# General-Purpose FET-INPUT OPERATIONAL AMPLIFIERS 

## FEATURES

- FET INPUT: $I_{B}=50 p A \max$
- LOW OFFSET VOLTAGE: $750 \mu \mathrm{~V}$ max
- WIDE SUPPLY RANGE: $\pm 4.5 \mathrm{~V}$ to $\pm 18 \mathrm{~V}$
- SLEW RATE: 10V/ $\mu \mathrm{s}$
- WIDE BANDWIDTH: 4MHz
- EXCELLENT CAPACITIVE LOAD DRIVE
- SINGLE, DUAL, QUAD VERSIONS



## DESCRIPTION

The OPA131 series of FET-input op amps provides high performance at low cost. Single, dual, and quad versions in industry-standard pinouts allow cost-effective design options.
The OPA131 series offers excellent general-purpose performance, including low offset voltage, drift, and good dynamic characteristics

Single, dual, and quad versions are available in DIP and SO packages. Performance grades include commercial and industrial temperature ranges.


Please be aware that an important notice concerning availability, standard warranty, and use in critical applications of Texas Instruments semiconductor products and disclaimers thereto appears at the end of this data sheet.

ABSOLUTE MAXIMUM RATINGS ${ }^{(1)}$


NOTES: (1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. (2) Short-circuit to ground, one amplifier per package.

## ELECTROSTATIC DISCHARGE SENSITIVITY

This integrated circuit can be damaged by ESD. Texas Instruments 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-LEAD | PACKAGE DESIGNATOR ${ }^{(1)}$ | SPECIFIED TEMPERATURE RANGE | PACKAGE MARKING | ORDERING NUMBER | TRANSPORT MEDIA, QUANTITY |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
| Single OPA131 OPA131 OPA131 | $\begin{gathered} \mathrm{SO}-8 \\ \text { " } \\ \mathrm{SO}-8 \\ \text { " } \\ \mathrm{SO}-8 \end{gathered}$ | $\begin{aligned} & \text { D } \\ & " \\ & \text { D } \\ & " \\ & \text { D } \end{aligned}$ | $\begin{gathered} -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \\ " \\ -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \\ \text { " } \\ -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \end{gathered}$ | OPA131UJ <br> OPA131UA <br> OPA131U | OPA131UJ OPA131UJ/2K5 OPA131UA OPA131UA/2K5 OPA131U OPA131U/2K5 | Rails, 100 Tape and Reel, 2500 Rails, 100 Tape and Reel, 2500 Rails, 100 Tape and Reel, 2500 |
| Dual <br> OPA2131 <br> OPA2131 | $\begin{gathered} \mathrm{SO}-8 \\ " \\ \mathrm{SO}-8 \end{gathered}$ | $\begin{aligned} & \text { D } \\ & " \\ & \text { D } \\ & " \end{aligned}$ | $\begin{gathered} -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \\ \text { " } \\ -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \end{gathered}$ | OPA2131UJ <br> OPA2131UA | OPA2131UJ OPA2131UJ/2K5 OPA2131UA OPA2131UA/2K5 | Rails, 100 <br> Tape and Reel, 2500 <br> Rails, 100 <br> Tape and Reel, 2500 |
| Quad OPA4131 OPA4131 " OPA4131 | $\begin{gathered} \text { DIP-14 } \\ \text { " } \\ \text { SOL-16 } \\ " " \\ \text { SOL-14 } \end{gathered}$ | $\begin{gathered} \mathrm{N} \\ " \\ \text { DW } \\ " \\ \text { D } \\ \hline " \end{gathered}$ | $\begin{gathered} -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \\ " \\ -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \\ \text { " } \\ -40^{\circ} \mathrm{C} \text { to }+85^{\circ} \mathrm{C} \end{gathered}$ | OPA4131PJ <br> OPA4131PA <br> OPA4131UA <br> OPA4131NJ <br> OPA4131NA | OPA4131PJ OPA4131PA OPA4131UA OPA4131UA/1K OPA4131NJ OPA4131NA | Rails, 25 Rails, 25 Rails, 48 Tape and Reel, 1000 Rails, 58 Rails, 58 |

NOTE: (1) For the most current specifications and package information, refer to our web site at www.ti.com.

