

INA132

## Low Power, Single-Supply DIFFERENCE AMPLIFIER

### FEATURES

- LOW QUIESCENT CURRENT: 160 $\mu$ A
- WIDE SUPPLY RANGE  
Single Supply: 2.7V to 36V  
Dual Supplies:  $\pm 1.35$ V to  $\pm 18$ V
- LOW GAIN ERROR:  $\pm 0.075\%$  max
- LOW NONLINEARITY: 0.001% max
- HIGH CMR: 90dB
- HIGHLY VERSATILE CIRCUIT
- EASY TO USE
- LOW COST
- 8-PIN DIP AND SO-8 PACKAGES

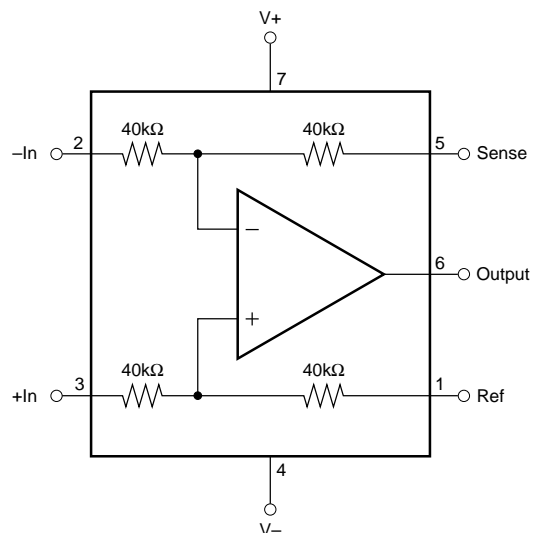
### APPLICATIONS

- DIFFERENTIAL INPUT AMPLIFIER
- INSTRUMENTATION AMPLIFIER BUILDING BLOCK
- UNITY-GAIN INVERTING AMPLIFIER
- G = 1/2 AMPLIFIER
- G = 2 AMPLIFIER
- SUMMING AMPLIFIER
- DIFFERENTIAL CURRENT RECEIVER
- VOLTAGE-CONTROLLED CURRENT SOURCE
- BATTERY-POWERED SYSTEMS
- GROUND LOOP ELIMINATOR

### DESCRIPTION

The INA132 is a low power, unity-gain differential 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 internal op amp's common-mode range extends to the negative supply—ideal for single-supply applications. It operates on single (2.7V to 36V) or dual supplies ( $\pm 1.35$ V to  $\pm 18$ V).

The differential amplifier is the foundation of many commonly used circuits. The INA132 provides this circuit function without using an expensive precision resistor network. The INA132 is available in 8-pin DIP and SO-8 surface-mount packages 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  $T_A = +25^\circ C$ ,  $V_S = \pm 15V$ ,  $R_L = 10k\Omega$  connected to Ground, and Reference Pin connected to Ground, unless otherwise noted.

