

**INA137**  
**INA2137**

## AUDIO DIFFERENTIAL LINE RECEIVERS

### $\pm 6\text{dB}$ ( $G = 1/2$ or $2$ )

### FEATURES

- SINGLE AND DUAL VERSIONS
- LOW DISTORTION: 0.0005% at  $f = 1\text{kHz}$
- HIGH SLEW RATE:  $14\text{V}/\mu\text{s}$
- FAST SETTLING TIME:  $3\mu\text{s}$  to  $0.01\%$
- WIDE SUPPLY RANGE:  $\pm 4\text{V}$  to  $\pm 18\text{V}$
- LOW QUIESCENT CURRENT:  $2.9\text{mA}$  max
- HIGH CMRR:  $90\text{dB}$
- FIXED GAIN =  $\pm 6\text{dB}$
- PACKAGES—SINGLE: 8-PIN DIP, SO-8  
DUAL: 14-PIN DIP, SO-14

### DESCRIPTION

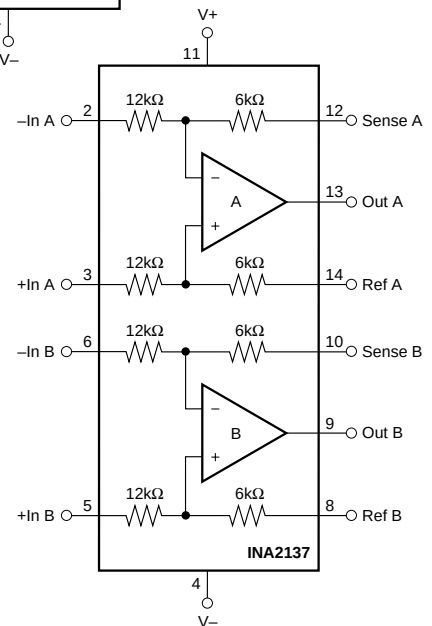
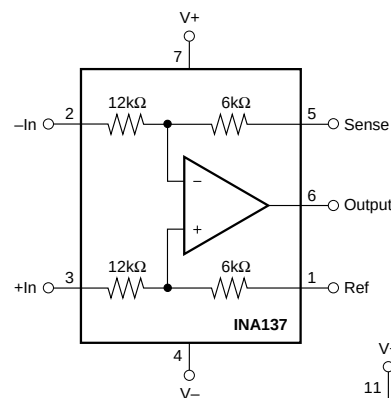
The INA137 and INA2137 are differential line receivers consisting of high performance op amps with on-chip precision resistors. They are fully specified for high performance audio applications and have excellent ac specifications, including low distortion (0.0005% at 1kHz) and high slew rate ( $14\text{V}/\mu\text{s}$ ), assuring good dynamic response. In addition, wide output voltage swing and high output drive capability allow use in a wide variety of demanding applications. The dual version features completely independent circuitry for lowest crosstalk and freedom from interaction, even when overdriven or overloaded.

The INA137 and INA2137 on-chip resistors are laser trimmed for accurate gain and optimum common-mode rejection. Furthermore, excellent TCR tracking of the resistors maintains gain accuracy and common-mode rejection over temperature. Operation is guaranteed from  $\pm 4\text{V}$  to  $\pm 18\text{V}$  (8V to 36V total supply).

The INA137 is available in 8-pin DIP and SO-8 surface-mount packages. The INA2137 comes in 14-pin DIP and SO-14 surface-mount packages. Both are specified for operation over the extended industrial temperature range,  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ .

### APPLICATIONS

- AUDIO DIFFERENTIAL LINE RECEIVER
- $G = 1/2$  OR  $G = 2$  AMPLIFIER
- INSTRUMENTATION BUILDING BLOCK
- CURRENT SHUNT MONITOR
- VOLTAGE-CONTROLLED CURRENT SOURCE
- GROUND LOOP ELIMINATOR



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# SPECIFICATIONS: $V_S = \pm 18V$

At  $T_A = +25^\circ C$ ,  $V_S = \pm 18V$ ,  $R_L = 2k\Omega$ ,  $G = 1/2$ , and Ref Pin connected to Ground, unless otherwise noted.

