# INA280 2.7-V to 120-V, 1.1-MHz, High Precision Current Sense Amplifier in Small (SC-70) Package

### 1 Features

Wide common-mode voltage:

 Operational voltage: 2.7 V to 120 V Survival voltage: -20 V to +122 V

Excellent CMRR:

120-dB DC (Minimum)

85-dB AC at 50 kHz

Accuracy

- Gain:

Gain error: ±0.5% (maximum)

Gain drift: ±20 ppm/°C (maximum)

- Offset:

Offset voltage: ±150 µV (maximum)

Offset drift: ±1 µV/°C (maximum)

Available gains:

– INA280A1: 20 V/V

– INA280A2: 50 V/V

– INA280A3: 100 V/V

– INA280A4: 200 V/V – INA280A5: 500 V/V

High bandwidth: 1.1 MHz

Slew rate: 2 V/µs

Quiescent current: 370 µA

### 2 Applications

Active antenna system mMIMO (AAS)

Macro remote radio unit (RRU)

48-V rack server

48-V merchant network & server power supply

Test and measurement

### 3 Description

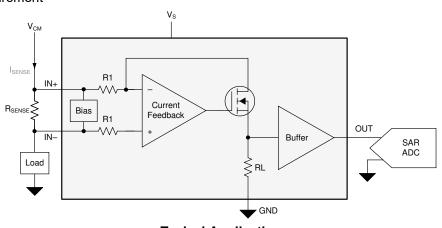
The INA280 is a current sense amplifier that can measure voltage drops across shunt resistors over a wide common-mode range from 2.7 V to 120 V. It is in a highly space-efficient SC-70 package with a PCB footprint of only 2.0 mm × 2.1 mm. The current measurement accuracy is achieved thanks to the combination of an ultra-low offset voltage of ±150 µV (maximum), a small gain error of ±0.5% (maximum), and a high DC CMRR of 140 dB (typical). The INA280 is not only designed for DC current measurement, but also for high-speed applications (like fast overcurrent protection, for example) with a high bandwidth of 1.1 MHz (at gain of 20 V/V) and an 85-dB AC CMRR (at 50 kHz).

The INA280 operates from a single 2.7-V to 20-V supply and draws a 370-µA supply current (typical). The INA280 available with five gain options: 20 V/V, 50 V/V. 100 V/V. 200 V/V. and 500 V/V. The low offset and drift of the INA280 enables accurate current sensing over the extended operating temperature range of -40°C to +125°C.

#### **Device Information**

PART NUMBER	PACKAGE <sup>(1)</sup>	BODY SIZE (NOM)	
INA280	SC-70 (5)	2.00 mm × 1.25 mm	

For all available packages, see the package option addendum at the end of the data sheet.



**Typical Application** 



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**4 Revision History**NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

DATE	REVISION	NOTES
October 2020	*	Initial Release

# **5 Pin Configuration and Functions**

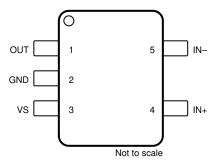


Figure 5-1. DCK Package 5-Pin SC-70 Top View

### **Pin Functions**

	PIN		DESCRIPTION	
NAME	NO.	TYPE	DESCRIPTION	
GND	2	Ground Ground		
IN-	5	Input	Connect to load side of shunt resistor	
IN+	4	Input	Connect to supply side of shunt resistor	
OUT	1	Output	Output voltage	
VS	3	Power	Power supply	



### **6 Specifications**

### 6.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted)(1)

		MIN	MAX	UNIT
V <sub>s</sub>	Supply Voltage	-0.3	22	V
Analog Inputs,	Differential (V <sub>IN+</sub> ) – (V <sub>IN</sub> –)	-30	30	V
$V_{IN+}, V_{IN-}$ (2)	Common - mode	-20	122	V
Output		GND - 0.3	Vs + 0.3	V
T <sub>A</sub>	Operating Temperature	<b>–</b> 55	150	°C
T <sub>J</sub>	Junction temperature		150	°C
T <sub>stg</sub>	Storage temperature	-65	150	°C

<sup>(1)</sup> Stresses beyond those listed under Absolute Maximum Rating may cause permanent damage to the device. These are stress ratings only, which do not imply functional operation of the device at these or any other conditions beyond those indicated under Recommended Operating Condition. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability

### 6.2 ESD Ratings

			VALUE	UNIT
		Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins <sup>(1)</sup>	±2000	
V <sub>(ESD)</sub>	Electrostatic discharge	Charged device model (CDM), per JEDEC specification JESD22-C101, all pins <sup>(2)</sup>	±1000	V

<sup>(1)</sup> JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.

### **6.3 Recommended Operating Conditions**

over operating free-air temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
V <sub>CM</sub>	Common-mode input range <sup>(1)</sup>	Vs	48	120	V
Vs	Operating supply range	2.7	5	20	V
T <sub>A</sub>	Ambient temperature	-40		125	°C

<sup>(1)</sup> Common-mode voltage can go below V<sub>S</sub> under certain conditions. See Figure 7-1 for additional infromation on operating range.

