INA293-Q1 Automotive, 110-V Common-Mode, High-Voltage, High-Bandwidth, Zero-Drift, Unidirectional, Current-Sense Amplifier

1 Features

- AEC-Q100 qualified for automotive applications:
  - Temperature grade 1: –40°C to +125°C, T_A
- Wide common-mode voltage:
  - Operational voltage: −4 V to +110 V
  - Survival voltage: −20 V to +116 V
- Excellent CMRR
  - 160-dB dc CMRR
  - 85-dB ac CMRR at 50 kHz
- Accuracy
  - Gain
    - Gain error: 0.2% (maximum)
    - Gain drift: 10 ppm/°C (maximum)
  - Offset
    - Offset voltage: ±200 µV (maximum)
    - Offset drift: ±1 µV/°C (maximum)
- Available gains:
  - INA293A1-Q1, INA293B1-Q1: 20 V/V
  - INA293A2-Q1, INA293B2-Q1: 50 V/V
  - INA293A3-Q1, INA293B3-Q1: 100 V/V
  - INA293A4-Q1, INA293B4-Q1: 200 V/V
  - INA293A5-Q1, INA293B5-Q1: 500 V/V
- Bandwidth: 1 MHz
- Slew rate: 3 V/µs
- Quiescent current: 1.5 mA

2 Applications

- 48-V automotive
- Solenoid control
- 48-V DC/DC converter
- Valve control
- Telecom equipment
- Power supplies

3 Description

The INA293-Q1 is a versatile, automotive, high-voltage, unidirectional, voltage-output, current-sense amplifier that senses voltage drops across external sense (shunt) resistors over a wide common-mode voltage range from –4 V to 110 V. The negative common-mode voltage allows the device to operate below ground, thus accommodating the precise measurement of a recirculating current in typical h-bridge applications. The INA293-Q1 amplifier has a bandwidth of 1 MHz at gain of 20 V/V. The 1-MHz bandwidth in combination with a low offset of < 200 uV (max) provides fast settling response with accurate measurements in a large common-mode switching transients.

The INA293-Q1 operates from a single 2.7-V to 20-V supply, drawing 1.5 mA of supply current. The INA293-Q1 is available with five gain options: 20 V/V, 50 V/V, 100 V/V, 200 V/V, and 500 V/V. These gain options address wide dynamic current-sensing applications.

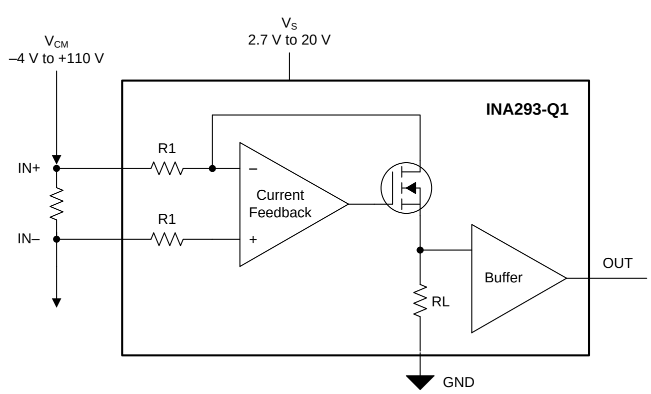
The INA293-Q1 is specified over the operating temperature range of −40°C to +125°C, and is offered in a space-saving SOT-23 package.

Device Information(1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
INA293-Q1	SOT-23 (5)	2.90 mm × 1.60 mm

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

Functional Block Diagram



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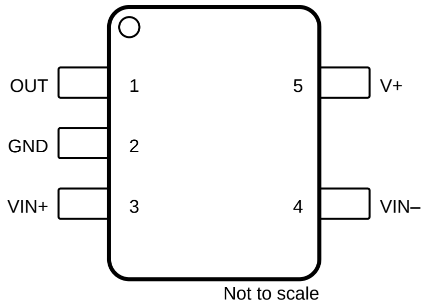
4 Revision History

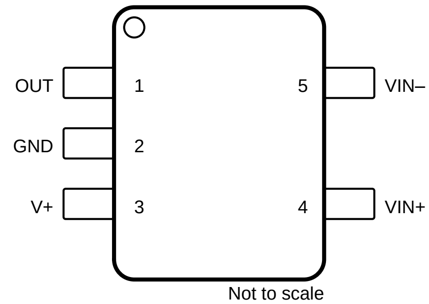
DATE	REVISION	NOTES
May 2019	*	Initial release

5 Pin Configuration and Functions

INA293A-Q1: DBV Package
5-Pin SOT-23
Top View



INA293B-Q1: DBV Package[(1)]
5-Pin SOT-23
Top View



(1) INA293B-Q1 is a preview device.

Pin Functions

PIN			TYPE	DESCRIPTION
NAME	INA293A-Q1	INA293B-Q1		
GND	2	2	Ground	Ground
OUT	1	1	Output	Output voltage
V+	5	3	Analog	Power supply, 2.7 V to 20 V
VIN+	3	4	Input	Connect to supply side of shunt resistor
VIN–	4	5	Input	Connect to load side of shunt resistor

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
V_S	Supply voltage		21	V
	Analog input, differential ($V_{IN+} – V_{IN–}$) [(2)]	–12	12	V
	Analog inputs, V_{IN+}, $V_{IN–}$ common-mode [(2)]	–20	116	V
	Output	GND – 0.3	V_S + 0.3	V
T_A	Operating temperature	–55	150	°C
T_J	Junction temperature		150	°C
T_{stg}	Storage temperature	–65	150	°C

(1) 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.
(2) VIN+ and VIN– are the voltages at the IN+ and IN– pins, respectively.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human body model (HBM), per AEC Q100-002[(1)] HBM ESD Classification Level 2	±2000	V
		Charged device model (CDM), per AEC Q100-011 CDM ESD Classification Level C6	±1000	

(1) AEC Q100-002 indicates that HBM stressing shall be in accordance with the ANSI/ESDA/JEDEC JS-001 specification.

