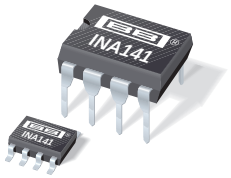
BURR - BROWN®



INA141

Precision, Low Power, G = 10, 100 INSTRUMENTATION AMPLIFIER

FEATURES

- LOW OFFSET VOLTAGE: 50μV max
- LOW DRIFT: 0.5μV/°C max
- ACCURATE GAIN: ±0.05% at G = 10
- LOW INPUT BIAS CURRENT: 5nA max
- HIGH CMR: 117dB min
- INPUTS PROTECTED TO ±40V
- WIDE SUPPLY RANGE: ±2.25 to ±18V
- LOW QUIESCENT CURRENT: 750μA
- 8-PIN PLASTIC DIP, SO-8

APPLICATIONS

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

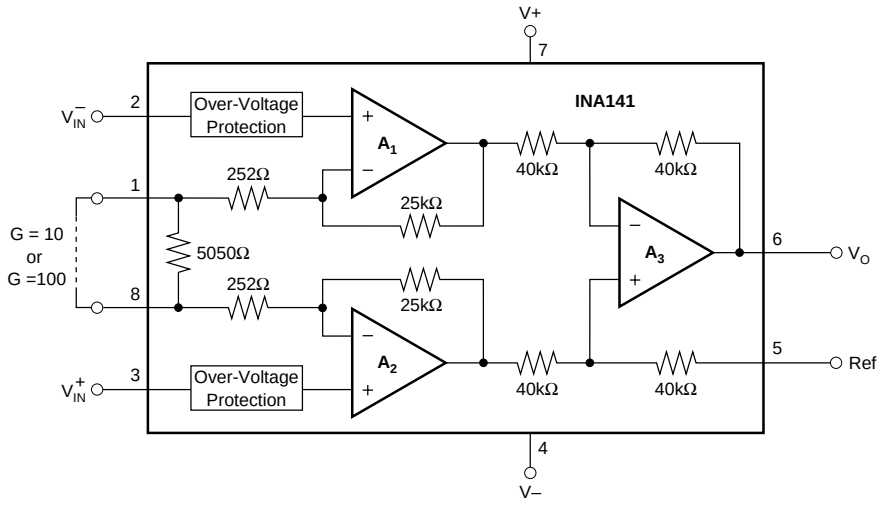
DESCRIPTION

The INA141 is a low power, 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. Current-feedback input circuitry provides wide bandwidth even at high gain (200kHz at G = 100).

Simple pin connections set an accurate gain of 10 or 100V/V without external resistors. Internal input protection can withstand up to ±40V without damage.

The INA141 is laser trimmed for very low offset voltage (50μV), drift (0.5μV/°C) and high common-mode rejection (117dB at G = 100). It operates with power supplies as low as ±2.25V, and quiescent current is only 750μA—ideal for battery operated systems.

The INA141 is available in 8-pin plastic DIP, and SO-8 surface-mount packages, specified for the –40°C to +85°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

At T_A = +25°C, V_S = ±15V, and R_L = 10kΩ, unless otherwise noted.

PARAMETER	CONDITIONS	INA141P, U			INA141PA, UA			UNITS
		MIN	TYP	MAX	MIN	TYP	MAX	
INPUT								
Offset Voltage, RTI	G = 100		±20	±50		*	±125	µV
	G = 10		±50	±100		*	±250	µV
vs Temperature	G = 100		±0.2	±0.5		*	±1.5	µV/°C
	G = 10[2]		±0.5	±2		*	±2.5	µV/°C
vs Power Supply	V_S = ±2.25 to ±18V, G = 100		±0.4	±1		*	±3	µV/V
	G = 10		±2	±10		*	±20	µV/V
Long-Term Stability	G = 100		0.2			*		µV/mo
	G = 10		0.5			*		µV/mo
Impedance, Differential			10^{10} || 2			*		Ω || pF
Common-Mode			10^{10} || 9			*		Ω || pF
Common-Mode Voltage Range[1]	V_O = 0V	(V+) – 2	(V+) – 1.4		*	*		V
		(V–) + 2	(V–) + 1.7		*	*		V
Safe Input Voltage				±40			*	V
Common-Mode Rejection	V_{CM} = ±13V, ΔR_S = 1kΩ							
	G = 100	117	125		110	120		dB
	G = 10	100	106		93	100		dB
BIAS CURRENT			±2	±5		*	±10	nA
vs Temperature			±30			*		pA/°C
Offset Current			±1	±5		*	±10	nA
vs Temperature			±30			*		pA/°C
NOISE VOLTAGE, RTI								
f = 10Hz	G = 100, R_S = 0Ω		10			*		nV/√Hz
f = 100Hz			8			*		nV/√Hz
f = 1kHz			8			*		nV/√Hz
f_B = 0.1Hz to 10Hz			0.2			*		µVp-p
f = 10Hz	G = 10, R_S = 0Ω		22			*		nV/√Hz
f = 100Hz			13			*		nV/√Hz
f = 1kHz			12			*		nV/√Hz
f_B = 0.1Hz to 10Hz			0.6			*		µVp-p
Noise Current								
f = 10Hz			0.9			*		pA/√Hz
f = 1kHz			0.3			*		pA/√Hz
f_B = 0.1Hz to 10Hz			30			*		pAp-p
GAIN								
Gain Error	V_O = ±13.6V, G = 100		±0.03	±0.075		*	±0.15	%
	G = 10		±0.01	±0.05		*	±0.15	%
Gain vs Temperature[2]	G = 10, 100		±2	±10		*	*	ppm/°C
Nonlinearity	G = 100		±0.0005	±0.002		*	±0.004	% of FSR
	G = 10		±0.0003	±0.001		*	±0.002	% of FSR
OUTPUT								
Voltage: Positive	R_L = 10kΩ	(V+) – 1.4	(V+) – 0.9		*	*		V
Negative	R_L = 10kΩ	(V–) + 1.4	(V–) + 0.9		*	*		V
Load Capacitance Stability			1000			*		pF
Short-Circuit Current			+6/–15			*		mA
FREQUENCY RESPONSE								
Bandwidth, –3dB	G = 100		200			*		kHz
	G = 10		1			*		MHz
Slew Rate	V_O = ±10V, G = 10		4			*		V/µs
Settling Time, 0.01%	V_O = ±5V, G = 100		9			*		µs
	G = 10		7			*		µs
Overload Recovery	50% Overdrive		4			*		µs
POWER SUPPLY								
Voltage Range		±2.25	±15	±18	*	*	*	V
Current, Total	V_{IN} = 0V		±750	±800		*	*	µA
TEMPERATURE RANGE								
Specification		–40		85	*		*	°C
Operating		–40		125	*		*	°C
θ_{JA} 8-Pin DIP			80			*		°C/W
SO-8 SOIC			150			*		°C/W