| PARAMETER                                 | CONDITIONS                                 | INA132P, U |              |             | INA132PA, UA |     |                | UNITS            |
|---|--|------------|--------------|-------------|--------------|-----|----------------|------------------|
|   |  | MIN        | TYP          | MAX         | MIN          | TYP | MAX            |                  |
| <b>OFFSET VOLTAGE<sup>(1)</sup></b>       | RTO  |            |              |             |              |     |                |                  |
| Initial                                   |  |            | $\pm 75$     | $\pm 250$   |              | *   | $\pm 500$      | $\mu V$          |
| vs Temperature                            |  |            | $\pm 1$      | $\pm 5$     |              | *   | $\pm 10^{(4)}$ | $\mu V/^\circ C$ |
| vs Power Supply                           | $V_S = \pm 1.35V$ to $\pm 18V$             |            | $\pm 5$      | $\pm 30$    |              | *   | *              | $\mu V/V$        |
| vs Time                                   |  |            | 0.3          |             |              | *   |                | $\mu V/mo$       |
| <b>INPUT IMPEDANCE<sup>(2)</sup></b>      |  |            |              |             |              |     |                |                  |
| Differential                              |  |            | 80           |             |              | *   |                | k $\Omega$       |
| Common-Mode                               |  |            | 80           |             |              | *   |                | k $\Omega$       |
| <b>INPUT VOLTAGE RANGE</b>                |  |            |              |             |              |     |                |                  |
| Common-Mode Voltage Range                 | $V_O = 0V$                                 | (V-)       |              | $2(V+)-2$   | *            |     | *              | V                |
| Common-Mode Rejection                     | $V_{CM} = -15V$ to $28V$ , $R_S = 0\Omega$ | 76         | 90           |             | 70           | *   |                | dB               |
| <b>OUTPUT VOLTAGE NOISE<sup>(3)</sup></b> | RTO  |            |              |             |              |     |                |                  |
| f = 0.1Hz to 10Hz                         |  |            | 1.6          |             |              | *   |                | $\mu Vp-p$       |
| f = 1kHz                                  |  |            | 65           |             |              | *   |                | nV/ $\sqrt{Hz}$  |
| <b>GAIN</b>                               |  |            |              |             |              |     |                |                  |
| Initial                                   |  |            | 1            |             |              | *   |                | V/V              |
| Error                                     | $V_O = -14V$ to $13.5V$                    |            | $\pm 0.01$   | $\pm 0.075$ |              | *   | $\pm 0.1$      | %                |
| vs Temperature <sup>(4)</sup>             |  |            | $\pm 1$      | $\pm 10$    |              | *   | *              | ppm/ $^\circ C$  |
| vs Nonlinearity                           | $V_O = -14V$ to $13.5V$                    |            | $\pm 0.0001$ | $\pm 0.001$ |              | *   | $\pm 0.002$    | % of FS          |
| <b>OUTPUT</b>                             |  |            |              |             |              |     |                |                  |
| Voltage, Positive                         | $R_L = 100k\Omega$ to Ground               | (V+)-1     | (V+)-0.8     |             | *            | *   |                | V                |
| Negative                                  | $R_L = 100k\Omega$ to Ground               | (V-)+0.5   | (V-)+0.15    |             | *            | *   |                | V                |
| Positive                                  | $R_L = 10k\Omega$ to Ground                | (V+)-1.5   | (V+)-0.8     |             | *            | *   |                | V                |
| Negative                                  | $R_L = 10k\Omega$ to Ground                | (V-)+1     | (V-)+0.25    |             | *            | *   |                | V                |
| Current Limit, Continuous to Common       |  |            | $\pm 12$     |             |              | *   |                | mA               |
| Capacitive Load (Stable Operation)        |  |            | 10,000       |             |              | *   |                | pF               |
| <b>FREQUENCY RESPONSE</b>                 |  |            |              |             |              |     |                |                  |
| Small Signal Bandwidth                    | -3dB                                       |            | 300          |             |              | *   |                | kHz              |
| Slew Rate                                 |  |            | 0.1          |             |              | *   |                | V/ $\mu s$       |
| Settling Time: 0.1%                       | $V_O = 10V$ Step                           |            | 85           |             |              | *   |                | $\mu s$          |
| 0.01%                                     | $V_O = 10V$ Step                           |            | 88           |             |              | *   |                | $\mu s$          |
| Overload Recovery Time                    | 50% Overdrive                              |            | 7            |             |              | *   |                | $\mu s$          |
| <b>POWER SUPPLY</b>                       |  |            |              |             |              |     |                |                  |
| Rated Voltage                             |  |            | $\pm 15$     |             |              | *   |                | V                |
| Voltage Range                             |  | $\pm 1.35$ |              | $\pm 18$    | *            |     | *              | V                |
| Quiescent Current                         | $I_O = 0mA$                                |            | $\pm 160$    | $\pm 185$   |              | *   | *              | $\mu A$          |
| <b>TEMPERATURE RANGE</b>                  |  |            |              |             |              |     |                |                  |
| Specification                             |  | -40        |              | +85         | *            |     | *              | $^\circ C$       |
| Operation                                 |  | -55        |              | +125        | *            |     | *              | $^\circ C$       |
| Storage                                   |  | -55        |              | +125        | *            |     | *              | $^\circ C$       |
| Thermal Resistance, $\theta_{JA}$         |  |            |              |             |              |     |                |                  |
| 8-Pin DIP                                 |  |            | 100          |             |              | *   |                | $^\circ C/W$     |
| SO-8 Surface-Mount                        |  |            | 150          |             |              | *   |                | $^\circ C/W$     |

\*Specifications the same as INA132P.

NOTES: (1) Includes effects of amplifier's input bias and offset currents. (2) 40k $\Omega$  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. (4) Guaranteed by wafer test to 95% confidence level.

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# SPECIFICATIONS: $V_S = +5V$

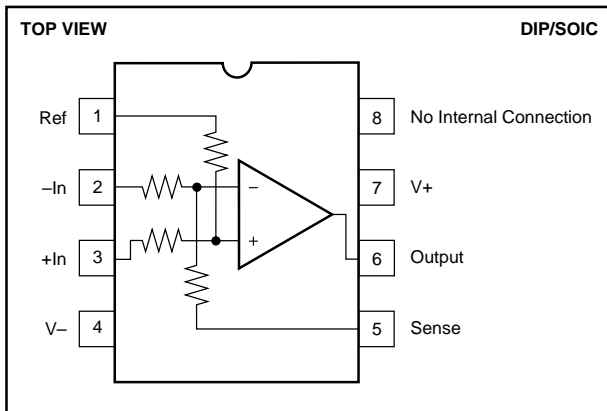
At  $T_A = +25^\circ\text{C}$ ,  $V_S = +5V$ ,  $R_L = 10k\Omega$  connected to  $V_G/2$ , and Reference Pin connected to  $V_G/2$ , unless otherwise noted.

