

1. General Description

The WA3199 series of voltage-output, current-shunt monitors (also called current-sense amplifiers) are commonly used for overcurrent protection, precision current measurement for system optimization, or in closed-loop feedback circuits.

This series of devices can sense drops across shunt resistors at common-mode voltages from -0.3 V to 26 V , independent of the supply voltage. Three fixed gains are available: 50 V/V . The low offset of the zero-drift architecture enables current sensing with maximum drops across the shunt as low as 10-mV full-scale.

These devices operate from a single 2.7V to 26V power supply, drawing a maximum of $100\text{ }\mu\text{A}$ of supply current. All versions are specified from -40°C to 125°C , and offered in both SOT363 packages.

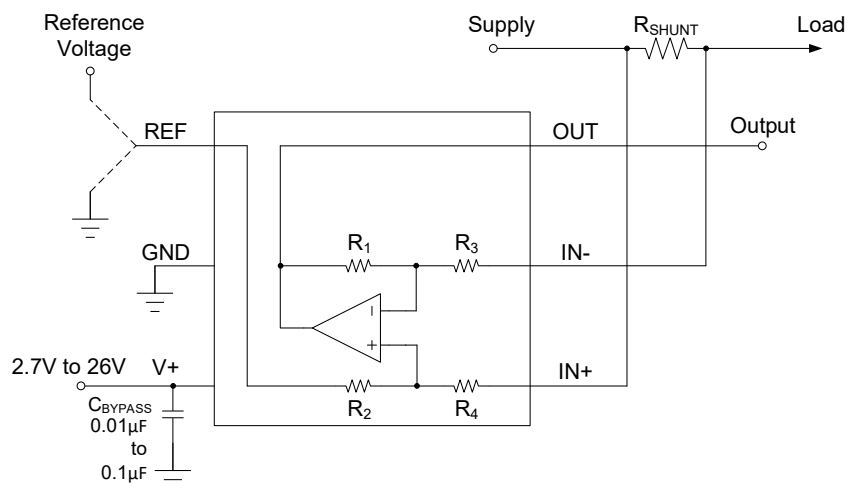
2. Features

- Wide Common-mode Range: -0.3V to 26V
- Offset Voltage: $\pm 200\mu\text{V}$ (Maximum)
(Enables Shunt Drops of 10-mV Full-Scale)
- Accuracy:
 $\pm 1.5\%$ Gain Error (Maximum):
 $0.5\text{ }\mu\text{V}/^{\circ}\text{C}$ Offset Drift (Maximum)
 $10\text{ ppm}/^{\circ}\text{C}$ Gain Drift (Maximum)
- Choice of Gains:
WA3199-A1: 50 V/V
- Quiescent Current: $100\text{ }\mu\text{A}$ (Maximum)
- Packages: SOT363

3. Applications

- Notebook Computers
- Cell Phones
- Qi-Compliant Wireless Charging Transmitters
- Telecom Equipment
- Power Management
- Battery Chargers

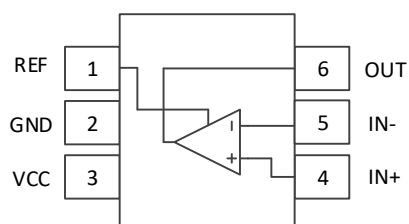
4. Typical Application Circuit



5. Pin Configuration

(Top View)

WA3199
SOT363



6. Pin Description

PIN NUMBER	PIN NAME	I/O	PIN FUNCTION
1	REF	Analog input	Reference Voltage, 0 V to VCC
2	GND	Analog	Ground
3	VCC	Analog	Power supply, 2.7 V to 26 V
4	IN+	Analog input	Positive Input. Connect to supply side of shunt resistor.
5	IN-	Analog input	Negative Input. Connect to load side of shunt resistor.
6	OUT	Analog output	Output voltage