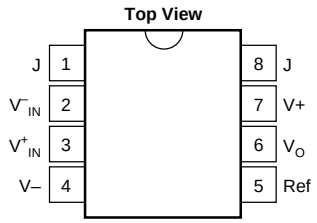
* Specification same as INA141P, U.

NOTE: (1) Input common-mode range varies with output voltage—see typical curves. (2) Guaranteed by wafer test.

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 CONFIGURATION

8-Pin DIP and SO-8



ABSOLUTE MAXIMUM RATINGS

Supply Voltage	±18V
Analog 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

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.

ORDERING INFORMATION

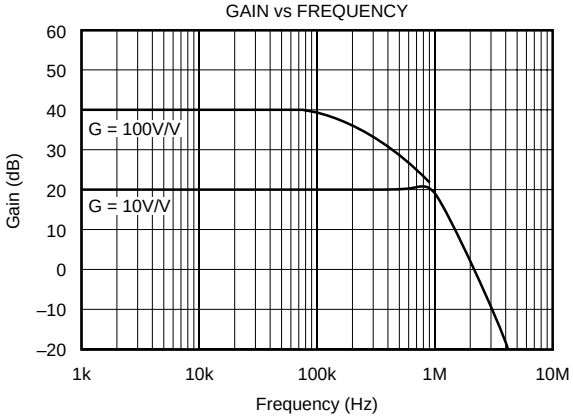
PRODUCT	PACKAGE	PACKAGE DRAWING NUMBER(1)	TEMPERATURE RANGE
INA141PA	8-Pin Plastic DIP	006	–40°C to +85°C
INA141P	8-Pin Plastic DIP	006	–40°C to +85°C
INA141UA	SO-8 Surface-Mount	182	–40°C to +85°C
INA141U	SO-8 Surface-Mount	182	–40°C to +85°C

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

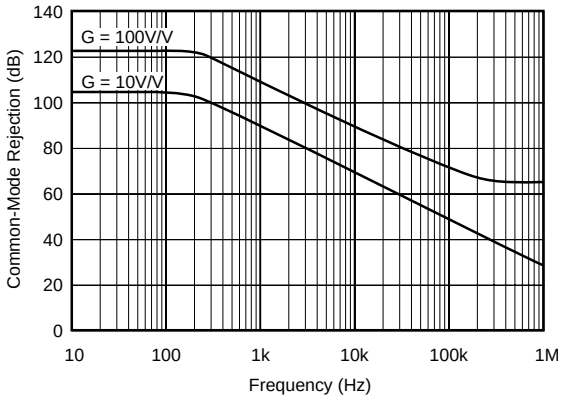
TYPICAL PERFORMANCE CURVES

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

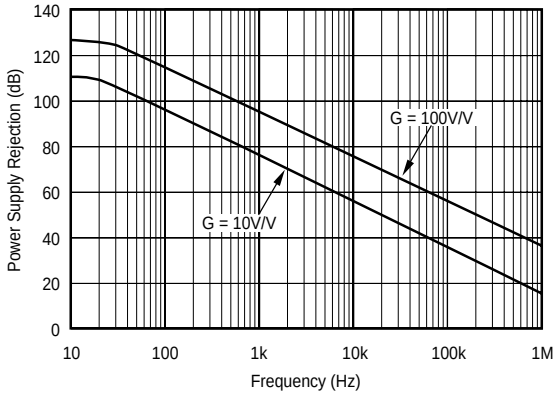
GAIN vs FREQUENCY



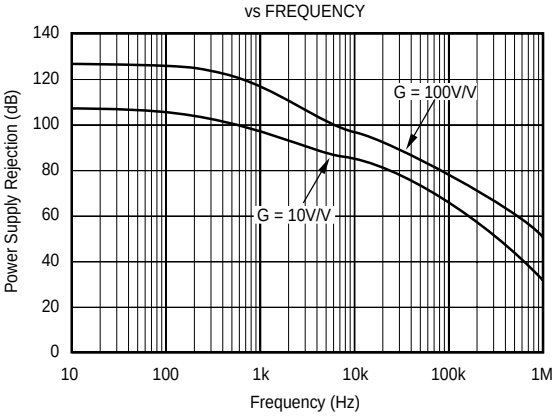
COMMON-MODE REJECTION vs FREQUENCY



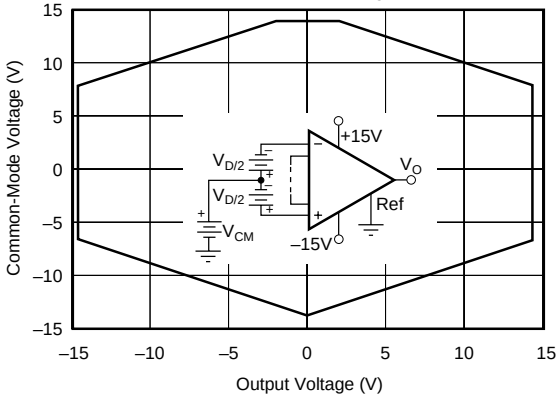
POSITIVE POWER SUPPLY REJECTION vs FREQUENCY



