BLDC / PMSM motor control reference design

S12ZVM-EFP Electronical Fuel Pump Reference Design

Most of automotive Electrical Fuel Pumps (EFP) are based on a DC motor, but BLDC based EFPs are becoming more and more popular, especially in high-end brand cars, both diesel and gasoline pump. The S12ZVM-EFP RD was developed to meet this growing market.

THE REFERENCE DESIGN FEATURES

This Reference Design (RD) is based on NXP's S12ZVML128 high-performance and integrated automotive-grade MCU which integrates a 100 MHz S12Z core, gate driver unit, power regulators and LIN PHY; the S12ZVM-EFP RD provides the following features:

- Supports 12 V power supply system with up to 250 W automotive BLDC/PMSM motor control system
- Supports BLDC/PMSM sensorless FOC control, both dual shunt and single shunt
- Robust and fast start up, meet the strict start up condition < 150 ms from standstill to the rated speed
- Crossing current I/F start up and initial position detection algorithm to make sure successful startup
- Fuel pump system passed the supply voltage changing, load changing, speed command jumping and temperature rising test
- Supports multiple diagnose and protection covering UV, OV, OT, OC, Short, Stall Detection, etc.
- Not only supports fuel pumps, but is suitable for other automotive BLDC/PMSM applications

Figure 1. S12ZVM-EFP RDB

HARDWARE SYSTEM FUNCTIONALITY

This RD is designed to deliver a total solution for BLDC or PMSM fuel pump application in a 12 V automotive system.

To achieve the function features, the 8-16 V VBAT input is first connected to an anti-reverse protection circuit and gets output of VIN. VIN is then connected to the 3-phase inverter bridge and charge pump circuit. The charge pump circuit can pump the input voltage to a higher voltage and make sure the reverse circuit can work correctly. VIN also connects to the boost circuit and then to the VSUP PIN of S12ZVML128. If the boost circuit is enabled, the input voltage can be down to 3.5 V. There are 3 shunts in the 3-phase inverter circuit: 2 shunts are in the phase A and phase C leg, and 1 shunt is in the minus bus to GND. There are 2 jumper settings for single-shunt and dual-shunt switch; the default setting is dual shunt.

The Reference Design Board (RDB) has hall/encoder interface for position sensor support. For debug purposes, not only BDM and FreeMASTER TTL (SCI) are placed, but also the PTU monitor (PTU0/1/RE) is placed. Some other PINs, like Port AD and T, and one SPI which would be used are there for reference.

The main devices used in the RDB are:

- **S12ZVML128:** Highly integrated automotive-grade 16-bit MCU using NVM+UHV technology. The chip integrated S12Z core-based MCU, and 40 V analog components (VREG, GDU, LIN PHY), which makes it suitable for single-chip BLDC or PMSM control. Memory including 128 K Flash, 8 K RAM, 512 B EEPROM all with ECC. The operating junction temperature can be up to 175 °C.
- **BUK7J1R4-40H:** N-channel FET with LFPAK56 (Power-SO8) package.

SOFTWARE ARCHITECTURE OVERVIEW

The motor control software package is developed on NXP's **S12ZVM FOC example project** and **AMMCLIB 1.1.20**. The software architecture is shown in figure 3. The lowest is S12ZVM-EFP hardware, and then is the LLD and middleware, which includes the key motor control peripheral driver, like CPMU, ADC, GDU, PMF and PTU. The highest layer, the application software, includes user APP, communication stack (LIN and PWM) and motor control. Customers can add their code in the user app to drive the fuel pump or other BLDC/PMSM by using motor control API.

