

INA114

Precision INSTRUMENTATION AMPLIFIER

FEATURES

- LOW OFFSET VOLTAGE: 50 μ V max
- LOW DRIFT: 0.25 μ V/ $^{\circ}$ C max
- LOW INPUT BIAS CURRENT: 2nA max
- HIGH COMMON-MODE REJECTION: 115dB min
- INPUT OVER-VOLTAGE PROTECTION: \pm 40V
- WIDE SUPPLY RANGE: \pm 2.25 to \pm 18V
- LOW QUIESCENT CURRENT: 3mA max
- 8-PIN PLASTIC AND SOL-16

APPLICATIONS

- BRIDGE AMPLIFIER
- THERMOCOUPLE AMPLIFIER
- RTD SENSOR AMPLIFIER
- MEDICAL INSTRUMENTATION
- DATA ACQUISITION

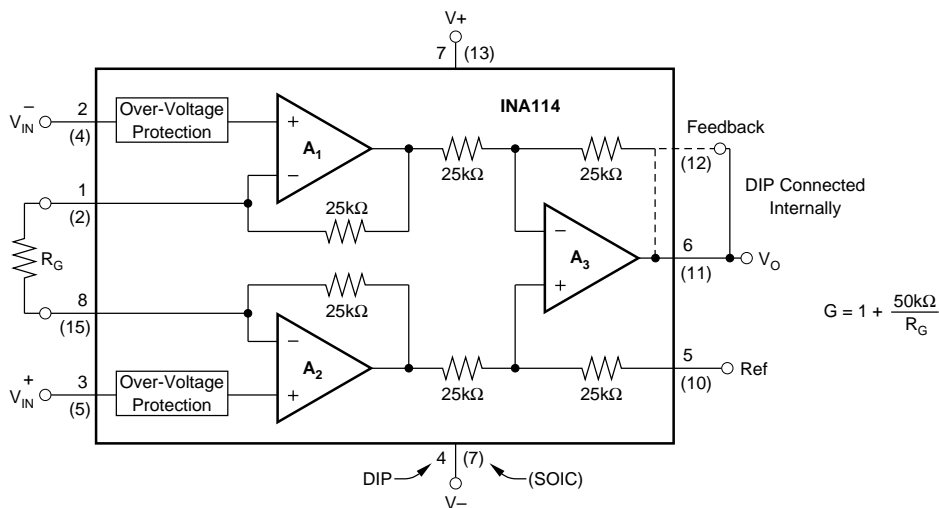
DESCRIPTION

The INA114 is a low cost, general purpose instrumentation amplifier offering excellent accuracy. Its versatile 3-op amp design and small size make it ideal for a wide range of applications.

A single external resistor sets any gain from 1 to 10,000. Internal input protection can withstand up to \pm 40V without damage.

The INA114 is laser trimmed for very low offset voltage (50 μ V), drift (0.25 μ V/ $^{\circ}$ C) and high common-mode rejection (115dB at G = 1000). It operates with power supplies as low as \pm 2.25V, allowing use in battery operated and single 5V supply systems. Quiescent current is 3mA maximum.

The INA114 is available in 8-pin plastic and SOL-16 surface-mount packages. Both are specified for the -40° C to $+85^{\circ}$ C temperature range.



International Airport Industrial Park • Mailing Address: PO Box 11400, Tucson, AZ 85734 • Street Address: 6730 S. Tucson Blvd., Tucson, AZ 85706 • Tel: (520) 746-1111 • Twx: 910-952-1111
Internet: <http://www.burr-brown.com/> • FAXLine: (800) 548-6133 (US/Canada Only) • Cable: BBRCORP • Telex: 066-6491 • FAX: (520) 889-1510 • Immediate Product Info: (800) 548-6132

SPECIFICATIONS

ELECTRICAL

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, $R_L = 2\text{k}\Omega$, unless otherwise noted.

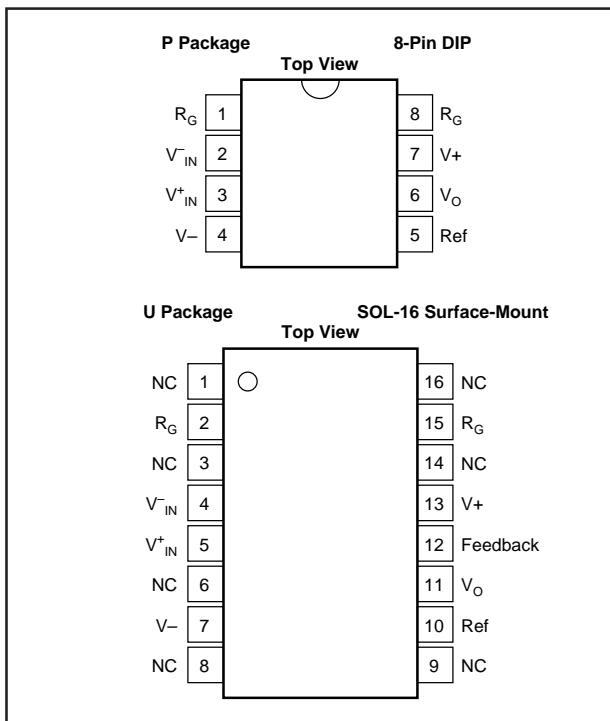
PARAMETER	CONDITIONS	INA114BP, BU			INA114AP, AU			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT Offset Voltage, RTI Initial vs Temperature vs Power Supply Long-Term Stability Impedance, Differential Common-Mode Input Common-Mode Range Safe Input Voltage Common-Mode Rejection	$T_A = +25^\circ\text{C}$ $T_A = T_{\text{MIN}}$ to T_{MAX} $V_S = \pm 2.25\text{V}$ to $\pm 18\text{V}$ $V_{\text{CM}} = \pm 10\text{V}$, $\Delta R_S = 1\text{k}\Omega$ $G = 1$ $G = 10$ $G = 100$ $G = 1000$		$\pm 10 + 20/G$ $\pm 0.1 + 0.5/G$ $0.5 + 2/G$ $\pm 0.2 + 0.5/G$ $10^{10} \parallel 6$ $10^{10} \parallel 6$ ± 13.5	$\pm 50 + 100/G$ $\pm 0.25 + 5/G$ $3 + 10/G$		$\pm 25 + 30/G$ $\pm 0.25 + 5/G$ * * * * *	$\pm 125 + 500/G$ $\pm 1 + 10/G$ * *	μV $\mu\text{V}/^\circ\text{C}$ $\mu\text{V/V}$ $\mu\text{V/mo}$ $\Omega \parallel \text{pF}$ $\Omega \parallel \text{pF}$ V V
		± 11		± 40	*	*		
		80	96		75	90		dB
		96	115		90	106		dB
		110	120		106	110		dB
		115	120		106	110		dB
BIAS CURRENT vs Temperature			± 0.5 ± 8	± 2		* *	± 5	nA $\text{pA}/^\circ\text{C}$
OFFSET CURRENT vs Temperature			± 0.5 ± 8	± 2		* *	± 5	nA $\text{pA}/^\circ\text{C}$
NOISE VOLTAGE, RTI $f = 10\text{Hz}$ $f = 100\text{Hz}$ $f = 1\text{kHz}$ $f_B = 0.1\text{Hz}$ to 10Hz Noise Current $f = 10\text{Hz}$ $f = 1\text{kHz}$ $f_B = 0.1\text{Hz}$ to 10Hz	$G = 1000$, $R_S = 0\Omega$		15 11 11 0.4			* * * *		$\text{nV}/\sqrt{\text{Hz}}$ $\text{nV}/\sqrt{\text{Hz}}$ $\text{nV}/\sqrt{\text{Hz}}$ $\mu\text{Vp-p}$
			0.4 0.2 18			* * *		$\text{pA}/\sqrt{\text{Hz}}$ $\text{pA}/\sqrt{\text{Hz}}$ pAp-p
GAIN Gain Equation Range of Gain Gain Error Gain vs Temperature 50k Ω Resistance ⁽¹⁾ Nonlinearity	$G = 1$ $G = 10$ $G = 100$ $G = 1000$ $G = 1$ $G = 1$ $G = 10$ $G = 100$ $G = 1000$	1	$1 + (50\text{k}\Omega/R_G)$	10000	*	*	*	V/V V/V
			± 0.01	± 0.05		*	*	%
			± 0.02	± 0.4		*	± 0.5	%
			± 0.05	± 0.5		*	± 0.7	%
			± 0.5	± 1		*	± 2	%
			± 2	± 10		*	± 10	$\text{ppm}/^\circ\text{C}$
			± 25	± 100		*	*	$\text{ppm}/^\circ\text{C}$
			± 0.0001	± 0.001		*	± 0.002	% of FSR
			± 0.0005	± 0.002		*	± 0.004	% of FSR
			± 0.0005	± 0.002		*	± 0.004	% of FSR
OUTPUT Voltage Load Capacitance Stability Short Circuit Current	$I_O = 5\text{mA}$, T_{MIN} to T_{MAX} $V_S = \pm 11.4\text{V}$, $R_L = 2\text{k}\Omega$ $V_S = \pm 2.25\text{V}$, $R_L = 2\text{k}\Omega$	± 13.5 ± 10 ± 1	± 13.7 ± 10.5 ± 1.5		* * *	* * *		V V V
			1000 $+20/-15$			* *		pF mA
FREQUENCY RESPONSE Bandwidth, -3dB Slew Rate Settling Time, 0.01% Overload Recovery	$G = 1$ $G = 10$ $G = 100$ $G = 1000$ $V_O = \pm 10\text{V}$, $G = 10$ $G = 1$ $G = 10$ $G = 100$ $G = 1000$ 50% Overdrive	0.3	1 100 10 1 0.6 18 20 120 1100 20			* * * * * * * * * *		MHz kHz kHz kHz V/ μs μs μs μs μs μs
POWER SUPPLY Voltage Range Current	$V_{\text{IN}} = 0\text{V}$	± 2.25	± 15 ± 2.2	± 18 ± 3	*	*	*	V mA
					*	*	*	
TEMPERATURE RANGE Specification Operating θ_{JA}		-40 -40		85 125	*		*	$^\circ\text{C}$ $^\circ\text{C}$
			80		*	*	*	$^\circ\text{C}/\text{W}$

