INA1x8ハイサイド計測電流シャント・モニタ

1 特長

- 完全なユニポーラ・ハイサイド電流測定回路
- 広い電源電圧範囲と同相電圧範囲
- INA138：2.7V～36V
- INA168：2.7V～60V
- 独立した電源電圧と同相入力電圧
- 1つの抵抗器でゲインを設定可能
- 低い静止電流（標準値25μA）
- 広い温度範囲: −40℃～＋125℃
- 5ピンのSOT-23パッケージ

2 アプリケーション

- 電流シャント測定:
  – 電話、コンピュータ
- ポータブル・システムやバッテリ・バックアップ・システム
- バッテリ充電器
- パワー・マネージメント
- 携帯電話
- 高精度電流源

3 概要

INA138およびINA168 (INA1x8)はハイサイド、ユニポーラの電流シャント・モニタです。同相入力電圧範囲が広く、静止電流が小さく、小型のSOT-23パッケージに格納されているため、さまざまな用途に使用できます。

同相入力と電源電圧は独立しており、許容電圧範囲は、INA138の場合は2.7V～36V、INA168の場合は2.7V～60Vです。静止電流がわずかに25μAと小さいため、電流測定シャントのどちらの側にも電源を接続でき、誤差を最小限に抑えることができます。

本デバイスは差動入力電圧を電流出力に変換します。1～100以上の範囲で任意のゲインを設定できる外付けの負荷抵抗器を使用してこの電流が逆に変換され、電圧値が得られます。本回路は電流シャント測定向けに設計されていますが、測定やレベルシフトなど有効なさまざまなアプリケーションにご使用ください。

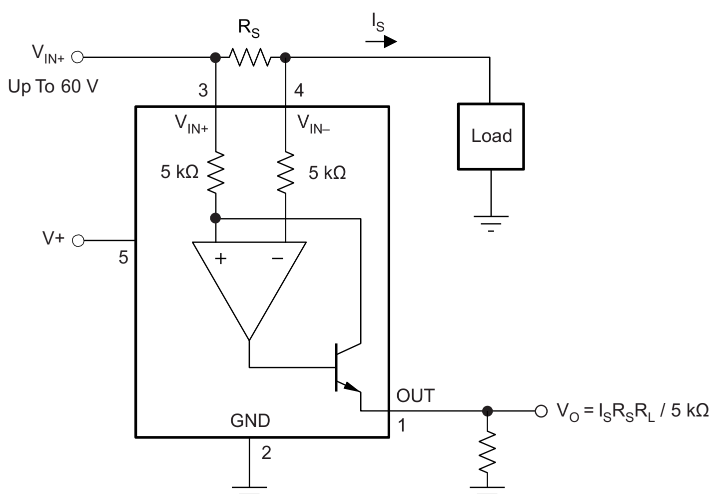
INA138とINA168はいずれもSOT23-5パッケージに格納されており、定格温度範囲は–40°C～125°Cです。

製品情報(1)

型番	パッケージ	本体サイズ(公称)
INA138	SOT-23 (5)	2.90mm×1.60mm
INA168		

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にあるパッケージ・オプションについての付録を参照してください。

代表的なアプリケーション回路



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English Data Sheet: SBOS122

目次

4 改訂履歴

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

Revision D (December 2014) から Revision E に変更 — Page

- 表紙の上端のナビゲーション・バーにリファレンス・デザインへのリンクを 追加 1
- 「製品情報」表で本体サイズを18.00mm×18.00mmから2.90mm×1.60mmに 変更 1
- Changed pin numbers in pin functions table to match pin configuration figure 3
- Changed *Absolute Maximum Ratings* table for clarity; no values were changed 4
- Changed *Recommended Operating Conditions* table; moved some content from *Electrical Characteristics* table, but no values changed 4
- Changed all values in Thermal Information table 5
- Changed *Electrical Characteristics* table; reformatted for clarity; moved some content to *Recommended Operating Conditions* table, and deleted duplicate content 5
- Changed common-mode rejection test conditions to better highlight each device in *Electrical Characteristics* table 5
- Changed offset voltage vs temperature to offset voltage drift in *Electrical Characteristics* table 5
- Changed offset voltage vs power supply test conditions to better highlight each device in *Electrical Characteristics* table 5
- Changed reference in text from Figure 10 to Figure 11 in last paragraph of *Selecting the Shunt Resistor and R_L* section 12

Revision C (November 2005) から Revision D に変更 — Page

- 「*ESD定格*」表、「*機能説明*」セクション、「*デバイスの機能モード*」セクション、「*アプリケーションと実装*」セクション、「*電源に関する推奨事項*」セクション、「*レイアウト*」セクション、「*デバイスおよびドキュメントのサポート*」セクション、「*メカニカル、パッケージ、および注文情報*」セクション 追加 1

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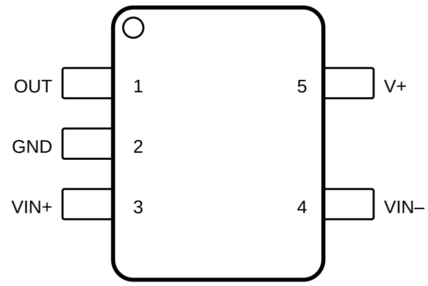
5 Pin Configuration and Functions

DBV Package
5-Pin SOT-23
Top View



Not to scale

Pin Functions

PIN		I/O	DESCRIPTION
NO.	NAME		
1	OUT	O	Output current
2	GND	—	Ground
3	VIN+	I	Positive input voltage
4	VIN–	I	Negative input voltage
5	V+	I	Power supply voltage

6 Specifications

6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) [1]

				MIN	MAX	UNIT
Voltage	Supply, V+	INA138		–0.3	60	V
		INA168		–0.3	75	
	Analog input, V_{IN+}, $V_{IN–}$	INA138	Common mode [2]	–0.3	60	
			Sense voltage, V_{SENSE} = (V_{IN+} – $V_{IN–}$)	–40	2	
		INA168	Common mode [2]	–0.3	75	
			Sense voltage, V_{SENSE} = (V_{IN+} – $V_{IN–}$)	–40	2	
	Analog output, OUT pin [2]			–0.3	40	
Current	Input current into any pin				10	mA
Temperature	Operating, T_A			–55	150	°C
	Junction, T_J				150	
	Storage, T_{stg}			–65	150	

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.
(2) The input voltage at any pin may exceed the voltage shown if the current at that pin is limited to 10 mA.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 [1]	±1000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101 [2]	±500	

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
INA138					
V+	Supply voltage	2.7	5	36	V
V_{SENSE}	Full-scale sense voltage (V_{IN+} – $V_{IN–}$)		100	500	mV
	Common-mode voltage	2.7	12	36	V
T_A	Operating temperature	–40	25	125	°C
INA168					
V+	Supply voltage	2.7	5	60	V
V_{SENSE}	Full-scale sense voltage (V_{IN+} – $V_{IN–}$)		100	500	mV
	Common-mode voltage	2.7	12	60	V
T_A	Operating temperature	–40	25	125	°C

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6.4 Thermal Information

THERMAL METRIC[1]		INA1x8 DBV 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	168.3	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	73.8	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	28.1	°C/W
ψ_{JT}	Junction-to-top characterization parameter	2.5	°C/W
ψ_{JB}	Junction-to-board characterization parameter	27.6	°C/W

(1) For more information about traditional and new thermal metrics, see the *Semiconductor and IC Package Thermal Metrics* application report.