| PARAMETER                                                                                                                                                                                        | CONDITIONS                                                                         | INA137PA, UA<br>INA2137PA, UA |                                                           |                            | UNITS                                                                                                  |
|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------|-------------------------------|-----------------------------------------------------------|----------------------------|--------------------------------------------------------------------------------------------------------|
|                                                                                                                                                                                                  |                                                                                    | MIN                           | TYP                                                       | MAX                        |                                                                                                        |
| <b>AUDIO PERFORMANCE</b><br>Total Harmonic Distortion + Noise, $f = 1kHz$<br>Noise Floor, RTO <sup>(1)</sup><br>Headroom, RTO <sup>(1)</sup>                                                     | $V_{IN} = 10V_{rms}$<br>20kHz BW<br>THD+N < 1%                                     |                               | 0.0005<br>-106<br>+23                                     |                            | %<br>dBu<br>dBu                                                                                        |
| <b>FREQUENCY RESPONSE</b><br>Small-Signal Bandwidth<br>Slew Rate<br>Settling Time: 0.1%<br>0.01%<br>Overload Recovery Time<br>Channel Separation (dual), $f = 1kHz$                              | 10V Step, $C_L = 100pF$<br>10V Step, $C_L = 100pF$<br>50% Overdrive                |                               | 4.0<br>14<br>2<br>3<br>3<br>123                           |                            | MHz<br>V/ $\mu s$<br>$\mu s$<br>$\mu s$<br>$\mu s$<br>dB                                               |
| <b>OUTPUT NOISE VOLTAGE<sup>(2)</sup></b><br>$f = 20Hz$ to $20kHz$<br>$f = 1kHz$                                                                                                                 |                                                                                    |                               | 3.5<br>26                                                 |                            | $\mu V_{rms}$<br>nV/ $\sqrt{Hz}$                                                                       |
| <b>OFFSET VOLTAGE<sup>(3)</sup></b><br>Input Offset Voltage<br>vs Temperature<br>vs Power Supply                                                                                                 | RTO<br>$V_{CM} = 0V$<br>Specified Temperature Range<br>$V_S = \pm 4V$ to $\pm 18V$ |                               | $\pm 100$<br>$\pm 2$<br>$\pm 5$                           | $\pm 1000$<br><br>$\pm 60$ | $\mu V$<br>$\mu V/^\circ C$<br>$\mu V/V$                                                               |
| <b>INPUT</b><br>Common-Mode Voltage Range: Positive<br>Negative<br>Differential Voltage Range<br>Common-Mode Rejection<br>Impedance <sup>(4)</sup><br>Differential<br>Common-Mode                | $V_O = 0V$<br>$V_O = 0V$<br>$V_{CM} = \pm 46.5V$ , $R_S = 0\Omega$                 | 3(V+)-7.5<br>3(V-)+7.5<br>74  | 3(V+)-6<br>3(V-)+3<br>See Typical Curve<br>90<br>24<br>18 |                            | V<br>V<br>dB<br>k $\Omega$<br>k $\Omega$                                                               |
| <b>GAIN</b><br>Initial<br>Error<br>vs Temperature<br>Nonlinearity                                                                                                                                | $V_O = -10V$ to $10V$<br>$V_O = -10V$ to $10V$                                     |                               | 0.5<br>$\pm 0.01$<br>$\pm 1$<br>0.0001                    | $\pm 0.1$<br>$\pm 10$      | V/V<br>%<br>ppm/ $^\circ C$<br>%                                                                       |
| <b>OUTPUT</b><br>Voltage Output, Positive<br>Negative<br>Current Limit, Continuous to Common<br>Capacitive Load (Stable Operation)                                                               |                                                                                    | (V+)-2<br>(V-)+2              | (V+)-1.8<br>(V-)+1.6<br>$\pm 60$<br>500                   |                            | V<br>V<br>mA<br>pF                                                                                     |
| <b>POWER SUPPLY</b><br>Rated Voltage<br>Voltage Range<br>Quiescent Current (per Amplifier)                                                                                                       | $I_O = 0$                                                                          | $\pm 4$                       | $\pm 18$<br>$\pm 2.4$                                     | $\pm 18$<br>$\pm 2.9$      | V<br>V<br>mA                                                                                           |
| <b>TEMPERATURE RANGE</b><br>Specification Range<br>Operation Range<br>Storage Range<br>Thermal Resistance, $\theta_{JA}$<br>8-Pin DIP<br>SO-8 Surface-Mount<br>14-Pin DIP<br>SO-14 Surface-Mount |                                                                                    | -40<br>-55<br>-55             | 100<br>150<br>80<br>100                                   | 85<br>125<br>125           | $^\circ C$<br>$^\circ C$<br>$^\circ C$<br>$^\circ C/W$<br>$^\circ C/W$<br>$^\circ C/W$<br>$^\circ C/W$ |

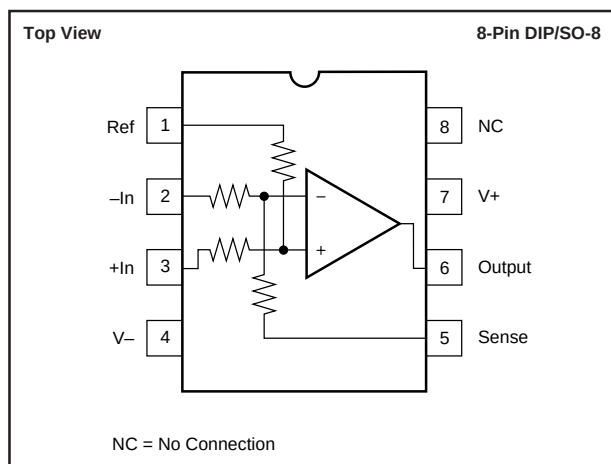
RTO = Referred to Output.

NOTES: (1) dBu =  $20\log(V_{rms}/0.7746)$ . (2) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network. (3) Includes effects of amplifier's input bias and offset currents. (4) Internal resistors are ratio matched but have  $\pm 25\%$  absolute value.

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## PIN CONFIGURATIONS



## ABSOLUTE MAXIMUM RATINGS<sup>(1)</sup>

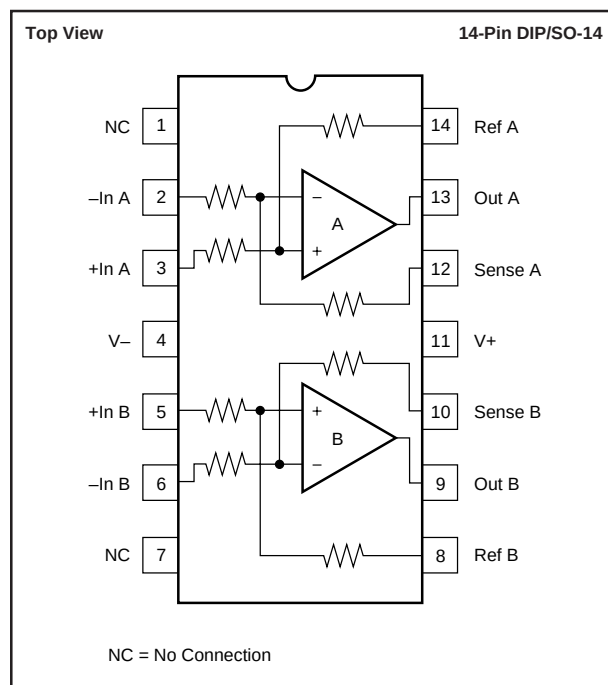
|                                                       |                 |
|-------------------------------------------------------|-----------------|
| Supply Voltage, V+ to V-.....                         | 40V             |
| Input Voltage Range .....                             | ±80V            |
| Output Short-Circuit (to ground) <sup>(2)</sup> ..... | 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.  
 (2) One channel per package.

