参考資料

TI Designs: TIDA-01543
過電流検出機能付きトラクション・インバータ用の絶縁電流検出のリファレンス・デザイン(±300A)

TEXAS INSTRUMENTS

概要

このTI Designは、トラクション・モータの位相電流を検出します。TIDA-01543デザインは、絶縁電流センサ・ソリューションを実現します。AMC1305M05-Q1デルタ-シグマ(ΔΣ)変調器とINA301-Q1デバイスにより、シャント・ベースの高精度インライン・モータ位相電流検出が行われます。変調器のCMTIが高いため、インバータのスイッチング過渡電圧が原因でコントローラ側のデータが破壊されることを抑制できます。INA301-Q1の高速な応答により、過電流事象に短時間で反応できます。TIDA-01543は外部のMCUに接続するためのインターフェイスとなり、デジタルSINCフィルタを実装することで、AMC1305M05-Q1の出力ビット・ストリームを復調できます。このTI Designは、C2000™ファミリの車載用認定済みF280049M Piccolo™マイクロコントローラ制御カードを使用します。

リソース

TIDA-01543	デザイン・フォルダ
AMC1305M05-Q1	プロダクト・フォルダ
SN6501-Q1	プロダクト・フォルダ
TPS717-Q1	プロダクト・フォルダ
ISO7710-Q1	プロダクト・フォルダ
INA301-Q1	プロダクト・フォルダ

TI E2E™ Community

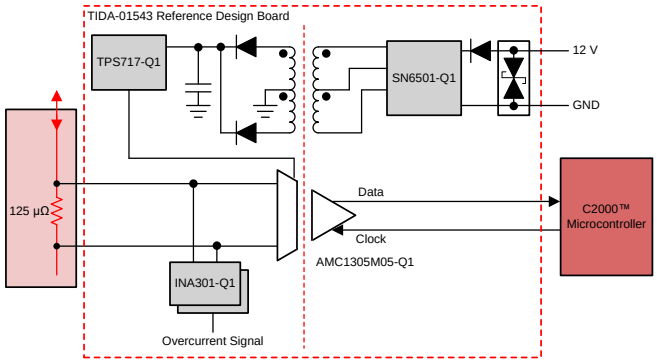
E2E™エキスパートに質問

特長

- 強化絶縁のΔΣ変調器により、シャント抵抗でインライン・モータ位相電流を測定
- SINC 3フィルタおよびOSR 8での短絡応答時間1.5µs未満
- 公称位相電流測定範囲±300A、100µΩのシャント抵抗により過渡ピーク範囲±80Apk
- 0℃～125℃の温度範囲にわたってフルスケール誤差0.5%未満に較正済み
- INA301-Q1での短絡応答時間300ns（AMC変調器との並列構成）
- 変調器のCMTIが高い(15kV/µs超)ため、スイッチング過渡電圧へのノイズ耐性が向上

アプリケーション

- トラクション・インバータのACモータ位相電流センシング
- DC-DCコンバータの電流センシング



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1 System Description

High-resolution, accurate, isolated phase current measurement is vital in automotive traction inverter applications, where high-performance torque and motion control are required. The options available for phase-current measurement are to use Hall-effect sensors, flux-gate sensors, current transformers, and shunt resistors. The first three options have inherent galvanic isolation benefits and a high current measurement range, but the linearity, bandwidth, and drift are of lower performance when compared to the shunt-resistor option. Shunt resistors provide a highly linear, high-bandwidth, and cost-effective measurement solution. Reinforced isolation provides both benefits of isolation and high linearity and bandwidth.

Isolated shunt-based current measurement is accomplished either by using an isolated amplifier or an isolated delta-sigma (ΔΣ) modulator. The amplifier-based solution has three conversion stages consisting of an isolated amplifier, a differential-to-single-ended amplifier with a filter, and a SAR ADC. Each stage adds error and delay, and achieves an accuracy of < 10 bits on the system level. Short-circuit detection using isolation amplifiers require additional circuitry, which consist of window comparators and reference generators for setting short-circuit thresholds. The short-circuit detection delay is higher in this case because of the propagation delays of the amplifier plus the comparator. The ΔΣ modulator-based solution has a single conversion stage, and most of the processing is done in the digital domain. which makes it less susceptible to noise in the system and it is possible to get accuracy of > 14 bits at the system level.

図 1 shows the mechanism of phase current sensing in traction motors, there are two paths implemented in the design, (1) sigma-delta (ΣΔ) filter module (SDFM) to demodulate data, and (2) IN301-based comparators for overcurrent.

The first path is a high-resolution, precise data filter unit. This unit has a configurable SINC filter and high oversampling ratio (OSR), preferably SINC 3 and OSR of > 64. The output of the filter unit is stored in data registers and used for position and torque control. The output of this filter is not preferred for drive protection because of the high latency of the path.

The second path is a low-latency, lower resolution overcurrent sense comparator path. this is realized in two ways:

1. Using external comparators with INA301-Q1 devices: This mechanism has two INA301-Q1 devices for bidirectional current sense. Using the Alert pin capability of the INA301-Q1 device, it is possible to get a response time of less than 300 ns.
2. Using the C2000 Internal comparator: This unit also has configurable SINC filters and OSR. The OSR is usually limited to a much lower range, which enables low latency. The output of the filter is passed through a digital window comparator with programmable thresholds. The comparator output is used to trip the PWM signals in case of a short circuit. It is possible to achieve a response time of < 1.5 µs with a SINC 3 filter and OSR of 8.

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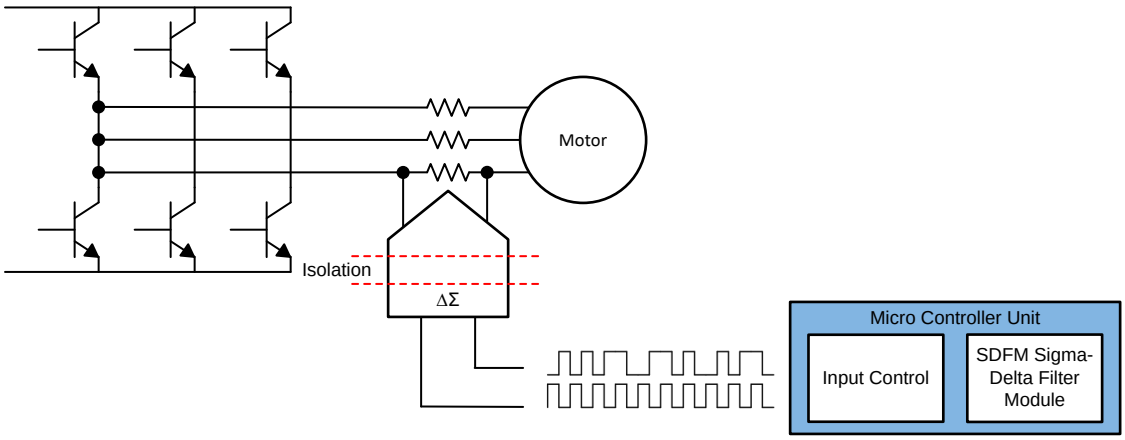

図 1. Phase-Current Sensing in Traction Motor

This reference design consists of the ΔΣ modulator AMC1305M05-Q1 for in-line phase current sensing and is intended to give phase current information to the motor controller unit for traction inverter efficient closed-loop operation. The INA301-Q1 module is specifically used for short-circuit or overcurrent response times. The AMC1305M05-Q1 modulator, along with the INA301-Q1 device is used in this reference design for phase current information sensing.

This TI Design demonstrates the following in a real system:

- Loss of high-side power detection
- Modulator input overrange detection
- Short-circuit detection and response time
- Current measurement accuracy

1.1 Key System Specifications

表 1. Key System Specifications

PARAMETER	SPECIFICATIONS
Continuous motor phase current	28 Arms (40 Apk) per phase maximum
Sensor type	Shunt
Transient overload maximum	80 Apk with 4-mΩ shunt resistor
Phase current measurement error	< 0.5% calibrated
Current consumption	20 mA
Maximum modulator clock frequency	20 MHz
Phase current (protection)	Inverter shutdown on overload
Isolation	Reinforced isolated
Operating temperature range	–40°C to 125°C (temperature range ?)
Microcontroller interface	7 PWM signals, current-sense modulator bit streams for two motor phases, DC-link voltage sense modulator bit stream, temperature sense modulator bit stream, clock signal, 5 V for the controller board
Primary side power	5 V ±5%, 500 mA
Secondary side power	15 V ±5%, 200 mA
PCB layer stack	4 layer, 1-oz copper
PCB size	60 × 42 mm

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2 System Overview

2.1 Block Diagram

図 2 shows the system block diagram of the reinforced isolated in-line precision phase current sensing with a shunt resistor. The TIDA-01543 design is highlighted with a black dashed box.

