

INA148-Q1

www.ti.com

SBOS472A - MARCH 2009 - REVISED OCTOBER 2011

±200-V COMMON-MODE VOLTAGE DIFFERENCE AMPLIFIER

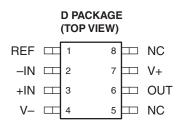
Check for Samples: INA148-Q1

FEATURES

- Qualified for Automotive Applications
- High Common-Mode Voltage
 - 75 V at V_S = 5 V
 - $\pm 200 \text{ V}$ at V_S = $\pm 15 \text{ V}$
- Fixed Differential Gain = 1 V/V
- Low Quiescent Current: 260 µA
- Wide Supply Range
 - Single Supply: 2.7 V to 36 V
 - Dual Supplies: ±1.35 V to ±18 V
- Low Gain Error: 0.075% Max
- Low Nonlinearity: 0.002% Max
- High CMR: 86 dB
- Surface-Mount SO-8 (D) Package

APPLICATIONS

- Current-Shunt Measurements
- Differential Sensor Amplifiers
- Line Receivers
- Battery-Powered Systems
- Automotive Instrumentation
- Stacked-Cell Monitors



NC - No internal connection

DESCRIPTION

The INA148 is a precision low-power unity-gain difference amplifier with a high common-mode input voltage range. It consists of a monolithic precision bipolar operational amplifier with a thin-film resistor network.

The on-chip resistors are laser trimmed for an accurate 1-V/V differential gain and high common-mode rejection. Excellent temperature tracking of the resistor network maintains high gain accuracy and common- mode rejection over temperature. The INA148 operates on single or dual supplies.

The INA148 is available in a small SO-8 surface-mount package, and it is specified for operation over the temperature range of -40°C to 125°C.

ORDERING INFORMATION⁽¹⁾

T _A	PACK	AGE ⁽²⁾	ORDERABLE PART NUMBER	TOP-SIDE MARKING	
–40°C to 125°C	SOIC – D	Reel of 2500	INA148QDRQ1	148Q1	

(1) For the most current package and ordering information, see the Package Option Addendum at the end of this document, or see the TI web site at www.ti.com.

(2) Package drawings, thermal data, and symbolization are available at www.ti.com/packaging.



Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

INA148-Q1



SBOS472A-MARCH 2009-REVISED OCTOBER 2011



This integrated circuit can be damaged by ESD. Texas Instruments recommends that all integrated circuits be handled with appropriate precautions. Failure to observe proper handling and installation procedures can cause damage.

ESD damage can range from subtle performance degradation to complete device failure. Precision integrated circuits may be more susceptible to damage because very small parametric changes could cause the device not to meet its published specifications.

ABSOLUTE MAXIMUM RATINGS⁽¹⁾

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

Vs	Supply voltage, V+ to V-		36 V
V		Continuous	±200 V
V _{IN}	Input voltage	Peak (0.1 second)	±500 V
t _{SS}	Short circuit to ground duration	Continuous	
θ_{JA}	Package thermal impedance, junction to free air	97.1°C/W	
T _A	Operating free-air temperature range		-40°C to 125°C
TJ	Maximum operating virtual-junction temperature		150°C
T _{stg}	Storage temperature range		–65°C to 150°C
T _{lead}	Lead temperature range (soldering, 10 seconds)		300°C
		Human-Body Model (HBM)	1500 V
ESD	Electrostatic discharge rating	Machine Model (MM)	150 V
		Charged-Device Model (CDM)	2000 V

(1) Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

RECOMMENDED OPERATING CONDITIONS

			MIN	MAX	UNIT
V	Supply voltage	Single supply	2.7	36	V
Vs	Supply voltage	Dual supply	±1.35	±18	v
T _A	Operating free-air temperature		-40	125	°C

EXAS **STRUMENTS**

SBOS472A - MARCH 2009 - REVISED OCTOBER 2011

www.ti.com

ELECTRICAL CHARACTERISTICS

 $V_{\rm S} = \pm 5$ V to ± 15 V (dual supply), R_I = 10 k Ω to ground, $V_{\rm RFF} = 0$ V, T_A = 25°C (unless otherwise noted)