#### 6.4 Thermal Information

		INA280	
THERMAL METRIC <sup>(1)</sup>		DCK (SC-70)	UNIT
		5 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	191.6	°C/W
R <sub>0JC(top)</sub>	Junction-to-case (top) thermal resistance	144.4	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	69.2	°C/W
$\Psi_{JT}$	Junction-to-top characterization parameter	46.2	°C/W
$\Psi_{JB}$	Junction-to-board characterization parameter	69.0	°C/W
R <sub>0JC(bot)</sub>	Junction-to-case (bottom) thermal resistance	N/A	°C/W

<sup>(1)</sup> For more information about traditional and new thermal metrics, see the Semiconductor and IC Package Thermal Metrics application report.

<sup>(2)</sup> VIN+ and VIN- are the voltages at the VIN+ and VIN- pins, respectively.

<sup>(2)</sup> JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.



### **6.5 Electrical Characteristics**

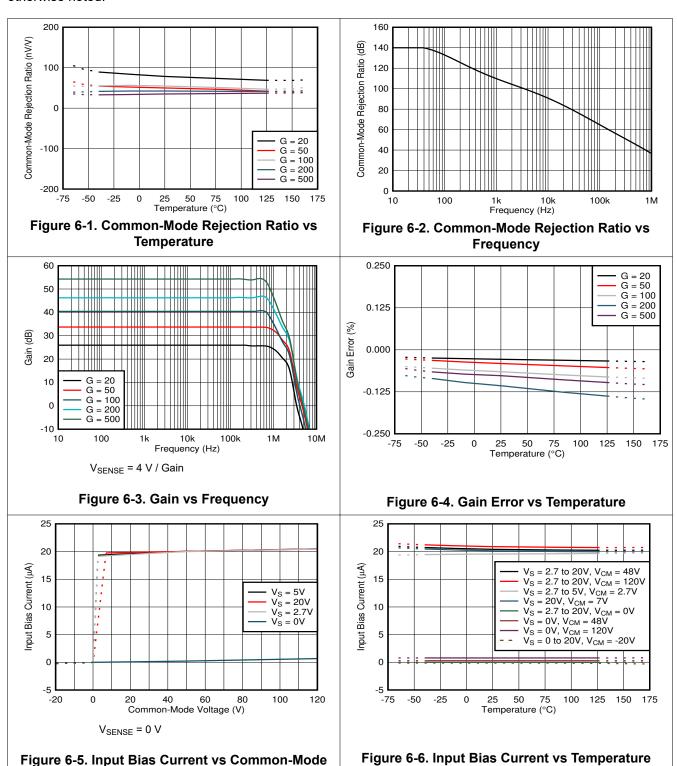
at  $T_A = 25$  °C,  $V_S = 5$  V,  $V_{SENSE} = V_{IN+} - V_{IN-} = 0.5$  V / Gain,  $V_{CM} = V_{IN-} = 48$  V (unless otherwise noted)

	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT						
01400		V <sub>CM</sub> = 2.7 V to 120 V, T <sub>A</sub> = -40 °C to +125 °C	120	140		
CMRR	Common-mode rejection ratio	f = 50 kHz		85		dB
V <sub>os</sub>	Offset voltage, input referred			15	±150	μV
dV <sub>os</sub> /dT	Offset voltage drift	T <sub>A</sub> = -40 °C to +125 °C			1	μV/°C
PSRR	Power supply rejection ratio, input refered	V <sub>S</sub> = 2.7 V to 20 V, T <sub>A</sub> = -40 °C to +125 °C		1	±10	μV/V
	liament bisas summand	I <sub>B+</sub> , V <sub>SENSE</sub> = 0 mV	10	20	30	
I <sub>B</sub>	Input bias current	I <sub>B-</sub> , V <sub>SENSE</sub> = 0 mV	10	20	30	μA
OUTPUT	•					
		A1 devices		20		
		A2 devices		50		V/V
G	Gain	A3 devices		100		
		A4 devices		200		
		A5 devices		500		
	Gain error	GND + 50 mV ≤ V <sub>OUT</sub> ≤ V <sub>S</sub> – 200 mV		0.1	±0.5	%
	Gain error drift	T <sub>A</sub> = -40 °C to +125 °C		2.5	20	ppm/°C
	Nonlinearity error			0.01		%
	Maximum capacitive load	No sustained oscillations, no isolation resistor		500		pF
VOLTAG	E OUTPUT			,		
	Swing to V <sub>S</sub> power supply rail	$R_{LOAD}$ = 10 k $\Omega$ , $T_A$ = -40 °C to +125 °C		V <sub>S</sub> – 0.07	V <sub>S</sub> - 0.2	V
	Swing to ground	$R_{LOAD}$ = 10 k $\Omega$ , $V_{SENSE}$ = 0 V, $T_A$ = -40 °C to +125 °C		0.005	0.025	٧
FREQUE	NCY RESPONSE					
		A1 devices, C <sub>LOAD</sub> = 5 pF, V <sub>SENSE</sub> = 200 mV		1100		
		A2 devices, C <sub>LOAD</sub> = 5 pF, V <sub>SENSE</sub> = 80 mV		1100		
BW	Bandwidth	A3 devices, C <sub>LOAD</sub> = 5 pF, V <sub>SENSE</sub> = 40 mV		900		kHz
		A4 devices, C <sub>LOAD</sub> = 5 pF, V <sub>SENSE</sub> = 20 mV		850		
		A5 devices, C <sub>LOAD</sub> = 5 pF, V <sub>SENSE</sub> = 8 mV		800		
SR	Slew rate			2		V/µs
	Cottling time	V <sub>OUT</sub> =4 V ± 0.1 V step, output settles to 0.5%		9		
	Settling time	V <sub>OUT</sub> =4 V ± 0.1 V step, output settles to 1%		5		μs
NOISE						
Ve <sub>n</sub>	Voltage noise density			50		nV/√Hz
POWER	SUPPLY					
Vs	Supply voltage	$T_A = -40  ^{\circ}\text{C} \text{ to } +125  ^{\circ}\text{C}$	2.7		20	V
ı	Quiocoopt ourrent			370	500	, . ^
$I_Q$	Quiescent current	T <sub>A</sub> = -40 °C to +125 °C	,		600	μA



