Test Report

TIDA-00827 – Integrated Sensored BLDC Motor Controller Reference Design

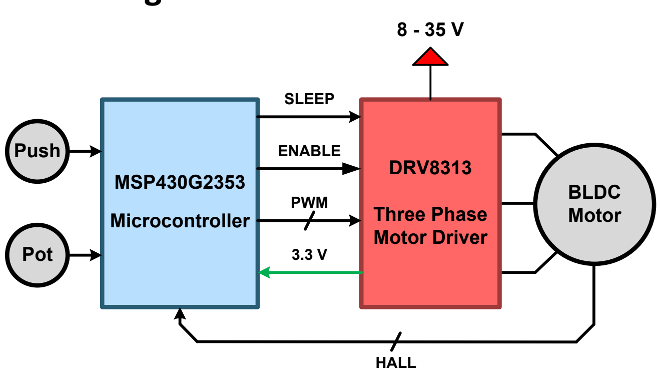
Design Overview

TIDA-00827 is an integrated, sensored BLDC motor controller suitable for low-powered, battery operated, brushless DC motor applications. These applications include camera gimbals, low power fans, and robotics. The TIDA-00827 has an 8 to 35 V operating voltage range to support 3S to 6S LiPo battery supplies. The motor controller is composed of the MSP430G2353 16-bit, ultra-low-power microcontroller and the DRV8313 highly integrated, 2.5 A triple half-bridge driver. The MSP430G2353 utilizes hall sensor commutation feedback to provide the correct drive voltages to the motor through the DRV8313. An onboard potentiometer and push button provide a simple interface to control the motor.

Design Resources

TIDA-00643	Design Folder
DRV8313	Product Folder
MSP430G2353	Product Folder
Sensored BLDC Control	App Report

Block Diagram



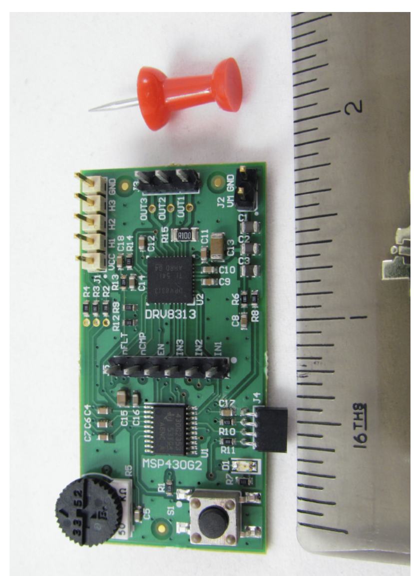
Design Features

- 8 to 35 V operating voltage range
- 2.5 A peak output current capability
- Small form factor: 2.0" x 1.0" (L x W)
- Sensored BLDC motor control through MSP430 microcontroller
- Integrated current limiting comparator
- Integrated undervoltage, overtemperature, and overcurrent protection
- Integrated 3.3 V, 10 mA LDO regulator

