



# INA154

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## High-Speed, Precision DIFFERENCE AMPLIFIER (G = 1)

### FEATURES

- DESIGNED FOR LOW COST
- LOW OFFSET VOLTAGE:  $\pm 750\mu\text{V}$  max
- LOW OFFSET DRIFT:  $\pm 2\mu\text{V}/^\circ\text{C}$
- LOW GAIN ERROR:  $\pm 0.05\%$  max
- WIDE BANDWIDTH: 3MHz
- 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: 2.4mA
- SO-8 SURFACE-MOUNT PACKAGE

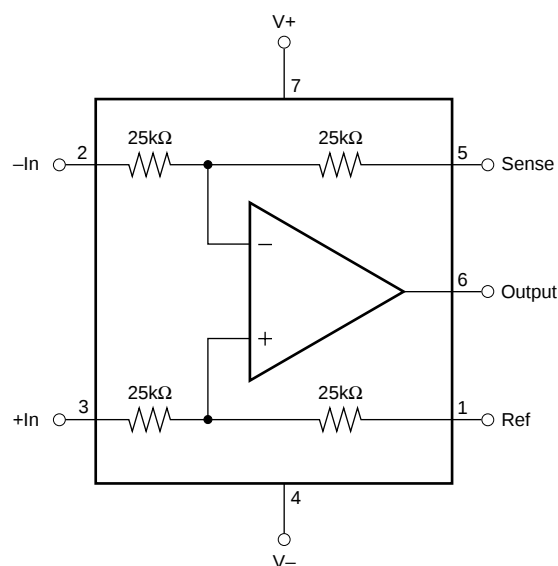
### APPLICATIONS

- DIFFERENTIAL INPUT AMPLIFIER
- INSTRUMENTATION AMPLIFIER BUILDING BLOCK
- UNITY-GAIN INVERTING AMPLIFIER
- SUMMING AMPLIFIER
- DIFFERENTIAL CURRENT RECEIVER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- SYNCHRONOUS DEMODULATOR

### DESCRIPTION

The INA154 is a high slew rate, unity-gain difference amplifier consisting of a precision op amp with a precision resistor network. The on-chip resistors are laser trimmed for accurate gain and high common-mode rejection. Excellent TCR tracking of the resistors maintains gain accuracy and common-mode rejection over temperature. The input common-mode voltage range extends beyond the positive and negative supply rails. It operates on  $\pm 4\text{V}$  to  $\pm 18\text{V}$  supplies.

The difference amplifier is the foundation of many commonly used circuits. The INA154 provides this circuit function without using an expensive precision resistor network. The INA154 is available in a SO-8 surface-mount package and is specified for operation over the extended industrial temperature range,  $-40^\circ\text{C}$  to  $+85^\circ\text{C}$ .



# SPECIFICATIONS: $V_S = \pm 15V$

At  $T_A = +25^\circ C$ ,  $V_S = \pm 15V$ ,  $R_L = 2k\Omega$  connected to ground, and reference pin connected to ground, unless otherwise noted.