| PARAMETER                           | CONDITIONS                              | INA132P, U |                      |            | INA132PA, UA |     |           | UNITS   |
|-------------------------------------|---|------------|----------------------|------------|--------------|-----|-----------|---|
|                                     |   | MIN        | TYP                  | MAX        | MIN          | TYP | MAX       |   |
| <b>OFFSET VOLTAGE<sup>(1)</sup></b> | RTO                                     |            |                      |            |              |     |           |   |
| Initial vs Temperature              |   |            | $\pm 150$<br>$\pm 2$ | $\pm 500$  |              | *   | $\pm 750$ | $\mu\text{V}$<br>$\mu\text{V}/^\circ\text{C}$ |
| <b>INPUT VOLTAGE RANGE</b>          |   |            |                      |            |              |     |           |   |
| Common-Mode Voltage Range           |   | 0          |                      | $2(V^+)-2$ | *            |     | *         | V   |
| Common-Mode Rejection               | $V_{CM} = 0V$ to $8V$ , $R_S = 0\Omega$ | 76         | 90                   |            | 70           | *   |           | dB  |
| <b>OUTPUT</b>                       |   |            |                      |            |              |     |           |   |
| Voltage, Positive                   | $R_L = 100k\Omega$                      | $(V^+)-1$  | $(V^+)-0.75$         |            | *            | *   |           | V   |
| Negative                            | $R_L = 100k\Omega$                      | $+0.25$    | $+0.06$              |            | *            | *   |           | V   |
| Positive                            | $R_L = 10k\Omega$                       | $(V^+)-1$  | $(V^+)-0.8$          |            | *            | *   |           | V   |
| Negative                            | $R_L = 10k\Omega$                       | $+0.25$    | $+0.12$              |            | *            | *   |           | V   |
| <b>POWER SUPPLY</b>                 |   |            |                      |            |              |     |           |   |
| Rated Voltage                       |   |            | +5                   |            | *            | *   |           | V   |
| Voltage Range                       |   | +2.7       |                      | +36        | *            |     | *         | V   |
| Quiescent Current                   | $I_O = 0\text{mA}$                      |            | $\pm 155$            | $\pm 185$  |              | *   | *         | $\mu\text{A}$                                 |

\*Specifications the same as INA132P.

NOTE: (1) Include effects of amplifier's input bias and offset currents.

## PIN CONFIGURATION



## ABSOLUTE MAXIMUM RATINGS

|   |   |
|---|---|
| Supply Voltage, $V^+$ to $V^-$ .....    | 36V   |
| Input Voltage Range .....               | $\pm 80V$                                   |
| Output Short-Circuit (to ground) .....  | Continuous                                  |
| Operating Temperature .....             | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ |
| Storage Temperature .....               | $-55^\circ\text{C}$ to $+125^\circ\text{C}$ |
| Junction Temperature .....              | $+150^\circ\text{C}$                        |
| Lead Temperature (soldering, 10s) ..... | $+300^\circ\text{C}$                        |

## ORDERING INFORMATION

| PRODUCT  | PACKAGE            | PACKAGE DRAWING NUMBER <sup>(1)</sup> | TEMPERATURE RANGE                          |
|----------|--------------------|---------------------------------------|--|
| INA132PA | 8-Pin Plastic DIP  | 006                                   | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ |
| INA132P  | 8-Pin Plastic DIP  | 006                                   | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ |
| INA132UA | SO-8 Surface-Mount | 182                                   | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ |
| INA132U  | SO-8 Surface-Mount | 182                                   | $-40^\circ\text{C}$ to $+85^\circ\text{C}$ |

