



For most current data sheet and other product information, visit www.burr-brown.com

±200V Common-Mode Voltage DIFFERENCE AMPLIFIER

FEATURES

- **HIGH COMMON-MODE VOLTAGE:**
 +75V at $V_s = +5V$
 ±200V at $V_s = ±15V$
- **FIXED DIFFERENTIAL GAIN = 1V/V**
- **LOW QUIESCENT CURRENT: 260µA**
- **WIDE SUPPLY RANGE:**
 Single Supply: 2.7V to 36V
 Dual Supplies: ±1.35V to ±18V
- **LOW GAIN ERROR: 0.075% max**
- **LOW NONLINEARITY: 0.002% max**
- **HIGH CMR: 86dB**
- **SO-8 PACKAGE**

DESCRIPTION

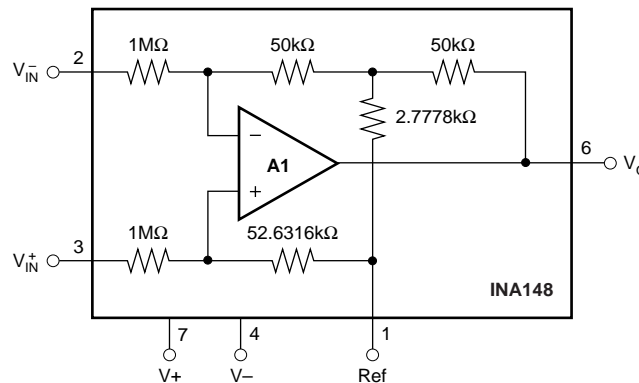
The INA148 is a precision, low-power, unity-gain difference amplifier with a high common-mode input voltage range. It consists of a monolithic precision bipolar op amp with a thin-film resistor network.

The on-chip resistors are laser trimmed for an accurate 1V/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 will operate on single or dual supplies.

The INA148 is available in a small SO-8 surface-mount package and it is specified for the -40°C to +85°C extended industrial temperature range.

APPLICATIONS

- **CURRENT SHUNT MEASUREMENTS**
- **DIFFERENTIAL SENSOR AMPLIFIERS**
- **LINE RECEIVERS**
- **BATTERY POWERED SYSTEMS**
- **AUTOMOTIVE INSTRUMENTATION**
- **STACKED CELL MONITORS**



SPECIFICATIONS: $V_S = \pm 5V$ to $\pm 15V$ Dual Supplies

At $T_A = +25^\circ C$, $R_L = 10k\Omega$ connected to ground and Ref pin connected to ground, unless otherwise noted.

PARAMETER	CONDITIONS	INA148UA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE (V_O)	RTI⁽¹⁾⁽²⁾				
Input Offset Voltage	V_{OS} $V_S = \pm 15V, V_{CM} = 0V$ $V_S = \pm 5V, V_{CM} = 0V$		± 1	± 5	mV
Drift	$\Delta V_{OS}/\Delta T$ At $T_A = -40^\circ C$ to $+85^\circ C$		± 1	± 5	mV
vs Power Supply	PSRR $V_S = \pm 1.35V$ to $\pm 18V, V_{CM} = 0V$		± 10	± 50	$\mu V/^\circ C$ $\mu V/V$
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM} $V_S = \pm 15V, (V_{IN}^+) - (V_{IN}^-) = 0V$ $V_S = \pm 5V, (V_{IN}^+) - (V_{IN}^-) = 0V$	-200 -100		+200 +80	V V
Common-Mode Rejection	CMRR $V_S = \pm 15V, V_{CM} = -200V$ to $+200V, R_S = 0\Omega$ $V_S = \pm 5V, V_{CM} = -100V$ to $+80V, R_S = 0\Omega$	70 70	86 86		dB dB
INPUT IMPEDANCE					
Differential			2		$M\Omega$
Common Mode			1		$M\Omega$
NOISE	RTI⁽¹⁾⁽³⁾				
Voltage Noise, $f = 0.1Hz$ to $10Hz$	e_n		17		$\mu Vp-p$
Voltage Noise Density, $f = 1kHz$			880		nV/\sqrt{Hz}
GAIN					
Initial ⁽¹⁾			1		V/V
Gain Error	$V_O = (V-) + 0.5$ to $(V+) - 1.5$		± 0.01	± 0.075	%
vs Temperature			± 3	± 10	ppm/ $^\circ C$
Nonlinearity	$V_S = \pm 15V, V_O = (V-) + 0.5$ to $(V+) - 1.5$ $V_S = \pm 5V, V_O = (V-) + 0.5$ to $(V+) - 1.5$		± 0.001	± 0.002	% of FSR % of FSR
FREQUENCY RESPONSE					
Small Signal Bandwidth			100		kHz
Slew Rate			1		V/ μs
Settling Time: 0.1%	$V_S = \pm 15V, 10V$ Step		21		μs
0.01%	$V_S = \pm 15V, 10V$ Step		25		μs
0.1%	$V_S = \pm 5V, 6V$ Step		21		μs
0.01%	$V_S = \pm 5V, 6V$ Step		25		μs
Overload Recovery	50% Input Overload		24		μs
OUTPUT (V_O)					
Voltage Output	$R_L = 100k\Omega$ $R_L = 10k\Omega$	$(V-) + 0.25$ $(V-) + 0.5$		$(V+) - 1$ $(V+) - 1.5$	V V
Output Current	I_O		± 13		mA
Short-Circuit Current	Continuous to Common		10		nF
Capacitive Load	Stable Operation				
POWER SUPPLY					
Operating Range, Dual Supplies		± 1.35		± 18	V
Quiescent Current	$V_{IN} = 0, I_O = 0$		± 260	± 300	μA
TEMPERATURE RANGE					
Specified		-40		85	$^\circ C$
Operating		-55		125	$^\circ C$
Storage		-55		125	$^\circ C$
Thermal Resistance	θ_{JA} SO-8 Surface Mount		150		$^\circ C/W$

NOTES: (1) Overall difference amplifier configuration. Referred to input pins (V_{IN}^+ and V_{IN}^-), gain = 1V/V (2) Input offset voltage specification includes effects of amplifier's input bias and offset currents. (3) Includes effects of input current noise and thermal noise contribution of resistor network.

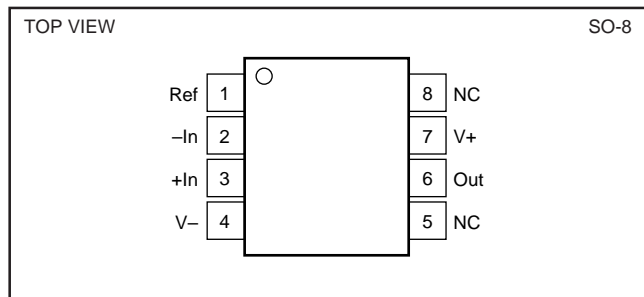
SPECIFICATIONS: $V_S = +5V$ Single Supply

At $T_A = +25^\circ\text{C}$, $R_L = 10\text{k}\Omega$ connected to $V_S/2$ and Ref pin connected to $V_S/2$, unless otherwise noted.

