参考資料

TI Designs: TIDA-01569
デジタル診断および保護機能を持つ4チャネル・アンテナLDOのリファレンス・デザイン

TEXAS INSTRUMENTS

概要

この車載用リファレンス・デザインは、リモート、オフボードの負荷に、多くの場合は同軸ケーブルで給電する方法を示しています。このデザインは、オフボードのケーブルに発生しやすい各種の障害からの保護と、デジタル的な診断を行います。I^{2}Cおよびフォルト・フラグにより、逆極性、逆電流、バッテリへの短絡、グランドへの短絡、サーマル・シャットダウンに対する保護、およびこれらの診断が行われます。内蔵の逆電流保護機能は、デバイスの出力に外付けダイオードを必要としないため、コストを削減でき、ドロップアウト電圧の増大を避けることができます。

リソース

TIDA-01569	デザイン・フォルダ
TPS7B7702-Q1	プロダクト・フォルダ
ADS7142	プロダクト・フォルダ
TPS7B69-Q1	プロダクト・フォルダ

TI E2E™ Community

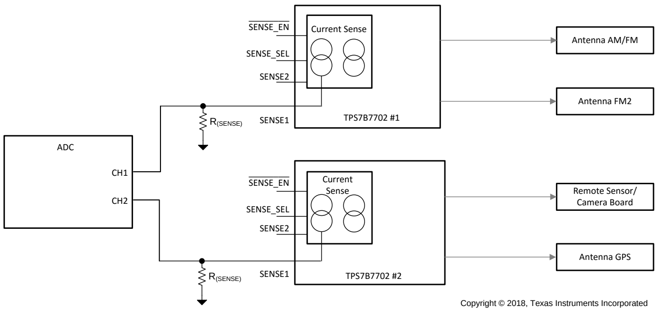
E2Eエキスパートに質問

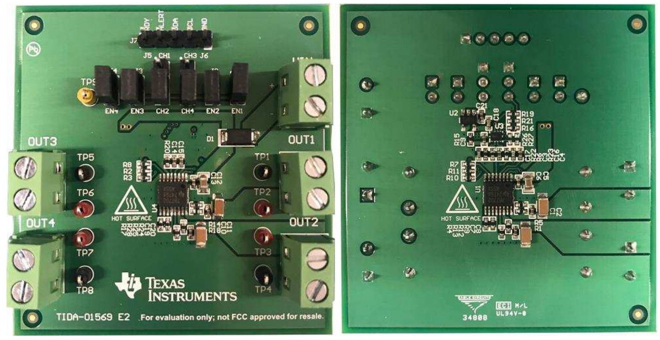
特長

- 4.5V～40Vの広い入力電圧範囲と、45Vの負荷ダンプ
- 出力電圧は1.5V～20Vに可変、出力電流はチャネルごとに最大300mA
- アンテナのオープン、正常、過電流、短絡を高精度で検出
  - I/O < 10 mAで20%
- I^{2}C互換のインターフェイス: 2線式I^{2}Cで1.8Vおよび3.3Vをサポート
- チャネルおよびデバイス間の電流検出の多重化により、ADCチャネル数を削減
- インテリジェントなデジタル機能
  - HIGHおよびLOWのスレッショルドをプログラム可能な、デジタル・ウィンドウ・コンパレータ
  - データ・バッファとアキュムレータ
- 完全な診断機能と内蔵の保護機能
  - 電流検出により、I^{2}Cですべてのフォルトを識別可能
  - 開放負荷検出
  - バッテリ逆極性保護
  - 出力過電流検出
  - -1Vの出力誘導性負荷クランプ

アプリケーション

- 車載用ヘッド・ユニット
- 車載用アフターマーケット・ヘッド・ユニット
- 車載用eCall
- 車載用TCU
- 車載センサ・フュージョン
- 車載用サラウンド・ビュー・システムのECU





1 System Description

The end equipment for many automotive infotainment systems and advanced driver assistance systems (ADAS) require use of a remote phantom power supply. Antennas, remote sensor boards, and microphones are all pieces of end equipment that require a remote phantom power supply. Typically, this power is delivered over a coaxial cable and can span 1 m to 5 m in length. Diagnostics are crucial in these applications because such long spans of cable can face exposure to a variety of faults, such as shorting to the ground and battery, or becoming an open circuit. Antennas are often present at different locations on a vehicle and in a variety of form factors. Additionally, a single-antenna unit may encompass multiple communication functions and low-noise amplifiers; for example, some cars may have an AM/FM antenna on the rear window as well as a shark fin antenna on top of the car for cellular, GPS, and satellite radio. These various antenna types usually require the allocation of several channels from an antenna low-dropout linear regulator (LDO).. Powering a remote camera or sensor board is also a common application for antenna LDOs in automotive applications, in addition to microphones, which are used for hands-free communication. Microphones typically require a separate location from the head unit because the power must be provided through the same transmission lines as the data.

1.1 Key System Specifications

表 1. Key System Specifications

PARAMETER	SPECIFICATIONS	DETAILS
Input voltage	13.5 V	
Output channels	4	2.3.1
Channel 1	Output 1 on LDO 1 (U4)	
Output voltage	Switch (V_{IN} – V_{DROP})	2.3.2
Current limit	300 mA	2.3.5
Channel 2	Output 2 on LDO 1 (U4)	
Output voltage	12 V	2.3.2
Current limit	250 mA	2.3.5
Channel 3	Output 1 on LDO 2 (U1)	
Output voltage	10 V	2.3.2
Current limit	150 mA	2.3.5

表 **1. Key System Specifications (continued)**

PARAMETER	SPECIFICATIONS	DETAILS
Channel 4	Output 2 on LDO 2 (U1)	
Output voltage	8 V	2.3.2
Current limit	50 mA	2.3.5
Board size	56 mm × 58 mm	2.3.3
Solution size	17 mm × 23 mm (approximately 390 mm^2)	2.3.3

2 System Overview

2.1 Block Diagram

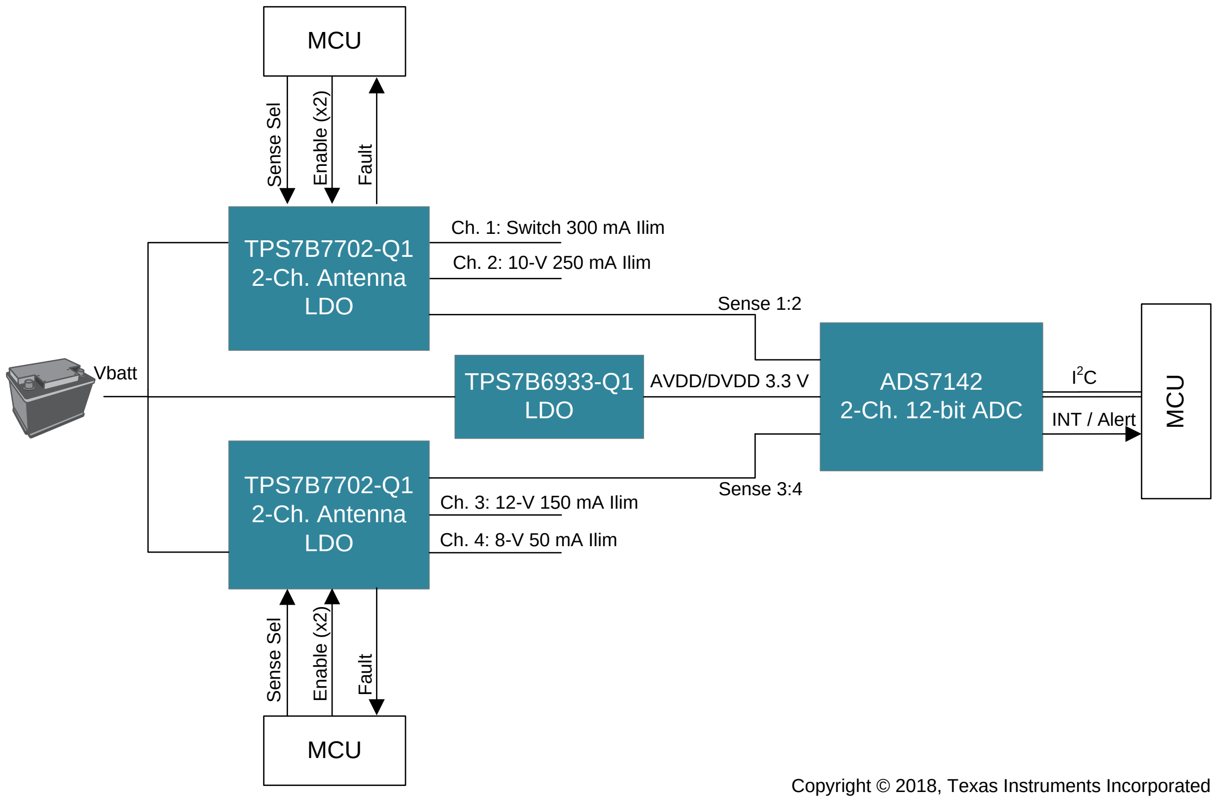


図 1. TIDA-01569 Block Diagram

2.2 Highlighted Products

2.2.1 TPS7B7702-Q1

The TPS7B770x-Q1 family of devices are single- or dual-channel, high-voltage, LDO regulators with a current-sense function. The device is designed to operate with a wide input-voltage range of 4.5 V to 40 V (45-V load dump protection). The device also offers protection against electrostatic discharge (ESD) for antenna lines and protection from short-to-ground, short-to-battery (STB), and thermal overstress. The device output voltage is adjustable from 1.5 V to 20 V through an external resistor divider. Alternatively, each channel can be configured as a switch.