Featured Applications

- BLDC gimbals
- Lower power fans
- Robotics

Board Image

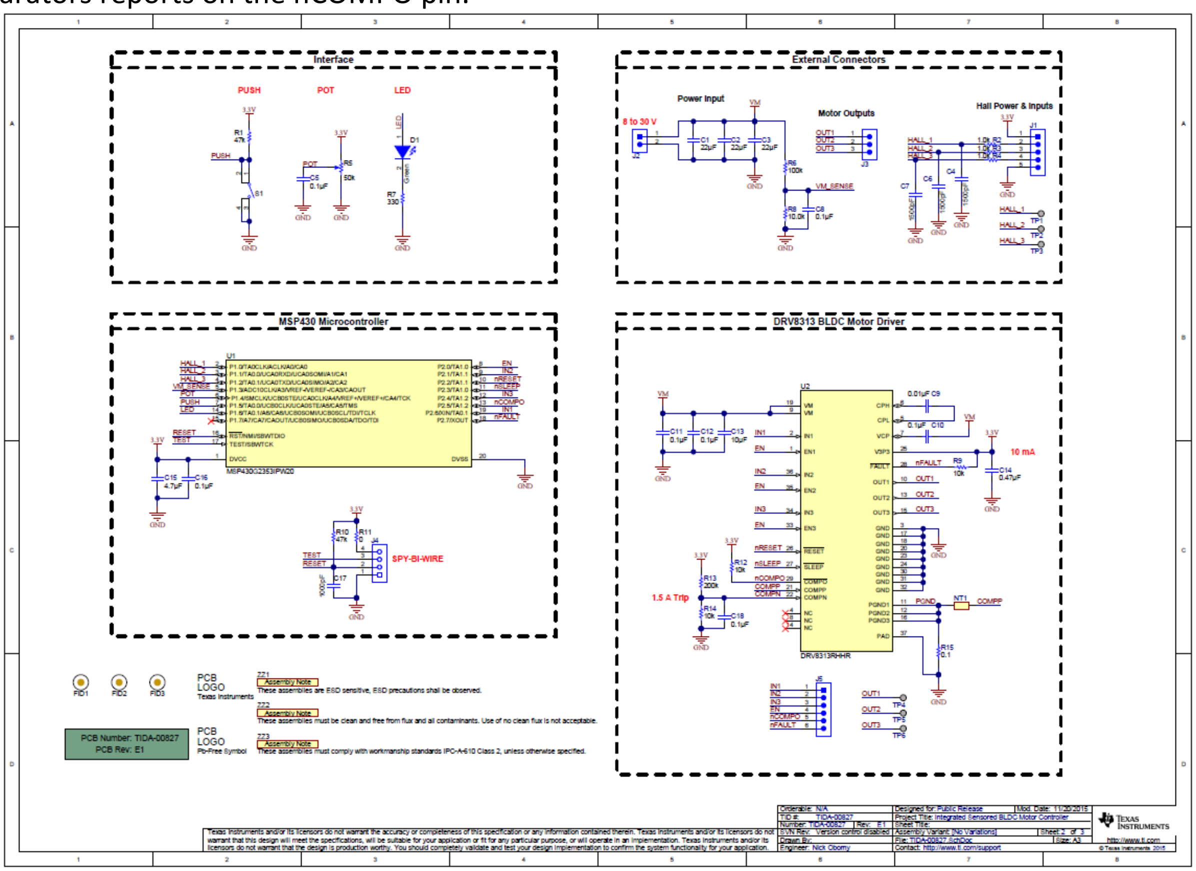


System Overview

TIDA-00827 is a highly integrated sensored BLDC motor controller that can be used for lower power gimbal and fans applications. It uses two devices, MSP430G2353 and DRV8313, to create the entire system. Standard 100 mil connectors provide connection points for power, motor, sensors, and test signals. An onboard potentiometer and push button can be used to implement functions to control the speed and direction of the motors through the MCU. A general purpose LED can be used to indicate system status, motor speed, or other system indicators.

The MSP430G2353 is a low power, 16-bit microcontroller often used in battery powered applications. The microcontroller is powered by the integrated 3.3 V, 10 mA LDO regulator of the DRV8313. The microcontroller is programmed through a four pin spy-bi-wire connection that can interface directly with an MSP430G2 LaunchPad. Timers A0 and A1 are used to generate the three PWM signals that are required for BLDC motor control. The hall sensor inputs are fed to pins with both digital and analog input capability and a resistor divider provides the value of the main supply voltage to monitor for low or high voltage conditions.

The DRV8313 is a highly integrated, triple half-bridge motor driver that is commonly used for BLDC motor applications. It incorporates three half-bridge gate drivers and MOSFETs, a charge pump for the high-side gate bias, a linear regulator for the low-side gate bias, a 3.3 V, 10 mA linear regulator for the microcontroller, a current limiting comparator, and a suite of power stage protection features. The half-bridge outputs are controlled through the EN and IN pins which allow each output to be low, high, or hi-z. Fault conditions are reported through the nFAULT pin to the microcontroller and the current comparators reports on the nCOMPO pin.



Test Data

This section will provide lab data on several parameters of the reference design.

An important parameter in a motor drive system is the propagation delay from the input to the output. Long and mismatched delays can lead to distortion between the inputs and outputs. The blue signal is the input and the yellow signal is the output.