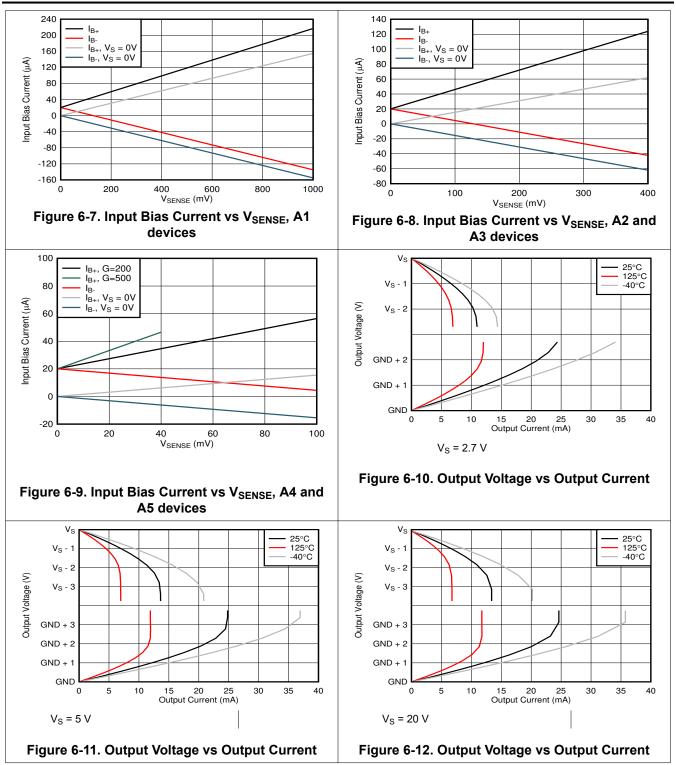
### 6.6 Typical Characteristics

All specifications at  $T_A$  = 25 °C,  $V_S$  = 5 V,  $V_{SENSE}$  =  $V_{IN+} - V_{IN-}$  = 0.5 V / Gain, and  $V_{CM}$  =  $V_{IN-}$  = 48 V, unless otherwise noted.

