76V, High-Side, Current-Sense Amplifiers with Voltage Output

1 FEATURES

- **Bidirectional sensing**
- **Wide Common Mode Voltage Range: 4.5 V to 76 V**
- **Supply Voltage Range: 4.5 V to 76 V**
- **Choice of Gains:**
  - **RS299B Gain: 20V/V**
  - **RS299C Gain: 50V/V**
  - **RS299D Gain: 60V/V**
  - **RS299E Gain: 100V/V**
- **Gain Accuracy: ±0.25%**
- **Input Offset Voltage: ±100µV**
- **Bandwidth (-3 dB): 135KHz**
- **Quiescent Current: 135µA**
- **Input Bias Current: 9.5µA**
- **Operating temperature: -40°C to +125°C**
- **Micro SIZE PACKAGES: MSOP8**

2 APPLICATIONS

- **48V Telecom and Backplane Current Measurement**
- **Bidirectional Motor Control**
- **Power-Management Systems**
- **Avalanche Photodiode and PIN-Diode Current Monitoring**
- **General System/Board-Level Current Sensing**
- **Precision High-Voltage Current Sources**

3 DESCRIPTIONS

The RS299 are high-side, current-sense amplifiers with an input voltage range that extends from 4.5V to 76V making them ideal for telecom, backplane, and other systems where high-voltage current monitoring is critical. The RS299 allows bidirectional current sensing. The RS299 single output pin continuously monitors the transition from charge to discharge and avoids the need for a separate polarity output. The RS299 requires an external reference to set the zero-current output level (V_{SENSE}=0V). The charging current is represented by an output voltage from V_{REF} to V_{CC}, while discharge current is given from V_{REF} to GND.

For maximum versatility, the 76V input voltage range applies independently to both supply voltage (V_{CC}) and common-mode input voltage (V_{RS+}). High-side current monitoring does not interfere with the ground path of the load being measured, making the RS299 particularly useful in a wide range of high-voltage systems.

The combination of three gain versions (20V/V, 50V/V, 60V/V, 100V/V = B, C, D, E) and a user-selectable, external sense resistor sets the full-scale current reading and its proportional output voltage. The RS299 offer a high level of integration, resulting in a simple, accurate, and compact current-sense solution. The RS299 operate from a 4.5V to 76V single supply and draw only 135µA of supply current.

The RS299 is available in Green MSOP8 packages. It operates over an ambient temperature range of -40°C to +125°C.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE (NOM)
RS299	MSOP8	3.00mm x 3.00mm

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

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4 REVISION HISTORY

Note: Page numbers for previous revisions may different from page numbers in the current version.

Version	Change Date	Change Item
A.0	2023/10/10	Preliminary version completed
A.0.1	2024/02/29	Modify packaging naming
A.1	2024/11/06	Initial version completed
A.2	2025/02/17	Delete SOP8 Package and add MSOP8 Package

5 PACKAGE/ORDERING INFORMATION [(1)]

Orderable Device	Package Type	Pin	Channel	Op Temp(°C)	Device Marking [(2)]	MSL [(3)]	Package Qty
RS299BXM	MSOP8	8	1	-40°C ~125°C	RS299B	MSL1	Tape and Reel,4000
RS299CXM	MSOP8	8	1	-40°C ~125°C	RS299C	MSL1	Tape and Reel,4000
RS299DXM	MSOP8	8	1	-40°C ~125°C	RS299D	MSL1	Tape and Reel,4000
RS299EXM	MSOP8	8	1	-40°C ~125°C	RS299E	MSL1	Tape and Reel,4000

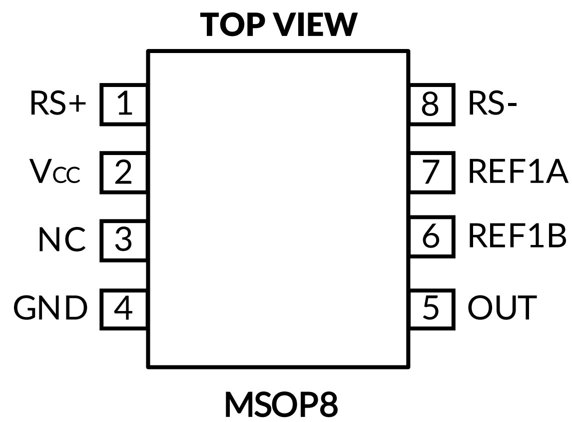
NOTE:

(1) 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 right-hand navigation.

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

(3) RUNIC classify the MSL level with using the common preconditioning setting in our assembly factory conforming to the JEDEC industrial standard J-STD-20F, Please align with RUNIC if your end application is quite critical to the preconditioning setting or if you have special requirement.