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6.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{CM}	Common-mode input voltage range	–4	12	110	V
V_S	Operating supply voltage range	2.7	5	20	V
T_A	Ambient temperature	–40		125	°C

6.4 Thermal Information

THERMAL METRIC (1)		INA293-Q1 DBV (SOT-23) 5 PINS	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	221.7	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	144.7	°C/W
$R_{\theta JB}$	Junction-to-board thermal resistance	49.7	°C/W
Ψ_{JT}	Junction-to-top characterization parameter	26.1	°C/W
Ψ_{JB}	Junction-to-board characterization parameter	49	°C/W

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

6.5 Electrical Characteristics

at T_A = 25 °C, V_S = 5 V, $V_{SENSE} = V_{IN+} – V_{IN–}$, V_{SENSE} = 5 mV, and V_{CM} = 12 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT						
V_{CM}	Common-mode input voltage range	$V_{IN+} = V_{IN–}$ = –4 V to +110 V, T_A = –40°C to +125°C	–4		110	V
CMRR	Common-mode rejection ratio	$V_{IN+} = V_{IN–}$ = –4 V to +110 V, T_A = –40°C to +125°C	130	160		dB
		f = 50 kHz		85		dB
V_{OS}	Offset voltage, input referred	$V_{IN+} = V_{IN–}$ = 12 V		25	200	µV
dV_{OS}/dT	Offset voltage drift	$V_{IN+} = V_{IN–}$ = 12 V, T_A = –40℃ to +125℃			1	µV/C
PSRR	Power supply rejection ratio	V_S = 2.7 V to 20 V, T_A = –40°C to +125°C		1	5	µV/V
I_B	Input bias current	I_{B+}, $V_{IN+} = V_{IN–}$ = 12 V, V_{SENSE} = 0 mV		20		µA
		$I_{B–}$, $V_{IN+} = V_{IN–}$ = 12 V, V_{SENSE} = 0 mV		20		µA
OUTPUT						
G	Gain	INA293A1, INA293B1		20		V/V
		INA293A2, INA293B2		50		V/V
		INA293A3, INA293B3		100		V/V
		INA293A4, INA293B4		200		V/V
		INA293A5, INA293B5		500		V/V
	Gain error	GND + 50 mV ≤ V_{OUT} ≤ V_S – 200 mV		0.02	0.2	%
		T_A = –40°C to +125°C		2.5	10	ppm/°C
	Nonlinearity error			0.01		%
	THD + N	f = 1 kHz, V_{OUT} = 4 V_{PP}		65		dB
	Capacitance load	No sustained oscillations		1		nF
VOLTAGE OUTPUT						
	Swing to V_S power supply rail	R_{LOAD} = 10 kΩ to GND, T_A = –40°C to +125°C		V_S – 0.05	V_S – 0.2	V
	Swing to ground	R_{LOAD} = 10 kΩ to GND, V_{SENSE} = 0 mV, T_A = –40°C to +125°C		V_{GND} + 0.005	V_{GND} + 0.025	V

Electrical Characteristics (continued)

at T_A = 25 °C, V_S = 5 V, V_{SENSE} = V_{IN+} – $V_{IN–}$, V_{SENSE} = 5 mV, and V_{CM} = 12 V (unless otherwise noted)

PARAMETER		TEST CONDITIONS	MIN	TYP	MAX	UNIT
FREQUENCY RESPONSE						
BW	Bandwidth	Gain = 20 V/V, C_{LOAD} = 5 pF, V_{SENSE} = 200 mV		1000		kHz
		Gain = 50 V/V, C_{LOAD} = 5 pF, V_{SENSE} = 80 mV		900		kHz
		Gain = 100 V/V, C_{LOAD} = 5 pF, V_{SENSE} = 40 mV		850		kHz
		Gain = 200 V/V, C_{LOAD} = 5 pF, V_{SENSE} = 20 mV		800		kHz
		Gain = 500 V/V, C_{LOAD} = 5 pF, V_{SENSE} = 8 mV		750		kHz
SR	Slew rate			3		V/µs
	Settling time	V_{IN+} = $V_{IN–}$ = 12 V, V_{SENSE} = 0 mV to 100 mV, output settles to 0.5%		10		µs
		V_{IN+} = $V_{IN–}$ = 12 V, V_{SENSE} = 0 mV to 100 mV, output settles to 1%		5		µs
NOISE						
	Voltage noise density			55		nV/√Hz
POWER SUPPLY						
I_Q	Quiescent current	V_{IN+} = $V_{IN–}$ = 12 V		1.5	2.0	mA
		T_A = –40°C to +125°C			2.5	mA