## PACKAGE/ORDERING INFORMATION

| PRODUCT       | PACKAGE             | PACKAGE DRAWING NUMBER <sup>(1)</sup> | SPECIFICATION TEMPERATURE RANGE |
|---------------|---------------------|---------------------------------------|---------------------------------|
| <b>Single</b> |                     |                                       |                                 |
| INA137PA      | 8-Pin DIP           | 006                                   | -40°C to +85°C                  |
| INA137UA      | SO-8 Surface-Mount  | 182                                   | -40°C to +85°C                  |
| <b>Dual</b>   |                     |                                       |                                 |
| INA2137PA     | 14-Pin DIP          | 010                                   | -40°C to +85°C                  |
| INA2137UA     | SO-14 Surface-Mount | 235                                   | -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.



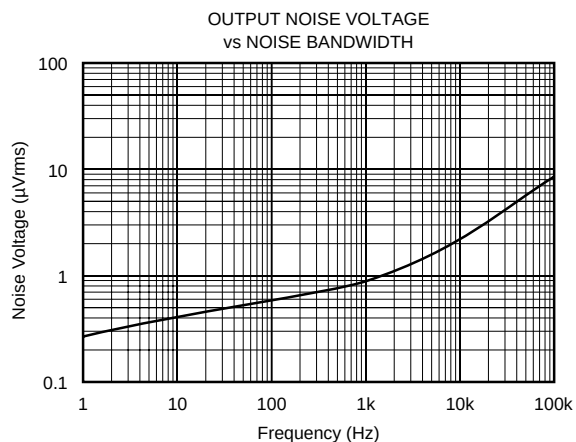
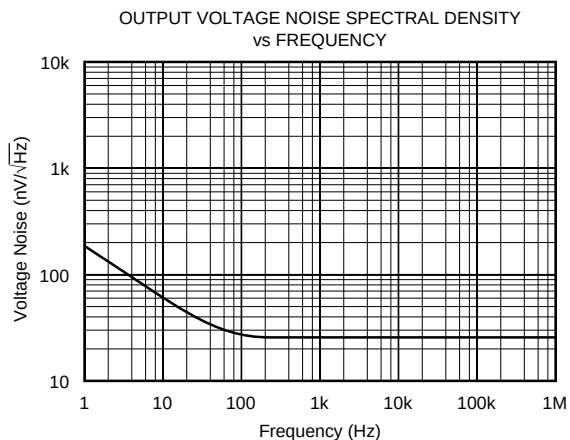
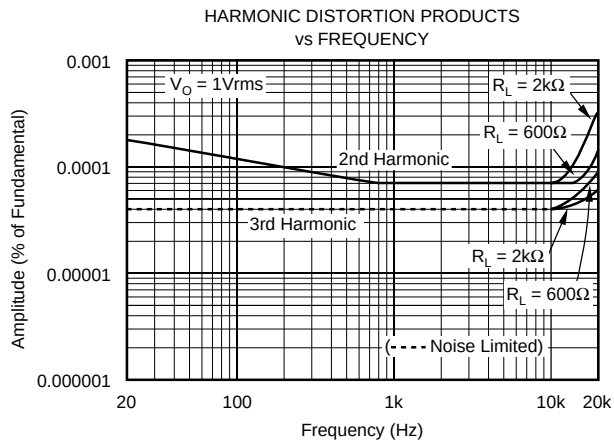
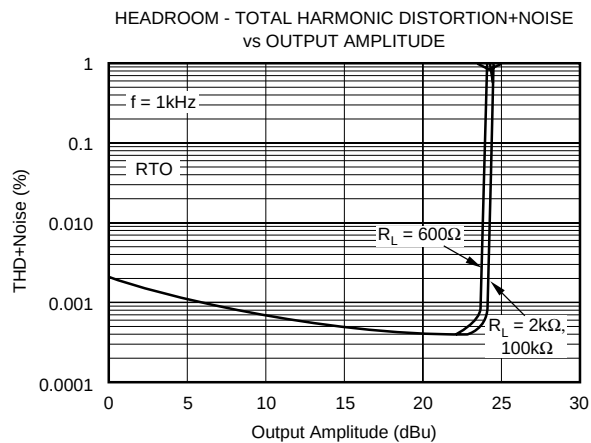
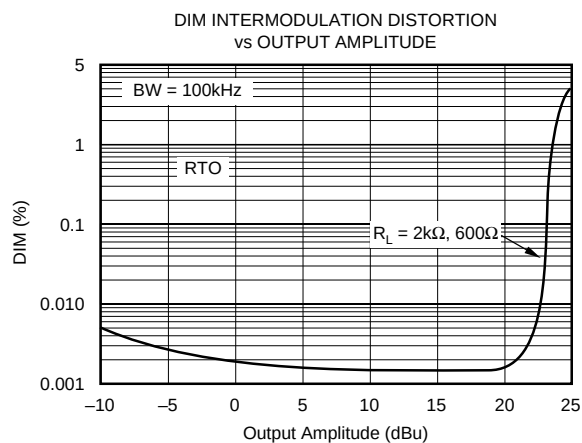
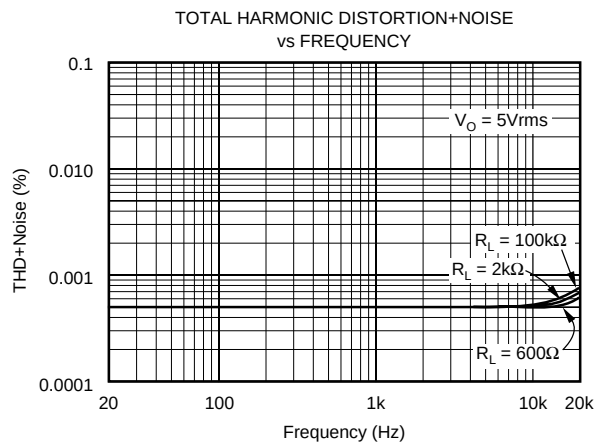
## ELECTROSTATIC DISCHARGE SENSITIVITY

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.