6 PIN CONFIGURATION AND FUNCTIONS



Pin Description

NAME	PIN	I/O [1]	DESCRIPTION
	MSOP8		
RS+	1	I	Power connection to the external-sense resistor.
V_{CC}	2	P	Supply Voltage Input. Decouple V_{CC} to GND with at least a 0.1µF capacitor to bypass line transients.
NC	3	-	No Connection. No internal connection. Leave open or connect to ground.
GND	4	-	Ground
OUT	5	O	Voltage Output. The difference voltage (V_{OUT} - V_{REF}) is proportional to V_{SENSE} and indicates the correct polarity.
REF1B	6	I	Reference Voltage Input: Connect REF1B to REF1A or to GND.
REF1A	7	I	Reference Voltage Input: Connect REF1A and REF1B to a fixed reference voltage (V_{REF}). V_{OUT} is equal to V_{REF} when V_{SENSE} is zero.
RS-	8	I	Load connection to the external sense resistor.

(1) I = Input, O = Output, P=Power.

7 SPECIFICATIONS

7.1 Absolute Maximum Ratings

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

			MIN	MAX	UNIT
Voltage	V_{CC} to GND		-0.3	80	V
	RS+, RS- to GND		-0.3	80	
	OUT to GND		-0.3V to the lesser of +20V or (V_{CC}+0.3V)		
	REF1A, REF1B to GND		-0.3V to the lesser of +20V or (V_{CC}+0.3V)		
	Differential Input Voltage (V_{RS+} - V_{RS-})		-20	20	V
Current	Current into Any Pin		-20	20	mA
	Output short-circuits to GND (2)		Continuous		
θ_{JA}	Package thermal impedance (3)	MSOP8		170	°C/W
Temperature	Operating range, T_A		-40	125	°C
	Junction, T_J (4)		-40	150	
	Storage, T_{stg}		-65	150	
	Lead Temperature (soldering, 10s)			300	
	Soldering Temperature (reflow)			260	

(1) Stresses above these ratings may cause permanent damage. Exposure to absolute maximum conditions for extended periods may degrade device reliability. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those specified is not implied.
(2) Short-circuit to ground, one amplifier per package.
(3) The package thermal impedance is calculated in accordance with JESD-51.
(4) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{\theta JA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{\theta JA}$. All numbers apply for packages soldered directly onto a PCB.

7.2 ESD Ratings

The following ESD information is provided for handling of ESD-sensitive devices in an ESD protected area only.

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-Body Model (HBM), ANSI/ESDA/JEDEC JS001-2017	±1000	V
		Charged-Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2018	±2000	

ESD SENSITIVITY CAUTION

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.

7.3 Recommended Operating Conditions

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

		MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage	4.5		76	V
T_A	Operating range	-40		125	°C

7.4 Electrical Characteristics

(V_{CC} = V_{RS+} = 4.5V to 76V, V_{REF1A} = V_{REF1B} = 5V, V_{SENSE} = (V_{RS+} - V_{RS-}) = 0V, R_{LOAD} = 100kΩ, unless otherwise noted. Typical values are at T_A = +25°C, Full = -40°C to +125°C.) [1][2]

SYMBOL	PARAMETER	CONDITIONS	T_J	MIN	TYP	MAX	UNIT
V_{CC}	Operating Voltage Range	Inferred from PSRR test	25°C	4.5		76	V
CMVR	Common-Mode Range	Inferred from CMRR test [3]	25°C	4.5		76	V
I_{CC}	Supply Current	V_{CC}=V_{RS+}=76V, no load	25°C		135	180	µA
IRS+, IRS-	Leakage Current	V_{CC}=0V, V_{RS+}=76V	25°C		0.05	0.2	µA
IRS+, IRS-	Input Bias Current	V_{CC}=V_{RS+}=76V	25°C		9.5	12	µA
V_{SENSE}	Full-Scale Sense Voltage	RS299B	Full		±300		mV
		RS299C	Full		±120		mV
		RS299D	Full		±100		mV
		RS299E	Full		±60		mV
A_V	Gain	RS299B	25°C		20		V/V
		RS299C	25°C		50		V/V
		RS299D	25°C		60		V/V
		RS299E	25°C		100		V/V
ΔAV	Gain Accuracy	V_{CC}=V_{RS+}=48V [4]	25°C	-0.8	±0.25	0.8	%
V_{OS}	Input Offset Voltage	V_{CC}=V_{RS+}=48V [5]	25°C	-0.8	±0.1	0.8	mV
CMRR	Common-Mode Rejection Ratio [6]	V_{CC}=48V, V_{RS+}=4.5V to 76V	25°C	105	130		dB
PSRR	Power-Supply Rejection Ratio [6]	V_{RS+}=48V, V_{CC}=4.5V to 76V	25°C	110	130		dB
V_{CC}-V_{OH}	OUT High Voltage	V_{CC}=4.5V, V_{RS+}=48V, V_{REF1A}=V_{REF1B}=2.5V, V_{SENSE}=100mV, I_{OUT} (sourcing)=+500µA [7]	25°C		60	80	mV
V_{OL}	OUT Low Voltage	V_{CC}=V_{RS+}=48V, V_{REF1A}=V_{REF1B}=2.5V, V_{SENSE}=-1000mV; I_{OUT} (sinking) =10µA	25°C		1	1.4	mV
		V_{CC}=V_{RS+}=48V, V_{REF1A}=V_{REF1B}=2.5V, V_{SENSE}=-1000mV; I_{OUT} (sinking) =500µA	25°C		23	30	mV
(V_{REF}-V_{GND})	REF1A = REF1B Input Voltage Range	Inferred from REF1A rejection ratio, V_{REF1A}=V_{REF1B}	25°C	0		6	V
(V_{REF1A}-V_{GND})	REF1A Input Voltage Range	Inferred from REF1A rejection ratio, V_{REF1B}=V_{GND}	25°C	0		12	V
	REF1A Rejection Ratio	V_{CC}=V_{RS+}=48V, V_{SENSE}=0V, V_{REF1A}=V_{REF1B}=0.1V to 6V	25°C	80	95		dB
	REF/REF1A Ratio	V_{REF1A}=10V, V_{REF1B}=V_{GND}, V_{CC}=V_{RS+}=48V [2]	25°C		0.5		
	REF1A Input Impedance	V_{REF1B}=V_{GND}	25°C		200		kΩ
BW	Bandwidth	V_{CC}=V_{RS+}=48V, V_{OUT}=1.2Vpp	25°C		135		kHz
	OUT Settling Time to 1% of Final Value	V_{SENSE}=10mV to 100mV	25°C		40		µs
		V_{SENSE}=100mV to 10mV	25°C		40		µs
	Capacitive-Load Stability	No sustained oscillations	25°C		500		pF
	Power-Up Time	V_{CC}=V_{RS+}=48V, V_{SENSE}=100mV [8]	25°C		100		µs
	Saturation Recovery Time [8][9]		25°C		50		µs