In-line motor phase current sensing is done by inserting a shunt resistor between the phase output of the inverter and the phase terminals of the motor. The voltage drop across the shunt resistor is sensed by an AMC1305M05-Q1 device. The transfer function of the current sense signal chain path is used to derive the phase current values in the controller.

The bit stream of the ΔΣ modulator output data is decoded and decoding of the data must be done before filtering it. A configurable digital SINC filter is implemented inside the controller to decimate the bit stream from the ΔΣ modulators. To detect the overcurrent conditions, two bidirectional comparators are provided externally. Overcurrent detection capability is provided in two parallel paths, one is with the external comparators and another is in the path of the AMC1305M05-Q1 modulator where internal comparators are used. Externally, comparator circuitry is provided at the isolation side to quickly trigger the IGBT gate driver for the sudden faults.

In this TI Design, SINC filters are implemented within dedicated SDFM present within the TMS320F280049M device. A **hot** side (isolated side) power supply is generated from the SN6501-Q1 device, which gets the supply from 5-V pin of the microcontroller. An LDO (TPS717-Q1) with less Power Supply Rejection Ratio (PSRR) is chosen to regulating the isolated power supply.

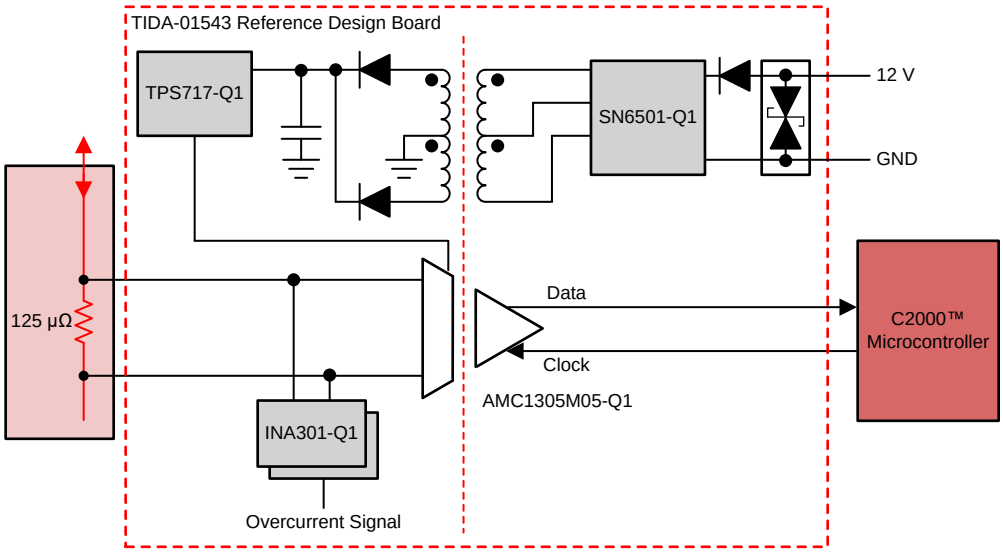

図 2. TIDA-01543 Block Diagram

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2.2 Highlighted Products

2.2.1 AMC1305M05-Q1

The AMC1305M05-Q1 device is a precision, ΔΣ modulator with the output separated from the input circuitry by a capacitive double isolation barrier that is highly resistant to magnetic interference. Used in conjunction with isolated power supplies, the device prevents noise currents on a high common-mode voltage line from entering the local system ground and interfering with or damaging low-voltage circuitry. The input of the AMC1305M05-Q1 device is optimized for direct connection to shunt resistors or other low-voltage level signal sources. The output bit stream of the AMC1305M05-Q1 device is a stream of ones and zeros. By using an appropriate digital filter to decimate the bit stream, the device can achieve 16 bits of resolution with a dynamic range of 85 dB at a rate of 78 ksps. 図 3 shows the conceptual functional block diagram of AMC1305M05-Q1

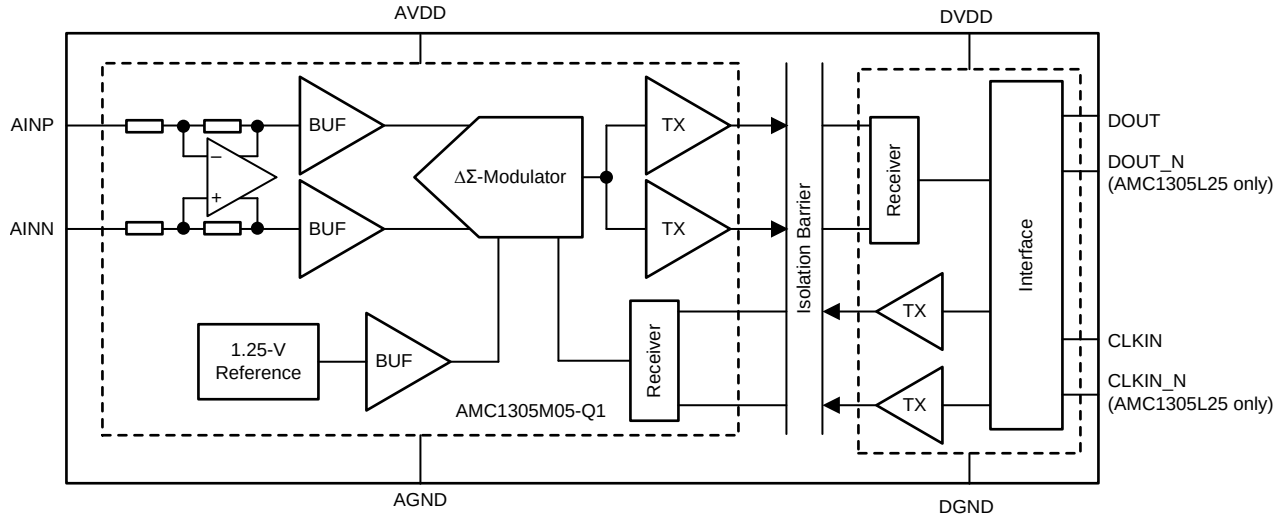

図 3. AMC1305M05-Q1 Functional Block Diagram

2.2.2 SN6501-Q1

図 4 shows the functional block diagram of the SN6501-Q1 device. The SN6501-Q1 device is a monolithic oscillator and power-driver designed for small form factor, isolated power supplies in isolated interface applications. The device drives a low-profile, center-tapped transformer primary from a 3.3- or 5-V DC power supply, has a 350-mA output drive, thermal shutdown and soft start features, and switches at 410 kHz. The secondary can be wound to provide any isolated voltage based on the transformer turns ratio.

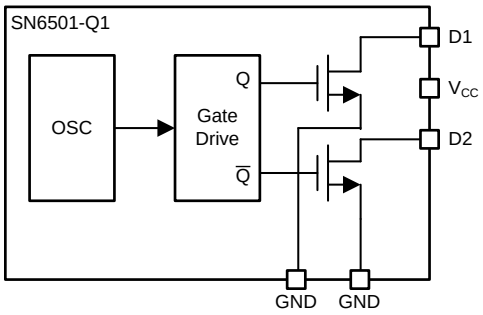

図 4. SN6501-Q1 Functional Block Diagram

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2.2.3 INA301-Q1

The comparator feature of the INA301-Q1 device is used to estimate the response time. The high-speed comparator is configured to provide overcurrent protection by measuring the voltage developed across a current-sensing or current-shunt resistor and comparing that voltage to a defined threshold limit. This device features an adjustable limit-threshold range that is set using a single external limit-setting resistor. This current-shunt monitor measures differential voltage signals on common-mode voltages that can vary from 0 V up to 36 V, independent of the supply voltage. The open-drain alert output can be configured to operate in either a transparent mode, where the output status follows the input state, or in a latched mode, where the alert output is cleared when the latch is reset. The device alert response time is under 1 µs, allowing for quick detection of overcurrent events. This device operates from a single 2.7- to 5.5-V supply, drawing a maximum supply current of 700 µA. The device is specified over the extended operating temperature range from –40°C to 125°C, and is available in an 8-pin VSSOP package. 図 5 shows the conceptual functional block diagram of INA301-Q1.

