

# INA901-SP 放射線耐性を強化した -15V~80V 同相の 単方向電流シャント・モニタ

## 1 特長

- 5962-1821001
  - 放射線耐性保証(RHA)  
低線量率で100krad(Si)
  - 単一イベント・ラッチアップ(SEL)耐性  
125°Cで93MeV·cm<sup>2</sup>/mgまで
    - 放射線耐性についてのレポートを参照
  - 軍事用温度範囲(-55°C~125°C)で認定済み
  - 高性能の8ピン・セラミック・フラット・パック・パッケージ(HKX)
- 広い同相電圧範囲: -15V~80V
- CMRR: 120dB
- 精度**
  - オフセット: ±0.5mV
  - ゲイン誤差: ±0.2%
  - オフセット・ドリフト: 2.5μV/°C
  - ゲイン・ドリフト: 50ppm/°C
- 帯域幅: 最大130kHz
- ゲイン: 20V/V
- 静止電流: 700μA
- 電源: 2.7V~16V
- フィルタリング用の機構

## 2 アプリケーション

- 電源監視
- 過電流および低電流の検出
- 衛星テレメトリ
- 宇宙での信号コンディショニング
- モータ制御ループ

## 3 概要

INA901-SP は、電源電圧にかかわらず -15V~80V の同相電圧でシャント抵抗両端の電圧降下を検出できる、電圧出力電流検出アンプです。INA901-SP は 2.7V~16V の単一電源で動作し、消費電流は 700μA (標準値) です。

INA901-SP のゲインは 20V/V です。130kHz の帯域幅により、電流制御ループで簡単に使用できます。ピン配置は、フィルタを簡単に接続できるよう設計されています。

### 製品情報<sup>(1)</sup>

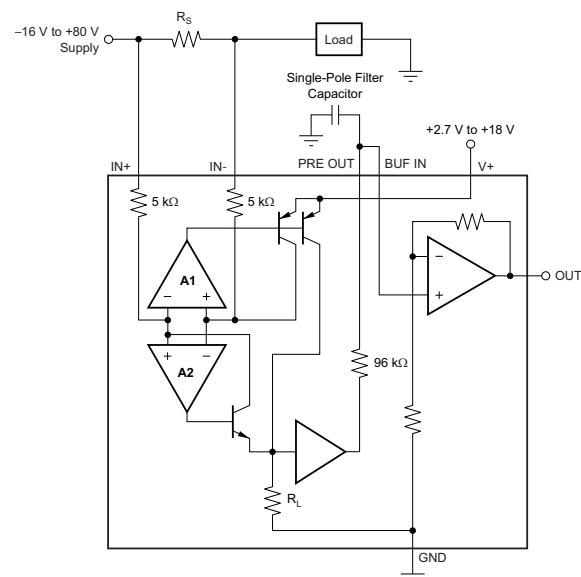
型番	グレード	パッケージ
5962R1821001VXC	QMLV RHA [100 krad(Si)]	8 リード CFP [HKX]
5962-1821001VXC	QMLV	6.48x6.48mm
INA901HKX/EM	エンジニアリング・サンプル <sup>(2)</sup>	重量: 0.39g <sup>(3)</sup>
INA901EVM-CVAL	セラミック評価ボード	—

(1) 利用可能なすべてのパッケージについては、このデータシートの末尾にある注文情報を参照してください。

(2) これらのユニットは、技術的な評価のみを目的としています。標準とは異なるフローに従って処理されています。これらのユニットは、認定、量産、放射線テスト、航空での使用には適していません。これらの部品は、MIL に規定されている温度範囲 -55°C~125°C、または動作寿命全体にわたる性能を保証されていません。

(3) 重量の精度は ±10% です。

### 概略回路図



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## 4 改訂履歴

資料番号末尾の英字は改訂を表しています。その改訂履歴は英語版に準じています。

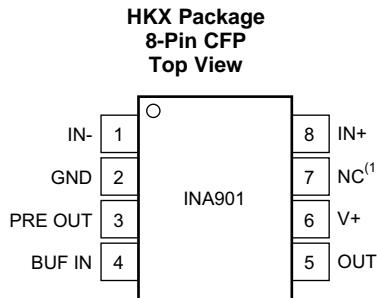
Revision A (December 2018) から Revision B に変更	Page
• デバイスのステータスを「事前情報」から「量産データ」に変更 .....	3

## 5 概要（続き）

INA901-SPのゲインは20V/Vです。130kHzの帯域幅により、電流制御ループで簡単に使用できます。ピン配置は、フィルタを簡単に接続できるよう設計されています。

このデバイスは、拡張動作温度範囲の-55°C～125°Cで動作が規定されており、8ピンのCFPパッケージで供給されます。

## 6 Pin Configuration and Functions



NOTE (1): NC denotes no internal connection.

### Pin Functions

PIN		I/O	TYPE <sup>(1)</sup>	DESCRIPTION
NAME	NO.			
BUF IN	4	I	A	Connect to output of filter from PRE OUT.
GND	2	—	GND	Ground.
IN–	1	I	A	Connect to load side of shunt resistor.
IN+	8	I	A	Connect to supply side of shunt resistor.
NC	7	—	—	Recommend connect to ground.
OUT	5	O	A	Output voltage.
PRE OUT	3	O	A	Connect to input of filter to BUF IN.
V+	6	—	P	Power supply, 2.7 V to 18 V.

(1) A = analog, P = power, GND = ground

## 7 Specifications

### 7.1 Absolute Maximum Ratings<sup>(1)</sup>

		MIN	MAX	UNIT
Supply voltage (Vs)			18	V
Analog inputs, $V_{IN+}$ , $V_{IN-}$	Differential, $(V_{IN+}) - (V_{IN-})$	-18	18	V
	Common-mode	-16	80	
Analog output: OUT and PRE OUT pins		GND – 0.3	$(V+) + 0.3$	V
Input current into any pin			5	mA
Operating temperature		-55	150	°C
Junction temperature			150	°C
Storage temperature, $T_{stg}$		-65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* 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 Conditions*. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

### 7.2 ESD Ratings

		VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/JEDEC JS-001 <sup>(1)</sup>	$\pm 3000$
		Charged-device model (CDM), per JEDEC specification JESD22-C101 <sup>(2)</sup>	$\pm 1000$

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.  
 (2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

### 7.3 Recommended Operating Conditions

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

		MIN	MAX	UNIT
$V_{CM}$	Common-mode input voltage	-15	80	V
$V_S$	Operating supply voltage	2.7	16	V
$T_A$	Operating free-air temperature	-55	125	°C

### 7.4 Thermal Information

THERMAL METRIC <sup>(1)</sup>	INA901-SP	UNIT
	HKX (CFP)	
	8 PINS	
$R_{\theta JA}$	Junction-to-ambient thermal resistance	116.7
$R_{\theta JC(\text{top})}$	Junction-to-case (top) thermal resistance	39.1
$R_{\theta JB}$	Junction-to-board thermal resistance	98.8
$\psi_{JT}$	Junction-to-top characterization parameter	32.5
$\psi_{JB}$	Junction-to-board characterization parameter	93.1
$R_{\theta JC(\text{bot})}$	Junction-to-case (bottom) thermal resistance	26.5

(1) For more information about traditional and new thermal metrics, see the [Semiconductor and IC Package Thermal Metrics](#) application report.

## 7.5 Electrical Characteristics

$V_S = 2.7 \text{ V}$  and  $16 \text{ V}$ ,  $V_{CM} = -15 \text{ V}$ ,  $12 \text{ V}$  and  $80 \text{ V}$ ,  $V_{SENSE} = 100 \text{ mV}$ , and PRE OUT connected to BUF IN, unless otherwise noted.  $T_A$  is as shown in SUBGROUP column.

