INA951-SEP –4V to 80V, 1.3MHz, Current Sense Amplifier

1 Features

- VID *In Progress*
- Radiation - Total Ionizing Dose (TID):
  - TID performance assurance up to 30krad(Si)
  - Radiation Lot Acceptance Testing (RLAT) for every wafer lot up to 30krad(Si)
- Radiation - Single-Event Effects (SEE):
  - Single Event Latch-Up (SEL) immune up to 43MeV-cm^2 /mg at 125°C
  - Single Event Transient (SET) characterized up to LET = 47.5MeV-cm2 /mg
- Supports defense, aerospace, and medical applications
  - Operating temperature from –55°C to +125°C
  - Controlled baseline
  - Au bondwire and NiPdAu lead finish
  - Outgassing test performed per ASTM E595
  - One fabrication, assembly, and test site
  - Extended product life cycle
  - Product traceability
- Wide common-mode voltage:
  - Operational voltage: −4V to +80V
  - Survival voltage: −20V to +85V
- Excellent CMRR:
  - 160dB DC-CMRR
  - 85dB AC-CMRR at 50kHz
- Accuracy:
  - Gain:
    - Gain error: ±0.15% (maximum)
    - Gain drift: ±10ppm/ °C (maximum)
  - Offset:
    - Offset voltage: ±30µV (typical)
    - Offset drift: ±0.05µV/ °C (typical)
- Available gain:
  - INA951-SEP A1, : 20V/V
- High bandwidth: 1.3MHz
- Slew rate: 2.5V/µs
- Quiescent current: 1.5mA

2 Applications

- Satellite electrical power system (EPS)
- Command and data handling (C&DH)
- Radar imaging payload
- Communications payload

3 Description

The INA951-SEP is a current sense amplifier that can measure voltage drops across shunt resistors over a wide common-mode range from –4V to 80V. The negative common-mode voltage allows the device to operate below ground, thus accommodating precise measurement of recirculating currents in half-bridge applications. The combination of a low offset voltage, small gain error and high DC CMRR enables highly accurate current measurement. The INA951-SEP is not only designed for DC current measurement, but also for high-speed applications (ex. Fast over-current protection) with a high bandwidth of 1.3MHz and an 85dB AC CMRR (at 50kHz).

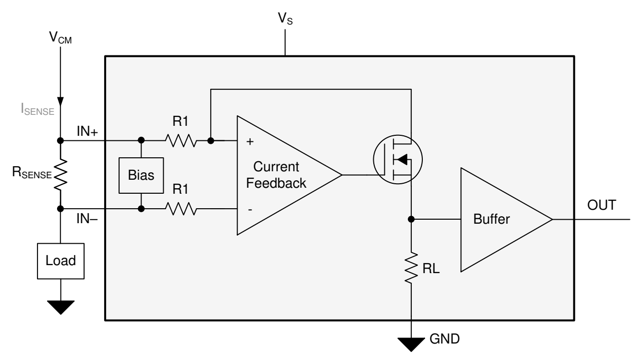
The INA951-SEP operates from a single 2.7V to 10V supply, drawing 1.5mA of supply current. The INA951-SEP is available with a gain option of 20V/V.

The INA951-SEP is specified over an operating temperature range of −40°C to +125°C and is offered in a space-saving SOT-23 package.

Packaging Information

PART NUMBER	PACKAGE(1)	PACKAGE SIZE(2)
INA951-SEP	DBV (SOT-23, 5)	2.90mm × 2.80mm

(1) For more information, see Section 10.
(2) The package size (length × width) is a nominal value and includes pins, where applicable.



Functional Block Diagram

ADVANCE INFORMATION

ADVANCE INFORMATION

Table of Contents

4 Pin Configuration and Functions

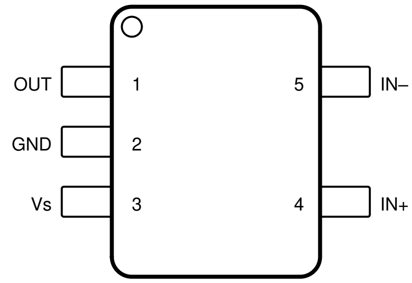


Figure 4-1. INA951-SEP DBV 5-Pin SOT-23 Top View

Table 4-1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	INA951-SEP		
GND	2	Ground	Ground
OUT	1	Output	Output voltage
Vs	3	Power	Power supply
IN+	4	Input	Shunt resistor positive sense input
IN–	5	Input	Shunt resistor negative sense input

