TI Designs

Automotive High Current Brushless DC Motor Drive

TEXAS INSTRUMENTS

System Description

This design implements a complete control and drive solution for 3-phase brushless DC motors up to about 3 kW in power rating. The design includes analog circuits, digital processor, and software to spin BLDC motors without the need for position feedback from Hall effect sensors or quadrature encoder. Operation is demonstrated with a 1 kW motor operating from a 12V supply, similar to many automotive applications. Test data shows the type of results which are easily measured at the board test points. References for the software and user documentation are provided to speed development time for similar BLDC motor applications.

Featured Applications

- AC Compressors
- BLDC Turbo

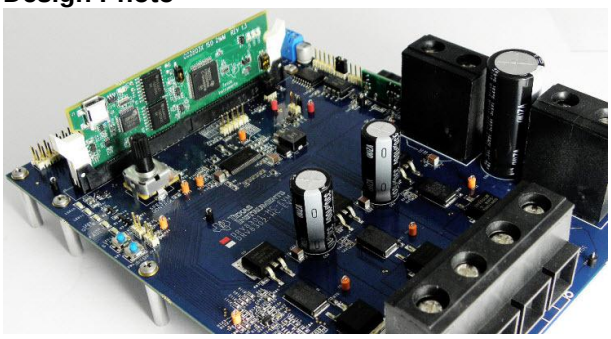
Design Resources

- Block Diagram and Schematic
- Test Data
- Gerber Files
- Design Files
- Bill of Materials
- User's Guide

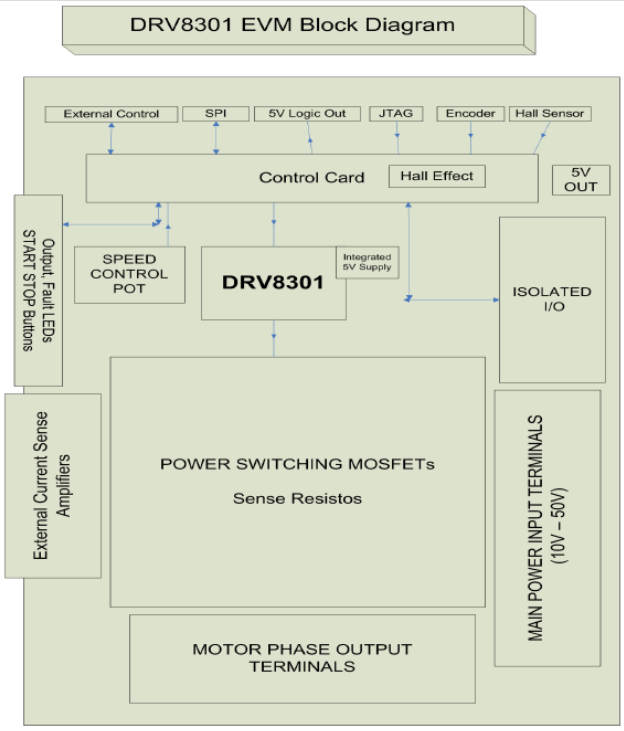
Design Features

- DRV8301 2.3A sink/ 1.7A source, three phase inverter with integrated buck converter for 1.5A external loads
- C2000 Piccolo F28035 MCU controlCARD- pre-flashed with code to spin motors using GUI
- Supports 60V and 82.5A full-scale range
- CCStudio v4.x Integrated Development Environment

Design Photo



Block Diagram



Jump start system design and speed time to market

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Associated Part Numbers

Part Number	Part Description	EVM Link
DRV8301-Q1	Automotive 3-Phase BLDC Pre-Driver w/ Dual Current Sense Amp and Buck Converter	EVM
TMS320F28035	Piccolo Microcontroller	EVM
OPA365-Q1	Automotive 2.2V, 50MHz, Low-Noise, Single-Supply Rail-to-Rail Operational Amplifier	
ISO7241C-Q1	Automotive Quad Channel, 3/1, 25Mbps, Digital Isolator	
SN74LVC2G17-Q1	Automotive Dual Schmitt-Trigger Buffer	

Design Considerations and Test Data:

1) **Current Sense Amplifiers:** The DRV8301 integrates two channels of differential amplifiers internally, allowing direct current measurement of two phase currents, and calculation of the third phase current.
   - **a)** Differential gain of the internal amplifiers can be selected as depending on the gain which best matches the motor current specifications (10, 20, 40, and 80 V/V).
   - **b)** **Direct Current Meausrement of All Three Phases:** Design includes three external op amps in differential amplifier configuration.
     - **i)** The op amp shave rail-to-rail operation allowing full use of the TMS320F28035 ADC range
     - **ii)** Gain bandwidth= 8MHz, adequate for siganl frequencies to 400kHz with a differential gail of 20
2) **Battery Power (PVDD) to 5V Buck:** The DRV8301 integrates a buck converter power supply controller which regulates a 5V (DC) supply using external components (inductors and diodes) along with capacitors and resistors.
   - **a)** The inductor and diodes are selected to provide a regulated 5V output, with a switching frequency (set by the resistor R1) of about 580 kHz
3) **Isolated Interface for CAN and SPI:** In order to isolate the communications interface from the potentailly high voltages on the motor drive, galvanic isolation is provided by U2, U4, and U5.
   - **a)** **ISO1050:** isolated CAN transceiver complies to the high-speed CAN standard
     - **i)** Provides isolation up to 5000 Vrms
4) **Three-Phase High-Side and Low-Side Drive Transistors (Q4-Q9):** These transistors must have low on resistance in order to maintain high effciency while switching high currents to the motor phases.
   - **a)** **SUM110N06 (n-Channel MOSFET):** rated for drain-to-source voltages up to 60V, and temperatures up to 175 C

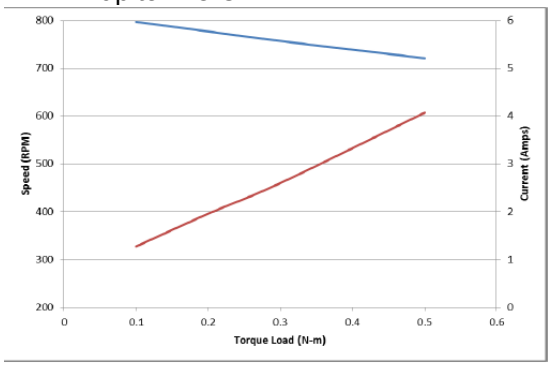

Figure 16 Motor speed (blue) and supply current (red) versus dynamometer load

Torque and speed versus time (constant Duty Cycle setting in InstaSPIN-BLDC GUI control panel)

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