## ELECTRICAL CHARACTERISTICS

At $T_{A}=+25^{\circ} \mathrm{C}, \mathrm{V}_{\mathrm{S}}= \pm 15 \mathrm{~V}$, and $\mathrm{R}_{\mathrm{L}}=2 \mathrm{k} \Omega$, unless otherwise noted.

| PARAMETER | CONDITION | OPA131UAOPA2131UAOPA4131PA, UA, NA |  |  | $\begin{gathered} \text { OPA131UJ } \\ \text { OPA2131UJ } \\ \text { OPA4131PJ, NJ } \end{gathered}$ |  |  | UNITS |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  |  | MIN | TYP | MAX | MIN | TYP | MAX |  |
| OFFSET VOLTAGE <br> Input Offset Voltage OPA131U model only vs Temperature ${ }^{(1)}$ vs Power Supply OPA131U model only | Operating Temperature Range $\mathrm{V}_{\mathrm{S}}= \pm 4.5 \mathrm{~V} \text { to } \pm 18 \mathrm{~V}$ |  | $\begin{gathered} \pm 0.2 \\ \pm 0.2 \\ \pm 2 \\ 50 \\ 50 \end{gathered}$ | $\begin{gathered} \pm 1 \\ 0.75 \\ \pm 10 \\ 200 \\ 100 \end{gathered}$ |  | * <br> * <br> * | $\begin{gathered} \pm 1.5 \\ * \\ * \end{gathered}$ | mV mV $\mu \mathrm{V} /{ }^{\circ} \mathrm{C}$ $\mu \mathrm{V} / \mathrm{V}$ $\mu \mathrm{V} / \mathrm{V}$ |
| INPUT BIAS CURRENT ${ }^{(2)}$ <br> Input Bias Current vs Temperature Input Offset Current | $\begin{aligned} & \mathrm{V}_{\mathrm{CM}}=0 \mathrm{~V} \\ & \mathrm{~V}_{\mathrm{CM}}=0 \mathrm{~V} \end{aligned}$ | See Ty | $\begin{aligned} & +5 \\ & \text { pical Charas } \\ & \mid \quad \pm 1 \\ & \hline \end{aligned}$ | $\begin{array}{r}  \pm 50 \\ \text { teristic } \\ \pm 50 \\ \hline \end{array}$ |  | $\begin{aligned} & * \\ & * \\ & * \end{aligned}$ | * <br> * | pA <br> pA |
| NOISE <br> Input Voltage Noise <br> Noise Density, $\begin{aligned} & f=10 \mathrm{~Hz} \\ & f=100 \mathrm{~Hz} \\ & f=1 \mathrm{kHz} \\ & f=10 \mathrm{kHz} \end{aligned}$ <br> Current Noise Density, $f=1 \mathrm{kHz}$ |  |  | $\begin{aligned} & 21 \\ & 16 \\ & 15 \\ & 15 \\ & 3 \end{aligned}$ |  |  | $\begin{aligned} & * \\ & * \\ & * \\ & * \\ & * \end{aligned}$ |  | $\mathrm{nV} / \sqrt{\mathrm{Hz}}$ <br> $\mathrm{nV} / \sqrt{\mathrm{Hz}}$ <br> $\mathrm{nV} / \sqrt{\mathrm{Hz}}$ <br> $\mathrm{nV} / \sqrt{\mathrm{Hz}}$ <br> $\mathrm{fA} / \sqrt{\mathrm{Hz}}$ |
| INPUT VOLTAGE RANGE <br> Common-Mode Voltage Range Common-Mode Rejection OPA131U model only | $\mathrm{V}_{\mathrm{CM}}=-12 \mathrm{~V}$ to +14 V | $\begin{gathered} (\mathrm{V}-)+3 \\ 70 \\ 80 \end{gathered}$ | $\begin{aligned} & 80 \\ & 86 \end{aligned}$ | (V+)-1 | $\begin{aligned} & * \\ & * \end{aligned}$ | * | * | $\begin{gathered} \mathrm{V} \\ \mathrm{~dB} \\ \mathrm{~dB} \end{gathered}$ |
| INPUT IMPEDANCE <br> Differential <br> Common-Mode | $\mathrm{V}_{\mathrm{CM}}=0 \mathrm{~V}$ |  | $\begin{aligned} & 10^{10}\| \| 1 \\ & 10^{12}\| \| \end{aligned}$ |  |  | $\begin{aligned} & * \\ & * \end{aligned}$ |  | $\begin{aligned} & \Omega \\| \mathrm{pF} \\ & \Omega \\| \mathrm{pF} \end{aligned}$ |