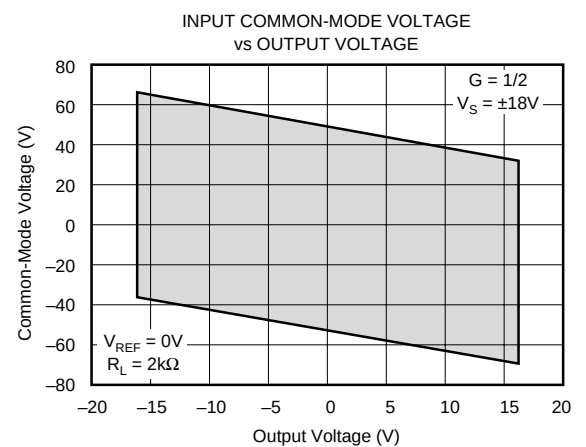
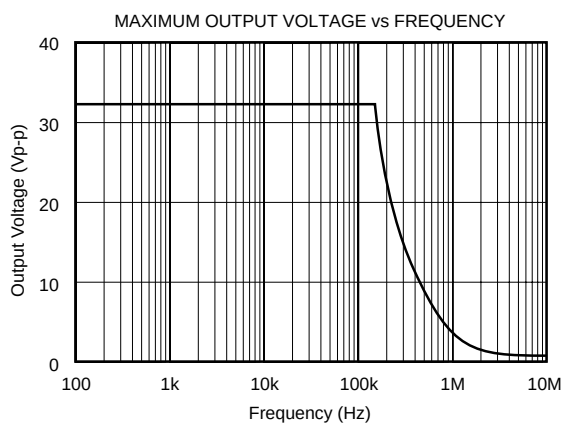
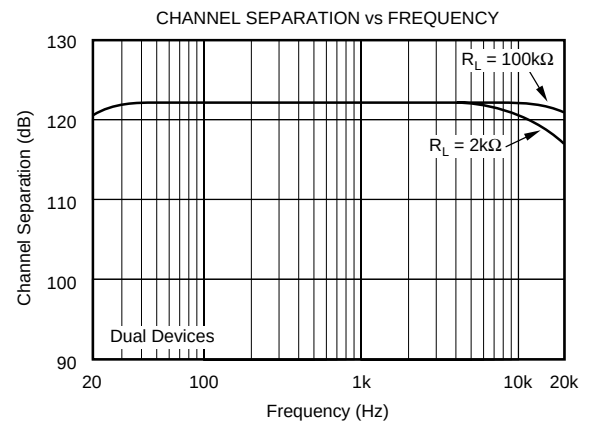
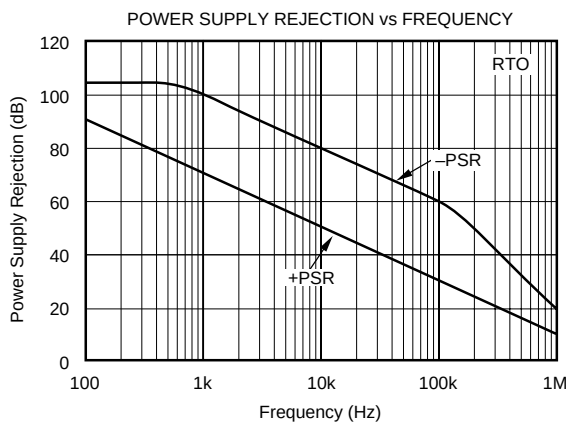
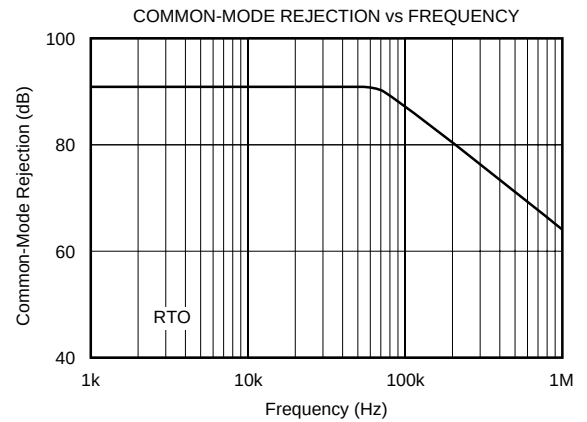
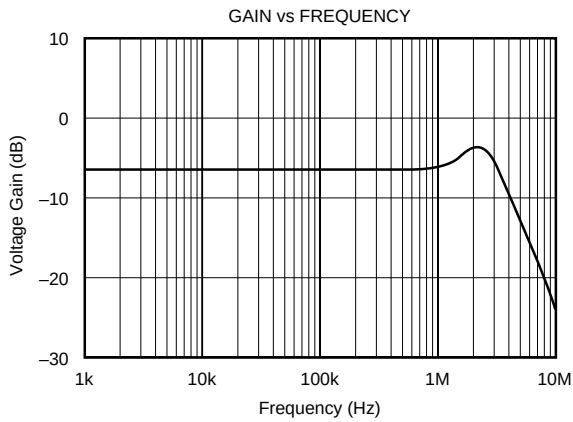
# TYPICAL PERFORMANCE CURVES

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 18\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



