TI Designs

Reference Design for Automotive HVAC Multiple-Flap Actuator and Damper Motor Drivers

Description

The TIDA-01357 TI Design offers a solution for DC motors by using the DRV8802-Q1 device to control automotive HVAC flap actuators or dampers. This design demonstrates a cost-effective motor driver solution for six flap actuator where all six motors can be driven simultaneously with an output current up to 0.4 A per motor. This reference design maintains a small solution size and low quiescent current in addition to offering reverse battery and load dump protection, all of which are highlighted in this guide.

Resources

TIDA-01357	Design Folder
DRV8802-Q1	Product Folder

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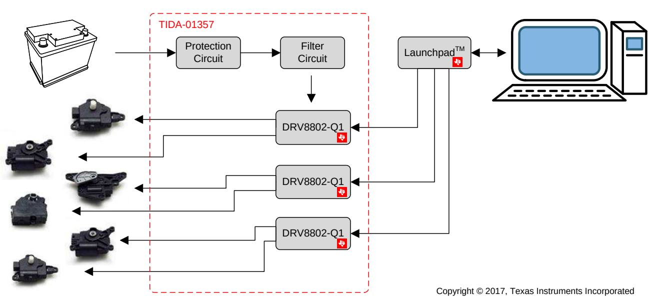
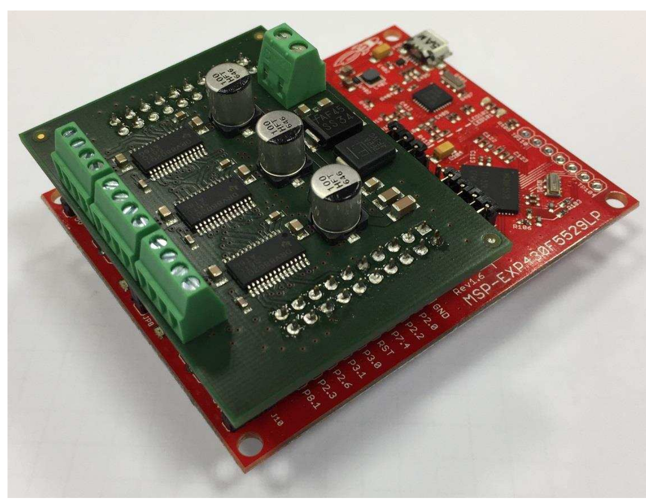
Features

- Survives Voltages up to 45 V
- Withstands Reverse Battery Conditions and Load Dump Conditions (12-V System)
- Three-Chip Solution to Drive up to Six Motors Simultaneously (Two DC Motors per IC)
- Compact Layout; Does Not Require External FETs
- Low Quiescent Current
- Components Selected for Automotive Temperature and Quality

Applications

- Automotive HVAC Flap Actuator and Damper Motor Drive
- Automotive HVAC Intake Air-Flap Motor Drive





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1 System Overview

1.1 System Description

Current automotive heating, ventilation, and air conditioning (HVAC) flap actuators are driven ether using brushed-DC motors or stepper motors. This TI Design offers a solution for DC-motor-based flap actuators. The end goal is to develop a cost-effective motor driver solution for six-flap actuators that can be driven simultaneously. This design includes protection features against load dump conditions and reverse battery conditions and maintains a small solution size and low quiescent current at the same time.

The TIDA-01357 has been designed with a focus on the following points:

- Simultaneously driving six brushed-DC motors for a flap actuator
- Capability to survive reverse battery and load dump conditions (12-V system)
- Low quiescent current
- Compact design and high performance
- Use of a diagnostics feature (output short detect)

1.2 Key System Specifications

Table 1. Electrical Characteristics

PARAMETER		COMMENTS	MIN	TYP	MAX	UNIT
SYSTEM INPUT AND OUTPUT						
V_{IN}	Operating-input voltage	Battery voltage range	9	13.5	25	V
V_{IN_MAX}	Maximum-input voltage	Maximum-battery voltage on module without device damage	—	—	45	V
V_{REV}	Reverse voltage	Reverse-polarity protection	–90	—	—	V
I_{IN_MAX}	Maximum-input current	All outputs at full load (400 mA)	—	2.4	—	A
I_{OUT_MAX}	Maximum-output current	Maximum-output current per H-bridge	—	0.4	—	A
V_{TR}	Transient immunity	Load dump (ISO 7637-2)	—	—	—	V
$OUTPUT_{short\ detect}$		H-Bridge (DRV8802-Q1) output short detection	—	Yes	—	
$R_{Current\_Sense}$	Current sense resistance	External low-side current sense resistance, (attached to DRV8802-Q1 ISENSx pin)	—	0.3	—	Ω
LOGIC LEVEL INPUTS (DRV8802-Q1)						
V_{IL}	Input low voltage		—	—	0.7	V
V_{IH}	Input high voltage		2.1	—	—	V
V_{hys}	Input hysteresis		—	0.45	—	V
I_{IL}	Input low current	V_I= 0 V	–20	—	20	µA
I_{IH}	Input high current	V_I= 3.3 V	—	—	100	µA
V3P3OUT REGULATOR						
$V_{(V3P3OUT)}$	V3P3OUT voltage	Voltage regulator with 3.3-V output supplies in this design logic pins AVREF, BVREF, AI1, BI1, and FAULT	3.1	3.3	3.5	V
DECAY INPUTS (DRV8802-Q1)						
V_{IL}	Input-low threshold voltage	For slow decay mode (used in this design)	0	—	0.8	V
V_{IH}	Input-high threshold voltage	For fast decay mode	2	—	—	V
I_I	Input current		—	—	±40	µA

Table 1. Electrical Characteristics (continued)

PARAMETER		COMMENTS	MIN	TYP	MAX	UNIT
H-BRIDGE FETS (DRV8802-Q1)						
$r_{DS(on)}$	HS FET on resistance	V_M = 24 V, I_O = 1 A, T_J = 25°C	—	0.63	—	Ω
		V_M = 24 V, I_O = 1 A, T_J = 85°C	—	0.76	0.9	
		V_M = 24 V, I_O = 1 A, T_J = 125°C	—	0.85	1	
$r_{DS(on)}$	LS FET on resistance	V_M = 24 V, I_O = 1 A, T_J = 25°C	—	0.65	—	Ω
		V_M = 24 V, I_O = 1 A, T_J = 85°C	—	0.78	0.9	
		V_M = 24 V, I_O = 1 A, T_J = 125°C	—	0.85	1	
$I_{lkg(OFF)}$	Off-state leakage current		–20	—	20	µA
PROTECTION CIRCUITS (DRV8802-Q1)						
$I_{(OCP)}$	Overcurrent protection trip level		1.8	—	5	A
$T_{(SD)}$	Thermal shutdown temperature	Die temperature	150	160	180	°C
THERMAL						
T_A	Temperature range	Operating and ambient temperature	–40	—	105	°C
BASEBOARD						
Number of layers	Four layers					
Form factor	58.42 mm x 43.43 mm					

1.3 Block Diagram

Figure 1 shows the block diagram of this TI Design, which comprises four main modules:

- Protection circuit
- Filter circuit
- TI motor driver chip x3
- TI LaunchPad™ Development Kit control

NOTE: The LaunchPad simultaneously acts as a bridge between this TI Design and a computer to monitor diagnostic features and control the connected brushed-DC (BDC) motors.