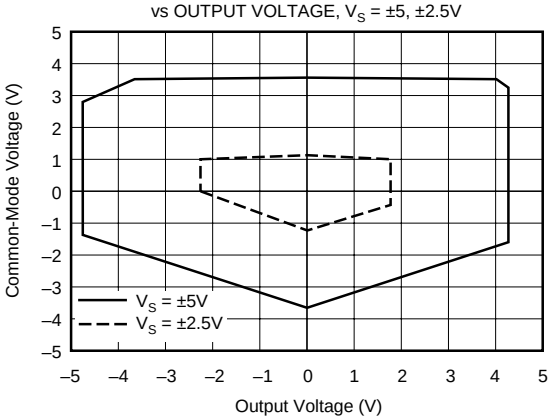
NEGATIVE POWER SUPPLY REJECTION vs FREQUENCY



INPUT COMMON-MODE RANGE vs OUTPUT VOLTAGE, V_S = ±15V



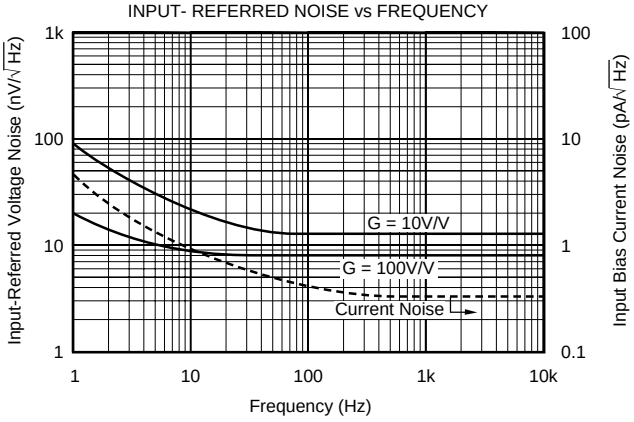
INPUT COMMON-MODE RANGE vs OUTPUT VOLTAGE, V_S = ±5, ±2.5V



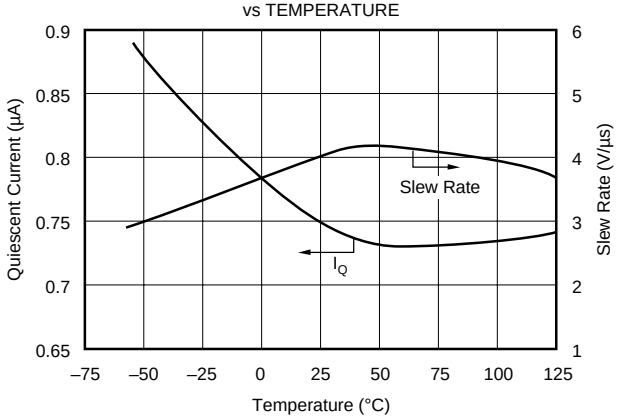
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

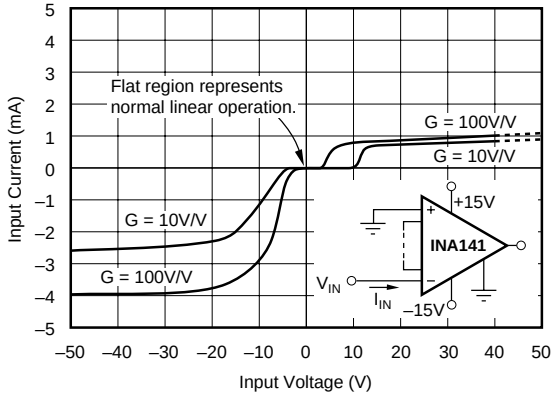
INPUT- REFERRED NOISE vs FREQUENCY



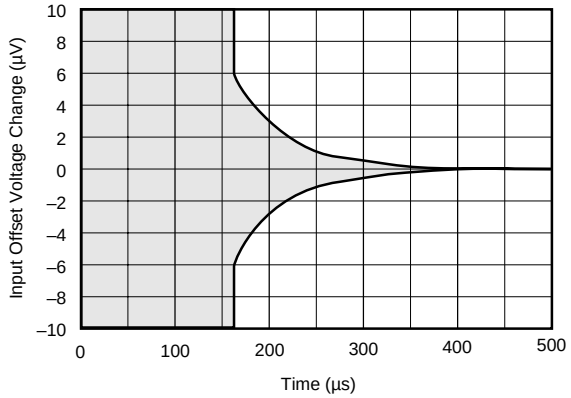
QUIESCENT CURRENT and SLEW RATE vs TEMPERATURE