ADVANCE INFORMATION

ADVANCE INFORMATION

5 Specifications

5.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Supply Voltage (V_s)		–0.3	12	V
Analog Inputs, V_{IN+}, $V_{IN–}$ [2]	Common - mode	–20	90	V
Output		GND – 0.3	Vs + 0.3	V
T_A	Operating temperature	–55	150	°C
T_J	Junction temperature		150	°C
T_{stg}	Storage temperature	–65	150	°C

(1) Operation outside the Absolute Maximum Ratings may cause permanent device damage. Absolute Maximum Ratings do not imply functional operation of the device at these or any other conditions beyond those listed under Recommended Operating Conditions. If used outside the Recommended Operating Conditions but within the Absolute Maximum Ratings, the device may not be fully functional, and this may affect device reliability, functionality, performance, and shorten the device lifetime.
(2) VIN+ and VIN– are the voltages at the IN+ and IN– pins, respectively.

5.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per ANSI/ESDA/JEDEC JS-001, all pins[1]	±2000	V
		Charged device model (CDM), per JEDEC specification JESD22C101, all pins[2]	±1000	

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

5.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{CM}	Common-mode input range	–4	48	80	V
V_S	Operating supply range	2.7	5	10	V
V_{SENSE}	Differential sense input range	0		V_S / 20	V
T_A	Ambient temperature	–55		125	°C

5.4 Thermal Information

THERMAL METRIC[1]		INA951-SEP DBV (SOT-23) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	184.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	105.6	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	47.2	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	21.5	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	46.9	°C/W
$R_{\theta JC(bot)}$	Junction-to-case (bottom) thermal resistance	N/A	°C/W

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

5.5 Electrical Characteristics

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

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT						
V_{CM}	Common-mode input range[(1)]	T_A = –55°C to +125°C	–4		80	V
CMRR	Common-mode rejection ratio, input referred	–4V ≤ V_{CM} ≤ 80V, T_A = –55°C to +125°C	140	160		dB
		f = 50kHz		85		dB
V_{os}	Offset voltage, input referred			±30	±150	µV
dV_{os}/dT	Offset voltage drift	T_A = –55°C to +125°C		±0.05		µV/°C
PSRR	Power supply rejection ratio, input referred	2.7V ≤ V_S ≤ 10V, T_A = –55°C to +125°C		±1	±8	µV/V
I_B	Input bias current	I_{B+}, V_{SENSE} = 0V	10	20	30	µA
		I_{B-}, V_{SENSE} = 0V	10	20	30	µA
OUTPUT						
G	Gain			20		V/V
G_{ERR}	Gain error	GND + 50mV ≤ V_{OUT} ≤ V_S – 200mV		±0.02	±0.15	%
		T_A = –55°C to +125°C		±1		ppm/°C
NL_{ERR}	Nonlinearity error			0.01		%
	Maximum capacitive load	No sustained oscillations, no isolation resistor		500		pF
VOLTAGE OUTPUT						
	Swing to Vs (Power supply rail)	R_{LOAD} = 10kΩ, T_A = –55°C to +125°C		Vs – 0.07	Vs – 0.15	V
	Swing to ground	R_{LOAD} = 10kΩ, V_{SENSE} = 0V, T_A = –55°C to +125°C		0.005	0.02	V
FREQUENCY RESPONSE						
BW	Bandwidth	C_{LOAD} = 5pF, V_{SENSE} = 200mV		1300		kHz
SR	Slew rate	Rising edge		2.5		V/µs
	Settling time	V_{OUT} = 4V ± 0.1V step, Output settles to 0.5%		10		µs
		V_{OUT} = 4V ± 0.1V step, Output settles to 1%		5		µs
		V_{OUT} = 4V ± 0.1V step, Output settles to 5%		1		µs
NOISE						
Ven	Voltage noise density			50		nV/√Hz
POWER SUPPLY						
Vs	Supply voltage	T_A = –55°C to +125°C	2.7		10	V
I_Q	Quiescent current			1.5	2	mA
		T_A = –55°C to +125°C			2.25	mA

(1) Common-mode voltage at both V_{IN+} and V_{IN-} must not exceed the specified common-mode input range.