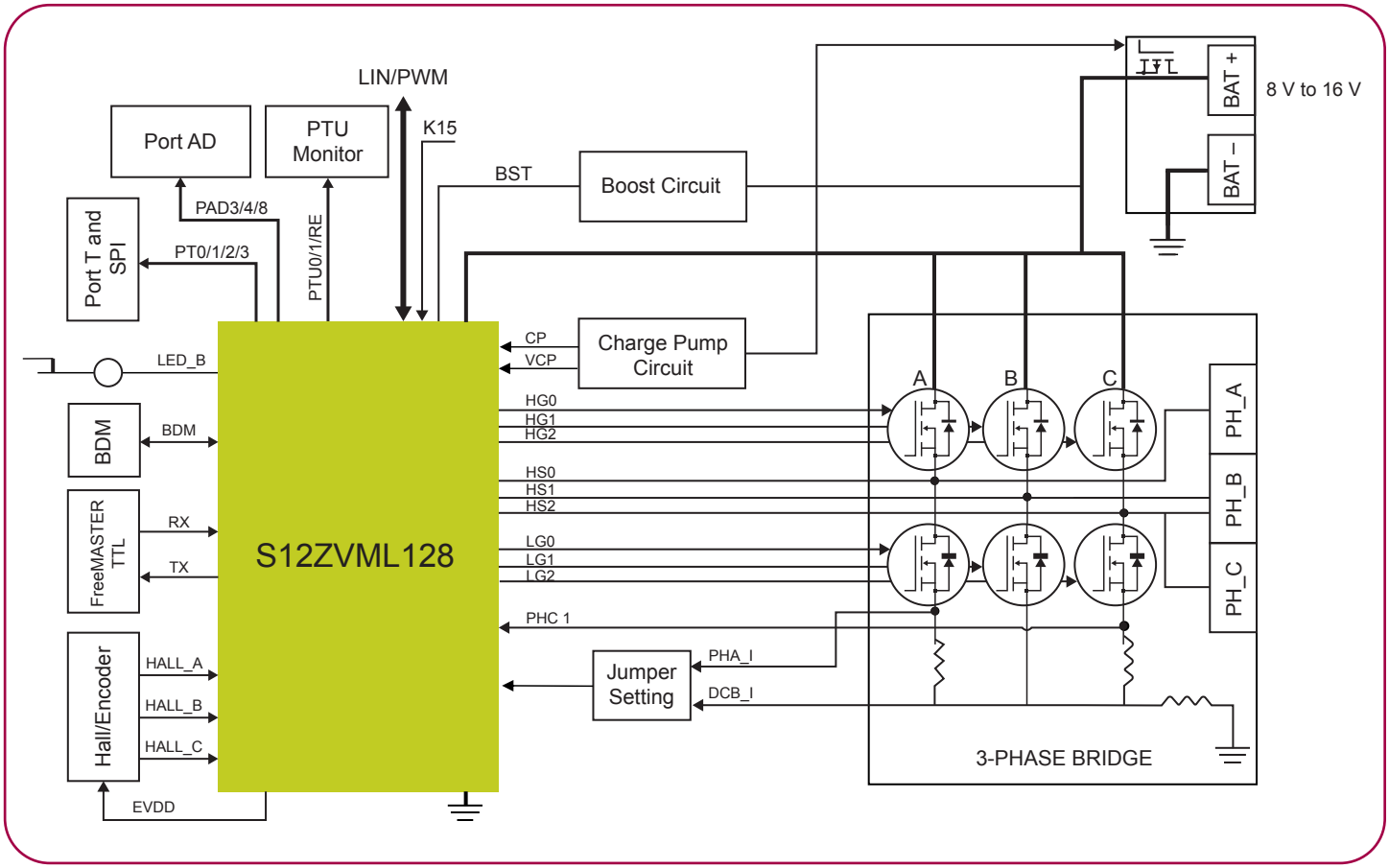

Figure 2. The RD hardware system block diagram

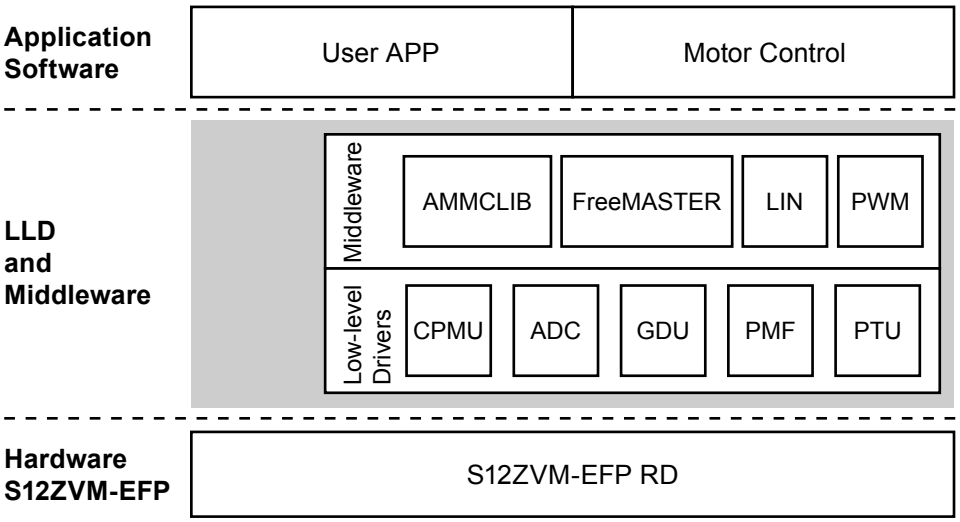

Figure 3. The RD software block diagram

The software package of the S12VM-EFP RD is available to help users evaluate the S12ZVM-based BLDC fuel pump and other BLDC/PMSM control performance out-of-box and build their own BLDC fuel pump and other BLDC/PMSM control product prototype as an integrated motor control platform.

The software package has the following features:

- Offers out-of-box motor control and tuning via FreeMASTER MCAT
- Implements advanced motor control algorithm—current crossing I/F start-up and initial position detection algorithm to make sure the every robust start-up
- Supports sensorless FOC and fuel pump motor parameters optimization to achieve the fast start-up
- Supports dual-shunt and single-shunt current sampling
- Supports rich motor control diagnosis and protection: OV, UV, OC, OT, etc.
- Integrates API of LIN and PWM communication for motor control

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