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

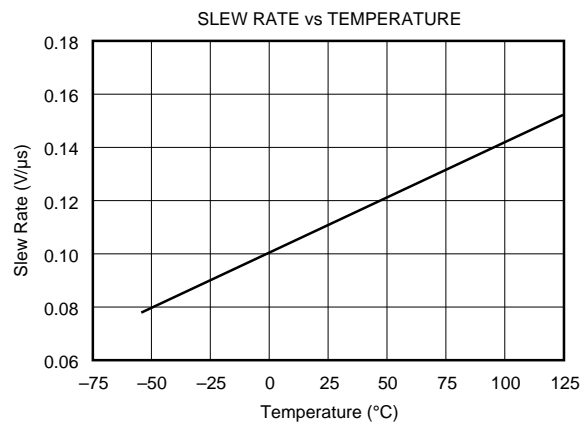
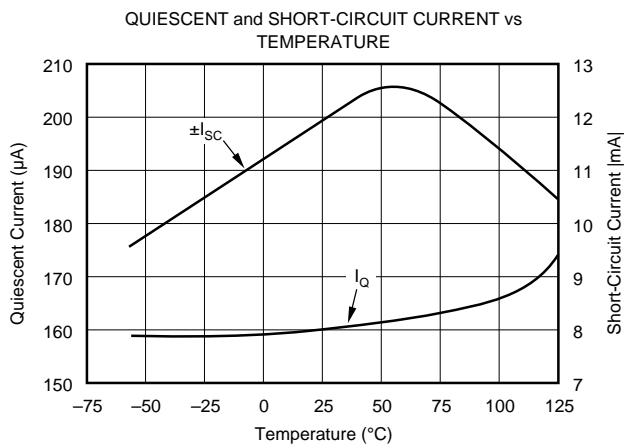
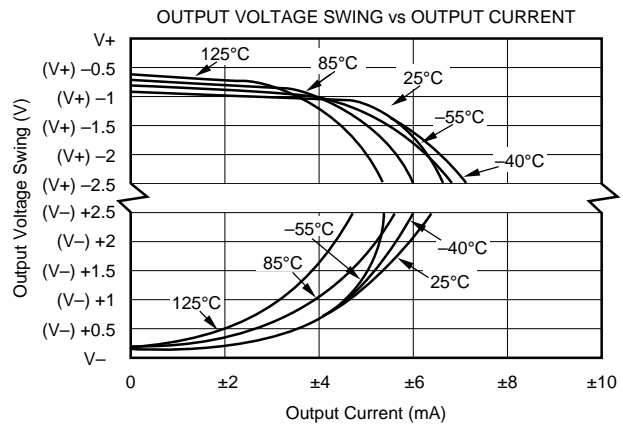
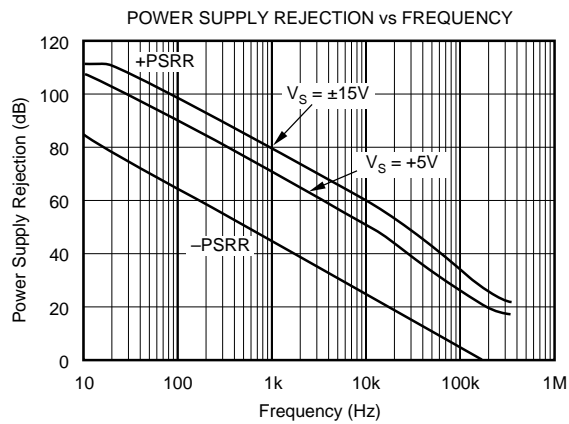
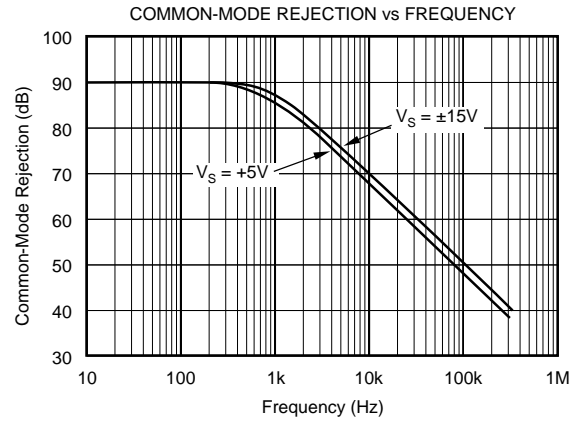
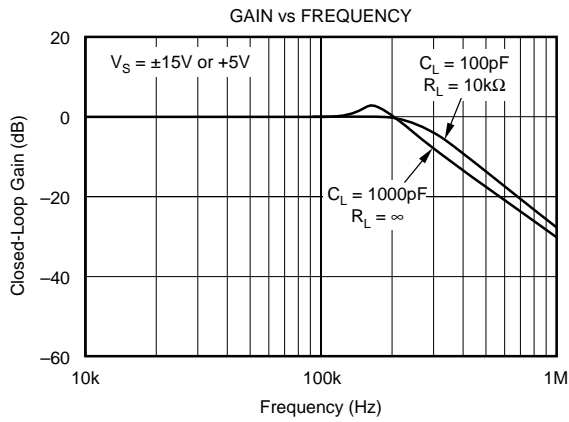
## ELECTROSTATIC DISCHARGE SENSITIVITY

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

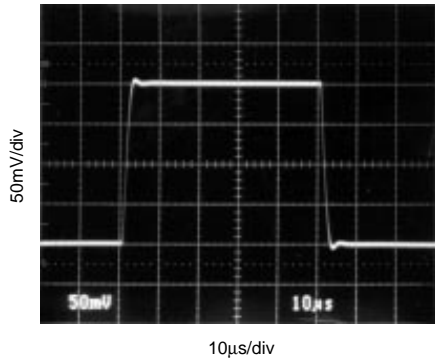
At  $T_A = +25^\circ\text{C}$  and  $V_S = \pm 15\text{V}$ , unless otherwise noted.