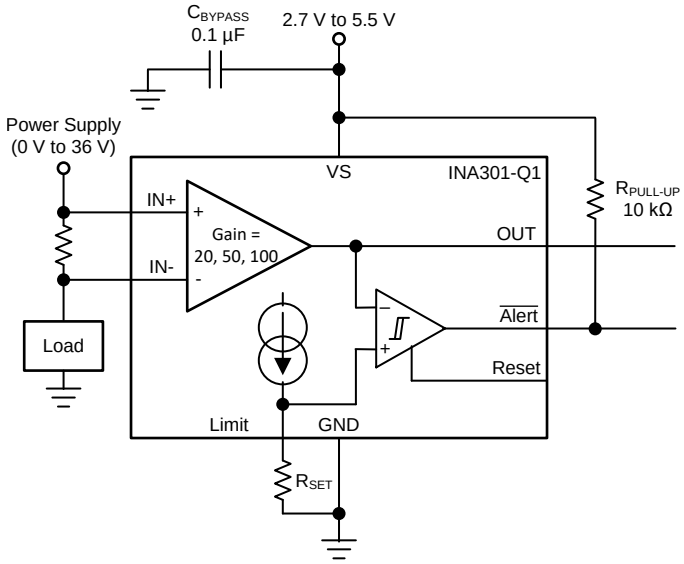

図 5. INA301-Q1 Functional Block Diagram

2.2.4 ISO7710-Q1

The ISO7710 device is a high-performance, single-channel digital isolator with 5000 V_{RMS} (DW package) and 3000 V_{RMS} (D package) isolation ratings per UL 1577. This device is also certified by VDE, TUV, CSA, and CQC.

The ISO7710 device provides high electromagnetic immunity and low emissions at low power consumption, while isolating CMOS or LVCMOS digital I/Os. The isolation channel has a logic input and output buffer separated by a silicon dioxide (SiO2) insulation barrier. In the event of input power or signal loss, the default output is high for a device without suffix F and low for a device with suffix F. Used in conjunction with isolated power supplies, the device helps prevent noise currents on a data bus or other circuits from entering the local ground and interfering with or damaging sensitive circuitry. Through innovative chip design and layout techniques, the electromagnetic compatibility of the ISO7710 device has been significantly enhanced to ease system-level ESD, EFT, surge, and emissions compliance. The ISO7710 device is available in 16-pin SOIC wide-body (DW) and 8-pin SOIC narrow body (D) packages. 図 6 shows the conceptual functional block diagram of the ISO7710-Q1 device.

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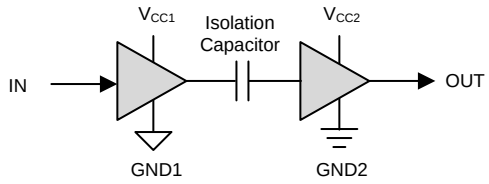

図 6. ISO7710 Functional Block Diagram

2.2.5 TPS71733

The TPS717 family of low-dropout (LDO), low-power linear regulators offer very high PSRR while maintaining very low 45-μA ground current in an ultra-small, five-pin SOT package. The family uses an advanced BiCMOS process and a PMOS pass device to achieve fast start-up, very low noise, excellent transient response, and excellent PSRR performance. The TPS717 is stable with a 1-μF ceramic output capacitor and uses a precision voltage reference and feedback loop to achieve a worst-case accuracy of 3% over all load, line, process, and temperature variations. The device family is fully specified from T_J = –40°C to 125°C and is offered in a small SOT (SC70-5) package, a 2-mm × 2-mm WSON-6 package with a thermal pad, and a 1.5-mm × 1.5-mm WSON-6 package, which are ideal for small form factor portable equipment (such as wireless handsets and PDAs). 図 7 shows the conceptual functional block diagram of TPS71733-Q1 device.

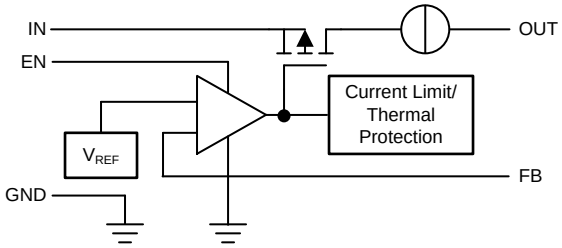

図 7. TPS71733 Functional Block Diagram

2.3 System Design Theory

2.3.1 In-Line Phase Current Sensing

Accurate, linear motor phase current feedback is very important for an accurate position and torque control of the motor. Phase-current information is also required to detect short circuits and overcurrent faults. In this TI Design, shunt-based in-line phase-current sensing is done. Shunt-based current sensing provides the benefits of being highly accurate, linear, and with the smallest form factor, and low cost when compared to Hall sensors or current transformers. The only disadvantage being higher power loss in the shunt resistors at higher currents and the resulting temperature drift. These drifts and non-linearities can be compensated by using a smaller value of shunt and digital processing techniques. The shunt-based approach in the current design measured at a maximum of 300 A with a 100-μΩ shunt. The AMC1305M05 ΔΣ modulators are used for isolated reading of the voltage drop across the shunt resistors. The exact phase current can be computed in software by multiplying the voltage across the shunt resistors by a scaling factor.

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図 8 shows that the OSR and ENOB are proportionally related. The relation between OSR and ENOB shows for all three SINC filters. The more the OSR, the better the resolution will be, but at the cost of settling time as 図 9 shows. Current design chooses the SINC 3 filter implementation for better resolution performance. SINC 2 and SINC 1 filters are also chosen for the overcurrent and sort-circuit detection faults.

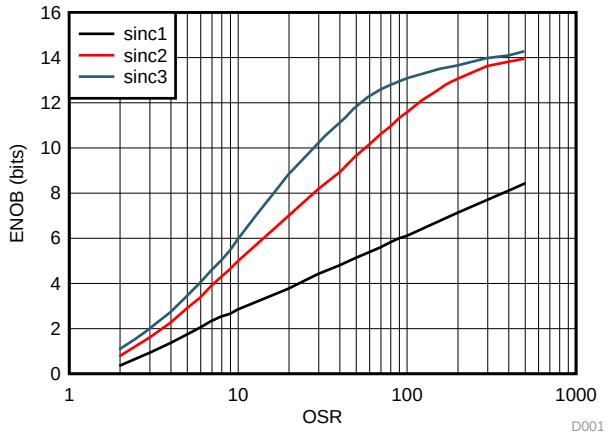

図 8. Measured Effective Number of Bits vs Oversampling Ratio

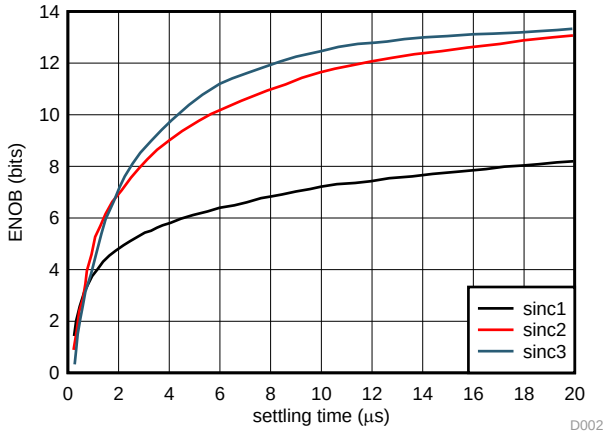

図 9. Measured Effective Number of Bits vs Settling Time

2.3.1.1 Traction Motor Specifications

表 2 shows the parameter specifications for the example traction motor.

表 2. Example Traction Motor Specifications

PARAMETER	SPECIFICATION
Output power	60 kW
Motor efficiency	0.87 per unit
Power factor	0.82
Line-to-line voltage	400 V

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The inverter output power required is calculated in 式 1. The maximum inverter output current taking a 15% tolerance on the minimum grid voltage is calculated in 式 2, it is calculated so that the line current of the motor is 121.394 A. This reflects the fact that for a 60-kW motor, a continuous line current of 121.394 A must be detected. As the wattage increases, the line current increases meaning the design must be scaled to that level.

$$\text{Efficiency} = \frac{\text{Output power in watts}}{\text{Input power in watts}}$$

$$\text{Efficiency} = \frac{\text{Output power in watts}}{\text{power factor} \times \sqrt{3}\, I_L\, V_L}$$

$$0.87 = \frac{60 \times 1000}{0.82 \times \sqrt{3} \times I_L \times 400}$$

$$I_L = \frac{60 \times 1000}{0.82 \times \sqrt{3} \times 0.87 \times 400}$$

$$I_L = 121.394 \text{ A } (\text{line current}) \quad (1)$$

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2.3.1.2 Current Sensing Specifications

As mentioned in 2.3.1.1, the maximum continuous current to be measured is approximately 121 Arms, which leads to a peak current of 143 Apk. A 125-μΩ shunt resistor is used in this TI Design.