The device monitors the load. Accurate current sense allows for detection of open, normal, and short-circuit conditions without the need for further calibration. The current sense can also be multiplexed between channels and devices to save analog-to-digital converter (ADC) resources. Each channel also provides an adjustable current limit with the external resistor.

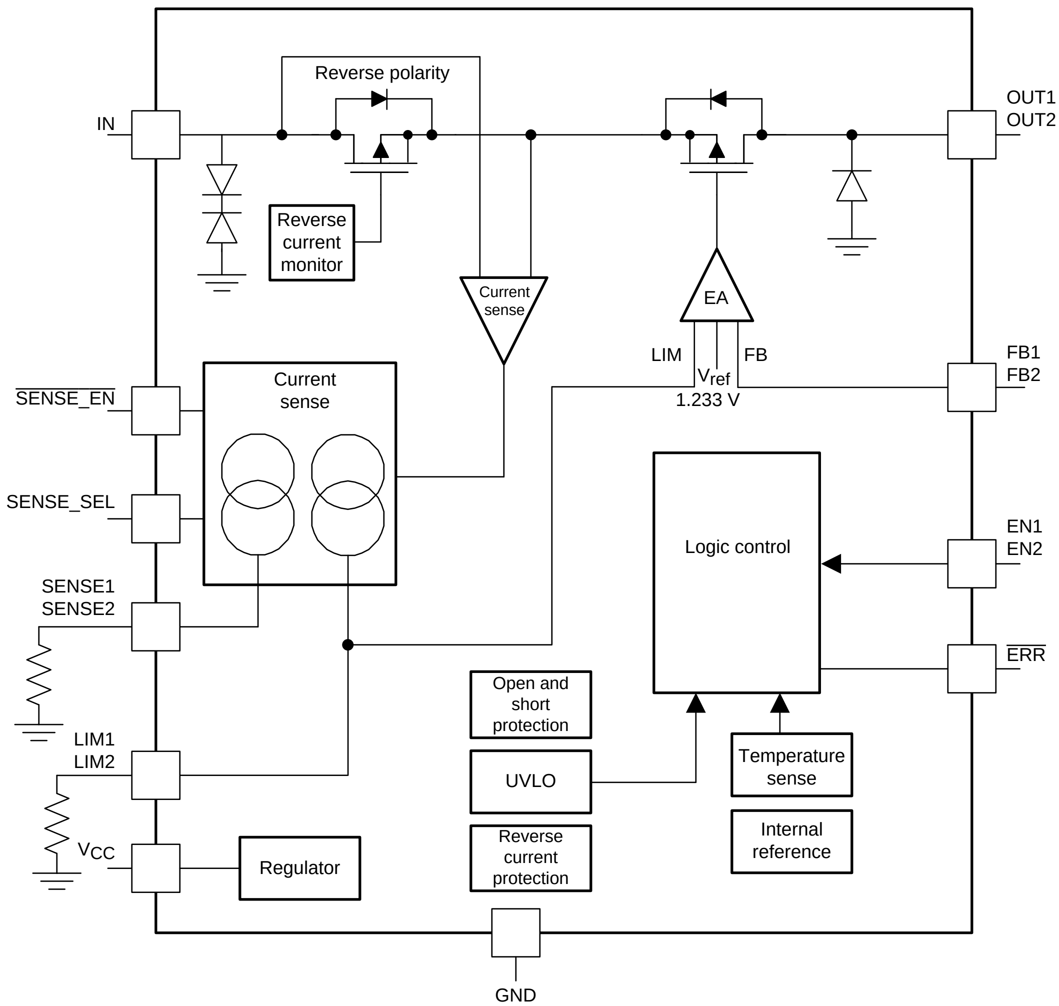


図 2. TPS7B7702-Q1 Functional Block Diagram

2.2.1.1 Fault Detection and Protection

The device includes both analog current sense and digital fault pins for full diagnostics of different fault conditions.

The current-sense voltage scale is selected based on the output current range of interest. 図 3 shows a recommended setting that allows for full diagnostics of each fault. Before the device goes into current-limit mode, the output current-sense voltage is linearly proportional to the actual load current. During a thermal-shutdown (TSD) or STB condition, the current-sense voltage is set to the fault voltage level that is specified in the Electrical Characteristics table available in *TPS7B770x-Q1 Single- and Dual-Channel Antenna LDO With Current Sense*.

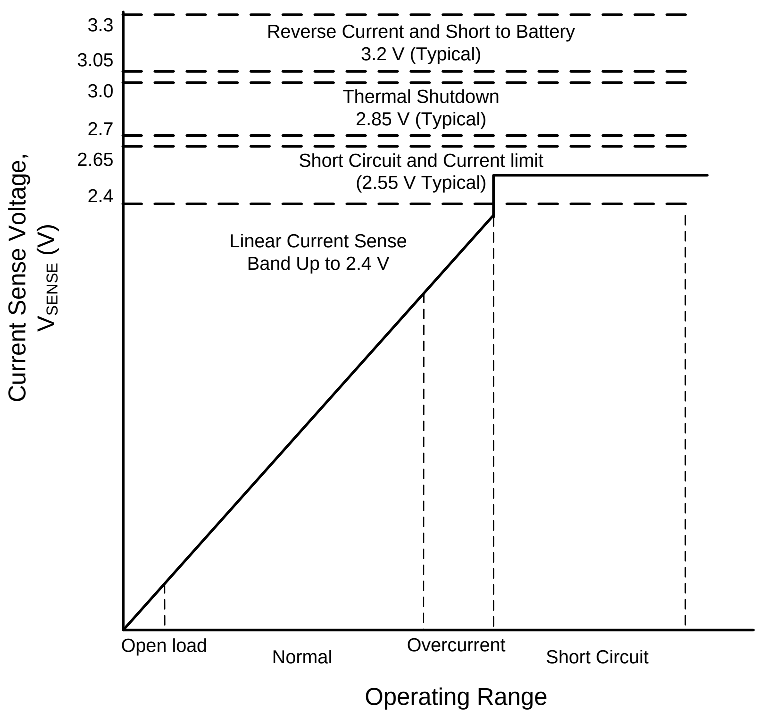


図 3. Functionality of Current-Sense Output

2.2.2 ADS4172

The ADS7142 is a nano-power, dual-channel, programmable sensor monitor with an integrated ADC, input multiplexer, digital comparator, data buffer, accumulator, and internal oscillator. The input multiplexer (see the Analog Input and Multiplexer section of *ADS7142 Nanopower, Dual-Channel, Programmable Sensor Monitor*) can either be configured as two single-ended channels, one single-ended channel with remote ground sensing, or one pseudo-differential channel where input can swing around AVDD/2. The device includes a digital window comparator (see the Digital Window Comparator section) with a dedicated output pin, which can be used to alert the host when a programmed high or low threshold is crossed. The device address is configured by the I^2C address selector block (see the I^2C Address Selector section). The device uses internal oscillators (high speed or low power) for conversion (see the Oscillator and Timing Control section). The start of conversion is controlled by the host in Manual mode (see the Manual Mode section) and by the device in Autonomous mode (see the Autonomous Modes section).

The device also features a data buffer (see the Data Buffer section) and an accumulator (see the Accumulator section). The data buffer can store up to 16 conversion results of the ADC in autonomous mode, and the accumulator can accumulate up to 16 conversion results of ADC in high precision mode (see the High Precision Mode section).

The device includes OFFSET calibration (see the OFFSET Calibration section) for calibration of its own offset.

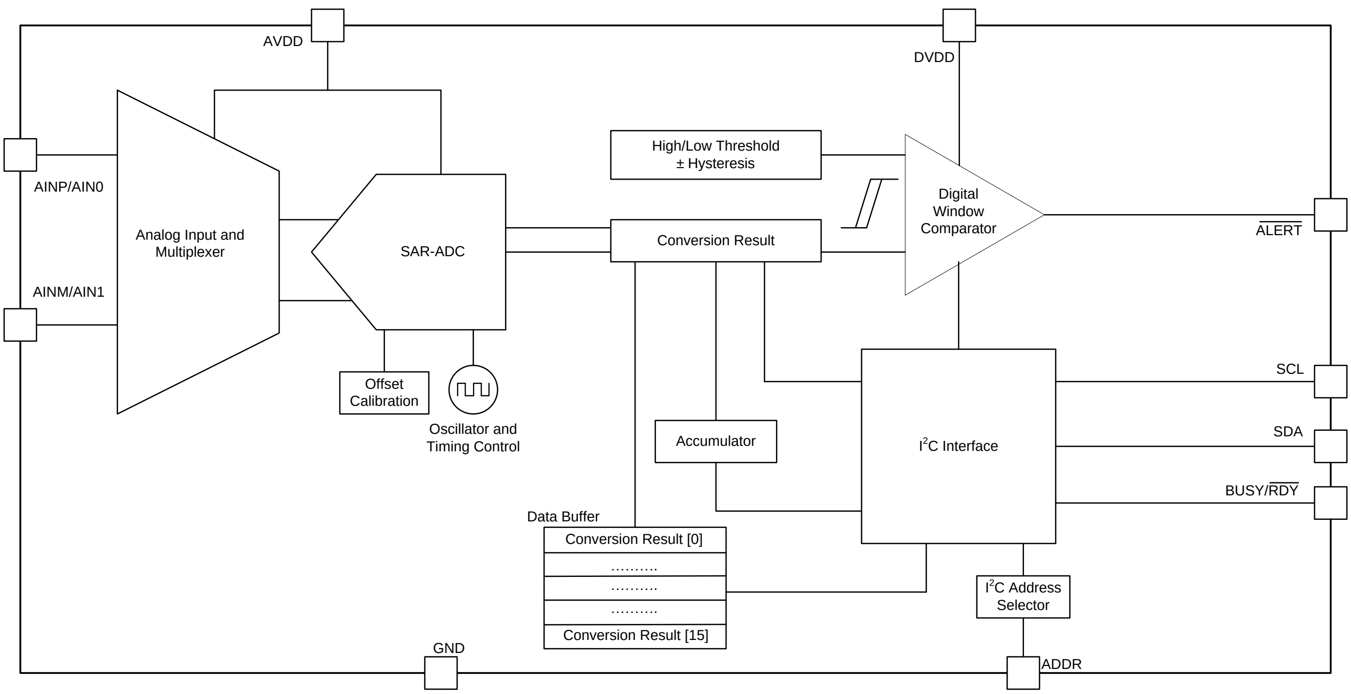


図 4. ADS4172 Functional Block Diagram

2.2.3 TPS7B69xx-Q1

The TPS7B69xx-Q1 is a high-voltage, linear regulator that operates over a 4-V to 40-V input voltage range. The device has an output current capability of 150 mA and offers fixed output voltages of 2.5 V (TPS7B6925-Q1), 3.3 V (TPS7B6933-Q1), or 5 V (TPS7B6950-Q1). The device features TSD and short-circuit protection to prevent damage during overtemperature and overcurrent conditions.

