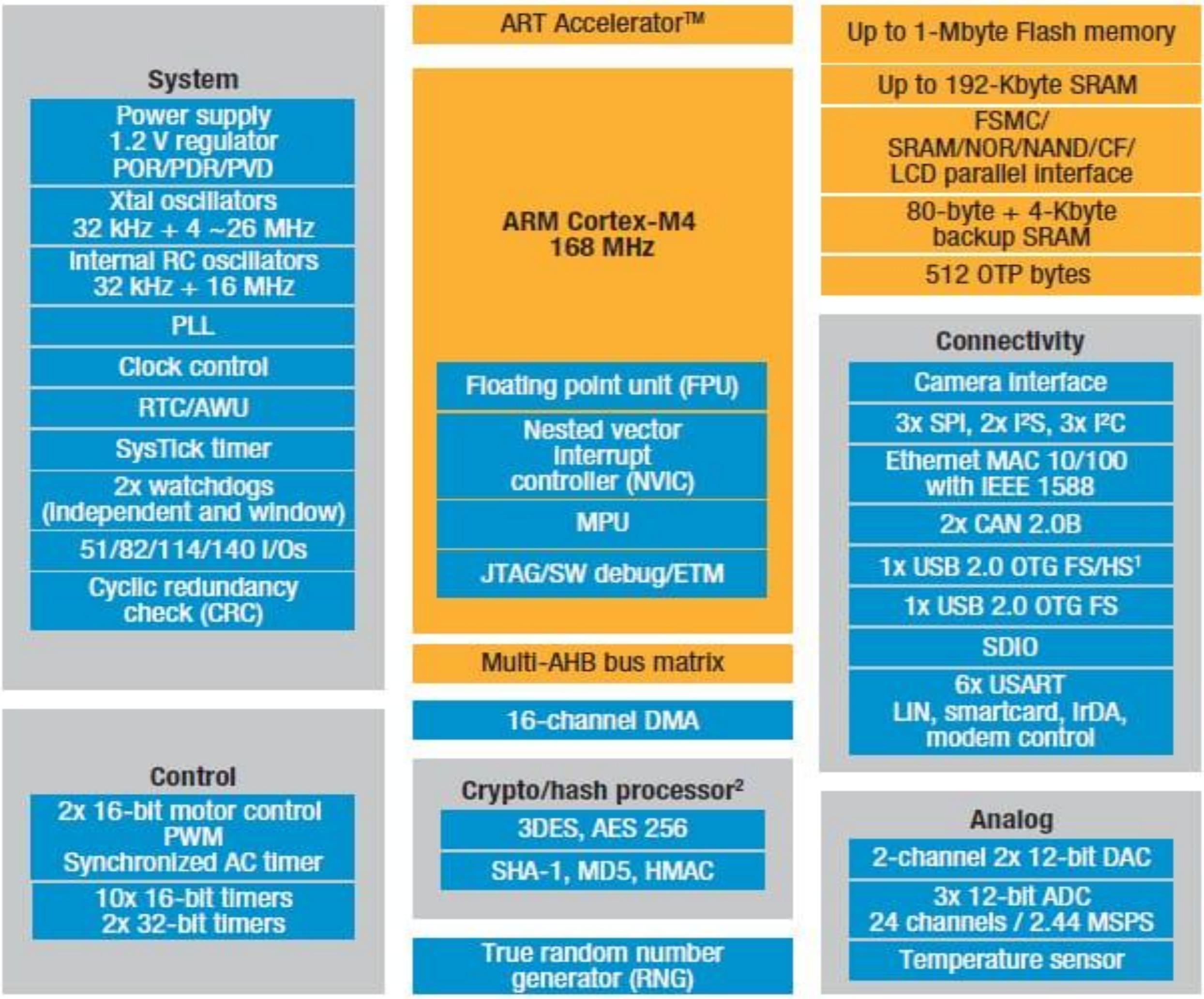

Figure 1. Stm32 f4 MCUs Block Diagram [1]