7. Absolute Maximum Ratings^[1] ($T_A=25^{\circ}\text{C}$)

SYMBOL	PARAMETER		VALUE	UNIT
V_{CC}	Supply voltage		+26	V
V_{DIFF}	Analogy inputs, V_{IN+} , $V_{IN-}^{(2)}$	Differential, $V_{IN+} - V_{IN-}^{[2]}$	-26 to +26	V
V_{CM}		Common mode	GND-0.3 to +26	V
V_{REF}	REF Input		GND-0.3 to (V_{CC}) +0.3	V
V_{OUT}	Output ⁽³⁾		GND-0.3 to (V_{CC}) +0.3	V
I_I	Input current Into all pins ^[3]		5	mA
T_{STG}	Storage Temperature Range		-65 to +150	$^{\circ}\text{C}$
T_J	Junction Temperature		150	$^{\circ}\text{C}$
ESD(HBM)	Electrostatic Discharge Voltage Human Body Mode		4	kV

NOTE1: 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.

NOTE2: V_{IN+} and V_{IN-} are the voltages at the $IN+$ and $IN-$ pins, respectively.

NOTE3: Input voltage at any pin can exceed the voltage shown if the current at that pin is limited to 5mA.

8. Recommended Operating Conditions

SYMBOL	PARAMETER	MIN	NOM	MAX	UNIT
V_{CC}	Supply voltage		5		V
V_{CM}	Common-mode input voltage		12		V
T_A	Operating ambient temperature	-40		125	$^{\circ}\text{C}$

9. Electrical Characteristics

$V_{CC} = 5\text{ V}$, $T_A = +25^\circ\text{C}$, $V_{IN+} = 12\text{ V}$, $V_{SENSE} = V_{IN+} - V_{IN-}$ and $V_{REF} = V_{CC} / 2$, (unless otherwise noted)

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
INPUT CHARACTERISTICS						
V_{CM}	Common-mode input range		-0.3		26	V
CMR	Common-mode rejection	$V_{IN+}=0\text{ V to }26\text{ V}$, $V_{SENSE}=0\text{ mV}$	90	100		dB
V_{OS}	Offset voltage, RTI ^[1]	$V_{SENSE}=0\text{ mV}$, $V_{IN+}=12\text{ V}$		± 60		μV
$\Delta V_{OS}/\Delta T$	Vos vs temperature	$T_A=-40^\circ\text{C to }+125^\circ\text{C}$		0.1	0.5	$\mu\text{V}/^\circ\text{C}$
PSR	Power supply rejection	$V_{CC}=2.7\text{ V to }18\text{ V}$ $V_{IN+}=18\text{ V}$, $V_{SENSE}=0\text{ mV}$		± 0.1		$\mu\text{V/V}$
I_B	Input bias current	$V_{SENSE}=0\text{ mV}$		28		μA
I_{OS}	Input offset current	$V_{SENSE}=0\text{ mV}$		± 0.02		μA
OUTPUT CHARACTERISTICS						
Gain	WA3199-A1			50		V/V
	WA3199-A2			100		V/V
Gain error		$V_{SENSE}=-5\text{ mV to }5\text{ mV}$		$\pm 0.1\%$	$\pm 1.5\%$	
Gain error vs temperature		$T_A=-40^\circ\text{C to }125^\circ\text{C}$		8		ppm/ $^\circ\text{C}$
Nonlinearity error		$V_{SENSE}=-5\text{ mV to }5\text{ mV}$		$\pm 0.01\%$		
Maximum capacitive load		No sustained oscillation		1		nF

SYMBOL	PARAMETER	TEST CONDITIONS	MIN	TYP	MAX	UNIT
VOLTAGE OUTPUT						
Swing to V_{CC} power-supply rail		$R_L=10K\Omega$ to GND	$(V_{CC})-0.2$	$(V_{CC})-0.05$		V
Swing to GND		$R_L=10K\Omega$ to GND		$(V_{GND})+0.005$	$(V_{GND})+0.05$	V
FREQUENCY RESPONSE						
GBW	Bandwidth	$C_{load}=10pF$, WA3199-A1		80		kHz
		$C_{load}=10pF$, WA3199-A2		50		
SR	Slew rate			0.2		V/ μs
NOISE, RTI ^[4]						
Voltage noise density				25		nV/ $\sqrt{Hz}$
POWER-SUPPLY						
V_{CC}	Operating voltage range	$T_A=-40^{\circ}C$ to $125^{\circ}C$	2.7		26	V
I_Q	Quiescent current	$V_{SENSE}=0mV$		65	100	μA

NOTE4: RTI = Referred-to-input.