NOTE:

(1) All devices are 100% production tested at T_A = +25°C. All temperature limits are guaranteed by design.
(2) V_{REF} is defined as the average voltage of V_{REF1A} and V_{REF1B}. REF1B is usually connected to REF1A or GND. V_{SENSE} is defined as V_{RS+} - V_{RS-}.
(3) The common-mode range at the low end of 4.5V applies to the most positive potential at RS+ or RS-. Depending on the polarity of V_{SENSE} and the device's gain, either RS+ or RS- can extend below 4.5V by the device's typical full-scale value of V_{SENSE}.
(4) V_{SENSE} is:
    RS299B, -150mV to +150mV
    RS299C, -60mV to +60mV
    RS299D, -50mV to +50mV
    RS299E, -30mV to +30mV
(5) V_{OS} is measured as (V_{OUT} - V_{REF})/AV at V_{SENSE} = 0V.
(6) V_{SENSE} is:
    RS299B/C/D/E, 0V
    V_{REF1B} = V_{REF1A} = 2.5V
(7) Output voltage is internally clamped not to exceed 20V.
(8) Output settles to within 1% of final value.
(9) The device will not experience phase reversal when overdriven.

7.5 Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

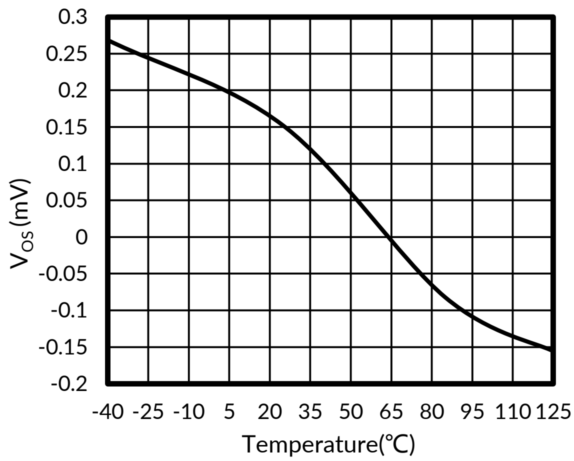


Figure 1. Input Offset Voltage (V_{OS}) vs Temperature

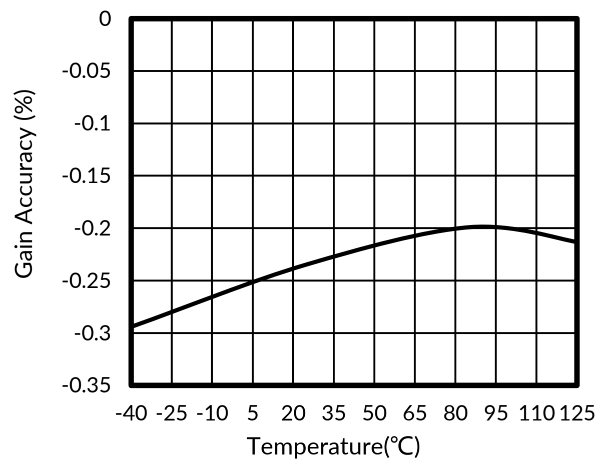


Figure 2. Gain Accuracy vs Temperature

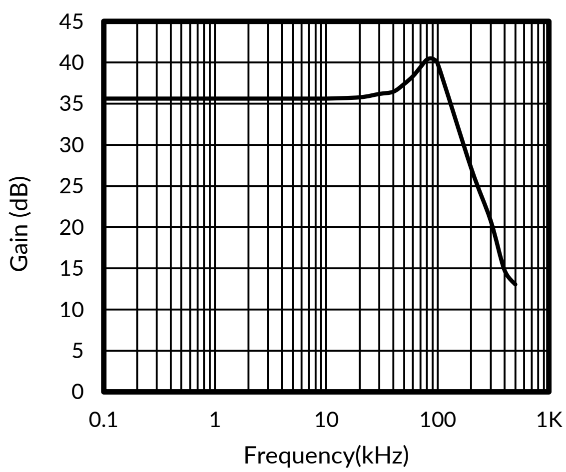


Figure 3. Small-Signal Gain vs Frequency

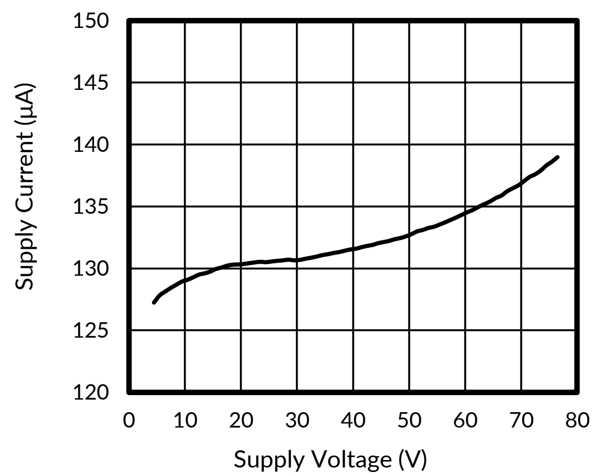


Figure 4. Supply Current vs Supply Voltage (V_{CC})

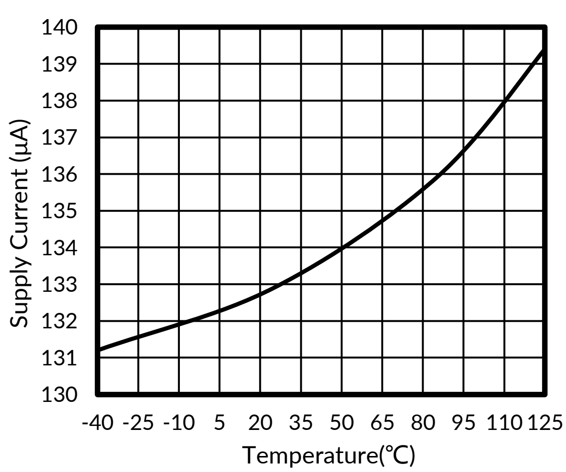


Figure 5. Supply Current vs Temperature

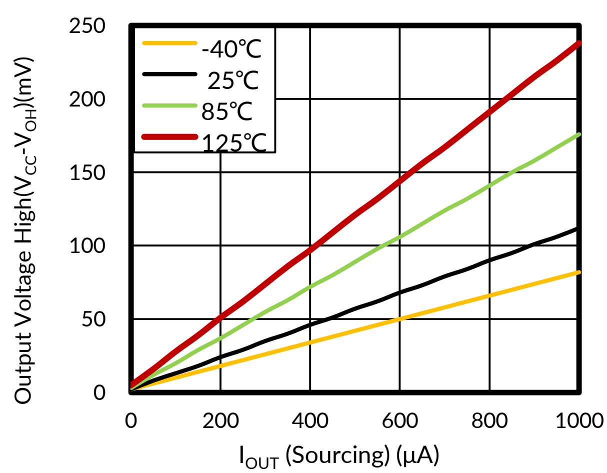


Figure 6. Output Voltage High (V_{OH}) vs I_{OUT} (Sourcing)

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

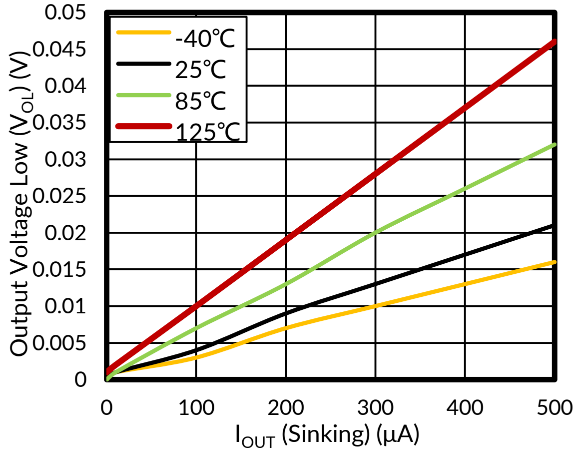


Figure 7. Output Voltage Low (V_{OL}) vs I_{OUT} (Sinking)