| OPEN-LOOP GAIN <br> Open-Loop Voltage Gain OPA131U model only | $\mathrm{V}_{\mathrm{O}}=-12 \mathrm{~V}$ to +12 V | $\begin{gathered} 94 \\ 100 \end{gathered}$ | $\begin{aligned} & 110 \\ & 110 \end{aligned}$ |  | * | * |  | $\begin{aligned} & \mathrm{dB} \\ & \mathrm{~dB} \end{aligned}$ |
| FREQUENCY RESPONSE <br> Gain-Bandwidth Product <br> Slew Rate <br> Settling Time 0.1\% $0.01 \%$ <br> Total Harmonic Distortion + Noise | $\begin{gathered} G=-1,10 \mathrm{~V} \text { Step, } \mathrm{C}_{\mathrm{L}}=100 \mathrm{pF} \\ \mathrm{G}=-1,10 \mathrm{~V} \text { Step, } \mathrm{C}_{\mathrm{L}}=100 \mathrm{pF} \\ 1 \mathrm{kHz}, \mathrm{G}=1, \mathrm{~V}_{\mathrm{O}}=3.5 \mathrm{Vrms} \end{gathered}$ |  | $\begin{gathered} 4 \\ 10 \\ 1.5 \\ 2 \\ 0.0008 \end{gathered}$ |  |  | $\begin{aligned} & * \\ & * \\ & * \\ & * \\ & * \end{aligned}$ |  | MHz <br> V/ $\mu \mathrm{s}$ <br> $\mu \mathrm{s}$ <br> $\mu \mathrm{s}$ <br> \% |
| OUTPUT <br> Voltage Output, Positive Negative <br> Short-Circuit Current |  | $\begin{aligned} & (\mathrm{V}+)-3 \\ & (\mathrm{~V}-)+3 \end{aligned}$ | $\left\lvert\, \begin{gathered} (\mathrm{V}+)-2.5 \\ (\mathrm{~V}-)+2.5 \\ \pm 25 \end{gathered}\right.$ |  | $\begin{aligned} & * \\ & * \end{aligned}$ | $\begin{aligned} & * \\ & * \\ & * \end{aligned}$ |  | $\begin{gathered} \mathrm{V} \\ \mathrm{~V} \\ \mathrm{~mA} \end{gathered}$ |
| POWER SUPPLY <br> Specified Operating Voltage Operating Voltage Range Quiescent Current (per amplifier) | $\mathrm{I}_{0}=0$ | $\pm 4.5$ | $\begin{aligned} & \pm 15 \\ & \pm 1.5 \end{aligned}$ | $\begin{gathered} \pm 18 \\ \pm 1.75 \end{gathered}$ | * | * <br> * | $\begin{gathered} * \\ \pm 2 \end{gathered}$ | $\begin{gathered} \mathrm{V} \\ \mathrm{~V} \\ \mathrm{~mA} \end{gathered}$ |
| TEMPERATURE RANGE <br> Operating Range <br> Storage <br> Thermal Resistance, $\theta_{\mathrm{JA}}$ <br> DIP-8 <br> SO-8 <br> DIP-14 <br> SO-14, SOL-16 |  | $\begin{aligned} & -55 \\ & -55 \end{aligned}$ | $\begin{gathered} 100 \\ 150 \\ 80 \\ 110 \end{gathered}$ | $\begin{aligned} & +125 \\ & +125 \end{aligned}$ | $\begin{gathered} -55 \\ * \end{gathered}$ | $\begin{aligned} & * \\ & * \\ & * \\ & * \end{aligned}$ | $\begin{gathered} +125 \\ * \end{gathered}$ | $\begin{gathered} { }^{\circ} \mathrm{C} \\ { }^{\circ} \mathrm{C} \\ { }^{\circ} \mathrm{C} / \mathrm{W} \\ { }^{\circ} \mathrm{C} / \mathrm{W} \\ { }^{\circ} \mathrm{C} / \mathrm{W} \\ { }^{\circ} \mathrm{C} / \mathrm{W} \end{gathered}$ |

* Specifications same as OPA131UA.