10. Typical Performance Characteristics

$T_A = +25^\circ\text{C}$, $V_{CC} = 5\text{ V}$, $V_{IN+} = 12\text{ V}$, and $V_{REF} = V_{CC} / 2$ (unless otherwise noted)

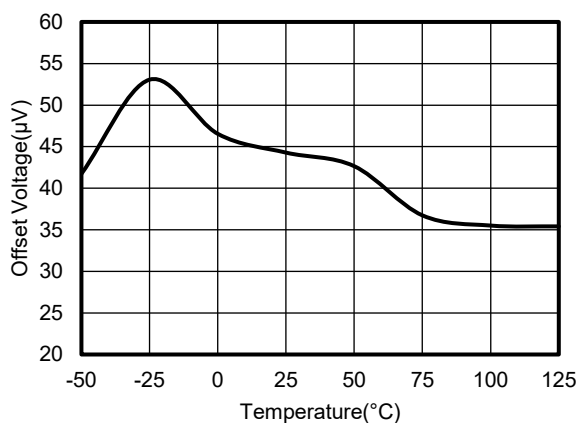


Figure 1. Offset Voltage vs. Temperature

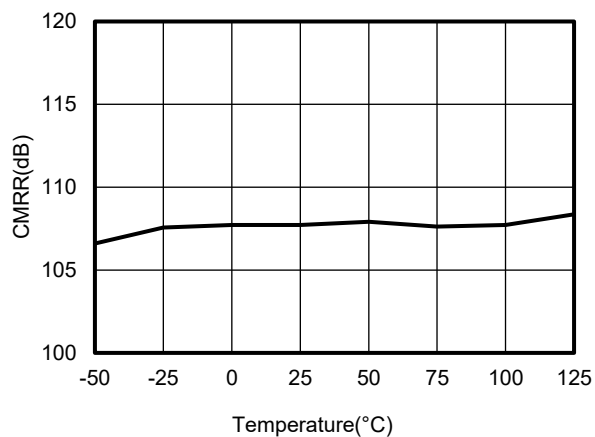


Figure 2. CMRR vs Temperature

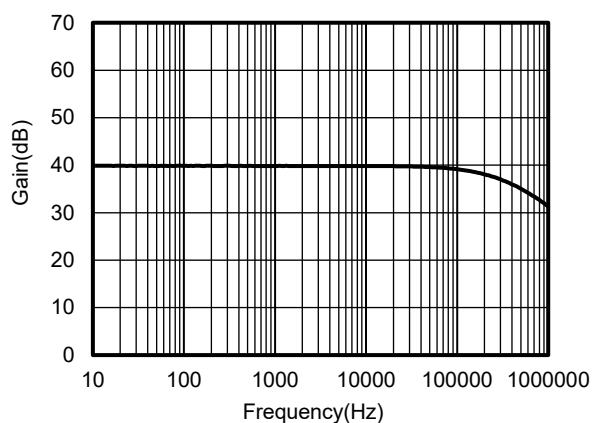