6.5 Electrical Characteristics

all other characteristics at T_A = +25°C, V_S = 5 V, V_{IN+} = 12 V, and R_{OUT} = 125 kΩ (unless otherwise noted)

PARAMETER	TEST CONDITIONS		INA1x8 MIN	INA1x8 TYP	INA1x8 MAX	UNIT
INPUT						
Common-mode rejection	V_{SENSE} = 50 mV	INA138, V_{IN+} = 2.7 V to 36 V	100	120		dB
		INA168, V_{IN+} = 2.7 V to 60 V	100	120		
Offset voltage[1]	T_A = 25°C			±0.2	±1	mV
	T_A = –40°C to +125°C				±2	
Offset voltage drift[1]	T_A = –40°C to +125°C			1		µV/°C
Offset voltage vs power supply, V+	V_{SENSE} = 50 mV	INA138, V+ = 2.7 V to 36 V		0.1	10	µV/V
		INA168, V+ = 2.7 V to 60 V		0.1	10	
Input bias current	T_A = 25°C			2		µA
	T_A = –40°C to +125°C, INA138				10	
OUTPUT						
Transconductance	V_{SENSE} = 10 mV to 150 mV, T_A = 25°C		198	200	202	µA/V
	V_{SENSE} = 100 mV, T_A = –40°C to +125°C		196		204	µA/V
Transconductance drift	T_A = –40°C to +125°C			10		nA/°C
Nonlinearity error	V_{SENSE} = 10 mV to 150 mV			±0.01%	±0.1%	
Total output error	V_{SENSE} = 100 mV	T_A = 25°C		±0.5%	±2%	
		T_A = –40°C to +125°C		±2.5%		
Output impedance				1 || 5		GΩ || pF
Voltage output swing	To power supply voltage, V+			(V+) – 0.8	(V+) – 1.0	V
	To common-mode voltage, V_{CM}			V_{CM} – 0.5	V_{CM} – 0.8	V
FREQUENCY RESPONSE						
Bandwidth	R_{OUT} = 5 kΩ			800		kHz
	R_{OUT} = 125 kΩ			32		kHz
Settling time	To 0.1%	5-V step, R_{OUT} = 5 kΩ		1.8		µs
		5-V step, R_{OUT} = 125 kΩ		30		µs
NOISE						
Output-current noise density				9		pA/√Hz
Total output-current noise	BW = 100 kHz			3		nA RMS
POWER SUPPLY						
Quiescent current	V_{SENSE} = 0 V, I_O = 0 mA	T_A = 25°C		25	45	µA
		T_A = –40°C to +125°C			60	µA

(1) Defined as the amount of input voltage, V_{SENSE}, to drive the output to zero.

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6.6 Typical Characteristics

At T_A = +25°C, V+ = 5 V, V_{IN+} = 12 V, and R_L = 125 kΩ, unless otherwise noted.

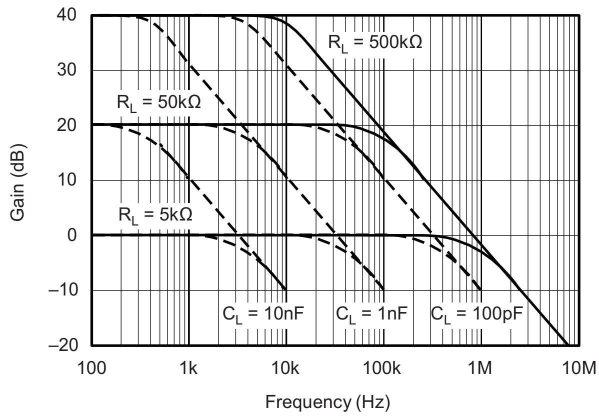

Figure 1. Gain vs Frequency

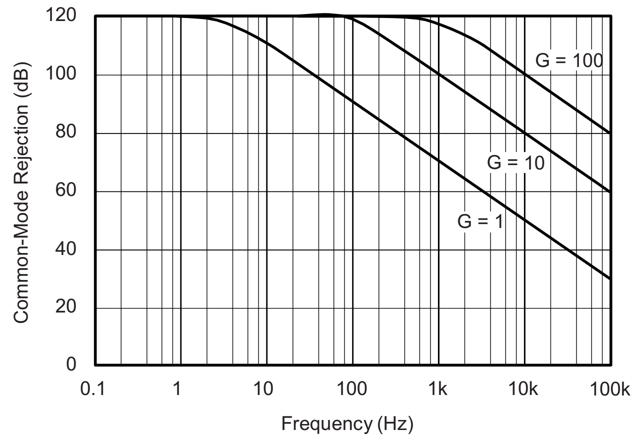

Figure 2. Common-Mode Rejection vs Frequency

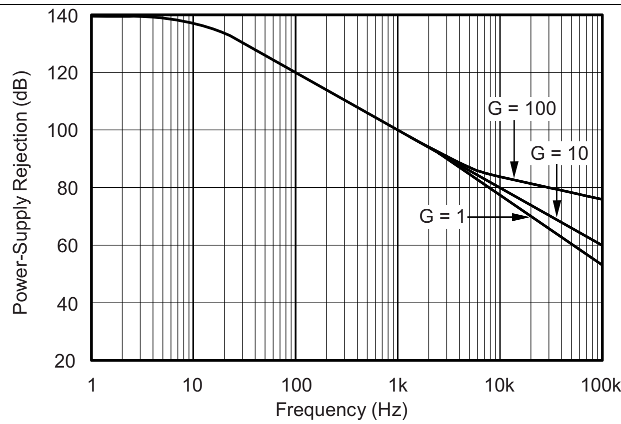

Figure 3. Power-Supply Rejection vs Frequency

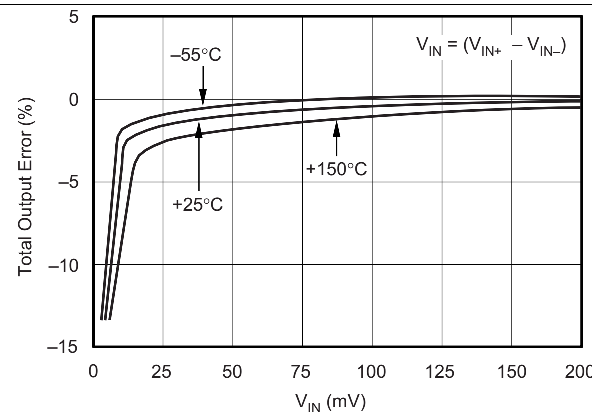

Figure 4. Total Output Error vs V_{IN}

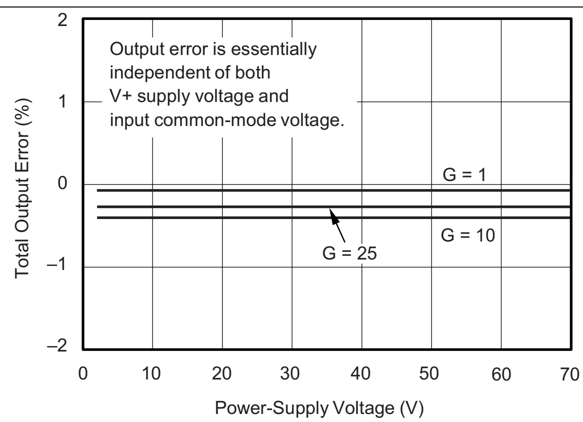

Figure 5. Total Output Error vs Power-Supply Voltage

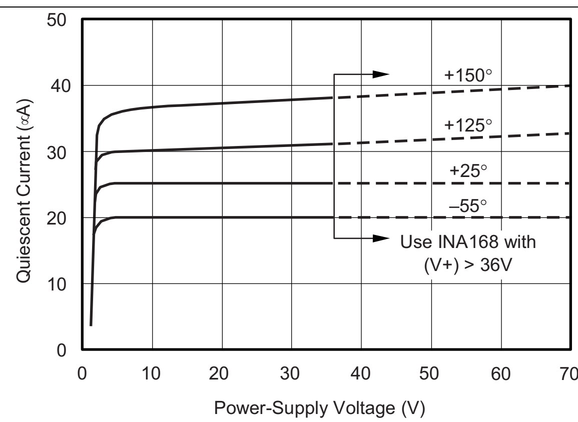

Figure 6. Quiescent Current vs Power-Supply Voltage

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Typical Characteristics (continued)

At T_A = +25°C, V+ = 5 V, V_{IN+} = 12 V, and R_L = 125 kΩ, unless otherwise noted.