* Specification same as INA114BP/BU.

NOTE: (1) Temperature coefficient of the "50k Ω " term in the gain equation.

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.

PIN CONFIGURATIONS



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.

PACKAGE/ORDERING INFORMATION

PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER ⁽¹⁾	TEMPERATURE RANGE
INA114AP	8-Pin Plastic DIP	006	-40°C to +85°C
INA114BP	8-Pin Plastic DIP	006	-40°C to +85°C
INA114AU	SOL-16 Surface-Mount	211	-40°C to +85°C
INA114BU	SOL-16 Surface-Mount	211	-40°C to +85°C

NOTE: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book.

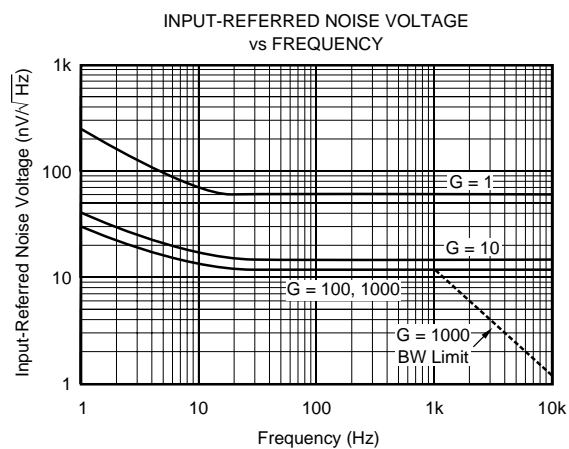
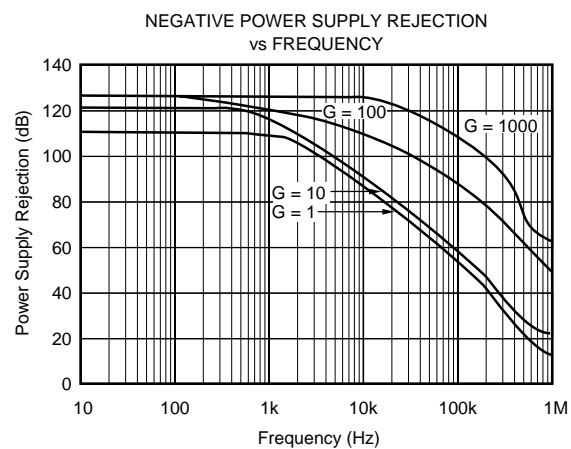
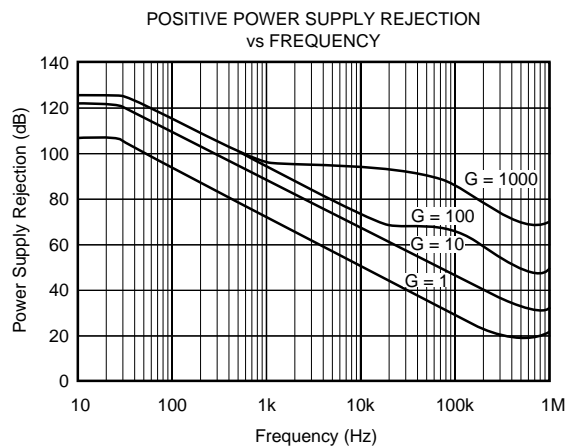
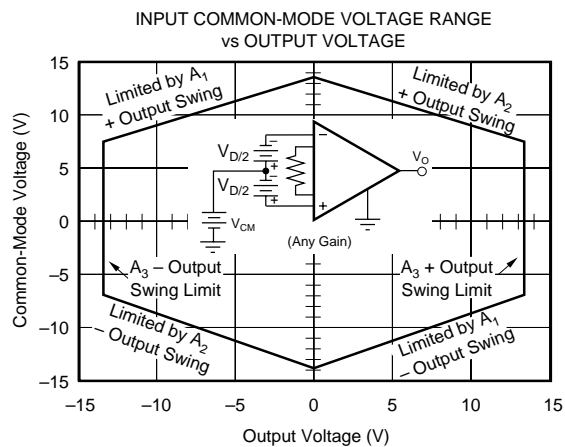
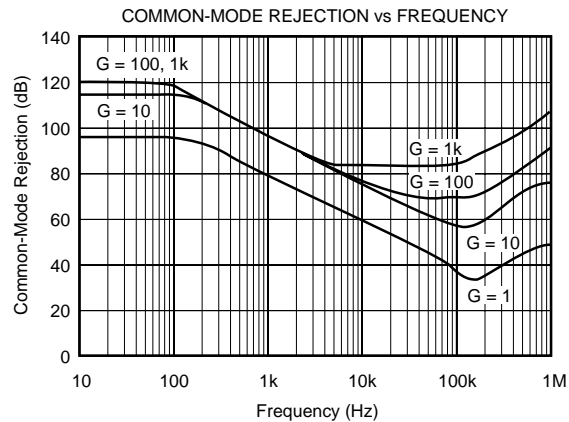
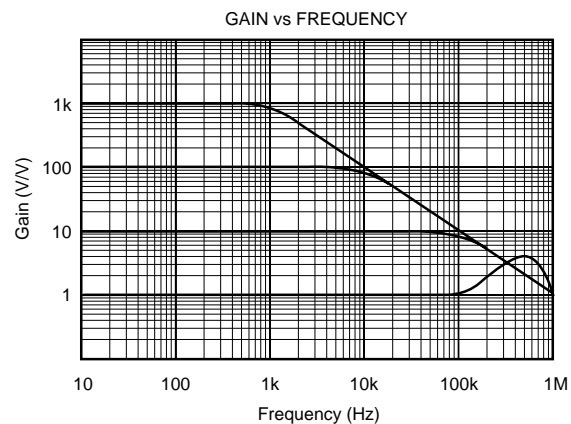
ABSOLUTE MAXIMUM RATINGS⁽¹⁾