Figure 3. Gain vs Frequency

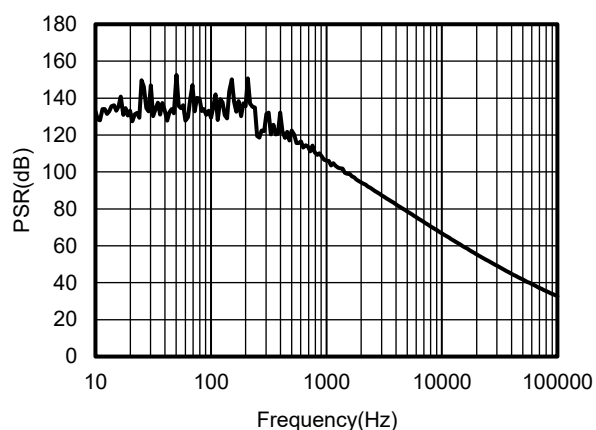


Figure 4. Power-Supply Rejection Ratio vs Frequency

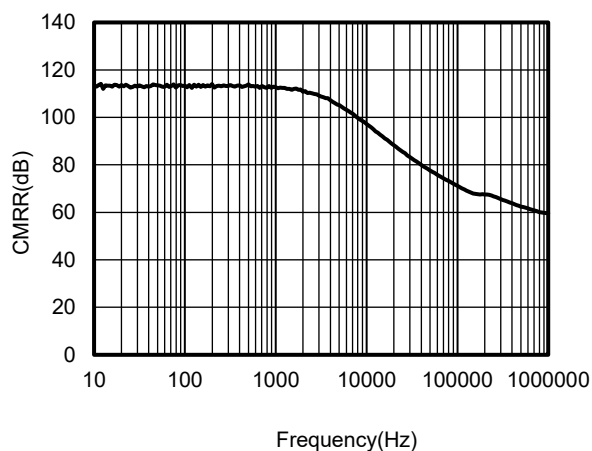


Figure 5. CMRR vs Frequency

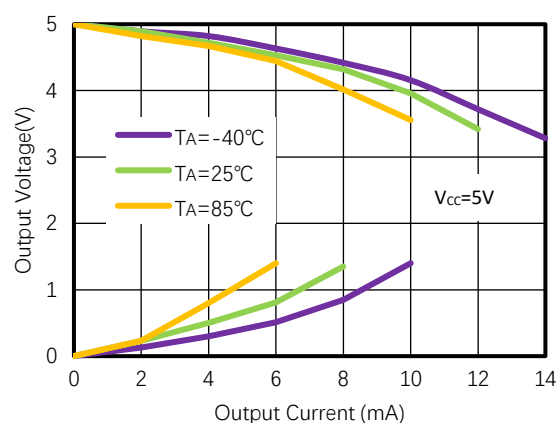


Figure 6. Output Voltage Swing vs Output Current

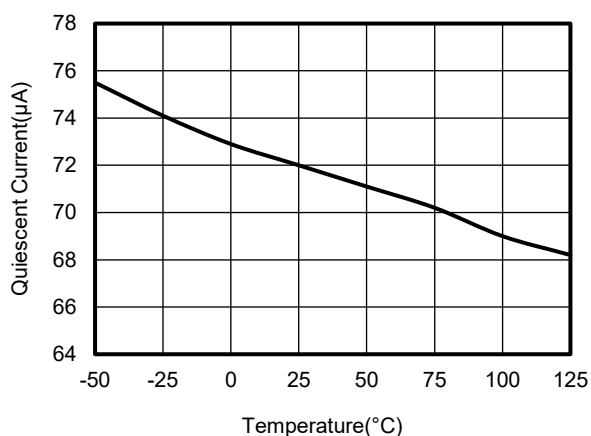


Figure 7. Quiescent Current vs. Temperature