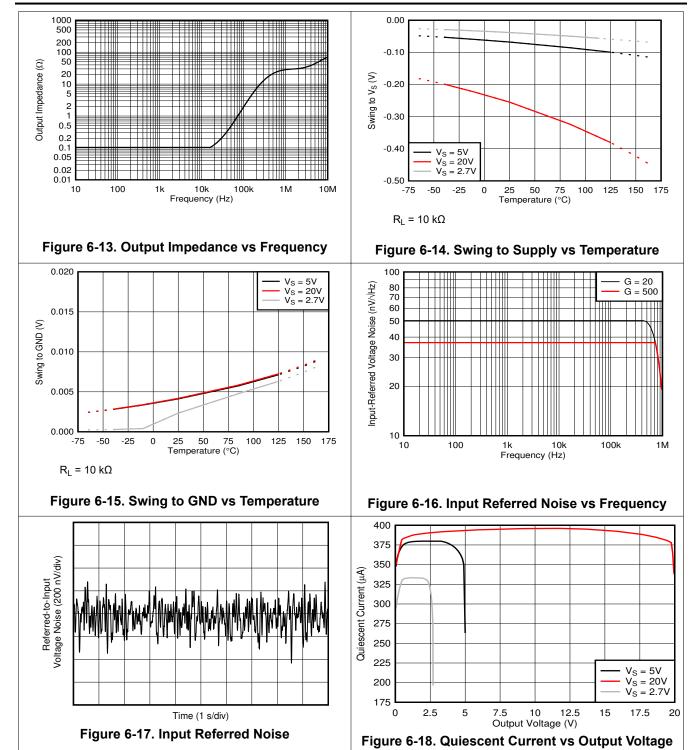


Voltage

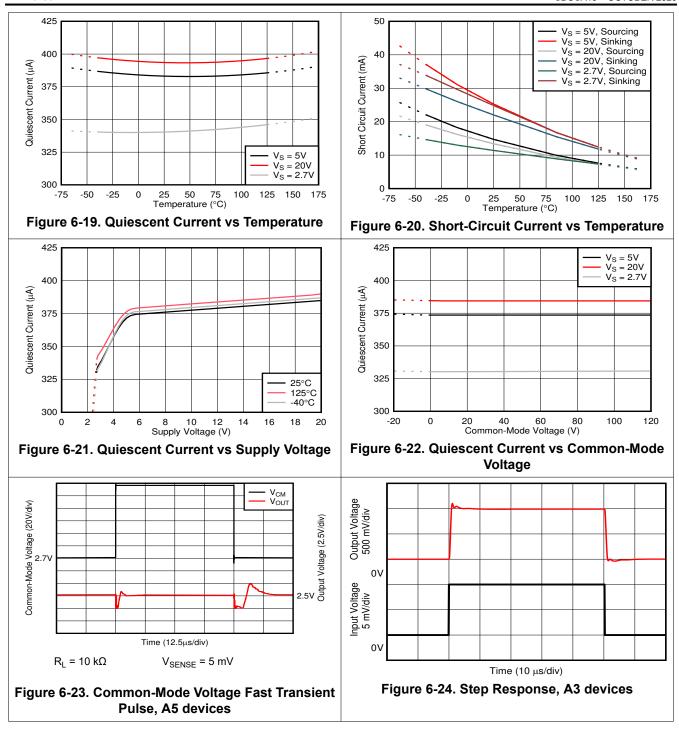




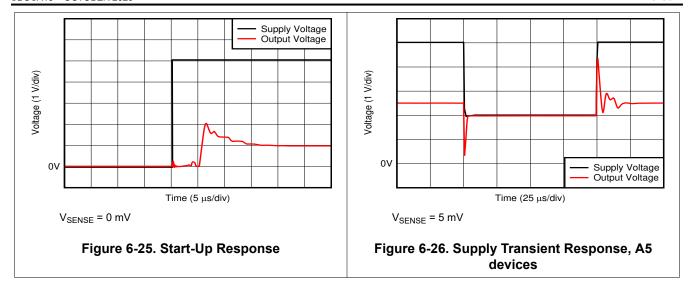












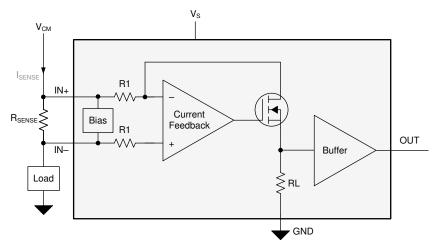


### 7 Detailed Description

### 7.1 Overview

The INA280 is a high-side only current-sense amplifier that offers a wide common-mode range, excellent common-mode rejection ratio (CMRR), high bandwidth, and fast slew rate. Different gain versions are available to optimize the output dynamic range based on the application. The INA280 is designed using a transconductance architecture with a current-feedback amplifier that enables low bias currents of 20  $\mu$ A and a common-mode voltage of 120 V.

### 7.2 Functional Block Diagram



### 7.3 Feature Description

#### 7.3.1 Amplifier Input Common-Mode Range

The INA280 supports large input common-mode voltages from 2.7 V to 120 V and features a high DC CMRR of 140 dB (typical) and a 85-dB AC CMRR at 50 kHz. The minimum common-mode voltage is restricted by the supply voltage as shown in Figure 7-1. The topology of the internal amplifiers INA280 restricts operation to high-side, current-sensing applications.

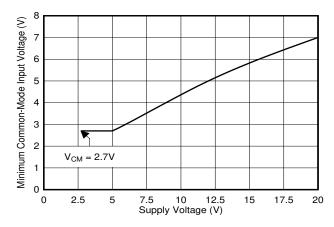


Figure 7-1. Minimum Common-Mode Voltage vs Supply

#### 7.3.1.1 Input-Signal Bandwidth

The INA280 –3-dB bandwidth is gain dependent with several gain options of 20 V/V, 50 V/V, 100 V/V, 200 V/V, and 500 V/V as shown in Figure 6-2. The unique multistage design enables the amplifier to achieve high bandwidth at all gains. This high bandwidth provides the throughput and fast response that is required for the rapid detection and processing of overcurrent events.

The bandwidth of the device also depends on the applied  $V_{SENSE}$  voltage. Figure 7-2 shows the bandwidth performance profile of the device over frequency as output voltage increases for each gain variation. As shown in Figure 7-2, the device exhibits the highest bandwidth with higher  $V_{SENSE}$  voltages, and the bandwidth is higher with lower device gain options. Individual requirements determine the acceptable limits of error for high-frequency, current-sensing applications. Testing and evaluation in the end application or circuit is required to determine the acceptance criteria and validate whether or not the performance levels meet the system specifications.

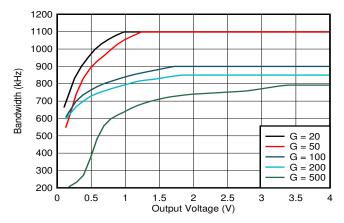


Figure 7-2. Bandwidth vs Output Voltage

#### 7.3.1.2 Low Input Bias Current

The INA280 input bias current draws 20  $\mu$ A (typical) even with common-mode voltages as high as 120 V. This enables precision current sensing in applications where the sensed current is small or applications that require lower input leakage current.

### 7.3.1.3 Multiple Fixed Gain Outputs

The INA280 gain error is < 0.5% at room temperature for all gain options, with a maximum drift of 20ppm/°C over the full temperature range of -40 °C to +125 °C. The INA280 is available in multiple gain options of 20 V/V, 50 V/V, 100 V/V, 200 V/V, and 500 V/V, which the system designer should select based on their desired signal-to-noise ratio and other system requirements.