PARAMETER	TEST CONDITIONS	SUBGROUP <sup>(1)</sup>	MIN	TYP	MAX	UNIT
<b>INPUT</b>						
$V_{SENSE}$	Full-scale input voltage	$V_{SENSE} = (V_{IN+}) - (V_{IN-})$	[1, 2, 3]	0.15	$(V_S - 0.2) / \text{Gain}$	V
$V_{CM}$	Common-mode input range		[1, 2, 3]	-16	80	V
CMRR	Common-mode rejection ratio	$V_{IN+} = -15 \text{ V}$ to $80 \text{ V}$	[1]	80	120	dB
			[2, 3]	70	120	
$V_{OS}$	Offset voltage, RTI		[1]	$\pm 0.5$	$\pm 2.5$	mV
			[2, 3]		$\pm 3.5$	
$dV_{OS}/dT$				2.5		$\mu\text{V}/^\circ\text{C}$
PSR	$V_{OS}$ vs power-supply		[1, 2, 3]	5	250	$\mu\text{V}/\text{V}$
$I_B$	Input bias current, $V_{IN-}$ pin		[1]	$\pm 8$	$\pm 16$	$\mu\text{A}$
			[2, 3]		$\pm 19$	
PRE OUT output impedance				96		$\text{k}\Omega$
Buffer input bias current				-50		nA
Buffer input bias current temperature coefficient				$\pm 0.03$		$\text{nA}/^\circ\text{C}$
<b>OUTPUT (<math>V_{SENSE} \geq 20 \text{ mV}</math>)<sup>(2)</sup></b>						
G	Gain			20		V/V
$G_{BUF}$	Output buffer gain			2		V/V
Total gain error	$V_{SENSE} = 20 \text{ mV}$ to $100 \text{ mV}$	[4, 5, 6]	$\pm 0.2\%$	$\pm 1.5\%$		
Total gain error vs temperature	$T_A = -55^\circ\text{C}$ to $125^\circ\text{C}$			50		$\text{ppm}/^\circ\text{C}$
Total output error <sup>(3)</sup>		[4]	$\pm 0.75\%$	$\pm 2\%$		
		[5, 6]		$\pm 3\%$		
Nonlinearity error	$V_{SENSE} = 20 \text{ mV}$ to $100 \text{ mV}$		$\pm 0.002\%$			
$R_O$	Output impedance, pin 5			1.5		$\Omega$
Maximum capacitive load	No sustained oscillation			10		nF
<b>VOLTAGE OUTPUT (<math>R_L = 10 \text{ k}\Omega</math> to GND)</b>						
Swing to $V_+$ power-supply rail		[1, 2, 3]	$(V_+) - 0.05$	$(V_+) - 0.2$		V
Swing to GND		[1, 2, 3]	$V_{GND} + 0.003$	$V_{GND} + 0.05$		V
<b>FREQUENCY RESPONSE</b>						
BW	Bandwidth	$C_{LOAD} = 5 \text{ pF}$		130		$\text{kHz}$
	Phase margin	$C_{LOAD} < 10 \text{ nF}$		40		°
SR	Slew rate			1		$\text{V}/\mu\text{s}$
$t_S$	Settling time (1%)	$V_{SENSE} = 10 \text{ mV}$ to $100 \text{ mV}_{PP}$ , $C_{LOAD} = 5 \text{ pF}$		2		$\mu\text{s}$

(1) For subgroup definitions, please see [Quality Conformance Inspection](#) table.

(2) For output behavior when  $V_{SENSE} < 20 \text{ mV}$ , see the [Accuracy Variations as a Result of  \$V\_{SENSE}\$  and Common-Mode Voltage](#) section.

(3) Total output error includes effects of gain error and  $V_{OS}$ .

## Electrical Characteristics (continued)

$V_S = 2.7$  V and 16 V,  $V_{CM} = -15$  V, 12 V and 80 V,  $V_{SENSE} = 100$  mV, and PRE OUT connected to BUF IN, unless otherwise noted.  $T_A$  is as shown in SUBGROUP column.

PARAMETER	TEST CONDITIONS	SUBGROUP <sup>(1)</sup>	MIN	TYP	MAX	UNIT
<b>NOISE, RTI<sup>(4)</sup></b>						
$e_n$	Voltage noise density			40		nV/ $\sqrt{\text{Hz}}$
<b>POWER SUPPLY</b>						
$V_S$	Operating range	[1, 2, 3]	2.7	16	V	
$I_Q$	$V_{OUT} = 2$ V	[1]	700	900		$\mu\text{A}$
		[2, 3]	700	1200		
	$V_{SENSE} = 0$ mV	[1]	350	500		
		[2, 3]	350	650		

(4) RTI means *Referred-to-Input*.

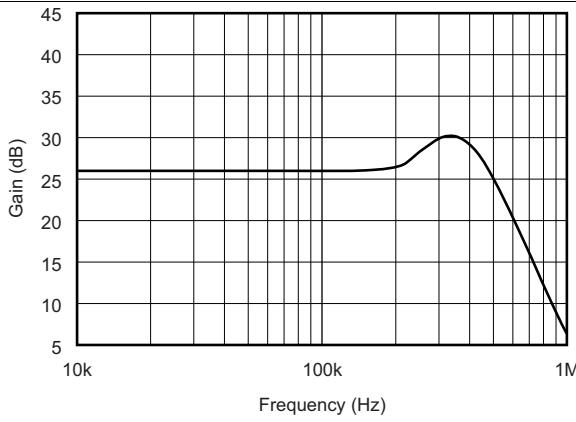
## 7.6 Quality Conformance Inspection

MIL-STD-883, Method 5005 - Group A

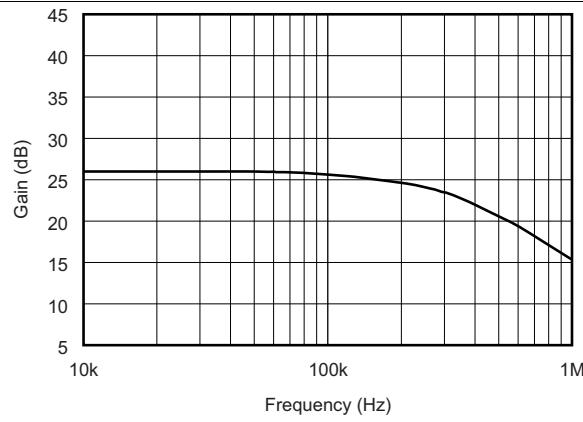
SUBGROUP	DESCRIPTION	TEMP (°C)
1	Static tests at	25
2	Static tests at	125
3	Static tests at	-55
4	Dynamic tests at	25
5	Dynamic tests at	125
6	Dynamic tests at	-55
7	Functional tests at	25
8A	Functional tests at	125
8B	Functional tests at	-55
9	Switching tests at	25
10	Switching tests at	125
11	Switching tests at	-55
12	Setting time at	25
13	Setting time at	125
14	Setting time at	-55

## 7.7 Typical Characteristics

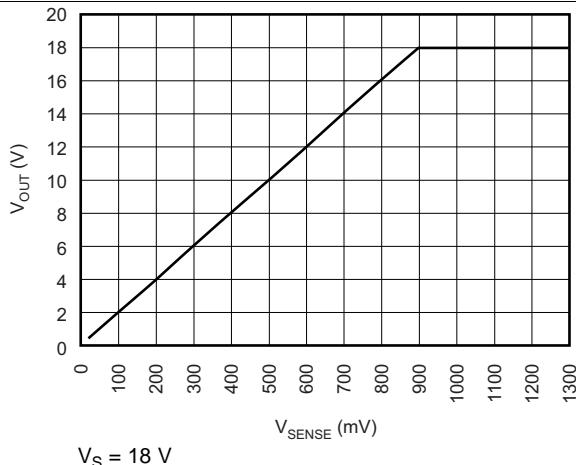
At  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ ,  $V_{CM} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.