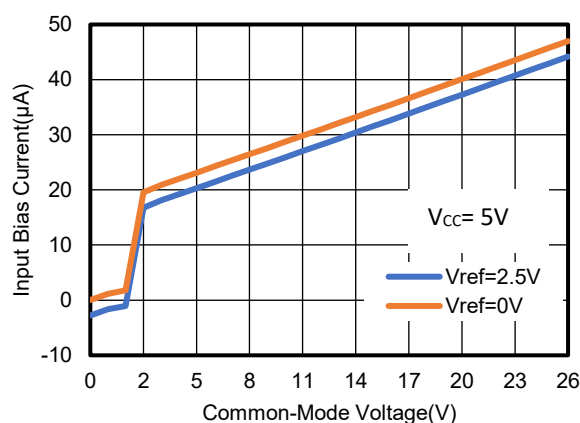


Figure 8. Input Bias Current vs Common-Mode Voltage

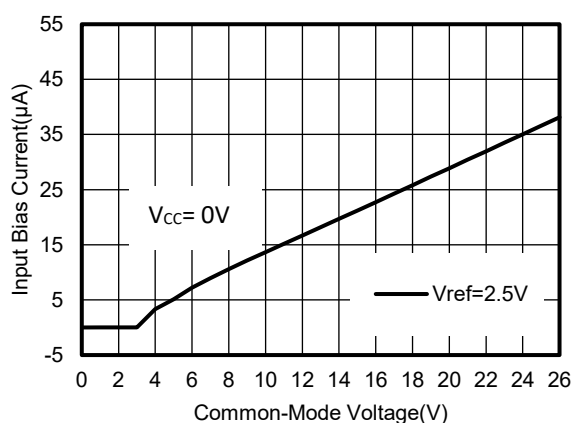


Figure 9. Input Bias Current vs Common-Mode Voltage

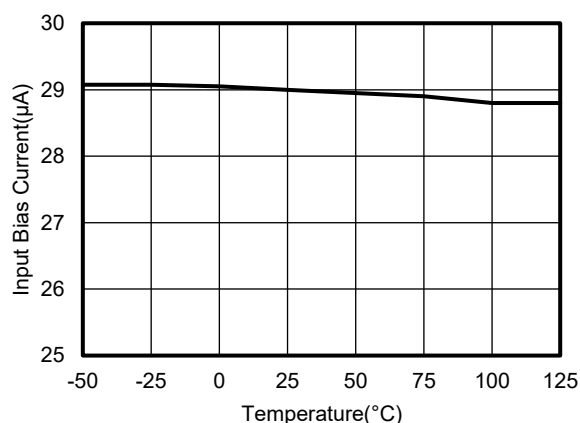


Figure 10. Bias Current vs. Temperature

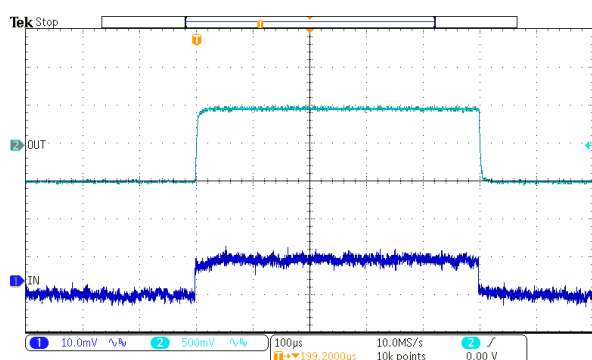


Figure 11. Step Response (10-mVPP Input Step)