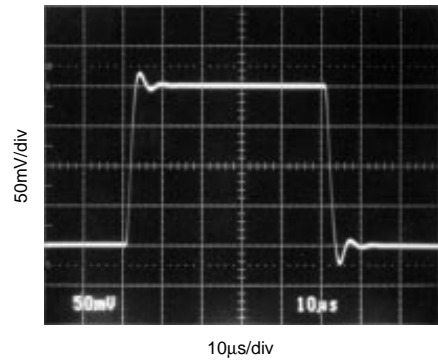
# TYPICAL PERFORMANCE CURVES (CONT)

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

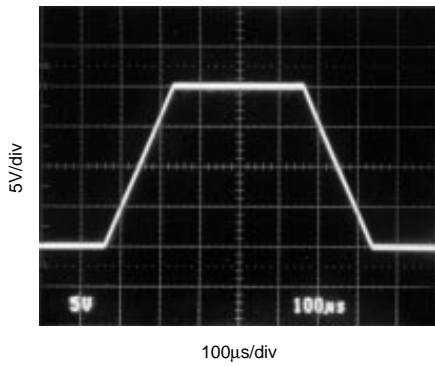
SMALL-SIGNAL STEP RESPONSE  
 $C_L = 200\text{pF}$



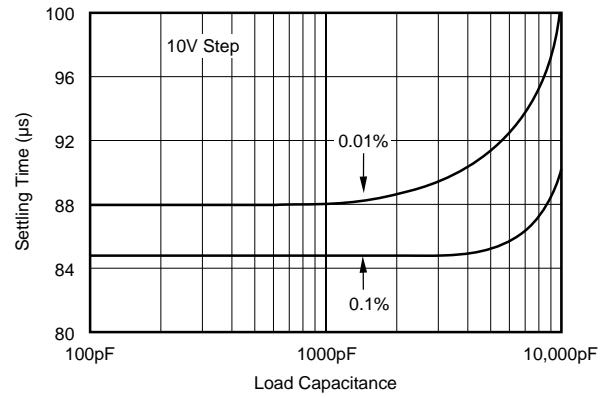
SMALL-SIGNAL STEP RESPONSE  
 $C_L = 1000\text{pF}$



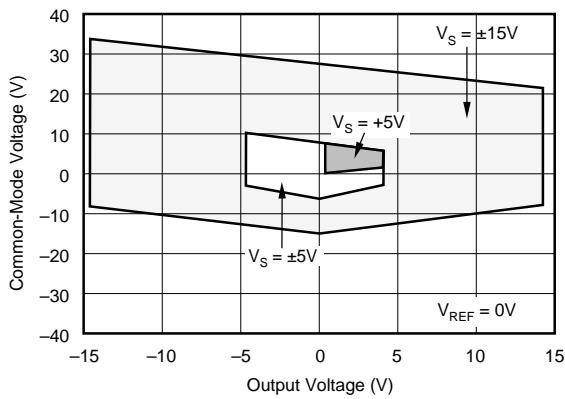
LARGE-SIGNAL STEP RESPONSE



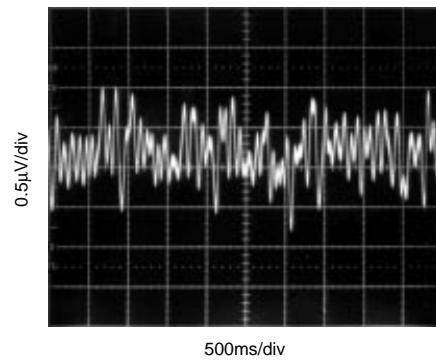
SETTLING TIME vs LOAD CAPACITANCE



INPUT COMMON-MODE VOLTAGE RANGE vs OUTPUT VOLTAGE

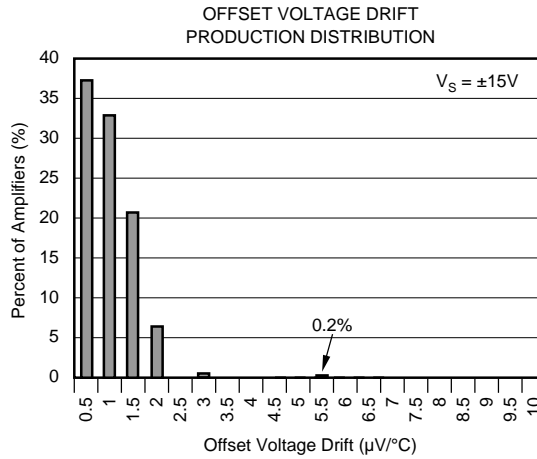
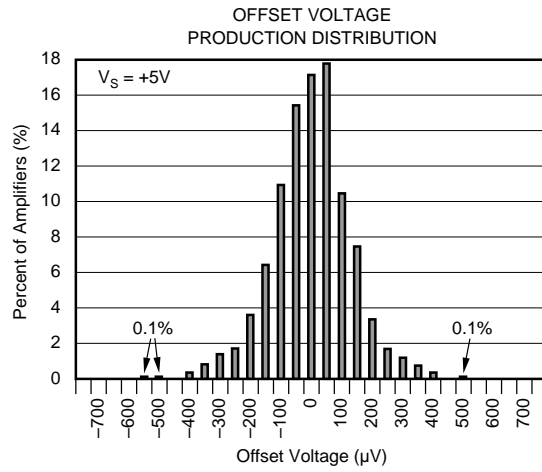
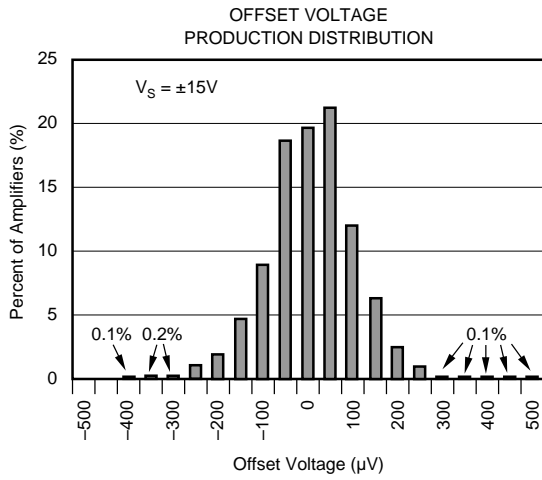