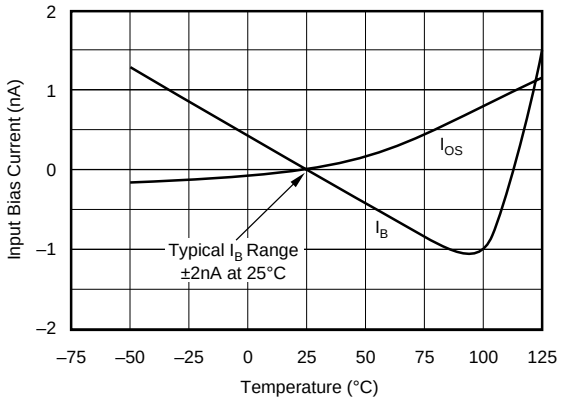
INPUT OVER-VOLTAGE V/I CHARACTERISTICS



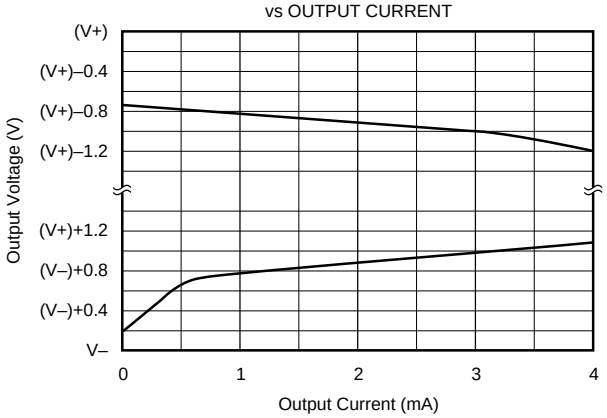
INPUT OFFSET VOLTAGE WARM-UP



INPUT BIAS CURRENT vs TEMPERATURE



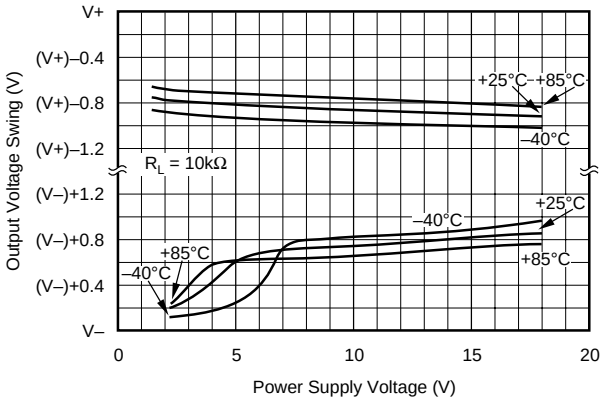
OUTPUT VOLTAGE SWING vs OUTPUT CURRENT



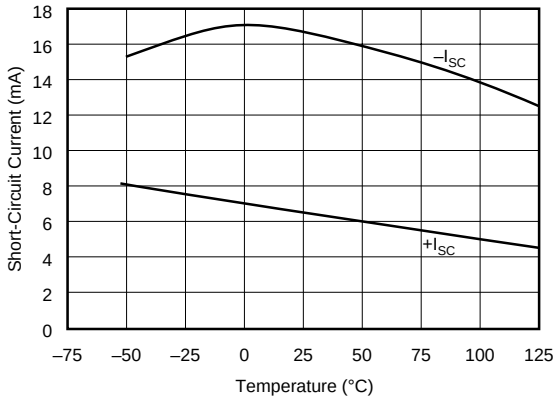
TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

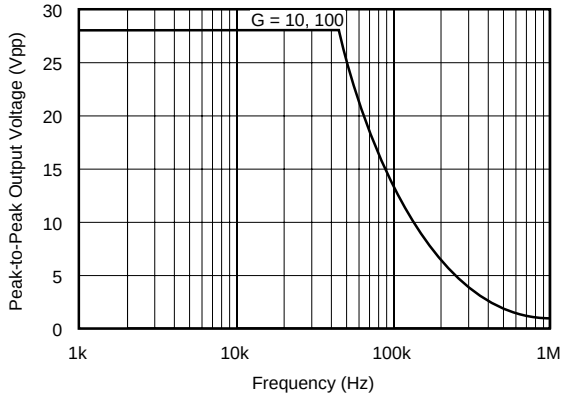
OUTPUT VOLTAGE SWING
vs POWER SUPPLY VOLTAGE



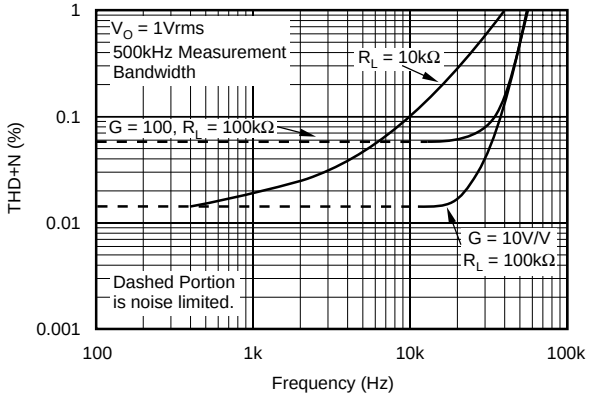
SHORT-CIRCUIT OUTPUT CURRENT
vs TEMPERATURE



MAXIMUM OUTPUT VOLTAGE vs FREQUENCY



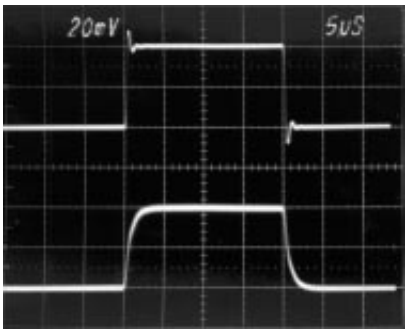
TOTAL HARMONIC DISTORTION + NOISE
vs FREQUENCY



TYPICAL PERFORMANCE CURVES (CONT)

At T_A = +25°C and V_S = ±15V, unless otherwise noted.