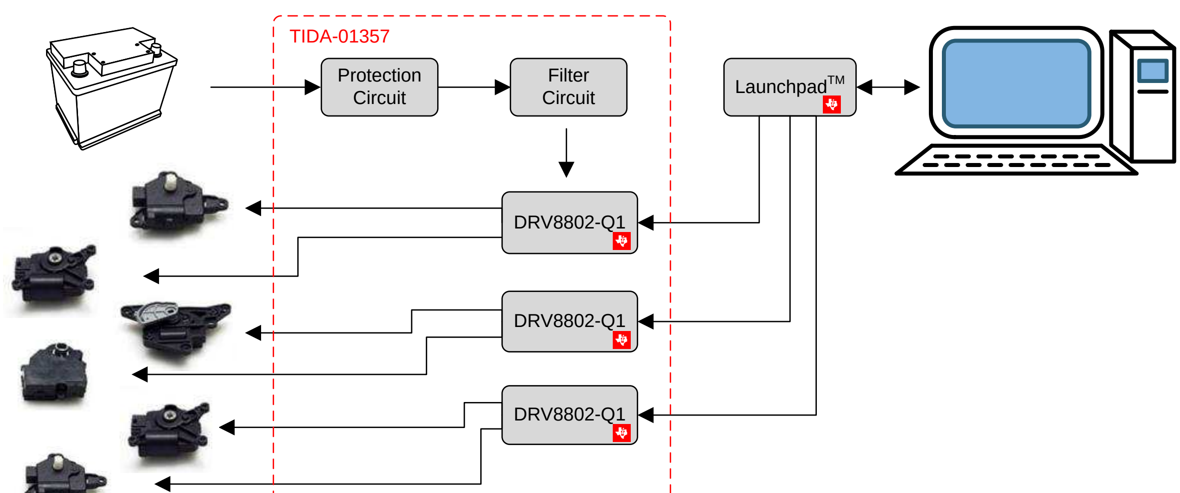

Figure 1. TIDA-01357 Block Diagram

1.4 Highlighted Products

1.4.1 DRV8802-Q1

The DRV8802-Q1 is an integrated motor driver solution for automotive applications. The device has two integrated H-bridge drivers, which do not require external field-effect transmitters (FETs), and is intended to drive DC motors. The H-bridges consist of N-channel power MOSFETs and each of them is capable of delivering a supply current up to a 1.6-A peak or 1.1 A_{RMS} on the output (with proper heatsinking at 24 V and 25°C). The DRV8802-Q1 has a programmable decay mode which allows breaking or coasting of the motor when disabled. The device is fully protected against undervoltage, overcurrent, and overtemperature events and also provides a diagnostic feature, which indicates overcurrent and overtemperature events on the FAULT pin. If at any time the supply voltage on the input pins (VMx) falls below the undervoltage lockout (UVLO) threshold, all circuitry in the DRV8802-Q1 become disabled and are kept at this condition until the supply voltage rises again above the UVLO threshold. Figure 2 shows the functional block diagram of the DRV8802-Q1, which consists of logic control, Internal reference and regulator part, two motor driver (A and B) units, and a charge pump to control the high-side N-MOSFETs in the H-bridge of each motor driver unit.

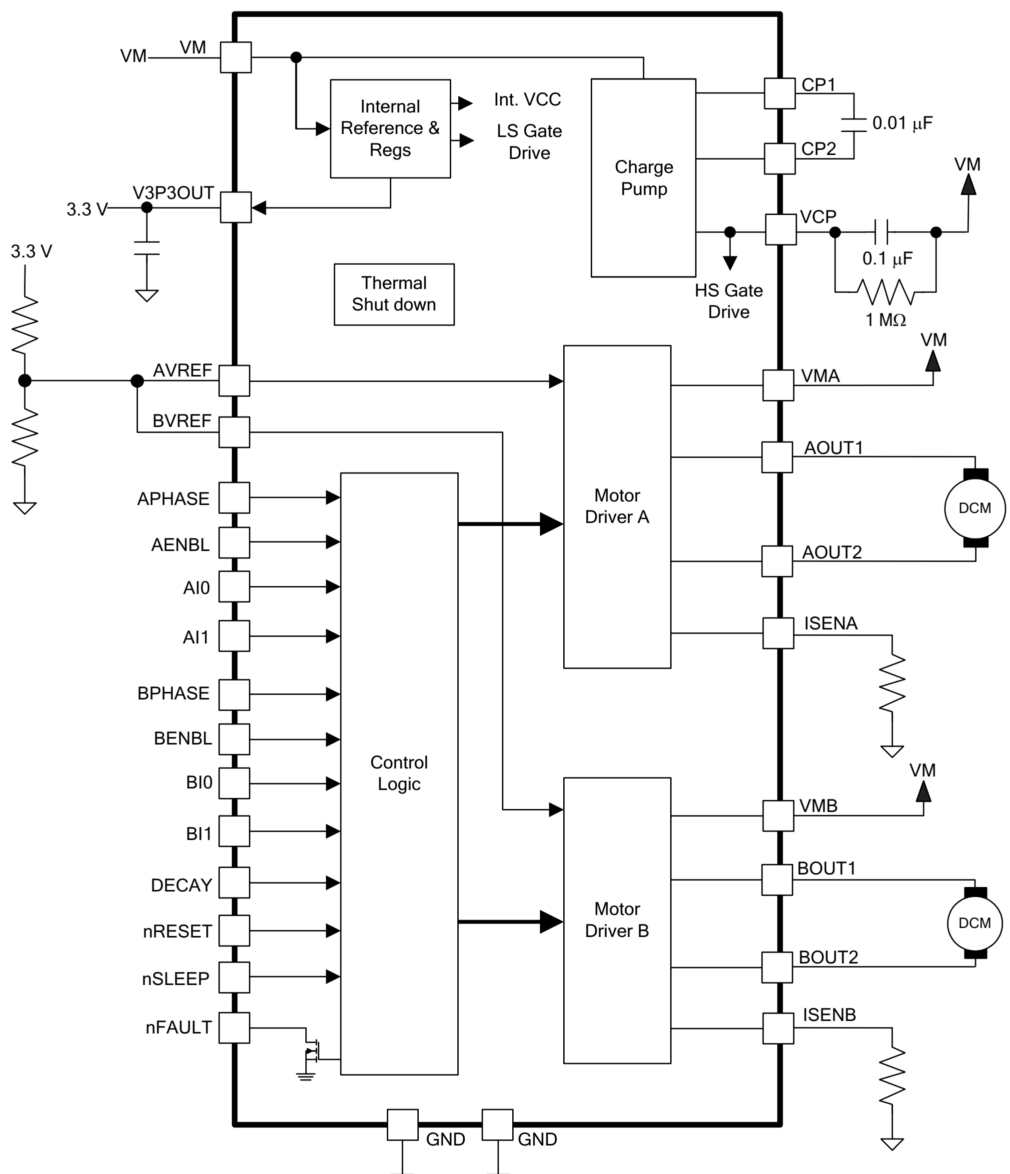

Figure 2. DRV8802-Q1 Functional Block Diagram

2 System Design Theory

The specific and primary goal of this TI Design with regards to the printed-circuit board (PCB) is to make a compact solution while still providing a way to test the performance of the board. The motor driver PCB is realized as an extension board to TI's LaunchPad™ Development Kit (MSP-EXP430F5529LP), which acts as a bridge between a computer and motor driver board. The LaunchPad controls all the DRV8802-Q1s populated on the PCB and monitors the fault condition, which occurs in the case of undervoltage, overcurrent, and overtemperature events. Figure 3 highlights the key components on the TIDA-01357 design.

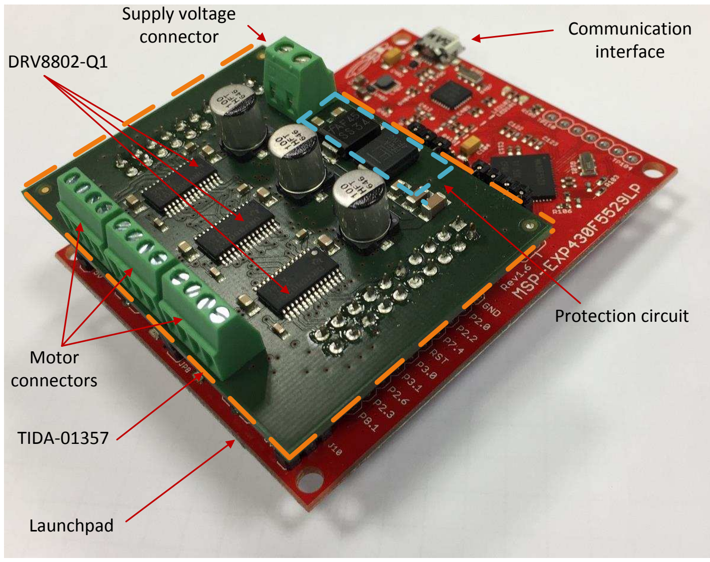

Figure 3. LaunchPad™ Development Kit With TIDA-01357

2.1 Circuit Diagram

The circuit diagram of TIDA-01357 consists of two main modules: a protection circuit and a power part, which are responsible for driving six BDC motors. Figure 4 shows a schematic of the protection circuit.