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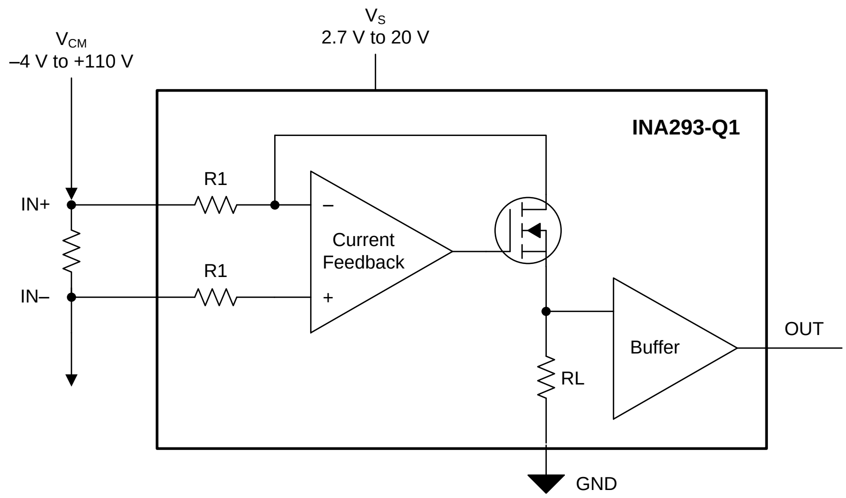
7 Detailed Description

7.1 Overview

The INA293-Q1 is an automotive current-sense amplifier that offers a wide common-mode range, precision, zero-drift topology, excellent common-mode rejection ratio (CMRR), and a high bandwidth with fast slew rate. Different gain versions are available to optimize the output voltage based on the application. The INA293-Q1 is designed using a transconductance architecture with a current-feedback amplifier that enables low bias currents of 20 µA with a common-mode voltage of 110 V.

7.2 Functional Block Diagram



7.3 Feature Description

7.3.1 Amplifier Input Common-Mode Signal

The INA293-Q1 handles large common-mode voltages from –4 V to +110 V, and large common-mode signals on the IN+ and IN– pins beyond the supply voltage, V_S, operating from 2.7 V to 20 V. The INA293-Q1 works in pulse width modulation (PWM) applications with high common-mode transients. PWM applications have high dv/dt signals; however, the INA293-Q1 output stage settles faster, and thus enables accurate real time PWM measurements with the least blanking time. The INA293-Q1 input offset voltage of < 100 µV enables small-signal measurements accurately across a shunt resistor. The INA293-Q1 is designed with a high bandwidth of 1 MHz at the gain of 20 V/V with an output slew rate of < 3 V/µs. The combination of low offset and high bandwidth enables accurate current measurement with fast throughput for fast overcurrent detection.

7.3.1.1 Input-Signal Bandwidth

The INA293-Q1 –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. The device is designed with a two-stage amplifier where the first stage is a transconductance amplifier measuring the voltage across the shunt. The differential voltage developed across the IN+ and IN– pins is converted to current output by the first-stage amplifier. The current output of the first-stage amplifier is internally converted to voltage output by connecting an internal precision resistor to ground. The second-stage amplifier, which is a voltage follower, buffers the voltage generated across the internal precision resistor to output pin VOUT. This unique multistage design enables the amplifier to achieve a high bandwidth of 1 MHz at a gain of 20 V/V. To maintain the stability of the amplifier as the gain increases, the amplifiers provide stable output by compensating for lower bandwidth. The INA293-Q1 with a gain of 500 V/V achieves a –3-dB bandwidth of 750 kHz. The device bandwidth provides the fast throughput and fast response that is required for the rapid detection and fast processing of overcurrent events. Figure 1 shows the performance profile of the device over frequency. The full amplifier bandwidth is always available for fast overcurrent events at the same time that the lower frequency signals are amplified at a low distortion level. The output signal accuracy is reduced for frequencies closer to the maximum bandwidth. Individual requirements determine the acceptable limits of distortion for high-frequency, current-sensing applications. Testing and evaluation in the end application or circuit is required to determine the acceptance criteria, and to validate that the performance levels meet the system specifications.

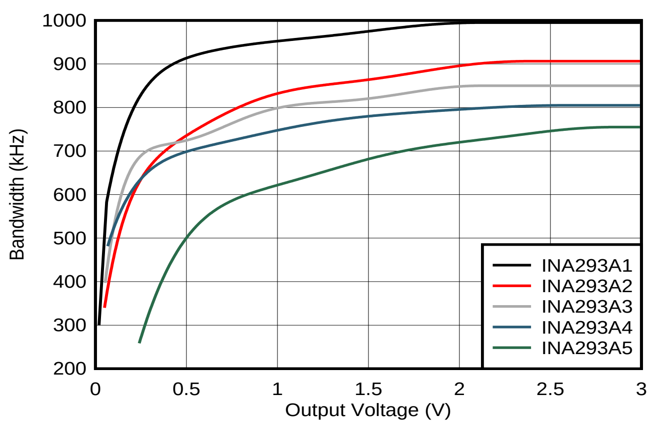


Figure 1. Bandwidth vs Output Voltage

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Feature Description (continued)

7.3.1.2 Low Input Bias Current

The INA293-Q1 measures currents on a common-mode voltage as high as 110 V. The INA293-Q1 can be configured as high side with direct connection to the battery to measure accurate currents. The INA293-Q1 input bias current draws < 20 µA at a common-mode voltage of 110 V. Bias currents of < 20 µA at a common-mode voltage of 110 V enable precision current sensing on applications that require lower leakage for high-side applications. The INA293-Q1 bias current consumption of < 20 µA enables precision current sensing for high-side only measurements.