SMALL-SIGNAL STEP RESPONSE



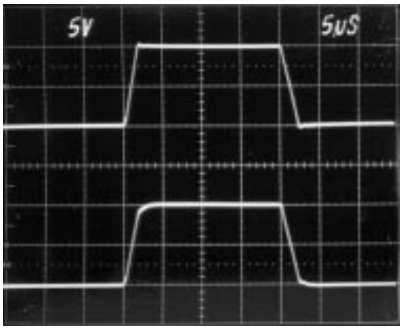
G = 10

20mV/div

G = 100

5µs/div

LARGE-SIGNAL STEP RESPONSE



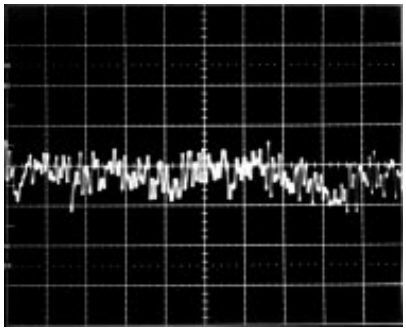
G = 10

5V/div

G = 100

5µs/div

VOLTAGE NOISE 0.1 to 10Hz
INPUT-REFERRED, G = 100



0.1µV/div

1s/div

APPLICATION INFORMATION

Figure 1 shows the basic connections required for operation of the INA141. 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 8Ω in series with the Ref pin will cause a typical device to degrade to approximately 80dB CMR (G = 1).

SETTING THE GAIN

Gain is selected with a jumper connection as shown in Figure 1. G = 10V/V with no jumper installed. With a jumper installed, G = 100V/V. To preserve good gain accuracy, this jumper must have low series resistance. A resistance of 0.5Ω in series with the jumper will decrease the gain by 0.1%.

Internal resistor ratios are laser trimmed to assure excellent gain accuracy. Actual resistor values can vary by approximately ±25% from the nominal values shown.

Gains between 10 and 100 can be achieved by connecting an external resistor to the jumper pins. This is not recommended, however, because the ±25% variation of internal resistor values makes the required external resistor value uncertain. A companion model, INA128, features accurately trimmed internal resistors so that gains from 1 to 10,000 can be set with an external resistor.

DYNAMIC PERFORMANCE

The typical performance curve "Gain vs Frequency" shows that, despite its low quiescent current, the INA141 achieves wide bandwidth, even at G = 100. This is due to the current-feedback topology of the INA141. Settling time also remains excellent at G = 100.

NOISE PERFORMANCE

The INA141 provides very low noise in most applications. Low frequency noise is approximately 0.2µVp-p measured from 0.1 to 10Hz (G = 100). This provides dramatically improved noise when compared to state-of-the-art chopper-stabilized amplifiers.

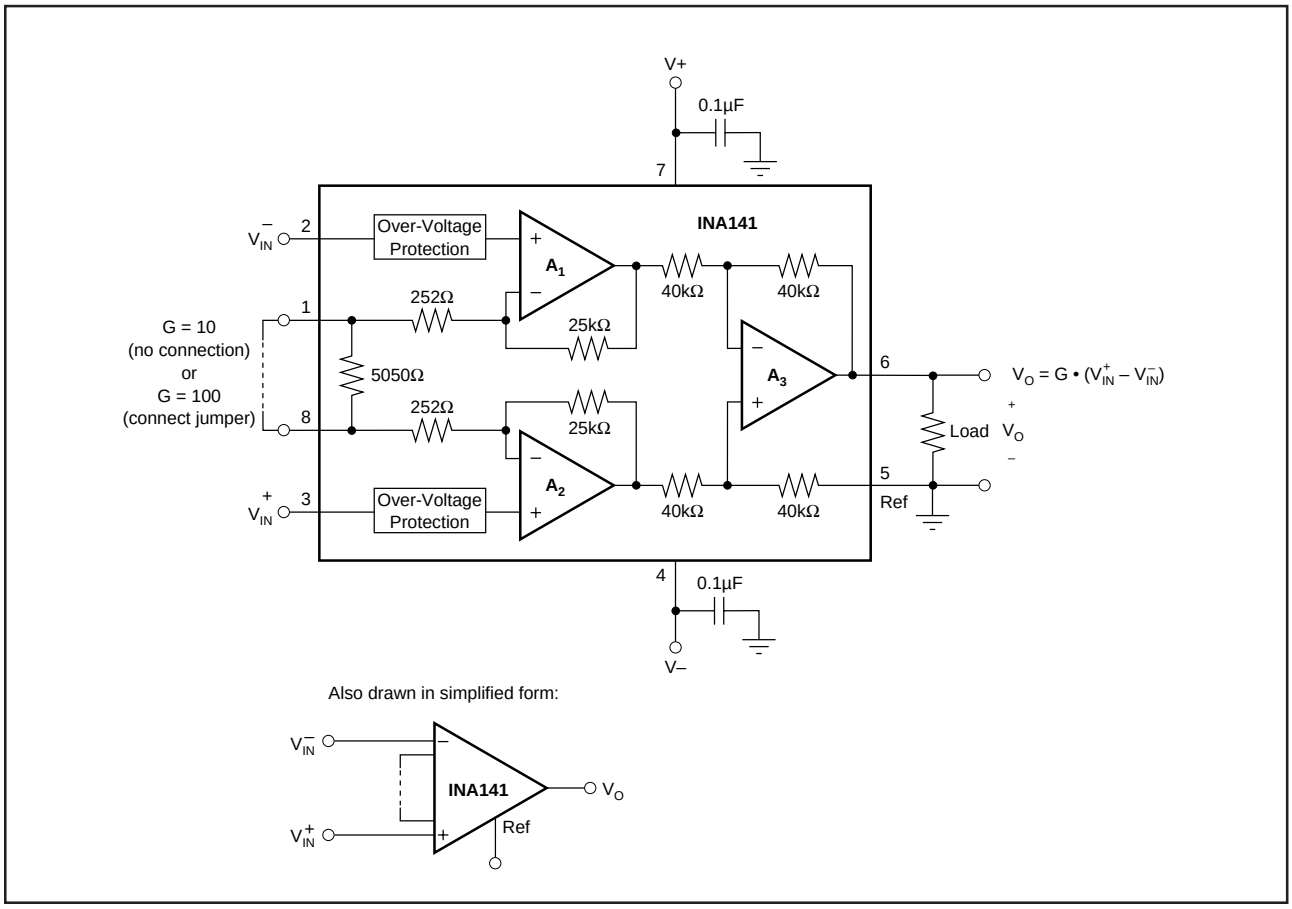


FIGURE 1. Basic Connections.