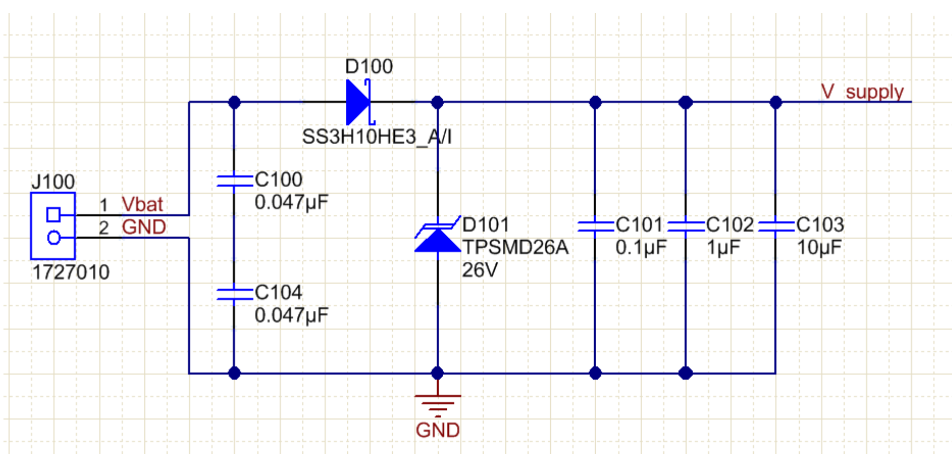

Figure 4. Protection Circuit

The protection circuit in Figure 4 consists of an electrostatic-discharge (ESD) protective part, reverse battery protection diode, transient voltage suppressor diode, and three ceramic capacitors for better noise (ripple) filtering.

Two in-series capacitors with high-voltage rating values (100 V) are used for ESD protection. These capacitors are populated on the PCB in an L-shape (90° rotated from each other), which is a common technique in automotive applications. This way of arranging the ESD capacitors can prevent short circuit. When PCB bending occurs due to vibrations, the ceramic capacitor is subject to mechanical damage and inner layers of the capacitor are at the risk of being shorted.

A transient-voltage-suppression (TVS) diode protects the circuit against load dump transient, which occurs in the event of disconnecting a discharged battery while the alternator is generating charging current to other loads which remain on the alternator circuit. Another important requirement for a TVS diode is the 24-V jump start (for 12-V systems). In this design, the TVS has been chosen in such a way that the standoff voltage value of the diode is above the voltage level, which could occur at jump start event. In other words, below this voltage level, which is called reverse standoff voltage, the TVS diode is transparent for the rest of the circuit.

Figure 5 shows the wiring of the motor driver chip, where the internal 3.3-V regulator is used to configure the logic pins for output current limit and decay mode. Output current is limited to 0.4 A on the output pins. A 0.3-Ω external low-side resistance is used for the monitoring of the motor current. The chip is configured for slow decay mode.

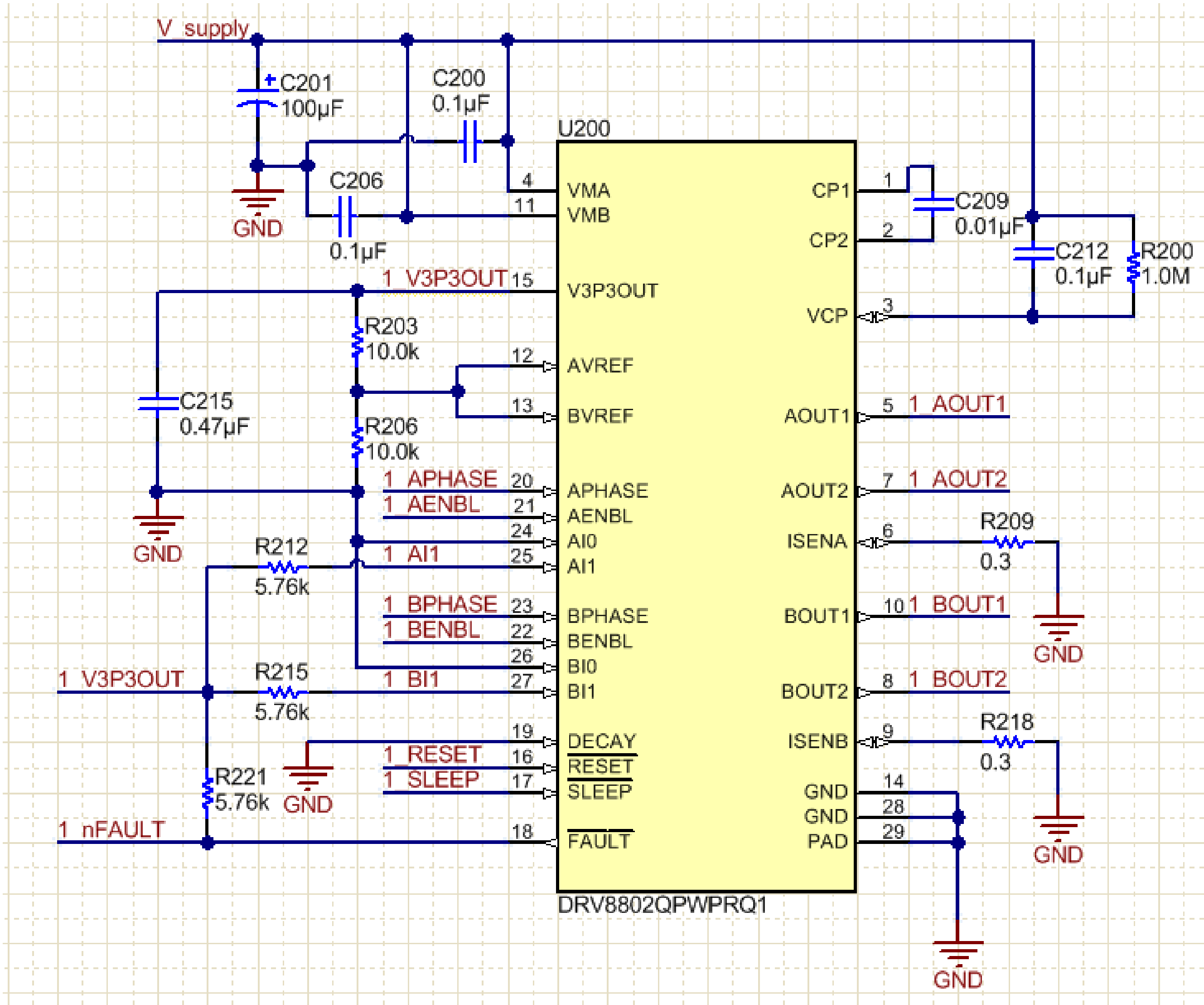

Figure 5. DRV8802-Q1 Wiring

C201 in Figure 5 represents the bulk capacitor sizing, which is an important factor. Correct sizing of the bulk capacitor is required to meet acceptable voltage ripple levels on the supply line. The process of this sizing depends on a variety of factors including the:

- Type of power supply
- Acceptable supply voltage ripple
- Parasitic inductance in the power supply wiring
- Type of motor (BDC, BLDC, stepper)
- Motor startup current
- Motor braking method

This design provides a recommended value for sizing the bulk capacitor; however, for applications that can slightly differ from this design, a system-level testing is required to determine the appropriate sized bulk capacitor.

2.2 Current Regulation

The current through the motor windings is regulated by a fixed-frequency PWM current regulation, or current chopping. When an H-bridge is enabled, current rises through the winding at a rate dependent on the DC voltage and inductance of the winding. When the current hits the current chopping threshold, the bridge disables the current until the beginning of the next PWM cycle. Figure 6 shows a diagram of the motor control circuitry.