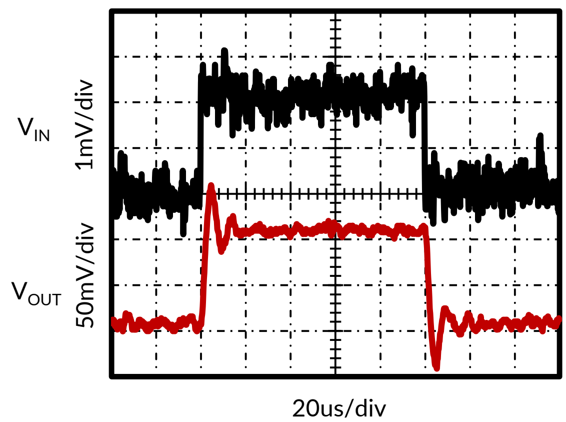


Figure 8. Small-Signal Transient Response(2mV)

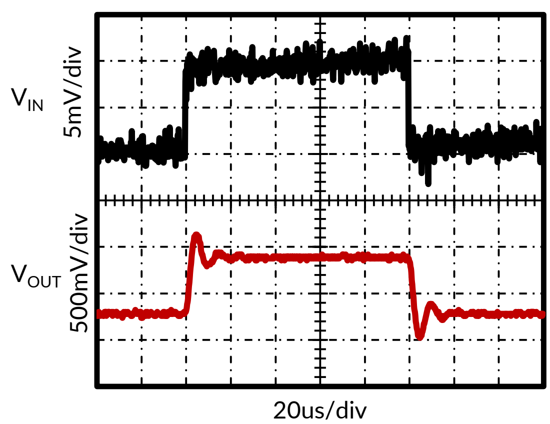


Figure 9. Small-Signal Transient Response(10mV)

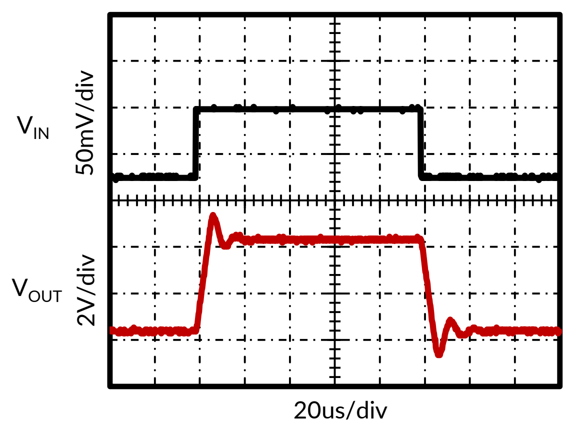


Figure 10. Large-Signal Transient Response

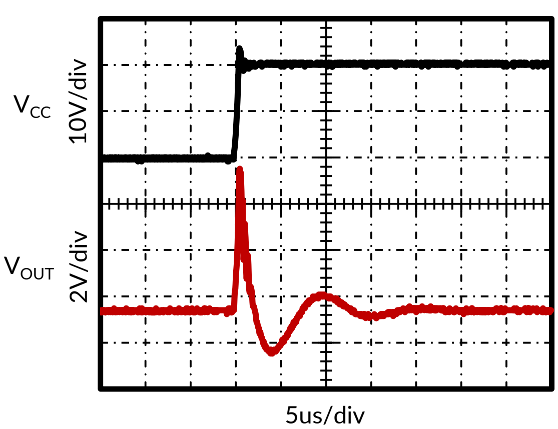


Figure 11. V_{CC} Transient Response

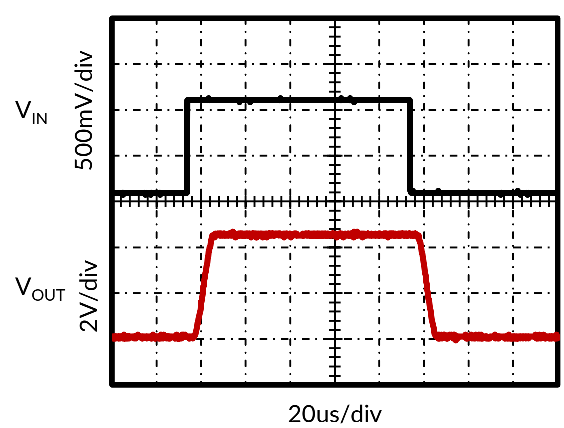


Figure 12. Saturation Recovery Response

Typical Characteristics

NOTE: The graphs and tables provided following this note are a statistical summary based on a limited number of samples and are provided for informational purposes only.