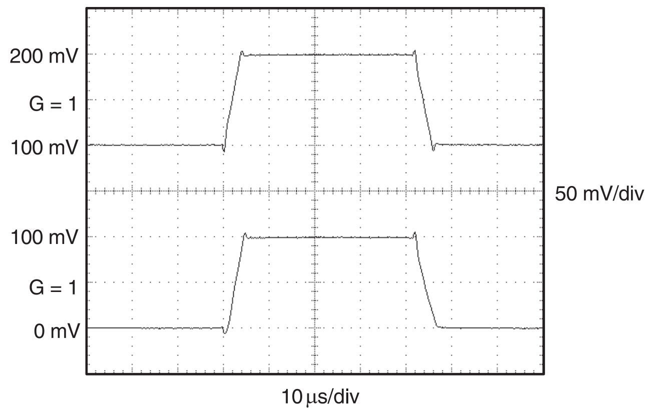


Figure 7. Step Response

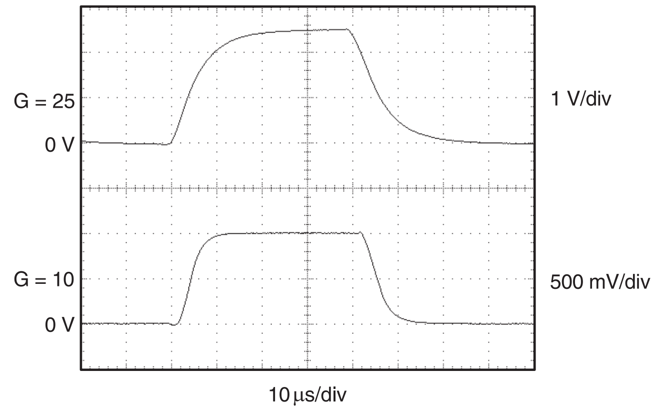


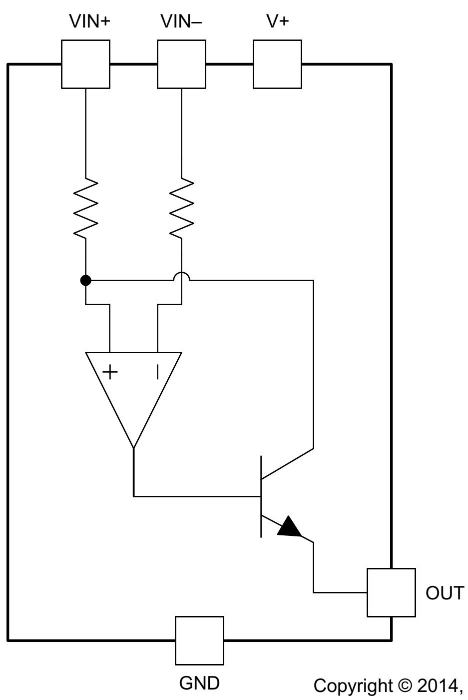
Figure 8. Step Response

7 Detailed Description

7.1 Overview

The INA138 and INA168 devices (INA1x8) are comprised of a high voltage, precision operational amplifier, precision thin film resistors trimmed in production to an absolute tolerance and a low noise output transistor. The INA1x8 devices can be powered from a single power supply and their input voltages can exceed the power supply voltage. The INA1x8 devices are ideal for measuring small differential voltages, such as those generated across a shunt resistor, in the presence of large common-mode voltages. Refer to *Functional Block Diagram* which illustrates the functional components within both INA1x8 devices.

7.2 Functional Block Diagram



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7.3 Feature Description

7.3.1 Output Voltage Range

The output of the INA1x8 device is a current that is converted to a voltage by the load resistor, R_L. The output current remains accurate within the compliance voltage range of the output circuitry. The shunt voltage and the input common-mode and power-supply voltages limit the maximum possible output swing. The maximum output voltage ($V_{out\ max}$) compliance is limited by either Equation 1 or Equation 2, whichever is lower:

$$V_{out\ max} = (V+) - 0.7\ V - (V_{IN+} - V_{IN-}) \quad (1)$$

or

$$V_{out\ max} = V_{IN-} - 0.5\ V \quad (2)$$

7.3.2 Bandwidth

Measurement bandwidth is affected by the value of the load resistor, R_L. High gain produced by high values of R_L will yield a narrower measurement bandwidth (see *Typical Characteristics*). For widest possible bandwidth, keep the capacitive load on the output to a minimum. Reduction in bandwidth due to capacitive load is shown in the *Typical Characteristics*.

If bandwidth limiting (filtering) is desired, a capacitor can be added to the output (see *Figure 12*). This will not cause instability.

7.4 Device Functional Modes

For proper operation the INA1x8 devices must operate within their specified limits. Operating either device outside of their specified power supply voltage range or their specified common-mode range will result in unexpected behavior and is not recommended. Additionally operating the output beyond their specified limits with respect to power supply voltage and input common-mode voltage will also produce unexpected results. Refer to *Electrical Characteristics* for the device specifications.

8 Application and Implementation

NOTE

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

8.1 Application Information

8.1.1 Operation

Figure 9 illustrates the basic circuit diagram for both the INA138 and INA168 devices. Load current I_S is drawn from supply V_S through shunt resistor R_S. The voltage drop in shunt resistor V_S is forced across R_{G1} by the internal op amp, causing current to flow into the collector of Q1. External resistor R_L converts the output current to a voltage, V_{OUT}, at the OUT pin. The transfer function for the INA138 device is:

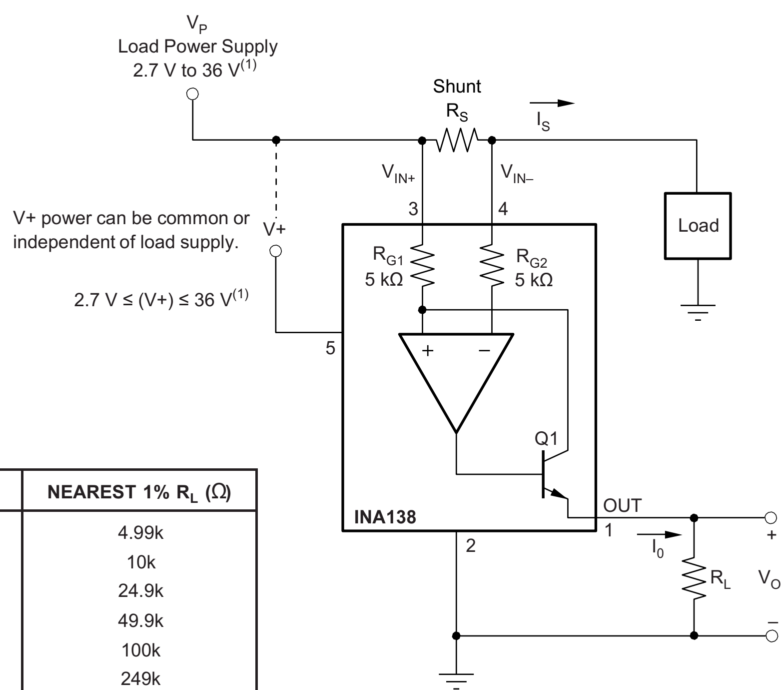
$$I_O = g_m(V_{IN+} - V_{IN-}) \quad (3)$$

where g_m = 200 µA/V.

In the circuit of Figure 9, the input voltage, $(V_{IN+} - V_{IN-})$, is equal to $I_S \times R_S$ and the output voltage, V_{OUT}, is equal to $I_O \times R_L$. The transconductance, g_m, of the INA138 device is 200 µA/V. The complete transfer function for the current measurement amplifier in this application is:

$$V_{OUT} = (I_S)(R_S)(200\ \mu A/V)(R_L) \quad (4)$$

The maximum differential input voltage for accurate measurements is 0.5 V, which produces a 100-µA output current. A differential input voltage of up to 2 V will not cause damage. Differential measurements (pins 3 and 4) must be unipolar with a more-positive voltage applied to pin 3. If a more-negative voltage is applied to pin 3, the output current, I_O, will be zero, but it will not cause damage.



VOLTAGE GAIN	EXACT R_L (Ω)	NEAREST 1% R_L (Ω)
1	5k	4.99k
2	10k	10k
5	25k	24.9k
10	50k	49.9k
20	100k	100k
50	250k	249k
100	500k	499k

(1) Maximum V_P and V+ voltage is 60 V with INA168.