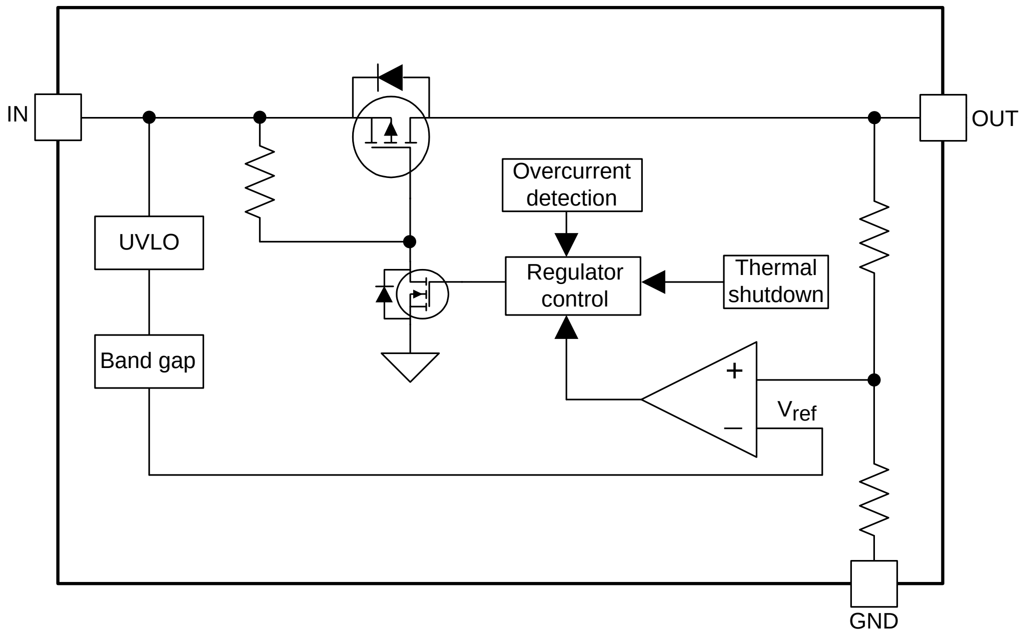


図 5. TPS7B69xx-Q1 Functional Block Diagram

2.3 System Design Theory

The TIDA-01569 reference design combines two, dual-channel, antenna LDOs with a two-channel ADC, to provide a four-channel system with current sensing and diagnostics over an I²C. The two, antenna LDOs (TPS7B7702) have analog output voltages that indicate output current and fault conditions. A common problem that customers run into is limited ADC resources within the microcontrollers (MCUs) in their system. A solution to mitigate this limitation is to digitally interface these diagnostics between the MCU and LDO using I²C communication.

The ADS7142, nano-power, dual-channel, sensor monitor is used to make this analog diagnostic output readable on the I²C bus or provide a stand-alone fault flag using the internal window comparators.

図 6 shows the schematic of the TIDA-01569 reference design, which features a four-channel antenna LDO with digital diagnostics and integrated protection.

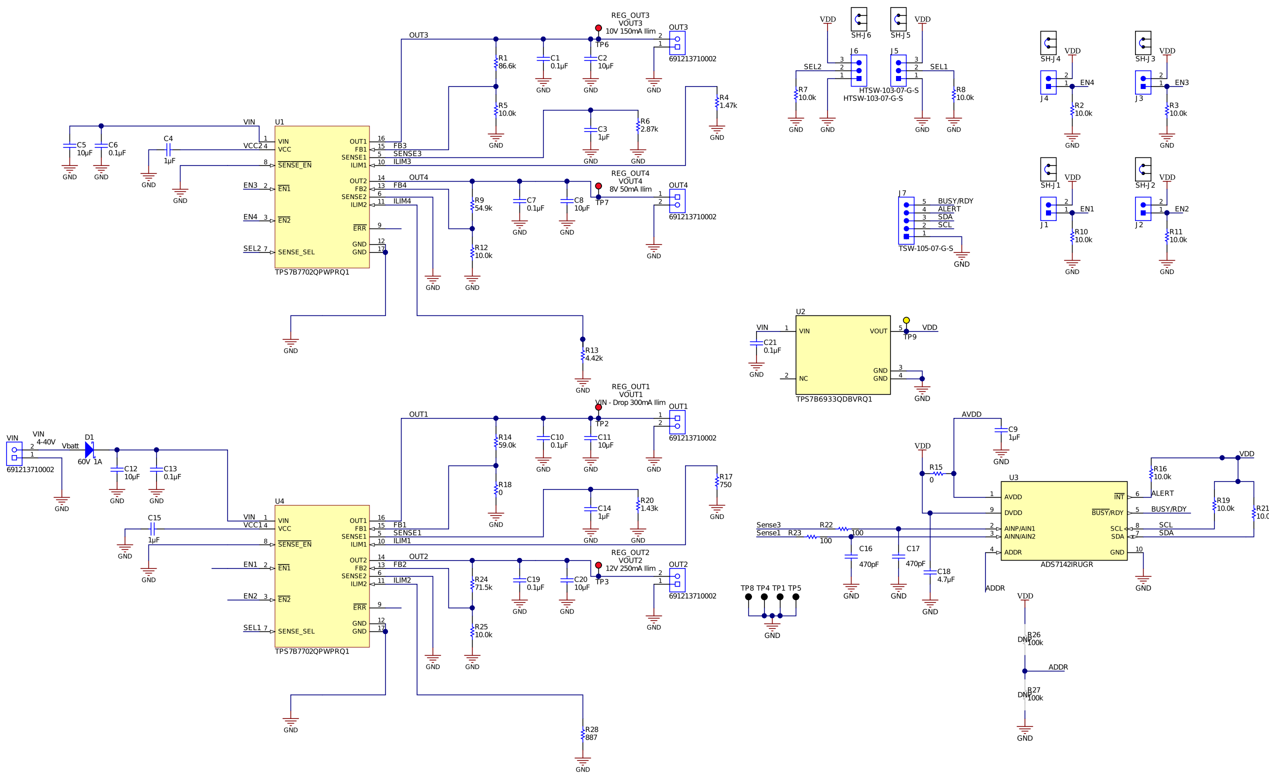


図 6. TIDA-01569 Schematic

2.3.1 LDO Channels and Configuration

This reference design has four output channels to reflect common use cases in automotive head unit applications. The use of multiple antennas, cameras, microphones, or combinations of such are common and require a two- or four-channel remote power solution.

Although this reference design has four channels, the system is still relevant for two-channel needs and is easily configurable as such by simply removing one of the dual-channel LDOs.

This reference design demonstrates that, while it is a discrete solution, a two- or four-channel antenna LDO solution is attainable using the TPS7B7702 and ADS7142 devices.

2.3.2 Output Voltages

The output voltage for each channel is set using a feedback network connected to the feedback pin and V_{OUT}. Using an external resistor divider selects an output voltage between 1.5 V and 20 V. Use 式 1 to calculate the output voltage (V_{OUT}). The recommended value for both R1 and R2 is less than 100 kΩ.

$$V_O = \frac{V_{(FB)} \times (R1 + R2)}{R2} \quad (1)$$

where,

- $V_{(FB)}$ = 1.233 V.

表 2. LDO Output Voltages

OUTPUT	CHANNEL	V_{OUT} (V)	R_{FB1} (kΩ)	R_{FB2} (kΩ)
U4 OUT1	1	Switch (V_{IN} – V_{DROP})	DNP	Short
U4 OUT2	2	10	71.5	10
U1 OUT1	3	12	86.6	10
U1 OUT2	4	8	54.9	10

2.3.3 Solution Size

図 7 shows a transparent rendering of the board to measure the total solution size of the two antenna LDOs, the ADC, and accessory components. The total size is calculated to be approximately 390 mm^2, using both the top and bottom board.

The designer can likely reduce the solution size to approximately 350 mm^2 by removing some of the non-vital components that provide ease of use, board modifications, and testing; some examples of which are shunts, Do Not Populate (DNP), and so forth.