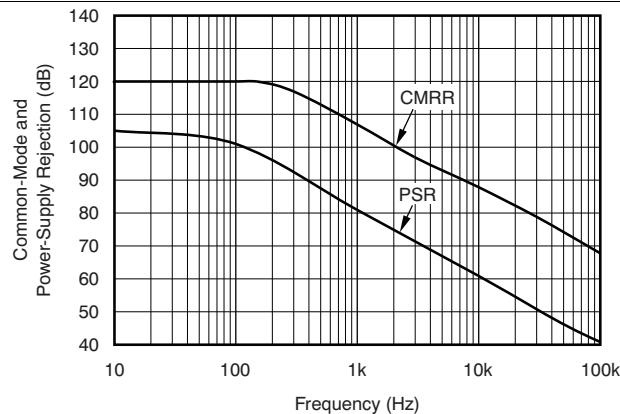
**Figure 1. Gain vs Frequency**



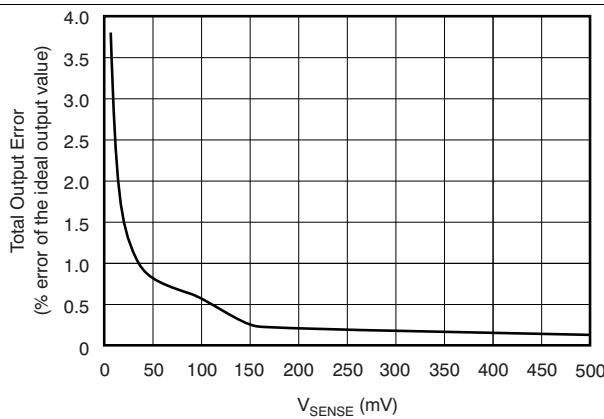
**Figure 2. Gain vs Frequency**



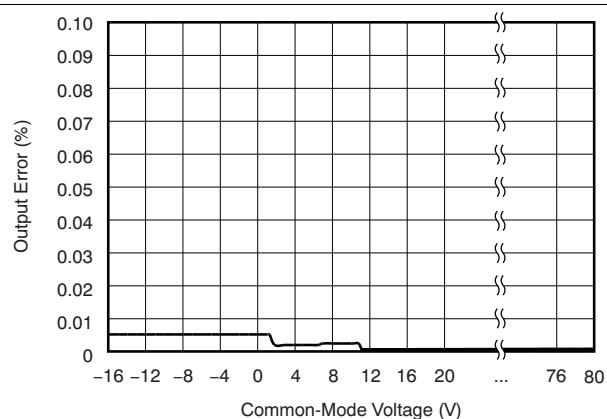
**Figure 3. Gain Plot**



**Figure 4. Common-Mode and Power-Supply Rejection vs Frequency**



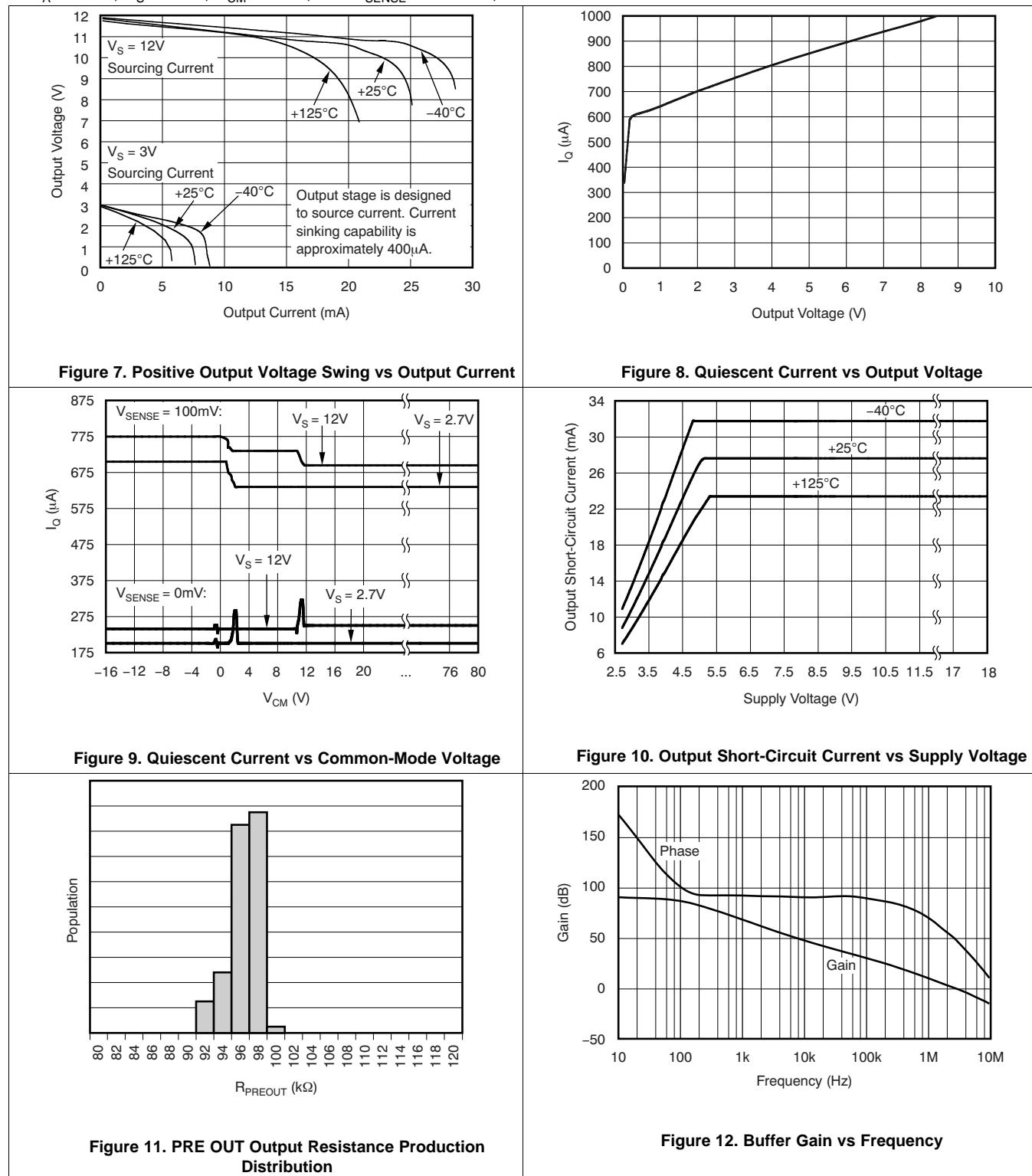
**Figure 5. Total Output Error vs  $V_{SENSE}$**



**Figure 6. Output Error vs Common-Mode Voltage**

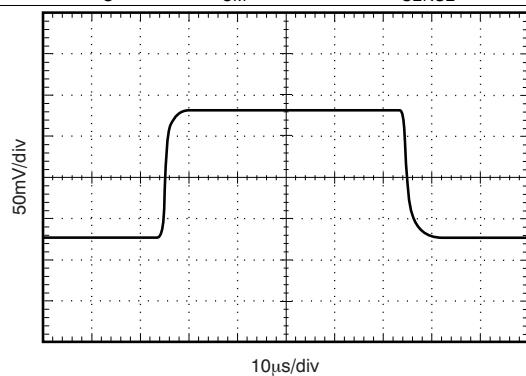
## Typical Characteristics (continued)

At  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ ,  $V_{CM} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.