0.1 to 10Hz PEAK-TO-PEAK VOLTAGE NOISE



# 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 INA132. Power supply bypass capacitors should be connected close to the device pins.

The differential input signal is connected to pins 2 and 3 as shown. The source impedances connected to the inputs must be nearly equal to assure good common-mode rejection. An  $8\Omega$  mismatch in source impedance will degrade the common-mode rejection of a typical device to approximately 80dB. Gain accuracy will also be slightly affected. If the source has a known impedance mismatch, an additional resistor in series with one 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. These resistors are laser trimmed for precise resistor ratios to achieve accurate gain and highest CMR. Interchanging these pins would not provide specified performance. As shown in Figure 1, measurements should be sensed at the load.

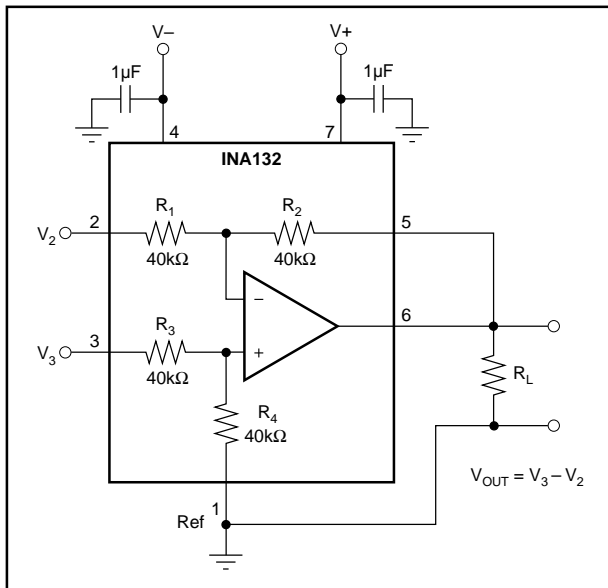


FIGURE 1. Basic Power Supply and Signal Connections.

### OPERATING VOLTAGE

The INA132 operates from single (+2.7V to +36V) or dual ( $\pm 1.35V$  to  $\pm 18V$ ) supplies with excellent performance. Specifications are production tested with +5V and  $\pm 15V$  supplies. Most behavior remains unchanged throughout the full operating voltage range. Parameters which vary significantly with operating voltage are shown in the typical performance curves.

The internal op amp in the INA132 is a single-supply design. This allows linear operation with the op amp's common-mode voltage equal to, or slightly below  $V-$  (or single

supply ground). Although input voltages on pins 2 and 3 that are below the negative supply voltage will not damage the device, operation in this region is not recommended. Transient conditions at the inverting input terminal below the negative supply can cause a positive feedback condition that could lock the INA132's output to the negative rail.

The INA132 can accurately measure differential signals that are above the positive power supply. Linear common-mode range extends to nearly twice the positive power supply voltage—see typical performance curve, Common-Mode Range vs Output Voltage.

### OFFSET VOLTAGE TRIM

The INA132 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. The source impedance of a signal applied to the Ref terminal should be less than  $8\Omega$  to maintain good common-mode rejection. To assure low impedance at the Ref terminal, the trim voltage can be buffered with an op amp, such as the OPA177.

### CAPACITIVE LOAD DRIVE CAPABILITY

The INA132 can drive large capacitive loads, even at low supplies. It is stable with a 10,000pF load. Refer to the "Small-Signal Step Response" and "Settling Time vs Load Capacitance" typical performance curves.

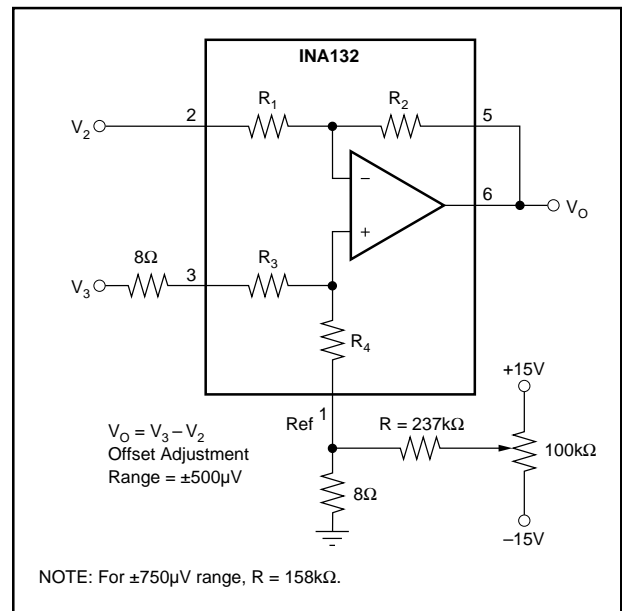


FIGURE 2. Offset Adjustment.