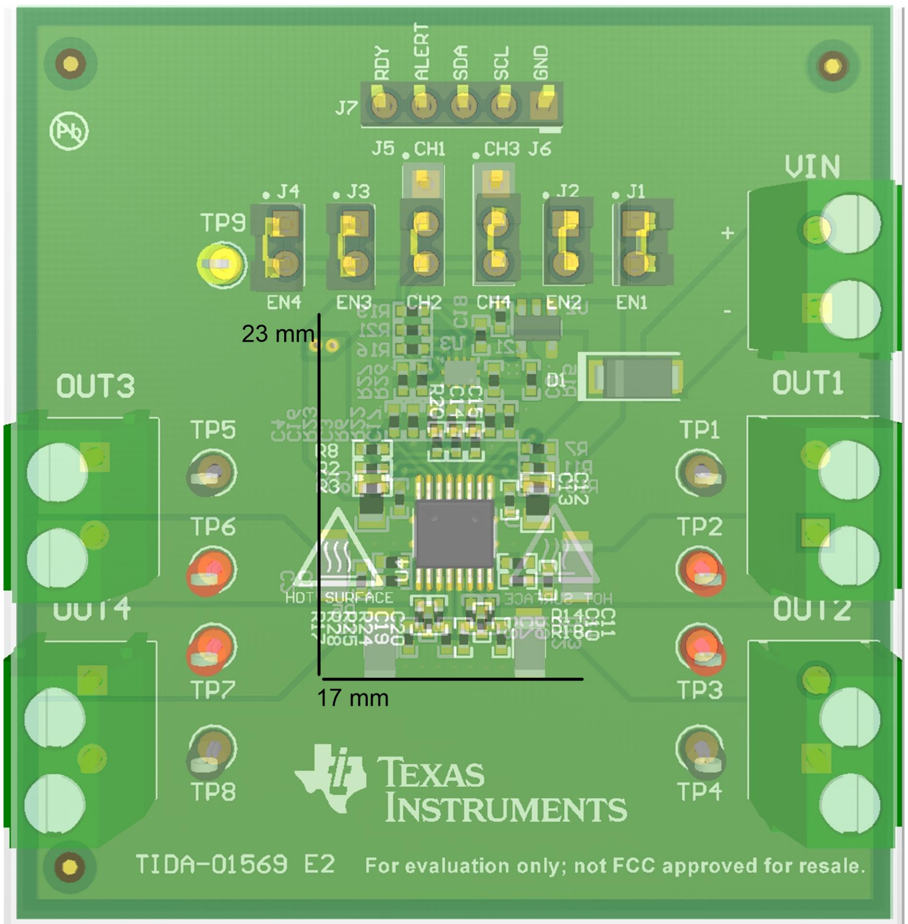


図 7. TIDA-01569 System Solution Size

2.3.4 Analog Current Sense and Diagnostics Output

The TPS7B7702 device has an analog current sense output for current sensing and fault detection. 図 8 shows the voltage thresholds for various faults and the linear current sense band. This reference design reads current sense output voltage directly into an ADC, which enables the diagnostic information to be analyzed and reacted upon using the I^2C.

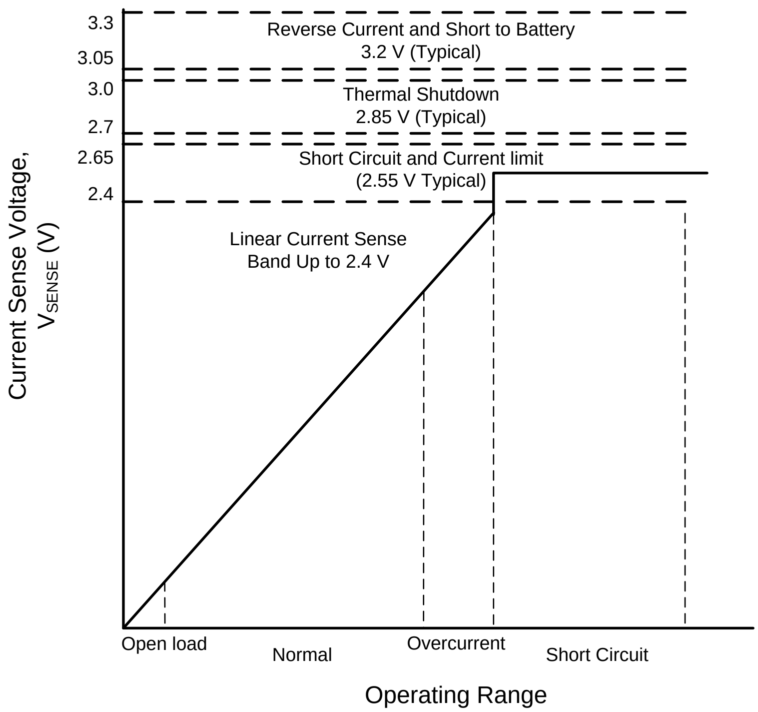


図 8. Analog Current Sense Output

2.3.4.1 Fault Detection and Behavior

表 3 lists the different failure modes and corresponding $V_{(SENSE)}$ thresholds. During some of the faults, the LDO switch output will disable. For more information on the behavior during fault conditions, see the Fault Detection and Protection section of *TPS7B770x-Q1 Single- and Dual-Channel Antenna LDO With Current Sense*.

表 3. Fault Table

FAILURE MODE	$V_{(SENSE)}$	$\overline{ERR}$	LDO SWITCH OUTPUT	LATCHED
Open load	$\frac{I_O \times R_{(SENSE)}}{198}$	High	Enabled	No
Normal				
Overcurrent				
Short-circuit or current limit	2.4 V to 2.65 V	Low	Enabled	No
Thermal shutdown	2.7 V to 3 V	Low	Disabled	No
Output short-to-battery	3.05 V to 3.3 V	Low	Disabled	Yes
Reverse current	3.05 V to 3.3 V	Low	Disabled	Yes

2.3.4.2 Current Sense Resistor

In the linear current-sense band up to 2.4 V, the current-sense outputs (U4 SENSE1, U4 SENSE2, U1 SENSE1, and U1 SENSE2) are proportional to the output current at the output pins by a factor of 1/198. An output resistor, $R_{(SENSE)}$, must be connected between the SENSEx pin and ground to generate a current sense voltage to be sampled by the ADC. 式 2 can be used to calculate the voltage at the SENSEx pins ($V_{(SENSEx)}$):

$$R_{(SENSEx)} \leq \frac{198 \times 2.4\ V}{I_{Omax}} \quad (2)$$

where,

- 198 is the output current to current-sense ratio,
- 2.4 V is the minimum possible voltage at the SENSEx pin under a short-circuit fault case,
- I_{Omax} is the maximum possible output current under normal operation.

$$I_{(SENSEx)} = \frac{198\ mA}{198} = 1\ mA \rightarrow V_{(SENSEx)} = 1\ mA \times 1.5\ k\Omega = 1.5\ V \quad (3)$$

To avoid any overlap between the normal operation and current-limit or short-to-ground phase, use 式 2 per TI recommendation to select the value of the SENSE resistor.

Because the SENSE1 pin receives multiplexing for both output channels on each TPS7B7702 device, both outputs will have the same $R_{(SENSE)}$ value.

表 4. Current Sense Resistors

OUTPUT	CHANNEL	MAXIMUM CURRENT (I_{LIM})	I_{Omax} SENSE	$R_{(SENSE)}$
U4 OUT1	1	300 mA	300 mA	1.43 kΩ
U4 OUT2	2	250 mA		
U1 OUT1	3	150 mA	150 mA	2.87 kΩ
U1 OUT2	4	50 mA		

A 1-µF ceramic capacitor at the SENSEx pins is required to stabilize the current-sense loop.

2.3.5 Output Current Limit

The current at the LIMx pins (U4 LIM1, U4 LIM2, U1 LIM1, and U1 LIM2) is proportional to the load current at the OUTx pins (U4 OUT1, U4 OUT2, U1 OUT1, and U1 OUT2), and is internally connected to a current-limit comparator referenced to 1.233 V. The current limit is programmable through the external resistor connected at the LIMx pin. Use 式 4 to calculate the value of the external resistor, $R_{(LIMx)}$.

$$R_{(LIMx)} = \frac{1.233V}{I_{(LIMx)}} \times 198 \quad (4)$$

The programmable current limit accuracy is ±8% across all conditions, so 8% was added to the desired current limit.

表 5. Current Limit

OUTPUT	CHANNEL	CURRENT LIMIT	$R_{(LIMx)}$	ACTUAL LIMIT
U4 OUT1	1	300 mA	750 kΩ	326 mA
U4 OUT2	2	250 mA	887 kΩ	275 mA
U1 OUT1	3	150 mA	1.47 kΩ	166 mA
U1 OUT2	4	50 mA	4.42 kΩ	55 mA

2.3.6 Sense Selection and Multiplexing

This reference design takes advantage of the current-sense multiplexing capability of the TPS7B7702 to decrease the number of ADCs required to read the four SENSEx voltages. The SEN_SEL pin multiplexes the two SENSEx voltages of one TPS7B7702 device out of the SENSE1 pin, which allows the connection of both current sense outputs to a single ADC input. Furthermore, the SENSE_EN pin can be pulled high to make both sense pins high impedance, which opens up the possibility to tie multiple TPS7B7702 devices to one ADC input. 表 6 lists the possible SENSEx configurations.

表 6. Sense Pin Configuration

SENSE_EN	SEN_SEL	SENSE1 STATUS	SENSE2 STATUS
Low	Low	CH1 current	CH2 current
Low	High	CH2 current	High impedance
High	—	High impedance	High impedance

For this reference design, the SENSE_EN pin on both TPS7B7702 devices is tied to ground, and the SENSE1 pins are connected to the two inputs of the ADC. 3.1.2 discusses the resulting SENSEx jumper settings to sense all four channels.

2.3.7 Current Sense Accuracy

The TPS7B7702 device uses an internal current mirror to measure the output currents. 表 7 lists the current sense accuracy characterized across temperature. 3.2.2.1 provides tests results for the accuracy measured during a bench test of the system.