PARAMETER	CONDITIONS	INA148UA			UNITS
		MIN	TYP	MAX	
OFFSET VOLTAGE (V_O)	RTI⁽¹⁾⁽²⁾				
Input Offset Voltage	V_{OS} $V_{CM} = V_S/2$		± 1	± 5	mV
Drift	$\Delta V_{OS}/\Delta T$ At $T_A = -40^\circ\text{C}$ to $+85^\circ\text{C}$		± 10		$\mu\text{V}/^\circ\text{C}$
vs Power Supply	PSRR $V_S = +2.7\text{V}$ to $+36\text{V}$, $V_{CM} = V_S/2$		± 50	± 400	$\mu\text{V}/\text{V}$
INPUT VOLTAGE RANGE					
Common-Mode Voltage Range	V_{CM} $(V_{IN+}) - (V_{IN-}) = 0\text{V}$, $V_{REF} = 0.25\text{V}$	-4		+75	V
Common-Mode Rejection	CMRR $(V_{IN+}) - (V_{IN-}) = 0\text{V}$, $V_{REF} = V_S/2$ $V_{CM} = -47.5\text{V}$ to $+32.5\text{V}$, $R_S = 0\Omega$	-47.5 70	86	+32.5	V dB
INPUT IMPEDANCE					
Differential			2		$\text{M}\Omega$
Common Mode			1		$\text{M}\Omega$
NOISE	RTI⁽¹⁾⁽³⁾				
Voltage Noise, $f = 0.1\text{Hz}$ to 10Hz	e_n		17		$\mu\text{Vp-p}$
Voltage Noise Density, $f = 1\text{kHz}$			880		$\text{nV}/\sqrt{\text{Hz}}$
GAIN					
Initial ⁽¹⁾			1		V/V
Gain Error	$V_O = +0.5\text{V}$ to $+3.5\text{V}$		± 0.01	± 0.075	%
vs Temperature			± 3	± 10	$\text{ppm}/^\circ\text{C}$
Nonlinearity	$V_O = +0.5\text{V}$ to $+3.5\text{V}$		± 0.001		% of FSR
FREQUENCY RESPONSE					
Small Signal Bandwidth			100		kHz
Slew Rate			1		$\text{V}/\mu\text{s}$
Settling Time: 0.1%	$V_S = +5\text{V}$, 3V Step		21		μs
0.01%	$V_S = +5\text{V}$, 3V Step		25		μs
Overload Recovery	50% Input Overload		13		μs
OUTPUT (V_O)					
Voltage Output	$R_L = 100\text{k}\Omega$ $R_L = 10\text{k}\Omega$	$(V-) + 0.25$ $(V-) + 0.5$		$(V+) - 1$ $(V+) - 1.5$	V V
Output Current	I_O		± 8		mA
Short-Circuit Current	Continuous to Common		10		nF
Capacitive Load	Stable Operation				
POWER SUPPLY					
Operating Range, Single Supply		+2.7		+36	V
Quiescent Current	$V_{IN} = 0$, $I_O = 0$		260	300	μA
TEMPERATURE RANGE					
Specified		-40		85	$^\circ\text{C}$
Operating		-55		125	$^\circ\text{C}$
Storage		-55		125	$^\circ\text{C}$
Thermal Resistance	θ_{JA} SO-8 Surface Mount		150		$^\circ\text{C}/\text{W}$

NOTES: (1) Overall difference amplifier configuration. Referred to input pins (V_{IN+} and V_{IN-}), gain = 1V/V (2) Input offset voltage specification includes effects of amplifier's input bias and offset currents. (3) Includes effects of input current noise and thermal noise contribution of resistor network.

PIN CONFIGURATION



ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Burr-Brown 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⁾

Supply Voltage, V+ to V-	36V
Signal Input Terminals, Continuous	±200V
Peak (0.1s)	±500V
Output Short Circuit to GND Duration	Continuous
Operating Temperature	-55°C to +125°C
Storage Temperature	-55°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.

PACKAGE/ORDERING INFORMATION

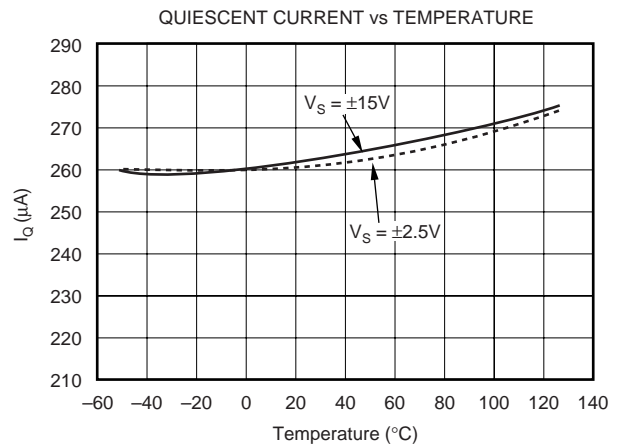
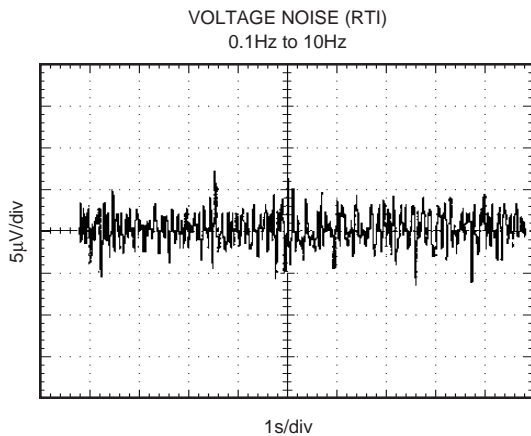
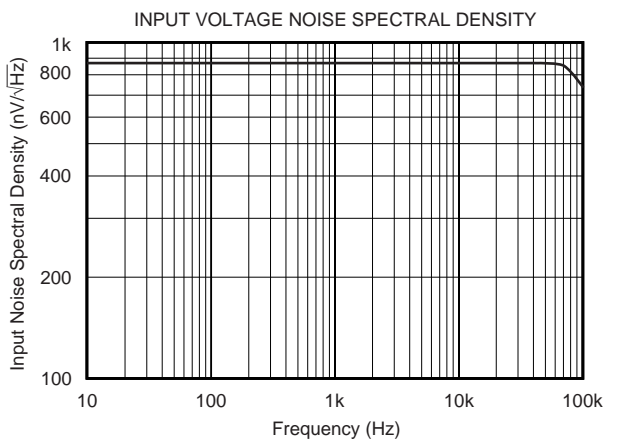
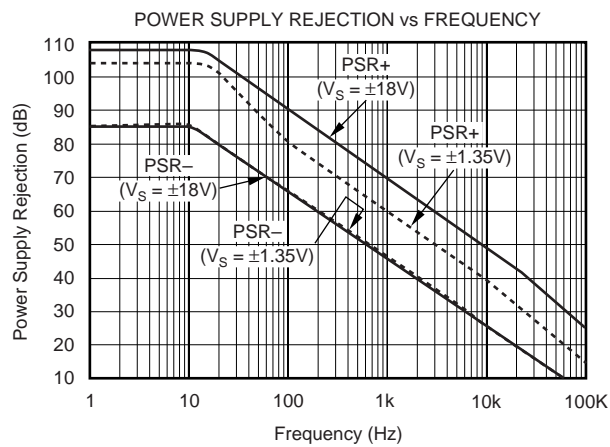
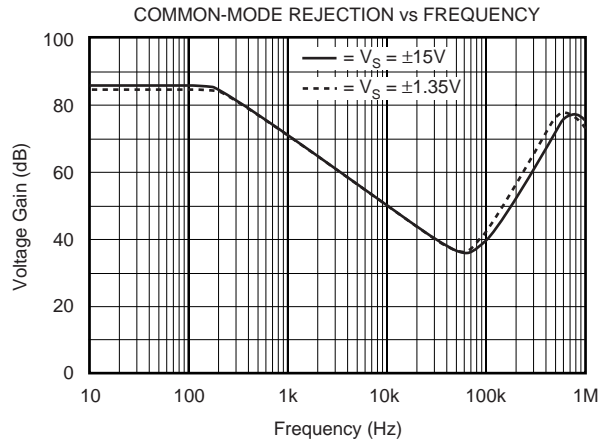
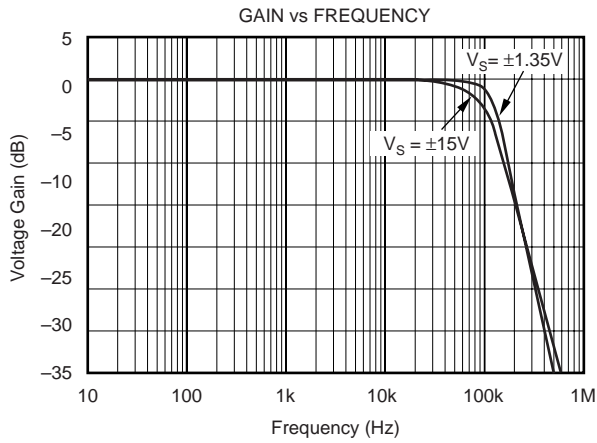
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER	SPECIFIED TEMPERATURE RANGE	PACKAGE MARKING	ORDERING NUMBER ⁽¹⁾	TRANSPORT MEDIA
INA148UA	SO-8	182	-40°C to +85°C	INA148UA	INA148UA	Rails
"	"	"	"	"	INA148UA/2K5	Tape and Reel