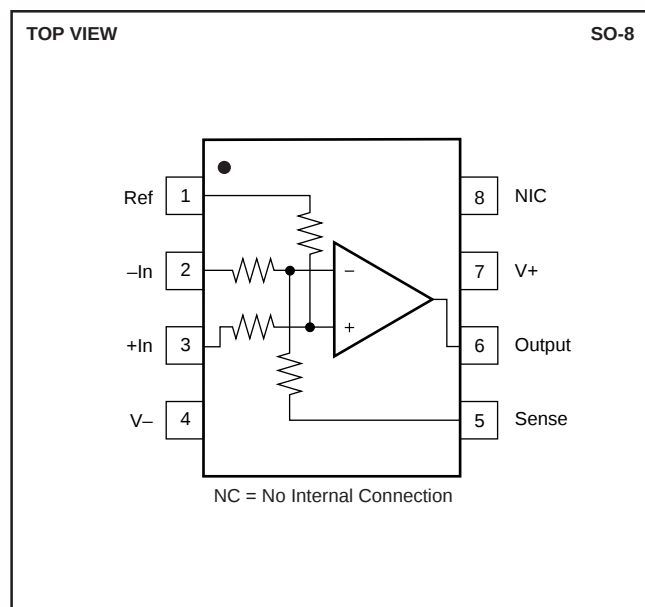
| PARAMETER                                                                                                                   | CONDITIONS                                                                      | INA154U                          |                                                 |                                       | INA154UA          |                                 |                                 | UNITS                                                  |
|-----------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|----------------------------------|-------------------------------------------------|---------------------------------------|-------------------|---------------------------------|---------------------------------|--------------------------------------------------------|
|                                                                                                                             |                                                                                 | MIN                              | TYP                                             | MAX                                   | MIN               | TYP                             | MAX                             |                                                        |
| <b>OFFSET VOLTAGE<sup>(1)</sup></b><br>Initial<br>vs Temperature<br>vs Power Supply<br>vs Time                              | RTO<br><br><br>$V_S = \pm 4V$ to $\pm 18V$                                      |                                  | $\pm 100$<br>$\pm 2$<br>$\pm 5$<br>0.5          | $\pm 750$<br>$\pm 20$<br>$\pm 60$     |                   | $*$<br>$*$<br>$*$<br>$*$        | $\pm 1500$<br>$*$<br>$*$        | $\mu V$<br>$\mu V/^\circ C$<br>$\mu V/V$<br>$\mu V/mo$ |
| <b>INPUT IMPEDANCE<sup>(2)</sup></b><br>Differential<br>Common-Mode                                                         |                                                                                 |                                  | 50<br>50                                        |                                       |                   | $*$<br>$*$                      |                                 | $k\Omega$<br>$k\Omega$                                 |
| <b>INPUT VOLTAGE RANGE</b><br>Common-Mode Voltage Range<br>Positive<br>Negative<br>Common-Mode Rejection Ratio              | $V_O = 0V$<br>$V_O = 0V$<br>$V_{CM} = -25V$ to $25V$ , $R_S = 0\Omega$          | $2(V+) - 5$<br>$2(V-) + 5$<br>80 | $2(V+) - 4$<br>$2(V-) + 2$<br>90                |                                       | $*$<br>$*$<br>74  | $*$<br>$*$<br>$*$               |                                 | V<br>V<br>dB                                           |
| <b>OUTPUT VOLTAGE NOISE<sup>(3)</sup></b><br>$f = 0.1Hz$ to $10Hz$<br>$f = 1kHz$                                            | RTO                                                                             |                                  | 2.6<br>52                                       |                                       |                   | $*$<br>$*$                      |                                 | $\mu Vp-p$<br>$nV/\sqrt{Hz}$                           |
| <b>GAIN</b><br>Initial<br>Error<br>vs Temperature<br>Nonlinearity                                                           | $V_O = -13V$ to $+13V$<br><br>$V_O = -13V$ to $+13V$                            |                                  | 1<br>$\pm 0.02$<br>$\pm 1$<br>$\pm 0.0001$      | $\pm 0.05$<br>$\pm 10$<br>$\pm 0.001$ |                   | $*$<br>$*$<br>$*$<br>$*$        | $\pm 0.1$<br>$*$<br>$\pm 0.002$ | V/V<br>%<br>$ppm/^\circ C$<br>% of FS                  |
| <b>OUTPUT</b><br>Voltage, 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 |                                       | $*$<br>$*$        | $*$<br>$*$<br>$*$<br>$*$        |                                 | V<br>V<br>mA<br>pF                                     |
| <b>FREQUENCY RESPONSE</b><br>Small-Signal Bandwidth<br>Slew Rate<br>Settling Time: 0.1%<br>0.01%<br>Overload Recovery Time  | -3dB<br><br>10V Step, $C_L = 100pF$<br>10V Step, $C_L = 100pF$<br>50% Overdrive |                                  | 3.1<br>14<br>2<br>3<br>3                        |                                       |                   | $*$<br>$*$<br>$*$<br>$*$<br>$*$ |                                 | MHz<br>V/ $\mu s$<br>$\mu s$<br>$\mu s$<br>$\mu s$     |
| <b>POWER SUPPLY</b><br>Rated Voltage<br>Operating Voltage Range<br>Quiescent Current                                        | <br><br>$I_O = 0mA$                                                             | $\pm 4$                          | $\pm 15$<br>$\pm 2.4$                           | $\pm 18$<br>$\pm 2.9$                 | $*$               | $*$<br>$*$                      | $*$<br>$*$                      | V<br>V<br>mA                                           |
| <b>TEMPERATURE RANGE</b><br>Specified<br>Operation<br>Storage<br>Thermal Resistance, $\theta_{JA}$<br>SO-8 Surface-Mount    |                                                                                 | -40<br>-55<br>-55                |                                                 | +85<br>+125<br>+125<br>150            | $*$<br>$*$<br>$*$ |                                 | $*$<br>$*$<br>$*$               | $^\circ C$<br>$^\circ C$<br>$^\circ C$<br>$^\circ C/W$ |

\*Specifications the same as INA154U.

NOTES: (1) Includes effects of amplifier's input bias and offset currents. (2) 25k $\Omega$  resistors are ratio matched but have  $\pm 20\%$  absolute value. (3) Includes effects of amplifier's input current noise and thermal noise contribution of resistor network.

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## PIN CONFIGURATION



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

|                                   |                 |
|-----------------------------------|-----------------|
| Supply Voltage, V+ to V-          | 40V             |
| Input Voltage Range               | ±80V            |
| Output Short Circuit (to ground)  | 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.



