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

Jump start system design and speed time to market
Comprehensive designs include schematics or block diagrams, BOMs, design files and test reports by experts with deep system and product knowledge. Designs span TI’s portfolio of analog, embedded processor and connectivity products and supports a board range of applications including industrial, automotive, medical, consumer, and more. To explore the designs, go to http://www.ti.com/tidesigns
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**TI Designs**

**Automotive High Current Brushless DC Motor Drive**

**Associated Part Numbers**

<table>
<thead>
<tr>
<th>Part Number</th>
<th>Part Description</th>
<th>EVM Link</th>
</tr>
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<tbody>
<tr>
<td>DRV8301-Q1</td>
<td>Automotive 3-Phase BLDC Pre-Driver w/ Dual Current Sense Amp and Buck Converter</td>
<td>EVM</td>
</tr>
<tr>
<td>TMS320F28035</td>
<td>Piccolo Microcontroller</td>
<td>EVM</td>
</tr>
<tr>
<td>OPA365-Q1</td>
<td>Automotive 2.2V, 50MHz, Low-Noise, Single-Supply Rail-to-Rail Operational Amplifier</td>
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<tr>
<td>ISO7241C-Q1</td>
<td>Automotive Quad Channel, 3/1, 25Mbps, Digital Isolator</td>
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<tr>
<td>SN74LVC2G17-Q1</td>
<td>Automotive Dual Schmitt-Trigger Buffer</td>
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**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 Measurement of All Three Phases:** Design includes three external op amps in differential amplifier configuration.
      i) The op amp shaves rail-to-rail operation allowing full use of the TMS320F28035 ADC range
      ii) Gain bandwidth= 8MHz, adequate for signal frequencies to 400kHz with a differential gain 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 potentially 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 efficiency 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

![Torque and speed versus time (constant Duty Cycle setting in InstaSPIN-BLDC GUI control panel)](image-url)
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