PARAMETER		TEST CONDITIO	NS	MIN	TYP	MAX	UNIT
V _{OS}	Input offset voltage ⁽¹⁾ (2)	V _{CM} = 0 V	$V_{S} = \pm 15 V$		±1	±5	mV
		-	$V_S = \pm 5 V$		±1	±5	
$\Delta V_{OS} / \Delta T$	Input offset voltage drift ⁽¹⁾	$T_A = -40^{\circ}C$ to $125^{\circ}C$			±10		μV/°C
PSRR	Power supply ripple rejection ⁽¹⁾	$V_{\rm S}$ = ±1.35 V to ±18 V, $V_{\rm CM}$ = 0			±50	±400	μV/V
V _{CM}	Common-mode voltage range	$V_{+IN} - V_{-IN} = 0$	$V_S = \pm 15 V$	-200		200	V
			$V_S = \pm 5 V$	-100		80	
CMRR	Common-mode rejection ratio	$V_{S} = \pm 15 \text{ V}, V_{CM} = -200 \text{ V} \text{ to } 200 \text{ V}$	00 V, $R_S = 0 \Omega$	70	86		dB
OWIN		$V_{S}=\pm 5$ V, $V_{CM}=-100$ V to 80	V, $R_S = 0 \Omega$	70	86		üВ
	Differential input impedance				2		MΩ
	Common-mode input impedance				1		MΩ
Vn	Voltage noise ^{(1) (3)}	f = 0.1 Hz to 10 Hz			17		μV _{p-p}
	Voltage noise density ^{(1) (3)}	f = 1 kHz			880		nV/√Hz
	Initial gain ⁽¹⁾				1		V/V
	Gain error	$V_{O} = (V - + 0.5)$ to $(V + - 1.5)$			±0.01	±0.075	%
	Gain error over temperature				±3	±10	ppm/°C
	Gain nonlinearity		$V_{\rm S} = \pm 15 \text{ V}$		±0.00 1	±0.002	%FSR
		$V_0 = (V - + 0.5)$ to $(V + - 1.5)$	$V_{\rm S} = \pm 5 \ V$		±0.00 1		%FSR
	Small signal bandwidth frequency response	andwidth frequency					kHz
SR	Slew rate				1		V/µs
			0.1%		21		
		$V_S = \pm 15 V$, 10-V step	0.01%		25		
t _s	Settling time		0.1%		21		μs
		$V_S = \pm 5 V, 6-V step$	0.01%		25		
	Overload recovery	50% input overload			24		μs
.,		R _L = 100 kΩ	V– + 0.25		V+ – 1	.,	
Vo	Output voltage	$R_L = 10 k\Omega$	V– + 0.5		V+ – 1.5	V	
lo	Output current	Short-circuit current, continuous	to common		±13		mA
CL	Load capacitance	Stable operation			10		nF
I _S	Supply current	$V_{IN} = 0, I_{O} = 0$			±260	±300	μA

Overall difference amplifier configuration. Referred to input pins (V_{+IN} and V_{-IN}), gain = 1 V/V. Includes effects of amplifier's input bias and offset currents. (1)

(2) (3)

Includes effects of input current noise and thermal noise contribution of resistor network.

www.ti.com

ELECTRICAL CHARACTERISTICS

$V_{S} = 5 V$ (single supply), $R_{L} = 10 k\Omega$ to $V_{S}/2$, $V_{REF} = V_{S}/2$, $T_{A} = 25^{\circ}C$ (unless otherwise noted)