Figure 9. Basic Circuit Connections

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8.2 Typical Applications

The INA1x8 devices are designed for current shunt measurement circuits, as shown in Figure 9, but basic device function is useful in a wide range of circuitry. A creative engineer will find many unforeseen uses in measurement and level-shifting circuits. A few ideas are illustrated in Figure 10 through Figure 18.

8.2.1 Buffering Output to Drive an ADC

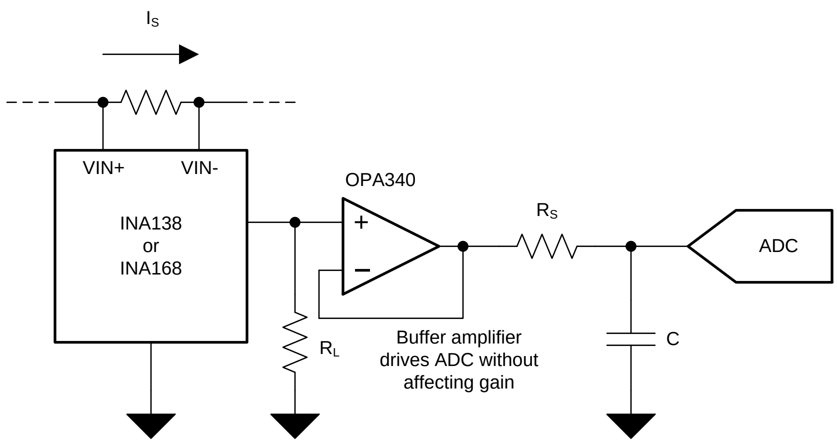

Figure 10. Buffering Output to Drive an ADC

8.2.1.1 Design Requirements

Digitize the output of the INA1x8 devices using a 1-MSPS analog-to-digital converter (ADC).

8.2.1.2 Detailed Design Procedure

8.2.1.2.1 Selecting the Shunt Resistor and R_L

In Figure 9 the value chosen for the shunt resistor depends on the application and is a compromise between small-signal accuracy and maximum permissible voltage loss in the measurement line. High values of shunt resistor provide better accuracy at lower currents by minimizing the effects of offset, while low values of shunt resistor minimize voltage loss in the supply line. For most applications, best performance is attained with a shunt resistor value that provides a full-scale shunt voltage range of 50 mV to 100 mV. Maximum input voltage for accurate measurements is 500 mV.

The load resistor, R_L, is chosen to provide the desired full-scale output voltage. The output impedance of the INA1x8 OUT terminal is very high which permits using values of R_L up to 500 kΩ with excellent accuracy. The input impedance of any additional circuitry at the output should be much higher than the value of R_L to avoid degrading accuracy.

Some analog-to-digital converters (ADCs) have input impedances that significantly affect measurement gain. The input impedance of the ADC can be included as part of the effective R_L if its input can be modeled as a resistor to ground. Alternatively, an op amp can be used to buffer the ADC input. The INA1x8 are current output devices, and as such have an inherently large output impedance. The output currents from the amplifier are converted to an output voltage via the load resistor, R_L, connected from the amplifier output to ground. The ratio of the load resistor value to that of the internal resistor value determines the voltage gain of the system.

In many applications digitizing the output of the INA1x8 device is required, and can be accomplished by connecting the output of the amplifier to an ADC. It is very common for an ADC to have a dynamic input impedance. If the INA1x8 output is connected directly to an ADC input, the input impedance of the ADC is effectively connected in parallel with the gain setting resistor R_L. This parallel impedance combination will affect the gain of the system and the impact on the gain is difficult to estimate accurately. A simple solution that eliminates the paralleling of impedances, simplifying the gain of the circuit is to place a buffer amplifier, such as the OPA340, between the output of the INA138 or INA168 device and the input to the ADC.

Typical Applications (continued)

Figure 10 illustrates this concept. Notice that a low pass filter is placed between the OPA340 output and the input to the ADC. The filter capacitor is required to provide any instantaneous demand for current required by the input stage of the ADC. The filter resistor is required to isolate the OPA340 output from the filter capacitor to maintain circuit stability. The values for the filter components will vary according to the operational amplifier used for the buffer and the particular ADC selected. More information can be found regarding the design of the low pass filter in the TI Precision Design , *16 bit 1MSPS Data Acquisition Reference Design for Single-Ended Multiplexed Applications (TIPD173)*.

Figure 11 shows the expected results when driving an analog-to-digital converter at 1MSPS with and without buffering the INA1x8 output. Without the buffer, the high impedance of the INA1x8 reacts with the input capacitance and sample and hold (S/H) capacitance of the ADC, and does not allow the S/H to reach the correct final value before it is reset and the next conversion starts. Adding the buffer amplifier significantly reduces the output impedance driving the S/H and allows for higher conversion rates than can be achieved without adding the buffer.

8.2.1.3 Application Curve

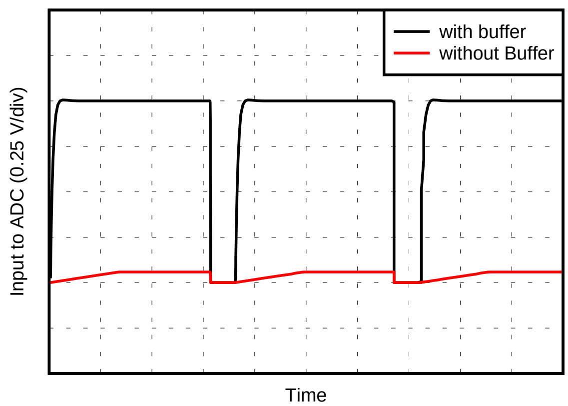

Figure 11. Driving an ADC With and Without a Buffer

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Typical Applications (continued)

8.2.2 Output Filter

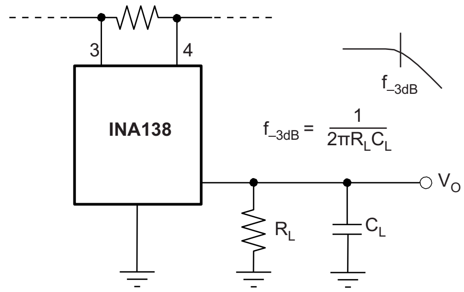

Figure 12. Output Filter

8.2.2.1 Design Requirements

Filter the output of the INA1x8 devices.

8.2.2.2 Detailed Design Procedure

A low-pass filter can be formed at the output of the INA1x8 devices simply by placing a capacitor of the desired value in parallel with the load resistor. First determine the value of the load resistor needed to achieve the desired gain. Refer to the table in Figure 9. Next, determine the capacitor value that will result in the desired cutoff frequency according to the equation shown in Figure 12. Figure 13 illustrates various combinations of gain settings (determined by R_L) and filter capacitors.

8.2.2.3 Application Curve

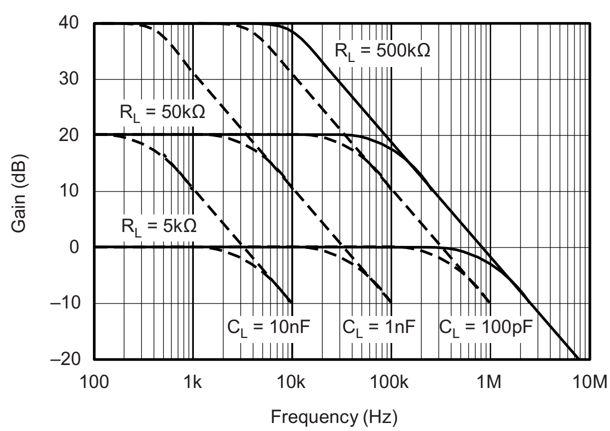

Figure 13. Gain vs Frequency

Typical Applications (continued)

8.2.3 Offsetting the Output Voltage

For many applications using only a single power supply it may be required to level shift the output voltage away from ground when there is no load current flowing in the shunt resistor. Level shifting the output of the INA1x8 devices is easily accomplished by one of two simple methods shown in Figure 14. The method on the left hand side of Figure 14 illustrates a simple voltage divider method. This method is useful for applications that require the output of the INA1x8 devices to remain centered with respect to the power supply at zero load current through the shunt resistor. Using this method the gain is determine by the parallel combination of R_1 and R_2 while the output offset is determined by the voltage divider ratio R_1 and R_2. For applications that may require a fixed value of output offset, independent of the power supply voltage, the current source method shown on the right-hand side of Figure 14 is recommended. With this method a REF200 constant current source is used to generate a constant output offset. Using his method the gain is determined by R_L and the offset is determined by the product of the value of the current source and R_L.