OFFSET TRIMMING

The INA141 is laser trimmed for low offset voltage and offset voltage 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 with the output. The op amp buffer provides low impedance at the Ref terminal to preserve good common-mode rejection.

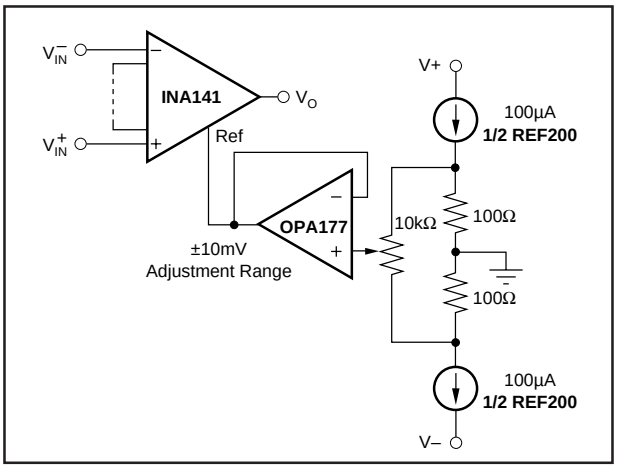


FIGURE 2. Optional Trimming of Output Offset Voltage.

INPUT BIAS CURRENT RETURN PATH

The input impedance of the INA141 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 approximately ±2nA. 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 for proper operation. Figure 3 shows various provisions for an input bias current path. Without a bias current path, the inputs will float to a potential which exceeds the common-mode range of the INA141 and the input amplifiers will saturate.

If the differential source resistance is low, the bias current return path can be connected to one input (see the thermocouple example in Figure 3). With higher source impedance, using two equal resistors provides a balanced input with possible advantages of lower input offset voltage due to bias current and better high-frequency common-mode rejection.

INPUT COMMON-MODE RANGE

The linear input voltage range of the input circuitry of the INA141 is from approximately 1.4V below the positive supply voltage to 1.7V above the negative supply. As a differential input voltage causes the output voltage to increase, however, the linear input range will be limited by the output voltage swing of amplifiers A_1 and A_2. So the linear common-mode input range is related to the output voltage of the complete amplifier. This behavior also depends on supply voltage—see performance curves "Input Common-Mode Range vs Output Voltage".

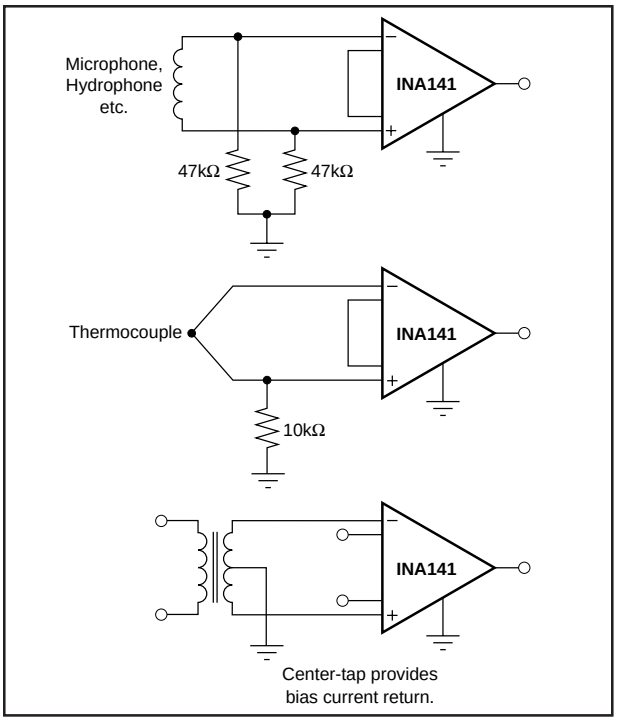


FIGURE 3. Providing an Input Common-Mode Current Path.

Input overload can produce an output voltage that appears normal. For example, if an input overload condition drives both input amplifiers to their positive output swing limit, the difference voltage measured by the output amplifier will be near zero. The output of the INA141 will be near 0V even though both inputs are overloaded.

LOW VOLTAGE OPERATION

The INA141 can be operated on power supplies as low as ±2.25V. Performance remains excellent with power supplies ranging from ±2.25V to ±18V. Most parameters vary only slightly through this supply voltage range—see Typical Performance Curves. Operation at very low supply voltage requires careful attention to assure that the input voltages remain within their linear range. Voltage swing requirements of internal nodes limit the input common-mode range with low power supply voltage. Typical performance curves, "Input Common-Mode Range vs Output Voltage" show the range of linear operation for ±15V, ±5, and ±2.5V supplies.

INPUT PROTECTION

The inputs of the INA141 are individually protected for voltages up to ±40V. For example, a condition of –40V on one input and +40V 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 of approximately 1.5 to 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 the power supplies are disconnected or turned off.