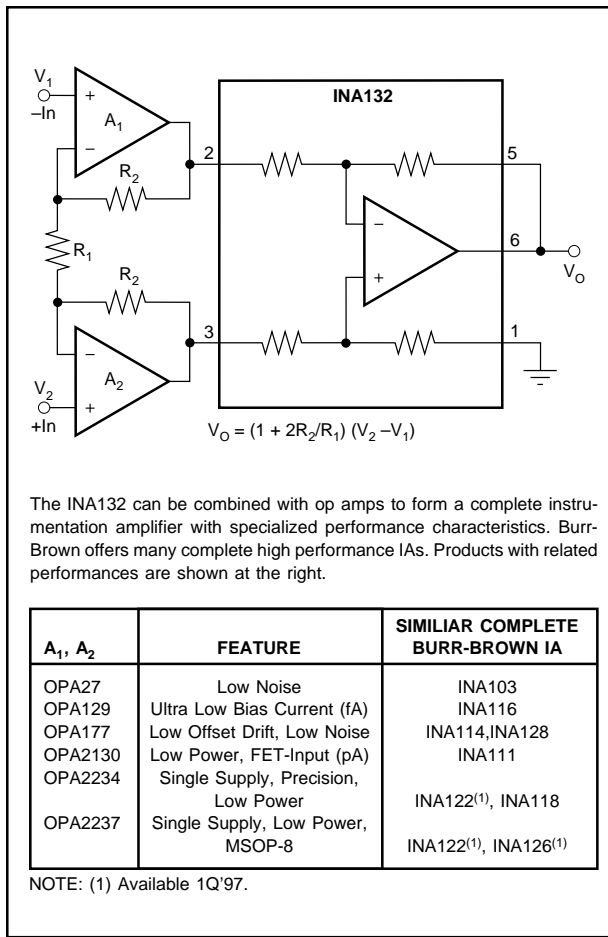


FIGURE 3. Precision Instrumentation Amplifier.

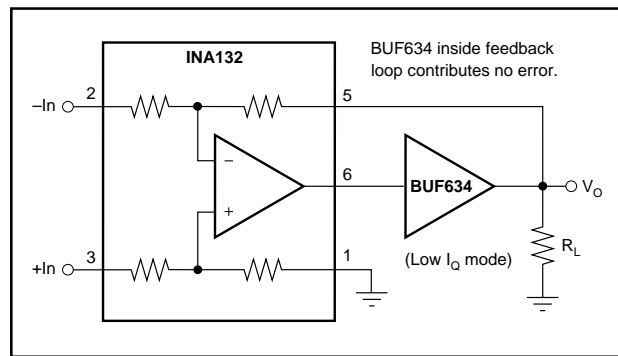


FIGURE 4. Low Power, High Output Current Precision Difference Amplifier.

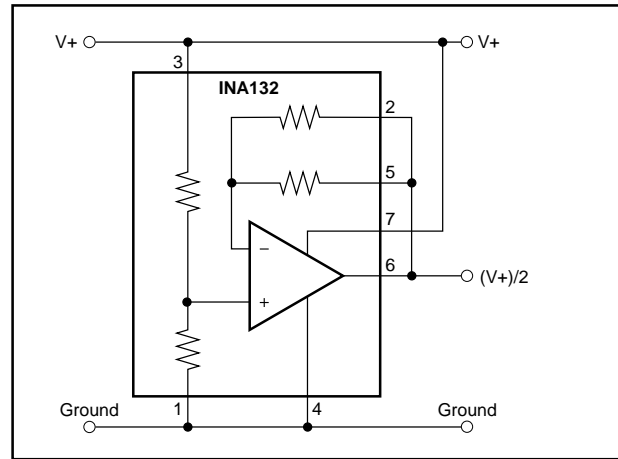


FIGURE 5. Pseudoground Generator.