NOTE: (1) Models with a slash (/) are available only in Tape and Reel in the quantities indicated (e.g., /2K5 indicates 2500 devices per reel). Ordering 2500 pieces of "INA148UA/2K5" will get a single 2500-piece Tape and Reel.

The information provided herein is believed to be reliable; however, BURR-BROWN assumes no responsibility for inaccuracies or omissions. BURR-BROWN assumes no responsibility for the use of this information, and all use of such information shall be entirely at the user's own risk. Prices and specifications are subject to change without notice. No patent rights or licenses to any of the circuits described herein are implied or granted to any third party. BURR-BROWN does not authorize or warrant any BURR-BROWN product for use in life support devices and/or systems.

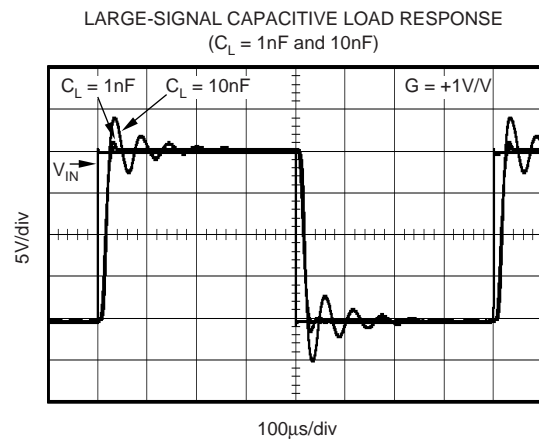
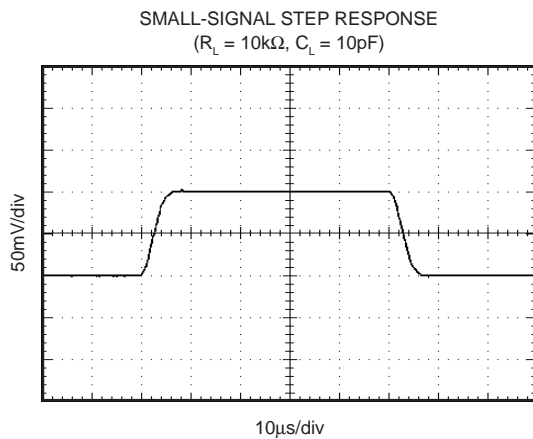
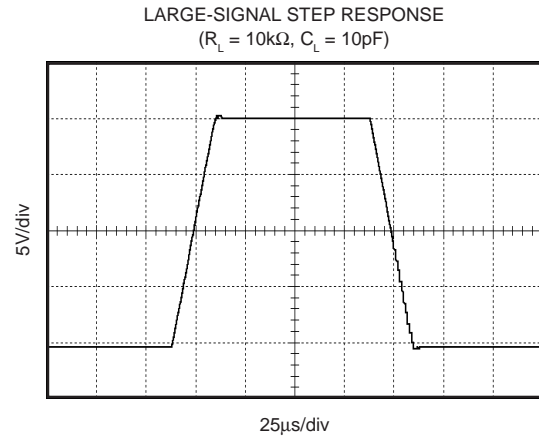
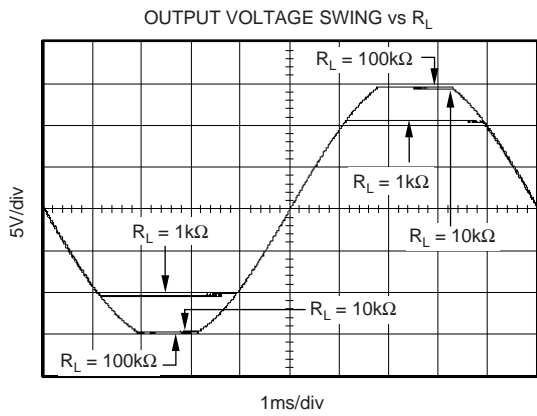
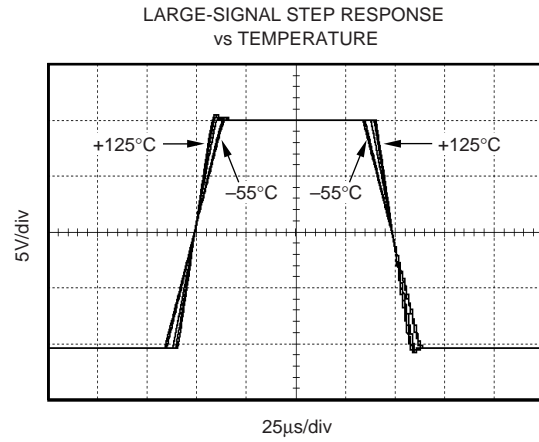
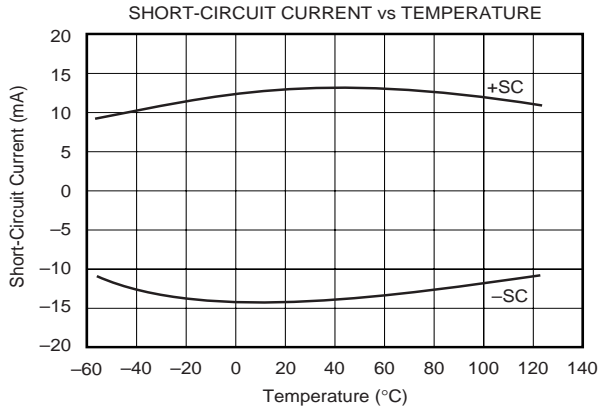
TYPICAL PERFORMANCE CURVES

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ to common, and $V_{\text{REF}} = 0\text{V}$, unless otherwise noted.