Supply Voltage	±18V
Input Voltage Range	±40V
Output Short-Circuit (to ground)	Continuous
Operating Temperature	-40°C to +125°C
Storage Temperature	-40°C to +125°C
Junction Temperature	+150°C
Lead Temperature (soldering, 10s)	+300°C

NOTE: (1) Stresses above these ratings may cause permanent damage.

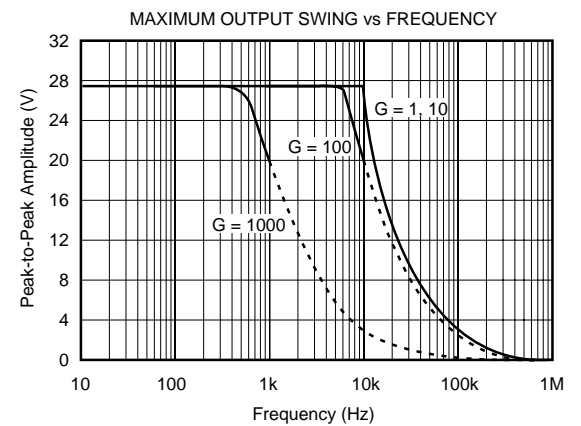
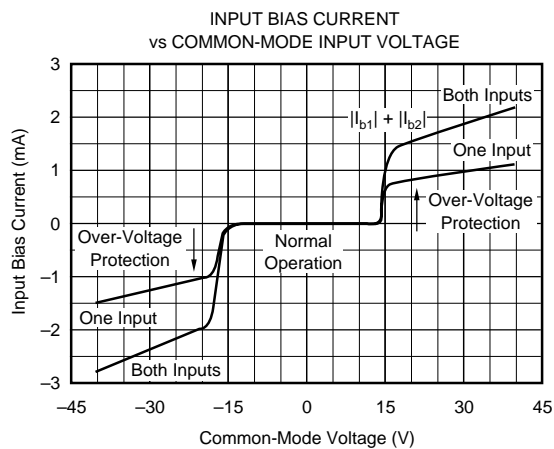
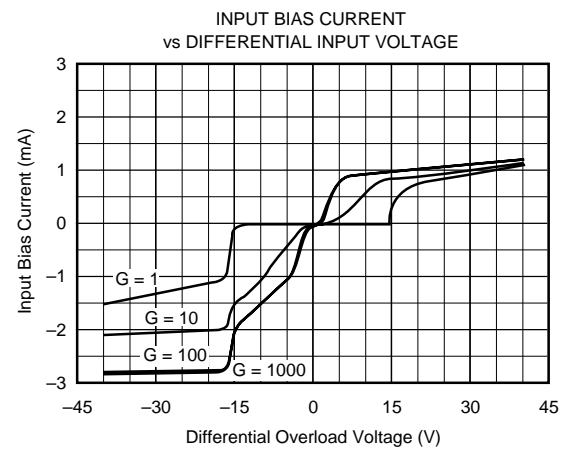
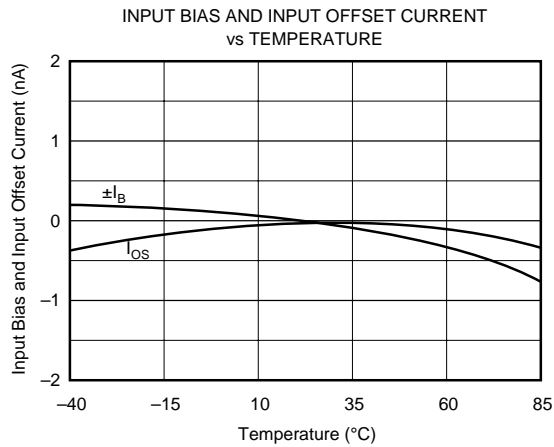
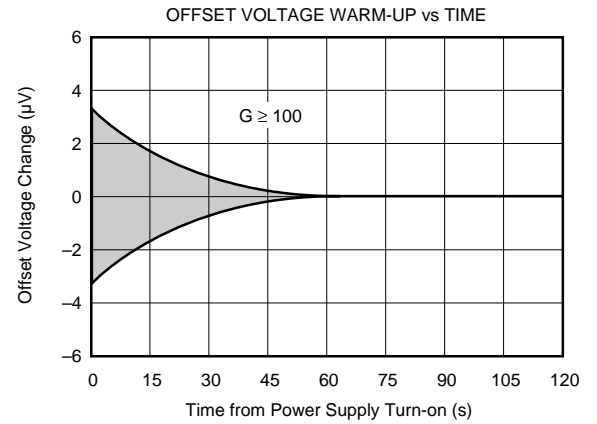
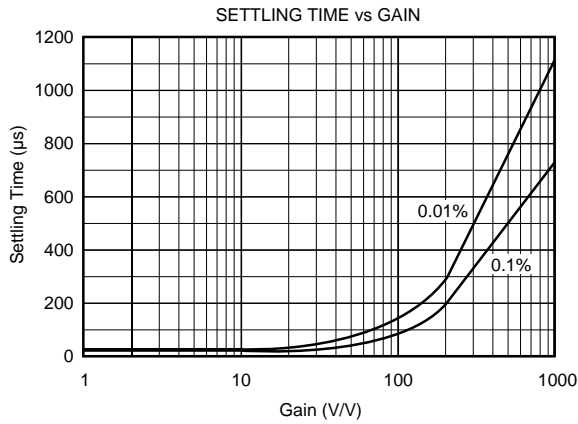
TYPICAL PERFORMANCE CURVES

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, unless otherwise noted.