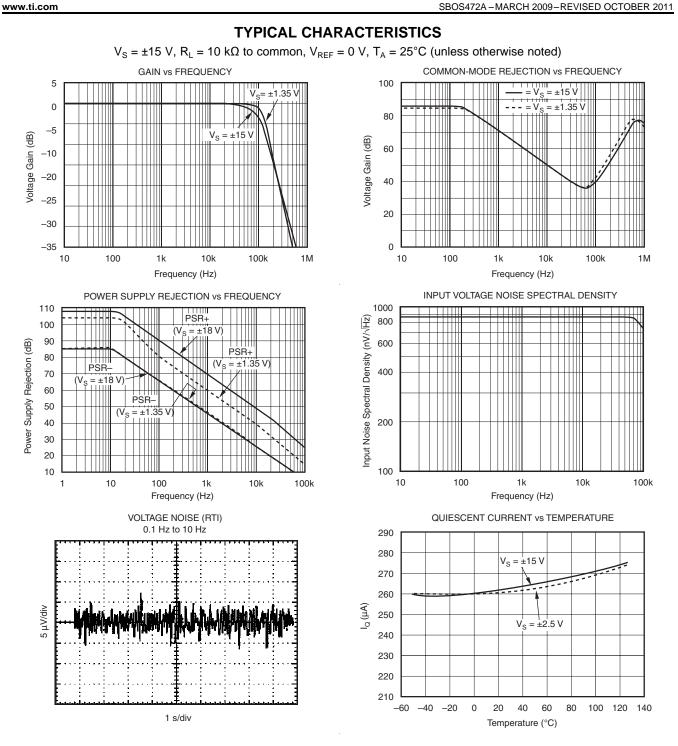
PARAMETER		TEST CO	MIN	TYP	MAX	UNIT		
V _{OS}	Input offset voltage ⁽¹⁾ ⁽²⁾	$V_{CM} = V_S/2$		±1	±5	mV		
ΔV _{OS} /ΔT	Input offset voltage drift ⁽¹⁾	$T_A = -40^{\circ}C$ to $125^{\circ}C$		±10		µV/°C		
PSRR	Power supply ripple rejection ⁽¹⁾	$V_{\rm S}$ = 2.7 V to 36 V, $V_{\rm CM}$	$1 = V_{\rm S}/2$		±50	±400	μV/V	
.,	0 1 1		V _{REF} = 0.25 V	-4		75	.,	
V _{CM}	Common-mode voltage range	$V_{+IN} - V_{-IN} = 0$	$V_{REF} = V_S/2$	-47.5		32.5	V	
CMRR	Common-mode rejection ratio	$V_{CM} = -47.5$ V to 32.5 V	70	86		dB		
	Differential input impedance				2		MΩ	
	Common-mode input impedance				1		MΩ	
V _n	Voltage noise ^{(1) (3)}	f = 0.1 Hz to 10 Hz			17		μV _{p-p}	
	Voltage noise density ^{(1) (3)}	f = 1 kHz			880		nV/√Hz	
	Initial gain ⁽¹⁾				1		V/V	
	Gain error	$V_{O} = 0.5 \text{ V} \text{ to } 3.5 \text{ V}$			±0.01	±0.075	%	
	Gain error over temperature				±3	±10	ppm/°C	
	Gain nonlinearity	$V_{O} = 0.5 V \text{ to } 3.5 V$		±0.00 1		%FSR		
	Small signal bandwidth				100		kHz	
SR	Slew rate				1		V/µs	
			0.1%		21			
t _s	Settling time	$V_{\rm S} = 5 \text{ V}, 3 \text{-V step}$ 0.01%		25			μs	
	Overload recovery	50% input overload			13		μs	
	O stand and the sec	R _L = 100 kΩ		V– + 0.25		V+ – 1	V	
Vo	Output voltage	R _L = 10 kΩ		V– + 0.5		V+ – 1.5	V	
lo	Output current	Short-circuit current, co	ntinuous to common		±8		mA	
CL	Load capacitance	Stable operation			10		nF	
l _Q	Quiescent current	$V_{IN} = 0, I_{O} = 0$			260	300	μA	

Overall difference amplifier configuration. Referred to input pins (V_{+IN} and V_{-IN}), gain = 1 V/V. Includes effects of amplifier's input bias and offset currents. Includes effects of input current noise and thermal noise contribution of resistor network. (1)

(2) (3)