## 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.

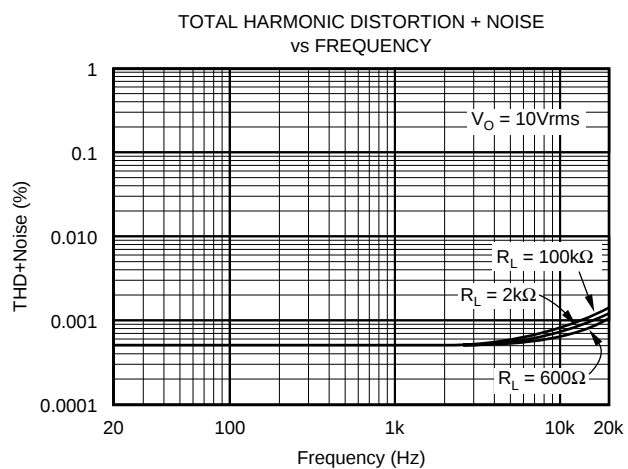
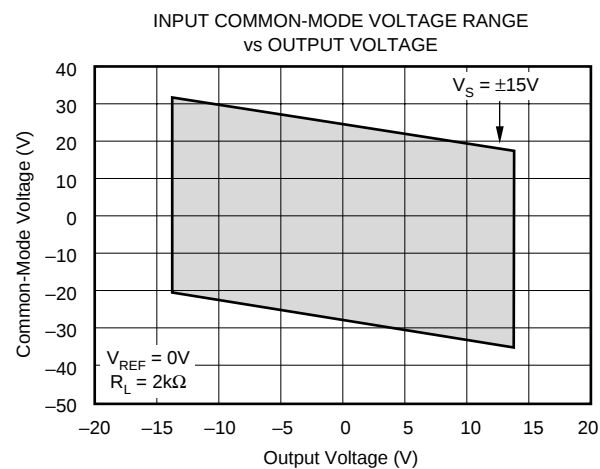
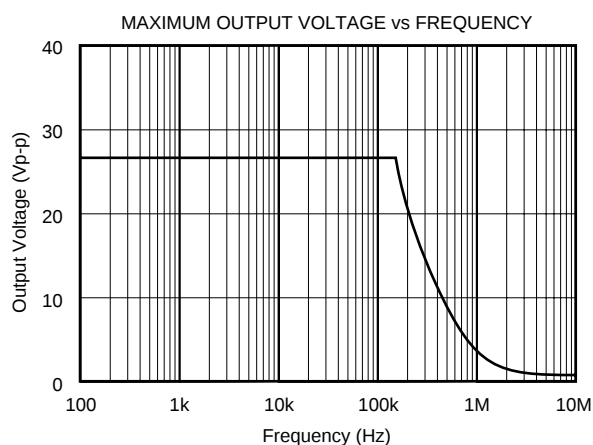
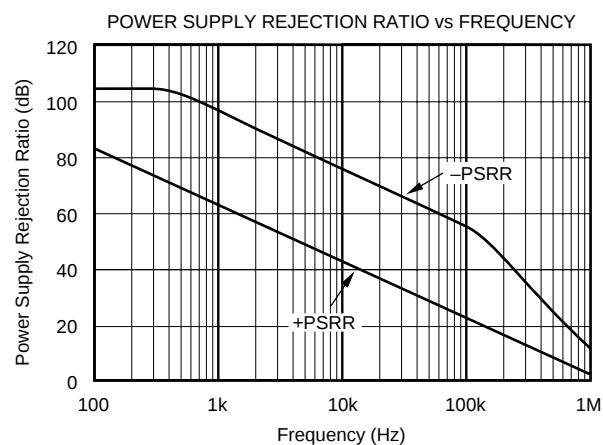
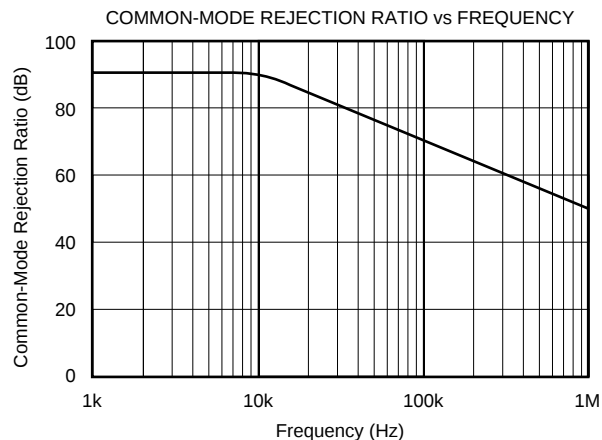
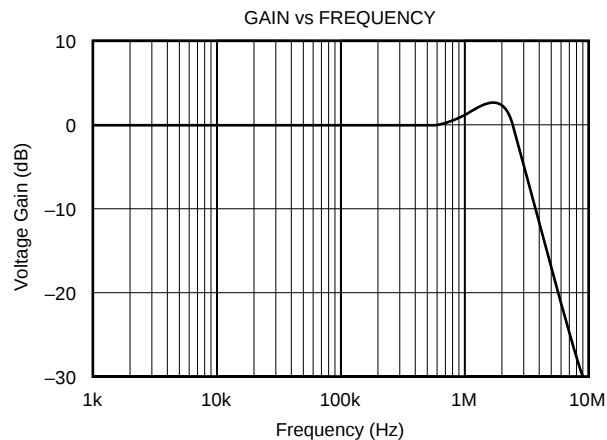
## PACKAGE/ORDERING INFORMATION

| PRODUCT  | PACKAGE            | PACKAGE DRAWING NUMBER <sup>(1)</sup> | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER <sup>(2)</sup> | TRANSPORT MEDIA |
|----------|--------------------|---------------------------------------|-----------------------------|-----------------|--------------------------------|-----------------|
| INA154U  | SO-8 Surface-Mount | 182                                   | -40°C to +85°C              | INA154U         | INA154U                        | Rails           |
| "        | "                  | "                                     | "                           | "               | INA154U/2K5                    | Tape and Reel   |
| INA154UA | SO-8 Surface-Mount | 182                                   | -40°C to +85°C              | INA154UA        | INA154UA                       | Rails           |
| "        | "                  | "                                     | "                           | "               | INA154UA/2K5                   | Tape and Reel   |

NOTES: (1) For detailed drawing and dimension table, please see end of data sheet, or Appendix C of Burr-Brown IC Data Book. (2) 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 "INA154U/2K5" will get a single 2500-piece Tape and Reel. For detailed Tape and Reel mechanical information, refer to Appendix B of Burr-Brown IC Data Book.