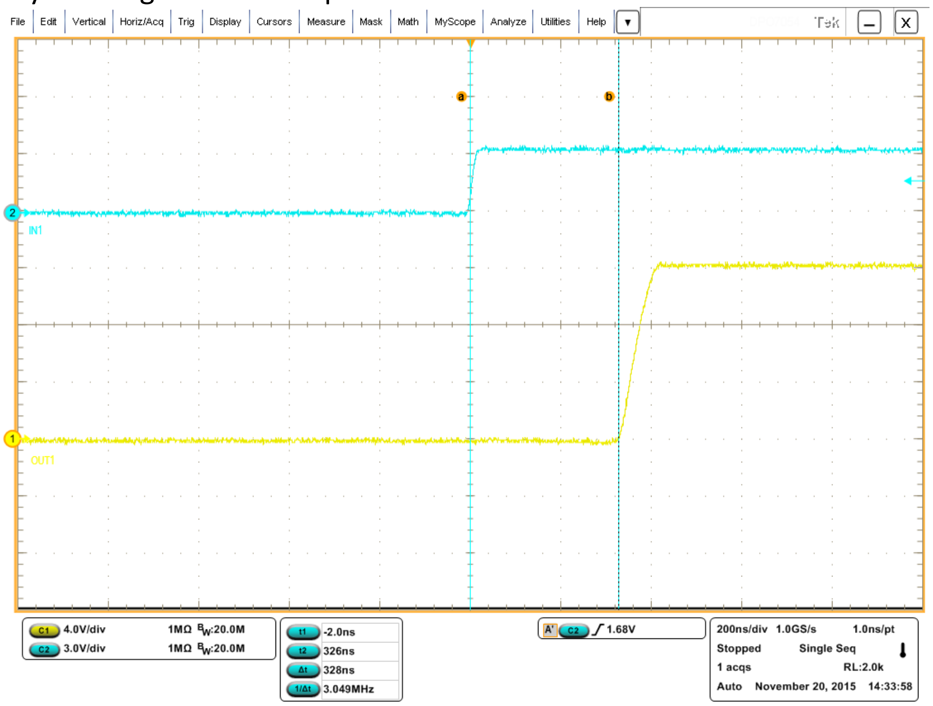


Figure 1: Rising Propagation Delay (328 ns)

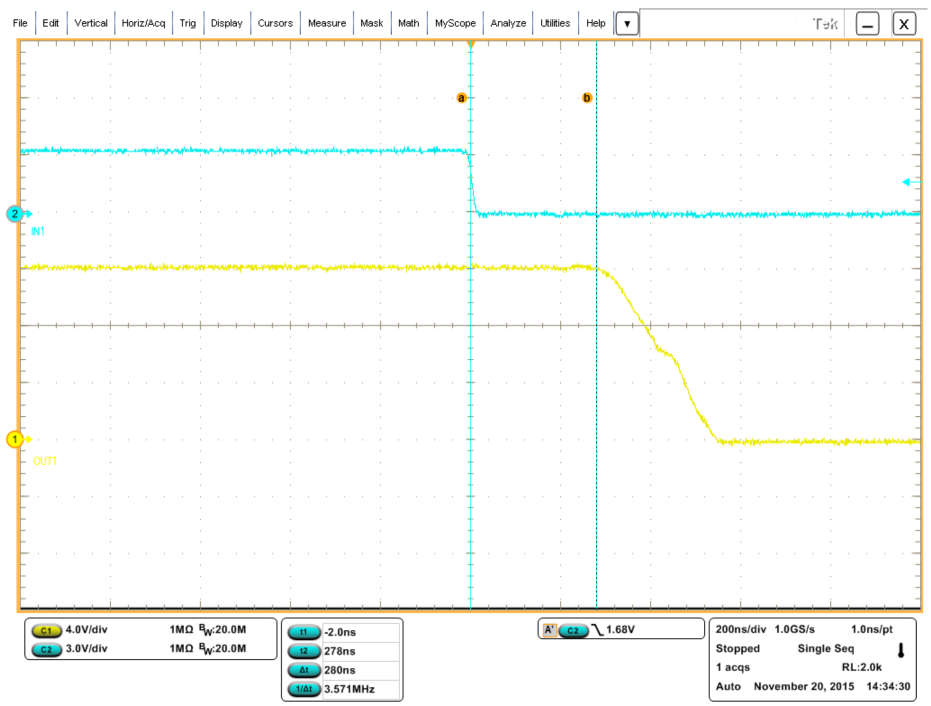


Figure 2: Falling Propagation Delay (280 ns)

The slew rate of the outputs is an important factor for efficiency, voltage transients, and output distortion. The blue signal is the input and the yellow signal is the output.