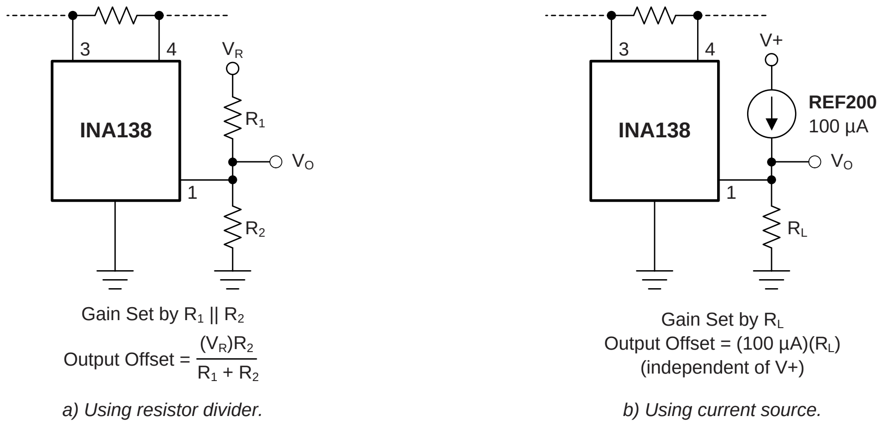

Figure 14. Offsetting the Output Voltage

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Typical Applications (continued)

8.2.4 Bipolar Current Measurement

The INA1x8 devices can be configured as shown in Figure 15 in applications where measuring current bi-directionally is required. Two INA devices are required connecting their inputs across the shunt resistor as shown in Figure 15. A comparator, such as the TLV3201, is used to detect the polarity of the load current. The magnitude of the load current is monitored across the resistor connected between ground and the connection labeled *Output*. In this example the 100-kΩ resistor results in a gain of 20 V/V. The 10-kΩ resistors connected in series with the INA1x8 output current are used to develop a voltage across the comparator inputs. Two diodes are required to prevent current flow into the INA1x8 output, as only one device at a time is providing current to the *Output* connection of the circuit. The circuit functionality is illustrated in Figure 16.

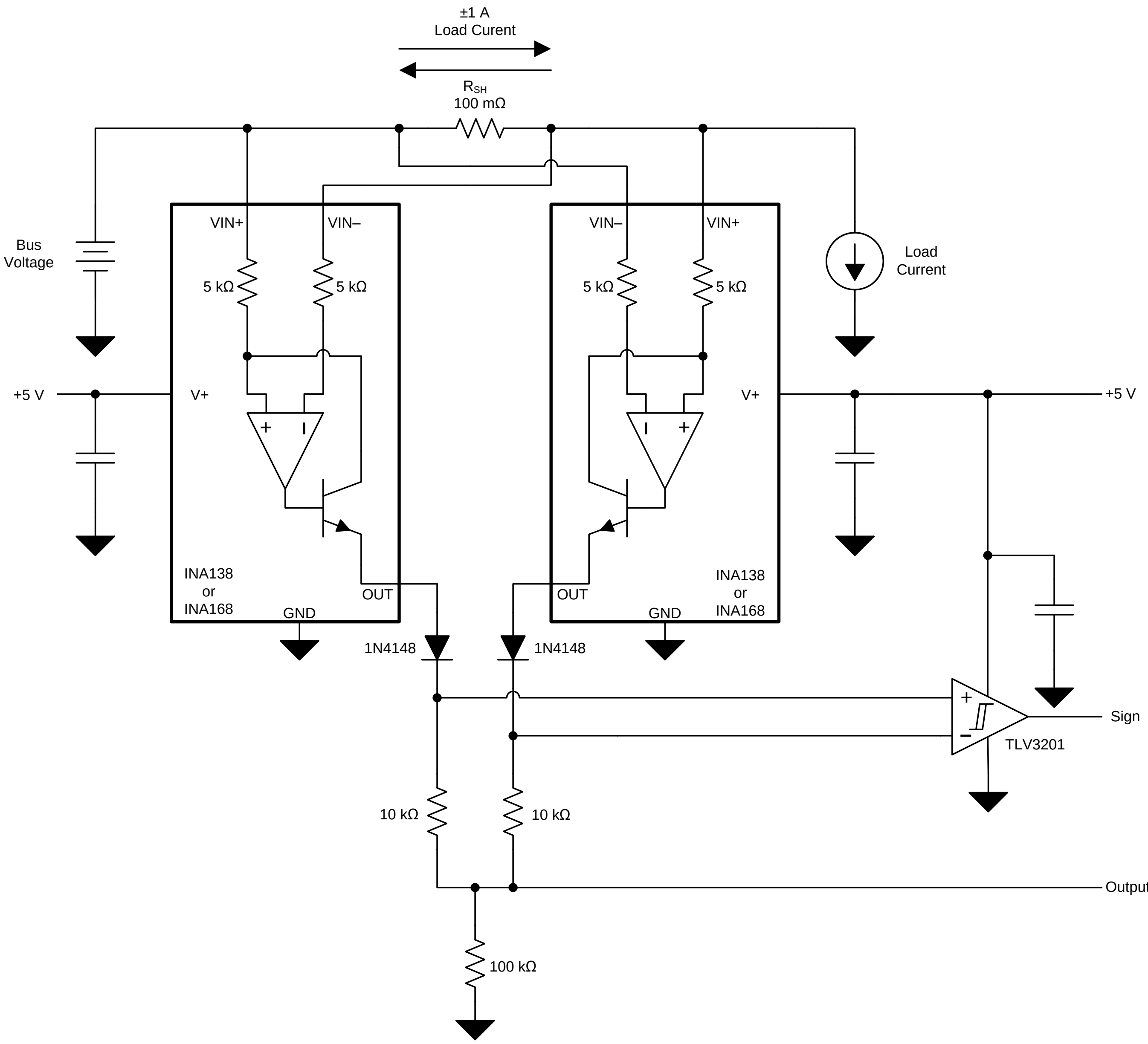

Figure 15. Bipolar Current Measurement

Typical Applications (continued)

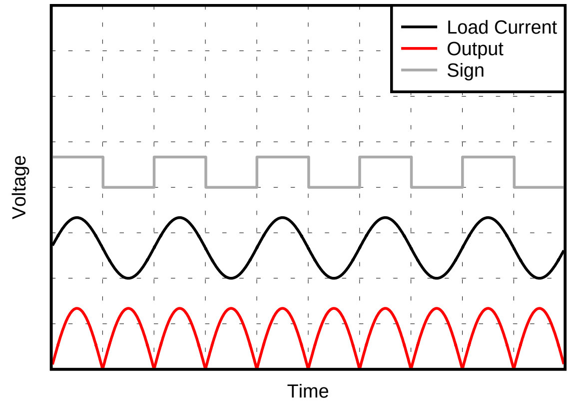

Figure 16. Bipolar Current Measurements Results (arbitrary scale)

8.2.5 Bipolar Current Measurement Using Differential Input of ADC

The INA1x8 devices can be used with an ADC such as the ADS7870 programmed for differential mode operation. Figure 17 illustrates this configuration. In this configuration the use of two INAs allows for bidirectional current measurement. Depending upon the polarity of the current, one of the INAs provides an output voltage, while the other output is zero. In this way the ADC reads the polarity of current directly, without the need for additional circuitry.