表 7. Current Sense Accuracy

OUTPUT CURRENT	CURRENT SENSE ACCURACY
5 mA to 10 mA	20%
10 mA to 50 mA	10%
50 mA to 100 mA	5%
100 mA to 300 mA	3%

2.3.8 Integrated Reverse Current Protection

A significant advantage of the TPS7B7702 antenna LDO over its competitors is the internal back-to-back MOSFET structure and free-wheeling diodes. During an STB fault condition, the input of the LDO is effectively grounded, thus V_{IN} is less than V_{OUT}, resulting in a reverse current flow that can damage the device. Other devices require an external diode which is placed at each output. These diodes add cost, size, and additional dropout per output. In systems with multiple output channels, these additional drawbacks become quite substantial to the overall system.

2.3.9 ADC: VDD and AVDD

The ADS7142 device has two separate power supplies: AVDD and DVDD (see 図 9). The device operates on AVDD; DVDD is used for the interface circuits. AVDD and DVDD can be independently set to any value within the permissible ranges. The AVDD supply also defines the full-scale input range of the device.

AVDD and DVDD were both set to 3.3 V from an OFF-battery LDO. The TPS7B69-Q1 OFF-battery LDO was used to provide 3.3 V to the system. Interface pullup resistors, enable, and sense select jumpers are also connected to VDD. The LDO will supply approximately 3 mA of current.

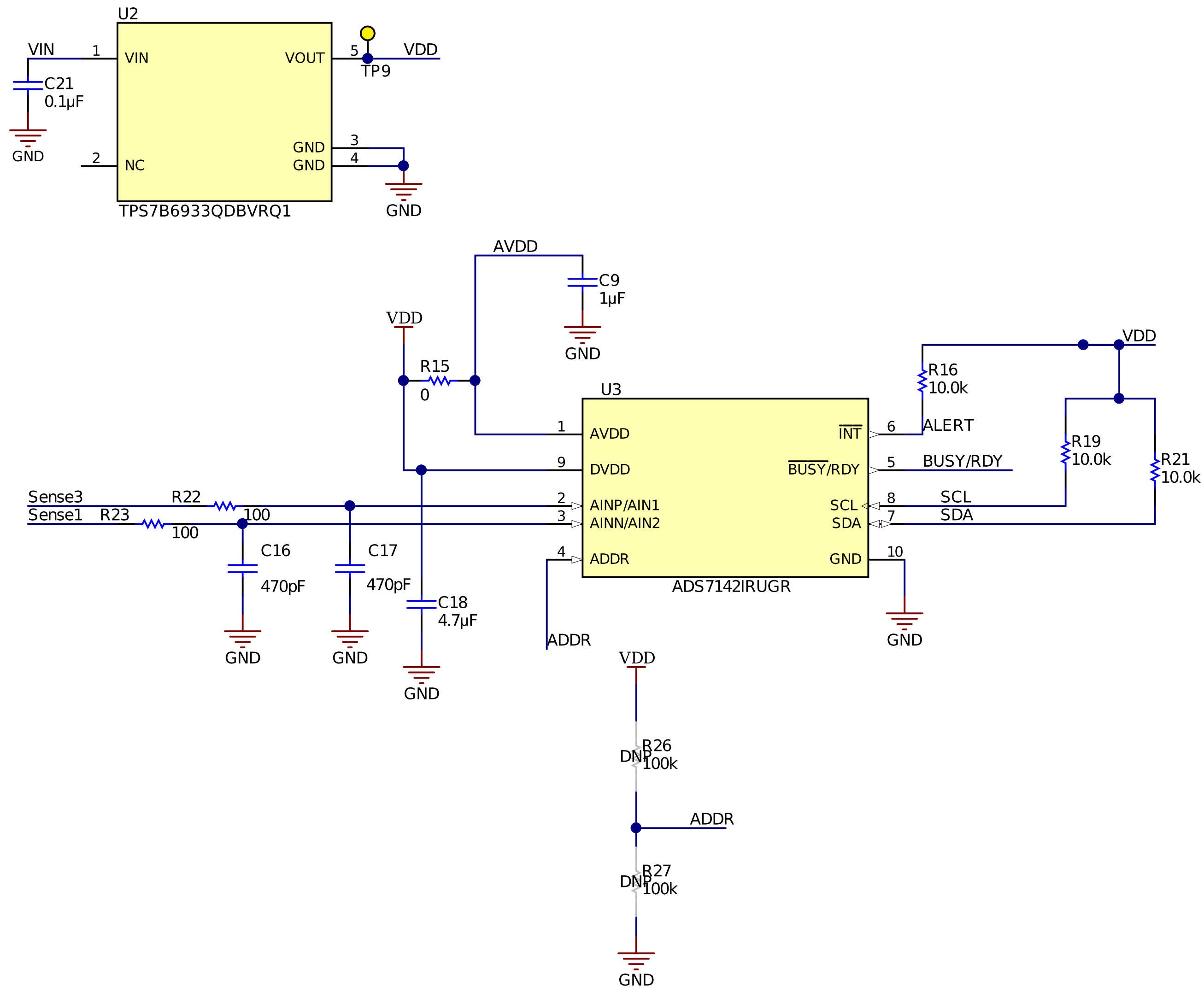


図 9. VDD and ADC Schematic

2.3.10 ADC Conversion Modes and Alert

2.3.10.1 I²C Command Mode

I²C command mode allows the external host processor to directly request and control when the data is sampled. The data capture is initiated by an I²C command from the host processor and the data is then returned over the I²C bus at a throughput rate of up to 140 kSPS.

2.3.10.2 Autonomous Mode With Threshold Monitoring and Diagnostics

The threshold monitoring mode automatically scans the input voltage on the input channel(s) and generates a signal when the programmable high or low threshold values are crossed. The user can program open circuit and overcurrent thresholds into the device and set it to continuously monitor, and action will only occur when the current deviates outside of those boundaries.

Autonomous mode can decrease the overhead of the MCU software, because it is not required to continuously read and analyze data. A simple interrupt can be used with a subsequent action to read the data following a fault condition.

2.3.10.3 Digital Window Comparator and Alert Pin

The internal digital window comparator is available in all modes. In autonomous mode with threshold monitoring and diagnostics, the digital window comparator controls the filling of the data and the output of the alert pin buffer. In I²C command mode, the digital window comparator only controls the output of the alert pin.

The low-side threshold, high-side threshold, and hysteresis parameters are independently programmable for each input channel. 図 10 shows the comparison thresholds and hysteresis for the two comparators. A pre-alert event counter after each comparator counts the output of the comparator and sets the latched flags. The pre-alert event counter settings are common to the two channels.

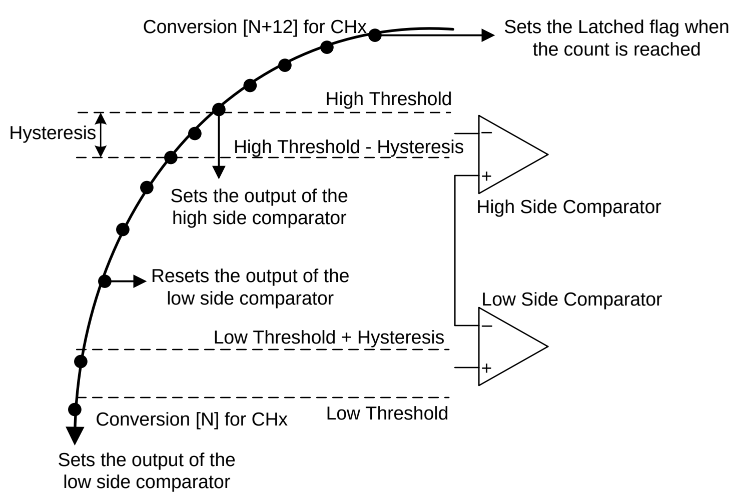


図 10. Thresholds and Hysteresis for Digital Window Comparator

2.3.11 ADC Input Filters

A charge kickback filter has been placed at the inputs of the two ADC inputs. This component not only filters noise from the current-sense path, but it also attenuates the sampling charge injection from the switched-capacitor input stage of the ADC. The capacitors help reduce the sampling charge injection and provides a charge bucket to quickly charge the internal sample-and-hold capacitors during the acquisition process.

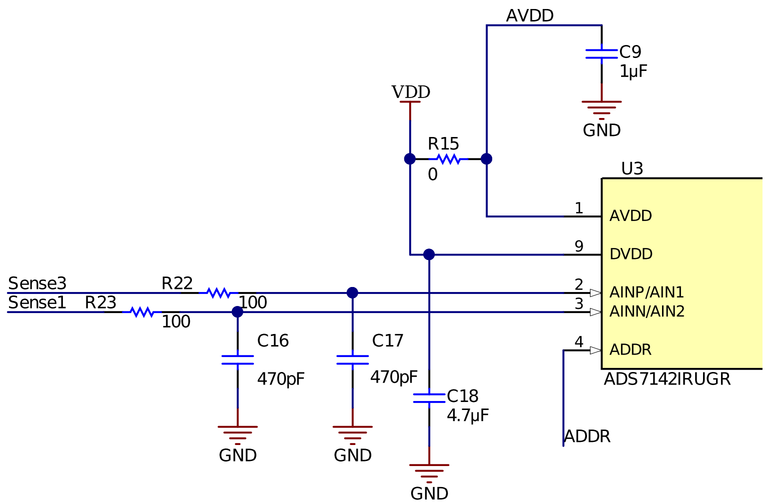


図 11. Schematic for Charge Kickback Filter

2.3.12 LSB and Resolution

The current sense resistor and AVDD decide the least significant bit (LSB) of the ADC. The ADS7142 device has 12 bits of resolution in its default mode. With AVDD at 3.3 V, the ADC will have an LSB of 800 µV (see 式 5).