ADVANCE INFORMATION

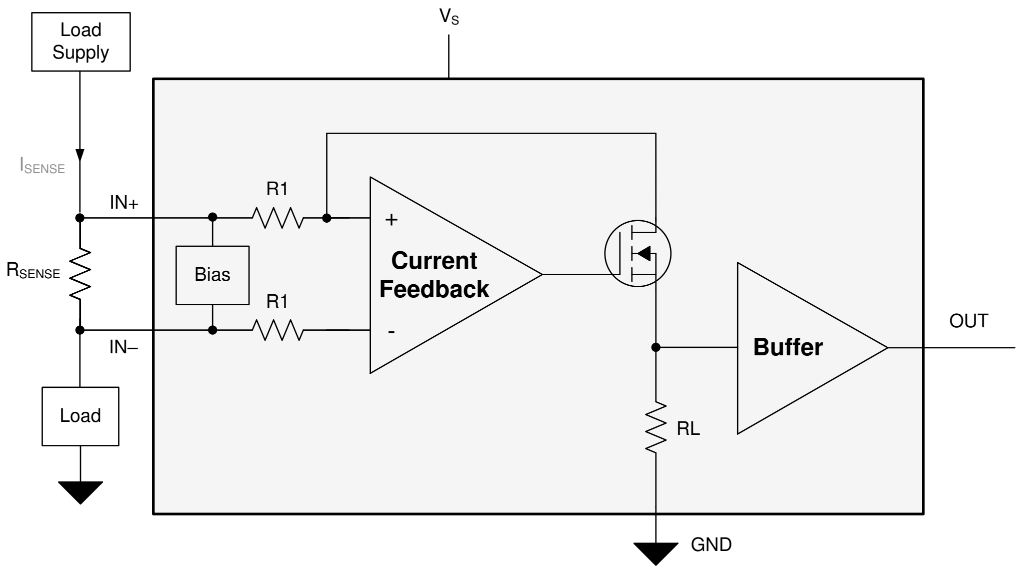
ADVANCE INFORMATION

6 Detailed Description

6.1 Overview

The INA951-SEP is a high- or low-side current-sense amplifier that offers a wide common-mode range, precision zero-drift topology, excellent common-mode rejection ratio (CMRR), high bandwidth, and fast slew rate. The device is designed using a transconductance architecture with a current-feedback amplifier that enables low bias currents of 20µA with a common-mode voltage of 80V.

6.2 Functional Block Diagram



6.3 Feature Description

6.3.1 Amplifier Input Common-Mode Signal

The INA951-SEP supports large input common-mode voltages from –4V to +80V. Because of the internal topology, the common-mode range is not restricted by the power-supply voltage (V_S). This allows for the INA951-SEP to be used for both low and high side current-sensing applications.

6.3.1.1 Input-Signal Bandwidth

The unique multistage design enables the amplifier to achieve high bandwidth. 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, with the bandwidth increasing with higher V_{SENSE} voltages.

6.3.1.2 Low Input Bias Current

The INA951-SEP inputs draw a 20µA (typical) bias current at a common-mode voltage as high as 80V, which enables precision current sensing on applications that require lower current leakage.

6.3.1.3 Low V_{SENSE} Operation

The INA951-SEP operates with high performance across the entire valid V_{SENSE} range. The zero-drift input architecture of the INA951-SEP provides the low offset voltage and low offset drift needed to measure low V_{SENSE} levels accurately across the wide operating temperature of –40°C to +125°C. Low V_{SENSE} operation is particularly beneficial when using low ohmic shunts for low current measurements, as power losses across the shunt are significantly reduced.

6.3.1.4 Wide Fixed Gain Output

The INA951-SEP gain error is < 0.15% at room temperature, with a maximum drift of 10ppm/°C over the full temperature range of –40°C to +125°C. The INA951-SEP is available in a gain option of 20V/V.

The INA951-SEP closed-loop gain is set by a precision, low drift internal resistor network. The ratio of these resistors are excellently matched, while the absolute values can vary significantly. Adding additional resistance around the INA951-SEP to change the effective gain is not recommended, however, because of this variation. The typical values of the gain resistors are described in Table 6-1.

Table 6-1. Fixed Gain Resistor

GAIN	R1	RL
20 (V/V)	25kΩ	500kΩ

6.3.1.5 Wide Supply Range

The INA951-SEP operates with a wide supply range from 2.7V to 10V. The output stage supports a wide output range while allowing a maximum acceptable differential input of 1V when operated at a supply voltage of 10V. When paired with the small input offset voltage of the INA951-SEP , systems with very wide dynamic range of current measurement can be supported.

ADVANCE INFORMATION

6.4 Device Functional Modes

6.4.1 Unidirectional Operation

The INA951-SEP measures the differential voltage developed by current flowing through a resistor, commonly referred to as a current-sensing resistor or a current-shunt resistor. The INA951-SEP operates in unidirectional mode only, meaning the device only senses current sourced from a power supply to a system load as shown in Figure 6-1.