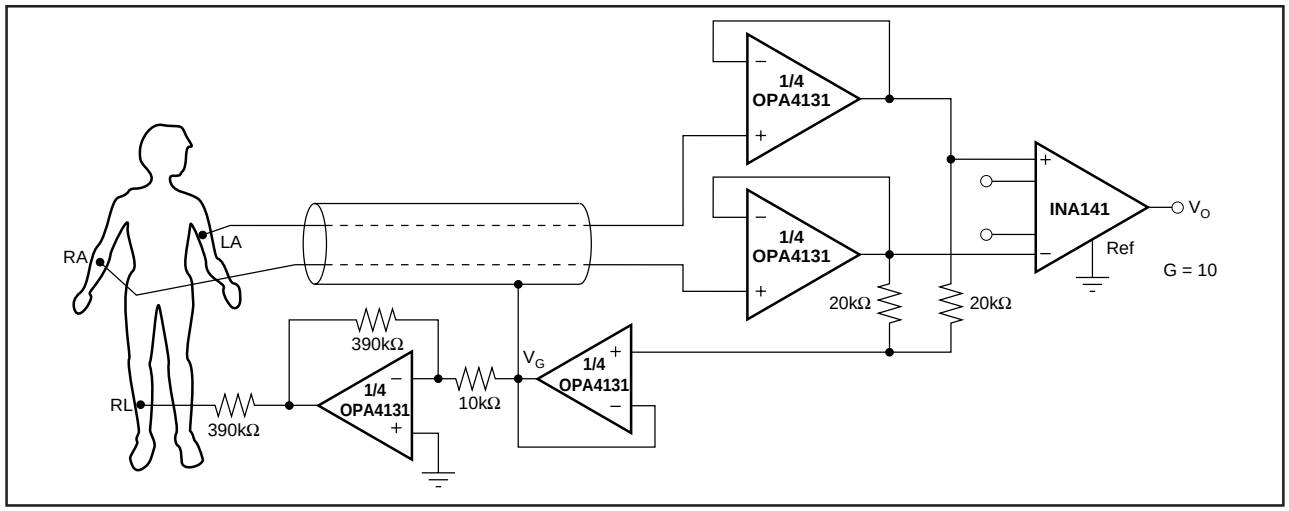


FIGURE 4. ECG Amplifier With Right-Leg Drive.

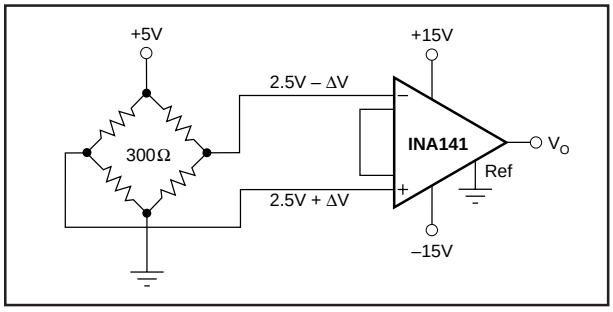


FIGURE 5. Bridge Amplifier.

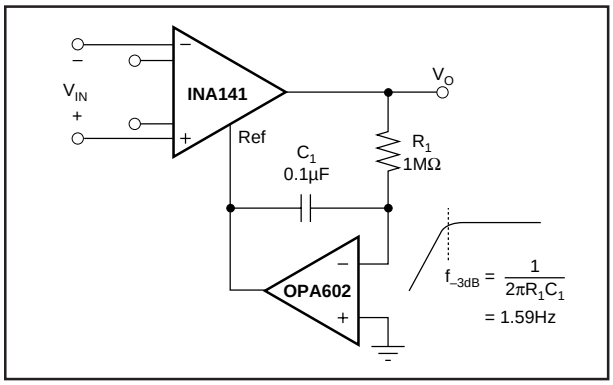
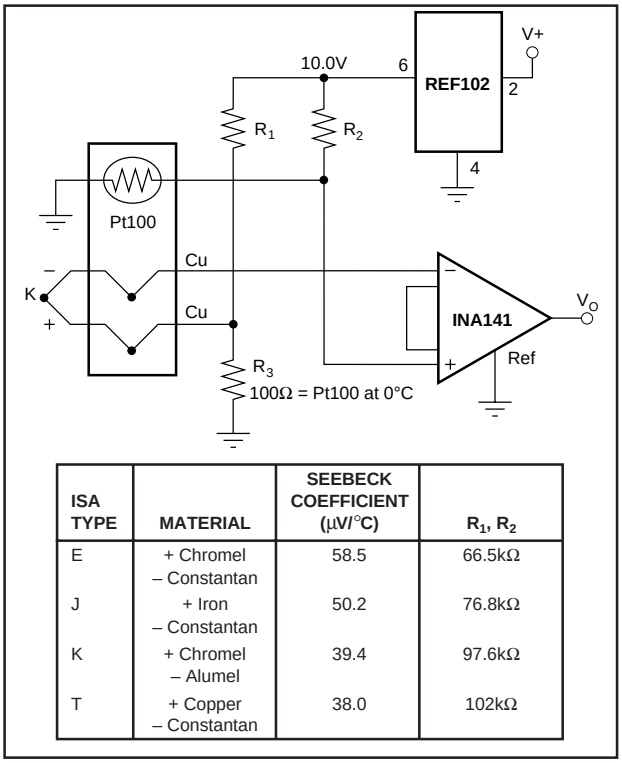
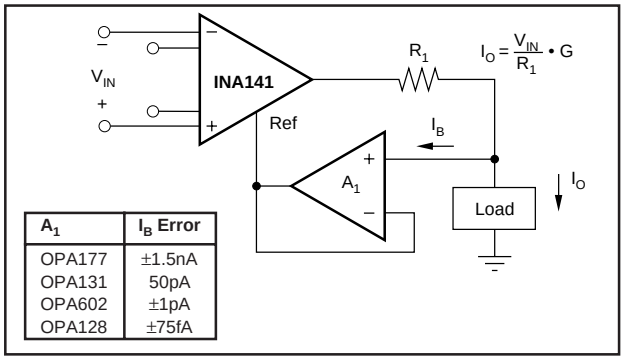


FIGURE 6. AC-Coupled Instrumentation Amplifier.