Copyright © 2009–2011, Texas Instruments Incorporated





TYPICAL CHARACTERISTICS (continued) V_{S} = ±15 V, R_{L} = 10 k Ω to common, V_{REF} = 0 V, T_{A} = 25°C (unless otherwise noted) SHORT-CIRCUIT CURRENT vs TEMPERATURE LARGE-SIGNAL STEP RESPONSE vs TEMPERATURE 20 15 +SC Short-Circuit Current (mA) 10 125°C 125°C 5 0 55°C -55°C 5 V/div -5 -10 -sc -15 -20 -60 -40 -20 0 20 40 60 80 100 120 140 Temperature (°C) 25 µs/div OUTPUT VOLTAGE SWING vs RL LARGE-SIGNAL STEP RESPONSE $(\mathsf{R}_{\scriptscriptstyle L}~=10~\mathsf{k}\Omega,~\mathsf{C}_{\scriptscriptstyle L}~=10~\mathsf{pF})$ $R_L = 100 \ k\Omega$ R = 1 kΩ 5 V/div 5 V/div Т Т $R_L = 1 \ k\Omega$ $R_1 = 10 k\Omega$ $R_L = 10 \ k\Omega$ = 100 kΩ 1 ms/div 25 ms/div SMALL-SIGNAL STEP RESPONSE LARGE-SIGNAL CAPACITIVE LOAD RESPONSE $(C_{L} = 1 \text{ nF and } 10 \text{ nF})$ $(R_{L} = 10 \text{ k}\Omega, C_{L} = 10 \text{ pF})$ G = +1 V/V CL = 1 nF CL = 10 nF V_{IN} 50 mV/div 5 V/div H +++++**|** ++-+++ 10 ms/div 100 µs/div

6



www.ti.com



4.0 5.0

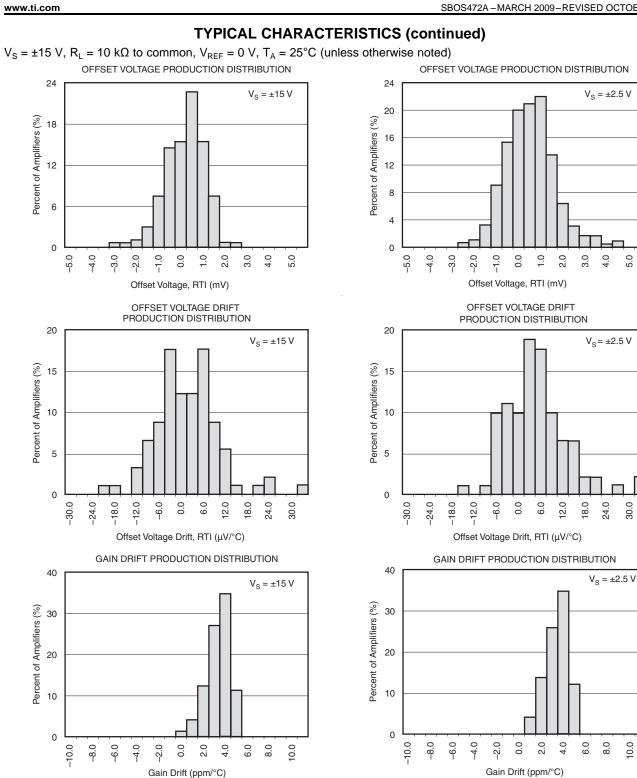
30.0

24.0

8.0

10.0

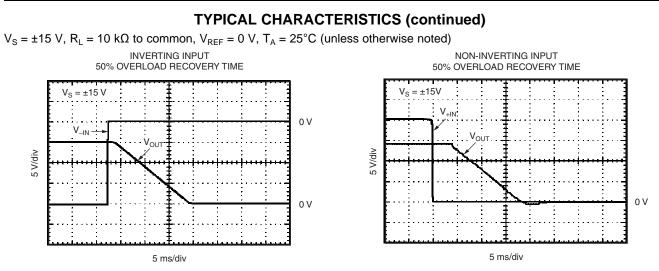
SBOS472A-MARCH 2009-REVISED OCTOBER 2011



INSTRUMENTS

Texas

www.ti.com





SBOS472A – MARCH 2009 – REVISED OCTOBER 2011

APPLICATION INFORMATION

The INA148 is a unity-gain difference amplifier with a high common-mode input voltage range. A basic diagram of the circuit and pin connections is shown in Figure 1.