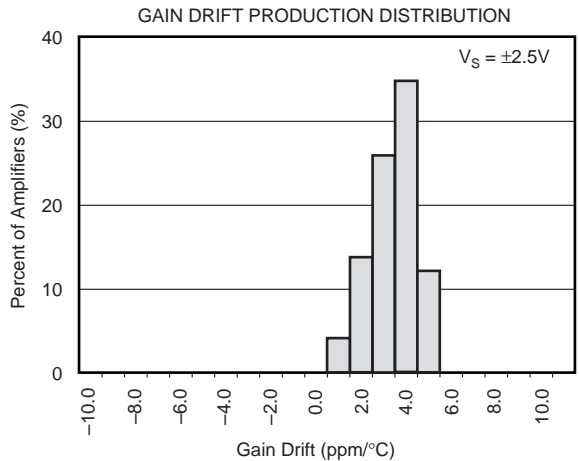
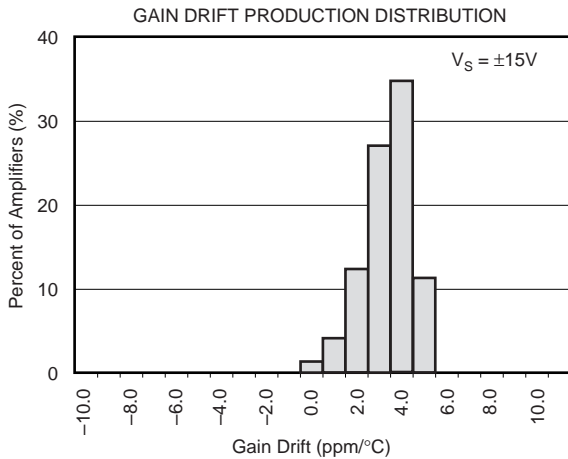
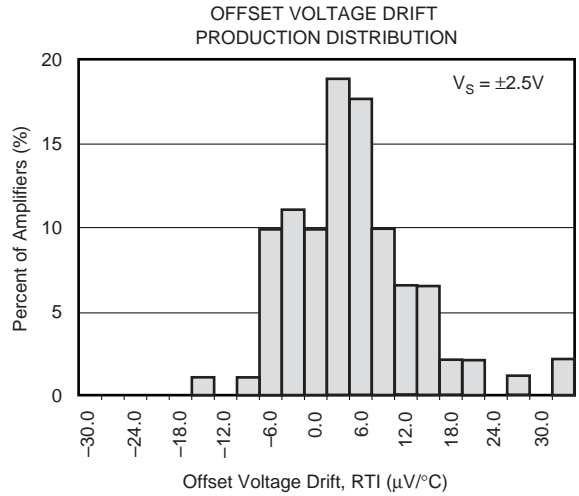
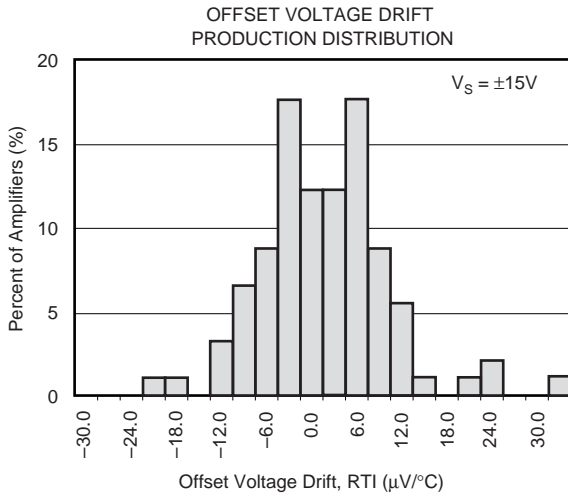
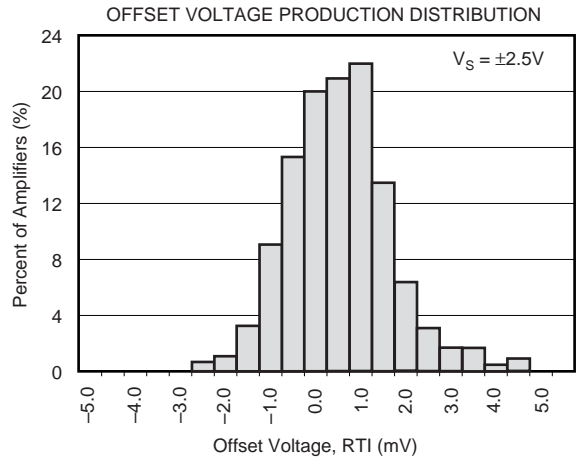
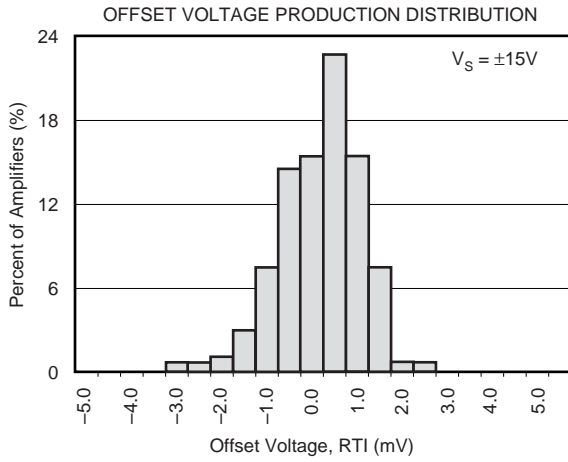
TYPICAL PERFORMANCE CURVES (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ to common, and $V_{REF} = 0\text{V}$, unless otherwise noted.