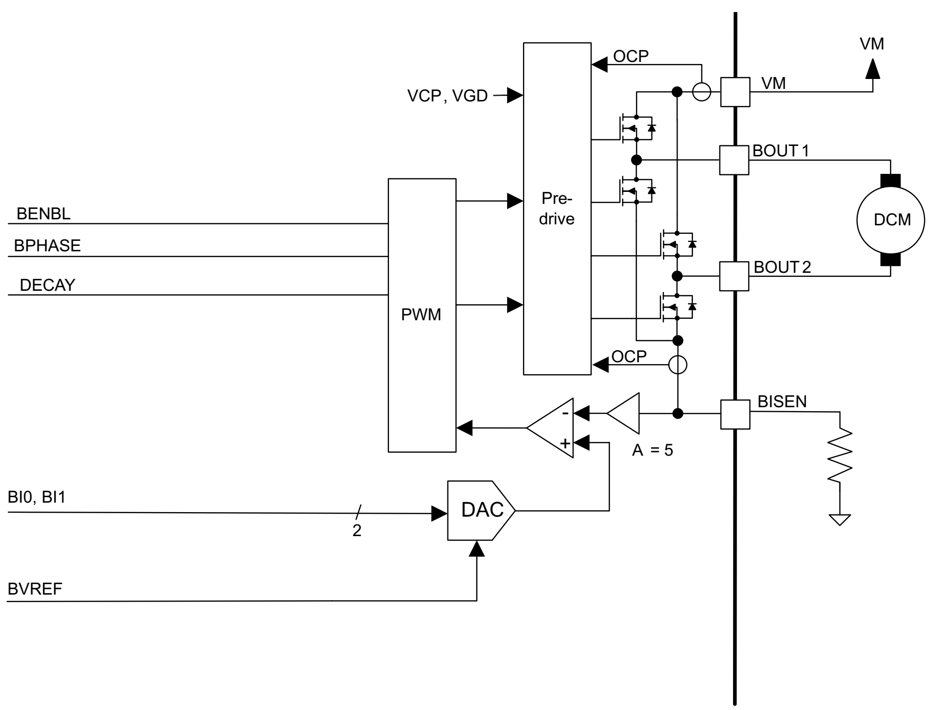

Figure 6. Motor Control Circuitry

The PWM chopping current is set by a comparator which compares the voltage across a current sense resistor connected to the xISEN pins, multiplied by a factor of 5, with a reference voltage. The reference voltage is input from the xVREF pins and is scaled by a two-bit digital-to-analog converter (DAC) which allows current settings of 38%, 71%, and 100% of full-scale plus zero.

The following Equation 1 shows the calculated value of the chopping current, which is chosen for each motor driver chip in this design.

$$I_{(CHOP)} = \frac{V_{(xVREF)}}{5 \times R_{(ISENx)}}$$

$$I_{(CHOP)} = \frac{1.65\ V}{5 \times 0.3\ \Omega} = 1.09\ A \quad (1)$$

Two input pins per H-bridge (×I0 and ×I1) are used to scale the current in each bridge as a percentage of the full-scale current set by the xVREF input pin and sense resistance (see Equation 1). According to the wiring configuration of DRV8802-Q1 in the preceding Figure 5, the chopping current is scaled down to 0.4 A, which matches with 38% of its full-scale value (see Table 2). Equation 2 calculates power dissipation in the low-side external resistor, where both H-bridges drive the motors with the max output current
(2 × 0.4 A).

$$P_{0.3\Omega} = I^2 \times R = 0.4^2 A \times 0.3\ \Omega = 0.192\ W \quad (2)$$

Note that overcurrent protection does not use the current sense circuitry used for PWM current control and is independent of the $R_{(ISENx)}$ resistor value or xVREF voltage (see Figure 6).

Table 2. H-Bridge Pin Functions

xI1	xI0	RELATIVE CURRENT (% FULL-SCALE CHOPPING CURRENT)
1	0	38%

2.2.1 Slow Decay

Case 1 (red path) in Figure 7 shows the current flow direction when the xENBL pin is high. During this state, the H-Bridge is enabled and drives current through the motor winding until reaching the PWM current chopping threshold. When the current through the motor windings rises above the threshold value, the H-bridge can operate in two different states: fast decay or slow decay.

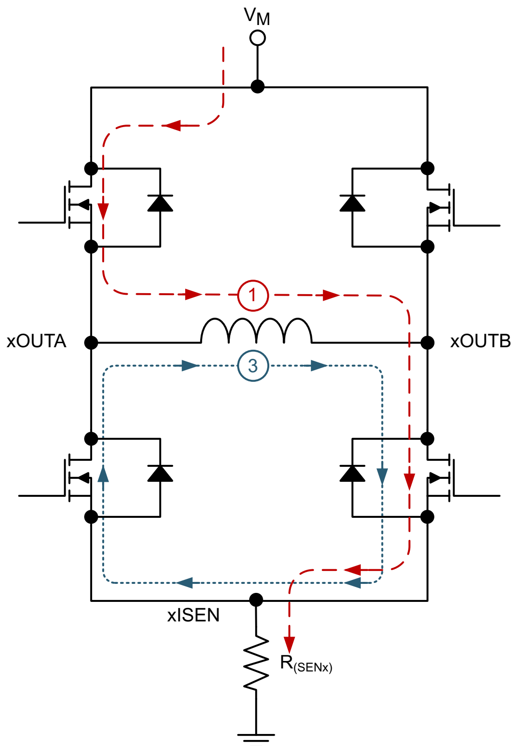

Figure 7. H-Bridge, Decay Mode

Table 3 shows the pin function of the decay state. For the DRV8802-Q1 can be chosen one of two available modes: slow decay or fast decay mode.

Table 3. Pin Function

PIN		TYPE	DESCRIPTION	MODE
NAME	NO.			
DECAY	19	Input	Decay (brake) mode	Low = brake (slow decay)
				High = coast (fast decay)

In this design, the DRV8802-Q1 device is configured for the slow-decay mode, where both low-side sinking drivers turn on, allowing the current to circulate through the low side of the H-bridge (two sink drivers) and the load (see the path representing case 3 in Figure 7). Equation 3 calculates the power dissipation loss for I^2R in the two sink-DMOS drivers.

$$P_D = I^2 \left(2 x r_{(DS(on)Sink)}\right) \quad (3)$$

3 Getting Started Hardware

3.1 Hardware

Figure 8 shows a screenshot of the TIDA-01357 connected with six BDC flap actuator motors. Perform the following steps to get started with this TI Design:

1. Connect the desired number of BDC motors (maximum of 6) to the output screw terminals.
2. Connect a supply voltage to the input screw terminal.
3. Connect the board to a computer through a USB cable for communication.

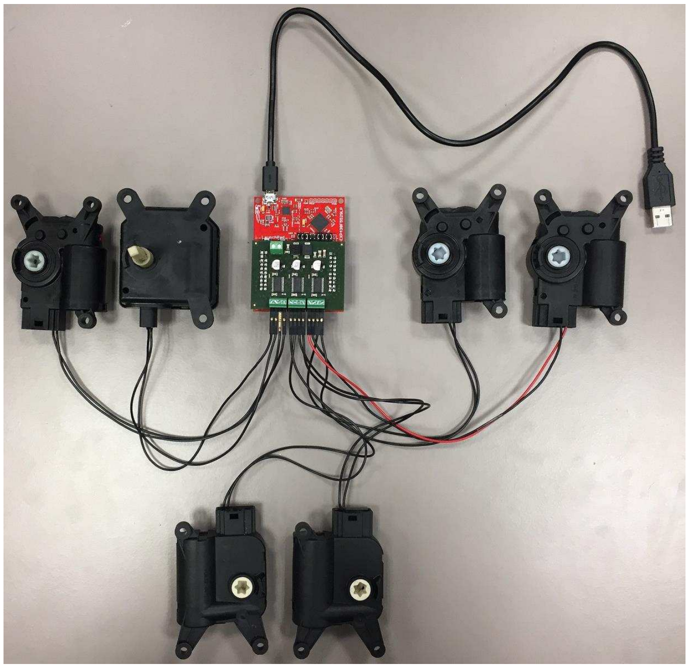

Figure 8. TIDA-01357 Daughterboard With Six BDC Flap Actuator Motors

The TIDA-01357 design allows for control of up to six BDC motors one at a time or simultaneously. A LaunchPad monitors the state of the FAULT pin of each DRV8802-Q1 (×3) and indicates any error condition that occurs before the next command can execute. If a FAULT pin goes low, which can happen if a short circuit occurs on the output, the DRVn-Q1 is disabled. During this period of time in which the DRVn-Q1 device has been disabled through internal protection circuit, if from the computer the next command is sent, the LaunchPad answers with the error signal (Err) until either the reset (rn) command is sent or a supply voltage is removed and reapplied. The "n" in rn represents the number of motor driver chips that require a restart.