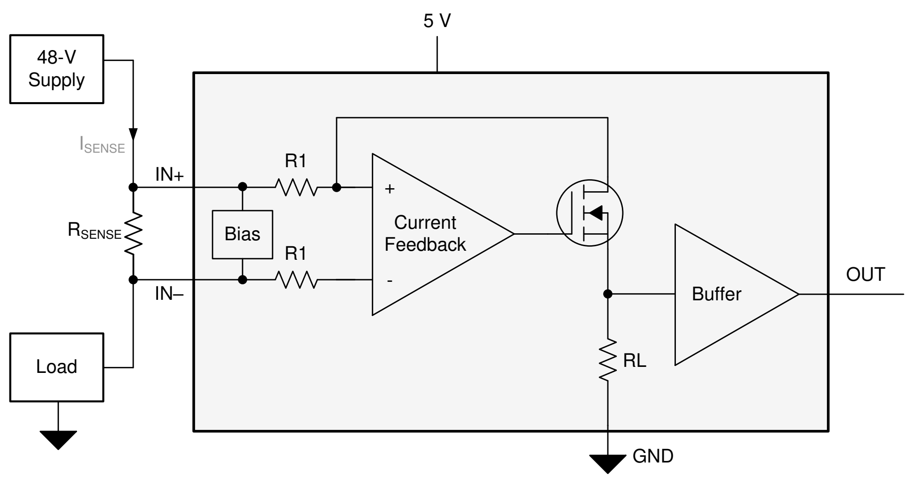


Figure 6-1. Unidirectional Application

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 INA951-SEP is very small, with a maximum of GND + 20mV. Make sure to apply a differential input voltage of (20mV / Gain) or greater to keep the INA951-SEP output in the linear region of operation.

6.4.2 High Signal Throughput

With a bandwidth of 1.3MHz at a gain of 20V/V and a slew rate of 2.5V/µs, the INA951-SEP is specifically designed for detecting and protecting applications from fast inrush currents. As shown in Table 6-2, the INA951-SEP responds in less than 2µs for a system measuring a 75A threshold on a 2mΩ shunt.

Table 6-2. Response Time

PARAMETER		EQUATION	INA951-SEP AT V_S = 5V
G	Gain		20V/V
I_{MAX}	Maximum current		100A
$I_{Threshold}$	Threshold current		75A
R_{SENSE}	Current sense resistor value		2mΩ
V_{OUT_MAX}	Output voltage at maximum current	$V_{OUT\_MAX} = I_{MAX} \times R_{SENSE} \times G$	4V
V_{OUT_THR}	Output voltage at threshold current	$V_{OUT\_THR} = I_{THR} \times R_{SENSE} \times G$	3V
SR	Slew rate		2.5V/µs
	Output response time	$T_{response} = V_{OUT\_THR} / SR$	< 2µs

ADVANCE INFORMATION

7 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, as well as validating and testing their design implementation to confirm system functionality.

7.1 Application Information

The INA951-SEP 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 INA951-SEP make it usable over a wide range of voltage rails while still maintaining an accurate current measurement.

7.1.1 R_{SENSE} 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_{MAX} is the maximum allowable power dissipation in R_{SENSE}.
- I_{MAX} is the maximum current that flows through R_{SENSE}.

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.

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

where:

- I_{MAX} is the maximum current that flows through R_{SENSE}.
- GAIN is the gain of the current-sense amplifier.
- V_{SP} is the positive output swing as specified in the data sheet.

To avoid positive output swing limitations when selecting the value of R_{SENSE}, 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 selecting a lower-gain device to avoid positive swing limitations is also possible.

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.

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

where:

- I_{MIN} is the minimum current that flows through R_{SENSE}.

ADVANCE INFORMATION

ADVANCE INFORMATION

- GAIN is the gain of the current-sense amplifier.
- V_{SN} is the negative output swing of the device.

Table 7-1 shows an example of the different results obtained from using five different gain versions of the INA951-SEP . From the table data, the highest gain device allows a smaller current-shunt resistor and decreased power dissipation in the element.

Table 7-1. R_{SENSE} Selection and Power Dissipation

PARAMETER[1]		EQUATION	RESULTS AT V_S = 5V
			A1 DEVICES
G	Gain		20V/V
V_{DIFF}	Ideal differential input voltage	$V_{DIFF} = V_{OUT} / G$	250mV
R_{SENSE}	Current sense resistor value	$R_{SENSE} = V_{DIFF} / I_{MAX}$	25mΩ
P_{SENSE}	Current-sense resistor power dissipation	$R_{SENSE} \times I_{MAX}2$	2.5W

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

7.1.2 Input Filtering

Note

Input filters are not required for accurate measurements using the INA951-SEP , 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 can 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 satisfies the filtering requirement also, however the components must be carefully selected to minimally impact device performance. Figure 7-1 shows a filter placed at the input pins.