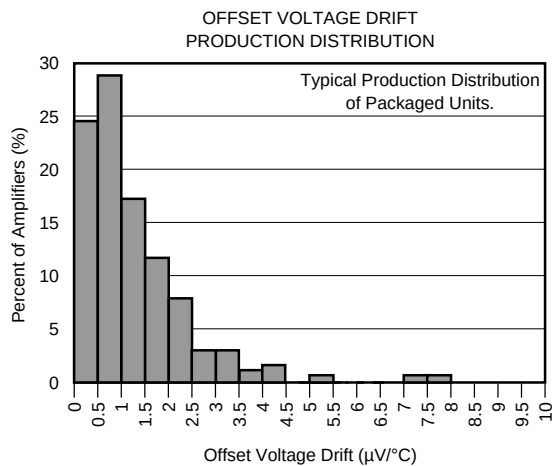
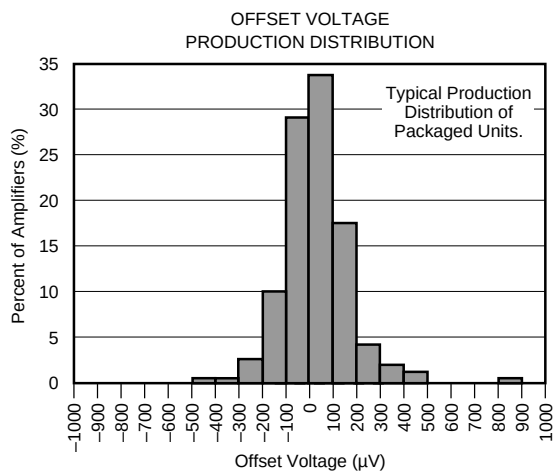
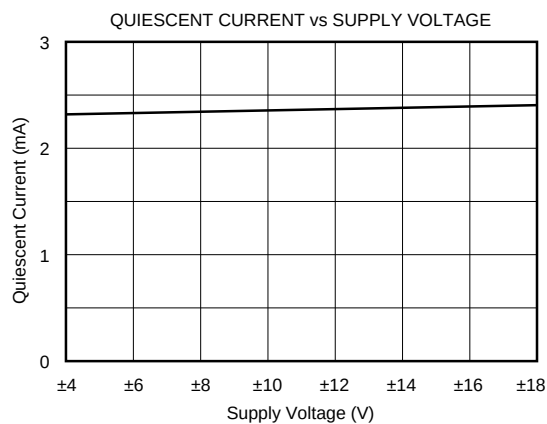
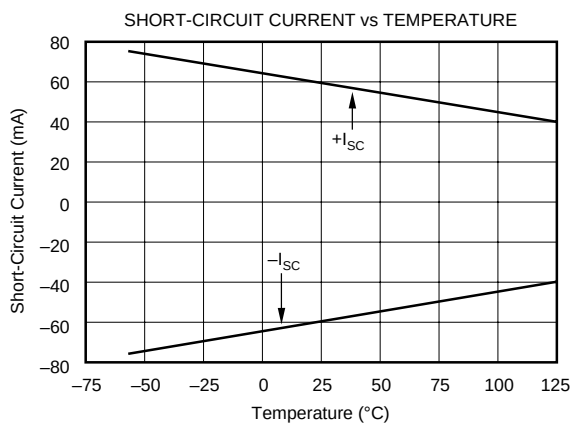
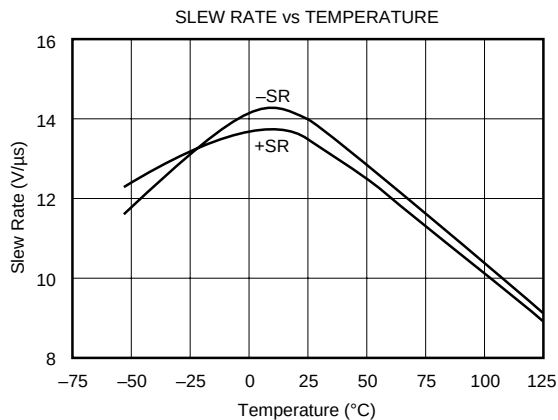
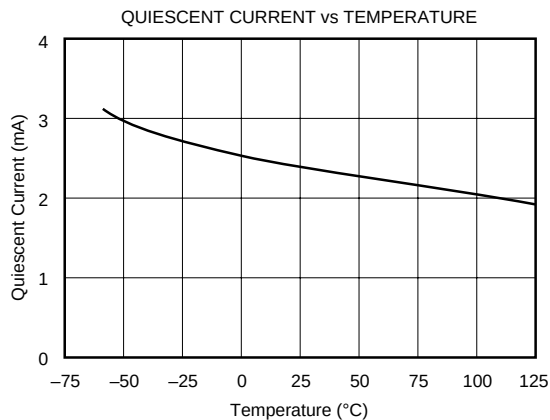
# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 18\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



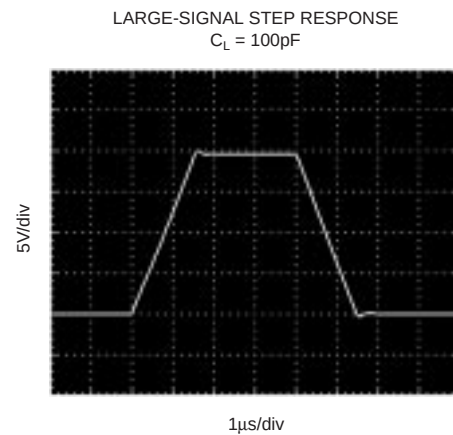
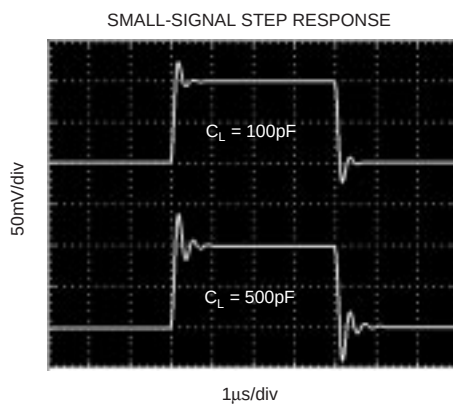
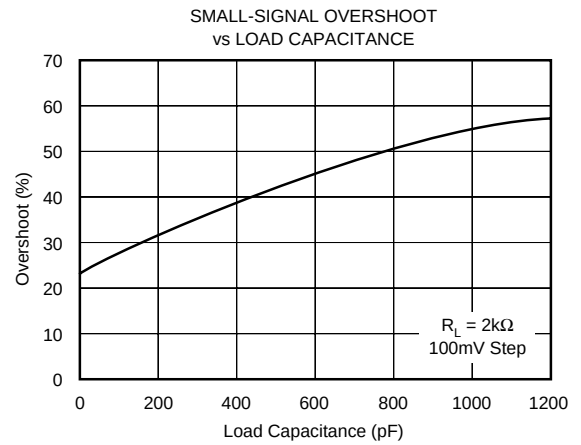
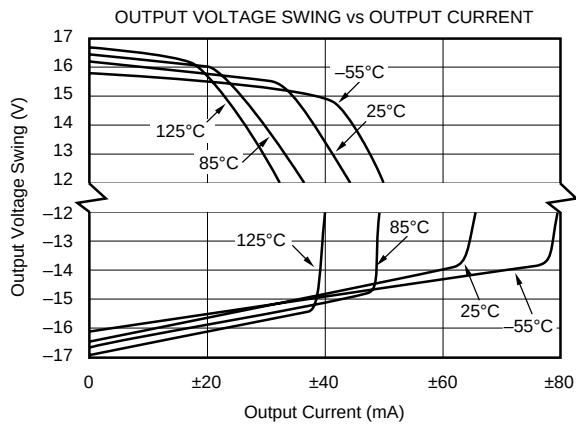
# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 18\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