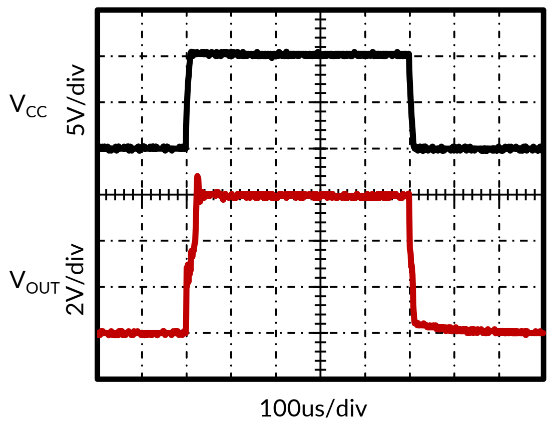


Figure 13. Startup Delay

8 FEATURE DESCRIPTION

8.1 Operation Overview

The RS299 is a high voltage power supply, zero drift, high-side current sense amplifiers with available fixed gains of 20, 50, 60 and 100. The power supply range is 4.5V to 76V, and the common-mode input voltage range is capable of 4.5V to 76V operation. The supply voltage and common-mode range are completely independent of each other, which causes the RS299 supply voltage to be extremely flexible because the RS299 supply voltage can be greater than, equal to, or less than the load source voltage, and allows the device to be powered from the system supply or the load supply voltage. The RS299 supply voltage does not have to be larger than the load source voltage. A 76V load source voltage with a 5V supply voltage is perfectly acceptable.

8.2 Recommended Component Values

Ideally, the maximum load current develops the full-scale sense voltage across the current-sense resistor. Choose the gain needed to match the maximum output voltage required for the application:

$$V_{OUT} = V_{SENSE} \times Av$$

Where V_{SENSE} is the full-scale sense voltage, 300mV for gain of 20V/V, 120mV for gain of 50V/V, 100mV for gain of 60V/V, 60mV for gain of 100V/V, and Av is the gain of the RS299.

8.3 V_{REFA} and V_{REFB} Pins

The voltage applied to the V_{REFA} and V_{REFB} pins controls the output zero reference level. Depending on how the pins are configured, the output reference level can be set to GND, or V_{CC} / 2, or external V_{REF} / 2, or the average of two different input references.

The reference inputs consist of a pair of divider resistors with equal values to a common summing point, V_{REF}', as shown in Figure 14. Assuming V_{SENSE} is zero, the output is at the same value as V_{REF}'.

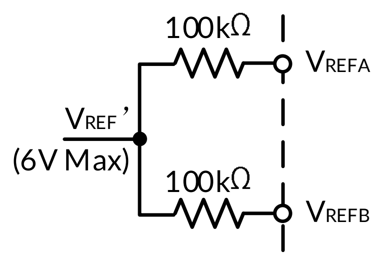


Figure 14. V_{REF} Input Resistor Network

V_{REF}' is the voltage at the resistor tap-point that is directly applied to the output as an offset. With the two V_{REF} inputs tied together, the output zero voltage has a 1:1 ratio relationship with V_{REF}.

$$V_{OUT} = ((V_{RSP} - V_{RSN}) \times Av) + V_{REF'} \quad (1)$$

Where:

$$V_{REF'} = V_{REFA} = V_{REFB} \text{ (Equal Inputs)} \quad (2)$$

or:

$$V_{REF'} = (V_{REFA} + V_{REFB}) / 2 \text{ (Different Inputs)} \quad (3)$$

8.3.1 One-to-One (1:1) Reference Input

To directly set the reference level, the two inputs are connected to the external reference voltage. The applied V_{REF} is reflected 1:1 on the output, as shown in Figure 15.

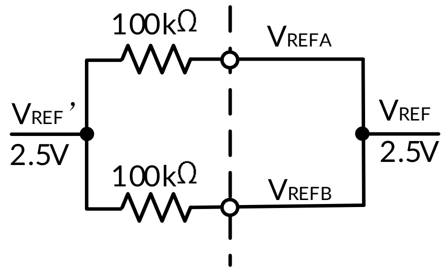


Figure 15. Applying 1:1 Direct Reference Voltage

8.3.2 Setting Output to One-Half V_{CC} or external V_{REF}

For mid-range operation, V_{REFB} must be tied to ground and V_{REFA} can be tied to V_{CC} or an external A/D reference voltage. The output is set to one-half the reference voltage. For example, a 5V reference results in a 2.5V output zero reference.

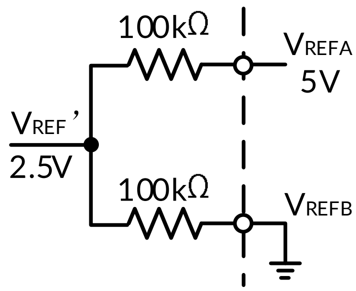


Figure 16. Applying a Divided Reference Voltage

$$V_{REF'} = (V_{REFA} - V_{REFB}) / 2 \quad (4)$$

When the reference pins are biased at different voltages, the output is referenced to the average of the two applied voltages.