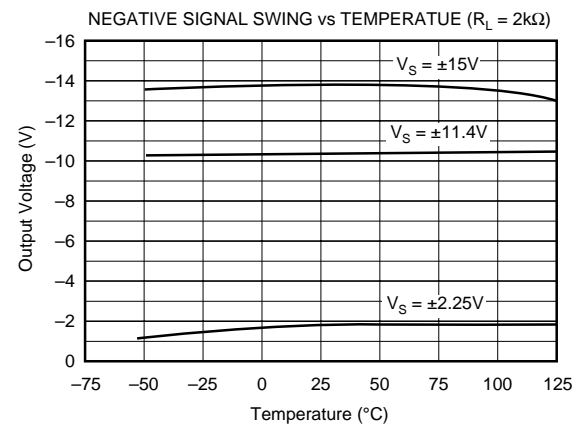
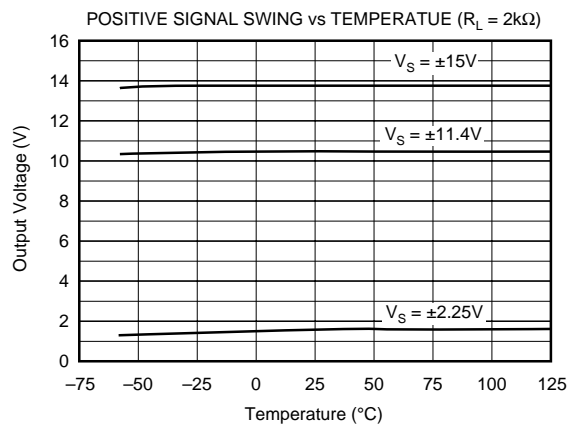
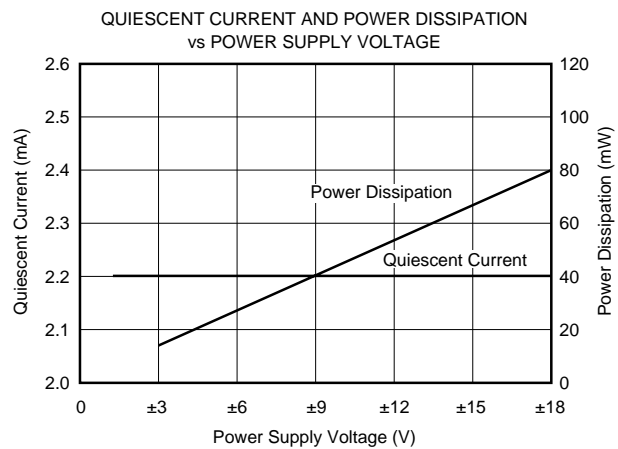
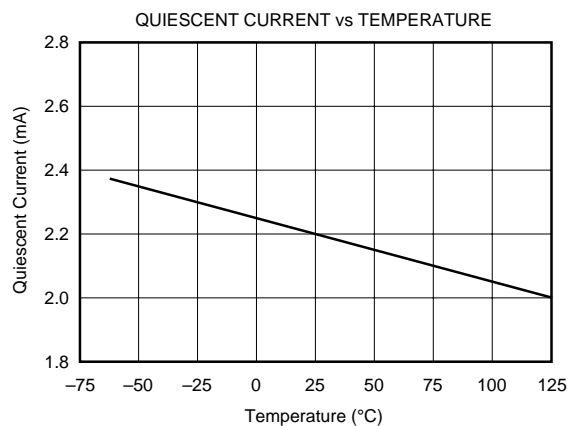
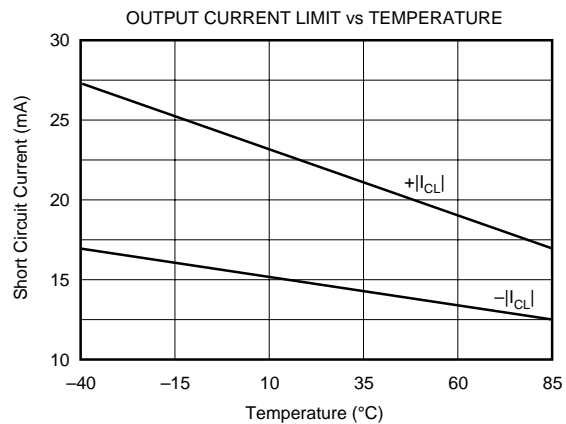
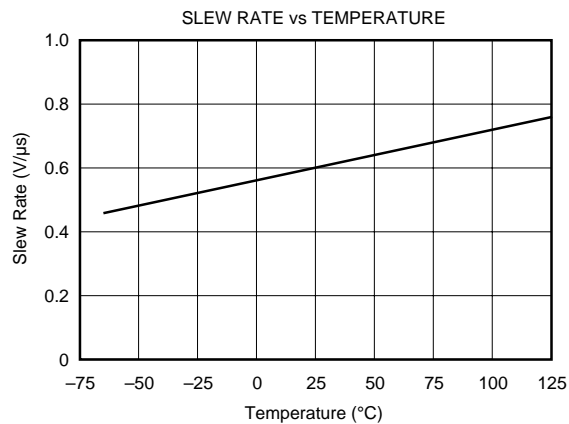
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, unless otherwise noted.



TYPICAL PERFORMANCE CURVES (CONT)

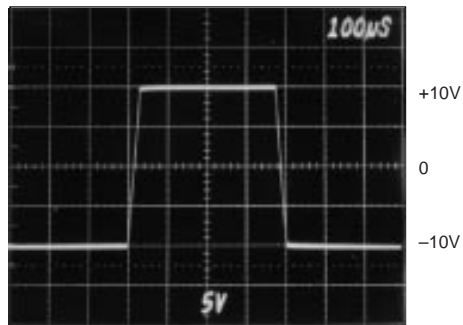
At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, unless otherwise noted.



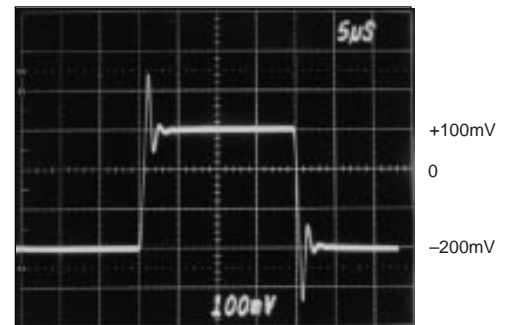
TYPICAL PERFORMANCE CURVES (CONT)

At $T_A = +25^\circ\text{C}$, $V_S = \pm 15\text{V}$, unless otherwise noted.

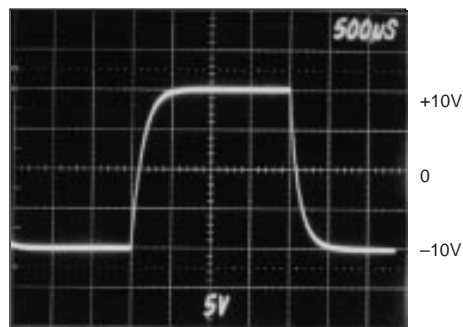
LARGE SIGNAL RESPONSE, $G = 1$



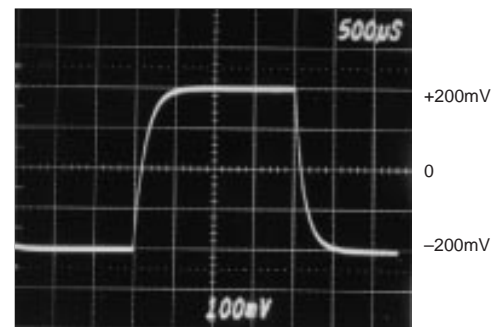
SMALL SIGNAL RESPONSE, $G = 1$



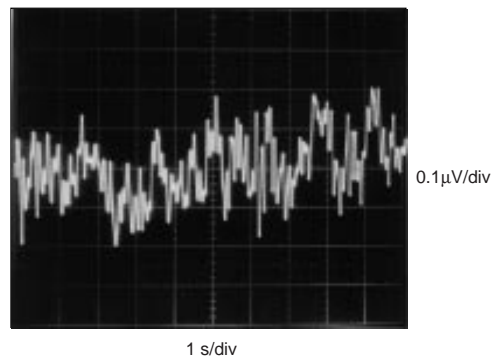
LARGE SIGNAL RESPONSE, $G = 1000$



SMALL SIGNAL RESPONSE, $G = 1000$



INPUT-REFERRED NOISE, 0.1 to 10Hz



APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA114. Applications with noisy or high impedance power supplies may require decoupling capacitors close to the device pins as shown.