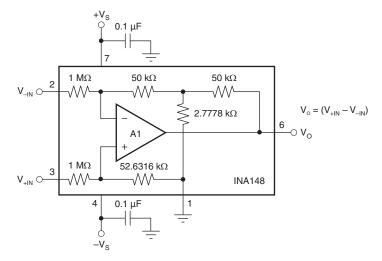


Figure 1. Basic Circuit Connections

To achieve its high common-mode voltage range, the INA148 features a precision laser-trimmed thin-film resistor network with a 20:1 input voltage divider ratio. High input voltages are thereby reduced in amplitude, allowing the internal operational amplifier (op amp) to "see" input voltages that are within its linear operating range. A "Tee" network in the op amp feedback network places the amplifier in a gain of 20 V/V, thus restoring the circuit's overall gain to unity (1 V/V).

External voltages can be summed into the amplifier's output by using the REF pin, making the differential amplifier a highly versatile design tool. Voltages on the REF pin also influence the INA148's common-mode voltage range.

In accordance with good engineering practice for linear integrated circuits, the INA148's power-supply bypass capacitors should be connected as close to pins 4 and 7 as practicable. Ceramic or tantalum types are recommended for use as bypass capacitors.

The input impedances are unusually high for a difference amplifier and this should be considered when routing input signal traces on a PC board. Avoid placing digital signal traces near the difference amplifier's input traces to minimize noise pickup.

Operating Voltage

The INA148 is specified for ±15-V and ±5-V dual supplies and 5-V single supplies. The INA148 can be operated with single or dual supplies with excellent performance.

The INA148 is fully characterized for supply voltages from ± 1.35 V to ± 18 V and over temperatures of -40° C to 125° C. Parameters that vary significantly with operating voltage, load conditions, or temperature are shown in the *Typical Characteristics* section.

Gain Equation

An internal on-chip resistor network sets the overall differential gain of the INA148 to precisely 1 V/V. Output is accordance with Equation 1.

 $V_{OUT} = (V_{+IN} - V_{-IN}) + V_{REF}$

(1)

(1)



Common-Mode Range

The 20:1 input resistor ratio of the INA148 provides an input common-mode range that extends well beyond its power supply rails.

The exact input voltage range depends on the amplifier's power-supply voltage and the voltage applied to the REF terminal (pin 1). Typical input voltage ranges at different power supply voltages can be found in the applications circuits section.

Offset Trim

The INA148 is laser-trimmed for low offset voltage and drift. Most applications require no external offset adjustment.

Because a voltage applied to the reference (REF) pin (pin 1) is summed directly into the amplifier's output signal, this technique can be used to null the amplifier's input offset voltage. Figure 2 shows an optional circuit for trimming the offset voltage.

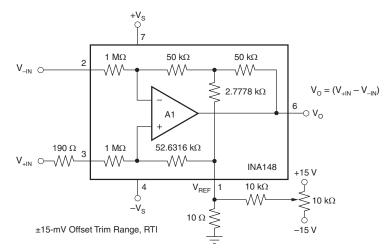


Figure 2. Optional Offset Trim Circuit

To maintain high common-mode rejection (CMR), the source impedance of any signal applied to the REF terminal should be very low ($\leq 5 \Omega$).

A source impedance of only 10 Ω at the REF pin reduces the INA148's CMR to approximately 74 dB. High CMR can be restored if a resistor is added in series with the amplifier's positive input terminal (pin 3). This resistor should be 19 times the source impedance that drives the REF pin. For example, if the REF pin sees a source impedance of 10 Ω , a resistor of 190 Ω should be added in series with pin 3.

Preferably, the offset trim voltage applied to the REF pin should be buffered with an amplifier such as an OPA237 (see Figure 3). In this case, the op amp output impedance is low enough that no external resistor is needed to maintain the INA148's excellent CMR.