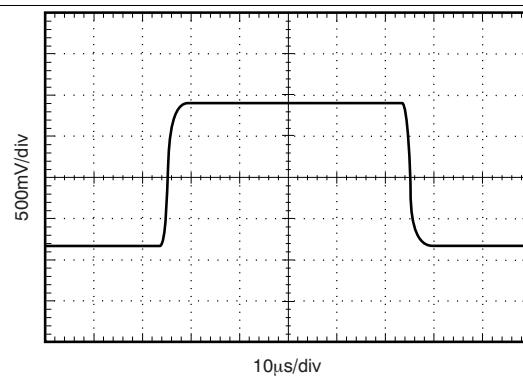


## Typical Characteristics (continued)

At  $T_A = 25^\circ\text{C}$ ,  $V_S = 12\text{ V}$ ,  $V_{CM} = 12\text{ V}$ , and  $V_{SENSE} = 100\text{ mV}$ , unless otherwise noted.



**Figure 13. Small-Signal Step Response  
(10-mV to 20-mV Input)**



**Figure 14. Large-Signal Step Response  
(10-mV to 100-mV Input)**

## 8 Detailed Description

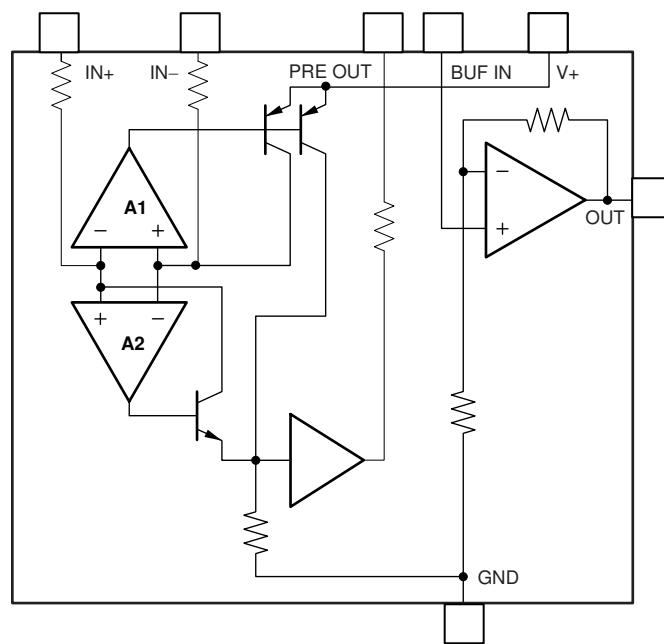
### 8.1 Overview

The INA901-SP current-shunt monitor with voltage output can sense drops across current shunts at common-mode voltages from  $-16$  V to  $80$  V, independent of the supply voltage. The INA901-SP pinouts readily enable filtering.

The INA901-SP is available with a  $20$ -V/V output voltage scale. The  $130$ -kHz bandwidth simplifies use in current-control loops.

The INA901-SP operates from a single  $2.7$ -V to  $18$ -V supply, drawing a maximum of  $900$   $\mu$ A of supply current. The devices are specified over the extended operating temperature range of  $-55^{\circ}\text{C}$  to  $125^{\circ}\text{C}$  and are offered in an 8-pin CFP package.

### 8.2 Functional Block Diagram



## 8.3 Feature Description

### 8.3.1 Basic Connection

Figure 15 shows the basic connection of the INA901-SP. Connect the input pins (IN+ and IN-) as closely as possible to the shunt resistor to minimize any resistance in series with the shunt resistance.

Power-supply bypass capacitors are required for stability. Applications with noisy or high-impedance power supplies may require additional decoupling capacitors to reject power-supply noise. Place minimum bypass capacitors of  $0.01\text{ }\mu\text{F}$  and  $0.1\text{ }\mu\text{F}$  in value close to the supply pins. Although not mandatory, an additional  $10\text{-mF}$  electrolytic capacitor placed in parallel with the other bypass capacitors may be useful in applications with particularly noisy supplies.

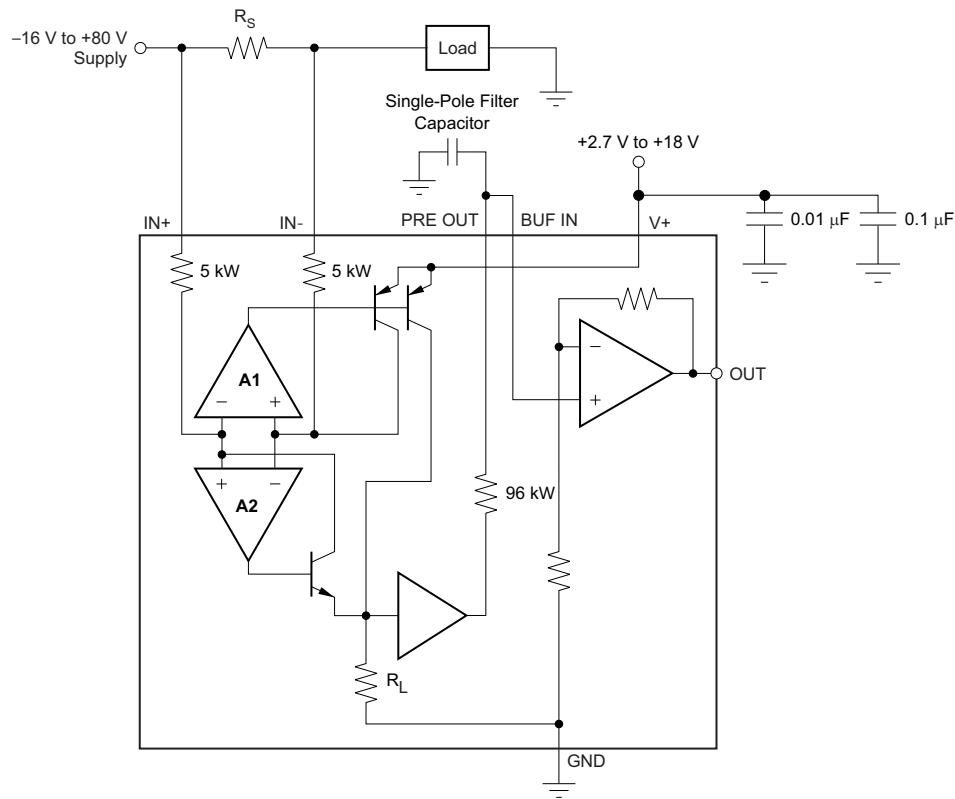


Figure 15. INA901-SP Basic Connections

### 8.3.2 Selecting $R_S$

The value chosen for the shunt resistor,  $R_S$ , depends on the application and is a compromise between small-signal accuracy and maximum permissible voltage loss in the measurement line. High values of  $R_S$  provide better accuracy at lower currents by minimizing the effects of offset, while low values of  $R_S$  minimize voltage loss in the supply line. For most applications, best performance is attained with an  $R_S$  value that provides a full-scale shunt voltage range of  $50\text{ mV}$  to  $100\text{ mV}$ . Maximum input voltage for accurate measurements is  $(V_S - 0.2) / \text{Gain}$ .

### 8.3.3 Transient Protection

The  $-16\text{-V}$  to  $80\text{-V}$  common-mode range of INA901-SP is ideal for withstanding fault conditions ranging from  $12\text{-V}$  battery reversal up to  $80\text{-V}$  transients because no additional protective components are needed up to those levels. In the event that INA901-SP is exposed to transients on the inputs in excess of their ratings, external transient absorption with semiconductor transient absorbers (Zeners or Transzorbs) are necessary.

## Feature Description (continued)

Use of MOVs or VDRs is not recommended except when they are used in addition to a semiconductor transient absorber. Select the transient absorber such that it never allows the INA901-SP to be exposed to transients greater than 80 V (that is, allow for transient absorber tolerance, as well as additional voltage because of transient absorber dynamic impedance). Despite the use of internal Zener-type ESD protection, the INA901-SP is not suited to using external resistors in series with the inputs because the internal gain resistors can vary up to  $\pm 30\%$ , but are tightly matched (if gain accuracy is not important, then resistors can be added in series with the INA901-SP inputs with two equal resistors on each input).