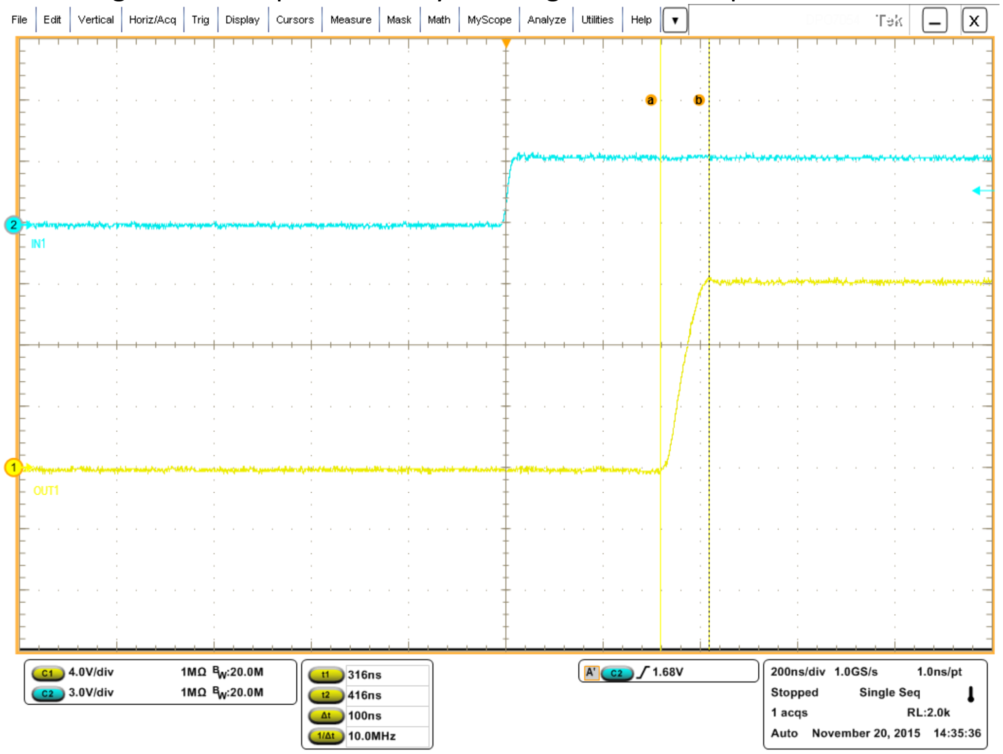


Figure 3: Rising Slew Rate (100 ns)

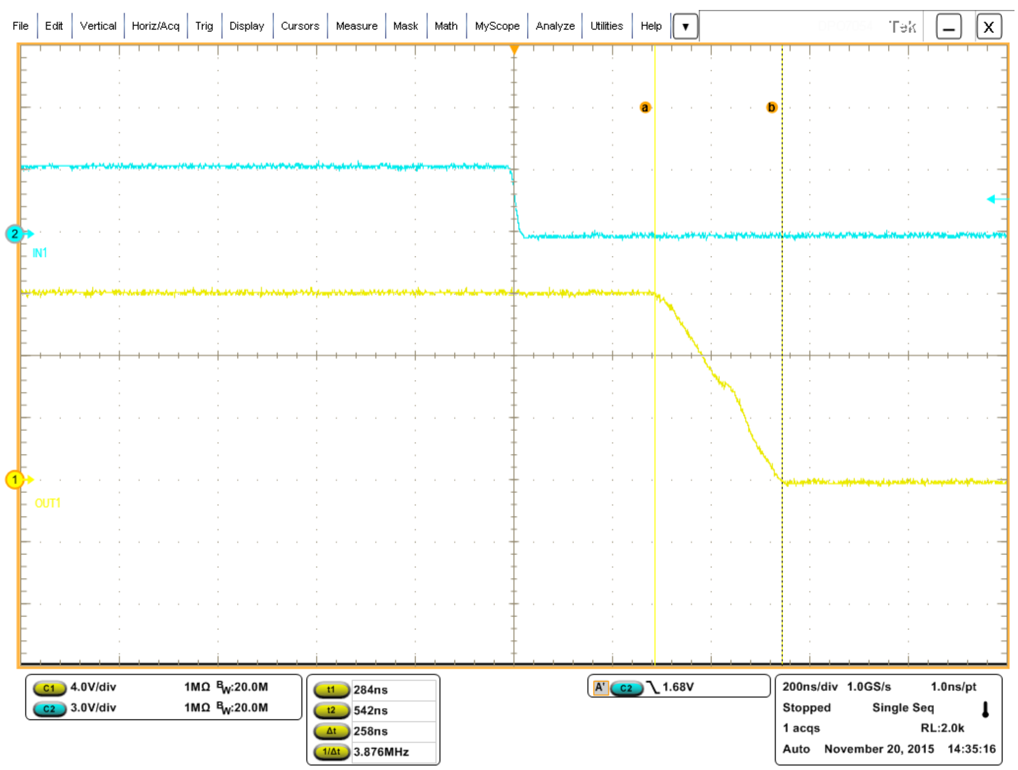


Figure 4: Falling Slew Rate (258 ns)

Dead time is the period of time between the HS MOSFET switching OFF and the LS MOSFET switching ON or vice versa. It is used to prevent shoot-through currents in the output state. Long dead time has the drawback of reduced efficiency and output distortion. The blue signal is the input and the yellow signal is the output.