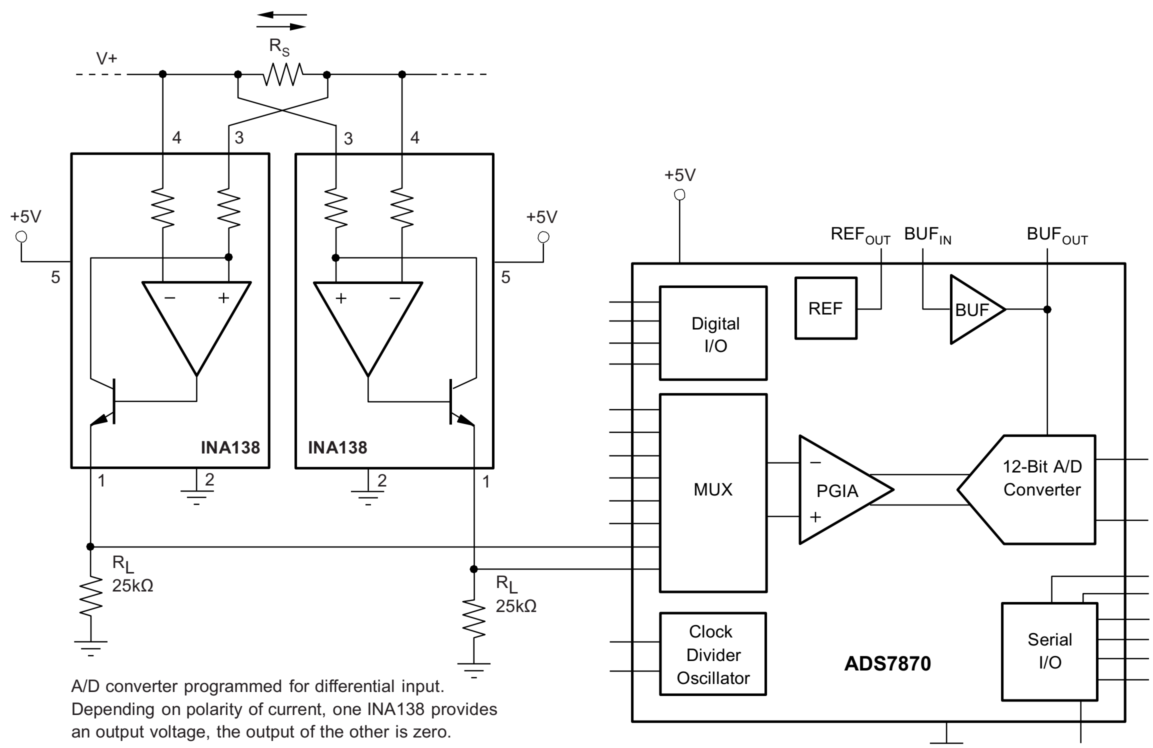

Figure 17. Bipolar Current Measurement Using Differential Input of ADC

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Typical Applications (continued)

8.2.6 Multiplexed Measurement Using Logic Signal for Power

Multiple loads can be measured as illustrated in Figure 18. In this configuration each INA1x8 device is powered by the digital I/O from the ADS7870. Multiplexing is achieved by switching on or off each the desired I/O.

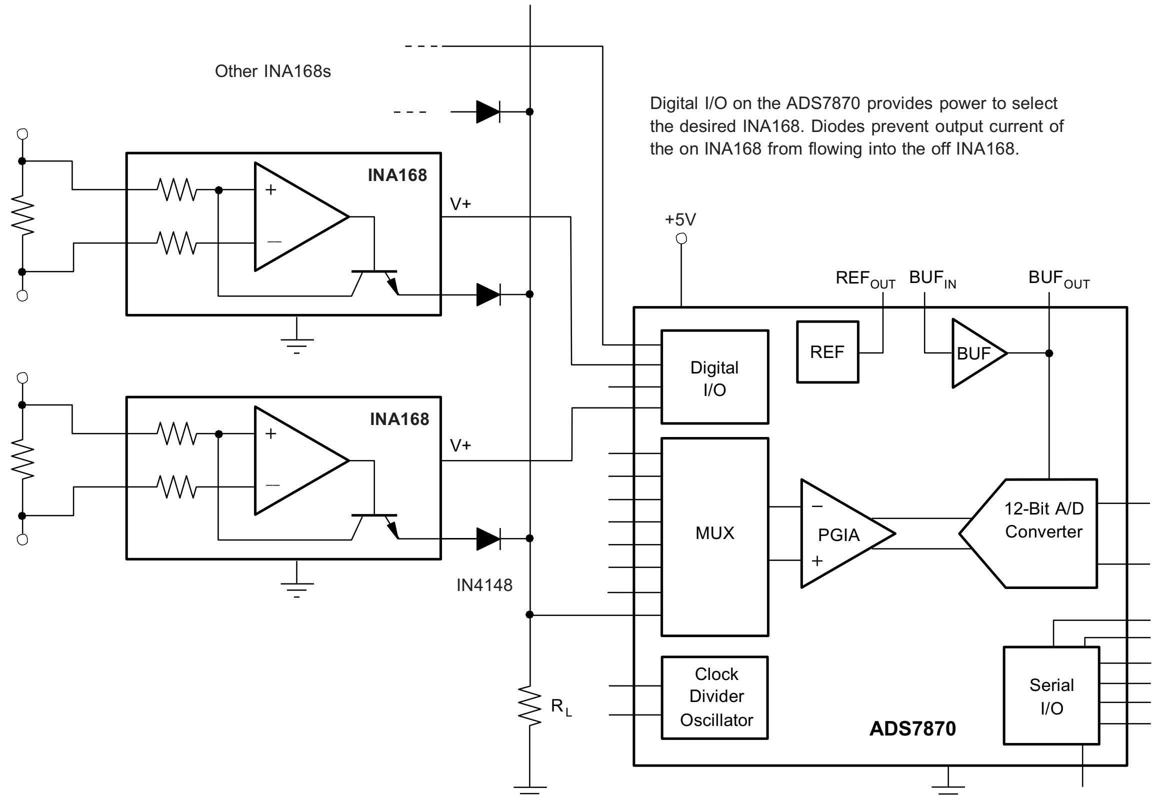

Figure 18. Multiplexed Measurement Using Logic Signal for Power

9 Power Supply Recommendations

The input circuitry of the INA138 can accurately measure beyond its power-supply voltage, V+. For example, the V+ power supply can be 5 V, whereas the load power supply voltage is up to 36 V (or 60 V with the INA168). The output voltage range of the OUT terminal, however, is limited by the lesser of the two voltages (see *Output Voltage Range*). A 0.1-µF capacitor is recommenced to be placed near the power supply pin on the INA138 or INA168. Additional capacitance may be required for applications with noisy power supply voltages.

10 Layout

10.1 Layout Guidelines

Figure 19 shows the basic connection of the INA138 device. The input pins, V_{IN+} and V_{IN-} , should be connected as closely as possible to the shunt resistor to minimize any resistance in series with the shunt resistance. The output resistor, R_L, is shown connected between pin 1 and ground. Best accuracy is achieved with the output voltage measured directly across R_L. This is especially important in high-current systems where load current could flow in the ground connections, affecting the measurement accuracy.

No power-supply bypass capacitors are required for stability of the INA138. However, applications with noisy or high-impedance power supplies may require decoupling capacitors to reject power-supply noise. Connect bypass capacitors close to the device pins.