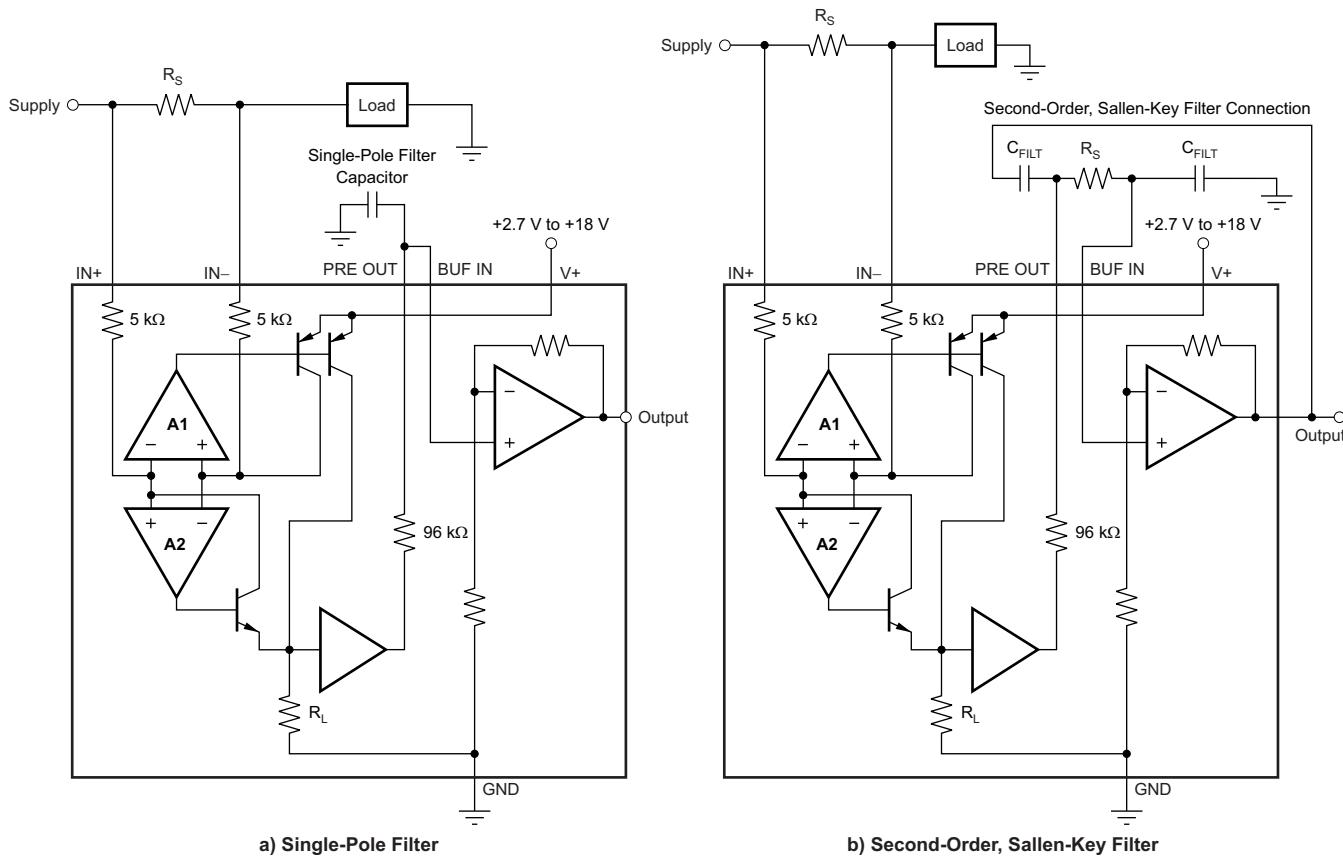
## 8.4 Device Functional Modes

### 8.4.1 First- or Second-Order Filtering

The output of the INA901-SP is accurate within the output voltage swing range set by the power-supply pin, V+.

The INA901-SP readily enables the inclusion of filtering between the preamp output and buffer input. Single-pole filtering can be accomplished with a single capacitor because of the 96-k $\Omega$  output impedance at PRE OUT on pin 3, as shown in [Figure 16a](#).

The INA901-SP readily lends to second-order Sallen-Key configurations, as shown in [Figure 16b](#). When designing these configurations consider that the PRE OUT 96-k $\Omega$  output impedance exhibits an initial variation of  $\pm 30\%$  with the addition of a  $-2200\text{-ppm}/^\circ\text{C}$  temperature coefficient.



NOTE: Remember to use the appropriate buffer gain = 2 when designing Sallen-Key configurations.

**Figure 16. The INA901-SP Can Be Easily Connected for First- or Second-Order Filtering**

### 8.4.2 Accuracy Variations as a Result of $V_{SENSE}$ and Common-Mode Voltage

The accuracy of the INA901-SP current shunt monitors is a function of two main variables:  $V_{SENSE}$  ( $V_{IN+} - V_{IN-}$ ) and common-mode voltage ( $V_{CM}$ ) relative to the supply voltage,  $V_S$ .  $V_{CM}$  is expressed as  $(V_{IN+} + V_{IN-}) / 2$ ; however, in practice,  $V_{CM}$  is used as the voltage at  $V_{IN+}$  because the voltage drop across  $V_{SENSE}$  is usually small.

This section addresses the accuracy of these specific operating regions:

Normal Case 1:  $V_{SENSE} \geq 20 \text{ mV}$ ,  $V_{CM} \geq V_S$

Normal Case 2:  $V_{SENSE} \geq 20 \text{ mV}$ ,  $V_{CM} < V_S$

Low  $V_{SENSE}$  Case 1:

$V_{SENSE} < 20 \text{ mV}$ ,  $-16 \text{ V} \leq V_{CM} < 0$

Low  $V_{SENSE}$  Case 2:

$V_{SENSE} < 20 \text{ mV}$ ,  $0 \text{ V} \leq V_{CM} \leq V_S$

## Device Functional Modes (continued)

Low  $V_{SENSE}$  Case 3:

$$V_{SENSE} < 20 \text{ mV}, V_S < V_{CM} \leq 80 \text{ V}$$

### 8.4.2.1 Normal Case 1: $V_{SENSE} \geq 20 \text{ mV}, V_{CM} \geq V_S$

This region of operation provides the highest accuracy. Here, the input offset voltage is characterized and measured using a two-step method. First, the gain is determined by [Equation 1](#).

$$G = \frac{V_{OUT1} - V_{OUT2}}{100\text{mV} - 20\text{mV}}$$

where

- $V_{OUT1}$  = Output voltage with  $V_{SENSE} = 100 \text{ mV}$  and
- $V_{OUT2}$  = Output voltage with  $V_{SENSE} = 20 \text{ mV}$ .

(1)

Then the offset voltage is measured at  $V_{SENSE} = 100 \text{ mV}$  and referred to the input (RTI) of the current shunt monitor, as shown in [Equation 2](#).

$$V_{OSRTI} \text{ (Referred-To-Input)} = \left( \frac{V_{OUT1}}{G} \right) - 100\text{mV} \quad (2)$$

In the [Typical Characteristics](#) section, the *Output Error vs Common-Mode Voltage* curve ([Figure 6](#)) shows the highest accuracy for this region of operation. In this plot,  $V_S = 12 \text{ V}$ ; for  $V_{CM} \geq 12 \text{ V}$ , the output error is at its minimum. This case is also used to create the  $V_{SENSE} \geq 20\text{-mV}$  output specifications in the [Electrical Characteristics](#) table.