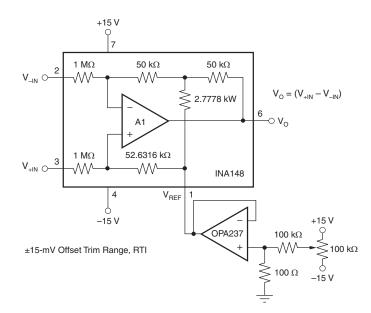


Figure 3. Preferred Offset Trim Circuit

Input Impedance

The input resistor network determines the impedance of each of the INA148 inputs. It is approximately 1 M Ω . Unlike an instrumentation amplifier, signal source impedances at the two input terminals must be nearly equal to maintain good common-mode rejection.

A mismatch between the two inputs' source impedances causes a differential amplifier's common-mode rejection to be degraded. With a source impedance imbalance of only 500 Ω , CMR can fall to approximately 66 dB.

Figure 4 shows a common application—measuring power supply current through a shunt resistor (R_S). A shunt resistor creates an unbalanced source resistance condition that can degrade a differential amplifier's common mode rejection.

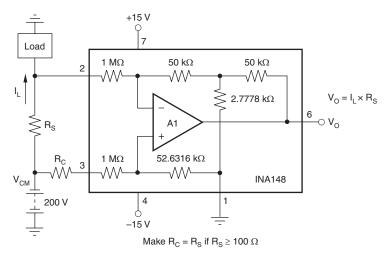


Figure 4. Shunt-Resistor Current Measurement Circuit

Unless the shunt resistor is less than approximately 100 Ω , an additional equal compensating resistor (RC) is recommended to maintain input balance and high CMR.



SBOS472A-MARCH 2009-REVISED OCTOBER 2011

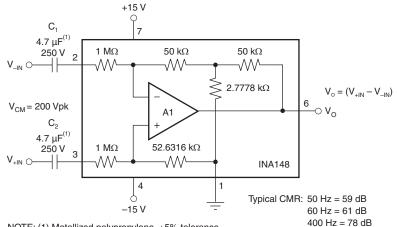
Source impedances (or shunts) greater than 5 k Ω are not recommended, even if they are "perfectly" compensated. This is because the internal resistor network is laser-trimmed for accurate voltage divider ratios, but not necessarily to absolute values. Input resistors are shown as 1 M Ω , however, this is only their nominal value.

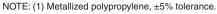
In practice, the input resistors' absolute values may vary by as much as 30%. The two input resistors match to about 5%, so adding compensating resistors greater than 5 k Ω can cause a serious mismatch in the resulting resistor network voltage divider ratios, thus degrading CMR.

Attempts to extend the INA148 input voltage range by adding external resistors is not recommended for the reasons described in the previous paragraph. CMR suffers serious degradation unless the resistors are carefully trimmed for CMR and gain. This is an iterative adjustment and can be tedious and time consuming.

Typical Application Circuits

Figure 5 through Figure 9 show typical application circuits for the INA148.







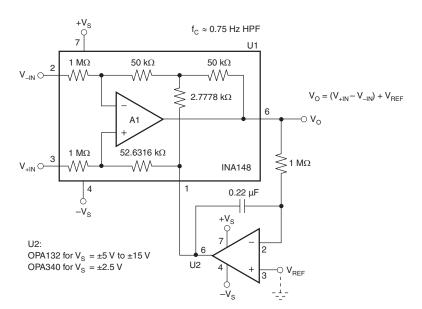
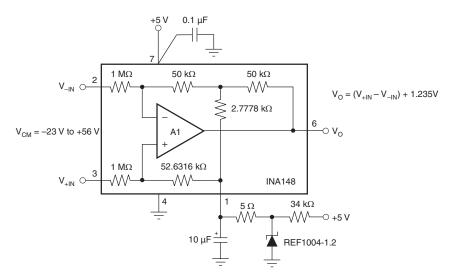
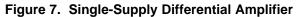