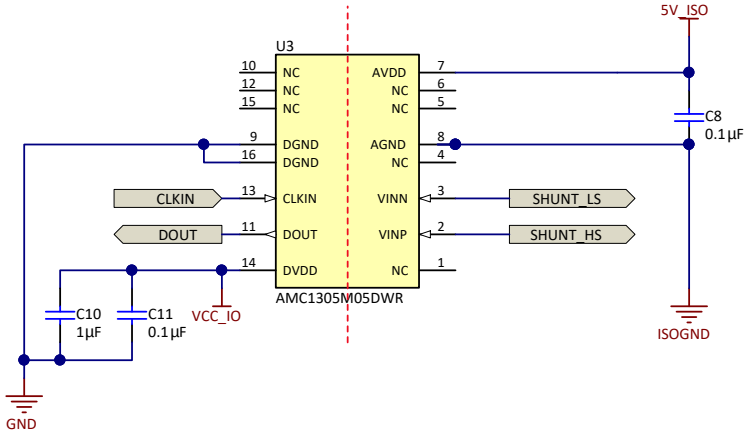

図 10. Phase-Current Sense Schematic With AMC1305M05-Q1

A peak current rating of ±443 Apk results in a ±0.16-V drop across the shunt resistor and a maximum power dissipation of 3.2 W. The AMC1305M05 device has a high-linearity input voltage range of ±50 mV and clips at ±65 mV. This enables a short-term overload current measurement of 1.2 times the maximum continuous current and a short-circuit measurement up to 80 Apk. C85 and C89 are noise-decoupling capacitors on the high-side power supply, and C62 and C66 are noise-decoupling capacitors on the low-side power supply. R47 and R46 are termination resistors on the high-frequency data and clock digital signals. The high-side of the AMC1305M05-Q1 device is powered from the high-side gate driver power supply of U Phase through LDO U22. The LDO LM3480 device is available in a SOT23 package, which enables a very compact solution. The primary-side operating current of the AMC1305M05-Q1 device is 9.8 mA (maximum). This leads to a maximum power dissipation of 98 mW across the LDO. The maximum junction temperature of the LDO at 55°C ambient will be ≈ 80°C.

The data output of the AMC1305M05-Q1 device is a train of pulses containing ones and zeros and connected to the Piccolo microcontroller TMS320F0049M. The controller SDFM peripheral decodes the data arriving from AMC. The decoded data is simultaneously passed through two paths. One path is a high-OSR, SINC 3 filter path with high accuracy and latency suitable for motor position and torque control. The other path is a low-OSR path with low accuracy and latency suitable for short-circuit detection. TI recommends using a 128-OSR, SINC 3 filter for motor phase current sensing and an 8-OSR, SINC 3 filter for short-circuit detection.

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2.3.2 Primary Side 3.3-V Power Supply

As 図 11 shows, the primary side of the board is provided with a 5-V input through terminal block J2 . D1 is a Schottky diode for reverse polarity input protection. C5 is the input bulk capacitor, and C14 is for noise decoupling. An LDO TLV1117-33 device is used to generate 3.3 V from the input supply. A 100-µF bulk capacitor and 0.1-µF noise-decoupling capacitor are used on the output. The maximum output current required from the LDO is 40 mA. The maximum power dissipation is 68 mW, which leads to a maximum junction temperature of 57.6°C for 55°C ambient.

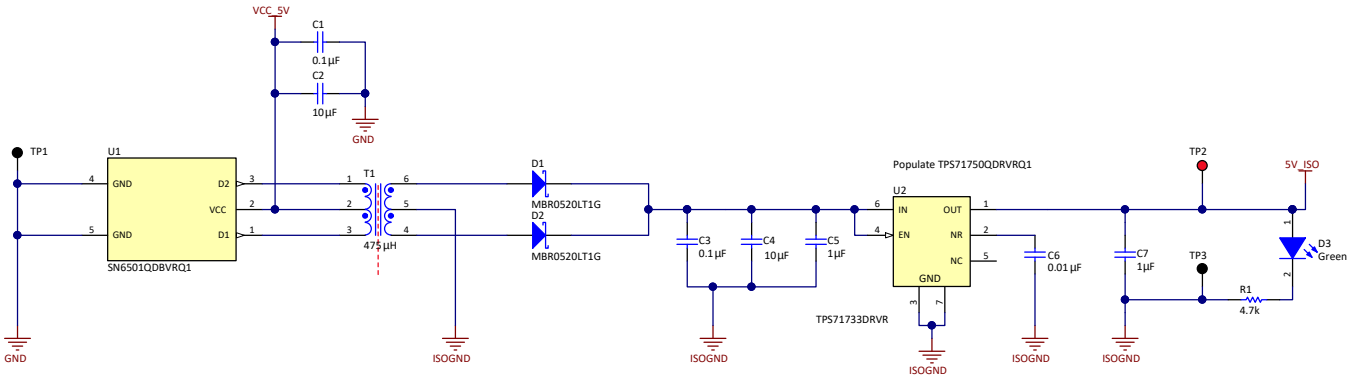

図 11. Isolated Power Supply Schematic

2.3.3 Digital Isolator

Short-circuit and overcurrent faults are estimated using the INA301-Q1 device. The INA sits on the isolated side and turn off the IBGT through the gate driver, whenever there is a fault. This protects the IGBTs from damage faults. There is also the possibility for the INA output to bring it to the cold side via a digital isolator, which facilitates the programming for the INA301-Q1 alert function. The ISO7710 device is used as a digital isolator to bring the INA output on the cold side. 図 12 shows the digital isolator schematic where the input of the isolator is connected to the INA301-Q1 ALERT pin and output (OC_OUT) is given to the one of the GPIO pins of the C2000 F0049M controller.

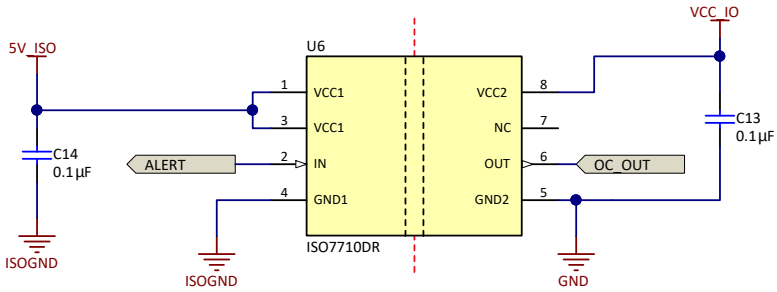

図 12. Digital Isolator Schematic

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2.3.4 Short-Circuit Response Time With the INA301-Q1

Overcurrent and short-circuit faults are detected using an external shunt monitor, as well as with the C2000 internal comparator. 図 13 shows the INA301-Q1 external shunt schematic.

Two INA301-Q1 devices are used in a Kelvin configuration for bidirectional current sensing. 図 13 shows the IN+ and IN– pins are connected to the shunt and overcurrent fault is directly reported to the gate driver module of the IGBT.

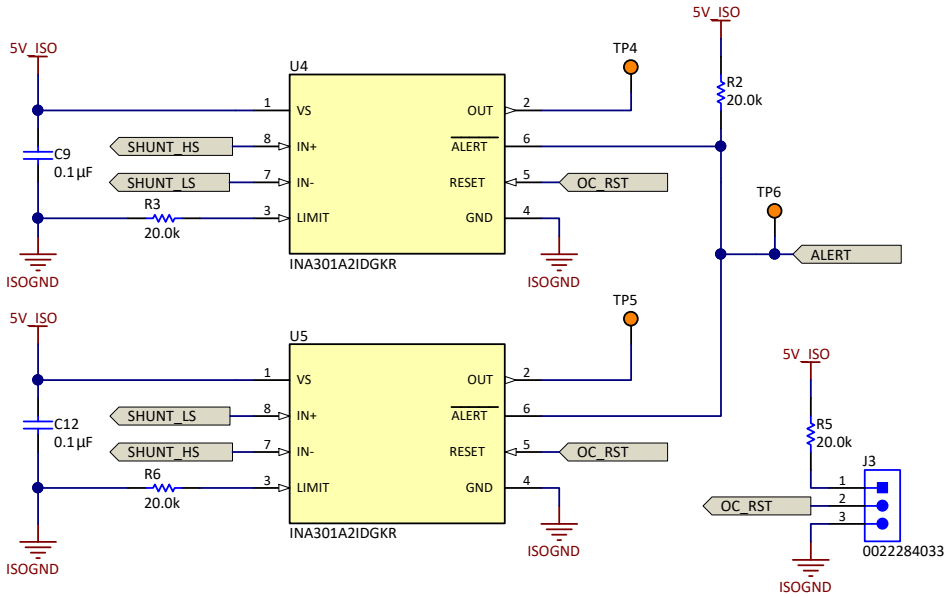

図 13. Overcurrent and Short-Circuit Detection Schematic

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3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

3.1.1 Hardware

図 14 shows the top view of the PCB. The respective blocks are shown with the red dashed lines. A shunt is placed on the left side connector, followed by INA301-Q1 circuitry and the isolated modulator. These are connected in a Kelvin configuration. The right bottom side has the SN6501-Q1 isolated power supply. A clear isolation barrier is maintained along the paths of the AMC1305M05-Q1, SN6501-Q1, and ISO7710. A 6-pin connector is connected to the microcontroller on the right side. 表 3 provides the pin descriptions of the connector and 図 15 shows the positions of the hardware.