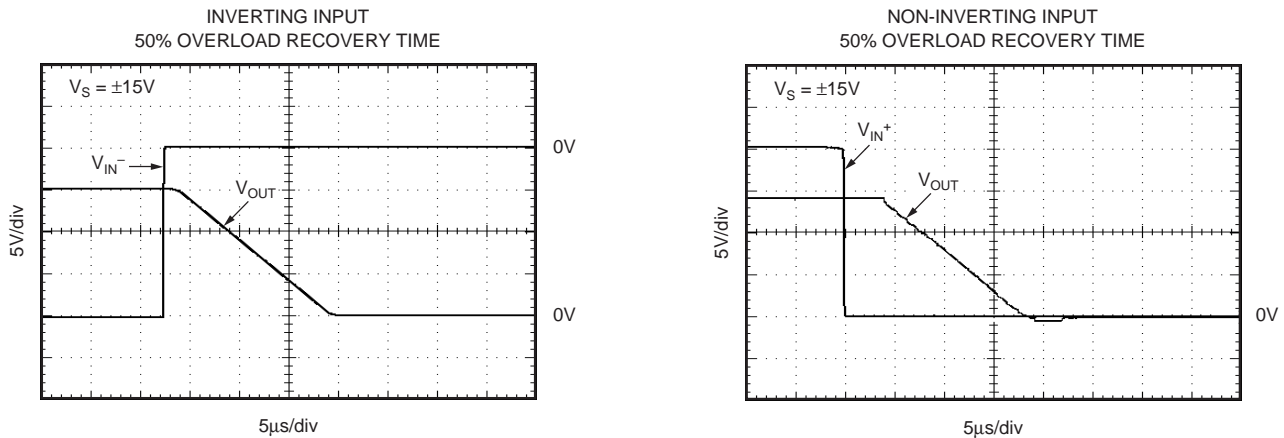
TYPICAL PERFORMANCE CURVES (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ to common, and $V_{\text{REF}} = 0\text{V}$, unless otherwise noted.



TYPICAL PERFORMANCE CURVES (Cont.)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_L = 10\text{k}\Omega$ to common, and $V_{REF} = 0\text{V}$, unless otherwise noted.



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.

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 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 20V/V, thus restoring the circuit’s overall gain to unity (1V/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 will 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 $\pm 15\text{V}$ and $\pm 5\text{V}$ dual supplies and $+5\text{V}$ single supplies. The INA148 can be operated with single or dual supplies with excellent performance.

The INA148 is fully characterized for supply voltages from $\pm 1.35\text{V}$ to $\pm 18\text{V}$ and over temperatures of -55°C to $+125^\circ\text{C}$. Parameters that vary significantly with operating voltage, load conditions, or temperature are shown in the Typical Performance Curves section.

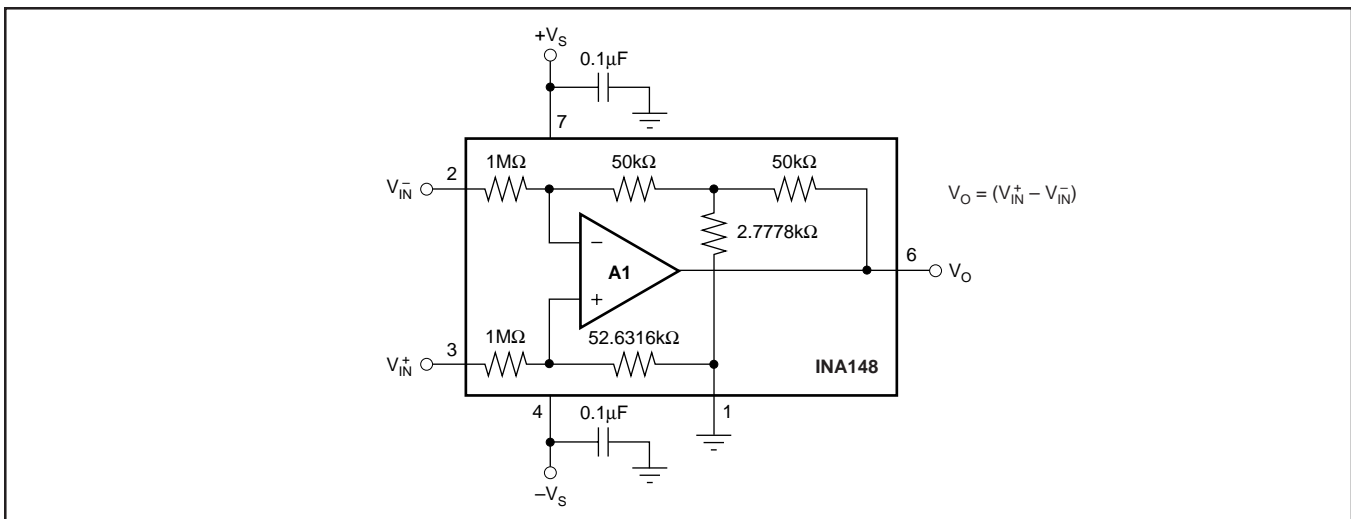


FIGURE 1. Basic Circuit Connections.

THE GAIN EQUATION

An internal on-chip resistor network sets the overall differential gain of the INA148 to precisely 1V/V. It's output is accordance with the equation:

$$V_{OUT} = (V_{IN}^+ - V_{IN}^-) + V_{REF} \quad (1)$$

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 will require no external offset adjustment.

Since a voltage applied to the reference (Ref) pin (pin 1) will be 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.

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 10Ω at the Ref pin will reduce the INA148's CMR to approximately 74dB. 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 10Ω, a resistor of 190Ω should be added in series with pin 3.

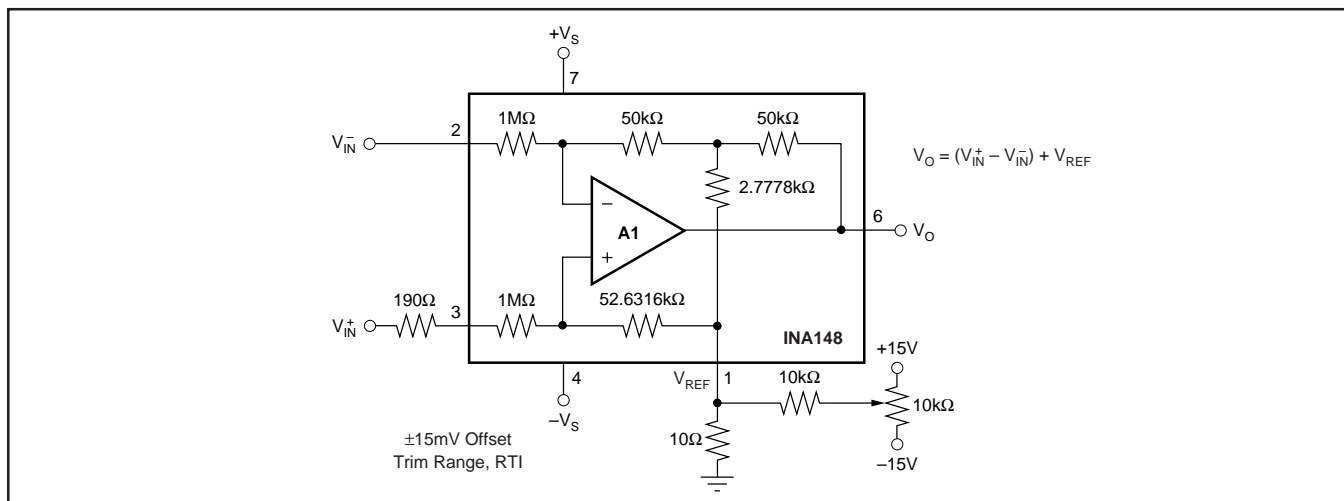


FIGURE 2. Optional Offset Trim Voltage.