Calculate the current step-size from the LSB using 式 5:

$$1\ \text{LSB} = V_{REF} / 2^{N} \quad (5)$$

where,

- V_{REF} = AVDD,
- N = 12 for autonomous monitoring modes and manual mode.

表 8. Current Step Size

CHANNELS	$R_{(SENSE)}$	CURRENT STEP SIZE
1 and 2	1.43 kΩ	111 µA
3 and 4	2.87 kΩ	56 µA

While the ADS7142 device has a 16-bit high resolution mode, it would have diminishing returns due to the accuracy of the current sense.

3 Hardware, Software, Testing Requirements, and Test Results

3.1 Required Hardware and Software

3.1.1 Hardware

図 12 and 図 13 show the board images of this reference design. The design features two, dual-channel LDOs, an ADC, and an OFF-battery LDO. The LDOs are placed back-to-back on the board with all the LDO components essentially reversed and visually mirrored across the vertical axis. A four-layer board was used with a thick layer stack-up to appropriately handle the heat.

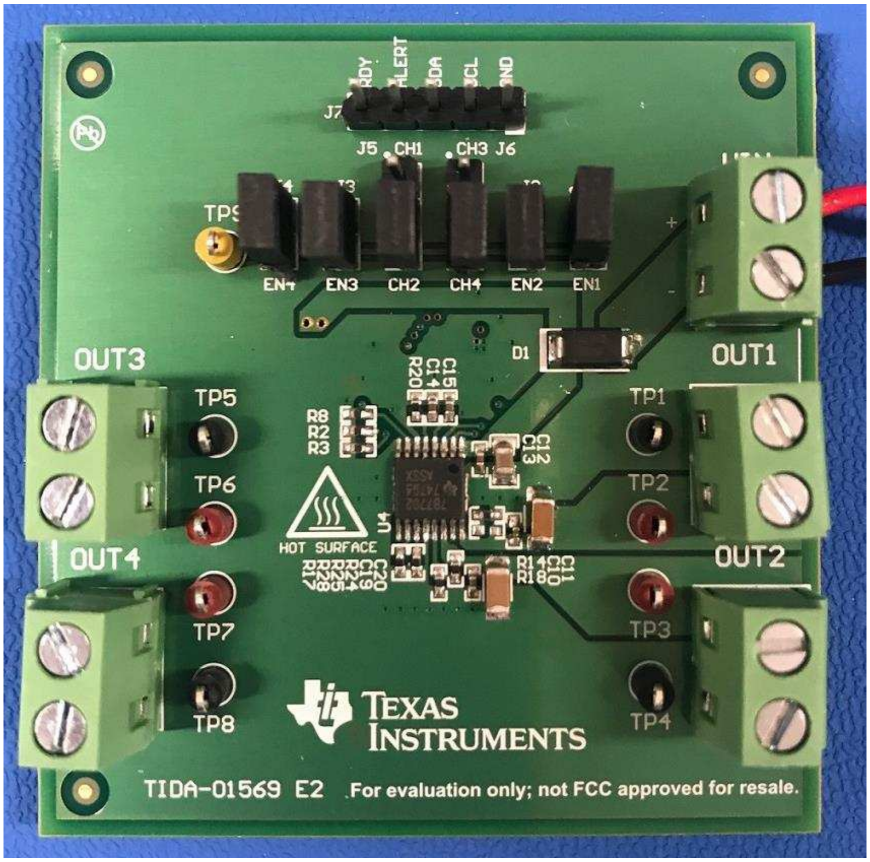


図 12. TIDA-01569 Board Top

The top of the board has LDO 1 (U4) with outputs 1 and 2 (OUT1 and OUT2, respectively). Also on top of the board are all four output terminals and test points. Lastly, the jumpers for enabling outputs and toggling the digital pins and channels sensed are located on top of the board.

The bottom of the board has LDO 2 (U4) with outputs 3 and 4 (OUT1 and OUT2, respectively). The back of the board also has the ADC and 3.3-V LDO.

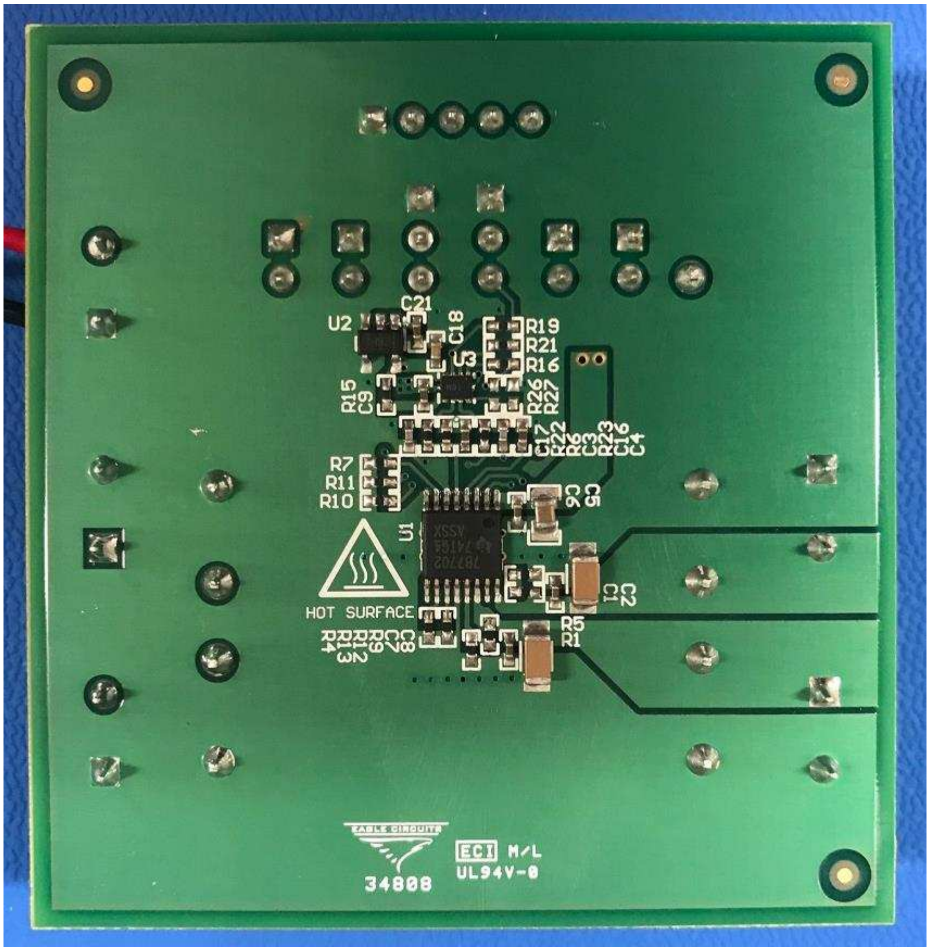


図 13. TIDA-01569 Board Bottom

3.1.2 Jumper Settings

This reference design has jumpers to allow for easy configuration of output channels and multiplexing of the current sense pins. Alternatively, these jumpers can be connected to a LaunchPad™ Development Kit or MCU to programmatically control the LDO outputs, toggle current sense channels, and read output currents and diagnostics. 図 14 shows the jumpers, nets, and pullup and pulldown resistors. 表 9 describes the functionality and placement of each jumper.

Jumpers J1 to J4 are attached to the output enable pins of the two TPS7B7702 devices to enable and disable each output. Pulldown resistors connected to each enable pin disable the output of the channel when the jumper is disconnected. When the jumper is placed, the enable pin is pulled up to the 3.3-V V_{DD} provided by the TPS7B69-Q1 LDO.

Jumpers J5 and J6 are connected to the SENSE_SEL pins on each TPS7B7702 device. The SENSE_SEL pins have a pulldown resistor, so when no jumper is connected, channels 1 and 3 are sensed by default.