# TYPICAL PERFORMANCE CURVES (CONT)

At  $T_A = +25^\circ\text{C}$ ,  $V_S = \pm 18\text{V}$ , and  $G = 1/2$ , unless otherwise noted.



## APPLICATIONS INFORMATION

The INA137 and INA2137 are differential line receivers suitable for a wide range of audio and general-purpose applications. Figure 1 shows the basic  $G = 1/2$  (–6dB) differential receiver configuration. The input and feedback resistors can be reversed to achieve  $G = 2$  (+6dB), as shown in Figure 2. For applications requiring  $G = 1$  (0dB), the INA134 and INA2134 are recommended.

Decoupling capacitors are strongly recommended for applications with noisy or high impedance power supplies. The capacitors should be placed close to the device pins as shown in Figure 1. All circuitry is completely independent in the dual version assuring lowest crosstalk and normal behavior when one amplifier is overdriven or short-circuited.

As shown in Figure 1, the differential input signal is connected to pins 2 and 3. The source impedances connected to the inputs must be nearly equal to assure good common-mode rejection. A  $5\Omega$  mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 77dB (RTO). If the source has a known impedance mismatch, an additional resistor in series with the opposite input can be used to preserve good common-mode rejection.

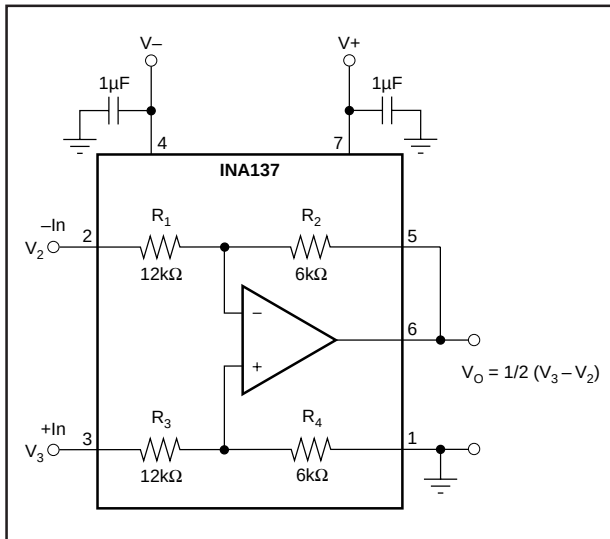


FIGURE 1.  $G = 1/2$  Differential Receiver (Basic Power Supply and Signal Connections).

### AUDIO PERFORMANCE

The INA137 and INA2137 were designed for enhanced ac performance. Very low distortion, low noise, and wide bandwidth provide superior performance in high quality audio applications. Laser-trimmed matched resistors provide optimum common-mode rejection (typically 90dB), especially when compared to circuits implemented with an op amp and discrete precision resistors. In addition, high slew rate (14V/μs) and fast settling time (3μs to 0.01%) ensure excellent dynamic performance.

The INA137 and INA2137 have excellent distortion characteristics. THD+Noise is below 0.001% throughout the audio frequency range. Up to approximately 10kHz distortion is below the measurement limit of commonly used test equipment. Furthermore, distortion remains relatively flat over its wide output voltage swing range (approximately 1.7V from either supply).

### OFFSET VOLTAGE TRIM

The INA137 and INA2137 are laser trimmed for low offset voltage and drift. Most applications require no external offset adjustment. Figure 3 shows an optional circuit for trimming the output offset voltage. The output is referred to the output reference terminal (pin 1), which is normally grounded. A voltage applied to the Ref terminal will be summed with the output signal. This can be used to null offset voltage as shown in Figure 3. The source impedance of a signal applied to the Ref terminal should be less than  $10\Omega$  to maintain good common-mode rejection.

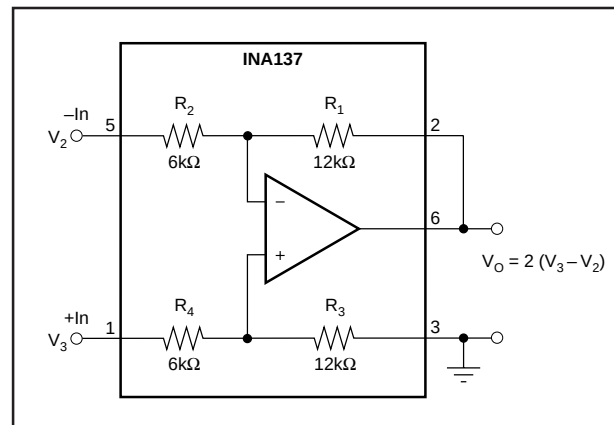


FIGURE 2.  $G = 2$  Differential Receiver.