Figure 5: Rising Dead Time (74 ns)

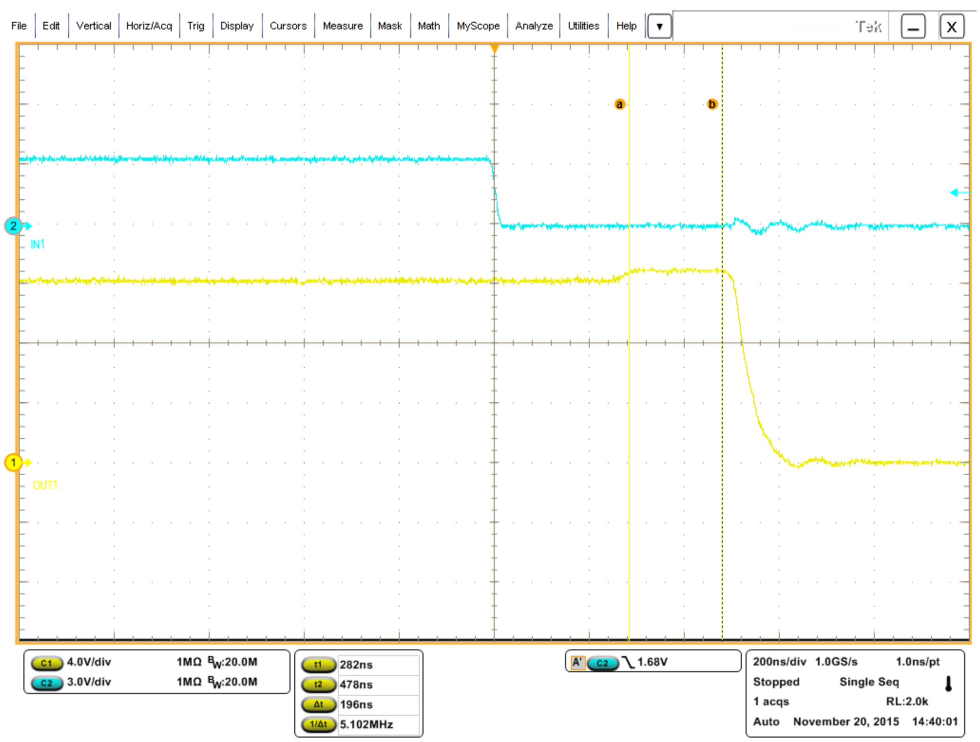


Figure 6: Falling Dead Time (196 ns)

The DRV8313 incorporates internal overcurrent protection (OCP) to protect the system in case of an output short circuit or motor overcurrent event. The DRV8313 OCP fires at approximately 5 A, then will disable the outputs and report a fault condition on the nFAULT pin. The blue signal is the input, the purple signal is nFAULT, the yellow signal is the output, and the green signal is the output current.