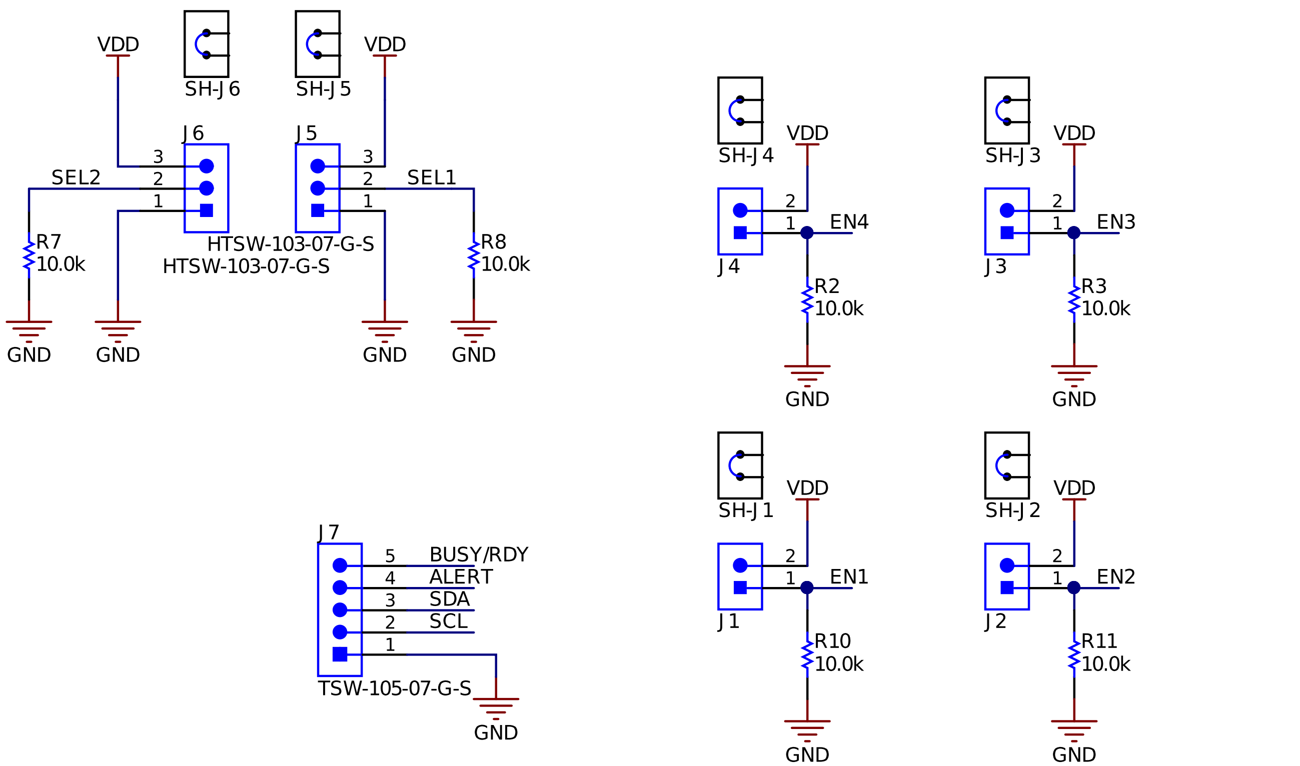


図 14. Jumpers Schematic

表 9 lists the jumper settings.

表 9. Jumper Settings

JUMPER	FUNCTION	JUMPER POSITION	STATE AND CHANNEL
J1	Ch 1 enable	Placed	Enabled
		Removed	Disabled
J2	Ch 2 enable	Placed	Enabled
		Removed	Disabled
J3	Ch 3 enable	Placed	Enabled
		Removed	Disabled
J4	Ch 4 enable	Placed	Enabled
		Removed	Disabled
J5	Sense 1 select	Top (GND)	Channel 1
		Bottom (VDD)	Channel 2
J6	Sense 2 select	Top (GND)	Channel 3
		Bottom (VDD)	Channel 4
J7	Digital connectors	—	—

3.1.3 Software

The ADS7142 device uses the standard I^2C bus protocol, which means that any MCU with the capability and peripherals for I^2C can read it.

3.1.3.1 Device Configuration

Simple I^2C reads and writes are used to communicate with the ADC. 図 15 shows the configuration sequence to choose the operating mode of the ADC.

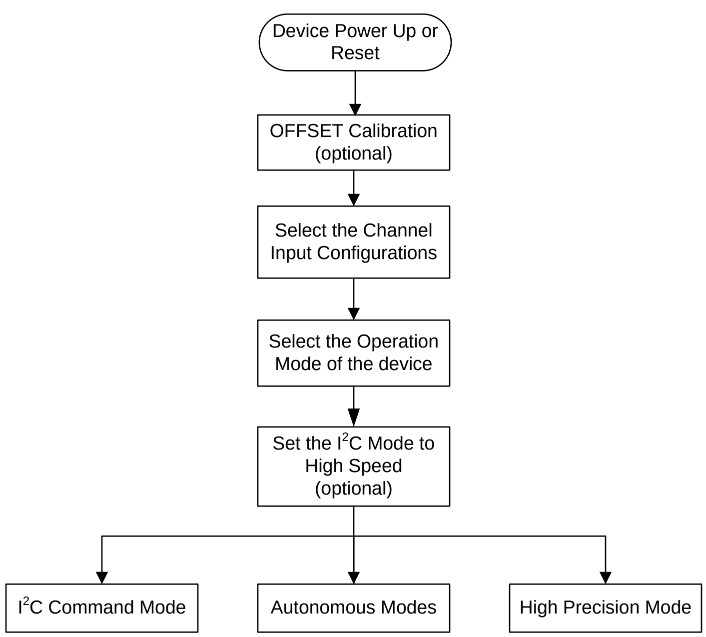


図 15. Configuring Device Into Different Modes

図 16 shows the I2C command mode read sequence.

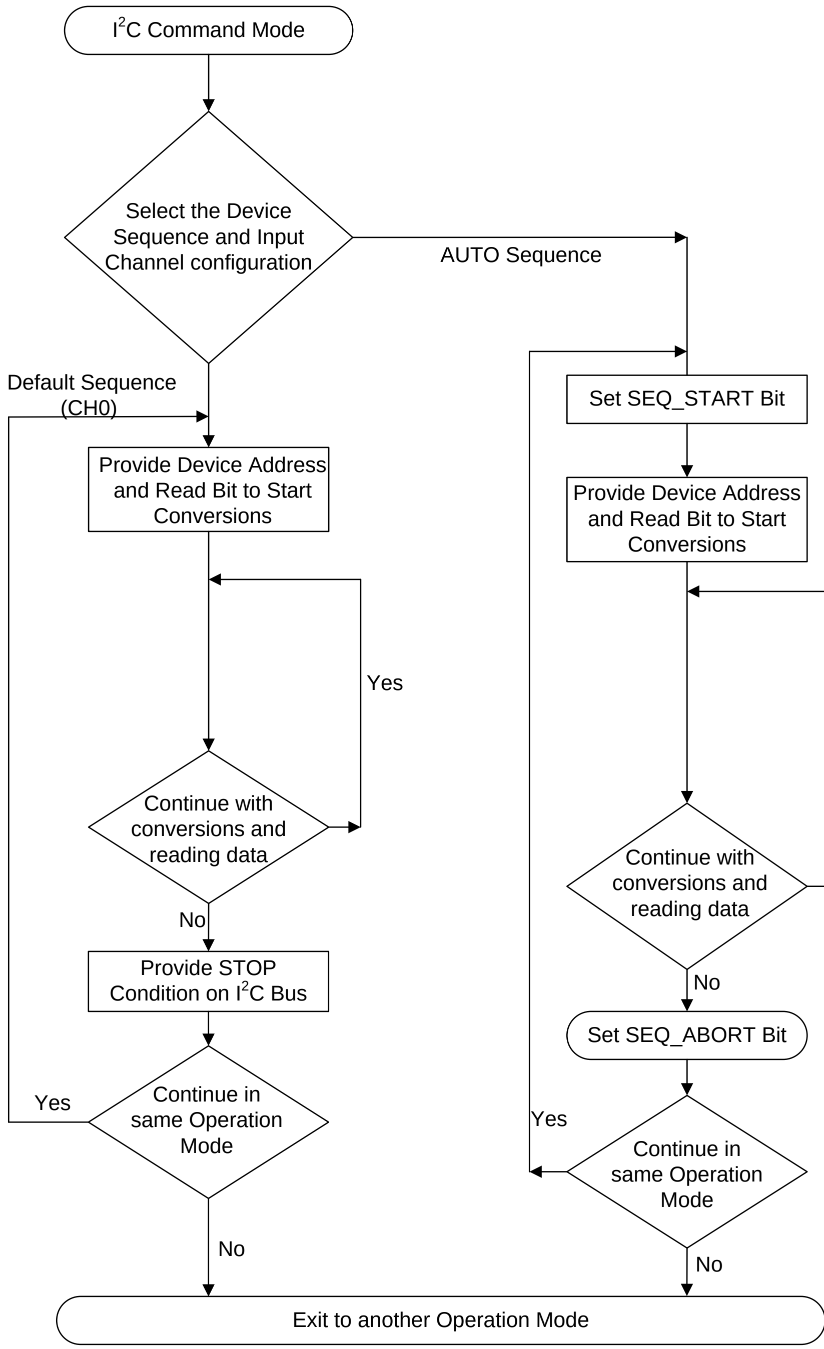


図 16. Device Operation in I^{2}C Command mode

図 17 shows the autonomous mode of the ADC.

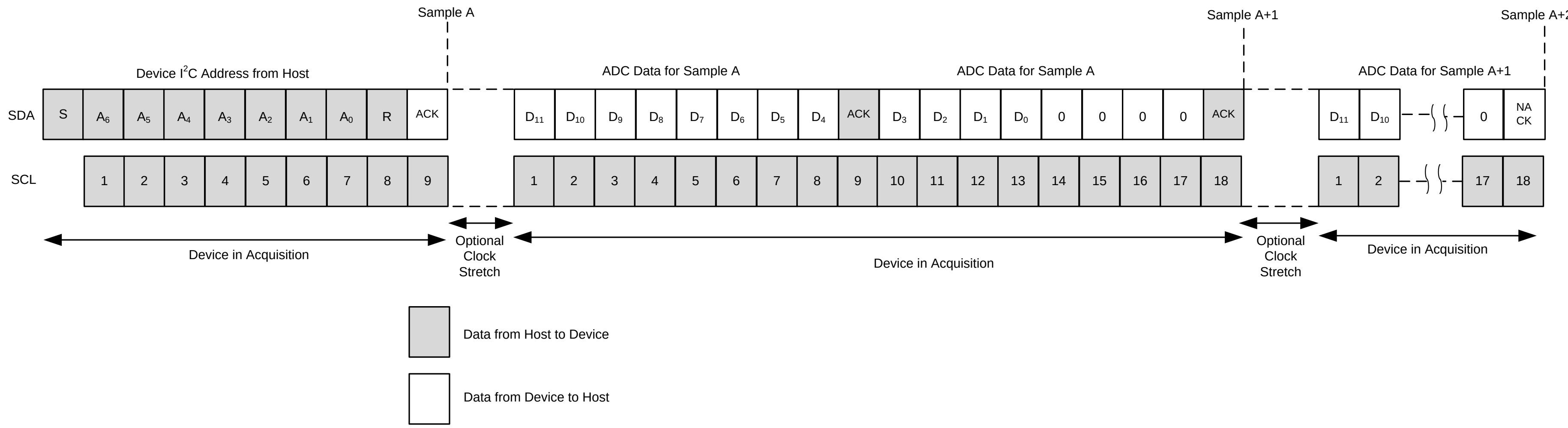


図 17. Starting Conversion and Reading Data in I²C Command Mode

3.2 Testing and Results

3.2.1 Test Setup

<u>WARNING</u>

Hot Surface. Contact may cause burns. Avoid touching to minimize risk of burns.