Figure 6. Quasi-AC-Coupled Differential Amplifier



SBOS472A-MARCH 2009-REVISED OCTOBER 2011





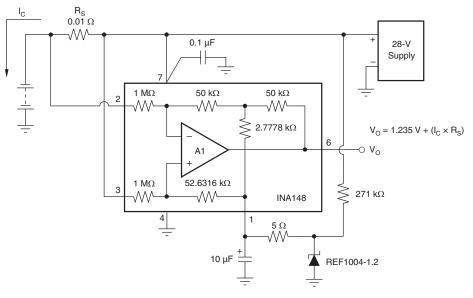


Figure 8. Battery Monitor Circuit



SBOS472A-MARCH 2009-REVISED OCTOBER 2011

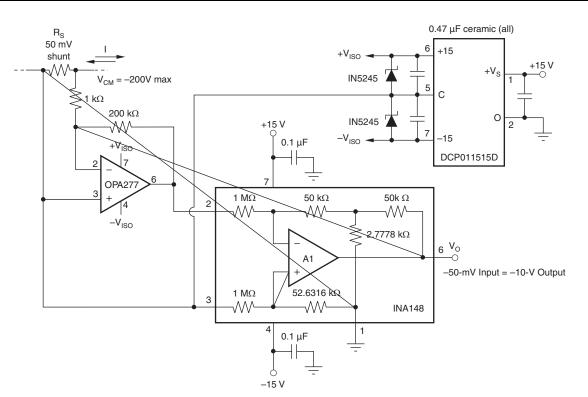


Figure 9. 50-mV Current-Shunt Amplifier with ±200-V Common-Mode Voltage Range

REVISION HISTORY

Changes from Original (March 2009) to Revision A

Page



PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/ Ball Finish	MSL Peak Temp ⁽³⁾	Samples (Requires Login)
INA148QDRQ1	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	

⁽¹⁾ The marketing status values are defined as follows:

ACTIVE: Product device recommended for new designs.

LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.

NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.

PREVIEW: Device has been announced but is not in production. Samples may or may not be available.

OBSOLETE: TI has discontinued the production of the device.

(2) Eco Plan - The planned eco-friendly classification: Pb-Free (RoHS), Pb-Free (RoHS Exempt), or Green (RoHS & no Sb/Br) - please check http://www.ti.com/productcontent for the latest availability information and additional product content details.

TBD: The Pb-Free/Green conversion plan has not been defined.

Pb-Free (RoHS): TI's terms "Lead-Free" or "Pb-Free" mean semiconductor products that are compatible with the current RoHS requirements for all 6 substances, including the requirement that lead not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, TI Pb-Free products are suitable for use in specified lead-free processes.

Pb-Free (RoHS Exempt): This component has a RoHS exemption for either 1) lead-based flip-chip solder bumps used between the die and package, or 2) lead-based die adhesive used between the die and leadframe. The component is otherwise considered Pb-Free (RoHS compatible) as defined above.

Green (RoHS & no Sb/Br): TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

⁽³⁾ MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.

OTHER QUALIFIED VERSIONS OF INA148-Q1 :

Catalog: INA148

NOTE: Qualified Version Definitions:

• Catalog - TI's standard catalog product

PACKAGE MATERIALS INFORMATION

www.ti.com

TAPE AND REEL INFORMATION

REEL DIMENSIONS

TEXAS INSTRUMENTS





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

 TAPE AND REEL INFORMATION

 *All dimensions are nominal

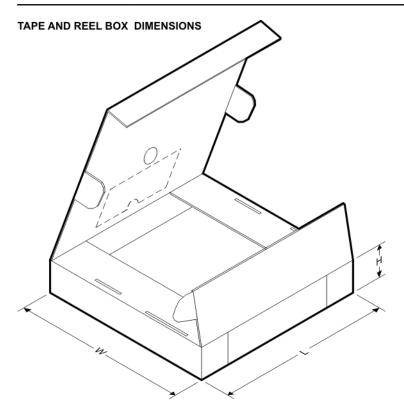
Device		Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
INA148QDRQ1	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TEXAS INSTRUMENTS

www.ti.com

PACKAGE MATERIALS INFORMATION

24-Oct-2011



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA148QDRQ1	SOIC	D	8	2500	346.0	346.0	29.0

D (R-PDSO-G8)

PLASTIC SMALL OUTLINE



NOTES: A. All linear dimensions are in inches (millimeters).