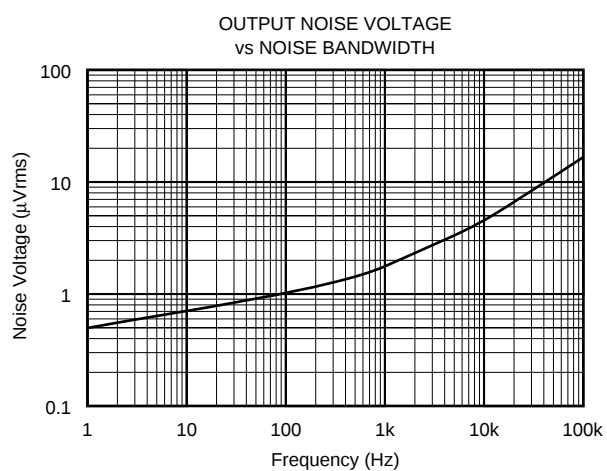
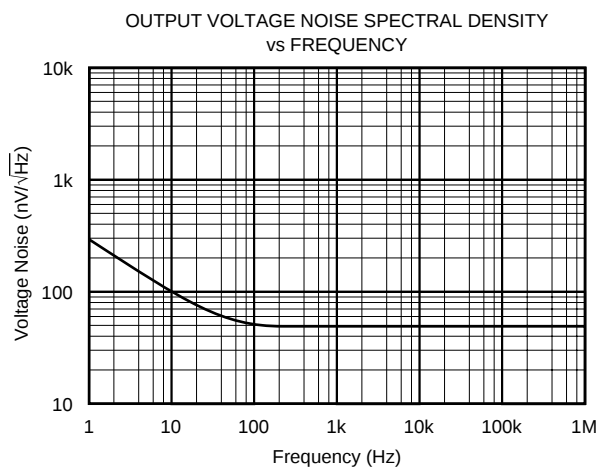
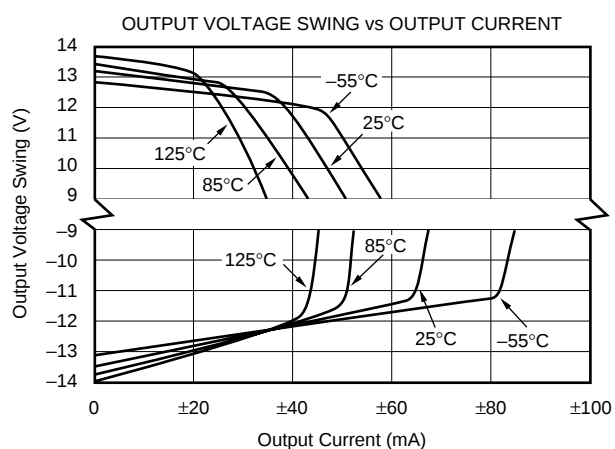
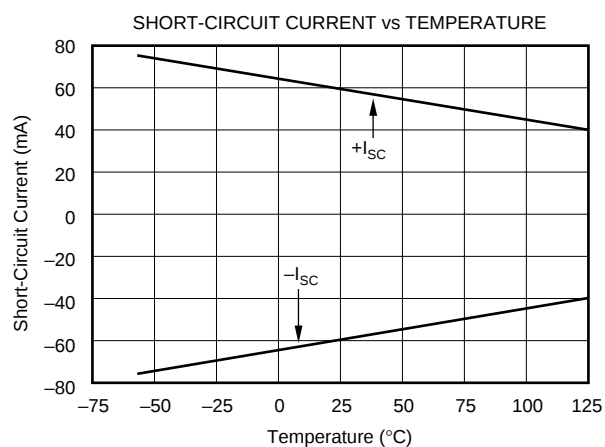
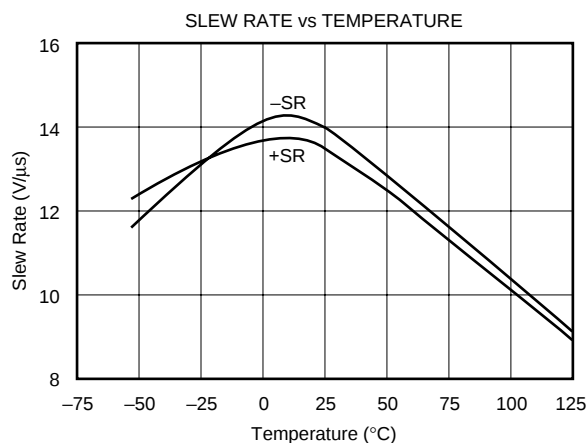
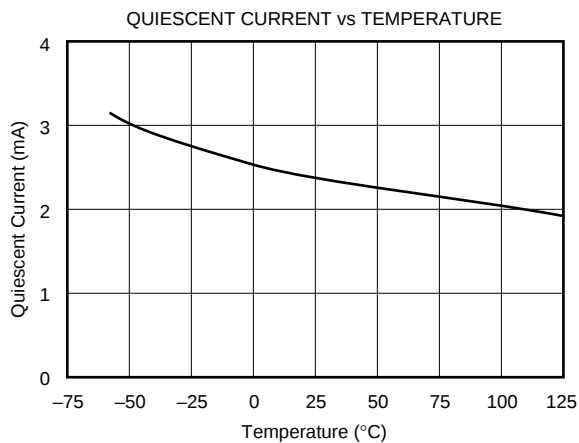
# TYPICAL PERFORMANCE CURVES