表 3. Pin Descriptions

TIDA-01543 SIDE CONNECTOR	C2000™ MICROCONTROLLER SIDE
VCC_IO	3.3-V connector
VCC_IO	5-V connector
CLKIN	Pin 49 and 69 together
DOUT	Pin 67
OC_OUT	Any of the GPIOs
GNF	GND

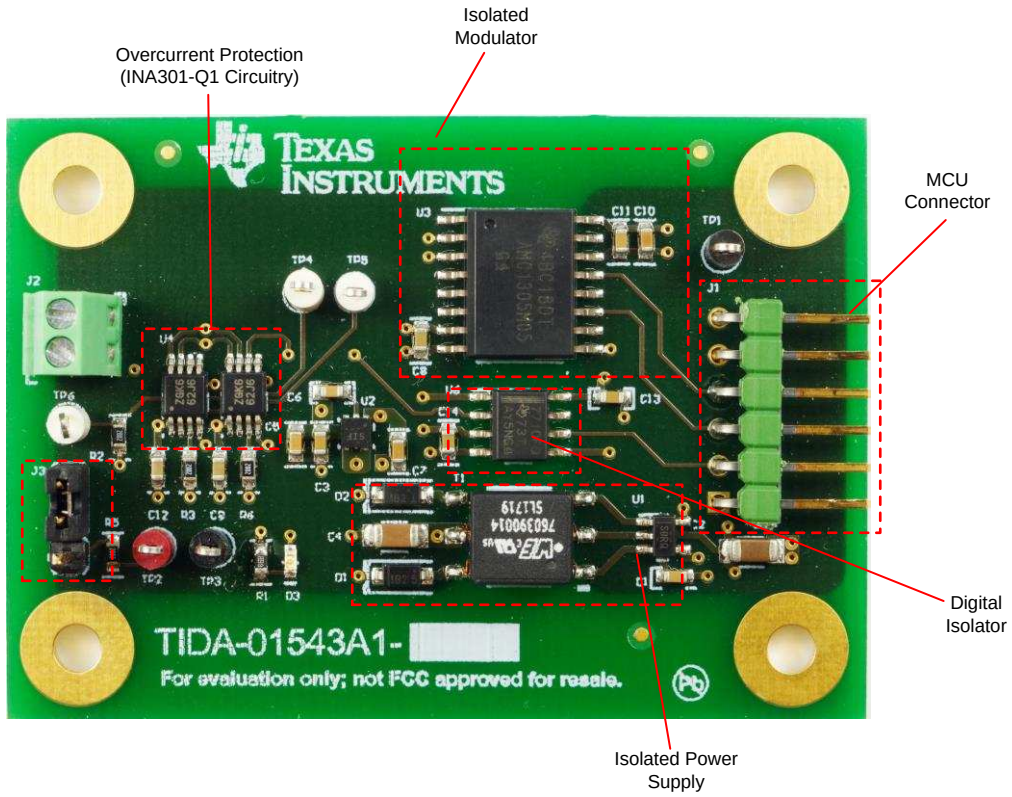

図 14. TIDA-01543 PCB Description

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The C2000 Piccolo microcontroller F20049M control card is interfaced as shown in 図 15 with the TIDA-01543 board. The USB communication control card communicates with the PC.

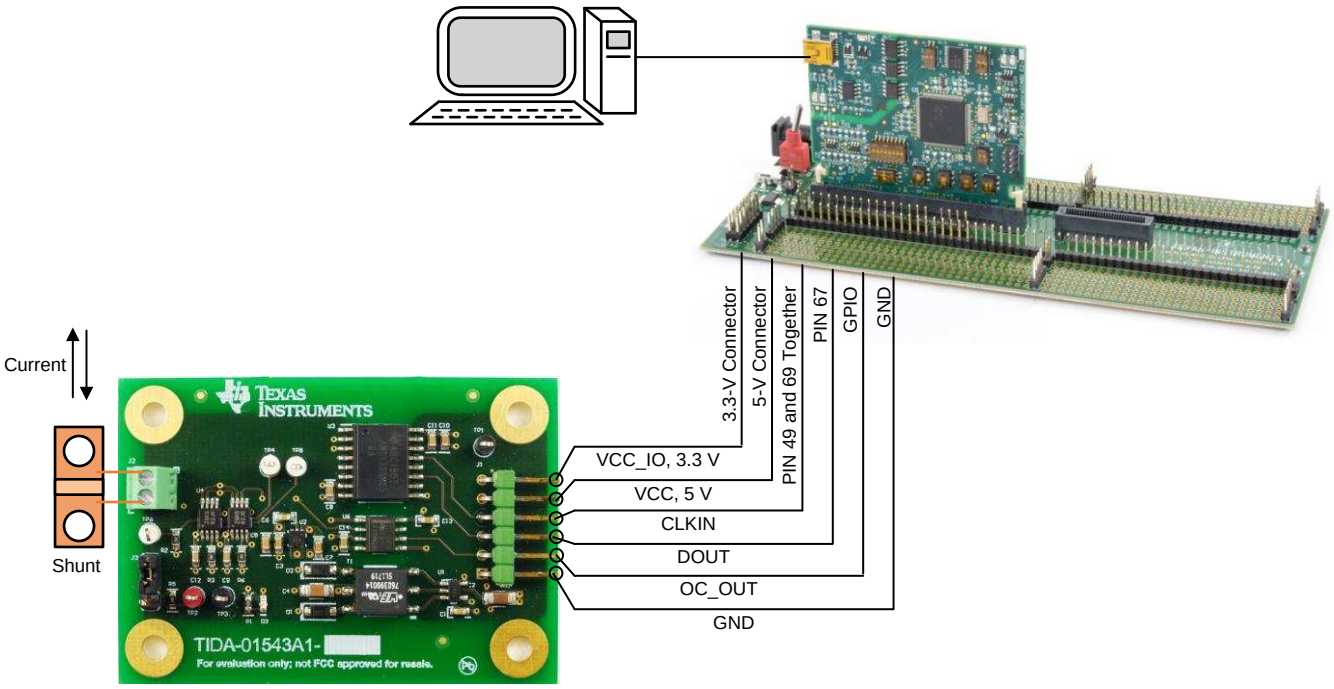

図 15. TIDA-01543 Board Setup

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3.2 Testing and Results

The focus of the tests is to evaluate the functionality and performance of the shunt resistor-based reinforced isolated in-line phase current sensing using the AMC1305M05 ΔΣ modulator. 表 4 lists the key test equipment used.

3.2.1 Test Setup

The TIDA-01543 is mainly tested for two aspects of phase current sensing:

1. Accuracy
2. Response time

図 16 and 図 17 show the test setup for the accuracy and response time, respectively. 表 4 shows the required test equipment needed for the two tests.