- B. This drawing is subject to change without notice.
- Body length does not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.006 (0,15) each side.
- Body width does not include interlead flash. Interlead flash shall not exceed 0.017 (0,43) each side.
- E. Reference JEDEC MS-012 variation AA.



LAND PATTERN DATA



NOTES: A. All linear dimensions are in millimeters.

- B. This drawing is subject to change without notice.
- C. Publication IPC-7351 is recommended for alternate designs.
- D. Laser cutting apertures with trapezoidal walls and also rounding corners will offer better paste release. Customers should contact their board assembly site for stencil design recommendations. Refer to IPC-7525 for other stencil recommendations.
 E. Customers should contact their board fabrication site for solder mask tolerances between and around signal pads.



IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, modifications, enhancements, improvements, and other changes to its products and services at any time and to discontinue any product or service without notice. Customers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All products are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its hardware products to the specifications applicable at the time of sale in accordance with TI's standard warranty. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by government requirements, testing of all parameters of each product is not necessarily performed.

TI assumes no liability for applications assistance or customer product design. Customers are responsible for their products and applications using TI components. To minimize the risks associated with customer products and applications, customers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any TI patent right, copyright, mask work right, or other TI intellectual property right relating to any combination, machine, or process in which TI products or services are used. Information published by TI regarding third-party products or services does not constitute a license from TI to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. Reproduction of this information with alteration is an unfair and deceptive business practice. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI products or services with statements different from or beyond the parameters stated by TI for that product or service voids all express and any implied warranties for the associated TI product or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

TI products are not authorized for use in safety-critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, unless officers of the parties have executed an agreement specifically governing such use. Buyers represent that they have all necessary expertise in the safety and regulatory ramifications of their applications, and acknowledge and agree that they are solely responsible for all legal, regulatory and safety-related requirements concerning their products and any use of TI products in such safety-critical applications, notwithstanding any applications-related information or support that may be provided by TI. Further, Buyers must fully indemnify TI and its representatives against any damages arising out of the use of TI products in such safety-critical applications.

TI products are neither designed nor intended for use in military/aerospace applications or environments unless the TI products are specifically designated by TI as military-grade or "enhanced plastic." Only products designated by TI as military-grade meet military specifications. Buyers acknowledge and agree that any such use of TI products which TI has not designated as military-grade is solely at the Buyer's risk, and that they are solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI products are neither designed nor intended for use in automotive applications or environments unless the specific TI products are designated by TI as compliant with ISO/TS 16949 requirements. Buyers acknowledge and agree that, if they use any non-designated products in automotive applications, TI will not be responsible for any failure to meet such requirements.

Following are URLs where you can obtain information on other Texas Instruments products and application solutions:

Products		Applications	
Audio	www.ti.com/audio	Communications and Telecom	www.ti.com/communications
Amplifiers	amplifier.ti.com	Computers and Peripherals	www.ti.com/computers
Data Converters	dataconverter.ti.com	Consumer Electronics	www.ti.com/consumer-apps
DLP® Products	www.dlp.com	Energy and Lighting	www.ti.com/energy
DSP	dsp.ti.com	Industrial	www.ti.com/industrial
Clocks and Timers	www.ti.com/clocks	Medical	www.ti.com/medical
Interface	interface.ti.com	Security	www.ti.com/security
Logic	logic.ti.com	Space, Avionics and Defense	www.ti.com/space-avionics-defense
Power Mgmt	power.ti.com	Transportation and Automotive	www.ti.com/automotive
Microcontrollers	microcontroller.ti.com	Video and Imaging	www.ti.com/video
RFID	www.ti-rfid.com		
OMAP Mobile Processors	www.ti.com/omap		
Wireless Connectivity	www.ti.com/wirelessconnectivity		
		u Hama Dawa	a O a Al a a m

TI E2E Community Home Page

e2e.ti.com

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265 Copyright © 2011, Texas Instruments Incorporated