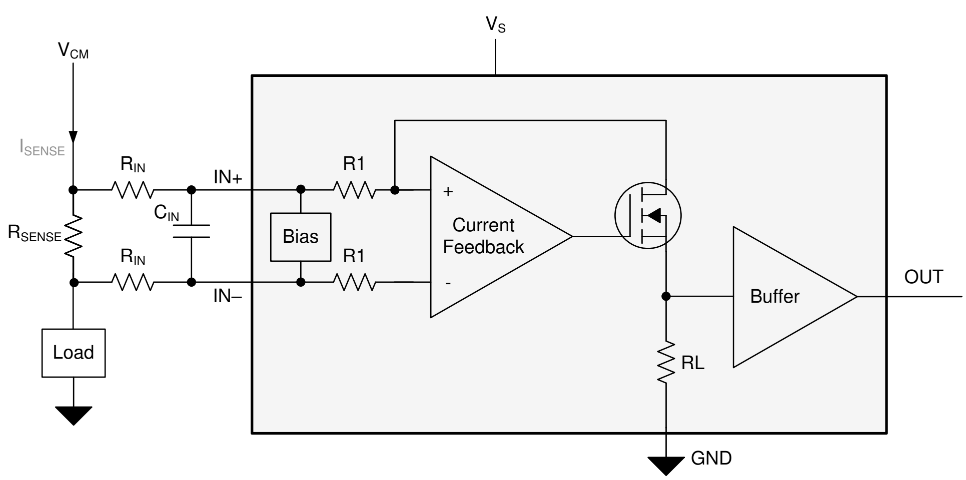


Figure 7-1. Filter at Input Pins

External series resistance provides a source of additional measurement error, so keep the value of these series resistors to 10Ω or less to reduce loss of accuracy. The internal bias network shown in Figure 7-1 creates a mismatch in input bias currents 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.

$$\text{Gain Error (\%)} = 100 - (100 \times \text{Gain Error Factor}) \quad (4)$$

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 7-2 provides the gain error factor and gain error for several resistor values.

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

Where:

- R_{IN} is the external filter resistance value.
- R1 is the INA951-SEP input resistance value specified in Table 6-1.
- R_B in the internal bias resistance, which is 6600Ω ± 20%.

Table 7-2. Example Gain Error Factor and Gain Error for 10Ω External Filter Input Resistors

DEVICE (GAIN)	GAIN ERROR FACTOR	GAIN ERROR (%)
INA951-SEP x1 (20)	0.997108386	-0.289161432

7.2 Typical Application

The INA951-SEP is a unidirectional, current-sense amplifier capable of measuring currents through a resistive shunt with shunt common-mode voltages from –4V to +80V.

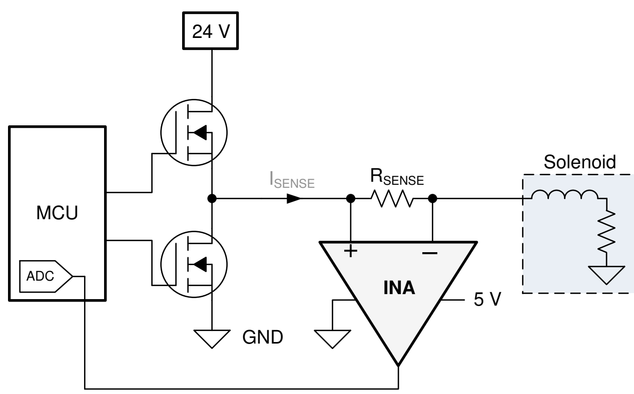


Figure 7-2. Current Sensing in a Solenoid Application

7.2.1 Design Requirements

In this example application, the common-mode voltage ranges from 0V to 24V. The maximum sense current is 1.5A, and a 5V supply is available for the INA951-SEP . Following the design guidelines from the *R_{SENSE} and Device Gain Selection* section, a R_{SENSE} of 125mΩ and a gain of 20V/V are selected to provide good output dynamic range. Table 7-3 lists the design setup for this application.