### 8.4.2.2 Normal Case 2: $V_{SENSE} \geq 20 \text{ mV}, V_{CM} < V_S$

This region of operation has slightly less accuracy than [Normal Case 1](#) as a result of the common-mode operating area in which the device functions, as illustrated in the *Output Error vs Common-Mode Voltage* curve ([Figure 6](#)). As noted, for this graph  $V_S = 12 \text{ V}$ ; for  $V_{CM} < 12 \text{ V}$ , the output error increases when  $V_{CM}$  becomes less than 12 V, with a typical maximum error of 0.005% at the most negative  $V_{CM} = -16 \text{ V}$ .

### 8.4.2.3 Low $V_{SENSE}$ Case 1: $V_{SENSE} < 20 \text{ mV}, -16 \text{ V} \leq V_{CM} < 0$ ; and Low $V_{SENSE}$ Case 3: $V_{SENSE} < 20 \text{ mV}, V_S < V_{CM} \leq 80 \text{ V}$

Although the INA901-SP is not designed for accurate operation in either of these regions, some applications are exposed to these conditions. For example, when monitoring power supplies that are switched on and off while  $V_S$  is still applied to the INA901-SP, knowing what the behavior of the devices is in these regions is important.

## Device Functional Modes (continued)

When  $V_{SENSE}$  approaches 0 mV, in these  $V_{CM}$  regions, the device output accuracy degrades. A larger-than-normal offset can appear at the current shunt monitor output with a typical maximum value of  $V_{OUT} = 60$  mV for  $V_{SENSE} = 0$  mV. When  $V_{SENSE}$  approaches 20 mV,  $V_{OUT}$  returns to the expected output value with accuracy as specified in the *Electrical Characteristics* table. Figure 17 shows this effect using the INA901-SP (gain = 20).

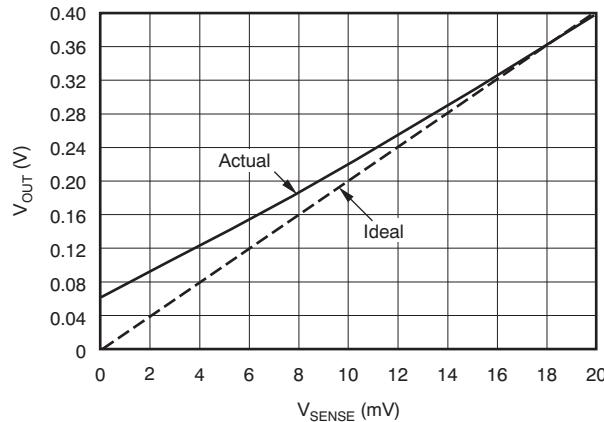


Figure 17. Example For Low  $V_{SENSE}$  Cases 1 and 3 (INA901-SP Gain = 20)

### 8.4.2.4 Low $V_{SENSE}$ Case 2: $V_{SENSE} < 20$ mV, $0$ V $\leq V_{CM} \leq V_S$

This region of operation is the least accurate for the INA901-SP. To achieve the wide input common-mode voltage range, these devices use two op amp front ends in parallel. One op amp front end operates in the positive input common-mode voltage range, and the other in the negative input region. For this case, neither of these two internal amplifiers dominates and overall loop gain is very low. Within this region,  $V_{OUT}$  approaches voltages close to linear operation levels for [Normal Case 2](#).

This deviation from linear operation becomes greatest the closer  $V_{SENSE}$  approaches 0 V. Within this region, when  $V_{SENSE}$  approaches 20 mV, device operation is closer to that described by [Normal Case 2](#). Figure 18 shows this behavior for the INA901-SP. The  $V_{OUT}$  maximum peak for this case is determined by maintaining a constant  $V_S$ , setting  $V_{SENSE} = 0$  mV, and sweeping  $V_{CM}$  from 0 V to  $V_S$ . The exact  $V_{CM}$  at which  $V_{OUT}$  peaks during this case varies from device to device. The maximum peak voltage for the INA901-SP is 0.4 V.

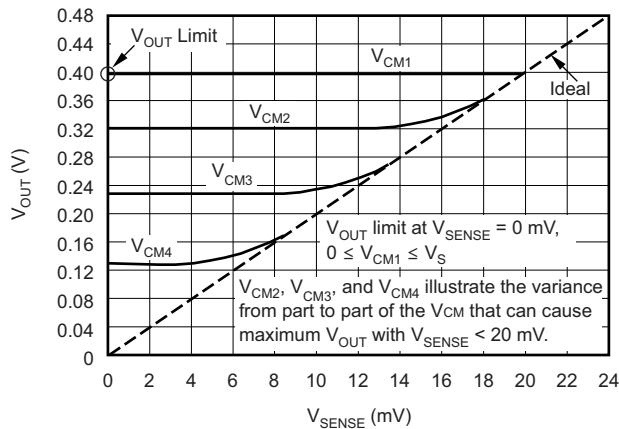


Figure 18. Example for Low  $V_{SENSE}$  Case 2 (INA901-SP, Gain = 20)

## 9 Application and Implementation

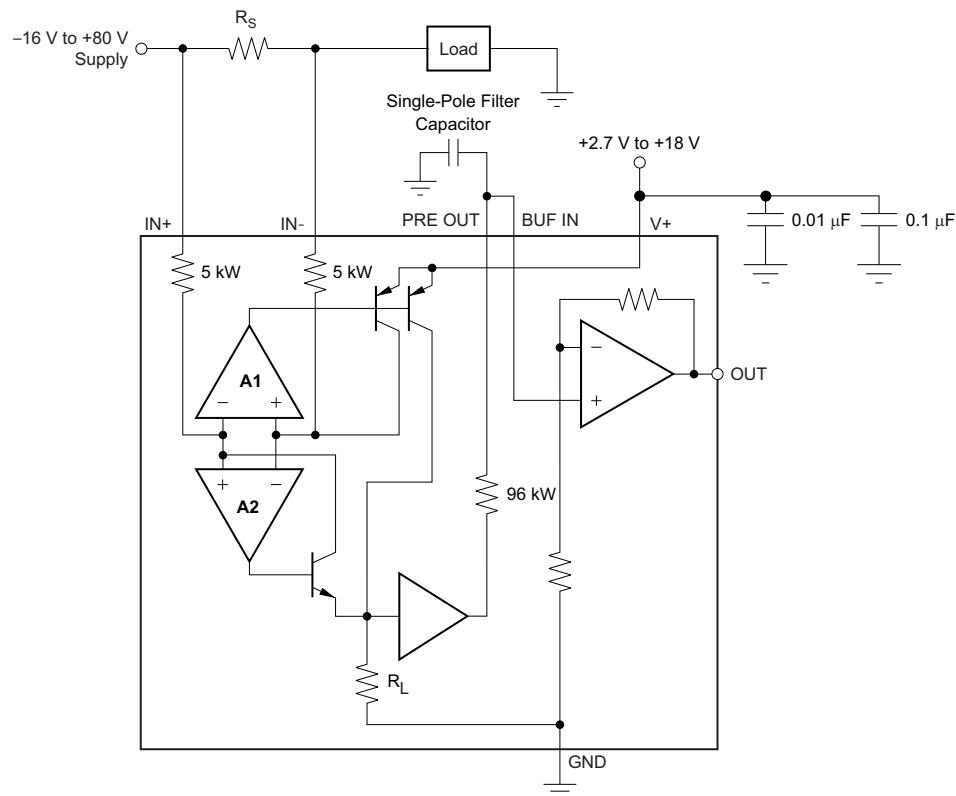
### NOTE

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.

### 9.1 Application Information

The INA901-SP measures the voltage developed across a current-sensing resistor when current passes through it. There is also a filtering feature to remove unwanted transients and smooth the output voltage.