ISA TYPE	MATERIAL	SEEBECK COEFFICIENT (µV/°C)	R_1, R_2
E	+ Chromel – Constantan	58.5	66.5kΩ
J	+ Iron – Constantan	50.2	76.8kΩ
K	+ Chromel – Alumel	39.4	97.6kΩ
T	+ Copper – Constantan	38.0	102kΩ

FIGURE 7. Thermocouple Amplifier With RTD Cold-Junction Compensation.



A_1	I_B Error
OPA177	±1.5nA
OPA131	50pA
OPA602	±1pA
OPA128	±75fA

FIGURE 8. Differential Voltage to Current Converter.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish	MSL Peak Temp (3)
INA141P	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
INA141PA	OBSOLETE	PDIP	P	8		TBD	Call TI	Call TI
INA141U	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141U/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141U/2K5E4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141UA	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141UA/2K5	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141UA/2K5E4	ACTIVE	SOIC	D	8	2500	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141UAE4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141UAG4	ACTIVE	SOIC	D	8	75	Green (RoHS & no Sb/Br)	CU NIPDAU	Level-3-260C-168 HR
INA141UG4	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)

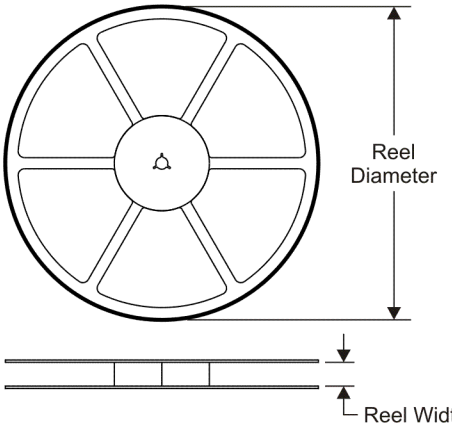
(3) MSL, Peak Temp. -- The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

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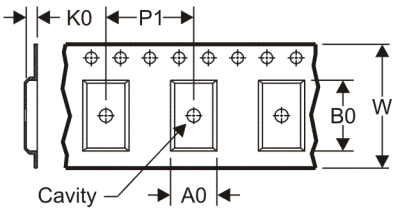
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TAPE AND REEL INFORMATION

REEL DIMENSIONS

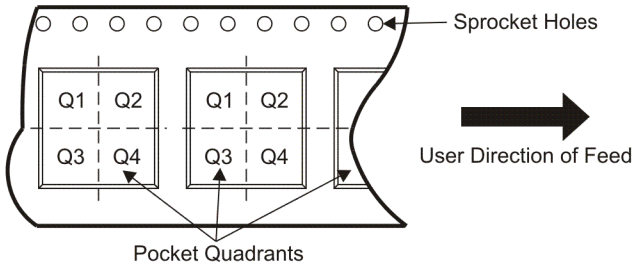


TAPE DIMENSIONS



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

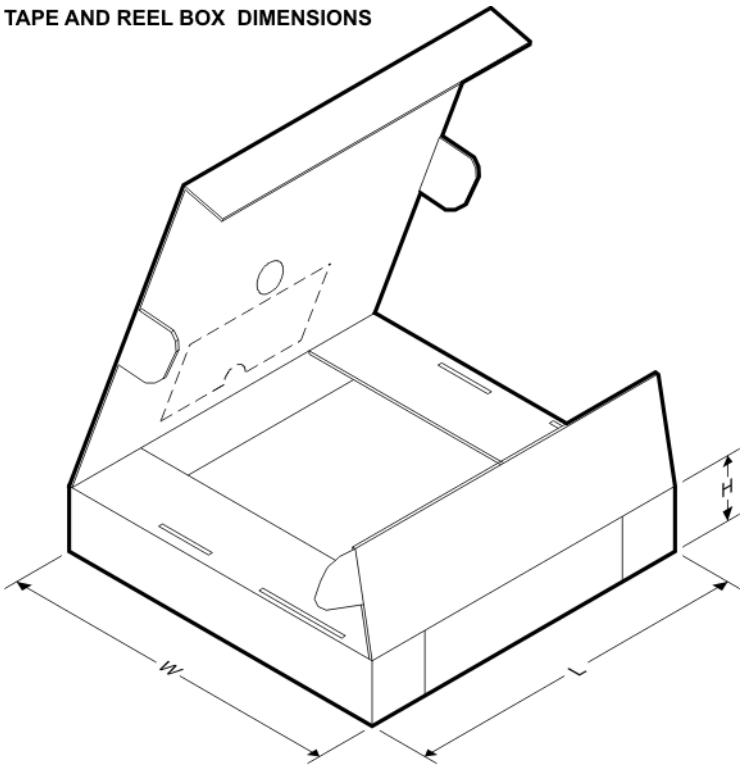
QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE



*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
INA141U/2K5	SOIC	D	8	2500	330.0	12.4	6.4	5.2	2.1	8.0	12.0	Q1
INA141UA/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)
INA141U/2K5	SOIC	D	8	2500	346.0	346.0	29.0
INA141UA/2K5	SOIC	D	8	2500	346.0	346.0	29.0

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