The output is referred to the output reference (Ref) terminal which is normally grounded. This must be a low-impedance connection to assure good common-mode rejection. A resistance of 5Ω in series with the Ref pin will cause a typical device to degrade to approximately 80dB CMR ($G = 1$).

SETTING THE GAIN

Gain of the INA114 is set by connecting a single external resistor, R_G :

$$G = 1 + \frac{50 \text{ k}\Omega}{R_G} \quad (1)$$

Commonly used gains and resistor values are shown in Figure 1.

The 50kΩ term in equation (1) comes from the sum of the two internal feedback resistors. These are on-chip metal film resistors which are laser trimmed to accurate absolute val-

ues. The accuracy and temperature coefficient of these resistors are included in the gain accuracy and drift specifications of the INA114.

The stability and temperature drift of the external gain setting resistor, R_G , also affects gain. R_G 's contribution to gain accuracy and drift can be directly inferred from the gain equation (1). Low resistor values required for high gain can make wiring resistance important. Sockets add to the wiring resistance which will contribute additional gain error (possibly an unstable gain error) in gains of approximately 100 or greater.

NOISE PERFORMANCE

The INA114 provides very low noise in most applications. For differential source impedances less than 1kΩ, the INA103 may provide lower noise. For source impedances greater than 50kΩ, the INA111 FET-input instrumentation amplifier may provide lower noise.

Low frequency noise of the INA114 is approximately 0.4μVp-p measured from 0.1 to 10Hz. This is approximately one-tenth the noise of "low noise" chopper-stabilized amplifiers.

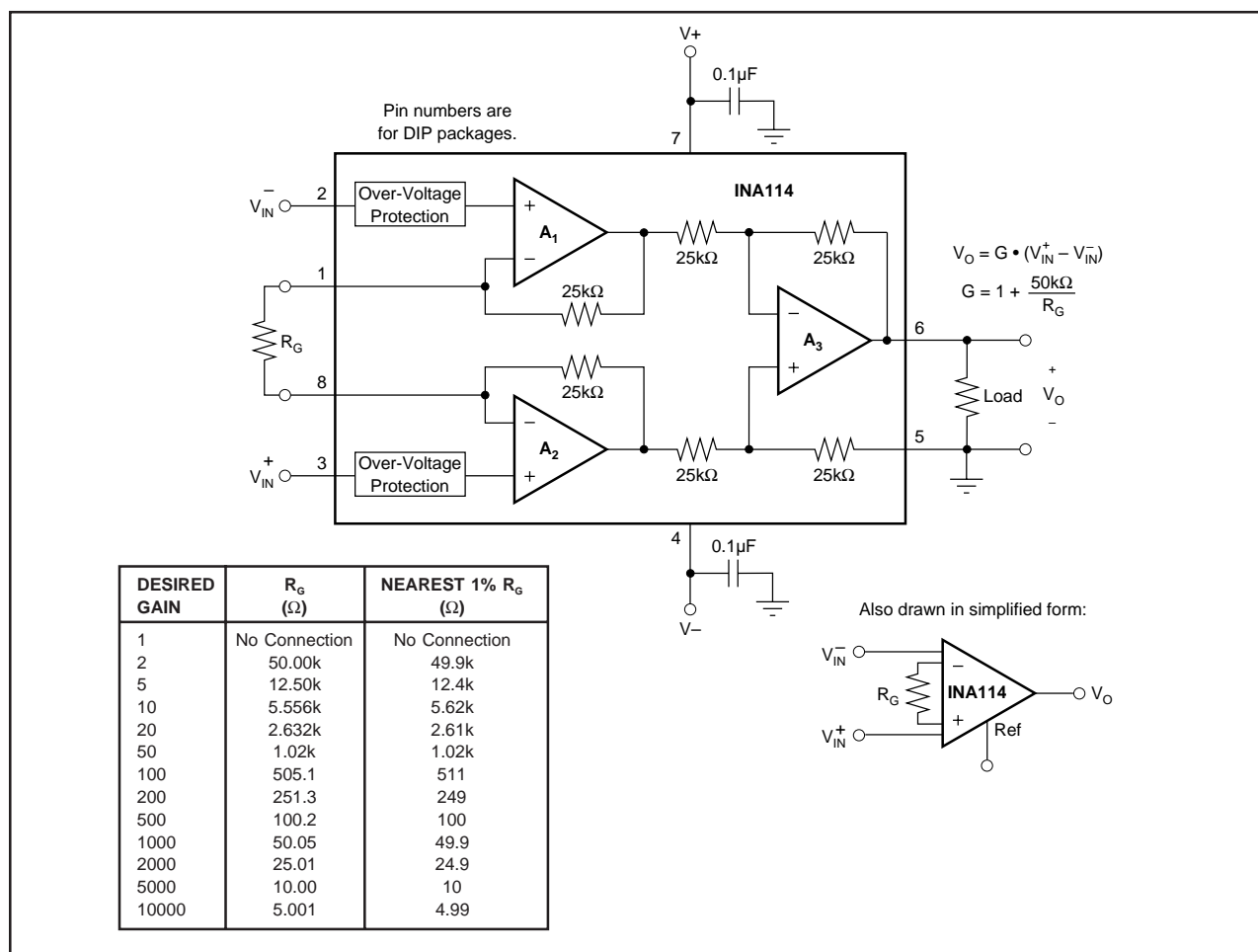


FIGURE 1. Basic Connections.

OFFSET TRIMMING

The INA114 is laser trimmed for very low offset voltage and drift. Most applications require no external offset adjustment. Figure 2 shows an optional circuit for trimming the output offset voltage. The voltage applied to Ref terminal is summed at the output. Low impedance must be maintained at this node to assure good common-mode rejection. This is achieved by buffering trim voltage with an op amp as shown.

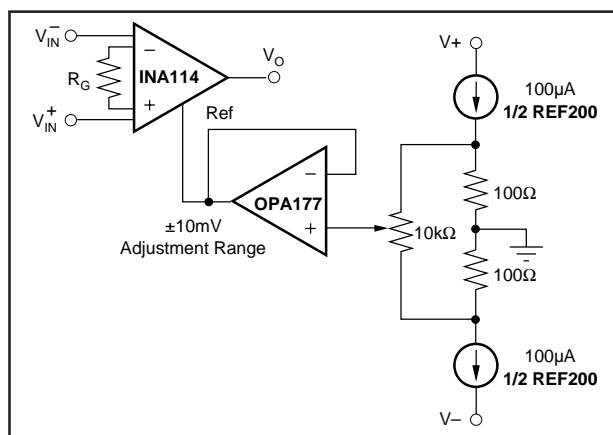


FIGURE 2. Optional Trimming of Output Offset Voltage.

INPUT BIAS CURRENT RETURN PATH

The input impedance of the INA114 is extremely high—approximately $10^{10}\Omega$. However, a path must be provided for the input bias current of both inputs. This input bias current is typically less than $\pm 1\text{nA}$ (it can be either polarity due to cancellation circuitry). High input impedance means that this input bias current changes very little with varying input voltage.