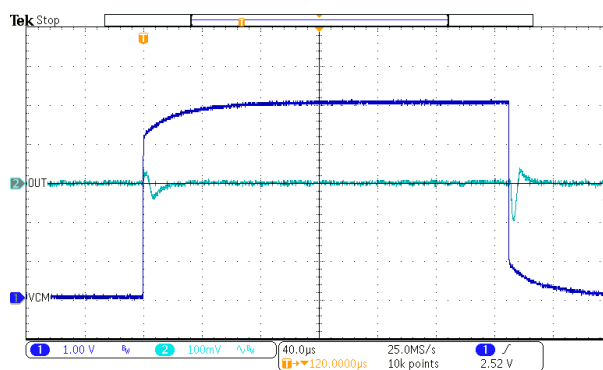


Figure 12. Common-Mode Voltage Transient Response

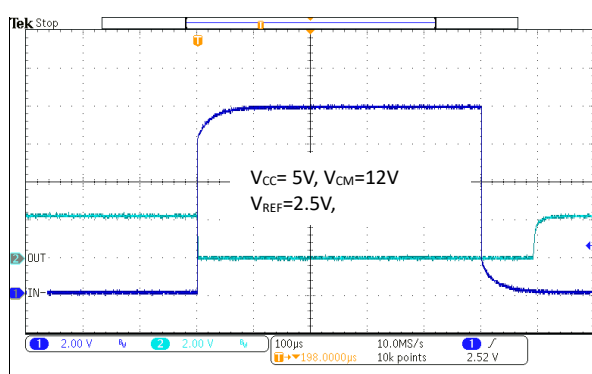


Figure 13. Inverting Differential Input Overload

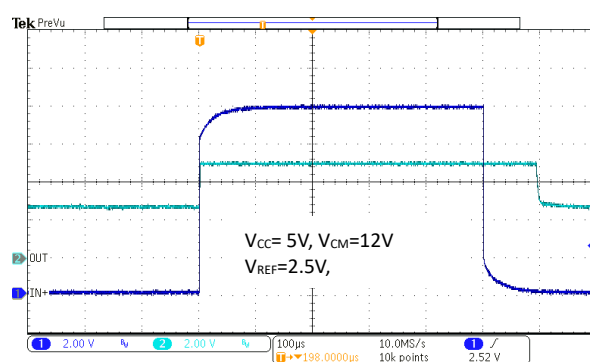


Figure 14. Noninverting Differential Input Overload

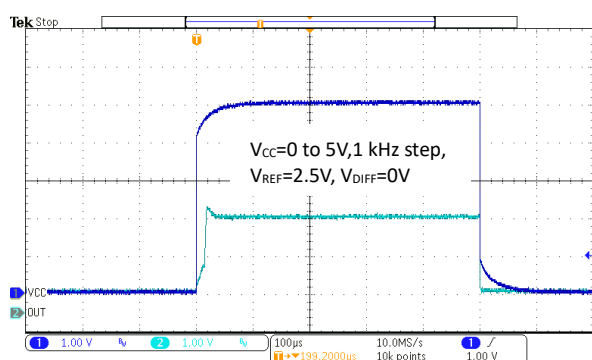


Figure 15. Start-Up Response

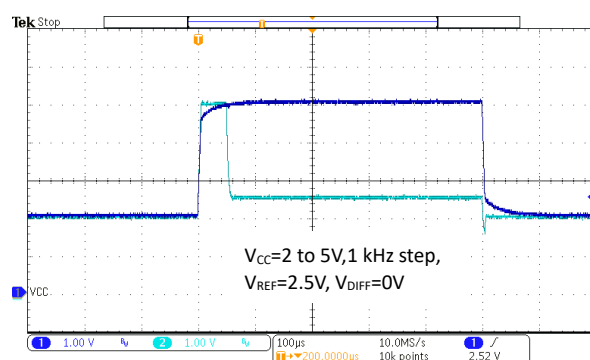


Figure 16. Brownout Recovery

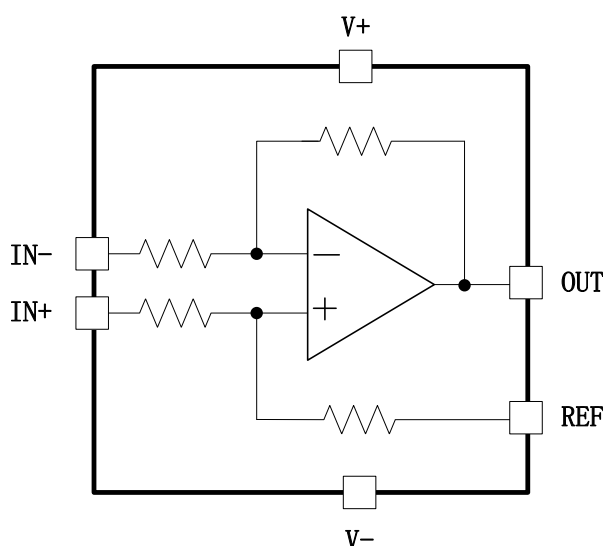
11. Function Description

11.1 Overview

The WA3199 is a 26 V common mode, zero-drift topology, current-sensing amplifier that can be used in both low-side and high-side configurations. The device is a specially-designed, current-sensing amplifier that is able to accurately measure voltages developed across a current-sensing resistor on common-mode voltages that far exceed the supply voltage powering the device. Current can be measured on input voltage rails as high as 26 V and the device can be powered from supply voltages as low as 2.7 V.