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



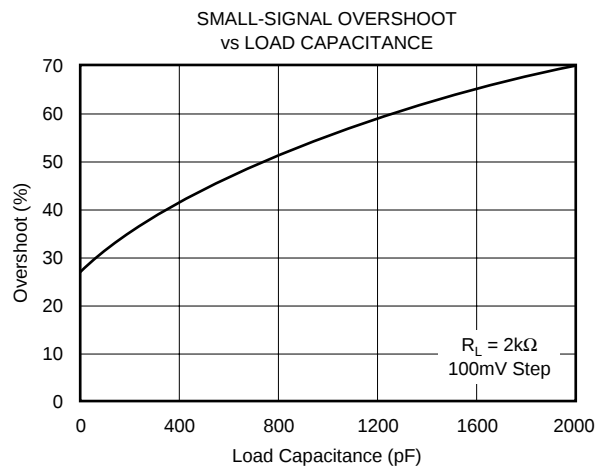
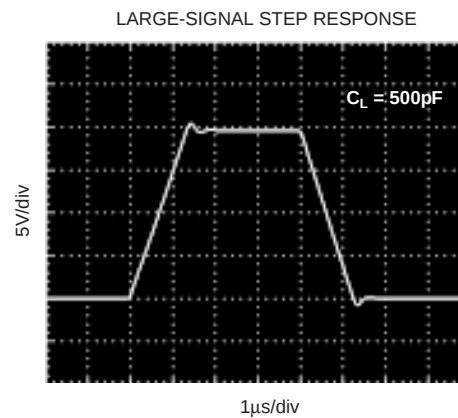
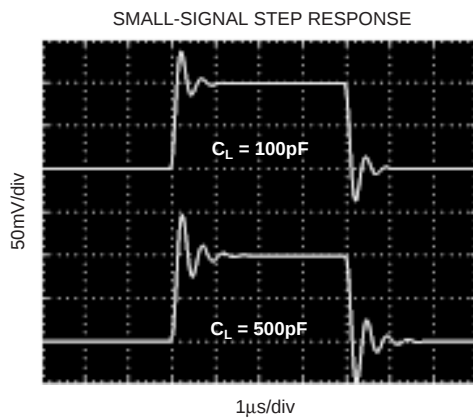
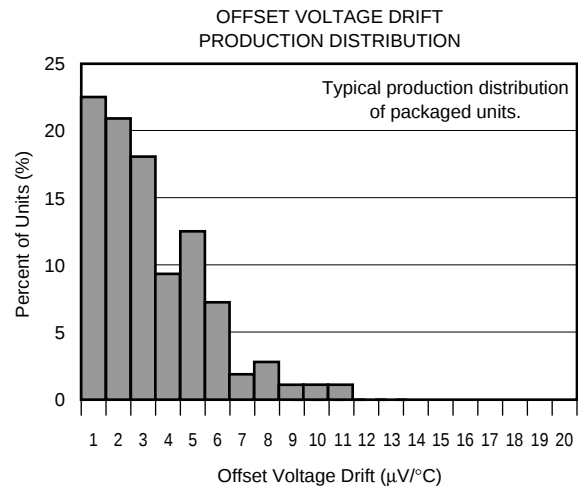
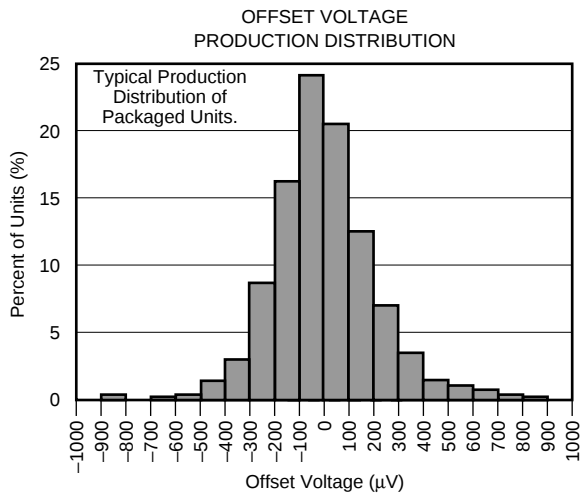
# TYPICAL PERFORMANCE CURVES (CONT)

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



# TYPICAL PERFORMANCE CURVES (CONT)

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



## APPLICATIONS INFORMATION

Figure 1 shows the basic connections required for operation of the INA154. Decoupling capacitors are strongly recommended in applications with noisy or high impedance power supplies. The capacitors should be placed close to the device pins as shown in Figure 1.

As shown in Figure 1, the output is referred to the reference terminal (pin 1). A voltage applied to this pin will be summed with output signal. The differential input signal is connected to pins 2 and 3. The source impedances connected to the pinouts 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 80dB (a  $10\Omega$  mismatch degrades CMR to 74dB). 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.

Do not interchange pins 1 and 3 or pins 2 and 5, even though nominal resistor values are equal. The resistors are laser trimmed for precise resistor ratios to achieve accurate gain and highest CMR. Interchanging these pins would not provide specified performance.