3.2.1.1 Current Accuracy Equipment

The 2400 Source Measure Unit (SMU) Instrument from Keithley was used to measure the current sense accuracy for this reference design. The source meter has source and sink (four-quadrant) operation with an accuracy of ±0.055% + 6 µA.

3.2.2 Test Results

The following subsections outline the tests conducted on this reference design.

3.2.2.1 Current Accuracy

表 10 lists the current sense accuracy of the system tested with a Keithley 2400 source meter.

表 10. Current Sense Accuracy

CURRENT (mA)	DIGITAL CURRENT SENSE READING			
	CH.1	CH.2	CH.3	CH.4
1	89.64%	0.40%	22.18%	0.05%
5	18.25%	0.40%	4.40%	1.06%
8	11.55%	0.40%	2.73%	0.65%
10	8.21%	0.40%	2.73%	1.06%
20	6.53%	0.40%	1.34%	0.51%
50	2.63%	0.18%	0.62%	0.29%
100	1.40%	0.29%	0.29%	—

3.2.2.2 Start-Up Waveforms

図 18 and 図 19 show the start-up waveform for the four outputs in this reference design.

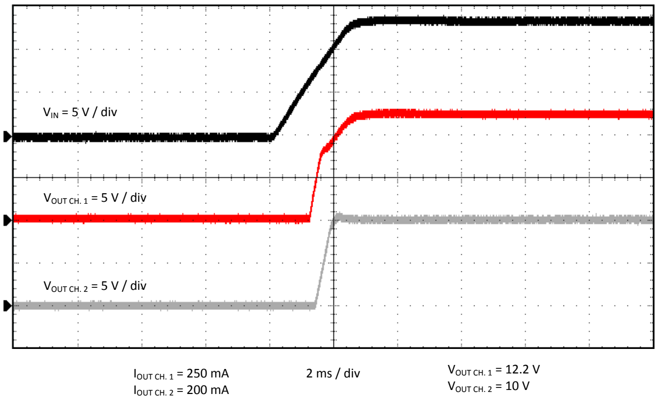


図 18. Ch.1 and Ch.2 Start-Up Waveform

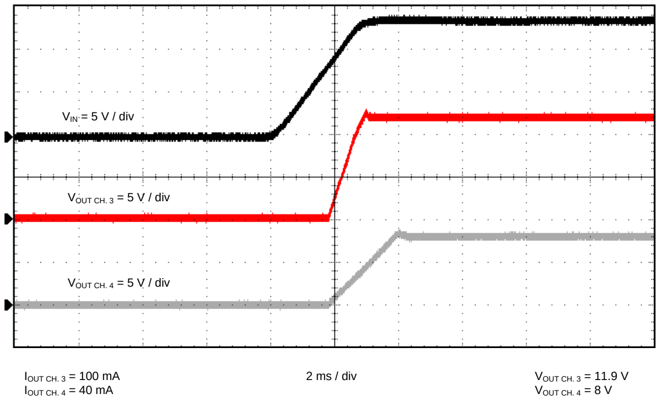


図 19. Ch.3 and Ch.4 Start-Up Waveform

3.2.2.3 Load Transient Performance

図 20 through 図 23 show the load transient performance for the four outputs in this reference design.

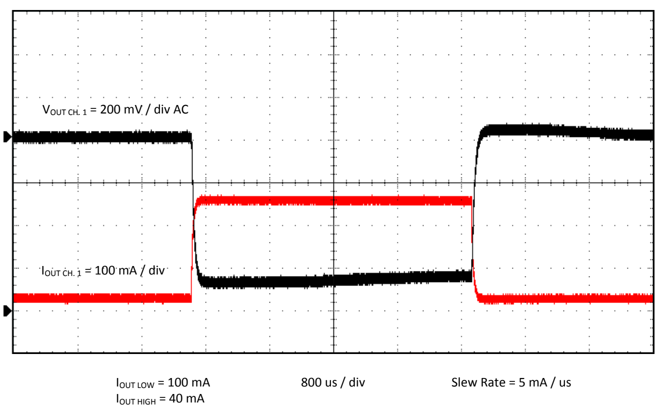


図 20. Ch.1 Load Transient Performance

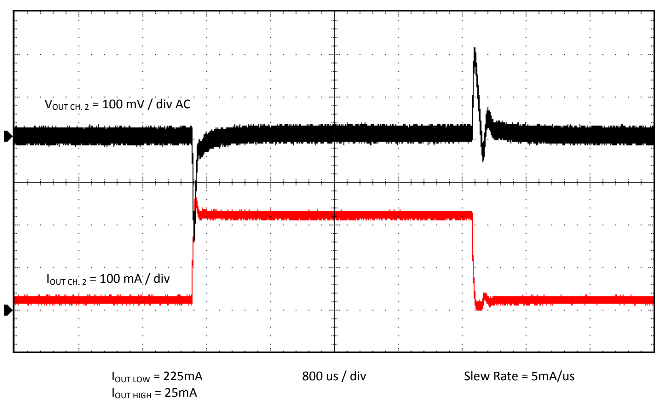


図 21. Ch.2 Load Transient Performance

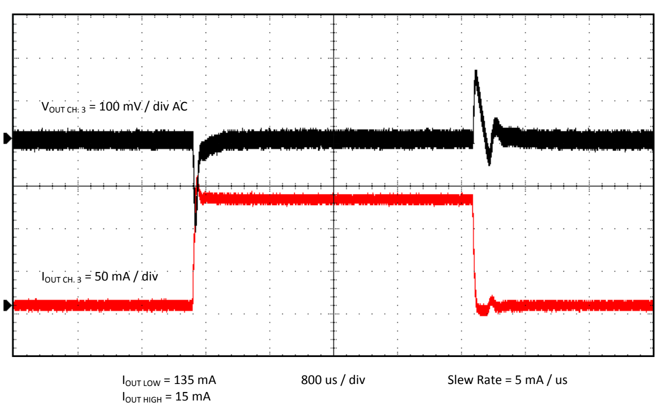


図 22. Ch.3 Load Transient Performance

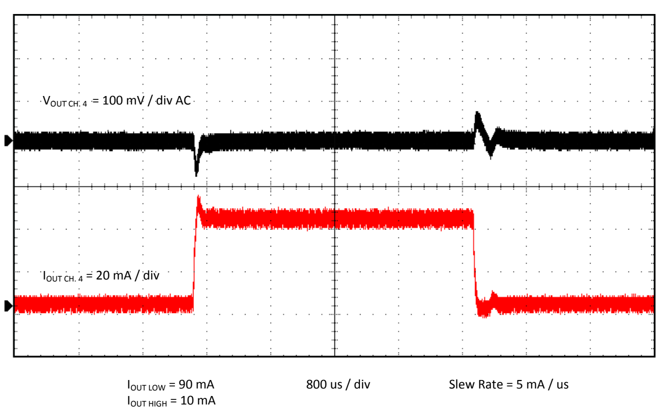


図 23. Ch.4 Load Transient Performance

4 Design Files

4.1 Schematics

To download the schematics, see the design files at TIDA-01569.

4.2 Bill of Materials

To download the bill of materials (BOM), see the design files at TIDA-01569.

4.3 PCB Layout Recommendations

- For the layout of the TPS7B770x-Q1 device, place the input and output capacitors close to the device. To enhance the thermal performance, TI recommends surrounding the device with some vias.
- Minimize equivalent-series inductance (ESL) and ESR to maximize performance and ensure stability. Place every capacitor as close as possible to the device and on the same side of the printed-circuit board (PCB) as the regulator.
- Do not place any of the capacitors on the opposite side of the PCB where the regulator is installed. TI strongly discourages the use of long traces because they can negatively impact system performance and cause instability.
- For the layout of the ADS7142 device, the power sources to the device must be clean and well bypassed.
- Use C_{AVDD} decoupling capacitors in close proximity to the analog (AVDD) power supply pin.
- Use a CDVDD decoupling capacitor close to the digital (DVDD) power-supply pin.
- Place the charge kickback filter components close to the device.
- Among ceramic surface-mount capacitors, COG (NPO) ceramic capacitors are recommended because these components provide the most stable electrical properties over voltage, frequency, and temperature changes.

4.3.1 Layout Prints

To download the layer plots, see the design files at TIDA-01569.

4.4 Altium Project

To download the Altium project files, see the design files at TIDA-01569.

4.5 Gerber Files

To download the Gerber files, see the design files at TIDA-01569.

4.6 Assembly Drawings

To download the assembly drawings, see the design files at TIDA-01569.

5 Related Documentation

1. Texas Instruments, *TPS7B770x-Q1 Single- and Dual-Channel Antenna LDO With Current Sense*
2. Texas Instruments, *ADS7142 Nanopower, Dual-Channel, Programmable Sensor Monitor*

5.1 商標

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6 About the Author

LOGAN CUMMINS is a systems engineer at Texas Instruments. Logan earned his bachelor of science in electrical engineering from Valparaiso University in 2016. As a member of the Automotive Systems Engineering team at Texas Instruments, he is responsible for developing reference design solutions for the Automotive Infotainment and Cluster segment.

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