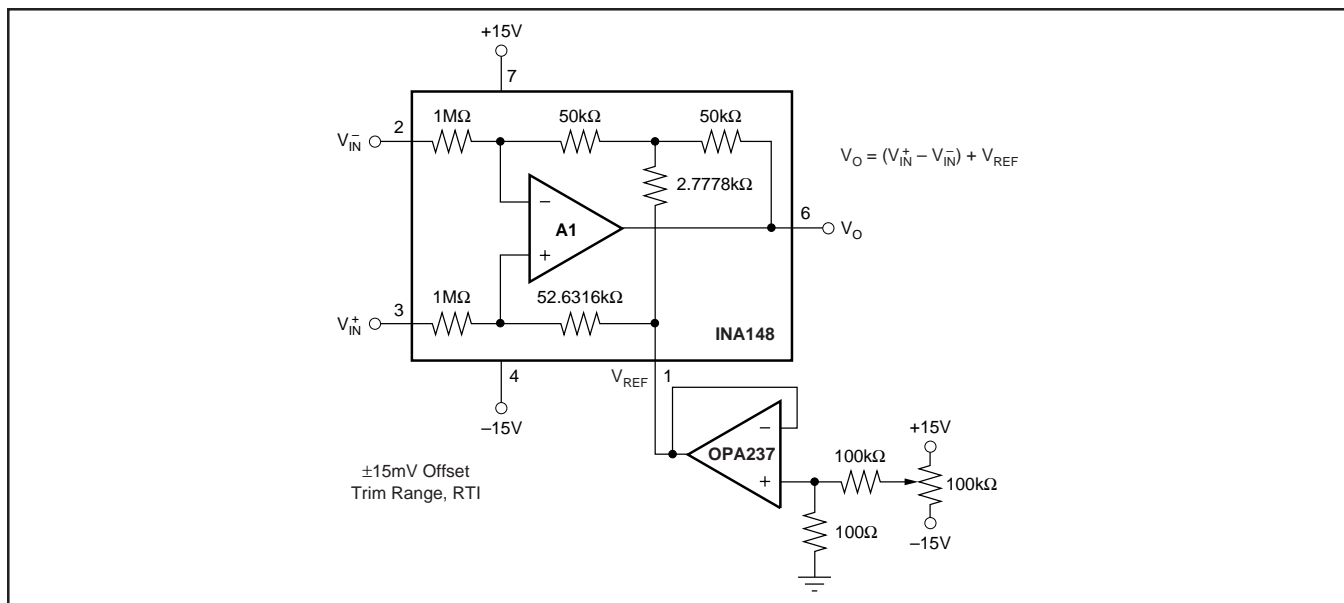


FIGURE 3. Preferred Offset Trim Circuit.

Preferably, the offset trim voltage applied to the Ref pin should be buffered with an amp 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.

INPUT IMPEDANCE

The input resistor network determines the impedance of each of the INA148's inputs. It is approximately 1MΩ. 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 will cause a differential amplifier's common-mode rejection to be degraded. With a source impedance imbalance of only 500Ω, CMR can fall to approximately 66dB.

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.

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

Source impedances (or shunts) greater than 5kΩ 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 1MΩ, however, this is only their nominal value.

In practice, the input resistors' absolute values may vary by as much as 30 percent. The two input resistors match to about 5 percent, so adding compensating resistors greater than 5kΩ 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 just described in the last paragraph. CMR will suffer a serious degradation unless the resistors are carefully trimmed for CMR and gain. This is an iterative adjustment and can be tedious and time consuming.

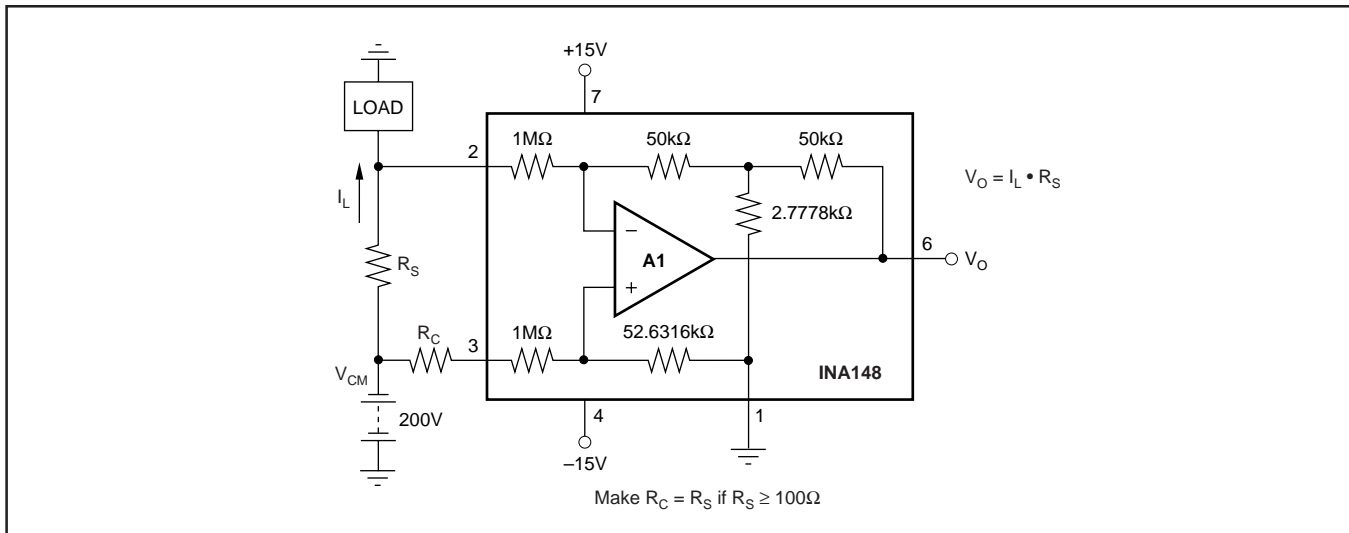


FIGURE 4. Shunt-Resistor Current Measurement Circuit.