10.2 Layout Example

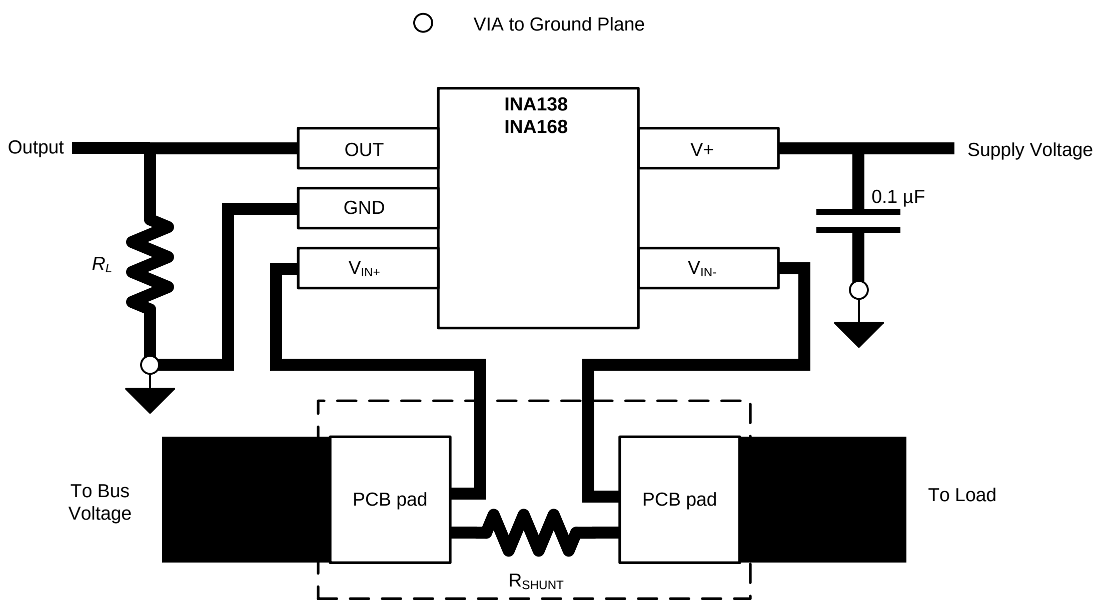

Figure 19. Typical Layout Example

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11 デバイスおよびドキュメントのサポート

11.1 ドキュメントのサポート

11.1.1 関連資料

関連資料については、以下を参照してください。

- *『シングルエンド・マルチプレクス・アプリケーション用の16ビット、1MSPSのデータ・アクイジションのリファレンス・デザイン』*
- *『ADS7870 12ビットADC、マルチプレクサ、プログラマブル・ゲイン・アンプ、内部リファレンスのデータ収集システム』*
- *『TLV3201、TLV3202 40ns、microPOWER、プッシュプル出力コンパレータ』*
- *『REF200デュアル電流源/電流シンク』*

11.2 関連リンク

表 1 に、クイック・アクセス・リンクの一覧を示します。カテゴリには、技術資料、サポートおよびコミュニティ・リソース、ツールとソフトウェア、およびサンプル注文またはご購入へのクイック・アクセスが含まれます。

表 1. 関連リンク

製品	プロダクト・フォルダ	サンプルとご購入	技術資料	ツールとソフトウェア	サポートとコミュニティ
INA138	ここをクリック	ここをクリック	ここをクリック	ここをクリック	ここをクリック
INA168	ここをクリック	ここをクリック	ここをクリック	ここをクリック	ここをクリック

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設計サポート ***TIの設計サポート*** 役に立つE2Eフォーラムや、設計サポート・ツールをすばやく見つけることができます。技術サポート用の連絡先情報も参照できます。

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11.7 Glossary

SLYZ022 — *TI Glossary*.

This glossary lists and explains terms, acronyms, and definitions.

12 メカニカル、パッケージ、および注文情報

以降のページには、メカニカル、パッケージ、および注文に関する情報が記載されています。この情報は、そのデバイスについて利用可能な最新のデータです。このデータは予告なく変更されることがあり、ドキュメントが改訂される場合もあります。本データシートのブラウザ版を使用されている場合は、画面左側の説明をご覧ください。

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PACKAGING INFORMATION

Orderable part number	Status (1)	Material type (2)	Package | Pins	Package qty | Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
INA138NA/250	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	B38
INA138NA/250.A	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	B38
INA138NA/3K	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	B38
INA138NA/3K.A	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	B38
INA168NA/250	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-	A68
INA168NA/250.A	Active	Production	SOT-23 (DBV) | 5	250 | SMALL T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A68
INA168NA/3K	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A68
INA168NA/3K.A	Active	Production	SOT-23 (DBV) | 5	3000 | LARGE T&R	Yes	NIPDAU	Level-2-260C-1 YEAR	-40 to 125	A68

(1) **Status:** For more details on status, see our product life cycle.

(2) **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

(6) **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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OTHER QUALIFIED VERSIONS OF INA138, INA168 :

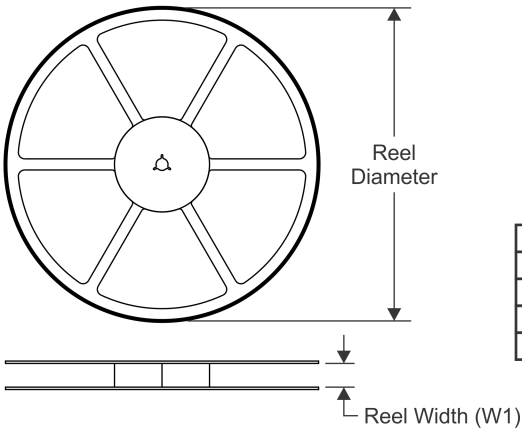
- Automotive : INA138-Q1, INA168-Q1

NOTE: Qualified Version Definitions:

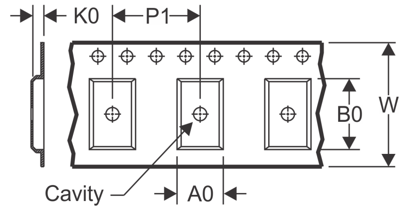
- Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

TAPE AND REEL INFORMATION

REEL DIMENSIONS

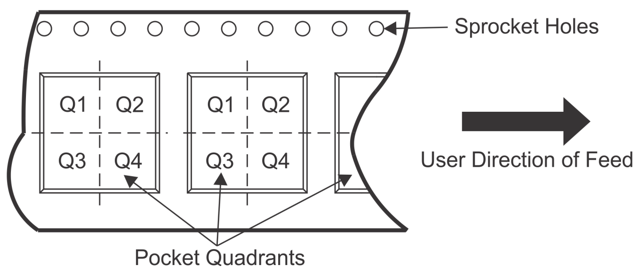


TAPE DIMENSIONS



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers

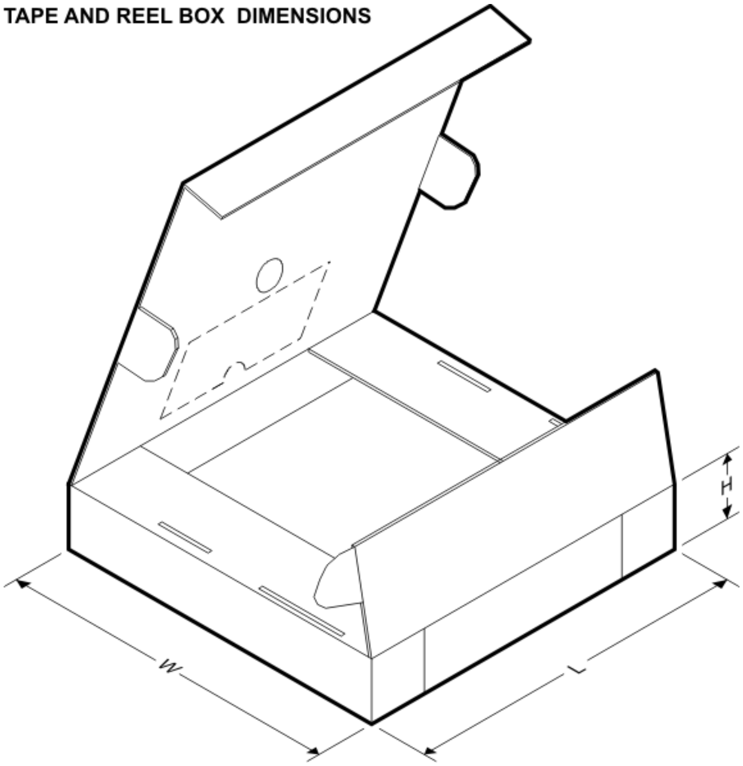
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