The reference pins must always be driven from clean, stable sources, such as A/D reference lines or clean supply lines. Any noise or drifts on the reference inputs are directly reflected in the output. Take care if the power supply is used as the reference source so as to not introduce supply noise, drift or sags into the measurement. Different resistor divider ratios can be set by adding external resistors in series with the internal 100kΩ resistors, though the temperature coefficient (tempco) of the external resistors may not tightly track the internal resistors and there are slight errors over temperature.

8.4 Minimum Output Voltage

The amplifier output cannot swing to exactly 0V. There is always a minimum output voltage set by the output transistor saturation and input offset errors. This voltage creates a minimum output swing around the zero current reading resulting from the output saturation. The user must be aware of this output swing when designing any servo loops or data acquisition systems that may assume 0V = 0A. If a true zero is required, use the RS299 with a V_{REF} set slightly above ground (> 50mV);

8.5 Maximum Output Voltage

Output voltage is internally clamped not to exceed 20V.

9 POWER SUPPLY RECOMMENDATIONS

9.1 Power Supply Decoupling

In order to decouple the RS299 from ac noise on the power supply, RUNIC recommends using a 0.1µF bypass capacitor between the V_{CC} and GND pins. This capacitor must be placed as close as possible to the supply pins. In some cases, an additional 10µF bypass capacitor can further reduce the supply noise.
Do not forget that these bypass capacitors must be rated for the full supply and load source voltage. RUNIC recommends that the working voltage of the capacitor (WVDC) be at least two times the maximum expected circuit voltage.

10 LAYOUT

10.1 Layout Guidelines

The traces leading to and from the sense resistor can be significant error sources. With small value sense resistors (< 100mΩ), any trace resistance shared with the load current can cause significant errors.
The amplifier inputs must be directly connected to the sense resistor pads using Kelvin or 4-wire connection techniques. The traces must be one continuous piece of copper from the sense resistor pad to the amplifier input pin pad, and ideally on the same copper layer with minimal vias or connectors. These recommendations can be important around the sense resistor if any significant heat gradients are being generated.
To minimize noise pickup and thermal errors, the input traces must be treated as a differential signal pair and routed tightly together with a direct path to the input pins. The input traces must be run away from noise sources, such as digital lines, switching supplies or motor drive lines. Remember that these traces can contain high voltage, and must have the appropriate trace routing clearances.
Because the sense traces only carry the amplifier bias current (approximately 7µA at room temperature), the connecting input traces can be thinner, signal level traces. Excessive resistance in the trace must also be avoided. The paths of the traces must be identical, including connectors and vias, so that these errors are equal and cancel.
The sense resistor heats up when the load increases. When the resistor heats up, the resistance generally goes up, which causes a change in the readings. The sense resistor must have as much heatsinking as possible to remove this heat through the use of heatsinks or large copper areas coupled to the resistor pads. A reading drifting over time after turn-on can usually be traced back to sense resistor heating.

10.2 Layout Example

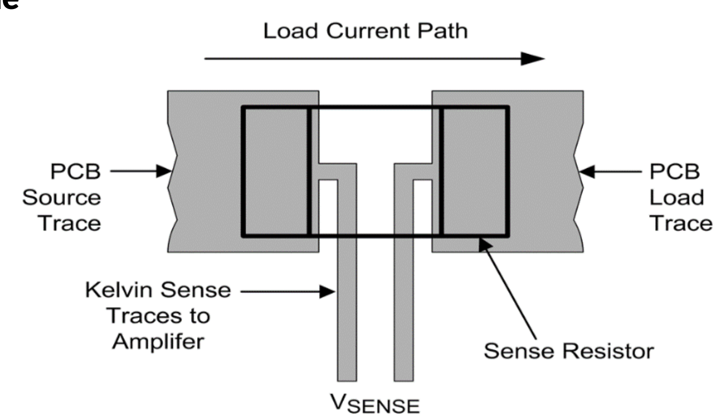
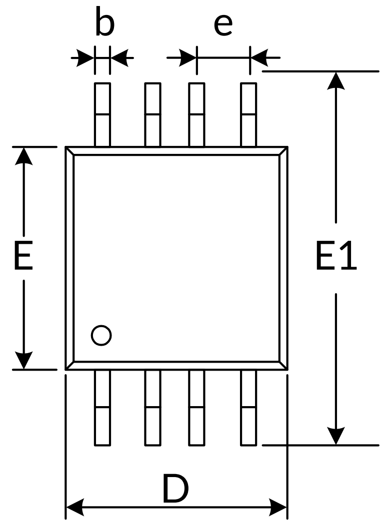
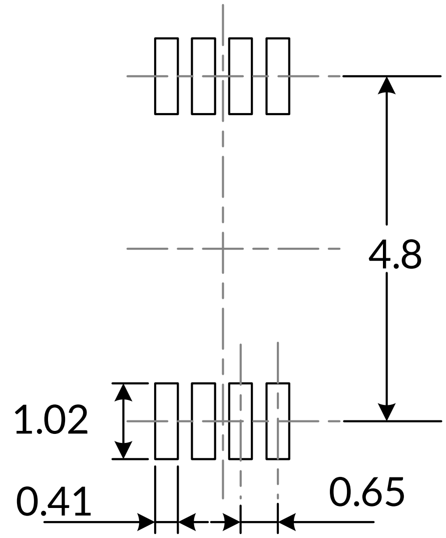