7.3.1.3 Low V_{SENSE} Operation

The INA293-Q1 operates at a low V_{SENSE} signal. The output of the INA293-Q1 is linear with differential input signals across IN+ and IN– as low as 200 µV, and is limited by the input offset voltage of the amplifier. The INA293-Q1 is a chopped input architecture with zero-drift implementation to make sure that performance is consistent across the wide temperature range of –40°C to +125°C. Low offset voltage with low temperature offset drift enables the INA293-Q1 to measure low V_{SENSE} voltage consistently across temperature. Low V_{SENSE} operation is particularly beneficial when using low ohmic shunts that enable low current measurements, thus saving significant power loss across shunt.

7.3.1.4 Wide Fixed Gain Output

The INA293-Q1 gain error is < 0.25% at room temperature with a maximum drift of 10 ppm/°C over the full temperature range of – 40°C to +125°C. The INA293-Q1 is available in multiple gain options of 20 V/V, 50 V/V, 100 V/V, 200 V/V and 500 V/V. Depending on the system requirements and signal-to-noise ratio requirements desired, the INA293-Q1 with the desired gain can be selected. A gain of 20 V/V is often selected for applications that require accurately measuring low-level signals that are sensitive to noise. In applications where large signal content is more critical, select a higher gain amplifier, such as 500 V/V.

Internally, the amplifier gain is set with fixed resistors with a set ratio. The resistors are precision components with very low drift that are very unique and specific to the Texas Instruments manufacturing process. The gain resistors are set and described in Table 1.

Table 1. Fixed Gain Resistor

GAIN	R1	RL
20 (V/V)	25 kΩ	500 kΩ
50 (V/V)	10 kΩ	500 kΩ
100 (V/V)	10 kΩ	1000 kΩ
200 (V/V)	5 kΩ	1000 kΩ
500 (V/V)	2 kΩ	1000 kΩ

7.3.1.5 Wide Supply Range

The INA293-Q1 operates with a wide supply range from a 2.7 V to 20 V. The output stage reaches a full-scale output to 20 V. Wide output range can enable very-wide dynamic current measurements. For a gain of 20 V/V, the maximum differential input acceptable is 1 V. The offset of the INA293-Q1 is ±200 µV, and is capable of measuring a wide dynamic range of current up to 74 dB.

7.4 Device Functional Modes

7.4.1 Unidirectional Operation

The INA293-Q1 measures the differential voltage developed across a resistor. This resistor is referred to as a current-sensing resistor or a current-shunt resistor. The INA293-Q1 operates in unidirectional mode only, and measures current in one direction only. The most common application of measuring unidirectional current is to measure current on a power supply to load, as shown in Figure 2.

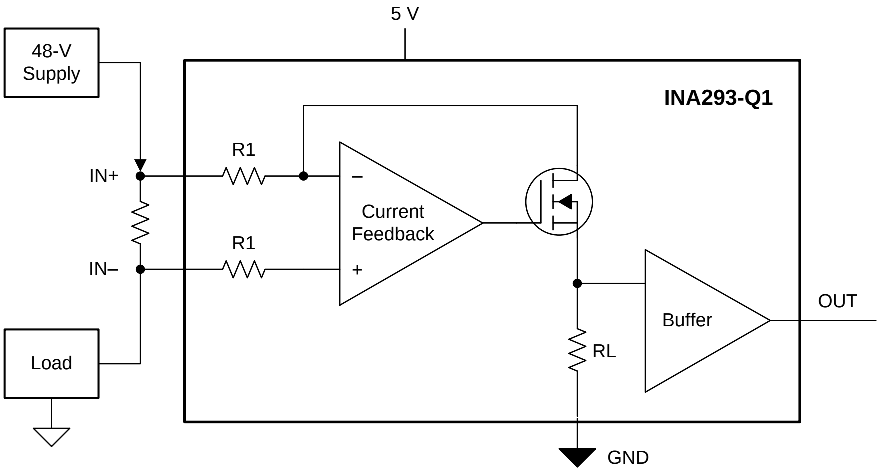

Figure 2. Unidirectional Application

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 INA293-Q1 is very small; for most unidirectional applications, the output is limited by the input offset specification of 100 µV. When designing a system with the INA293-Q1, take care so that the minimum current measured across the shunt resistor is at a minimum of 100 µV. The INA293-Q1 lowest output voltage measurement capability is limited by the output stage of the amplifier.

7.4.2 High Signal Throughput

With a bandwidth of 1 MHz at the gain of 20 V/V and a rising slew rate of 3 V/µs, the INA293-Q1 is specifically designed for detecting and protecting applications from fast inrush currents in the system. In Table 2, the INA293-Q1 responds in less than 1 µs for a system measuring a 75-A threshold on a 2 mΩ shunt. The INA293-Q1 high bandwidth and high slew rate are used to trigger and detect overcurrent events in less than microseconds to indicate faults in the system.

Table 2. Response Time

PARAMETER		EQUATION	INA293A1-Q1 AND INA293B1-Q1 AT V_S = 5 V
G	Gain		20 V/V
I_{MAX}	Maximum current		100 A
$I_{Threshold}$	Threshold current		75 A
R_{SENSE}	Current sense resistor value		2 mΩ
V_{OUT}	Output voltage		4 V
SR	Slew rate	$V_{OUT} = I_{MAX} \times R_{SENSE} \times G$	3 V/µs
	Output response time		< 1 µs

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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 INA293-Q1 measures the voltage developed across a current-sensing resistor when current passes through. The ability to have shunt common-mode voltages from −4 V to +110 V drive and control the output signal with V_S offers multiple configurations, as discussed throughout this section.