3.2 LaunchPad™

LaunchPads are MCU development kits from TI. These kits are available in a variety of types to address various applications. The MSP-EXP430F5529LP (or the F5529 LaunchPad) is an inexpensive and simple development kit for the MSP430F5529 USB MCU. This LaunchPad offers an easy way to begin developing on the TI MSP430™ MCU, with onboard emulation for programming and debugging as well as buttons and light-emitting diodes (LEDs) for user interface.

Figure 9 shows the pinout of the F5529 LaunchPad, which allows easy access to all the peripherals on the F5529 device

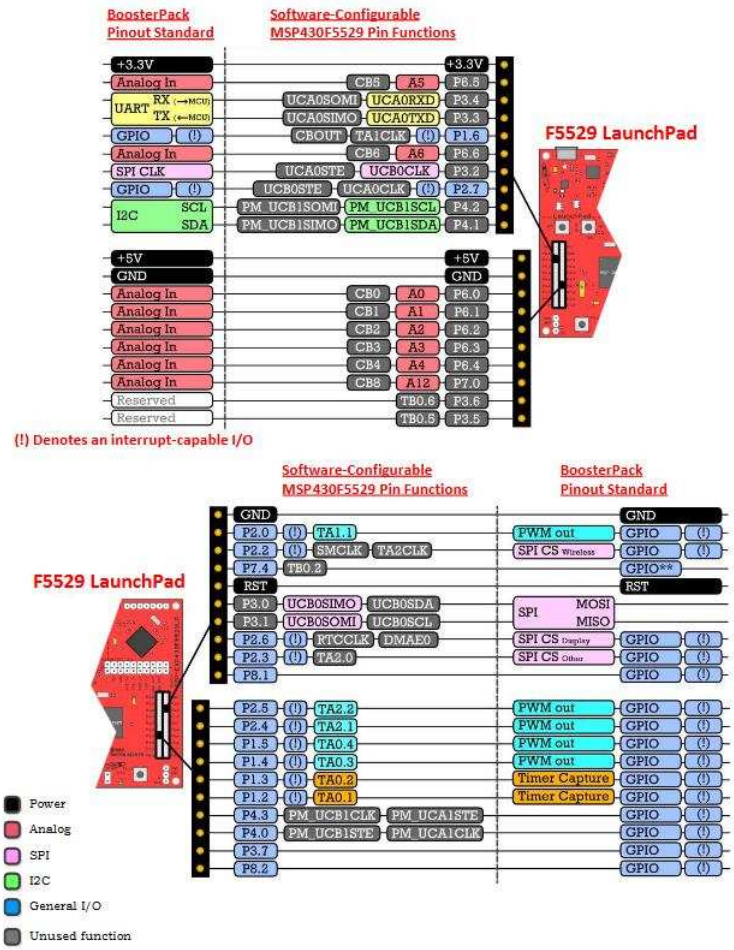

Figure 9. F5529 LaunchPad™ to BoosterPack™ and TIDA-01357 Connector Pinout

The schematic in Figure 10 shows the connections on the J300 and J301 pins, both of which are 20-pin connectors. The pin assignments are in accordance with the BoosterPack standard, which allows connection to various LaunchPad boards. All the logic signals from an MCU are referenced to the 3.3 V delivered from a LaunchPad. The nFAULT pin of the DRV8802-Q1 is an open-drain output; therefore, it is supplied from the V3P3OUT voltage regulator (in DRV8802-Q1) through an external pullup resistor, which is why the signal level on this pin is also 3.3 V.

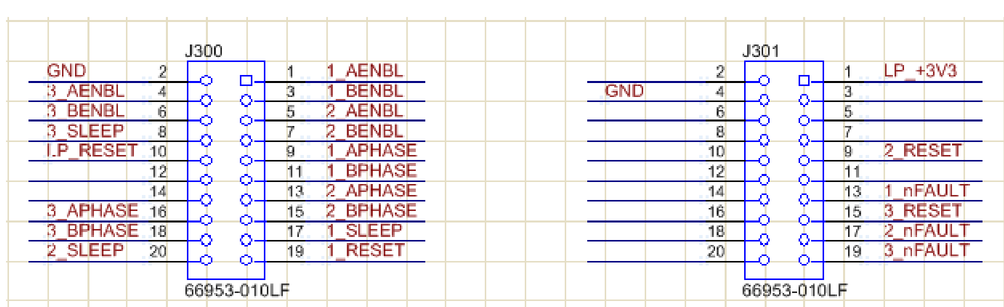

Figure 10. TIDA-01357 Board Connections to LaunchPad™

The control signals for this TIDA-01357 design are generated by the digital pins (GPIO) of the MCU. The feedback (FAULT) signal from the DRV8802-Q1 device is directly connected to the MCU, which continuously monitors the state of this pin.

3.3 Software

Communication between a host and the TIDA-01357 is realized through a "backchannel" universal asynchronous receiver and transmitter (UART), which is supplied by a LaunchPad (F5529). The backchannel UART enables communication with a USB host that is not part of the main functionality of the target application, which is very useful during development. When the F5529 LaunchPad enumerates on the host, the virtual COM port for the application backchannel UART is generated. So any PC application can be used that interfaces with COM ports, including hyperterminal, to open this port and communicate with the target application. Refer to the *MSP430F5529 LaunchPad™ Development Kit (MSP-EXP430F5529LP)* user's guide (SLAU533) [2] for further steps on how to set up a host PC with a backchannel UART.

Setting the baud rate to 28.8 kbps and disabling the flow control in a terminal software is an important step to follow when the communication between the host and LaunchPad has been established and before opening the port and sending the commands to the TIDA-01357 device. After all parameters have been set correctly the list of commands that Table 4 shows can be used to choose any kind of combination of rotation directions (CW or CCW) and motors, which is required to drive the DC motors connected to the TIDA-01357 device.

Table 4. List of Commands for Terminal Software

COMMAND	DESCRIPTION		
ASCII SYMBOLS	CHIP	H-BRIDGE	DIRECTION(1)
110	1	1	CW
111	1	1	CCW
120	1	2	CW
121	1	2	CCW
130	1	Both H-bridges	CW
131	1	Both H-bridges	CCW
210	2	1	CW
211	2	1	CCW
220	2	2	CW
221	2	2	CCW
230	2	Both H-bridges	CW
231	2	Both H-bridges	CCW
310	3	1	CW
311	3	1	CCW
320	3	2	CW
321	3	2	CCW
330	3	Both H-bridges	CW
331	3	Both H-bridges	CCW
410	All three	1	CW
411	All three	1	CCW
420	All three	2	CW
421	All three	2	CCW
430	All three	Both H-bridges	CW
431	All three	Both H-bridges	CCW
0	All three	Off	—
r1	1	-	(2)Restarts first DRV8802-Q1 of TIDA-01357
r2	2	-	(2)Restarts second DRV8802-Q1 of TIDA-01357
r3	3	-	(2)Restarts third DRV8802-Q1 of TIDA-01357

(1) The direction is dependent on the configuration in which the motor has been connected to the H-bridge.
(2) A restart of the chip is required to enable it again after it has been disabled due of a fault condition (short circuit on the output of the H-bridge).