Input circuitry must provide a path for this input bias current if the INA114 is to operate properly. Figure 3 shows various provisions for an input bias current path. Without a bias current return path, the inputs will float to a potential which exceeds the common-mode range of the INA114 and the input amplifiers will saturate. If the differential source resistance is low, bias current return path can be connected to one input (see thermocouple example in Figure 3). With higher source impedance, using two resistors provides a balanced input with possible advantages of lower input offset voltage due to bias current and better common-mode rejection.

INPUT COMMON-MODE RANGE

The linear common-mode range of the input op amps of the INA114 is approximately $\pm 13.75\text{V}$ (or 1.25V from the power supplies). As the output voltage increases, however, the linear input range will be limited by the output voltage swing of the input amplifiers, A_1 and A_2 . The common-mode range is related to the output voltage of the complete amplifier—see performance curve “Input Common-Mode Range vs Output Voltage.”

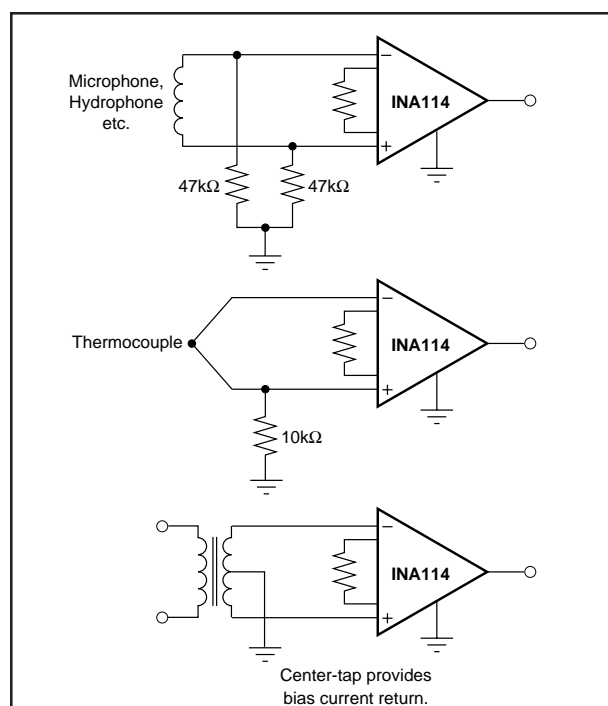


FIGURE 3. Providing an Input Common-Mode Current Path.

A combination of common-mode and differential input signals can cause the output of A_1 or A_2 to saturate. Figure 4 shows the output voltage swing of A_1 and A_2 expressed in terms of a common-mode and differential input voltages. Output swing capability of these internal amplifiers is the same as the output amplifier, A_3 . For applications where input common-mode range must be maximized, limit the output voltage swing by connecting the INA114 in a lower gain (see performance curve “Input Common-Mode Voltage Range vs Output Voltage”). If necessary, add gain after the INA114 to increase the voltage swing.

Input-overload often produces an output voltage that appears normal. For example, an input voltage of $+20\text{V}$ on one input and $+40\text{V}$ on the other input will obviously exceed the linear common-mode range of both input amplifiers. Since both input amplifiers are saturated to nearly the same output voltage limit, the difference voltage measured by the output amplifier will be near zero. The output of the INA114 will be near 0V even though both inputs are overloaded.

INPUT PROTECTION

The inputs of the INA114 are individually protected for voltages up to $\pm 40\text{V}$. For example, a condition of -40V on one input and $+40\text{V}$ on the other input will not cause damage. Internal circuitry on each input provides low series impedance under normal signal conditions. To provide equivalent protection, series input resistors would contribute excessive noise. If the input is overloaded, the protection circuitry limits the input current to a safe value (approximately 1.5mA). The typical performance curve “Input Bias Current vs Common-Mode Input Voltage” shows this input

current limit behavior. The inputs are protected even if no power supply voltage is present.

OUTPUT VOLTAGE SENSE (SOL-16 package only)

The surface-mount version of the INA114 has a separate output sense feedback connection (pin 12). Pin 12 must be connected to the output terminal (pin 11) for proper operation. (This connection is made internally on the DIP version of the INA114.)

The output sense connection can be used to sense the output voltage directly at the load for best accuracy. Figure 5 shows how to drive a load through series interconnection resistance. Remotely located feedback paths may cause instability. This can be generally be eliminated with a high frequency feedback path through C_1 . Heavy loads or long lines can be driven by connecting a buffer inside the feedback path (Figure 6).

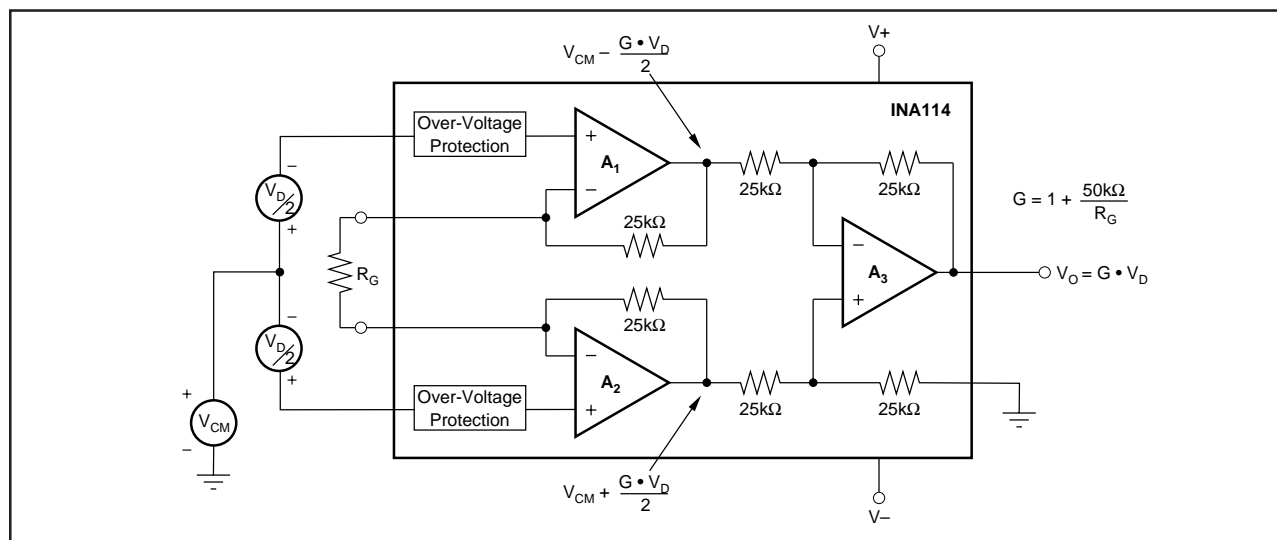


FIGURE 4. Voltage Swing of A_1 and A_2 .

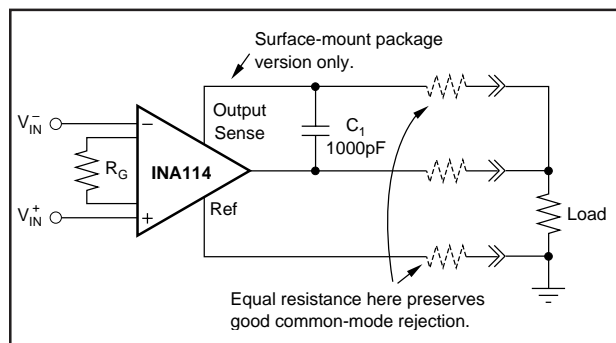


FIGURE 5. Remote Load and Ground Sensing.