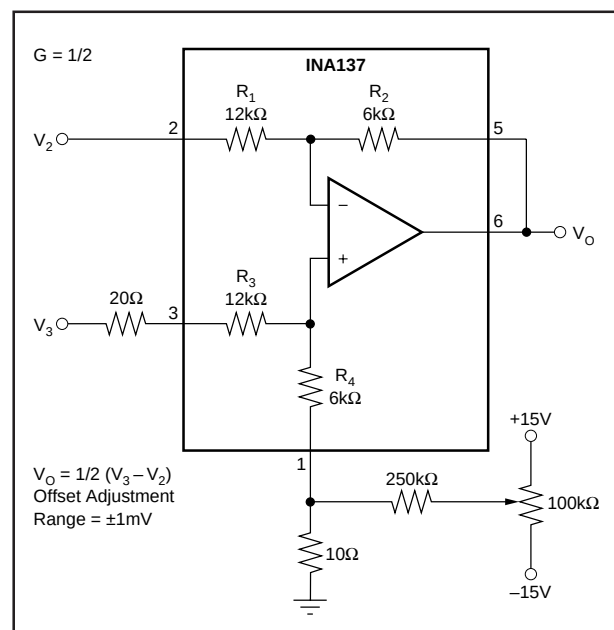


FIGURE 3. Offset Adjustment.



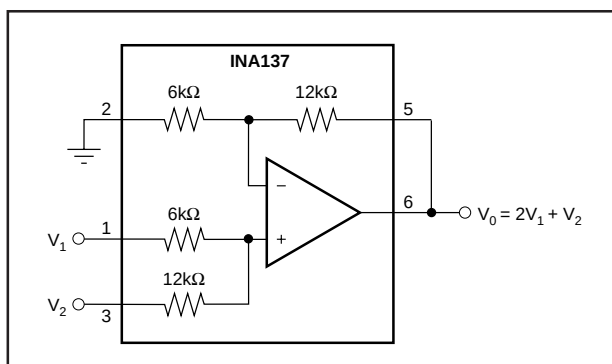


FIGURE 4. Precision Summing Amplifier.

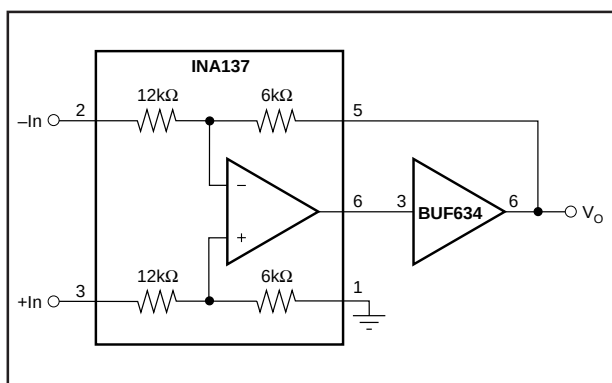


FIGURE 5. Boosting Output Current.

The difference amplifier is a highly versatile building block that is useful in a wide variety of applications. See the INA105 data sheet for additional applications ideas, including:

- Current Receiver with Compliance to Rails
- $\pm 10\text{V}$  Precision Voltage Reference
- $\pm 5\text{V}$  Precision Voltage Reference
- Precision Average Value Amplifier
- Precision Bipolar Offsetting
- Precision Summing Amplifier with Gain
- Instrumentation Amplifier Guard Drive Generator
- Precision Summing Instrumentation Amplifier
- Precision Absolute Value Buffer

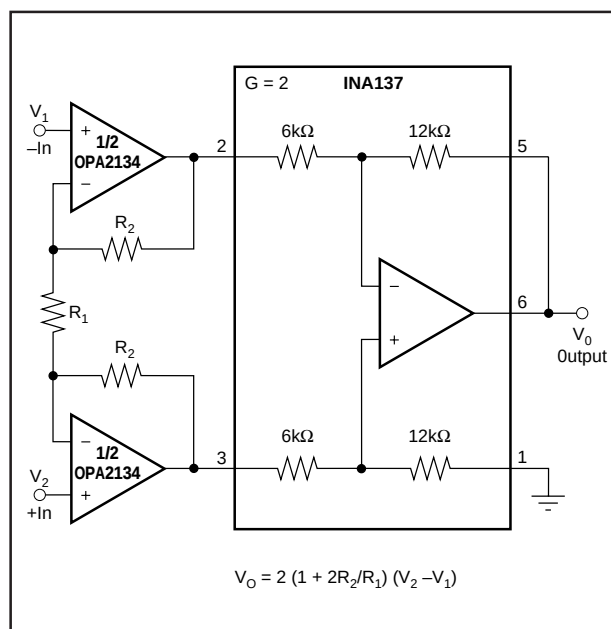


FIGURE 6. High Input Impedance Instrumentation Amplifier.

- Precision Voltage-to-Current Converter with Differential Inputs
- Differential Input Voltage-to-Current Converter for Low  $I_{OUT}$
- Isolating Current Source
- Differential Output Difference Amplifier
- Isolating Current Source with Buffering Amplifier for Greater Accuracy
- Window Comparator with Window Span and Window Center Inputs
- Precision Voltage-Controlled Current Source with Buffered Differential Inputs and Gain

**PACKAGING INFORMATION**

| Orderable Device | Status <sup>(1)</sup> | Package Type | Package Drawing | Pins | Package Qty | Eco Plan <sup>(2)</sup> | Lead/Ball Finish | MSL Peak Temp <sup>(3)</sup> |
|------------------|-----------------------|--------------|-----------------|------|-------------|-------------------------|------------------|------------------------------|
| INA137PA         | ACTIVE                | PDIP         | P               | 8    | 50          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| INA137PAG4       | ACTIVE                | PDIP         | P               | 8    | 50          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| INA137UA         | ACTIVE                | SOIC         | D               | 8    | 100         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA137UA/2K5     | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA137UA/2K5G4   | ACTIVE                | SOIC         | D               | 8    | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA137UAG4       | ACTIVE                | SOIC         | D               | 8    | 100         | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA2137PA        | ACTIVE                | PDIP         | N               | 14   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| INA2137PAG4      | ACTIVE                | PDIP         | N               | 14   | 25          | Green (RoHS & no Sb/Br) | CU NIPDAU        | N / A for Pkg Type           |
| INA2137UA        | ACTIVE                | SOIC         | D               | 14   | 58          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA2137UA/2K5    | ACTIVE                | SOIC         | D               | 14   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA2137UA/2K5E4  | ACTIVE                | SOIC         | D               | 14   | 2500        | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |
| INA2137UAE4      | ACTIVE                | SOIC         | D               | 14   | 58          | Green (RoHS & no Sb/Br) | CU NIPDAU        | Level-3-260C-168 HR          |

<sup>(1)</sup> 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.