8.1.1 Selecting R_{Sense}

The INA293-Q1 determines the current magnitude by measuring the differential voltage developed across a resistor. This resistor is referred to as a current-sensing resistor or a current-shunt resistor. The flexible design of the device allows a wide input signal range across this current-sensing resistor.

Choose a current-sensing resistor that is based on the full-scale current to be measured, the full-scale input range of the circuitry following the device, and the device gain selected. The minimum current-sensing resistor is a design-based decision in order to maximize the input range of the signal-chain circuitry. Full-scale output signals that are not maximized to the full input range of the system circuitry limit the ability of the system to exercise the full dynamic range of system control.

Two important factors to consider when finalizing the current-sensing resistor value are the required current measurement accuracy and the maximum power dissipation across the resistor. A larger resistor voltage provides for a more accurate measurement, but increases the power dissipation in the resistor. The increased power dissipation generates heat, and reduces the sense resistor accuracy because of the temperature coefficient. The voltage signal measurement uncertainty is reduced when the input signal gets larger because any fixed errors become a smaller percentage of the measured signal. The design trade-off to improve measurement accuracy increases the current-sensing resistor value. The increased resistance value results in an increased power dissipation in the system that can additionally decrease the overall system accuracy. Based on these relationships, the measurement accuracy is inversely proportional to both the resistance value and power dissipation contributed by the current-shunt selection.

By increasing the current-shunt resistor, the differential voltage is increased across the resistor. Larger input differential voltages require a smaller amplifier gain to achieve a full-scale amplifier output voltage. Smaller current-shunt resistors are desired, but require large amplifier gain settings. The larger gain settings often have increased error and noise parameters, and are not attractive for precision designs. Historically, the design goals for high-performance measurements forced designers to accept selecting larger current-sense resistors and lower gain amplifier settings. The INA293-Q1 provides 200-V/V and 500-V/V gain options that offer the high gain setting and maintains high-performance levels with offset values below 100 µV. These devices allow for the use of lower shunt resistor values to achieve lower power dissipation and still meet high system performance specifications.

Table 3 shows an example of the different results obtained from using five different gain versions of the INA293-Q1. From the table data, the highest gain device allows a smaller current-shunt resistor and decreased power dissipation in the element.

Table 3. R_{SENSE} Selection and Power Dissipation(1)

PARAMETER		EQUATION	RESULTS AT V_S = 5 V				
			A1, B1 DEVICES	A2, B2 DEVICES	A3, B3 DEVICES	A4, B4 DEVICES	A5, B5 DEVICES
G	Gain		20 V/V	50 V/V	100 V/V	200 V/V	500 V/V
V_{DIFF}	Ideal differential input voltage	$V_{DIFF} = V_{OUT} / G$	0.25 V	0.1 V	0.05 V	0.025 V	0.01 V
R_{SENSE}	Current sense resistor value	$R_{SENSE} = V_{DIFF} / I_{MAX}$	25 mΩ	10 mΩ	5 mΩ	2.5 mΩ	1 mΩ
P_{SENSE}	Current-sense resistor power dissipation	R_{SENSE} x I_{MAX}2	2.5 W	1 W	0.5W	0.25 W	0.1 W

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

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8.2 Typical Application

The INA293-Q1 is a unidirectional, current-sense amplifier capable of measuring currents through a resistive shunt with shunt common-mode voltages from −4 V to +110 V.

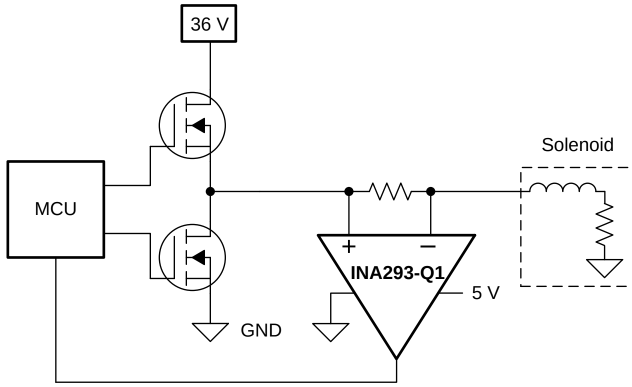

Figure 3. Current Sensing in a Solenoid Application

8.2.1 Design Requirements

V_{SUPPLY} is set to 12 V, Shunt resistor used is 50 mΩ, Common-mode voltage set to 36 V. Table 4 lists the design setup for this application

Table 4. Design Parameters

DESIGN PARAMETERS	EXAMPLE VALUE
Power supply voltage	12 V
High-side current sensing	36 V
Maximum current sense	5 A
R_{SENSE} resistor	50 mΩ
Gain option	50 V/V

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8.2.2 Detailed Design Procedure

The INA293-Q1 is designed to measure current in a typical solenoid application. The INA293-Q1 measures current across the 50-mΩ shunt that is placed directly across the h-bridge. The INA293-Q1 measures the differential voltage across the shunt resistor, and the signal is internally amplified with a gain of 50 V/V. The output of the INA293-Q1 is connected to the analog-to-digital converter (ADC) 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 the premature failure of solenoid, and 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 INA293-Q1, with high bandwidth and slew rate, is used to detect fast overcurrent conditions to prevent the solenoid damage from short-to-ground faults.

8.2.3 Application Curve

Figure 4 shows the output response of a solenoid.