Table 7-3. Design Parameters

DESIGN PARAMETERS	EXAMPLE VALUE
Power supply voltage	5V
Common-mode voltage range	0V to 24V
Maximum sense current	1.5A
R_{SENSE} resistor	125 mΩ

Table 7-3. Design Parameters (continued)

DESIGN PARAMETERS	EXAMPLE VALUE
Gain option	20V/V

7.2.2 Detailed Design Procedure

The INA951-SEP is designed to measure current in a typical solenoid application. The INA951-SEP measures current across the 125mΩ shunt that is placed at the output of the half-bridge. The INA951-SEP measures the differential voltage across the shunt resistor, and the signal is internally amplified with a gain of 20V/V. The output of the INA951-SEP is connected to the analog-to-digital converter (ADC) of an MCU to digitize the current measurements.

Solenoid loads are highly inductive and are often prone to failure. Solenoids are often used for position control, precise fluid control, and fluid regulation. Measuring real-time current on the solenoid continuously can indicate premature failure of the solenoid which can lead to a faulty control loop in the system. Measuring high-side current also indicates if there are any ground faults on the solenoid or the FETs that can be damaged in an application. The INA951-SEP , with high bandwidth and slew rate, can be used to detect fast overcurrent conditions to prevent the solenoid damage from short-to-ground faults.

7.2.2.1 Overload Recovery With Negative V_{SENSE}

The INA951-SEP is a unidirectional current sense amplifier that is meant to operate with a positive differential input voltage (V_{SENSE}). If negative V_{SENSE} is applied, the device is placed in an overload condition and requires time to recover once V_{SENSE} returns positive. The required overload recovery time increases with more negative V_{SENSE}.

7.2.3 Application Curve

Figure 7-3 shows the output response of a solenoid.

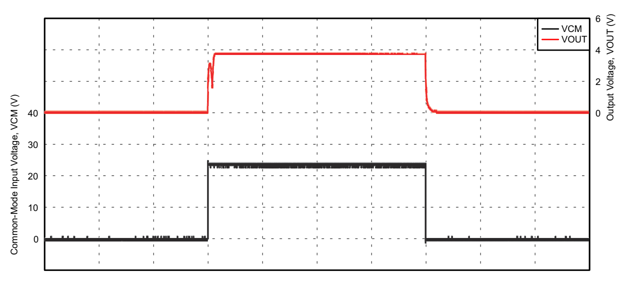


Figure 7-3. Solenoid Control Current Response

7.3 Power Supply Recommendations

The INA951-SEP power supply can be 5V, whereas the input common-mode voltage can vary between –4V to 80V. The output voltage range of the OUT pin, however, is limited by the voltage on the power-supply pin.

7.4 Layout

7.4.1 Layout Guidelines

Attention to good layout practices is always recommended.

- 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 as possible to the device power supply and ground pins. The recommended value of this bypass capacitor is 0.1μF. Additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies.

7.4.2 Layout Example

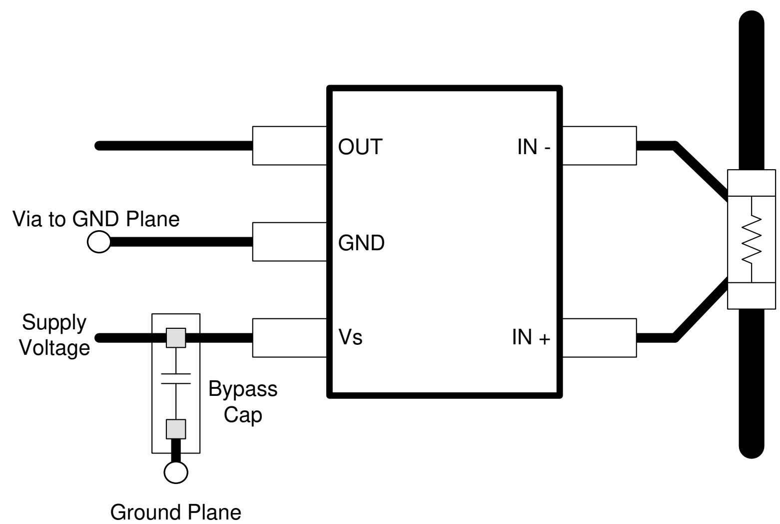


Figure 7-4. INA951-SEP Recommended Layout

ADVANCE INFORMATION

8 Device and Documentation Support

8.1 Receiving Notification of Documentation Updates

To receive notification of documentation updates, navigate to the device product folder on ti.com. Click on *Notifications* 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.

8.2 Support Resources

TI E2E™ 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.

Linked content is provided "AS IS" by the respective contributors. They do not constitute TI specifications and do not necessarily reflect TI's views; see TI's Terms of Use.

8.3 Trademarks

TI E2E™ is a trademark of Texas Instruments.
All trademarks are the property of their respective owners.

8.4 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.