4 Testing and Results

Figure 11 shows the test setup for this TI Design. The source voltage for BDC motors is delivered by a lab power supply. The LaunchPad communicates with a PC over backchannel UART (see Section 3.3). The current consumption of the motor driver board is monitored by an oscilloscope, which measures the voltage drop across the low-side shunt resistor (1 Ω). Additionally, the FAULT and RESET pin states are monitored by an oscilloscope, as well as the supply-voltage level after the filter circuit on the TIDA-01357 device.

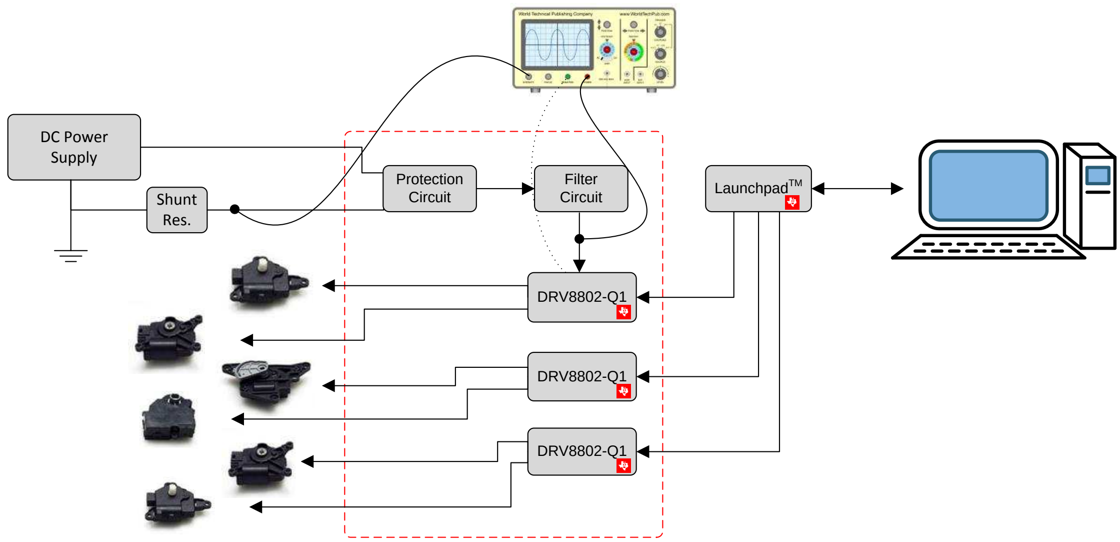

Figure 11. TIDA-01357 Test Setup

Several tests were conducted to verify the performance of the motor driver board:

- Fully-loaded board where two of six motors slowly went in a stall condition
- Short circuit on the output of one motor driver chip (fault condition)
- Resetting the chip after it was disabled (output shorted)
- Representation of the chopping current with simulated load

Figure 12 shows the current and voltage waveforms when the motor driver board is fully loaded (drives six BDC motors). The C1 waveform in this oscilloscope screenshot shows the total current, which flows through the external low-side shunt resistor (see preceding Figure 11). Because the value of the low-side shunt is 1 Ω, the voltage values shown in C1 correspond one-to-one to the current in mA. The peak value shown at the beginning (section numbered "2") of the waveform (C1) represents the total starting current for all connected motors. After the motors are moved, the currents through the motor windings are regulated by a fixed PWM current regulation, or current chopping. The section numbered "3" shows the rising current, which corresponds to the beginning of the stall condition in which two of six motors are slowly driven. The section numbered "4" shows the stable level of current, where two motors are blocked and driving a constant amount of (stall) current. The section numbered "5" shows that waveform C1 goes to zero, which corresponds with the stop condition, in which all motors are immediately stopped at the same time. Stop condition is triggered by the stop command ("0", see Figure 5).

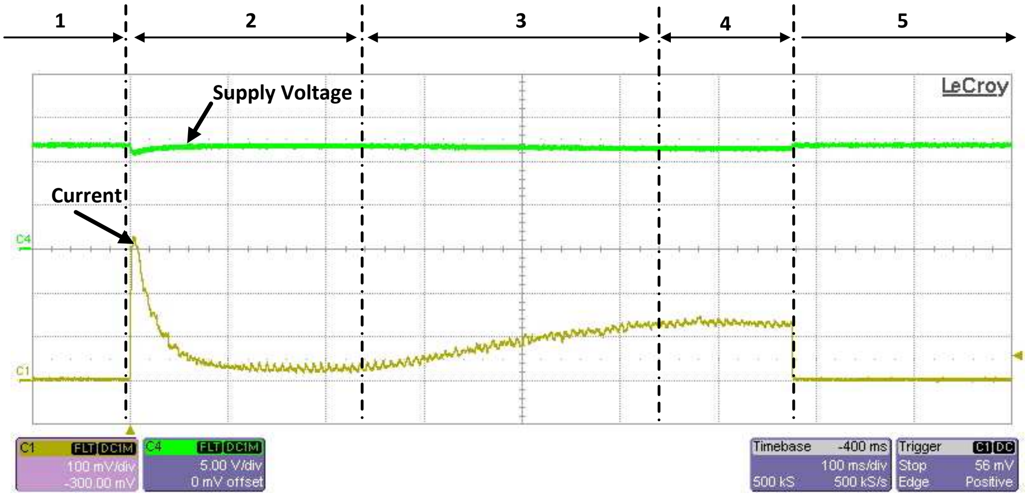

Figure 12. TIDA-01357 Current and Voltage

An analog current-limit circuit on each FET limits the current through the FET by removing the gate drive. If the analog current-limit persists for longer than the time required for overcurrent protection, all the FETs in the H-bridge are disabled and the FAULT pin is driven low. These kind of overcurrent conditions can happen when short-to-ground, supply, or across-the-motor-winding occurs. Figure 13 shows the initial phase (numbered "1"), starting one of six connected motors (numbered "2"), and FAULT mode (numbered "3"), which is caused by a short across the motor winding. When the motor winding is shorted, FAULT pin is driven low, and the motor driver chip is disabled, the device remains in this condition until ether the RESET pin is applied or the supply voltage is removed and reapplied.

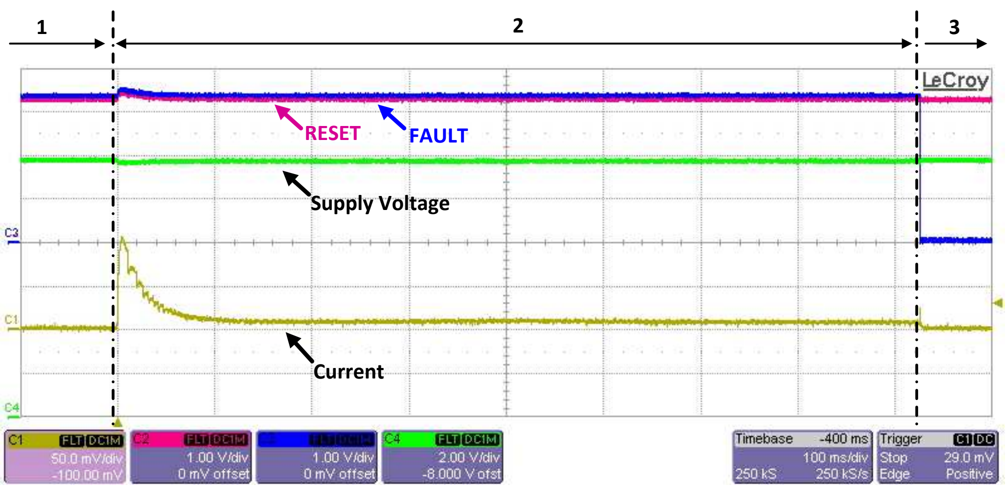

Figure 13. Representation of FAULT Mode Caused by Short Across Motor Winding (3)

[Figure 14](#) shows a reset (numbered "1") of the DRV8802-Q1 device by the LaunchPad, which is accomplished by sending a reset command "r1" (see [Table 4](#)). The oscilloscope screenshot also clearly shows the duration of the period in which the RESET pin remains in a low state. Immediately after the RESET pin goes high, followed by the FAULT pin, the device is enabled.

