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Z8 Encore! MC™

BLDC Motor Control Using the Z8FMC16100

Application Brief

AB000502-0710

Challenge

Create a low-cost controller that can provide both power control and battery charging for a typical BLDC motor used in personal motorized vehicles such as wheelchairs and electric bikes.

Solution

Use a Z8 Encore! MC™ FMC16100 microcontroller (MCU) and its built-in peripherals to reduce the number of components required for the design.

Result

A simple, easy-to-implement BLDC motor controller that radically reduces component count and manufacturing costs.

Features and Functions

We designed our BLDC personal motorized vehicle motor controller to provide the following features and functions:

- High starting torque.
- Use of IXYS compact and high efficient MOSFETs for the inverter power section.
- Use of regenerative braking to charge the battery.
- Hall sensor-based motor control.
- Reduced component count.

Simple Personal Motorized Vehicle Specification

A simple personal motorized vehicle built using this microcontroller must supply the following basic features:

- The vehicle must be fitted with a 200 W, 24 V; 300 W, 36 V; or 400-500 W, 48 V BLDC hub motor. For the purposes of our application, a 200 W, 36 V motor will support a payload of up to 220 lbs (100 kg).
- A potentiometer coupled to a throttle. The potentiometer output is the input used to control motor torque.

Hardware Circuit Details

We used the peripherals supported by the Z8FMC16100 MCU to implement the functions needed to control the BLDC motor. By using built-in peripherals, we were able to reduce the external components that would have otherwise been required. Vehicle manufacturing costs are therefore much lower.

A functional block diagram of the design is provided in Figure 1.

The Z8FMC16100 MCU PWM module is connected to the MOSFET driver through the gate driver circuitry. The PWM is switched according to the input from the throttle potentiometer connected to the throttle mechanism. We use the variation in the PWM duty cycle to control the motor speed.

Because speed is maintained by the throttle position and adjusted by the vehicle user, there was no need to include speed feedback. Our design is much simpler as a result.

We also implemented current and voltage monitoring to sense motor overload or phase breakdown. Operating temperature of the PWM driving module is also monitored.

When the vehicle travels downhill, the motor runs faster than the MOSFET driver switching speed. The motor then acts as a generator. We take the opportunity in such situations to charge the battery.

Note: Motor inductance is used to boost the voltage generated by the regenerative action of the motor. The voltage generated by the motor during free run is lower than the battery voltage until the motor speed drops below rated speed.

The motor usually runs at very low RPMs when the vehicle rider is pedaling (in an electric bike application), traveling downhill, or going down a ramp. The voltage thus generated by the motor could not be used to charge the battery. The MOSFET used to drive the motor can be used in conjunction with the motor winding inductance to boost the voltage generated by the motor and thereby charge the battery.

The duty cycle used to drive the MOSFET during boost conversion of the voltage is dependent on the difference between the throttle input and motor speed. The time period is dependent on the motor speed.

Functional Block Diagram

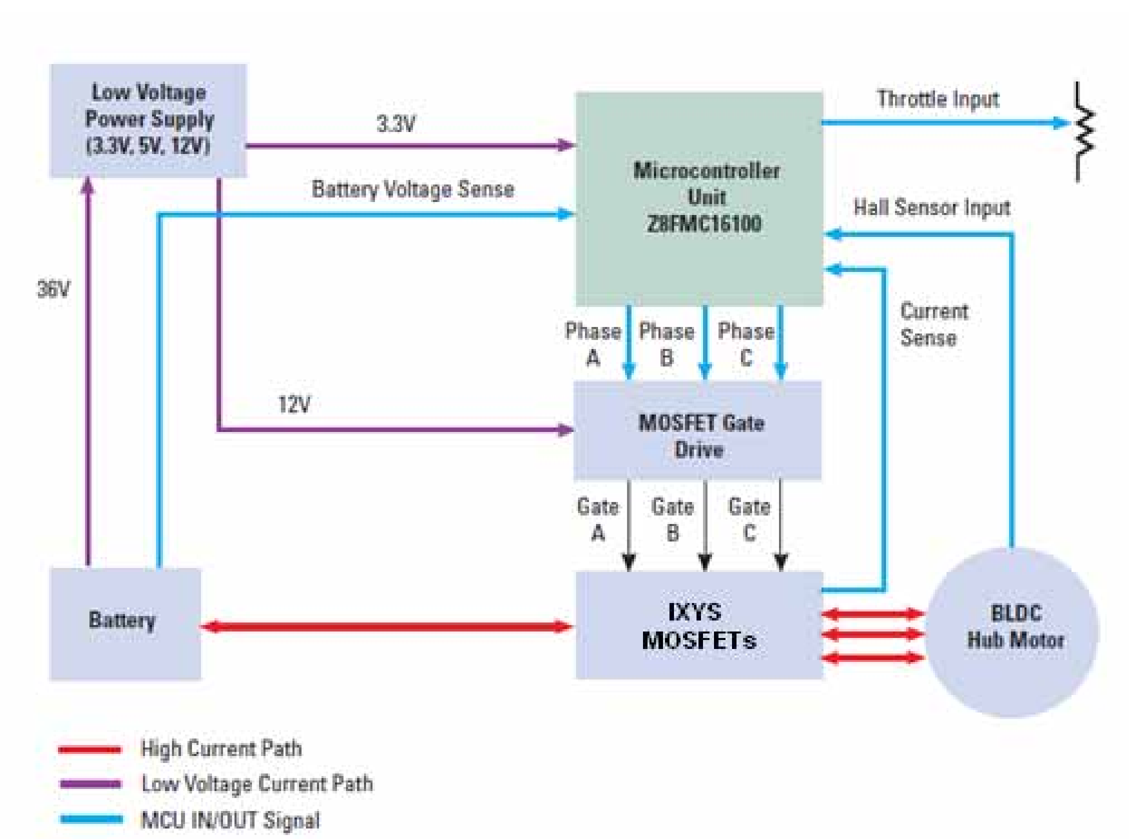

Figure 1. Functional Block Diagram for BLDC Personal Motorized Vehicle Motor Control

Software Features

The software designed for our personal motorized vehicle motor controller provides the following functions:

- Run the BLDC motor in the forward direction at a torque proportional to the throttle input.
- Generate high starting torque to drive the BLDC motor when the vehicle is at a standstill.
- Monitor the motor current, voltage, and temperature for abnormal conditions.
- Brake/run the motor as generator when riding downhill.
- Charge the battery when motor is run as generator.
- We also included the option to pass motor measurements to another microcontroller that could be used to create a status display for the vehicle rider.

Summary

The Z8FMC16100 MCU features an on-chip PWM hardware that we used to effectively drive the BLDC motor. Using the Z8 Encore! MC MCU allows us to simplify the design and greatly reduce the cost of the application by minimizing the external component count.

Applications and Support Tools

The Z8 Encore! MC Flash microcontrollers are supported by the Opto-Isolated USB Smart Cable.

The microcontroller is also supported by the ZDS II Z8 Encore! MC integrated development environment (IDE) with ANSI C-Compiler, available on www.zilog.com.

Related Products

More information about the Z8 Encore! MC FMC16100 MCU described in this application brief is available in the following documents:

- *Z8FMC16100 Series Flash Motor Control MCU Product Brief*, PB0166
- *Z8 Encore! Motor Control Flash MCUs Z8FMC16100 Series Product Specification*, PS0246
- *eZ8 CPU User Manual*, UM0128

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