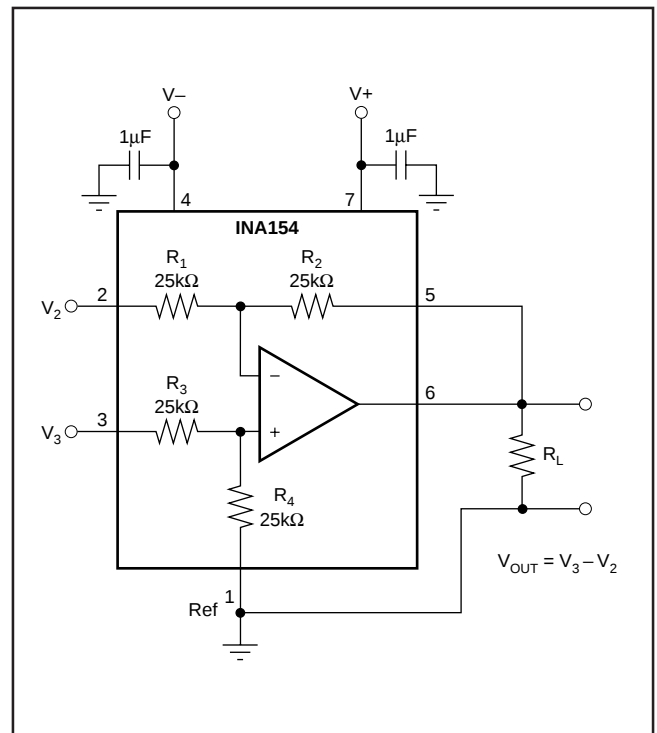


FIGURE 1. Basic Power Supply and Signal Connections.

### OPERATING VOLTAGE

The INA154 operates from  $\pm 4V$  to  $\pm 18V$  supplies with excellent performance. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the Typical Performance Curves.

### INPUT VOLTAGE RANGE

The INA154 can accurately measure differential signals that are beyond the positive or negative power supply rails. The linear common-mode range extends from  $2 \cdot (V+) - 5V$  to  $2 \cdot (V-) + 5V$ . See the Typical Performance Curve, "Input Common-Mode Range vs Output Voltage."

### OFFSET VOLTAGE TRIM

The INA154 is laser trimmed for 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 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 2. The source impedance of a signal applied to the Ref terminal should be less than  $10\Omega$  to maintain good common-mode rejection.

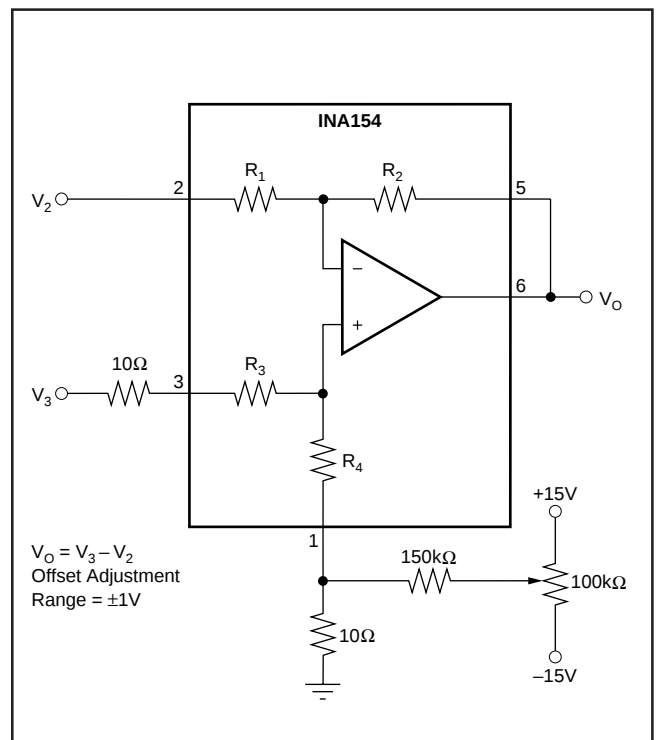


FIGURE 2. Offset Adjustment.

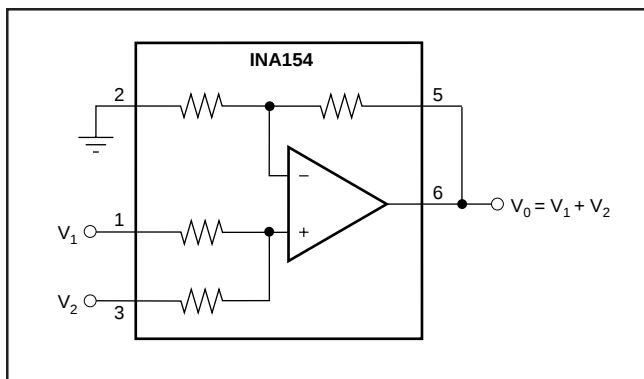


FIGURE 3. Precision Summing Amplifier.

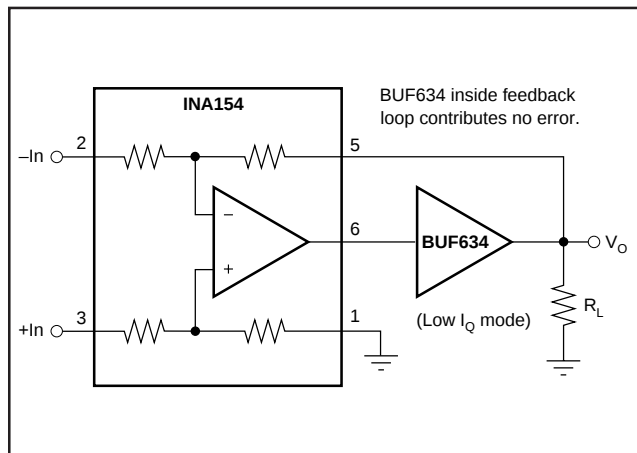


FIGURE 5. Boosting Output Current.