<sup>(2)</sup> 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.

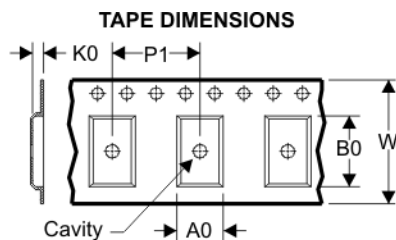
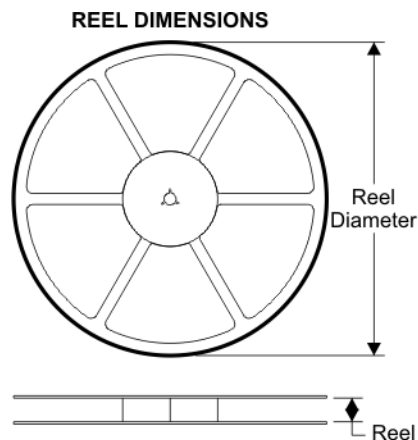
**Green (RoHS & no Sb/Br):** TI defines "Green" to mean Pb-Free (RoHS compatible), and free of Bromine (Br) and Antimony (Sb) based flame retardants (Br or Sb do not exceed 0.1% by weight in homogeneous material)

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

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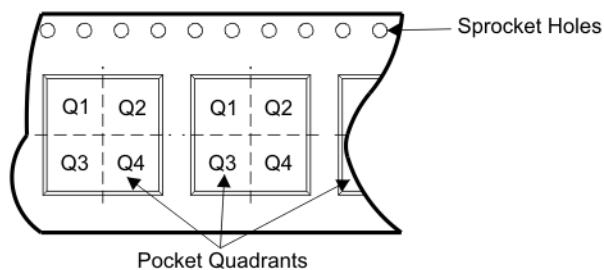
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**TAPE AND REEL BOX INFORMATION**



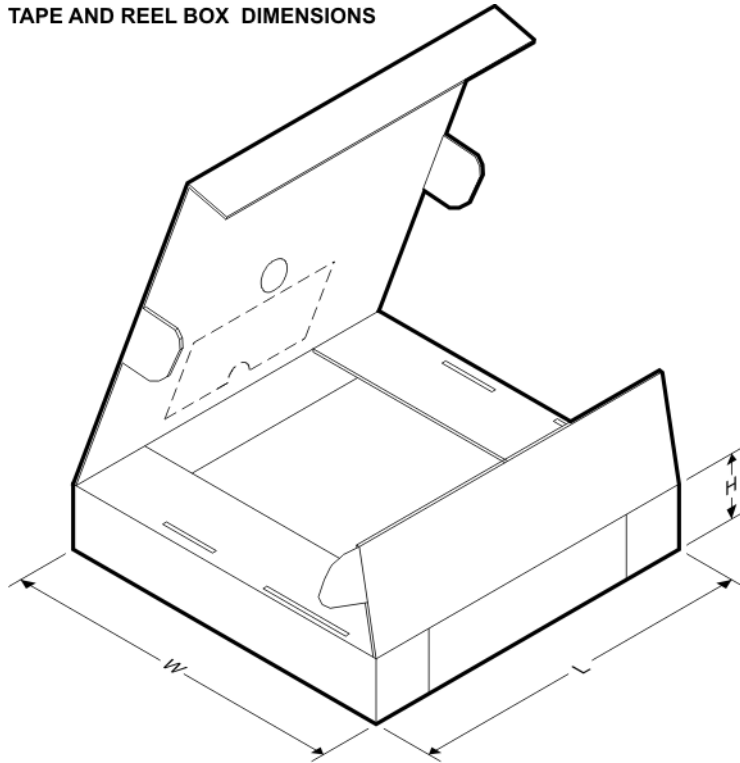
|    |                                                           |
|----|-----------------------------------------------------------|
| A0 | Dimension designed to accommodate the component width     |
| B0 | Dimension designed to accommodate the component length    |
| K0 | Dimension designed to accommodate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

**QUADRANT ASSIGNMENTS FOR PIN 1 ORIENTATION IN TAPE**



| Device        | Package | Pins | Site    | Reel Diameter (mm) | Reel Width (mm) | A0 (mm) | B0 (mm) | K0 (mm) | P1 (mm) | W (mm) | Pin1 Quadrant |
|---------------|---------|------|---------|--------------------|-----------------|---------|---------|---------|---------|--------|---------------|
| INA137UA/2K5  | D       | 8    | SITE 41 | 330                | 12              | 6.9     | 5.4     | 2.0     | 8       | 12     | Q1            |
| INA2137UA/2K5 | D       | 14   | SITE 41 | 330                | 16              | 6.5     | 9.0     | 2.1     | 8       | 16     | Q1            |

## TAPE AND REEL BOX DIMENSIONS



| Device        | Package | Pins | Site    | Length (mm) | Width (mm) | Height (mm) |
|---------------|---------|------|---------|-------------|------------|-------------|
| INA137UA/2K5  | D       | 8    | SITE 41 | 346.0       | 346.0      | 29.0        |
| INA2137UA/2K5 | D       | 14   | SITE 41 | 346.0       | 346.0      | 33.0        |

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