Figure 17. Kelvin or 4–Wire Connection to the Sense Resistor

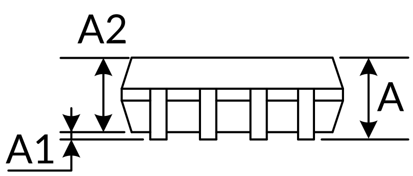
11 PACKAGE OUTLINE DIMENSIONS

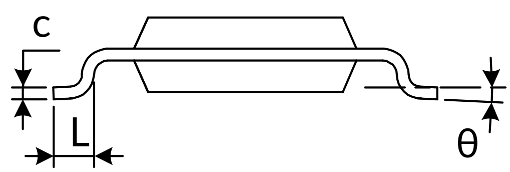
MSOP8 (3)





RECOMMENDED LAND PATTERN (Unit: mm)





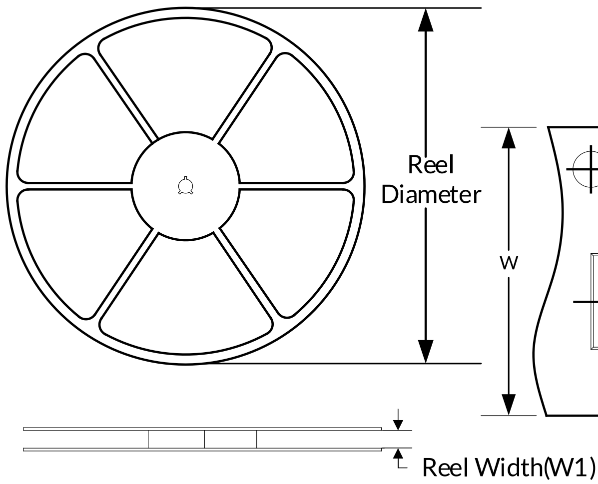
Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	0.820	1.100	0.032	0.043
A1	0.020	0.150	0.001	0.006
A2	0.750	0.950	0.030	0.037
b	0.250	0.380	0.010	0.015
c	0.090	0.230	0.004	0.009
D (1)	2.900	3.100	0.114	0.122
e	0.650(BSC) (2)		0.026(BSC) (2)	
E (1)	2.900	3.100	0.114	0.122
E1	4.750	5.050	0.187	0.199
L	0.400	0.800	0.016	0.031
θ	0°	6°	0°	6°

NOTE:

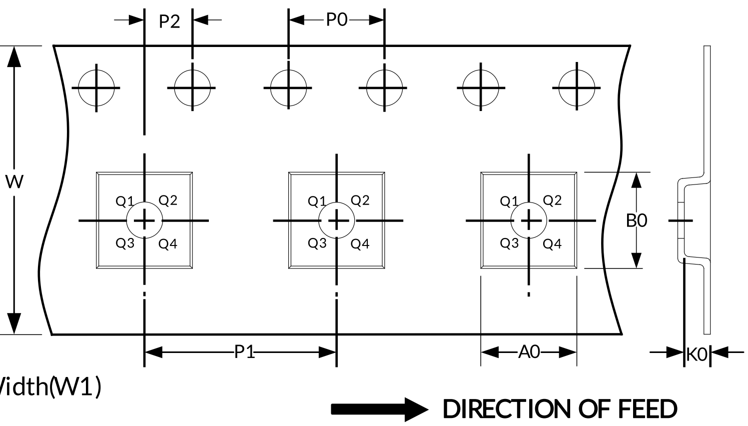
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. BSC (Basic Spacing between Centers), "Basic" spacing is nominal.
3. This drawing is subject to change without notice.

12 TAPE AND REEL INFORMATION

REEL DIMENSIONS



TAPE DIMENSION



NOTE: The picture is only for reference. Please make the object as the standard.

KEY PARAMETER LIST OF TAPE AND REEL

Package Type	Reel Diameter	Reel Width (mm)	A0 (mm)	B0 (mm)	K0 (mm)	P0 (mm)	P1 (mm)	P2 (mm)	W (mm)	Pin1 Quadrant
MSOP8	13''	12.4	5.20	3.30	1.50	4.0	8.0	2.0	12.0	Q1

NOTE:
1. All dimensions are nominal.
2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

IMPORTANT NOTICE AND DISCLAIMER