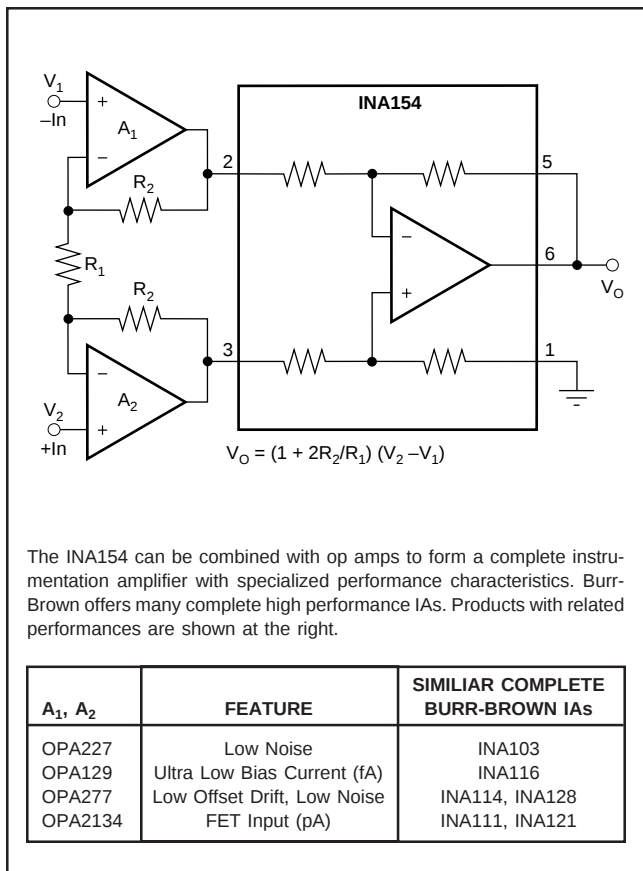


FIGURE 4. Precision Instrumentation Amplifier.

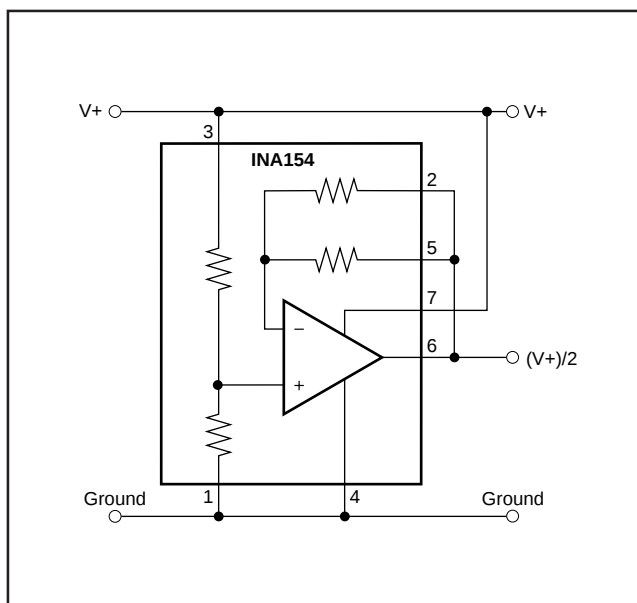


FIGURE 6. Pseudoground Generator.