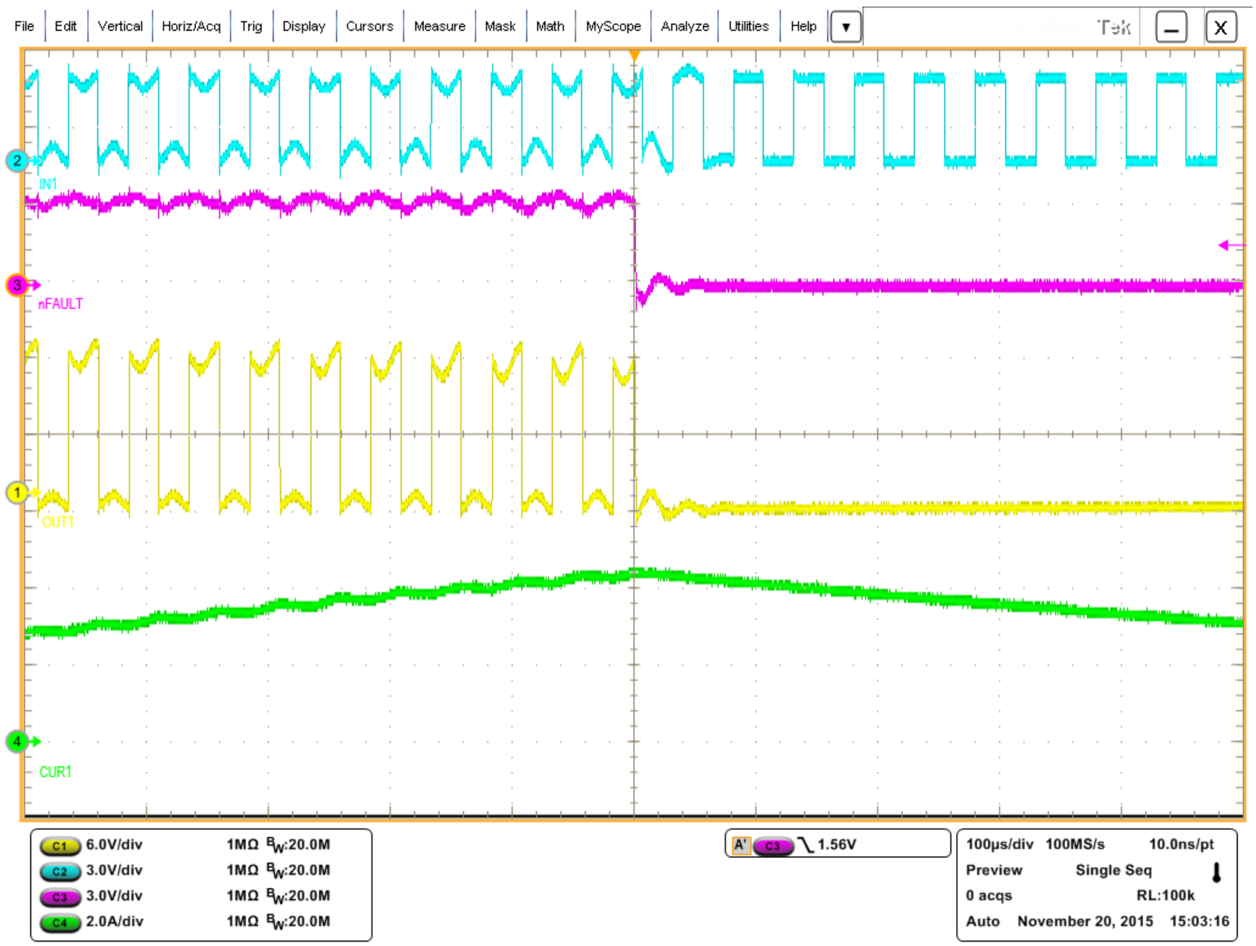


Figure 7: DRV8313 Overcurrent Protection

The DRV8313 incorporates a 3.3 V, 10 mA LDO regulator to power an external microcontroller. Two important parameters of an LDO supply are the output ripple and dynamic load response. The output ripple is shown with a differential probe (purple). The green signal indicates the LDO output current.

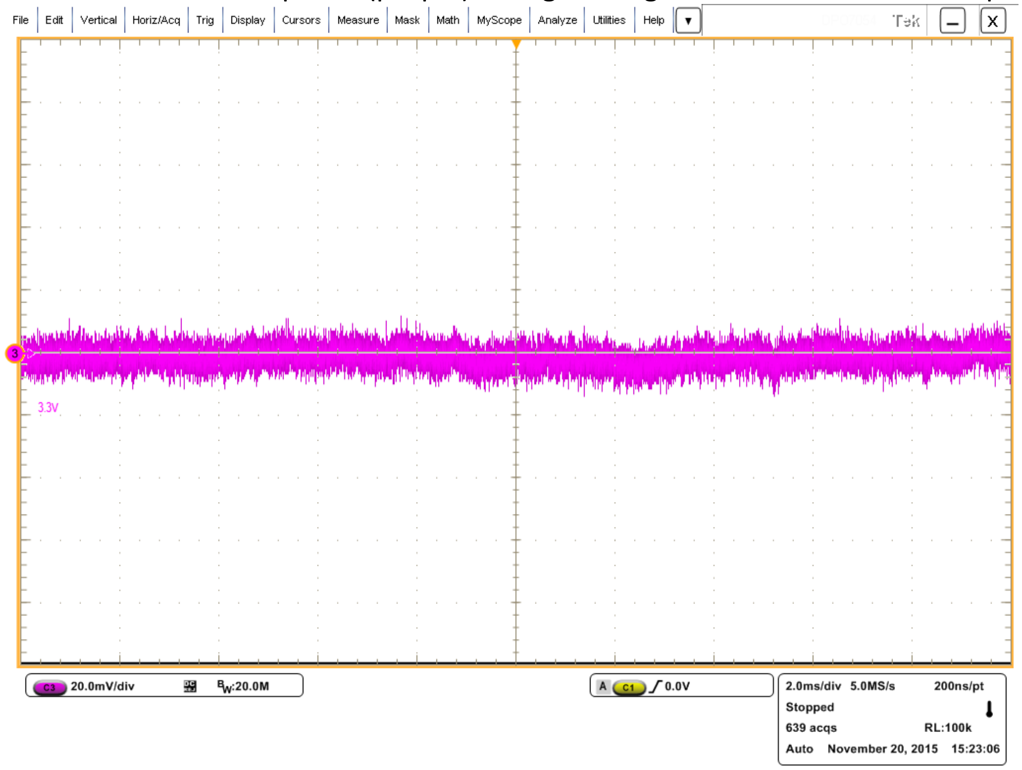


Figure 8: 3.3 V Output Ripple (+/- 10 mV)