The INA280 closed-loop gain is set by a precision, low-drift internal resistor network. Even though the ratio of these resistors are well matched, the absolute value of these reisistors may vary significantly. TI does not recommend adding additional resistance around the INA280 to change the effective gain because of this variation, however. The typical values of the gain resistors are described in Table 7-1.

**GAIN** RL R1 25 kΩ  $500 \text{ k}\Omega$ 20 (V/V) 50 (V/V) 10 kΩ  $500 \text{ k}\Omega$ 100 (V/V) 10 kΩ  $1000 \text{ k}\Omega$ 200 (V/V)  $5 k\Omega$  $1000 \text{ k}\Omega$ 1000 kΩ 500 (V/V)  $2 k\Omega$ 

Table 7-1. Fixed Gain Resistor

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### 7.3.1.4 Wide Supply Range

The INA280 operates with a wide supply range from a 2.7 V to 20 V. The output stage supports a full-scale output voltage range of up to  $V_S$ . Wide output range can enable very-wide dynamic range current measurements. For a gain of 20 V/V, the maximum differential input acceptable is 1 V.

#### 7.4 Device Functional Modes

### 7.4.1 Unidirectional Operation

The INA280 measures the differential voltage developed by current flowing through a resistor that is commonly referred to as a current-sensing resistor or a current-shunt resistor. The INA280 operates in unidirectional mode only, meaning it only senses current sourced from a power supply to a system load as shown in Figure 7-3.

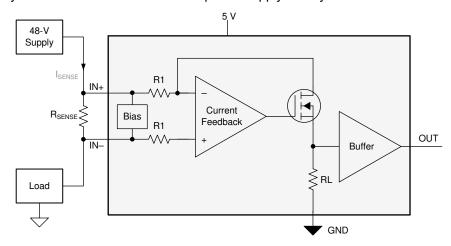


Figure 7-3. Unidirectional Application

The linear range of the output stage is limited to how close the output voltage can approach ground under zero-input conditions. The zero current output voltage of the INA280 is very small, with a maximum of GND + 25 mV. Make sure to apply a sense voltage of (25 mV / Gain) or greater to keep the INA280 output in the linear region of operation.

### 7.4.2 High Signal Throughput

With a bandwidth of 1.1 MHz at a gain of 20 V/V and a slew rate of 2 V/ $\mu$ s, the INA280 is specifically designed for detecting and protecting applications from fast inrush currents. As shown in Table 7-2, the INA280 responds in less than 2  $\mu$ s for a system measuring a 75-A threshold on a 2-m $\Omega$  shunt.

Table 1-2. Response Time					
	PARAMETER	EQUATION	INA280 AT V <sub>S</sub> = 5 V		
G	Gain		20 V/V		
I <sub>MAX</sub>	Maximum current		100 A		
I <sub>Threshold</sub>	Threshold current		75 A		
R <sub>SENSE</sub>	Current sense resistor value		2 mΩ		
V <sub>OUT_MAX</sub>	Output voltage at maximum current	V <sub>OUT</sub> = I <sub>MAX</sub> × R <sub>SENSE</sub> × G	4 V		
V <sub>OUT_THR</sub>	Output voltage at threshold current	V <sub>OUT_THR</sub> = I <sub>THR</sub> × R <sub>SENSE</sub> × G	3 V		
SR	Slew rate		2 V/μs		
	Output response time	$T_{response} = V_{OUT\_THR} / SR$	< 2 µs		

Table 7-2. Response Time

### 8 Application and Implementation

#### Note

Information in the following applications sections is not part of the TI component specification, and TI does not warrant its accuracy or completeness. TI's customers are responsible for determining suitability of components for their purposes. Customers should validate and test their design implementation to confirm system functionality.

### 8.1 Application Information

The INA280 amplifies the voltage developed across a current-sensing resistor as current flows through the resistor to the load. The wide input common-mode voltage range and high common-mode rejection of the INA280 allows use over a wide range of voltage rails while still maintaining an accurate current measurement.

#### 8.1.1 R<sub>SENSE</sub> and Device Gain Selection

The accuracy of any current-sense amplifier is maximized by choosing the current-sense resistor to be as large as possible. A large sense resistor maximizes the differential input signal for a given amount of current flow and reduces the error contribution of the offset voltage. However, there are practical limits as to how large the current-sense resistor can be in a given application because of the resistor size and maximum allowable power dissipation. Equation 1 gives the maximum value for the current-sense resistor for a given power dissipation budget:

$$R_{SENSE} < \frac{PD_{MAX}}{I_{MAX}^2} \tag{1}$$

#### where:

- PD<sub>MAX</sub> is the maximum allowable power dissipation in R<sub>SENSE</sub>.
- I<sub>MAX</sub> is the maximum current that will flow through R<sub>SENSE</sub>.

An additional limitation on the size of the current-sense resistor and device gain is due to the power-supply voltage,  $V_S$ , and device swing-to-rail limitations. To make sure that the current-sense signal is properly passed to the output, both positive and negative output swing limitations must be examined. Equation 2 provides the maximum values of  $R_{SENSE}$  and GAIN to keep the device from exceeding the positive swing limitation.

$$I_{MAX} \times R_{SENSE} \times GAIN < V_{SP}$$
 (2)

#### where:

- I<sub>MAX</sub> is the maximum current that will flow through R<sub>SENSE</sub>.
- · GAIN is the gain of the current-sense amplifier.
- V<sub>SP</sub> is the positive output swing as specified in the data sheet.