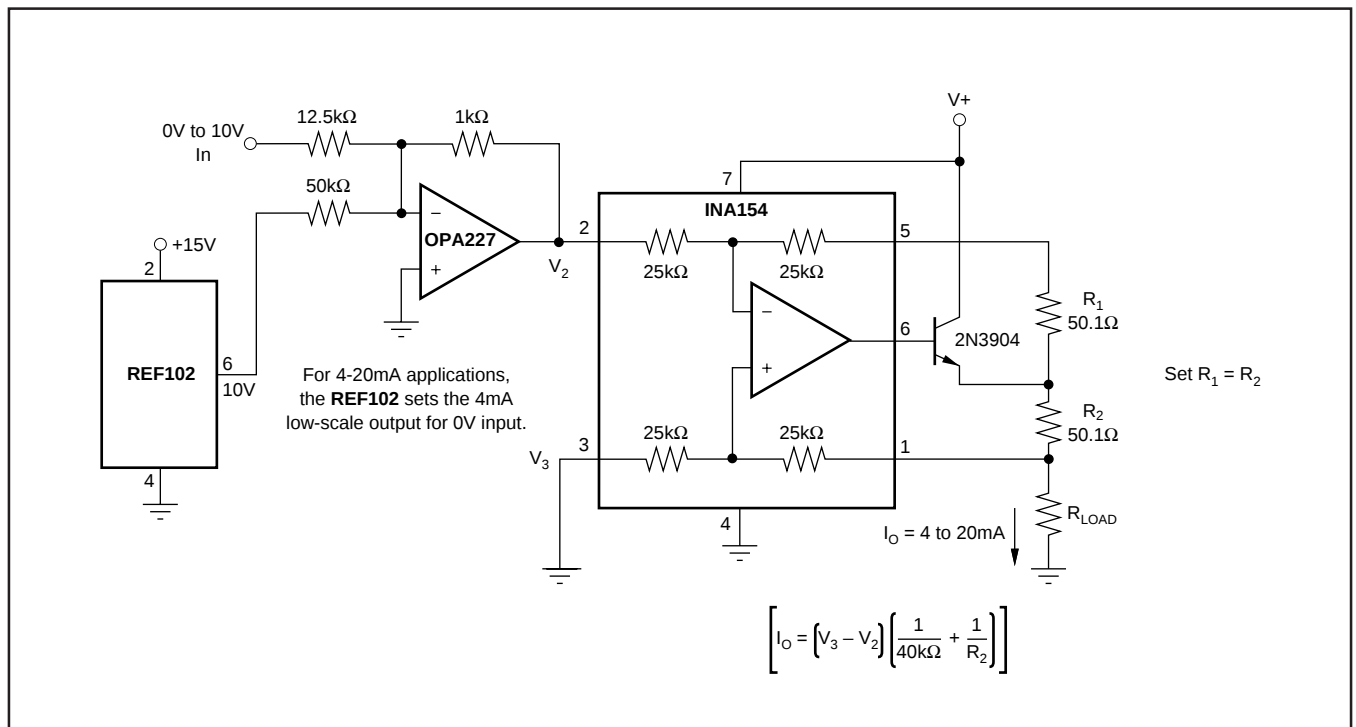


FIGURE 7. Precision Voltage-to-Current Conversion.

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
- Precision Unity-Gain Inverting Amplifier
- $\pm 10V$  Precision Voltage Reference
- $\pm 5V$  Precision Voltage Reference
- Precision Unity-Gain Buffer
- Precision Average Value Amplifier
- Precision  $G = 2$  Amplifier (see INA157)
- Precision  $G = 1/2$  Amplifier (see INA157)
- Precision Bipolar Offsetting
- Precision Summing Amplifier with Gain
- Instrumentation Amplifier Guard Drive Generator
- Precision Summing Instrumentation Amplifier
- Precision Absolute Value Buffer
- 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
- Digitally Controlled Gain of  $\pm 1$  Amplifier

## PACKAGING INFORMATION

| Orderable part number       | Status<br>(1) | Material type<br>(2) | Package   Pins | Package qty   Carrier | RoHS<br>(3) | Lead finish/<br>Ball material<br>(4) | MSL rating/<br>Peak reflow<br>(5) | Op temp (°C) | Part marking<br>(6) |
|-----------------------------|---------------|----------------------|----------------|-----------------------|-------------|--------------------------------------|-----------------------------------|--------------|---------------------|
| <a href="#">INA154U</a>     | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | Call TI                              | Level-3-260C-168 HR               | -40 to 85    | INA<br>154U         |
| INA154U.A                   | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | Call TI                              | Level-3-260C-168 HR               | -40 to 85    | INA<br>154U         |
| <a href="#">INA154U/2K5</a> | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | Call TI                              | Level-3-260C-168 HR               | -40 to 85    | INA<br>154U         |
| INA154U/2K5.A               | Active        | Production           | SOIC (D)   8   | 2500   LARGE T&R      | Yes         | Call TI                              | Level-3-260C-168 HR               | -40 to 85    | INA<br>154U         |
| <a href="#">INA154UA</a>    | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | Call TI                              | Level-3-260C-168 HR               | -40 to 85    | INA<br>154U<br>A    |
| INA154UA.A                  | Active        | Production           | SOIC (D)   8   | 75   TUBE             | Yes         | Call TI                              | Level-3-260C-168 HR               | -40 to 85    | INA<br>154U<br>A    |

<sup>(1)</sup> **Status:** For more details on status, see our [product life cycle](#).

<sup>(2)</sup> **Material type:** When designated, preproduction parts are prototypes/experimental devices, and are not yet approved or released for full production. Testing and final process, including without limitation quality assurance, reliability performance testing, and/or process qualification, may not yet be complete, and this item is subject to further changes or possible discontinuation. If available for ordering, purchases will be subject to an additional waiver at checkout, and are intended for early internal evaluation purposes only. These items are sold without warranties of any kind.

<sup>(3)</sup> **RoHS values:** Yes, No, RoHS Exempt. See the [TI RoHS Statement](#) for additional information and value definition.

<sup>(4)</sup> **Lead finish/Ball material:** Parts may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead finish/Ball material values may wrap to two lines if the finish value exceeds the maximum column width.

<sup>(5)</sup> **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will be used to mount the part to the printed circuit board.

<sup>(6)</sup> **Part marking:** There may be an additional marking, which relates to the logo, the lot trace code information, or the environmental category of the part.

Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "-" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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## 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 |
|-------------|--------------|-----------------|------|------|--------------------|--------------------|---------|---------|---------|---------|--------|---------------|
| INA154U/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) |
|-------------|--------------|-----------------|------|------|-------------|------------|-------------|
| INA154U/2K5 | SOIC         | D               | 8    | 2500 | 353.0       | 353.0      | 32.0        |

## TUBE



\*All dimensions are nominal

| Device     | Package Name | Package Type | Pins | SPQ | L (mm) | W (mm) | T (μm) | B (mm) |
|------------|--------------|--------------|------|-----|--------|--------|--------|--------|
| INA154U    | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| INA154U.A  | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| INA154UA   | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |
| INA154UA.A | D            | SOIC         | 8    | 75  | 506.6  | 8      | 3940   | 4.32   |

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