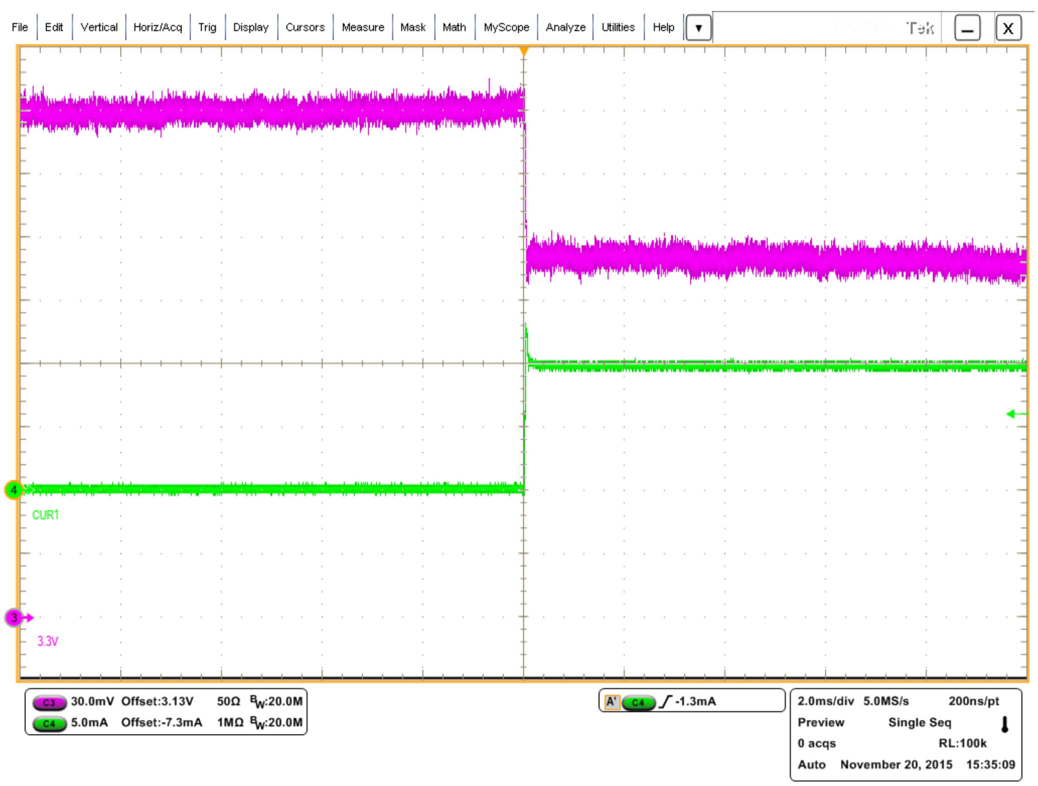


Figure 9: 3.3 V Load Response (10 mA Step)

A key parameter of battery powered motor drive system is the efficiency of the power stage. This can be calculated by comparing input power against output power.

The data below is calculated with the DRV8313 running off of 12 V and operating at 50 % duty cycle. It is driving a 1 mH, 10 Ω load. Two different switching frequencies were measured and the driver was operating at an output current of ~500 mA.

Switching Frequency (kHz)	Efficiency (%)
10	93.51
20	93.26

The efficiency loss will show up as heat dissipated in the system design. Using a thermal imaging camera this effect can be captured at various data points. The image below shows the system driving 0.5 A out of each of the outputs. The DRV8313 is at 47.6°C and the power sense resistor is slightly hotter at 57.7°C. The sense resistor is carrying the sum of the 3 outputs.