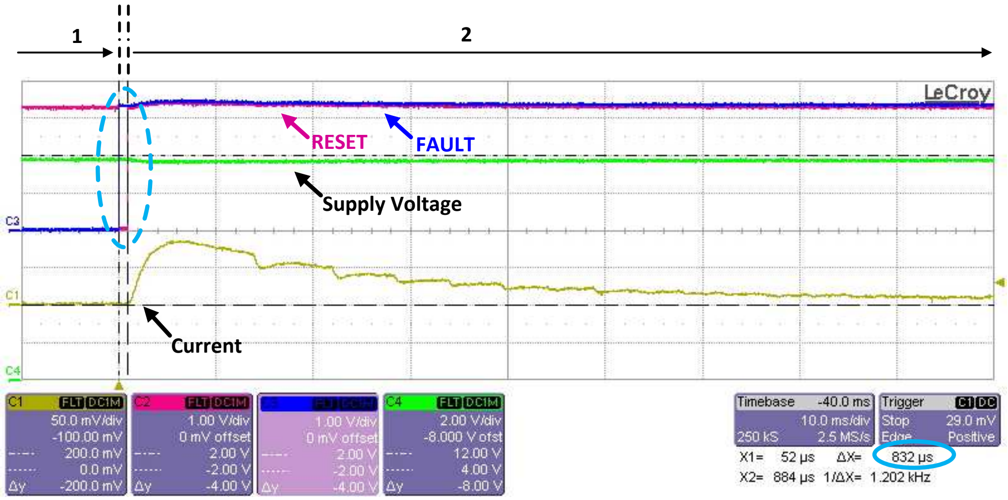

Figure 14. Resetting the DRV8802-Q1 After Being Driven into FAULT Mode (See [Figure 13](#))

The block diagram in [Figure 15](#) shows an external load resistor, which is used for the current regulation test. The value of the resistor is 2.6 Ω, which means that in the on-state of the H-bridge, the current at a given supply voltage (12 V) that can flow through the resistor is much higher (4.6 A) than the preset max output current (0.4 A) of the H-bridge (see [Section 2.2](#)). So, when the current hits the current-chopping threshold, the bridge disables the current until the beginning of the next PWM cycle (internal $F_{(PWM)}$ is 50 kHz).

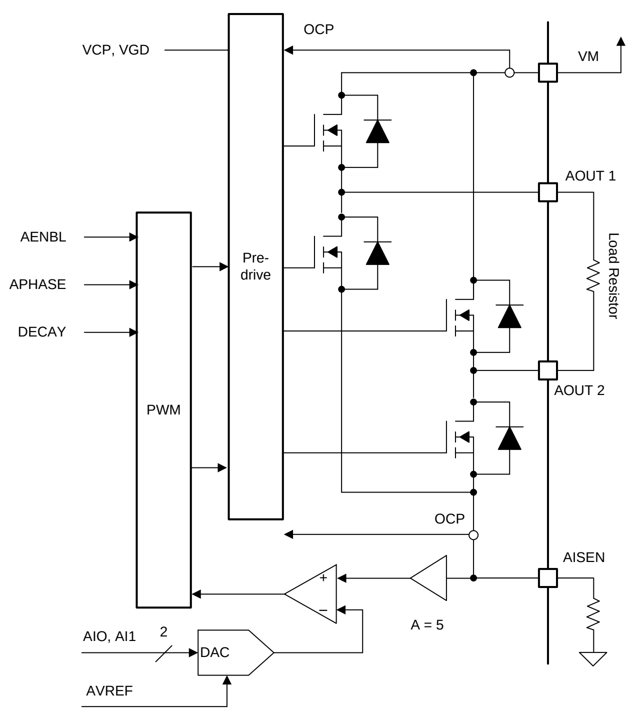

Figure 15. Block Diagram With External Load Resistor for Current Regulation Test

Figure 16 and Figure 17 show representations of the current regulation technique, where the load current value (2.4-Ω load resistor) is clamped at 400 mA, which was initially set by the DRV8802-Q1 device. The frequency of chopping current also corresponds to the value referred in the DRV8802-Q1 datasheet [1].

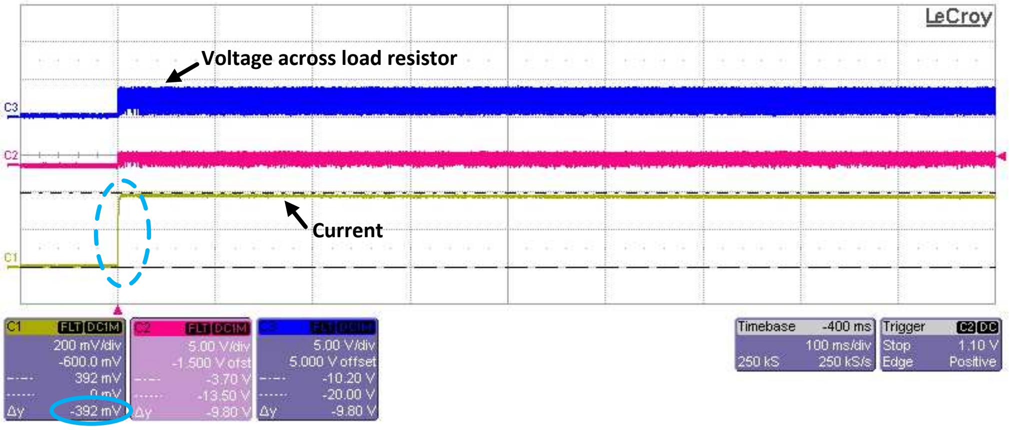

Figure 16. Current Regulation (OCP)

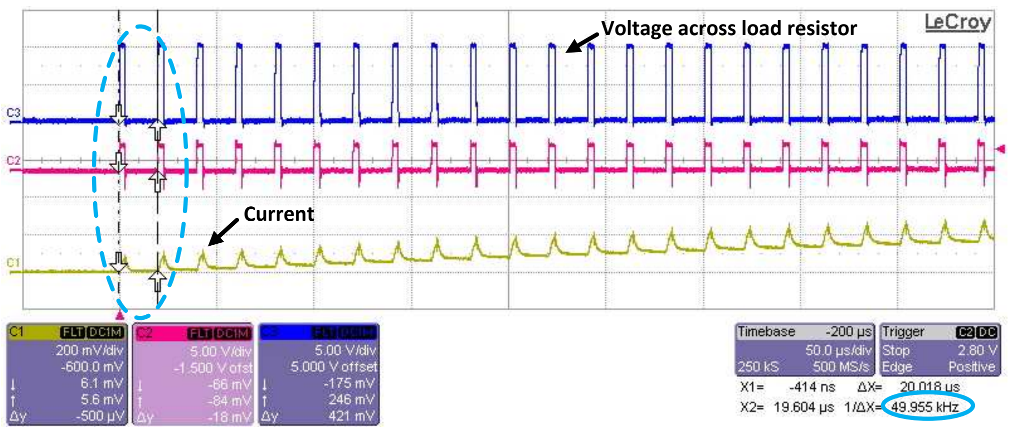

Figure 17. Current Regulation (Internal $F_{(PWM)}$)

Figure 18 and Figure 19 show thermal images of the TIDA-01357 driving six motors, two of which are in a stall condition, which means the current delivered by the motor driver chip is much higher for stalled motors than the current that is being consumed by the motors in a normal spin condition.