### 9.2 Typical Application



**Figure 19. Filtering Configuration**

#### 9.2.1 Design Requirements

In this application, the device is configured to measure a triangular periodic current at 10 kHz with filtering. The average current through the shunt is the information that is desired. This current can be either solenoid current or inductor current where current is being pulsed through.

Selecting the capacitor size is based on the lowest frequency component to be filtered out. The amount of signal that is filtered out is dependant on this cutoff frequency. From the cutoff frequency, the attenuation is 20 dB per decade.

## Typical Application (continued)

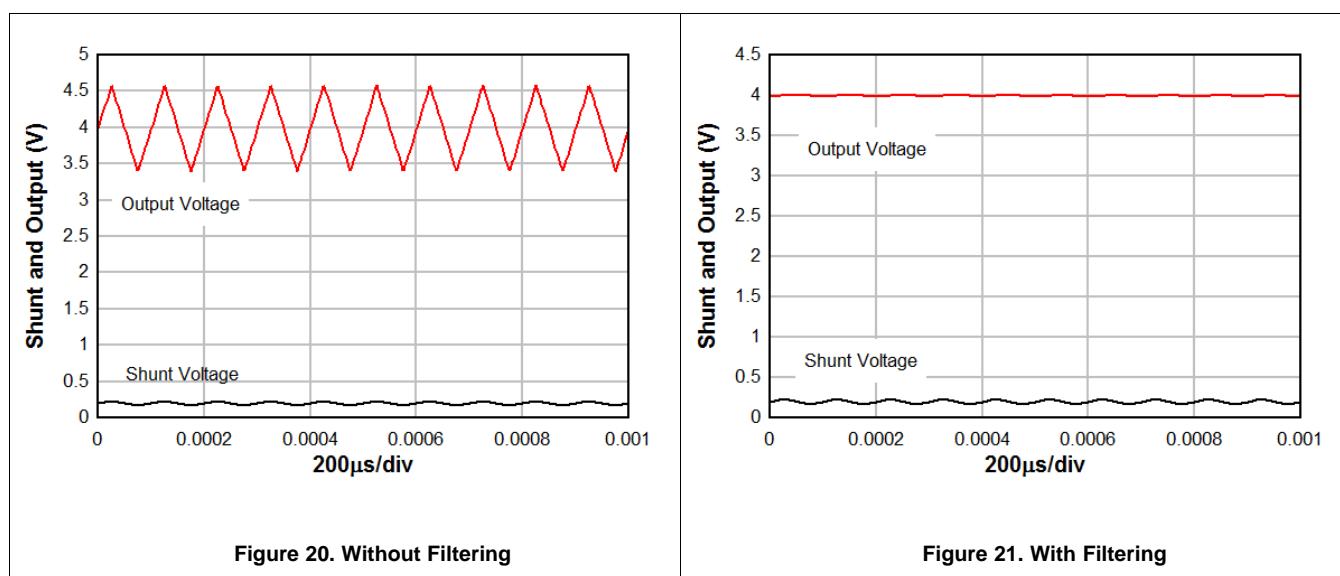
### 9.2.2 Detailed Design Procedure

Without this filtering capability, an input filter must be used. When series resistance is added to the input, large errors also come into play because the resistance must be large to create a low cutoff frequency. By using a 10-nF capacitor for the single-pole filter capacitor, the 10-kHz signal is averaged. The cutoff frequency made by the capacitor is set at 166-Hz frequency. This frequency is well below the periodic frequency and reduces the ripple on the output and the average current can easily be measured.

### 9.2.3 Application Curves

Figure 20 shows the output waveform without filtering. The output signal tracks the input signal with a large ripple. If this current is sampled by an ADC, many samples must be taken to average the current digitally. This process requires additional time for sampling or operating at a higher sampling rate, which may be undesirable for the application.

Figure 21 shows the output waveform with filtering. shows the output waveform with filtering. The average value of the current with a small ripple can now be easily sampled by the converter without the need for digital averaging.



## 10 Power Supply Recommendations

The input circuitry of the INA901-SP can accurately measure beyond its power-supply voltage, V+. For example, the V+ power supply can be 5 V, whereas the load power-supply voltage is up to 80 V. The output voltage range of the OUT terminal, however, is limited by the voltages on the power-supply pin.

## 11 Layout

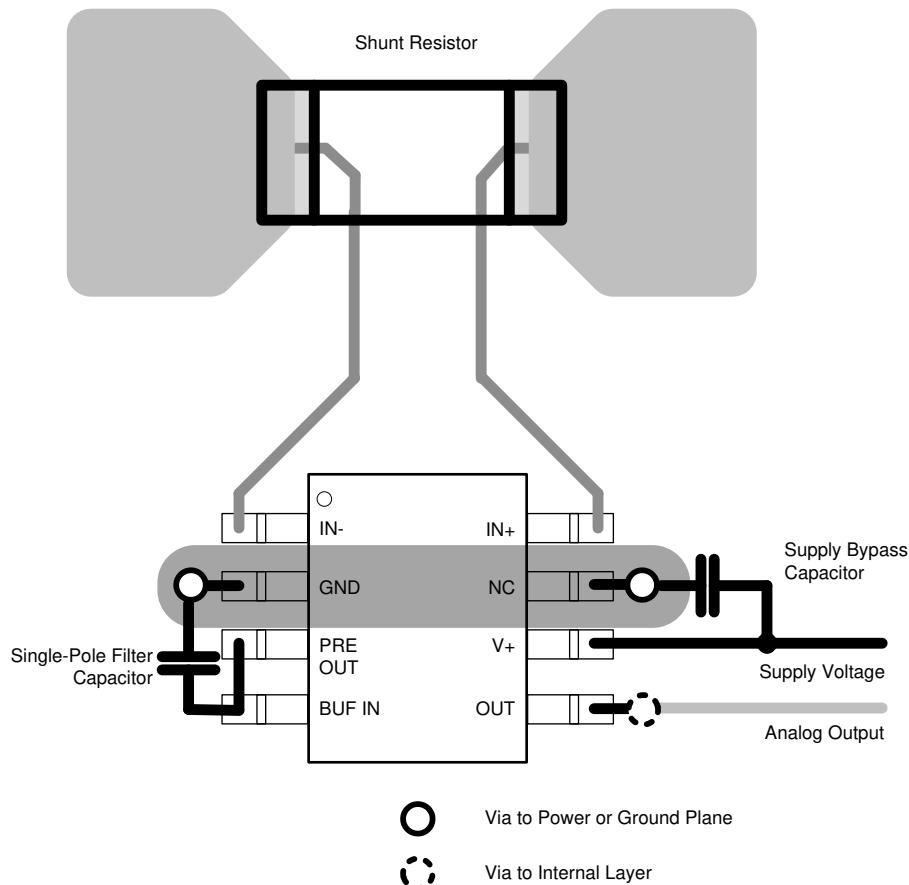
### 11.1 Layout Guidelines

- Connect the input pins to the sensing resistor using a Kelvin or 4-wire connection. This connection technique ensures 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 closely as possible to the supply and ground pins. The recommended value of this bypass capacitor is  $0.1 \mu\text{F}$ . Additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies.

#### 11.1.1 RFI and EMI

Attention to good layout practices is always recommended. Keep traces short and, when possible, use a printed circuit board (PCB) ground plane with surface-mount components placed as close to the device pins as possible. Small ceramic capacitors placed directly across amplifier inputs can reduce RFI and EMI sensitivity. PCB layout must locate the amplifier as far away as possible from RFI sources. Sources can include other components in the same system as the amplifier itself, such as inductors (particularly switched inductors handling a lot of current and at high frequencies). RFI can generally be identified as a variation in offset voltage or dc signal levels with changes in the interfering RF signal. If the amplifier cannot be located away from sources of radiation, shielding may be needed. Twisting wire input leads makes them more resistant to RF fields.