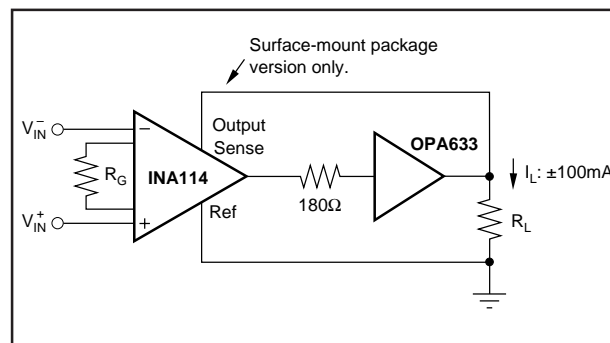


FIGURE 6. Buffered Output for Heavy Loads.

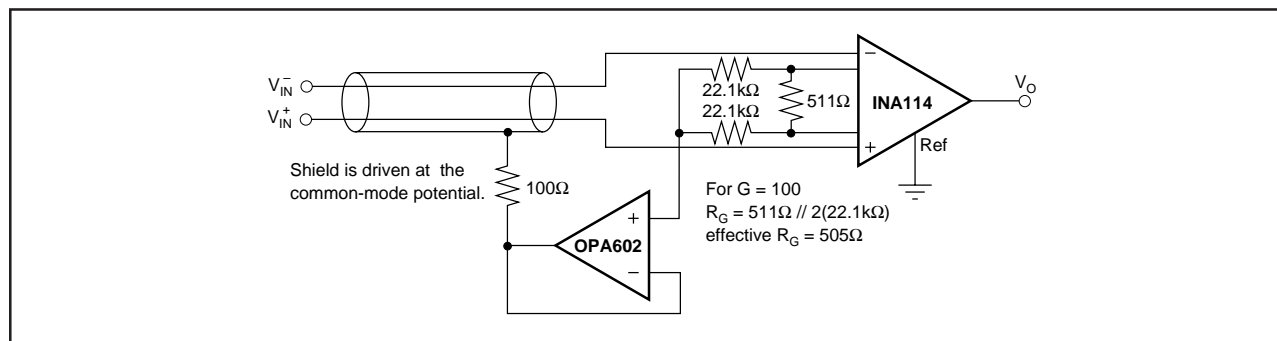


FIGURE 7. Shield Driver Circuit.

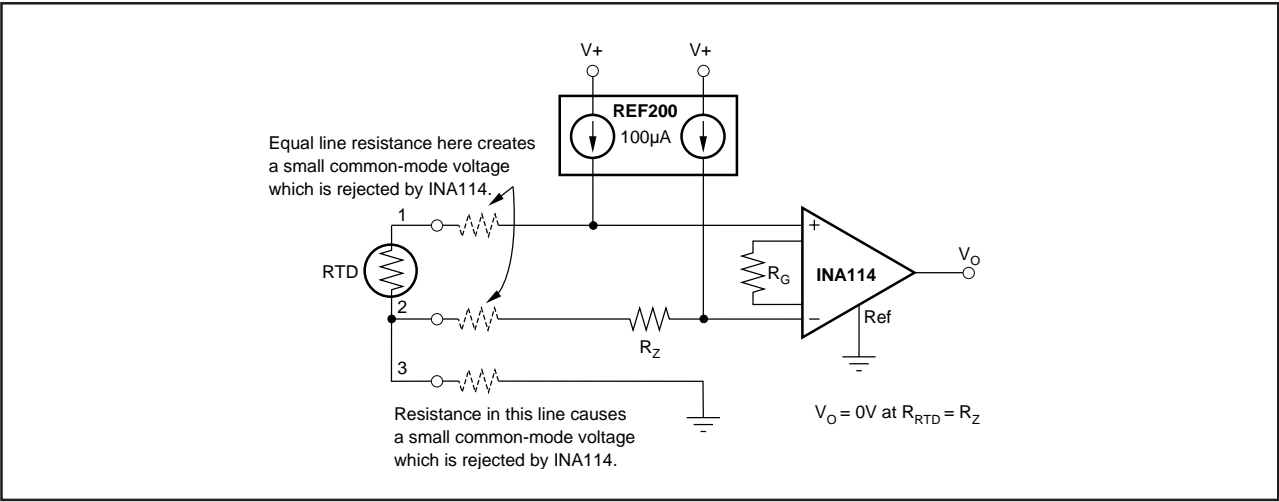


FIGURE 8. RTD Temperature Measurement Circuit.

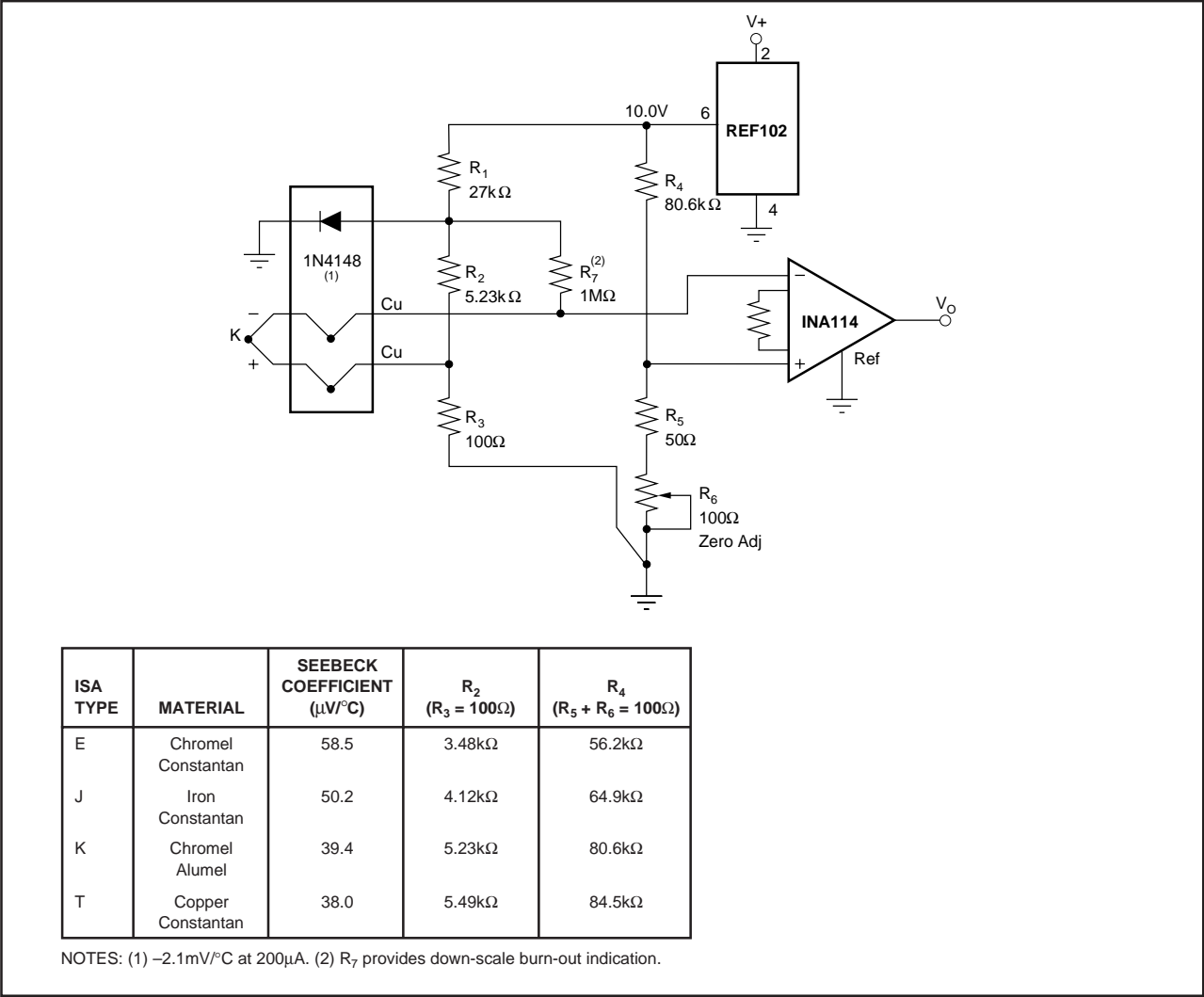


FIGURE 9. Thermocouple Amplifier With Cold Junction Compensation.