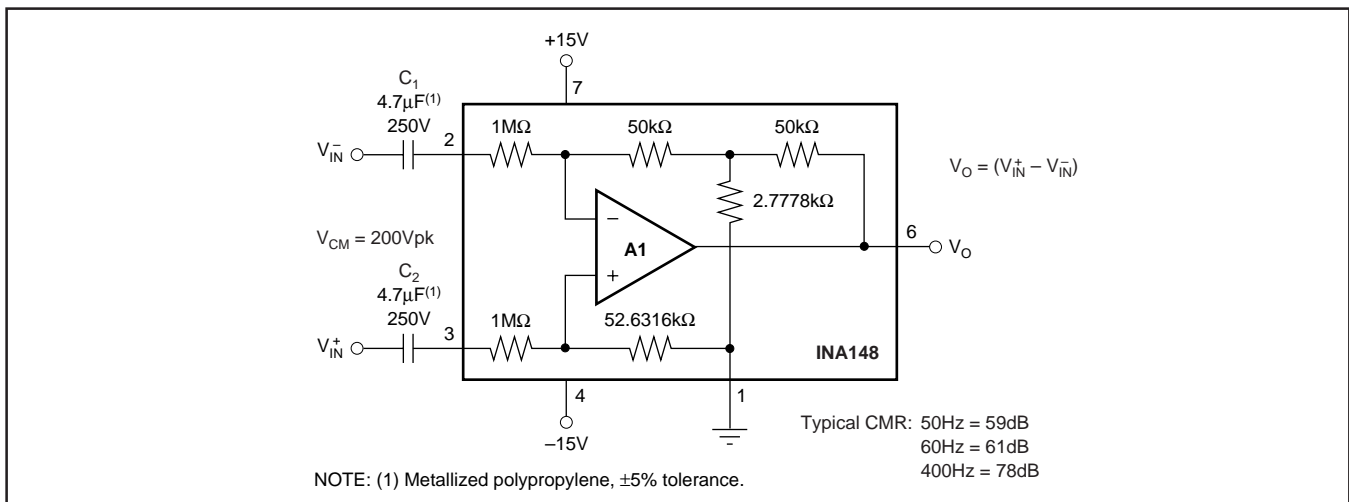


FIGURE 5. AC-Coupled Difference Amplifier.

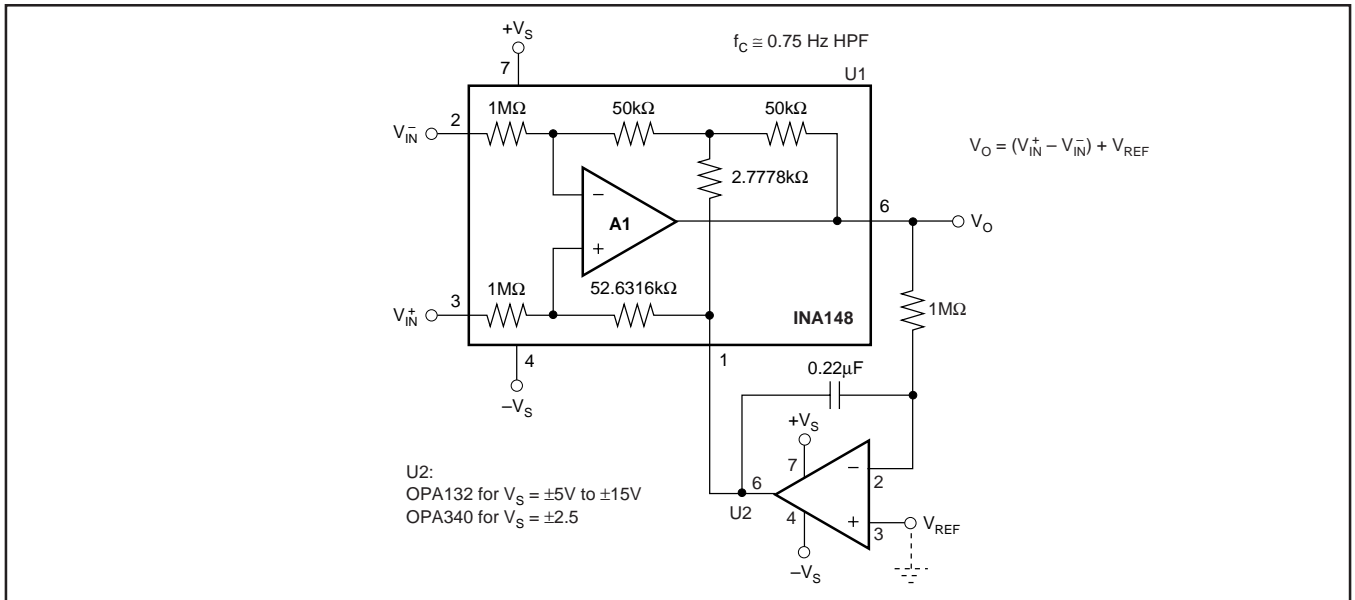


FIGURE 6. Quasi-AC-Coupled Differential Amplifier.

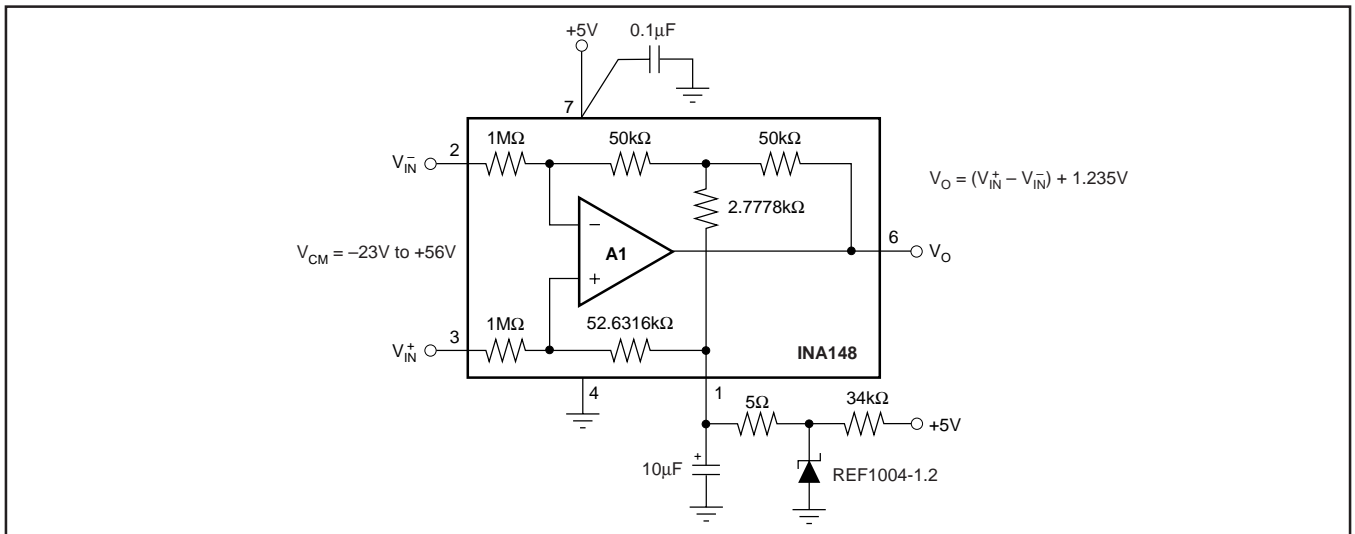


FIGURE 7. Single-Supply Differential Amplifier.