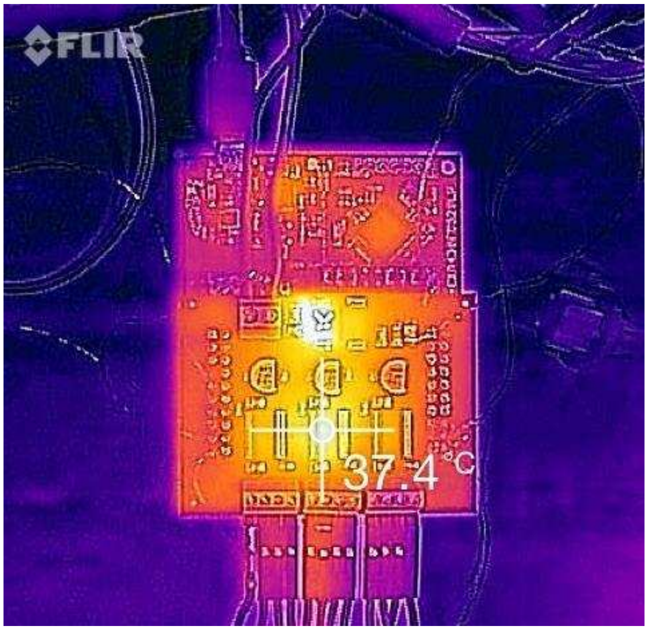

Figure 18. Thermal Image of TIDA-01357—Temperature of DRV8802-Q1 (Both Motors in Stall Condition)

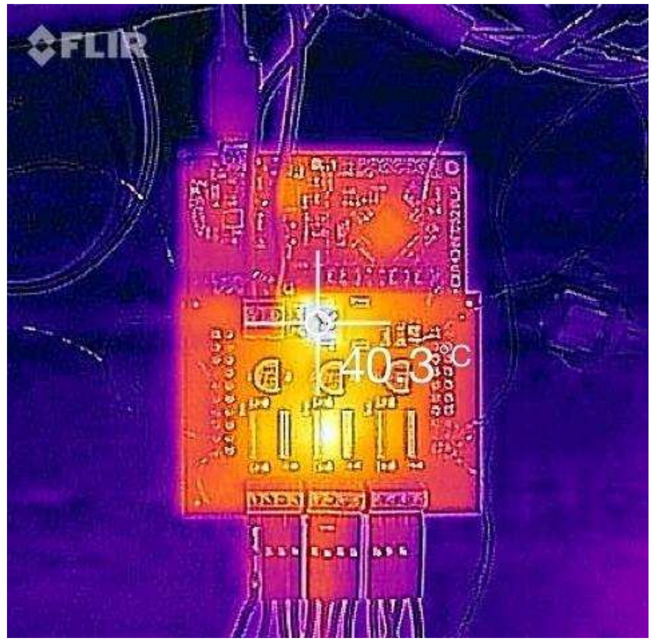

Figure 19. Thermal Image of TIDA-0135—Temperature of Reverse Polarity Diode

In the thermal image of Figure 18, the temperature marker focuses on one DRV8802-Q1 device, which is in the middle of the PCB and is connected with two motors, both of which are in a stall condition (rotors are blocked). The other two motor driver chips on the left and right side also drive two BDC motors each, but in normal spin mode (no stall condition). So the currents flowing through these two chips are much lower than the current that flows through the middle one, which causes the difference in temperature between these chips shown in the Figure 18 . The thermal image in Figure 19 shows the temperature of the reverse polarity diode, where the total current for all six BDC motors flows.

5 Design Files

5.1 Schematics

To download the schematics, see the design files at TIDA-01357.

5.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-01357.

5.3 PCB Layout Recommendations

Figure 20 shows the top view of the TIDA-01357 board and Figure 21 only shows the top layer of the PCB. Because the DRV8802-Q1 is designed to operate from an input voltage supply $V_{(sup)}$ range between 8.2 V and 45 V, two 100-nF ceramic capacitors rated for $V_{(max.supply)}$ must be placed as close as possible to the VMA and VMB pins, respectively. Place a bulk capacitor as close as possible too. As the top layer of the board shows, the supply voltage is delivered to the motor driver chips through a protection circuit, which consists of two ESD ceramic capacitances (L-shape placing), a reverse-polarity protection diode, and a TVS diode followed by three ceramic capacitances. All the components of the protection circuit are placed very close to each other.

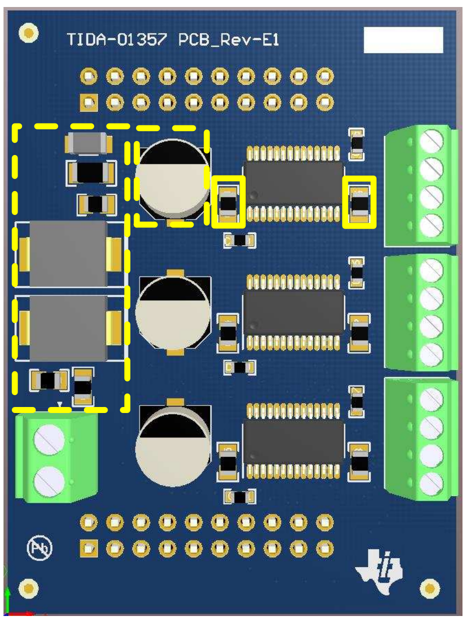

Figure 20. TIDA-01357 Top View

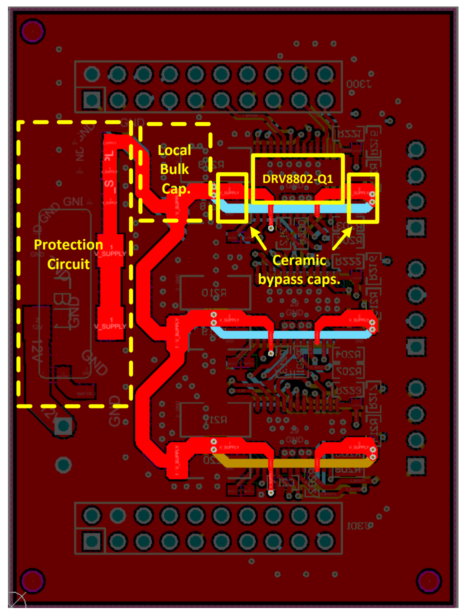

Figure 21. TIDA-01357 Top Layer

Figure 22 shows the bottom layer of the board. The current path between the H-bridge and external low-side current sense resistors should have a low Ω value.

The DRV8802-Q1 device uses an exposed pad for better heat sink. For proper operation, this pad must be thermally connected to copper on the PCB to dissipate heat. A PCB with four layers is used In this TI Design. Because the copper areas are on the top side and the bottom side of the PCB, thermal vias are used to transfer the heat between top and bottom layers.

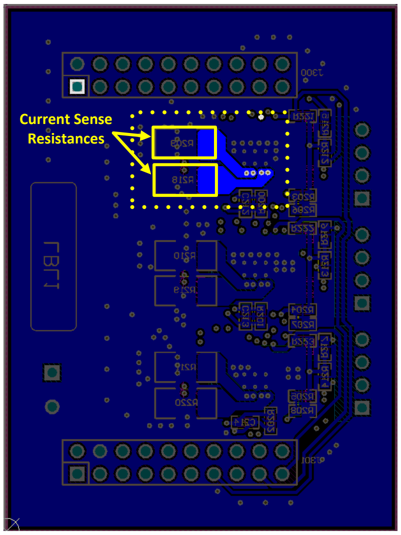

Figure 22. TIDA-01357 Bottom Layer

5.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-01357.

5.4 Altium Project

To download the Altium project files, see the design files at TIDA-01357.

5.5 Gerber Files

To download the Gerber files, see the design files at TIDA-01357.

5.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-01357.

6 Software Files

To download the software files, see the design files at TIDA-01357.

7 References

1. Texas Instruments, *DRV8802-Q1 Automotive DC Motor-Driver IC*, DRV8802-Q1 Datasheet (SLVSCI2)
2. Texas Instruments, *MSP430F5529 LaunchPad™ Development Kit (MSP-EXP430F5529LP)*, User's Guide (SLAU533)
3. Texas Instruments, *Reference Design for Reinforced Isolation Three-Phase Inverter With Current, Voltage, and Temp Protection*, TIDA-00366 Design Guide (TIDUBX1)

7.1 Trademarks

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8 Terminology

BDC— Brushed DC motor

BLDC— Brushless DC motor

FET— Field-effect transistor

GPIO— General purpose input/output (pins)

HVAC— Heating, ventilation, and air conditioning

9 About the Author

LEVAN BIDZISHVILI is a systems engineer at Texas Instruments where he is responsible for developing reference design solutions for the automotive body and HVAC segment. Levan brings his extensive experience of more than 6 years of automotive analog and digital applications to this role. Levan earned his master's degree of engineering in sensor systems technology from the University of Applied Sciences in Karlsruhe, Germany.