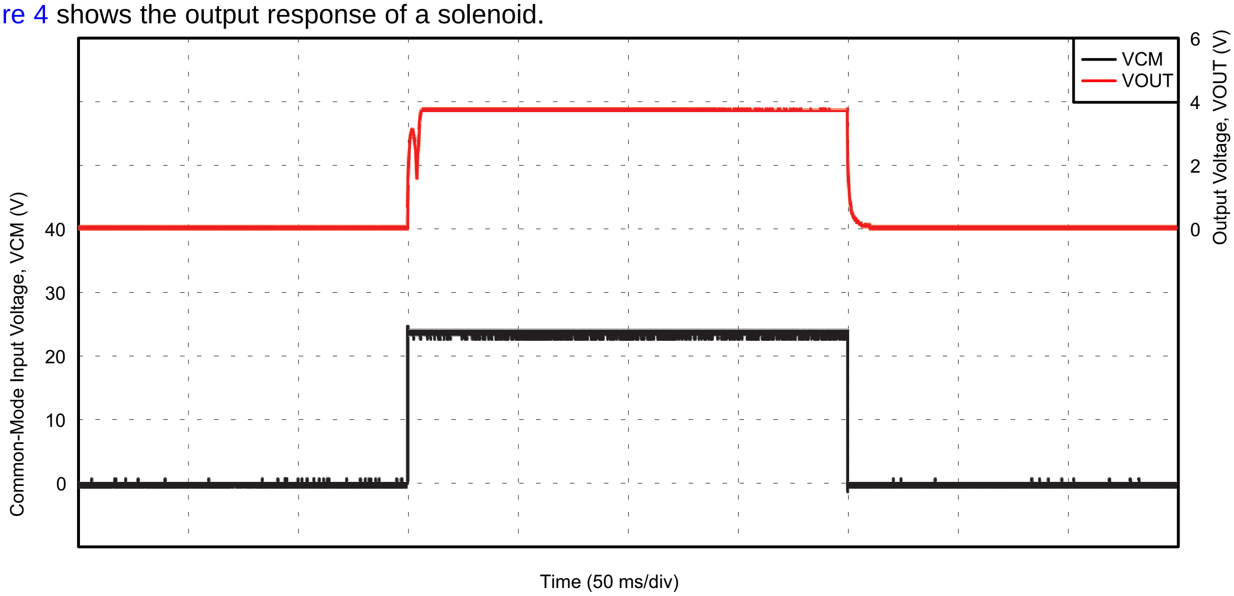

Figure 4. Solenoid Control Current Response

9 Power Supply Recommendations

The input circuitry of the INA293-Q1 device can accurately measure beyond the power-supply voltage, The power supply can be 5 V; whereas, the load power-supply voltage goes up to 110 V. The output voltage range of the OUT pin, however, is limited by the voltages on the power-supply pin.

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10 Layout

10.1 Layout Guidelines

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 as possible to the device pins.
- Place small ceramic capacitors directly across amplifier inputs to reduce RFI and EMI sensitivity.
- Place the amplifier as far away as possible from RFI sources on the PCB layout.
- Sources can include other components in the same system as the amplifier, 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.

10.2 Layout Example

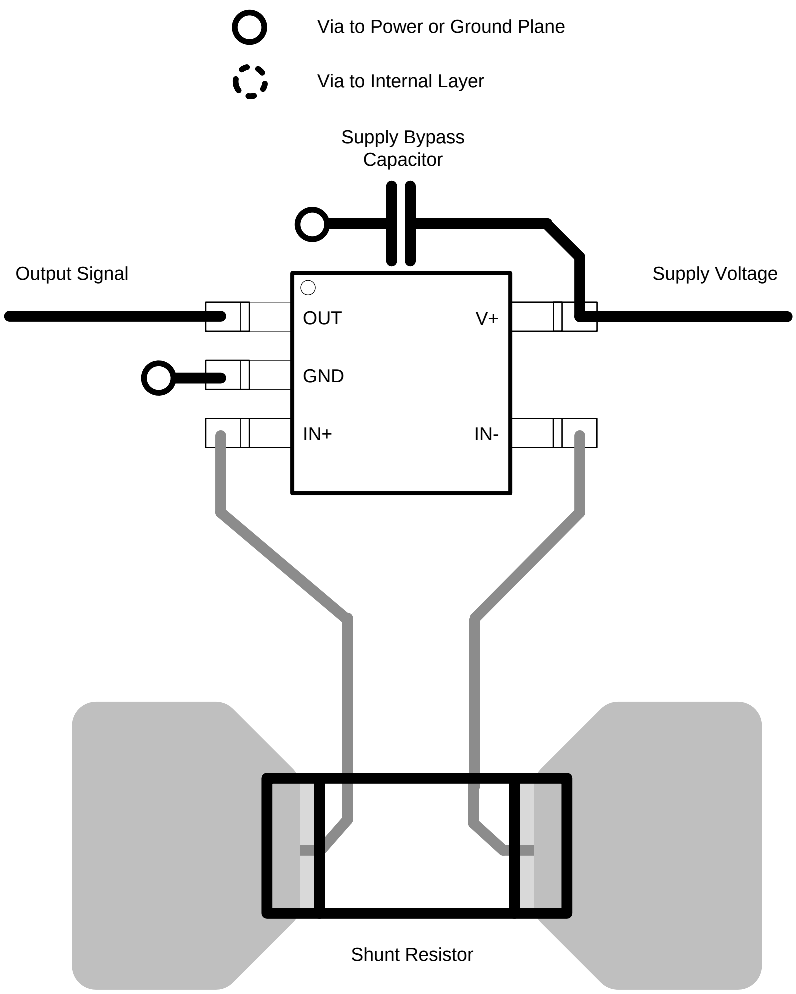

Figure 5. INA293A Recommended Layout

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11 Device and Documentation Support

11.1 Documentation Support

11.1.1 Related Documentation

For related documentation see the following: Texas Instruments, *INA293EVM* 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. In the upper right corner, click on *Alert me* 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 Community Resources

The following links connect to TI community resources. Linked contents are 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.