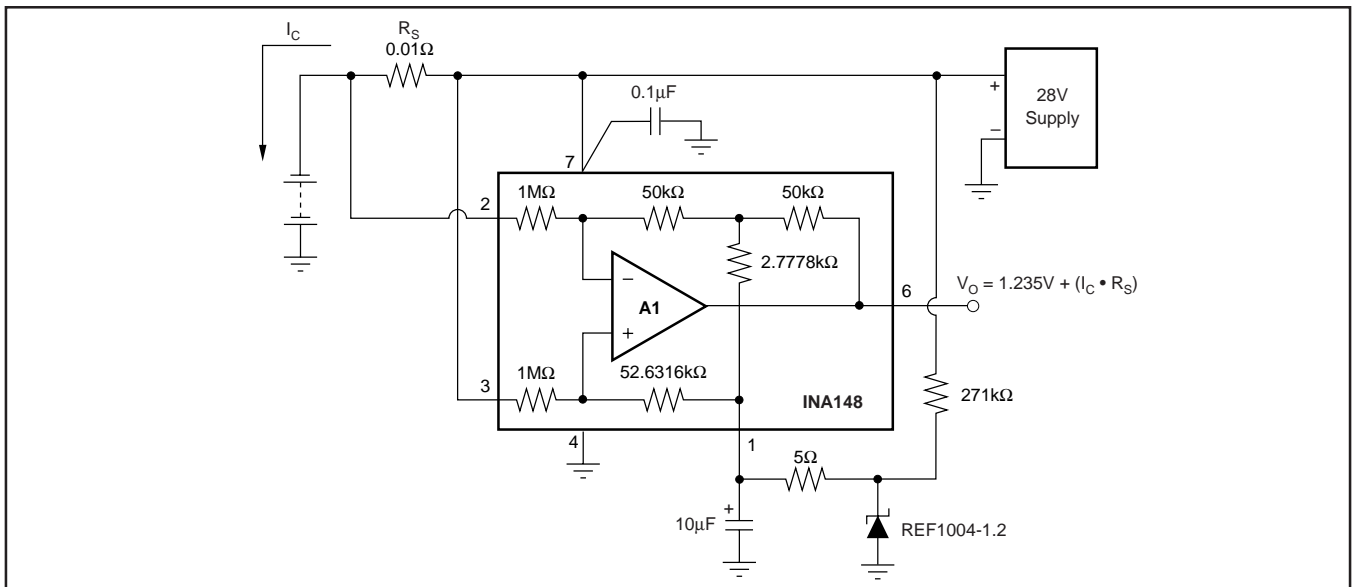


FIGURE 8. Battery Monitor Circuit.

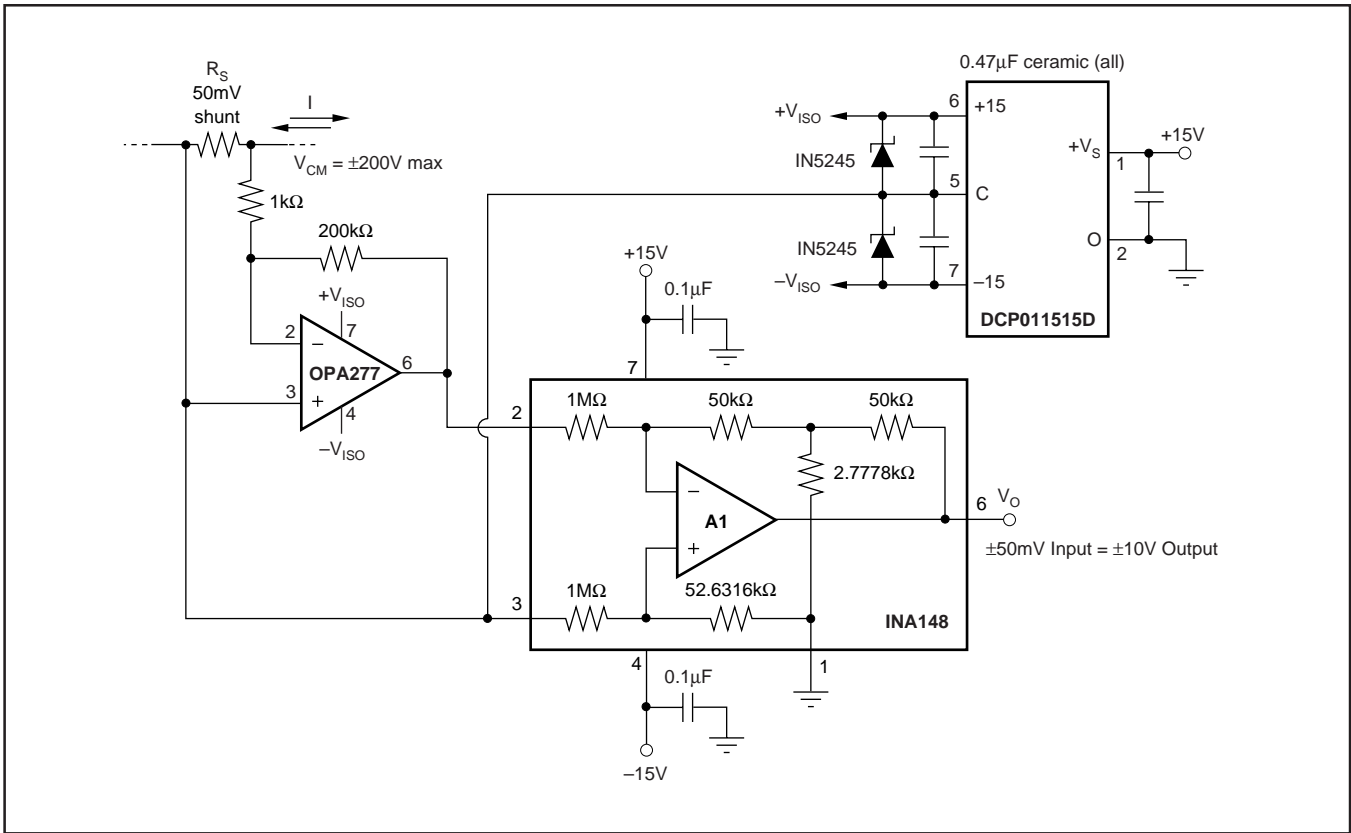


FIGURE 9. 50mV Current Shunt Amplifier with $\pm 200V$ Common-Mode Voltage Range.

PACKAGING INFORMATION

Orderable Device	Status ⁽¹⁾	Package Type	Package Drawing	Pins	Package Qty	Eco Plan ⁽²⁾	Lead/Ball Finish	MSL Peak Temp ⁽³⁾
INA148UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA148UA/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA148UA/2K5G4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA148UAG4	ACTIVE	SOIC	D	8	75	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.

TAPE AND REEL INFORMATION



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
INA148UA/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA148UA/2K5	SOIC	D	8	2500	346.0	346.0	29.0

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

Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
RF/IF and ZigBee® Solutions	www.ti.com/lprf

Applications

Audio	www.ti.com/audio
Automotive	www.ti.com/automotive
Broadband	www.ti.com/broadband
Digital Control	www.ti.com/digitalcontrol
Medical	www.ti.com/medical
Military	www.ti.com/military
Optical Networking	www.ti.com/opticalnetwork
Security	www.ti.com/security
Telephony	www.ti.com/telephony
Video & Imaging	www.ti.com/video
Wireless	www.ti.com/wireless

Mailing Address: Texas Instruments, Post Office Box 655303, Dallas, Texas 75265
Copyright © 2009, Texas Instruments Incorporated