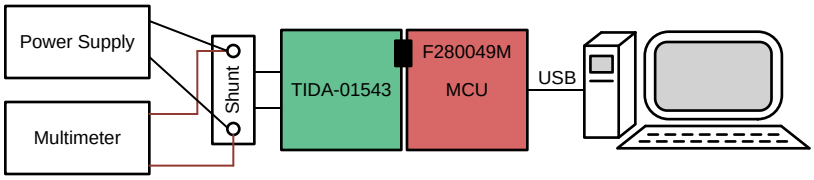

図 16. TIDA-01543 Accuracy Test Setup

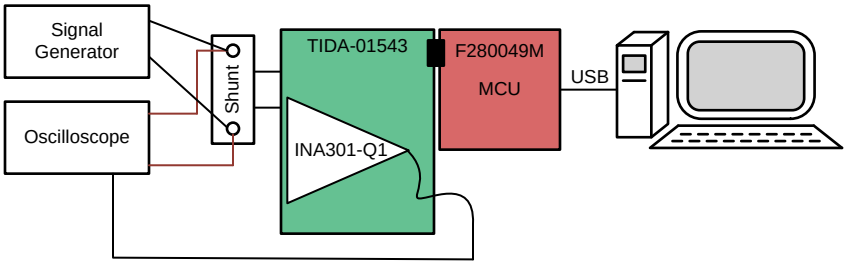

図 17. TIDA-01543 Response-Time Test Setup

表 4. Test Equipment

DESCRIPTION	PART NUMBER
Oscilloscope	Tektronix MDO4104B-3
Single-ended probes	Tektronix TPP1000
Current probe	Keysight N2781B
Current probe amplifier	Agilent N2779A
Multimeter	HP 3458 8 1/2 digit multimeter
Power supply	Keithley 2230G-30-1

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3.2.2 Test Results

The focus of the tests is to evaluate the functionality and performance of the shunt resistor-based reinforced isolated in-line phase current sensing using the AMC1305M05-Q1 ΔΣ modulator and INA301-Q1 comparator.

3.2.2.1 Short-Circuit Response Time

Short-circuit protection is very important to protect both the motor and inverter power stage from damage. On short circuits, the IGBTs have to be switched off within 1 µs. Newer generation IGBTs switch faster but usually trade off with robustness against short circuit. These IGBTs have to be switched off in less than 500 ns. The TIDA-01543 detects the short circuit in two configurations:

1. Using the AMC1305M05-Q1 modulator comparator block
2. Using the INA301-Q1 external comparator circuit

3.2.2.1.1 Short-Circuit Response Time Using AMC Modulator

The response time to short circuit depends on the order of the SINC filter used and the OSR chosen in the C2000 microcontroller. The Sigma delta filter module has separate comparator modules for short-circuit response time events. Response time can be represented with 式 2:

$$Response\ \ time\ \ Tr\ \ =\ \ n\ \ \times\ \ \frac{OSR}{Fs} \tag{2}$$

where

- n is the order of the SINC filter
- OSR is the oversampling ratio of the SDFM
- Fs is the modulator clock frequency

The short-circuit response time is captured for three different combinations of SINC filter order and OSR:

- SINC 1, 24 OSR
- SINC 2, 12 OSR
- SINC 3, 8 OSR

Each of the three combinations have the same theoretical response time of 1.2 µs. For the test setup, the shunt resistor is unpopulated and the AMC inputs (shunt connector) are instead connected to a function generator. The function generator applies a positive and negative step input. The output of the SDFM comparator module is routed to a GPIO. The response time is equal to the time delay between the rising edges of the step input and the GPIO signal. An additional delay of approximately 200 ns to 300 ns is captured in the test results, which is due to the time required to execute the instructions needed to toggle the GPIO pin. The short-circuit detection threshold is set to ±143 A. The threshold values must be set in the software for the different filter combinations.

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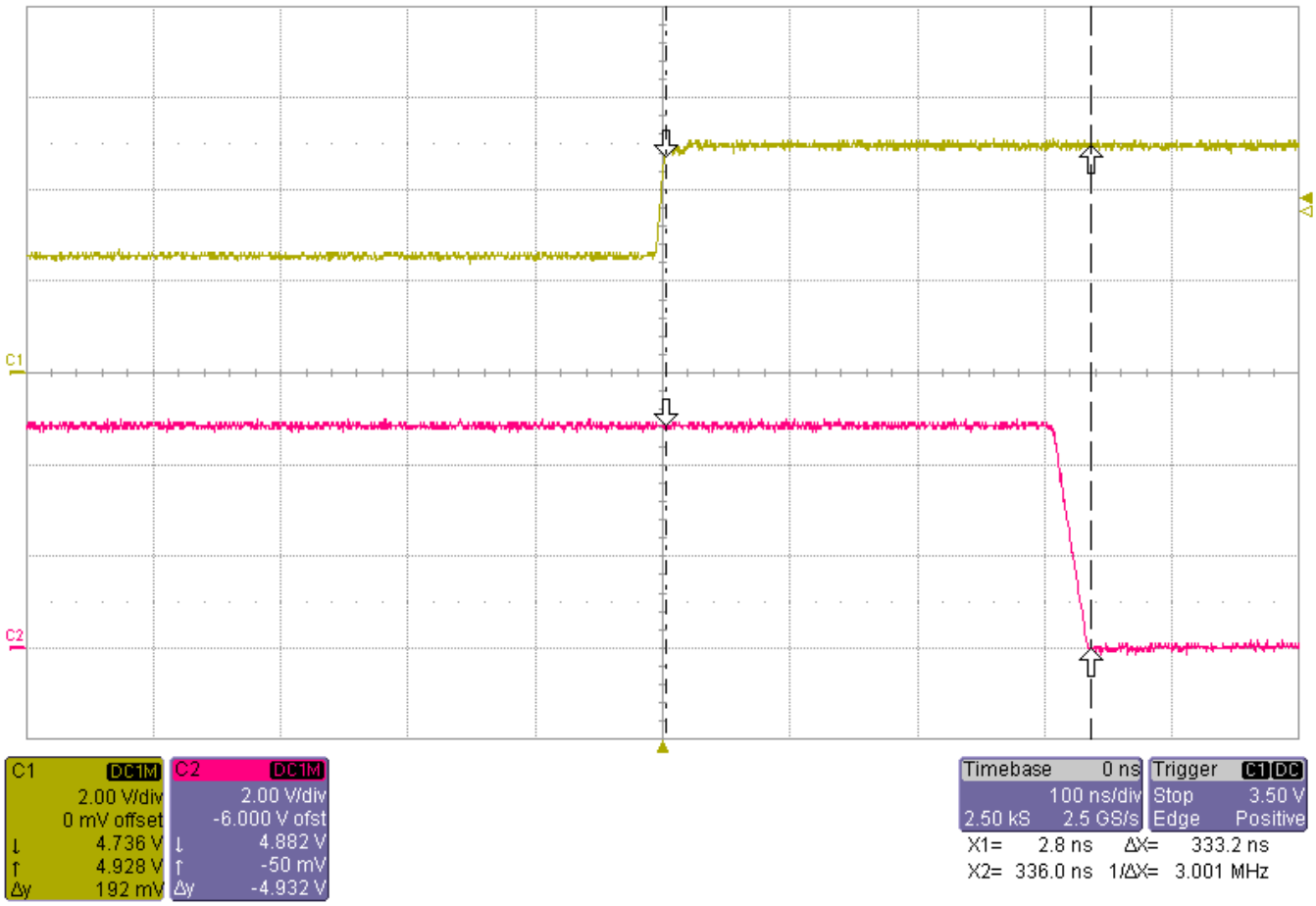
3.2.2.2 Short-Circuit Response Time Using INA301-Q1

The response time to overcurrent event should be very less to protect the IGBTs from overcurrent faults. To facilitate the fast response times, an external INA301-Q1 device is selected. 図 18 shows the short-circuit response time.

図 18 shows the response time plot verses input and output voltages. Output starts 333.2 ns after the input is triggered.



C1 – green: input, C2 – pink: output

図 18. Step Input Response Time

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図 19 shows the response time graph with the Alert output function. Alert output directly acts as a comparator and is used to directly give to the gate drivers. Alert output triggers at exactly 333.2 ns, a good turn off response time for IGBT.