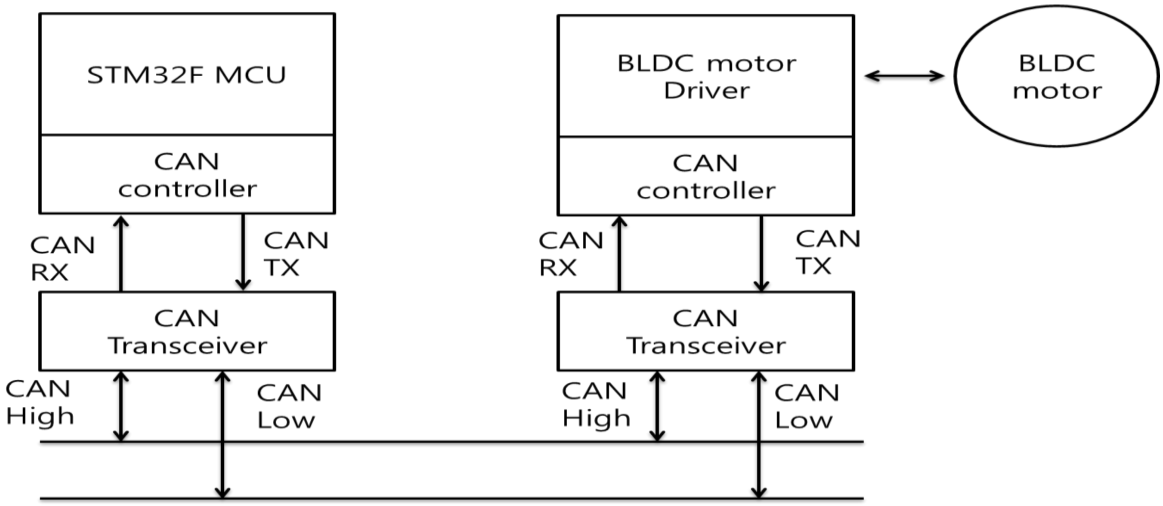

Figure 2. Circuit configuration of CAN communication

CAN communication

The data transmission and reception process is generally as follows. Note that the following procedure is performed by the mode MCU application.

- Static setting that will be used in the CAN communication such as transmission speed, time quantum configuration, etc. by setting the prescaler and bit segment of the CAN controller.

- Configure the filter that the CAN controller will receive.

- Input the valid data and the metadata of the data in the TX mailbox composed of 4 registers corresponding to the CAN data frame, and send to the CAN controller by writing 1 to the TXRQ (Transmit mailbox request) bit of the CAN_TI0R register.

- CAN controller -> the signal through the CAN transceiver is routed to the bus and to other nodes, and is filtered from the filter inside the CAN controller.

- The data frame passed through the filter is classified by the CAN controller into the same form as the TX mailbox, and is also arranged in the RX mailbox consisting of four registers.

The STM32F4 MCU contains an internal CAN controller, but the CAN transceiver must be configured separately. First, CAN communication is different from UART or SPI using Logic Low (0V) and Logic High (3.3V) signals. The CAN RX is not involved in the transmission at all, and uses the same 0V, 3.3V as the UART, SPI when the CAN controller sends the Logic Low signal and the Logic High signal to the CAN transceiver, but when the CAN transceiver sends data to the bus, The CAN low and CAN high signal lines are in the following states

The state in which the output voltage of CAN Low and CAN High are the same as the output voltage of CAN Low is called the logic state (Bus-on Logic High) because CAN TX is high, and the state where the output voltage of CAN Low and CAN High are changed because CAN TX is Low is called dominant state Logic Low on the bus.CAN Low and CAN High, which are changed by CAN TX, are sent back to CAN RX (RXD) from inside the CAN transceiver again, and the CAN controller monitors the status of the CAN bus[2].

Speed control

Rectification ensures proper rotor rotation of the BLDC motor, while motor speed depends only on the amplitude of the applied voltage. The amplitude of the applied voltage is adjusted using the PWM technique. The required speed is controlled by a speed controller implemented with a conventional proportional-integral (PI) controller. The difference between the actual speed and the required speed is input to the PI controller which, based on this difference, controls the duty cycle of the PWM pulse, which corresponds to the voltage amplitude required to maintain the desired speed. The speed controller calculates the PI algorithm given in the equation below: [3]

$$u(t) = K_c\left[e(t) + \frac{1}{T_I}\int_0^t e(\tau)d\tau\right]$$

$$u(k) = u_P(k) + u_I(k)$$

$$u_P(k) = K_c \cdot e(k)$$

$$u_I(k) = u_I(k-1) + K_c\frac{T}{T_I} \cdot e(k)$$

Where:

e(k) = Input error in step k

w(k) = Desired value in step k

m(k) = Measured value in step k

u(k) = Controller output in step k

$u_p(k)$ = Proportional output portion in step k

u_I (k) = Integral output portion in step k

u_I (k-1) = Integral output portion in step k-1

T_I = Integral time constant

T = Sampling time

Kc = Controller gain

User interface using ModBusRTU

The interface with PC is uart communication and the protocol is implemented with ModBus. In the MODBUS protocol, the frame format of the transmission message is as shown in the figure below. The query message and the response message are in the same format, but the data part is changed according to the function code.

Table 1. ModBusRTU frame

Address	Function	Data	CRC Check
8 bits	8 bits	N * 8 bits	16 bits

Control via HMI PC graphic user interface (GUI), status of application program variable real time and usage time. The GUI is designed to provide application debugging, diagnostic, and demonstration tools for algorithm and application development. PC runs via stm32f4 mcu uart via RS232 serial cable. This sends status information to the PC and processes the control information from the PC. The ON / OFF switch activates and deactivates the PWM phase. No voltage is applied to the motor windings when the switch is in the off position. When the ON / OFF switch is in the BLDC motor to control the Hall sensor and speed, the stm32f4 MCU can be used to control the motor speed from the On position with the Up and Down buttons.