### 11.2 Layout Example



**Figure 22. Example Layout**

## 12 デバイスおよびドキュメントのサポート

### 12.1 ドキュメントのサポート

#### 12.1.1 関連資料

ti.comのINA901-SPプロダクト・フォルダで、[技術資料](#)および[ツールとソフトウェア](#)へのリンクを参照してください。

### 12.2 ドキュメントの更新通知を受け取る方法

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### 12.6 Glossary

#### [SLYZ022 — TI Glossary](#).

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

## 13 メカニカル、パッケージ、および注文情報

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**PACKAGING INFORMATION**

Orderable part number	Status (1)	Material type (2)	Package   Pins	Package qty   Carrier	RoHS (3)	Lead finish/ Ball material (4)	MSL rating/ Peak reflow (5)	Op temp (°C)	Part marking (6)
5962-1821001VXC	Active	Production	CFP (HKX)   8	25   TUBE	Yes	NIAU	N/A for Pkg Type	-55 to 125	1821001VXC INA901-SP
5962-1821001VXC.A	Active	Production	CFP (HKX)   8	25   TUBE	Yes	NIAU	N/A for Pkg Type	-55 to 125	1821001VXC INA901-SP
5962L1821001VXC	Active	Production	CFP (HKX)   8	25   TUBE	Yes	NIAU	N/A for Pkg Type	-55 to 125	5962L1821001VXC INA901-SP
5962L1821001VXC.A	Active	Production	CFP (HKX)   8	25   TUBE	Yes	NIAU	N/A for Pkg Type	-55 to 125	5962L1821001VXC INA901-SP
INA901HKX/EM	Active	Production	CFP (HKX)   8	25   TUBE	Yes	NIAU	N/A for Pkg Type	25 to 25	INA901HKX/EM
INA901HKX/EM.A	Active	Production	CFP (HKX)   8	25   TUBE	Yes	NIAU	N/A for Pkg Type	25 to 25	INA901HKX/EM

<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.

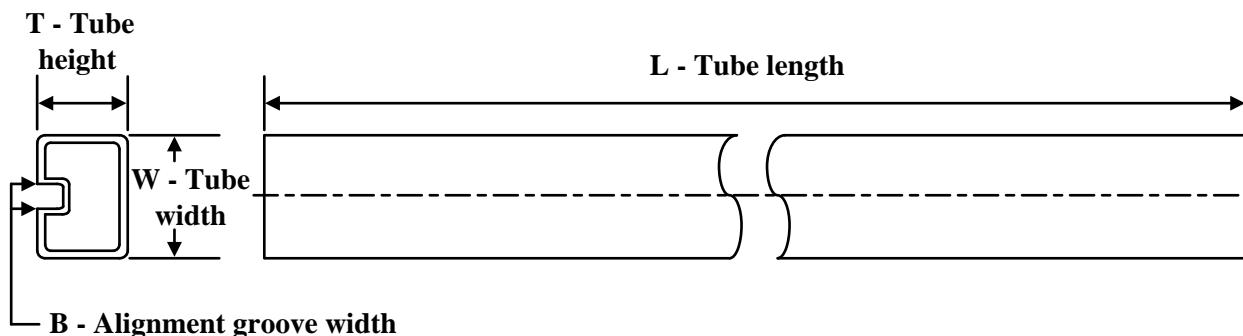
Multiple part markings will be inside parentheses. Only one part marking contained in parentheses and separated by a "~" will appear on a part. If a line is indented then it is a continuation of the previous line and the two combined represent the entire part marking for that device.

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**TUBE**


\*All dimensions are nominal

Device	Package Name	Package Type	Pins	SPQ	L (mm)	W (mm)	T ( $\mu$ m)	B (mm)
5962-1821001VXC	HKX	CFP (HSL)	8	25	506.98	26.16	6220	NA
5962-1821001VXC.A	HKX	CFP (HSL)	8	25	506.98	26.16	6220	NA
5962L1821001VXC	HKX	CFP (HSL)	8	25	506.98	26.16	6220	NA
5962L1821001VXC.A	HKX	CFP (HSL)	8	25	506.98	26.16	6220	NA
INA901HKX/EM	HKX	CFP (HSL)	8	25	506.98	26.16	6220	NA
INA901HKX/EM.A	HKX	CFP (HSL)	8	25	506.98	26.16	6220	NA

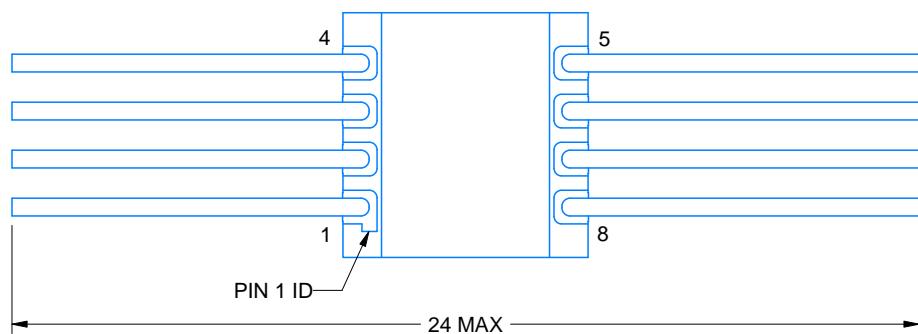
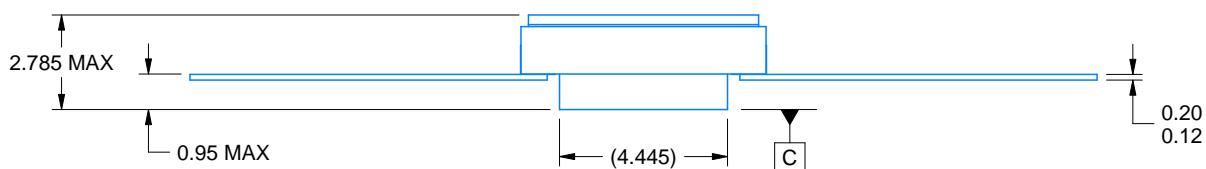
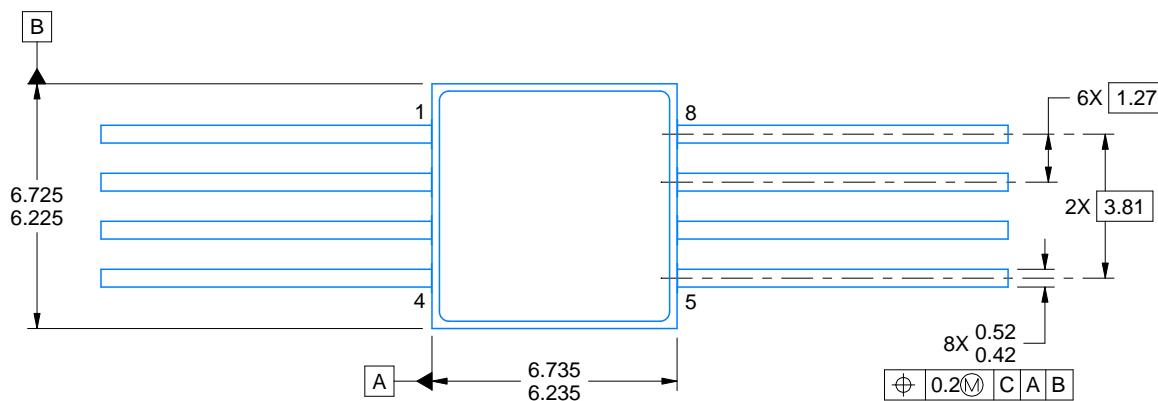


## PACKAGE OUTLINE

HKX0008A

**CFP - 2.785 mm max height**

## CERAMIC FLATPACK



4223439/C 08/2021

## 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. This package is hermetically sealed with a metal lid.
4. The leads are gold plated.

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