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Design Support ***TI's Design Support*** Quickly find helpful E2E forums along with design support tools and contact information for technical support.

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

SLYZ022 — *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.

PACKAGING INFORMATION

Orderable Device	Status (1)	Package Type	Package Drawing	Pins	Package Qty	Eco Plan (2)	Lead/Ball Finish (6)	MSL Peak Temp (3)	Op Temp (°C)	Device Marking (4/5)	Samples
PINA293A1QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125		Samples
PINA293A2QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125		Samples
PINA293A3QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125		Samples
PINA293A4QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125		Samples
PINA293A5QDBVRQ1	ACTIVE	SOT-23	DBV	5	3000	TBD	Call TI	Call TI	-40 to 125		Samples

(1) The marketing status values are defined as follows:
ACTIVE: Product device recommended for new designs.
LIFEBUY: TI has announced that the device will be discontinued, and a lifetime-buy period is in effect.
NRND: Not recommended for new designs. Device is in production to support existing customers, but TI does not recommend using this part in a new design.
PREVIEW: Device has been announced but is not in production. Samples may or may not be available.
OBSOLETE: TI has discontinued the production of the device.

(2) **RoHS:** TI defines "RoHS" to mean semiconductor products that are compliant with the current EU RoHS requirements for all 10 RoHS substances, including the requirement that RoHS substance do not exceed 0.1% by weight in homogeneous materials. Where designed to be soldered at high temperatures, "RoHS" products are suitable for use in specified lead-free processes. TI may reference these types of products as "Pb-Free".
RoHS Exempt: TI defines "RoHS Exempt" to mean products that contain lead but are compliant with EU RoHS pursuant to a specific EU RoHS exemption.
Green: TI defines "Green" to mean the content of Chlorine (Cl) and Bromine (Br) based flame retardants meet JS709B low halogen requirements of <=1000ppm threshold. Antimony trioxide based flame retardants must also meet the <=1000ppm threshold requirement.

(3) MSL, Peak Temp. - The Moisture Sensitivity Level rating according to the JEDEC industry standard classifications, and peak solder temperature.

(4) There may be additional marking, which relates to the logo, the lot trace code information, or the environmental category on the device.

(5) Multiple Device Markings will be inside parentheses. Only one Device Marking contained in parentheses and separated by a "~" will appear on a device. If a line is indented then it is a continuation of the previous line and the two combined represent the entire Device Marking for that device.

(6) Lead/Ball Finish - Orderable Devices may have multiple material finish options. Finish options are separated by a vertical ruled line. Lead/Ball Finish values may wrap to two lines if the finish value exceeds the maximum column width.

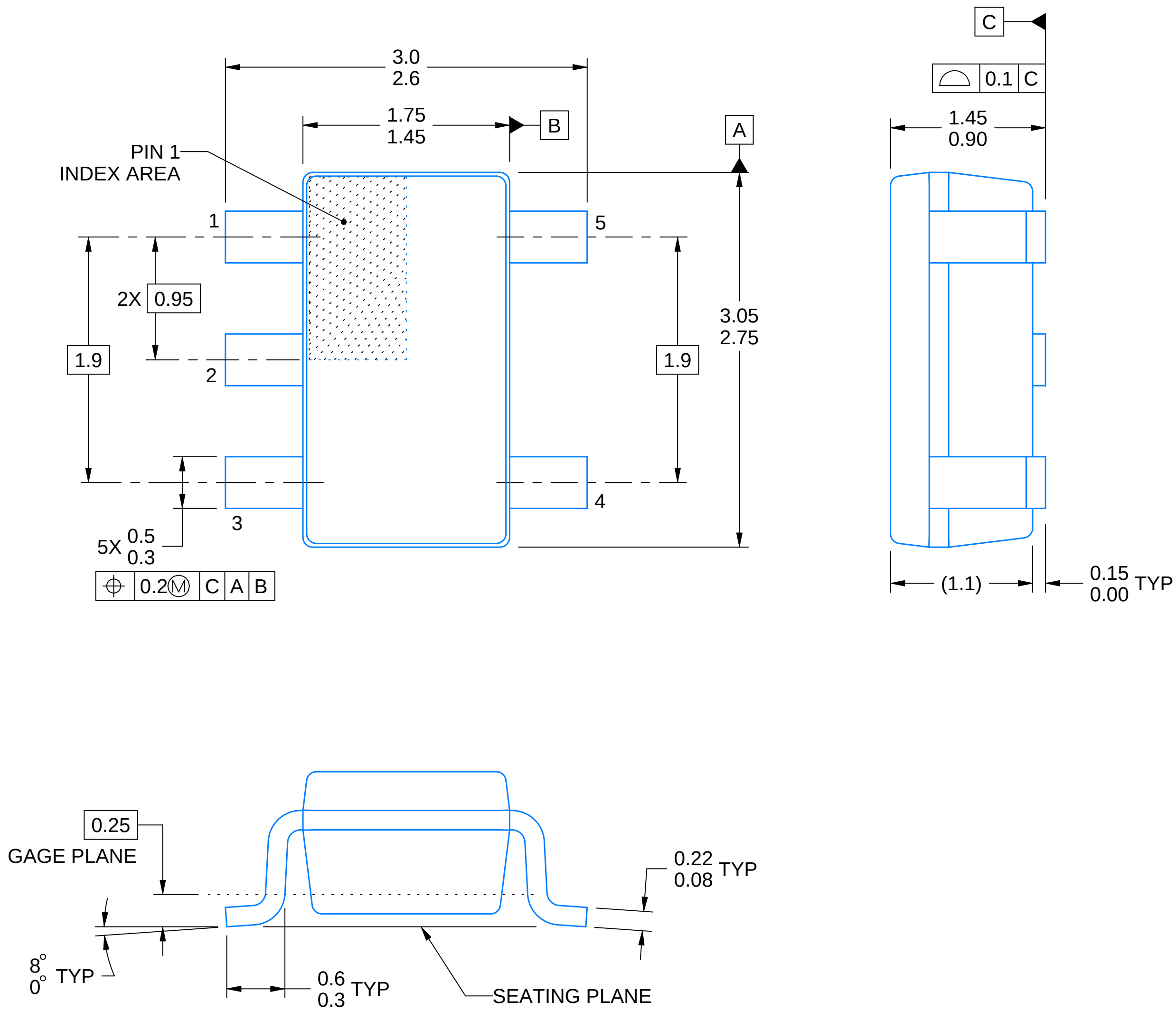
Important Information and Disclaimer: The information provided on this page represents TI's knowledge and belief as of the date that it is provided. TI bases its knowledge and belief on information provided by third parties, and makes no representation or warranty as to the accuracy of such information. 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.