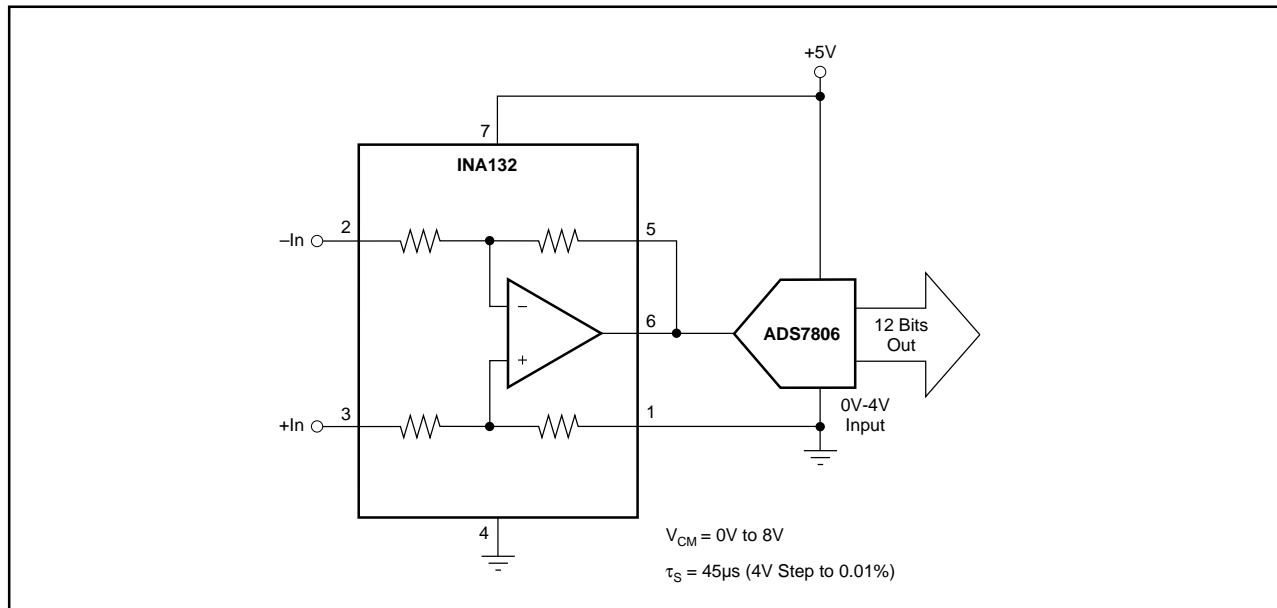


FIGURE 6. Differential Input Data Acquisition.

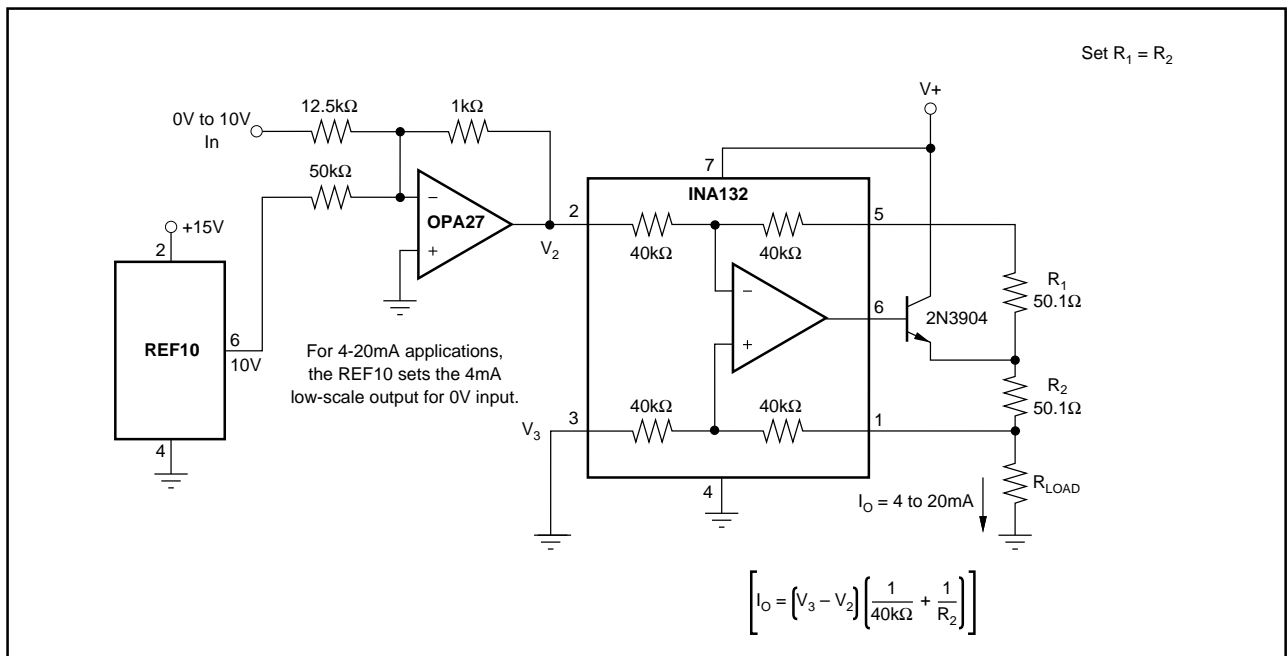


FIGURE 7. Precision Voltage-to-Current Conversion.

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
- Precision Summing Amplifier
- Precision  $G = 1/2$  Amplifier
- 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

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