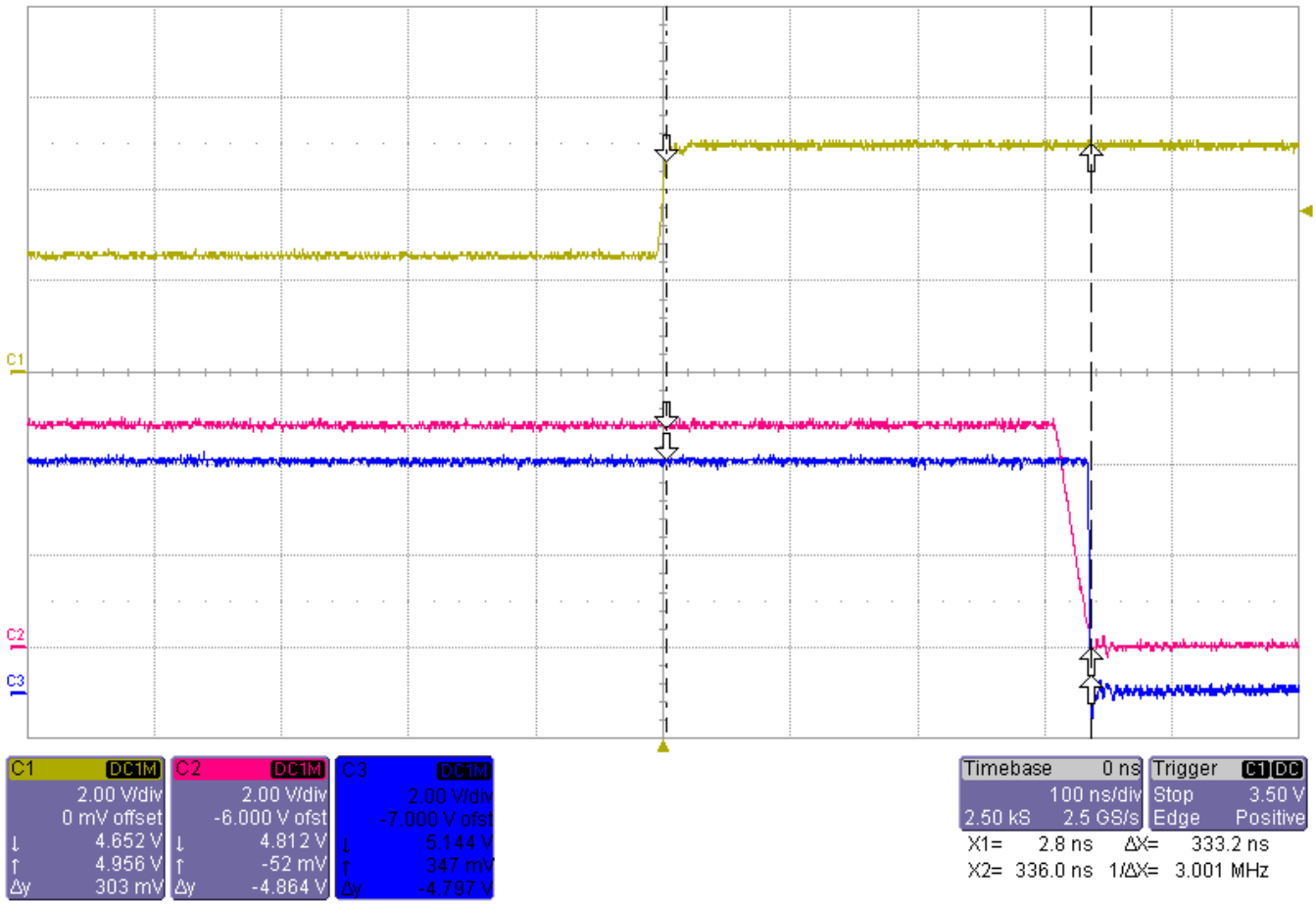

図 19. Step Input Response Time With Alert Output

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図 20 and 図 21 show the response times for pulse inputs. The edge of the pulse started at 330 ns. Using the edge-interrupt capability of the microcontroller and using the alert function (blue line), respective action can be taken for IGBT turn off.