To avoid positive output swing limitations when selecting the value of R<sub>SENSE</sub>, there is always a trade-off between the value of the sense resistor and the gain of the device under consideration. If the sense resistor selected for the maximum power dissipation is too large, then it is possible to select a lower-gain device in order to avoid positive swing limitations.

The negative swing limitation places a limit on how small the sense resistor value can be for a given application. Equation 3 provides the limit on the minimum value of the sense resistor.

$$I_{MIN} \times R_{SENSE} \times GAIN > V_{SN}$$
 (3)

#### where:

- I<sub>MIN</sub> is the minimum current that will flow through R<sub>SENSE</sub>.
- GAIN is the gain of the current-sense amplifier.



• V<sub>SN</sub> is the negative output swing of the device.

Table 8-1 shows an example of the different results obtained from using five different gain versions of the INA280. From the table data, the highest gain device allows a smaller current-shunt resistor and decreased power dissipation in the element.

	Table 6-1. RSENSE Selection and Power Dissipation								
	PARAMETER <sup>(1)</sup>	EQUATION	RESULTS AT V <sub>S</sub> = 5 V						
	PARAMETER	EQUATION	INA280A1	INA280A2	INA280A3	INA280A4	INA280A5		
G	Gain		20 V/V	50 V/V	100 V/V	200 V/V	500 V/V		
V <sub>SENSE</sub>	Ideal differential input voltage (Ignores swing limitation and power supply variation.)	V <sub>SENSE</sub> = V <sub>OUT</sub> / G	250 mV	100 mV	50 mV	25 mV	10 mV		
R <sub>SENSE</sub>	Current sense resistor value	R <sub>SENSE</sub> = V <sub>SENSE</sub> / I <sub>MAX</sub>	25 mΩ	10 mΩ	5 mΩ	2.5 mΩ	1 mΩ		
P <sub>SENSE</sub>	Current-sense resistor power dissipation	R <sub>SENSE</sub> x I <sub>MAX</sub> 2	2.5 W	1 W	0.5W	0.25 W	0.1 W		

Table 8-1. R<sub>SENSE</sub> Selection and Power Dissipation

(1) Design example with 10-A full-scale current with maximum output voltage set to 5 V.

#### 8.1.2 Input Filtering

#### Note

Input filters are not required for accurate measurements using the INA280, and use of filters in this location is not recommended. If filter components are used on the input of the amplifier, follow the guidelines in this section to minimize the effects on performance.

Based strictly on user design requirements, external filtering of the current signal may be desired. The initial location that can be considered for the filter is at the output of the current-sense amplifier. Although placing the filter at the output satisfies the filtering requirements, this location changes the low output impedance measured by any circuitry connected to the output voltage pin. The other location for filter placement is at the current-sense amplifier input pins. This location also satisfies the filtering requirement, but the components must be carefully selected to minimally impact device performance. Figure 8-1 shows a filter placed at the input pins.

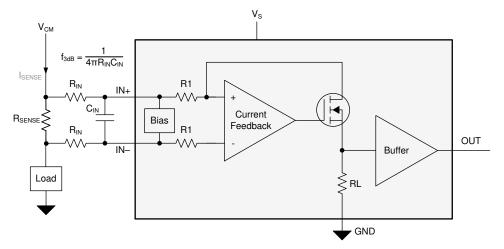


Figure 8-1. Filter at Input Pins

External series resistance provides a source of additional measurement error, so keep the value of these series resistors to 10  $\Omega$  or less to reduce loss of accuracy. The internal bias network shown in Figure 38 creates a mismatch in input bias currents (see Figure 6-7, Figure 6-8, and Figure 6-9) when a differential voltage is applied between the input pins. If additional external series filter resistors are added to the circuit, a mismatch is created in the voltage drop across the filter resistors. This voltage is a differential error voltage in the shunt resistor voltage. In addition to the absolute resistor value, mismatch resulting from resistor tolerance can significantly impact the error because this value is calculated based on the actual measured resistance.



The measurement error expected from the additional external filter resistors can be calculated using Equation 4, where the gain error factor is calculated using Equation 5.

Gain Error (%) = 
$$100 \times (Gain Error Factor - 1)$$
 (4)

The gain error factor, shown in Equation 4, can be calculated to determine the gain error introduced by the additional external series resistance. Equation 4 calculates the deviation of the shunt voltage, resulting from the attenuation and imbalance created by the added external filter resistance. Table 8-2 provides the gain error factor and gain error for several resistor values.

Gain Error Factor = 
$$\frac{R_B \times R1}{(R_B \times R1) + (R_B \times R_{IN}) + (2 \times R_{IN} \times R1)}$$
(5)

#### Where:

- R<sub>IN</sub> is the external filter resistance value.
- R1 is the INA280 input resistance value specified in Table 7-1.
- R<sub>B</sub> in the internal bias resistance, which is 6600  $\Omega$  ± 20%.