RESULTS AND DISCUSSION

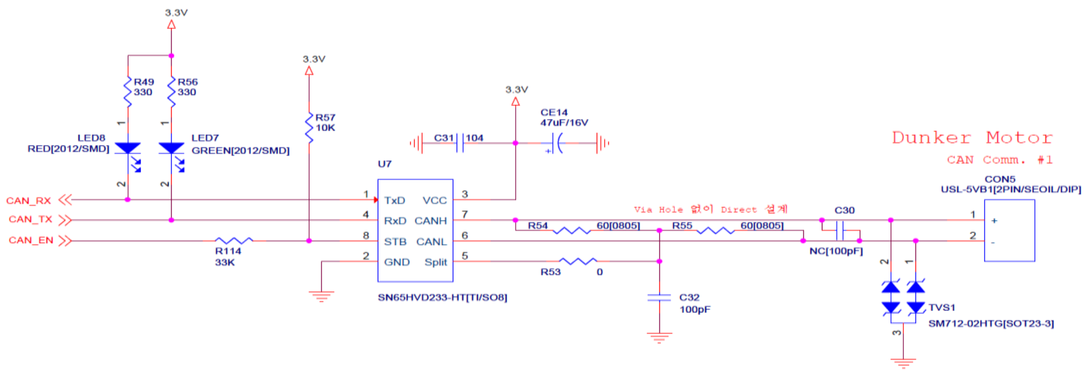

Figure 3. CAN transceiver circuit

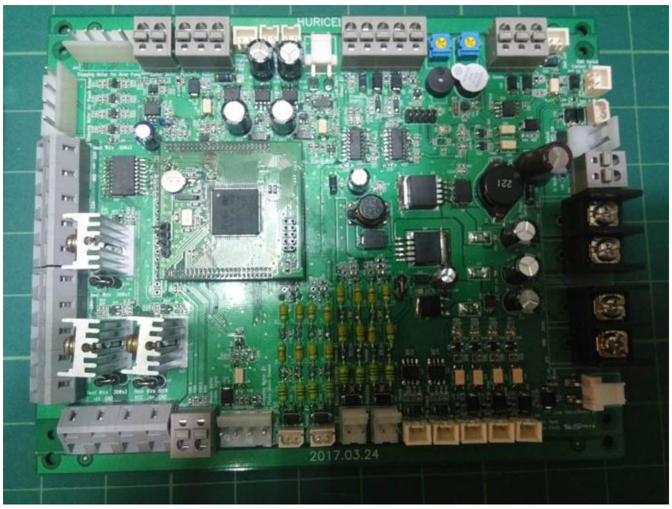

Figure 4. The entire system implemented

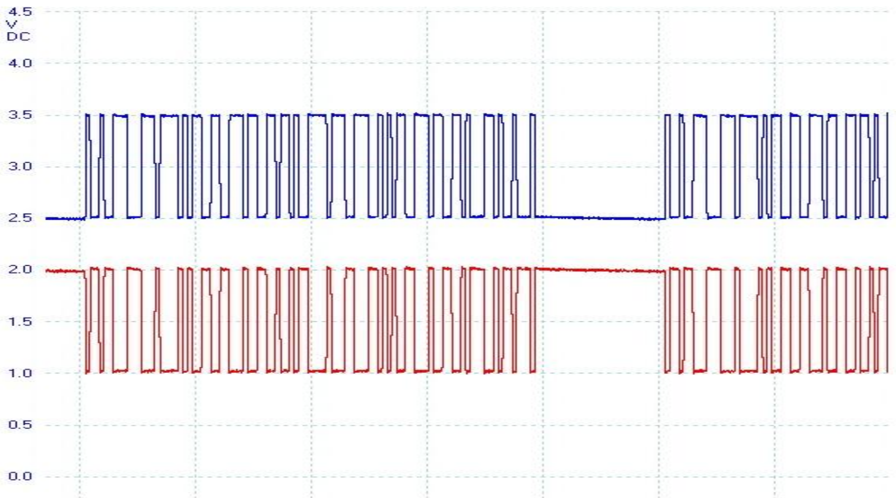

Figure 5. CAN-H and CAN-L waveforms

When you are transmitting something using the CAN bus, the same waveform is observed when you observe the signals of CAN TX and CAN RX with an oscilloscope. The dominant signal overrides the recursive signal. The output driver inside the CAN transceiver adjusts the gate of the transistor to which VCC and GND are connected when the CAN TX (TXD) signal is 1, so that both CANH and CANL signals are 2.5V and when the CAN TX (TXD) signal is 0 CANH allows 5V CANL to be 1.2V. The internal diode prevents the higher CANH and lower CANL voltages from the other nodes from affecting the output driver when the CAN TX (TXD) signal is 1, and the output driver of the node that outputs the resis- It will not affect the bus. However, since the input driver is connected directly to the CAN bus, if two or more nodes simultaneously output a recessive and a dominant, then the bus state will be dominant and all nodes on the bus will assume that the CAN bus is dominant .

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