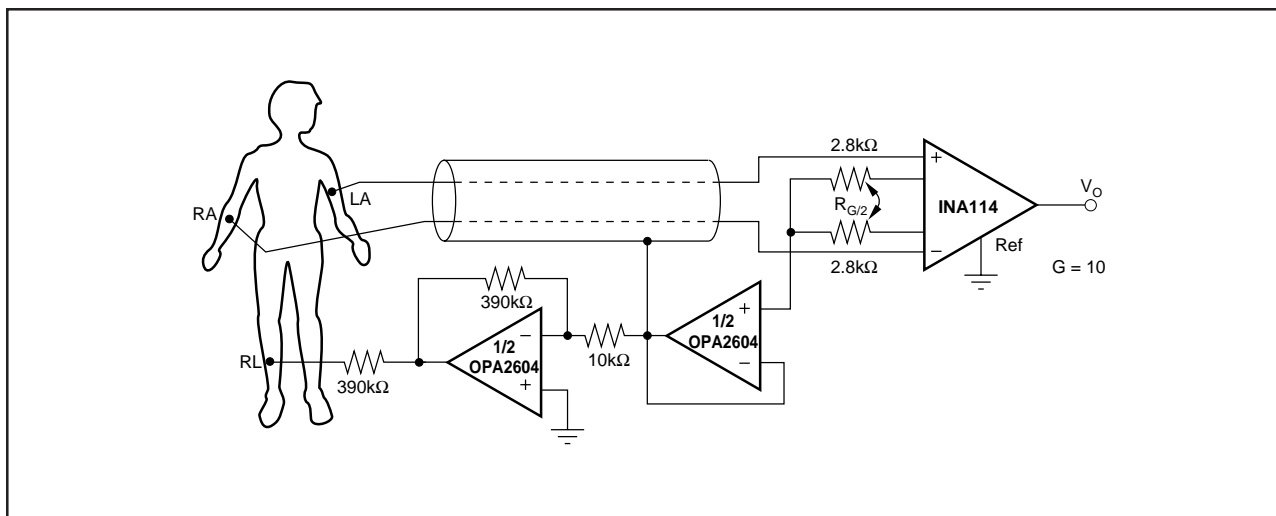


FIGURE 10. ECG Amplifier With Right-Leg Drive.

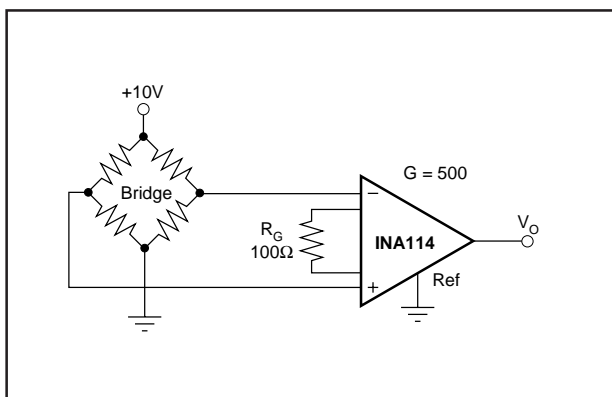


FIGURE 11. Bridge Transducer Amplifier.

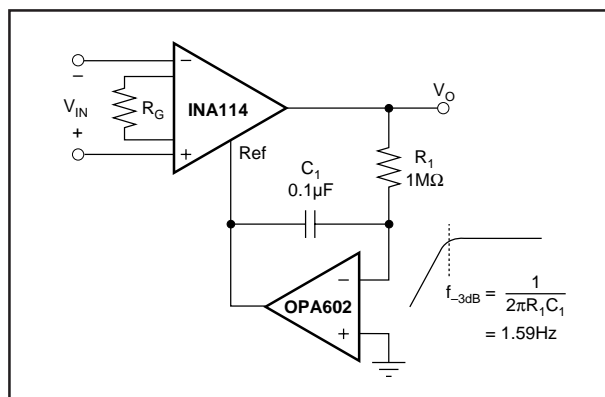


FIGURE 12. AC-Coupled Instrumentation Amplifier.

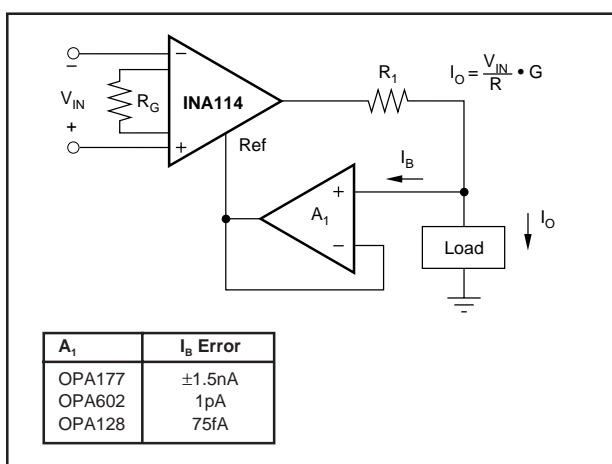


FIGURE 13. Differential Voltage-to-Current Converter.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
INA114AP	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type		INA114AP	Samples
INA114APG4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type		INA114AP	Samples
INA114AU	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	INA114AU	Samples
INA114AU/1K	ACTIVE	SOIC	DW	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	INA114AU	Samples
INA114AU/1KE4	ACTIVE	SOIC	DW	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	INA114AU	Samples
INA114AUE4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	INA114AU	Samples
INA114AUG4	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR	-40 to 85	INA114AU	Samples
INA114BP	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type		INA114BP	Samples
INA114BPG4	ACTIVE	PDIP	P	8	50	Green (RoHS & no Sb/Br)	CU NIPDAU	N / A for Pkg Type		INA114BP	Samples
INA114BU	ACTIVE	SOIC	DW	16	40	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		INA114BU	Samples
INA114BU/1K	ACTIVE	SOIC	DW	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		INA114BU	Samples
INA114BU/1KE4	ACTIVE	SOIC	DW	16	1000	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR		INA114BU	Samples

(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.

⁽⁴⁾ There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

⁽⁵⁾ Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

⁽⁶⁾ Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

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


*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
INA114AU/1K	SOIC	DW	16	1000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1
INA114BU/1K	SOIC	DW	16	1000	330.0	16.4	10.75	10.7	2.7	12.0	16.0	Q1

TAPE AND REEL BOX DIMENSIONS



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA114AU/1K	SOIC	DW	16	1000	367.0	367.0	38.0
INA114BU/1K	SOIC	DW	16	1000	367.0	367.0	38.0

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

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

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

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license 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 significant portions 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. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

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

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
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
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com