Table 8-2. Example Gain Error Factor and Gain Error for 10-Ω External Filter Input Resistors

DEVICE (GAIN)	GAIN ERROR FACTOR	GAIN ERROR (%)
A1 devices (20)	0.99658	-0.34185
A2 devices (50)	0.99598	-0.40141
A3 devices (100)	0.99598	-0.40141
A4 devices (200)	0.99499	-0.50051
A5 devices (500)	0.99203	-0.79663

### 8.2 Typical Application

The INA280 is a unidirectional, current-sense amplifier capable of measuring currents through a resistive shunt with shunt common-mode voltages from 2.7 V to 120 V. The circuit configuration for monitoring current in a high-side radio frequency (RF) power amplifier (PA) application is shown in Figure 8-2.

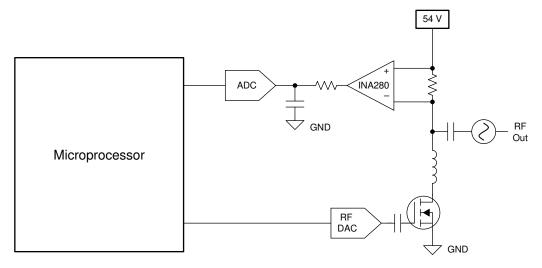


Figure 8-2. Current Sensing in a PA Application



### 8.2.1 Design Requirements

V<sub>SUPPLY</sub> is set to 5 V, and the common-mode voltage set to 54 V. Table 8-3 lists the design setup for this application.

Table 8-3	. Design	<b>Parameters</b>
-----------	----------	-------------------

DESIGN PARAMETERS	EXAMPLE VALUE				
INA280 supply voltage	5 V				
High-side supply voltage	5 V				
Maximum sense current (I <sub>MAX</sub> )	5 A				
Gain option	50 V/V				

#### 8.2.2 Detailed Design Procedure

The maximum value of the current-sense resistor is calculated based choice of gain, value of the maximum current the be sensed (I<sub>MAX</sub>), and the power-supply voltage (V<sub>S</sub>). When operating at the maximum current, the output voltage must not exceed the positive output swing specification, V<sub>SP</sub>. Under the given design parameters, Equation 6 calculates the maximum value for  $R_{SENSE}$  as 19.2 m $\Omega$ .

$$R_{SENSE} < \frac{V_{SP}}{I_{MAX} \times GAIN} \tag{6}$$

For this design example, a value of 15 m $\Omega$  is selected because, while the 15 m $\Omega$  is less than the maximum value calculated, 15 m $\Omega$  is still large enough to give adequate signal at the current-sense amplifier output.

### 8.2.2.1 Overload Recovery With Negative V<sub>SENSE</sub>

The INA280 is a unidirectional current-sense amplifier that is meant to operate with a positive differential input voltage (V<sub>SENSE</sub>). If negative V<sub>SENSE</sub> is applied, the device is placed in an overload condition and requires time to recover once V<sub>SENSE</sub> returns positive. The required overload recovery time increases with more negative V<sub>SENSE</sub>.

### 8.2.3 Application Curve

Figure 8-3 shows the output response of the device to a high frequency sinusoidal current.

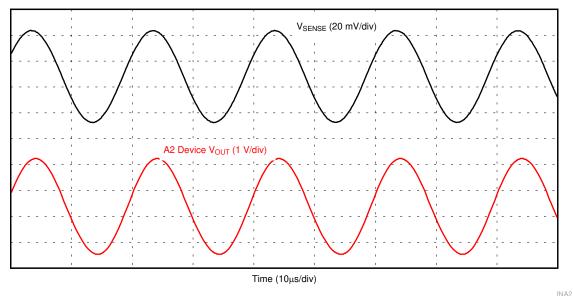


Figure 8-3. INA280 Output Response

### 9 Power Supply Recommendations

The input circuitry of the INA280 device can accurately measure beyond the power-supply voltage. The power supply can be 20 V, whereas the load power-supply voltage at IN+ and IN- can go up to 120 V. The output voltage range of the OUT pin is limited by the voltage on the  $V_S$  pin and the device swing to supply specification.

### 10 Layout

### 10.1 Layout Guidelines

TI always recommends to follow good layout practices:

- Connect the input pins to the sensing resistor using a Kelvin or 4-wire connection. This connection technique
  makes sure that only the current-sensing resistor impedance is detected between the input pins. Poor routing
  of the current-sensing resistor commonly results in additional resistance present between the input pins.
  Given the very low ohmic value of the current resistor, any additional high-current carrying impedance can
  cause significant measurement errors.
- Place the power-supply bypass capacitor as close to the device power supply and ground pins as possible.
   The recommended value of this bypass capacitor is 0.1 µF. Additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies.
- When routing the connections from the current-sense resistor to the device, keep the trace lengths as short as possible.

### 10.2 Layout Example

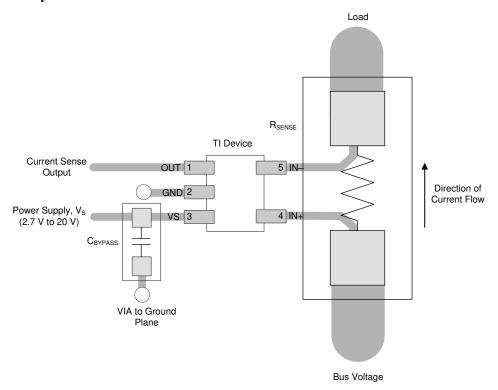


Figure 10-1. Recommended Layout for INA280



### 11 Device and Documentation Support

### 11.1 Documentation Support

#### 11.1.1 Related Documentation

For related documentation, see the following:

Texas Instruments, INA280EVM User's Guide

### 11.2 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Subscribe to updates* to register and receive a weekly digest of any product information that has changed. For change details, review the revision history included in any revised document.