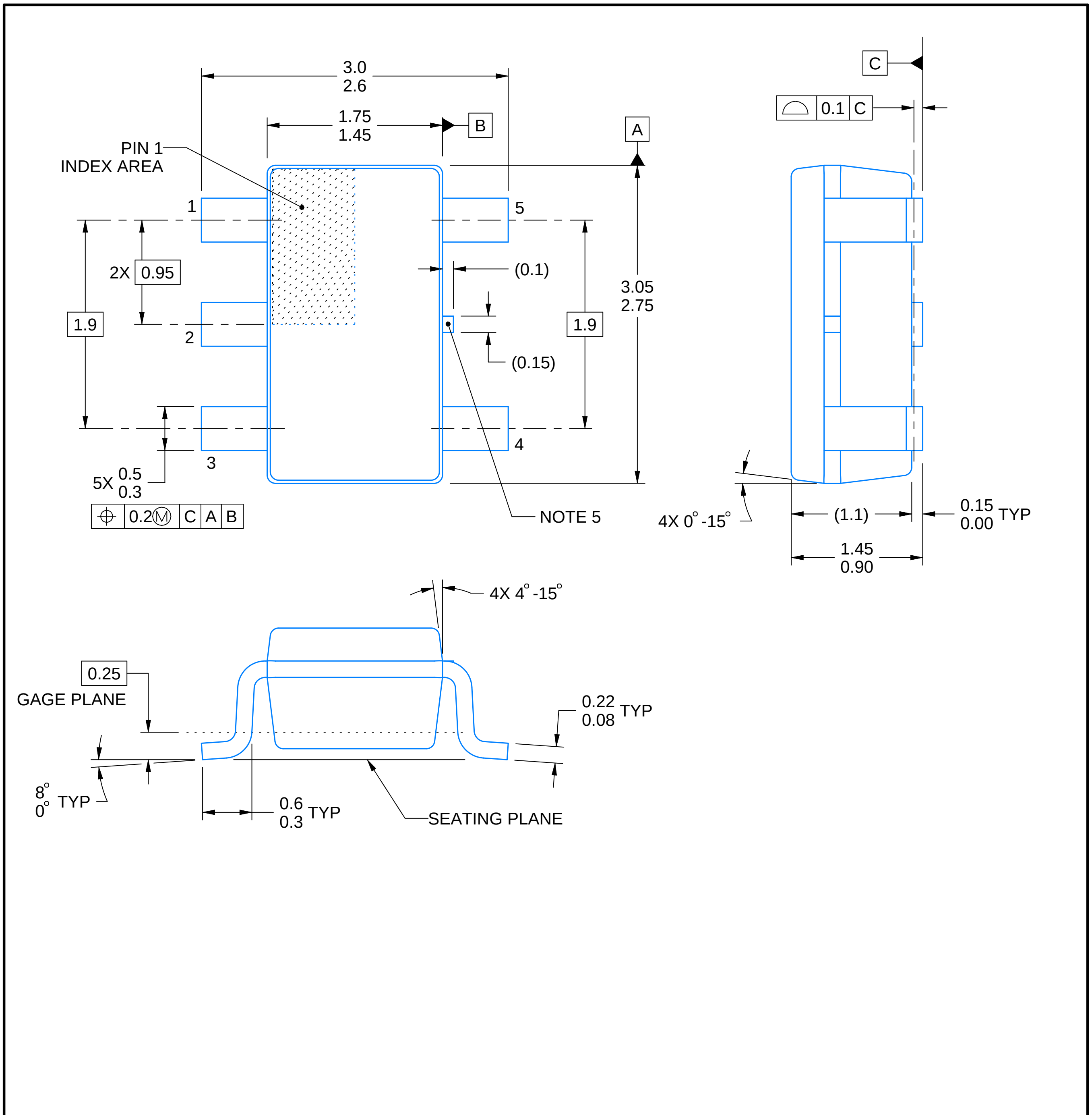
Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
INA138NA/250	SOT-23	DBV	5	250	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3
INA138NA/3K	SOT-23	DBV	5	3000	178.0	9.0	3.3	3.2	1.4	4.0	8.0	Q3
INA168NA/250	SOT-23	DBV	5	250	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3
INA168NA/3K	SOT-23	DBV	5	3000	178.0	9.0	3.23	3.17	1.37	4.0	8.0	Q3

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

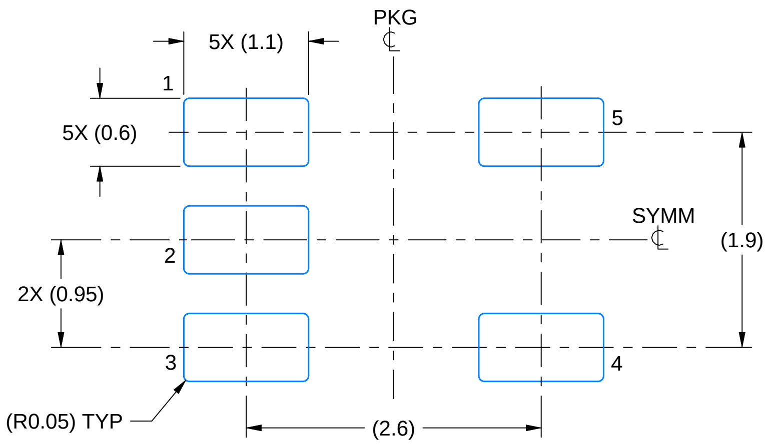
Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA138NA/250	SOT-23	DBV	5	250	180.0	180.0	18.0
INA138NA/3K	SOT-23	DBV	5	3000	180.0	180.0	18.0
INA168NA/250	SOT-23	DBV	5	250	180.0	180.0	18.0
INA168NA/3K	SOT-23	DBV	5	3000	180.0	180.0	18.0



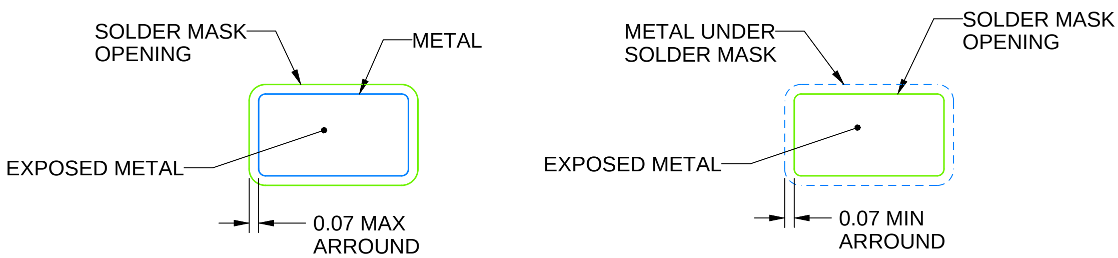
4214839/K 08/2024

NOTES:

1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
2. This drawing is subject to change without notice.
3. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



NON SOLDER MASK
DEFINED
(PREFERRED)

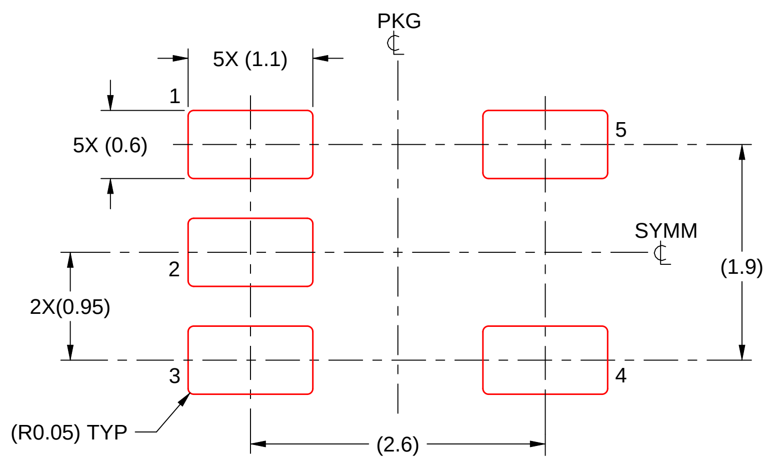
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4214839/K 08/2024

NOTES: (continued)

6. Publication IPC-7351 may have alternate designs.
7. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/K 08/2024

NOTES: (continued)

8. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
9. Board assembly site may have different recommendations for stencil design.

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