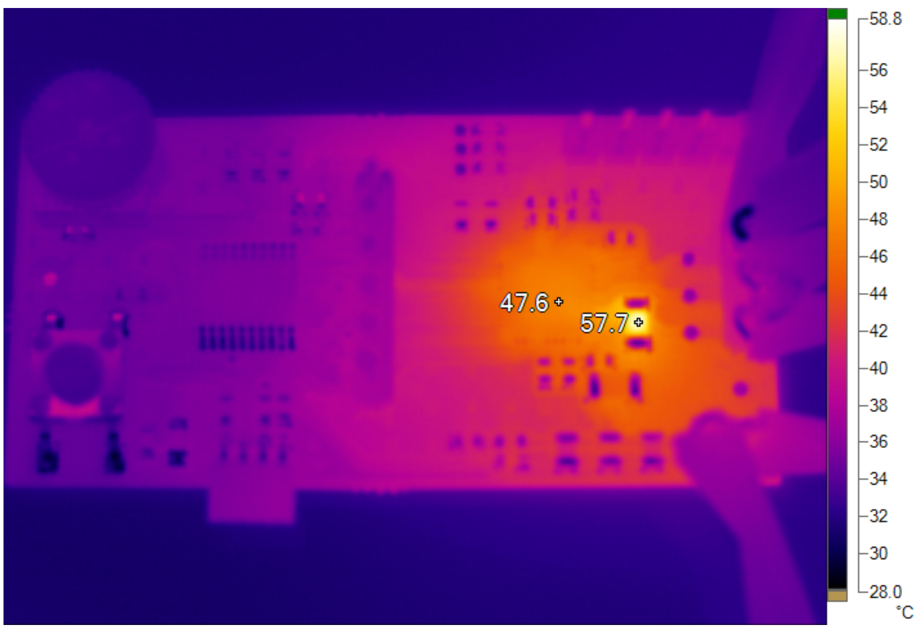


Figure 10: 0.5 A From Each Output

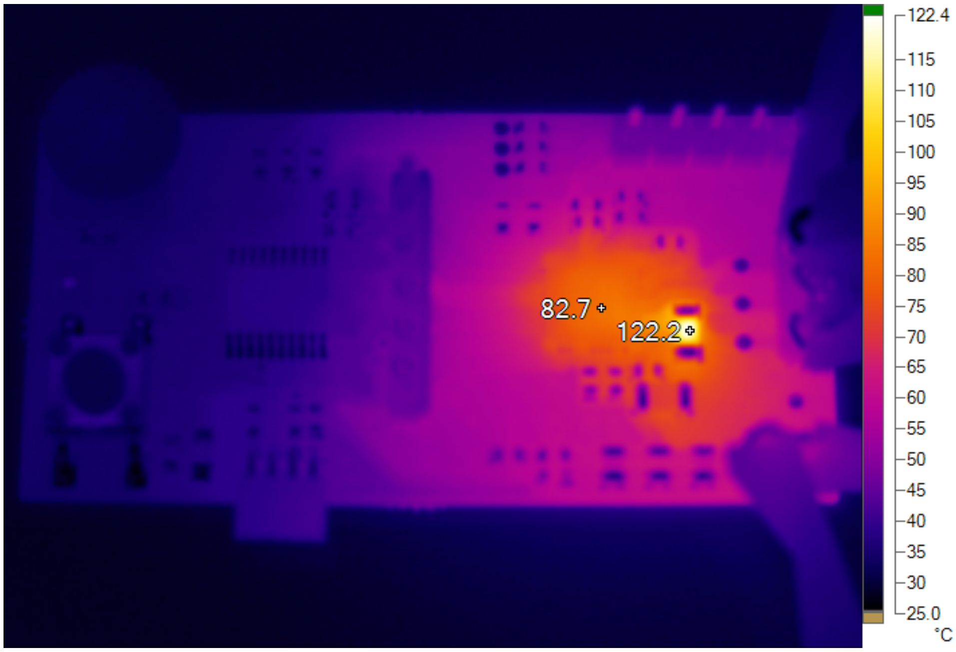


Figure 11: 1.0 A From Each Output

The image below shows the system driving 2.0 A from OUT2 only. This simulates a system that only has one phase active at a given time.

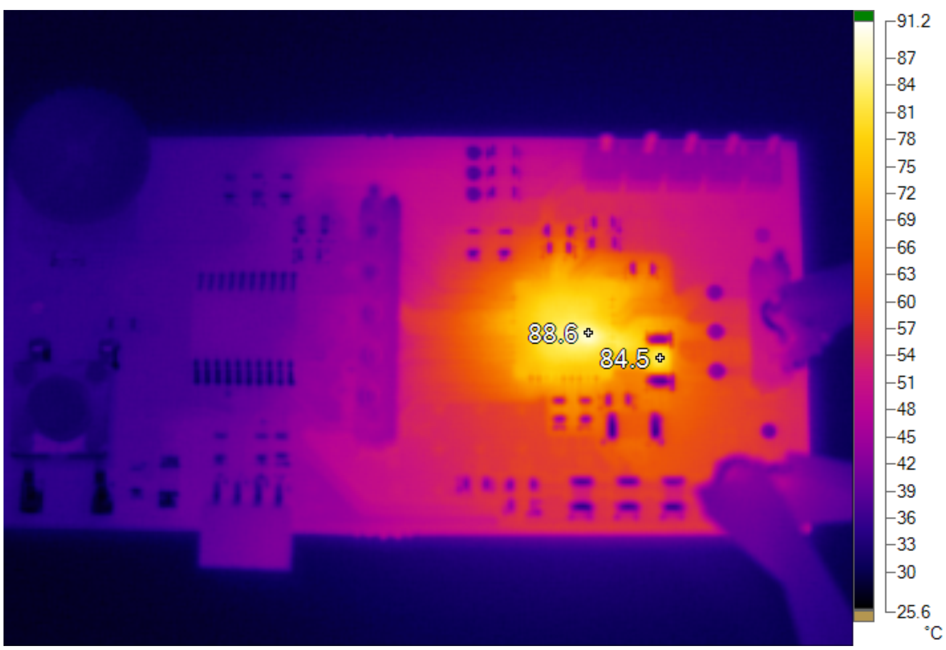


Figure 12: 2.0 A From Output 2