NOTES: (1) Ensured by wafer test. (2) High-speed test at $\mathrm{T}_{\mathrm{J}}=25^{\circ} \mathrm{C}$.

## TYPICAL CHARACTERISTICS

At $T_{A}=+25^{\circ} \mathrm{C}, \mathrm{V}_{\mathrm{S}}= \pm 15 \mathrm{~V}$, and $\mathrm{R}_{\mathrm{L}}=2 \mathrm{k} \Omega$, unless otherwise noted.


## TYPICAL CHARACTERISTICS (Cont.)

At $T_{A}=+25^{\circ} \mathrm{C}, \mathrm{V}_{\mathrm{S}}= \pm 15 \mathrm{~V}$, and $\mathrm{R}_{\mathrm{L}}=2 \mathrm{k} \Omega$, unless otherwise noted.





## TYPICAL CHARACTERISTICS (Cont.)

At $T_{\text {CASE }}=+25^{\circ} \mathrm{C}, \mathrm{V}_{\mathrm{S}}= \pm 15 \mathrm{~V}$, and $\mathrm{R}_{\mathrm{L}}=2 \mathrm{k} \Omega$, unless otherwise noted.


200ns/div

LARGE-SIGNAL STEP RESPONSE
$\mathrm{G}=1, \mathrm{C}_{\mathrm{L}}=300 \mathrm{pF}$

$1 \mu \mathrm{~s} / \mathrm{div}$


## APPLICATIONS INFORMATION

The OPA131 series op amps are unity-gain stable and suitable for a wide range of general-purpose applications. Power-supply pins should be bypassed with 10nF ceramic capacitors or larger.

The OPA131 series op amps are free from unexpected output phase-reversal common with FET op amps. Many FET-input op amps exhibit phase-reversal of the output when the input common-mode voltage range is exceeded. This can occur in voltage-follower circuits, causing serious problems in control-loop applications. All circuitry is completely independent in dual and quad versions, assuring normal behavior when one amplifier in a package is overdriven or shortcircuited.

## OFFSET VOLTAGE TRIM

The OPA131 (single op amp version) provides offset voltage trim connections on pins 1 and 5 . Offset voltage can be adjusted by connecting a potentiometer as shown in Figure 1. This adjustment should be used only to null the offset of the op amp, not system offset or offset produced by the signal source.


FIGURE 1. OPA131 Offset Voltage Trim Circuit.

## INPUT BIAS CURRENT

The input bias current is approximately 5 pA at room temperature and increases with temperature as shown in the typical characteristic "Input Bias Current vs Temperature."
Input bias current also varies with common-mode voltage and power supply voltage. This variation is dependent on the voltage between the negative power supply and the com-mon-mode input voltage. The effect is shown in the typical curve "Input Bias Current vs Common-Mode Voltage."

## D (R-PDSO-G**)

## 8 PINS SHOWN



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion, not to exceed $0.006(0,15)$.
D. Falls within JEDEC MS-012

PACKAGE DRAWINGS (Cont.)
DW (R-PDSO-G**)
PLASTIC SMALL-OUTLINE PACKAGE

## 16 PINS SHOWN



NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Body dimensions do not include mold flash or protrusion not to exceed $0.006(0,15)$.
D. Falls within JEDEC MS-013

N (R-PDIP-T**)
16 PINS SHOWN


NOTES: A. All linear dimensions are in inches (millimeters).
B. This drawing is subject to change without notice.
C. Falls within JEDEC MS-001 (20-pin package is shorter than MS-001).

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