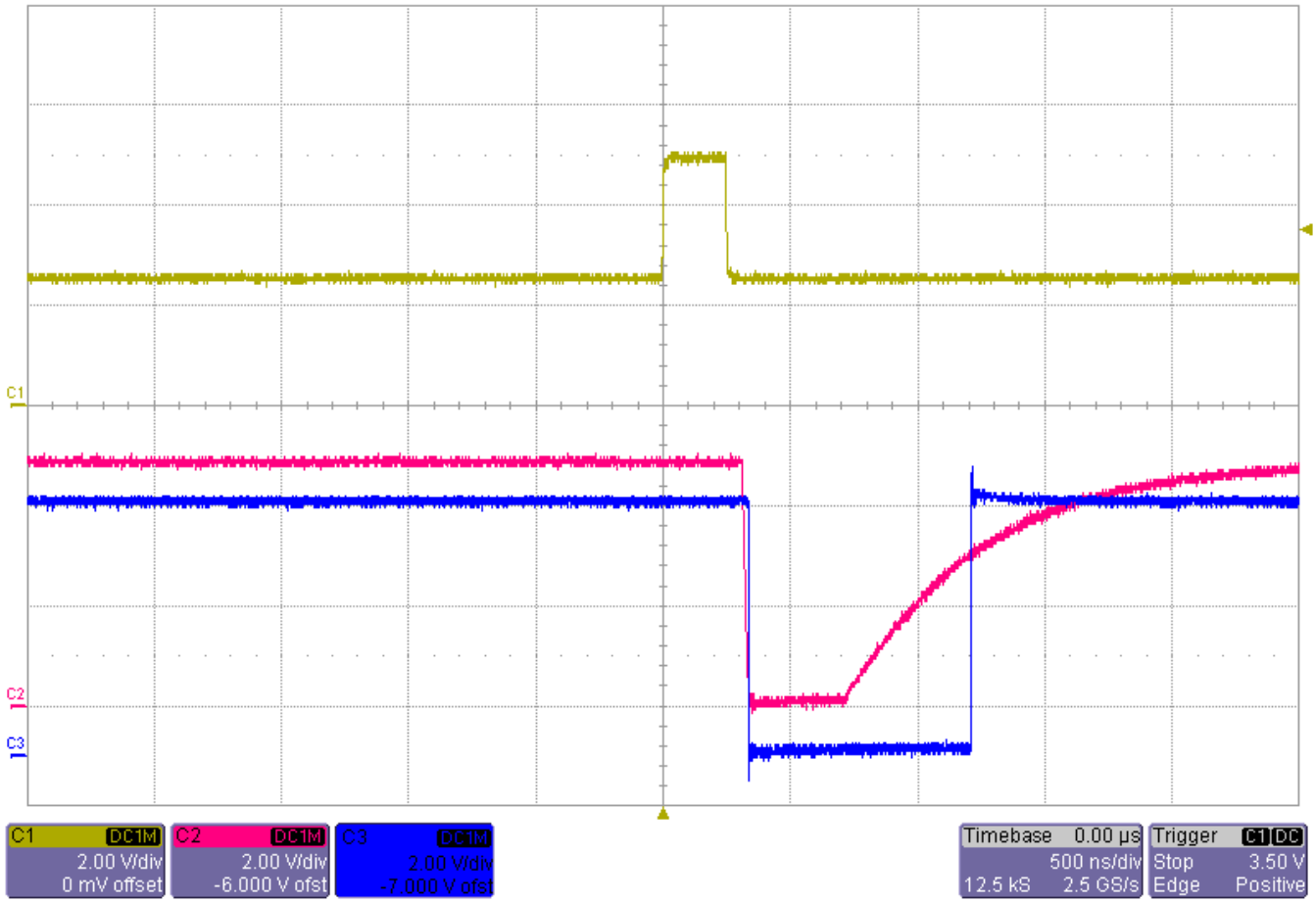

図 20. Pulse Input Response Time 25 mV to 50 mV

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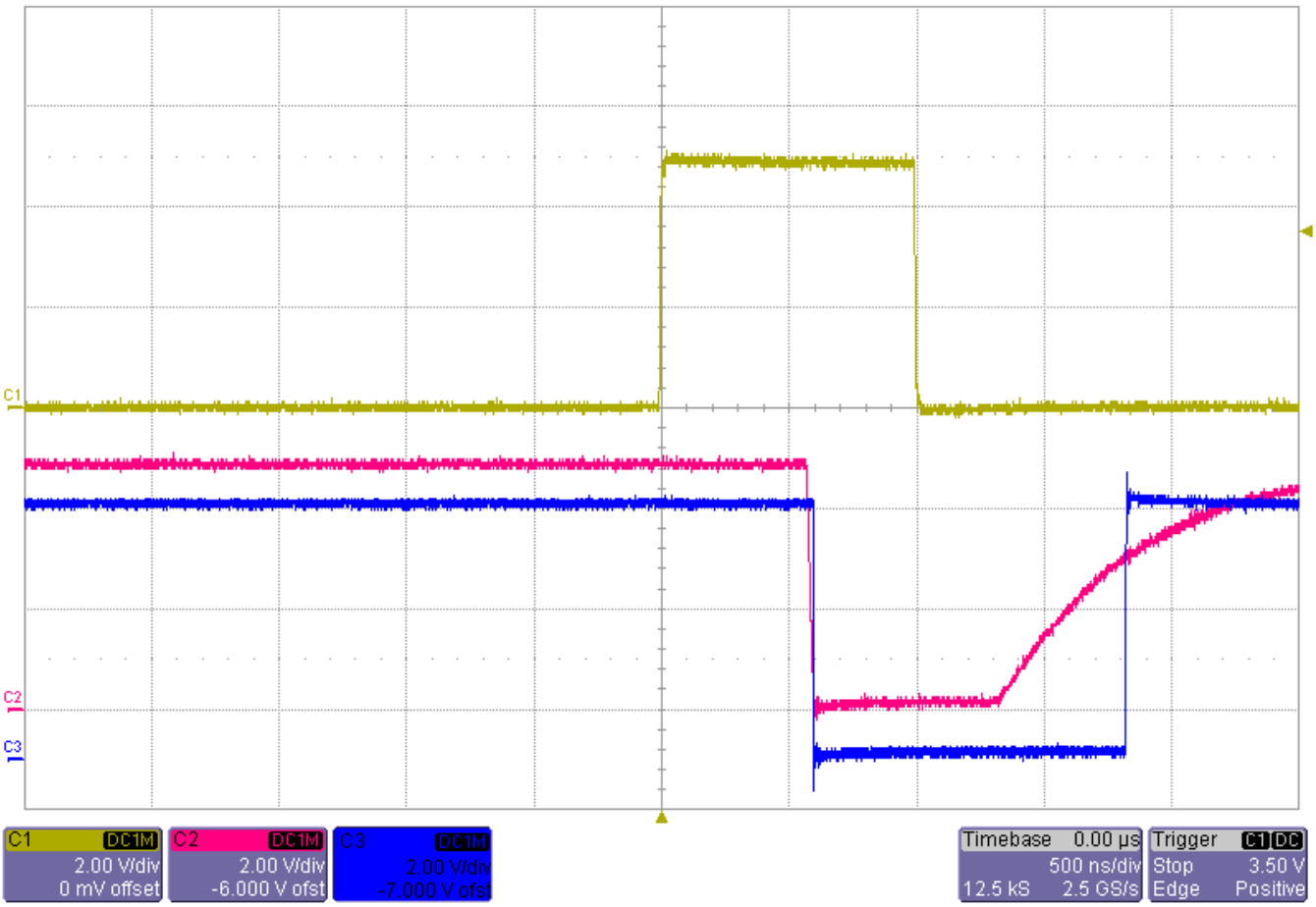

図 21. Pulse Input Response Time 0 mV to 50 mV

3.2.3 Current Sense Measurement Accuracy

図 22 shows the test setup for checking the performance of the current measurement. Current sense accuracy is tested in two different ways. One is using the direct shunt and another way is with the source meter connected to the terminals of the board (where the shunt usually connects).

A 1-mΩ and a 100-µΩ shunt are connected and tested. This shunt resistor is used to measure the phase current. The voltage drop across the shunt resistor is measured by the AMC1305M05-Q1 ΔΣ modulator. The modulator output bit stream is channeled into the control card. The control card is configured to implement SINC filters of different orders and OSRs. The reading from the control card is compared with the actual phase current measured with a multimeter to determine the measurement error. For characterizing the current measurement performance, a DC current has been pumped into the circuit.

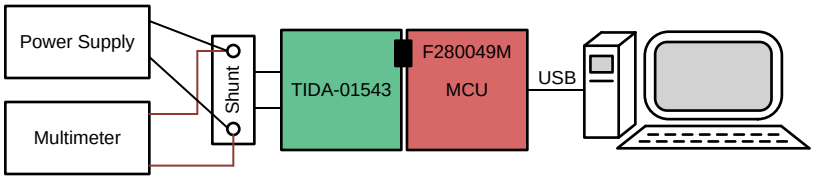

図 22. Accuracy Test Setup

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図 23 shows a graph of source meter voltages versus modulator output. To calculate the accuracy, a multimeter is connected across the input terminals of the AMC and it is accurate across the output terminals (output from the C2000 microcontroller). As 図 23 shows, the X axis indicates the current in Amperes and the Y axis shows the full-scale range error. The modulator is configured for SINC3 and 256 OSR, with the modulator clock frequency of 20 MHz. Because of the setup limitations, this is applied via the source meter.

図 23 shows the full-scale range accuracy plotted over different temperatures. A SINC 3 filter with 256 OSR is used, and the measurements are done at 0°C, 25°C, 50°C, and 100°C.

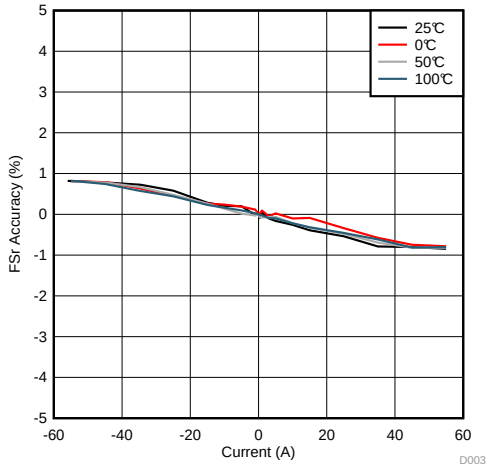

図 23. Accuracy Over Temperature

図 24 shows the accuracy plotted for a 100-µΩ shunt resistor. Here the shunt is connected to the terminals of the board and using 125-A power supply current, is made to flow through the resistor. The multimeter is connected across the terminals to precisely measure the current injected into the system.

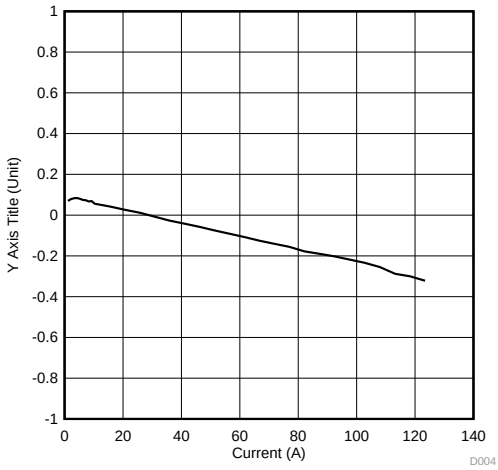

図 24. Accuracy With 100-µΩ Resistor

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4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDA-01543.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-01543.

4.3 PCB Layout Recommendations

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-01543.

4.4 Altium Project

To download the Altium project files, see the design files at TIDA-01543.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-01543.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-01543.

5 Software Files

To download the software files, see the design files at TIDA-01543.

6 Related Documentation

1. Texas Instruments, *AMC1305x-Q1 High-Precision, Reinforced Isolated Delta-Sigma Modulators*
2. Texas Instruments, *SN6501-Q1 Transformer Driver for Isolated Power Supplies*
3. Texas Instruments, *INA301-Q1 36-V, Automotive, High-Speed, Zero-Drift, Voltage-Output, Current-Shunt Monitor with High-Speed, Overcurrent Protection Comparator*
4. Texas Instruments, *ISO7710 High Speed, Robust EMC Reinforced Single-Channel Digital Isolator*
5. Texas Instruments, *TPS717xx Low Noise, High-Bandwidth PSRR Low-Dropout 150mA Linear Regulator in SC70-5*

7 About the Author

SANDEEP TALLADA is a systems engineer at Texas Instruments. As a member of the Automotive Systems Engineering team, Sandeep focuses on HEV/EV, powertrain end-equipments and creating subsystem reference designs. He brings to this role experience in sensor systems technology. Sandeep earned his master of science in sensor systems technology from the University of Applied Sciences Karlsruhe, Germany.

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2018年7月発行のものから更新 **Page**

- 「*概要*」セクションおよびドキュメント全体でAMC1305M05をAMC1305M05-Q1に 変更 1
- 「*特長*」セクション、およびドキュメント全体でINA301をINA301-Q1に 変更 1
- C20000 to C2000 in the *System Description* section, and globally throughout document. 変更 2
- AMC1305 to AMC1305M05-Q1 in the *Block Diagram* section, and globally throughout document. 変更 4
- SN6051-Q1 to SN6501-Q1 in the *SN6501-Q1 Functional Block Diagram* image. 変更 5
- MAC1305M05 to AMC1305M05-Q1 in the *Phase-Current Sense Schematic With AMC1305M05-Q1* figure caption. 変更 10
- AMC1306 and AMC1306E25 to AMC1305M05-Q1 in the *Current Sensing Specifications* section. 変更 10
- NA301-Q1 to INA301-Q1 in the *Short-Circuit Response Time With the INA301-Q1* section header. 変更 12
- SN6501 to SN6501-Q1 in the *Hardware* section. 変更 13

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