8.5 Glossary

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

9 Revision History

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

DATE	REVISION	NOTES
February 2026	*	Initial Release

10 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.

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)
PINA951A1MDBVTSEP	Active	Preproduction	SOT-23 (DBV) | 5	250 | SMALL T&R	-	Call TI	Call TI	-55 to 125	

(1) **Status:** For more details on status, see our product life cycle.

(2) **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.

(3) **RoHS values:** Yes, No, RoHS Exempt. See the TI RoHS Statement for additional information and value definition.

(4) **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.

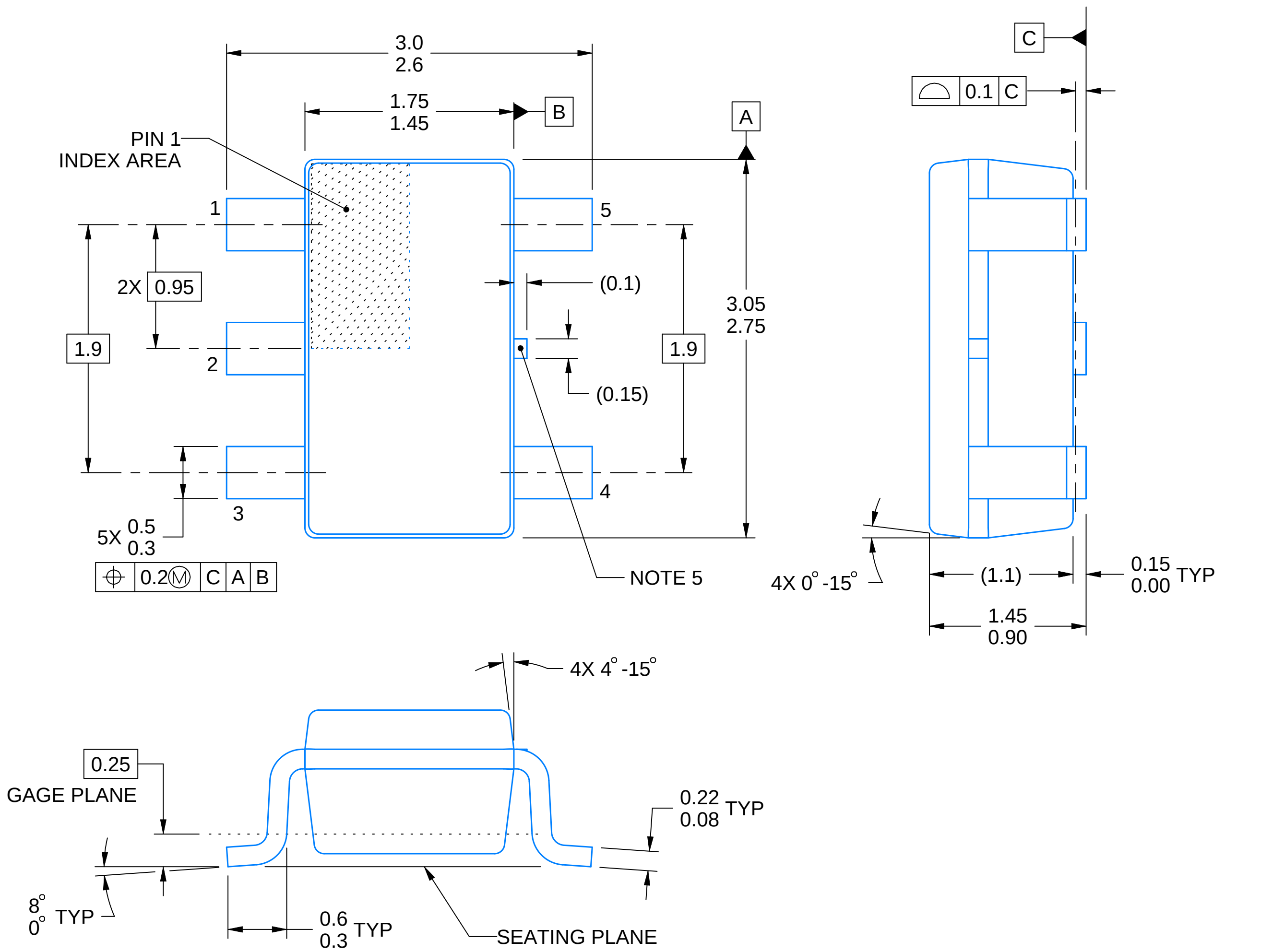
(5) **MSL rating/Peak reflow:** The moisture sensitivity level ratings and peak solder (reflow) temperatures. In the event that a part has multiple moisture sensitivity ratings, only the lowest level per JEDEC standards is shown. Refer to the shipping label for the actual reflow temperature that will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

(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.

Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. Efforts are underway to better integrate information from third parties. TI has taken and continues to take reasonable steps to provide representative and accurate information but may not have conducted destructive testing or chemical analysis on incoming materials and chemicals. TI and TI suppliers consider certain information to be proprietary, and thus CAS numbers and other limited information may not be available for release.

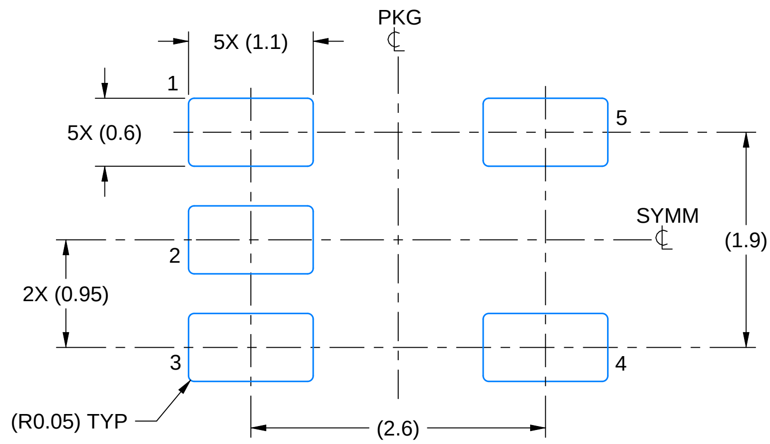
In no event shall TI's liability arising out of such information exceed the total purchase price of the TI part(s) at issue in this document sold by TI to Customer on an annual basis.



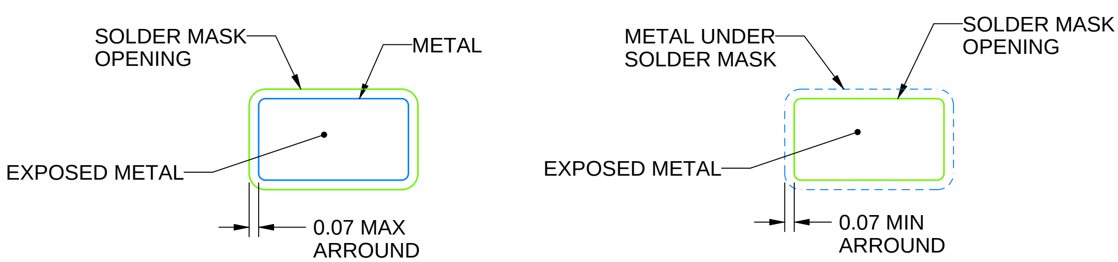
4214839/K 08/2024

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. Refernce JEDEC MO-178.
4. Body dimensions do not include mold flash, protrusions, or gate burrs. Mold flash, protrusions, or gate burrs shall not exceed 0.25 mm per side.
5. Support pin may differ or may not be present.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



NON SOLDER MASK
DEFINED
(PREFERRED)

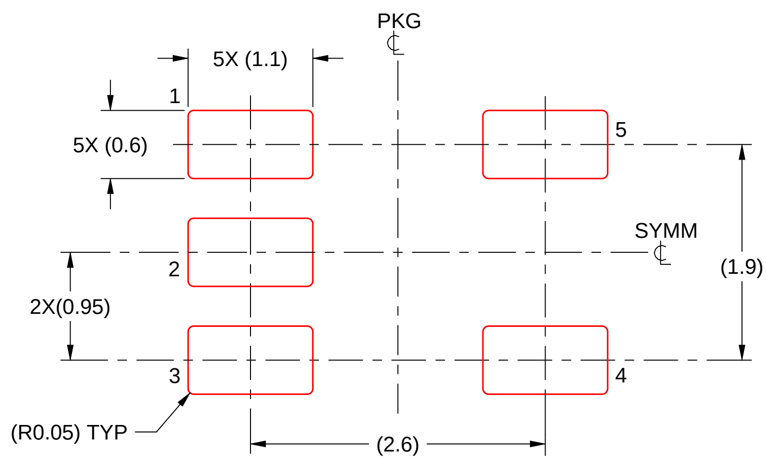
SOLDER MASK
DEFINED

SOLDER MASK DETAILS

4214839/K 08/2024

NOTES: (continued)

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



SOLDER PASTE EXAMPLE
BASED ON 0.125 mm THICK STENCIL
SCALE:15X

4214839/K 08/2024

NOTES: (continued)

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