### 11.3 Support Resources

TI E2E<sup>™</sup> support forums are an engineer's go-to source for fast, verified answers and design help — straight from the experts. Search existing answers or ask your own question to get the quick design help you need.

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#### 11.4 Trademarks

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#### 11.5 Electrostatic Discharge Caution



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.

#### 11.6 Glossary

**TI Glossary** 

This glossary lists and explains terms, acronyms, and definitions.

### 12 Mechanical, Packaging, and Orderable Information

The following pages include mechanical, packaging, and orderable information. This information is the most current data available for the designated devices. This data is subject to change without notice and revision of this document. For browser-based versions of this data sheet, refer to the left-hand navigation.

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#### PACKAGING INFORMATION

Orderable part number	Status (1)	Material type	Package   Pins	Package qty   Carrier	<b>RoHS</b> (3)	Lead finish/ Ball material	MSL rating/ Peak reflow	Op temp (°C)	Part marking (6)
INA280A1IDCKR	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HP
INA280A1IDCKR.B	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HP
INA280A1IDCKT	Obsolete	Production	SC70 (DCK)   5	-	-	Call TI	Call TI	-40 to 125	1HP
INA280A2IDCKR	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HQ
INA280A2IDCKR.B	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HQ
INA280A2IDCKT	Active	Production	SC70 (DCK)   5	250   SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HQ
INA280A2IDCKT.B	Active	Production	SC70 (DCK)   5	250   SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HQ
INA280A3IDCKR	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HR
INA280A3IDCKR.B	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HR
INA280A3IDCKRG4	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HR
INA280A3IDCKRG4.B	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HR
INA280A3IDCKT	Active	Production	SC70 (DCK)   5	250   SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HR
INA280A3IDCKT.B	Active	Production	SC70 (DCK)   5	250   SMALL T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HR
INA280A4IDCKR	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HS
INA280A4IDCKR.B	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HS
INA280A5IDCKR	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HT
INA280A5IDCKR.B	Active	Production	SC70 (DCK)   5	3000   LARGE T&R	Yes	NIPDAU	Level-1-260C-UNLIM	-40 to 125	1HT

<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.

## **PACKAGE OPTION ADDENDUM**

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(6) 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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#### OTHER QUALIFIED VERSIONS OF INA280:

Automotive : INA280-Q1

NOTE: Qualified Version Definitions:

Automotive - Q100 devices qualified for high-reliability automotive applications targeting zero defects

# **PACKAGE MATERIALS INFORMATION**

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### TAPE AND REEL INFORMATION





A0	Dimension designed to accommodate the component width
В0	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		SPQ	Reel Diameter (mm)	Reel Width W1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P1 (mm)	W (mm)	Pin1 Quadrant
INA280A1IDCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A2IDCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A2IDCKT	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A3IDCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A3IDCKRG4	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A3IDCKT	SC70	DCK	5	250	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A4IDCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3
INA280A5IDCKR	SC70	DCK	5	3000	180.0	8.4	2.47	2.3	1.25	4.0	8.0	Q3



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\*All dimensions are nominal

Device	Package Type	Package Drawing	Pins	SPQ	Length (mm)	Width (mm)	Height (mm)
INA280A1IDCKR	SC70	DCK	5	3000	183.0	183.0	20.0
INA280A2IDCKR	SC70	DCK	5	3000	183.0	183.0	20.0
INA280A2IDCKT	SC70	DCK	5	250	183.0	183.0	20.0
INA280A3IDCKR	SC70	DCK	5	3000	183.0	183.0	20.0
INA280A3IDCKRG4	SC70	DCK	5	3000	183.0	183.0	20.0
INA280A3IDCKT	SC70	DCK	5	250	183.0	183.0	20.0
INA280A4IDCKR	SC70	DCK	5	3000	183.0	183.0	20.0
INA280A5IDCKR	SC70	DCK	5	3000	183.0	183.0	20.0



SMALL OUTLINE TRANSISTOR



#### NOTES:

- 1. All linear dimensions are in millimeters. Any dimensions in parenthesis are for reference only. Dimensioning and tolerancing per ASME Y14.5M.
  2. This drawing is subject to change without notice.
  3. Reference JEDEC MO-203.

- 4. Support pin may differ or may not be present.5. Lead width does not comply with JEDEC.
- 6. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25mm per side



SMALL OUTLINE TRANSISTOR



NOTES: (continued)

7. Publication IPC-7351 may have alternate designs.8. Solder mask tolerances between and around signal pads can vary based on board fabrication site.



SMALL OUTLINE TRANSISTOR



NOTES: (continued)

- 9. Laser cutting apertures with trapezoidal walls and rounded corners may offer better paste release. IPC-7525 may have alternate design recommendations.
- 10. Board assembly site may have different recommendations for stencil design.



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