DBV0005A

SOT-23 - 1.45 mm max height

SMALL OUTLINE TRANSISTOR



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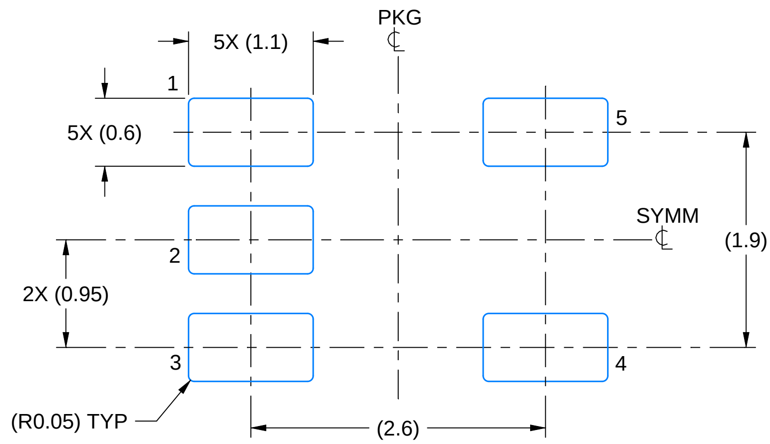
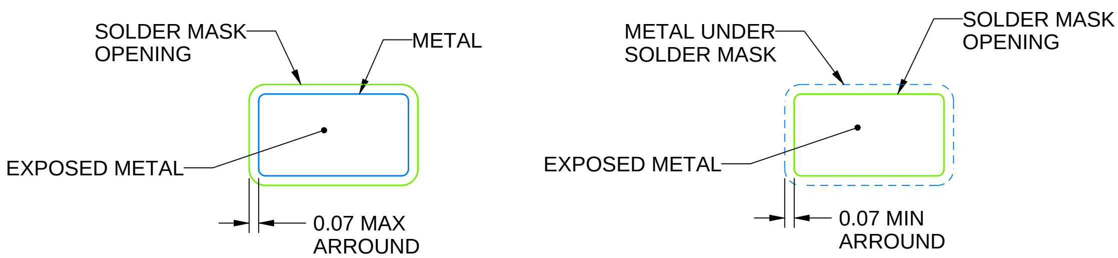
NOTES:

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 0.15 mm per side.



LAND PATTERN EXAMPLE
EXPOSED METAL SHOWN
SCALE:15X



NON SOLDER MASK DEFINED (PREFERRED)

SOLDER MASK DEFINED

SOLDER MASK DETAILS

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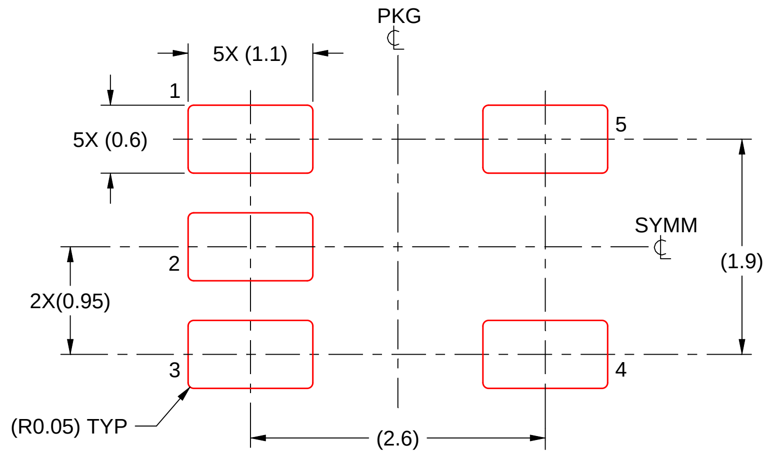
NOTES: (continued)

5. Publication IPC-7351 may have alternate designs.
6. 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

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NOTES: (continued)

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