The zero-drift topology enables high-precision measurements with maximum input offset voltages as low as 100 μV with a maximum temperature contribution of 0.5 $\mu\text{V}/^\circ\text{C}$ over the full temperature range of -40°C to $+125^\circ\text{C}$.

11.2 Block Diagram



11.3 Feature Description

11.3.1 Basic Connection

Figure 17 shows the basic connections for the WA3199. The input pins, IN+ and IN-, must be connected as close as possible to the shunt resistor to minimize any resistance in series with the shunt resistor. 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. Connect bypass capacitors close to the device pins.

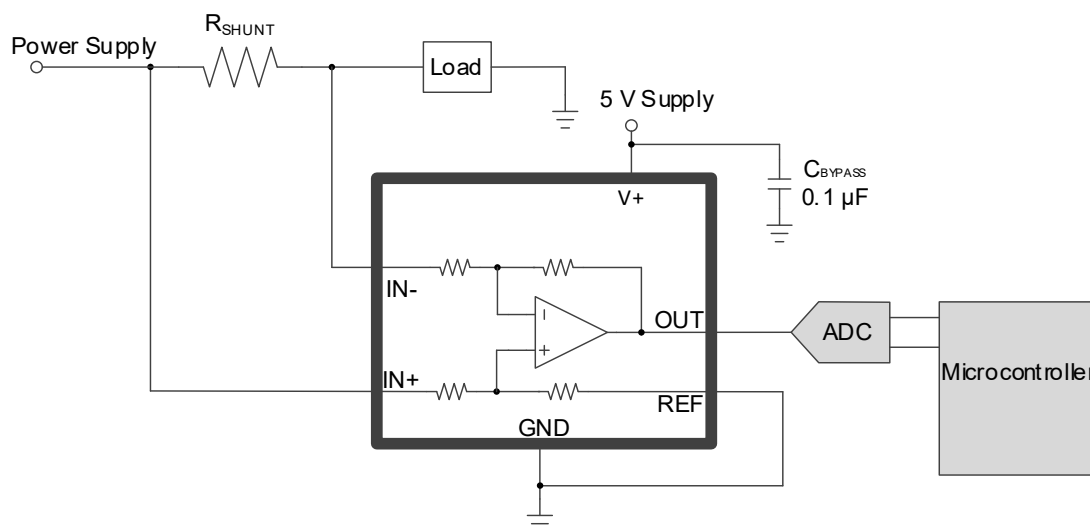


Figure 17. The Basic Connections for the WA3199

11.3.2 Selecting R_s

The zero-drift offset performance of the WA3199 offers several benefits. Most often, the primary advantage of the low offset characteristic enables lower full-scale drops across the shunt. For example, non-zero-drift current shunt monitors typically require a full-scale range of 100 mV. The WA3199 series gives equivalent accuracy at a full-scale range on the order of 10 mV. This accuracy reduces shunt dissipation by an order of magnitude with many additional benefits.

Alternatively, there are applications that must measure current over a wide dynamic range that can take advantage of the low offset on the low end of the measurement. Most often, these applications can use the lower gain of 50 or 100 to accommodate larger shunt drops on the upper end of the scale.

11.3.3 Using the WA3199 With Common-Mode Transients Above 26 V

With a small amount of additional circuitry, the WA3199 series can be used in circuits subject to transients higher than 26 V. Use only Zener diode or Zener-type transient absorbers; any other type of transient absorber has an unacceptable time delay. Start by adding a pair of resistors (see Figure 18) as a working impedance for the Zener. Keeping these resistors as small as possible is preferable, most often approximately 10Ω. Larger values can be used with an effect on gain as discussed in the Input Filtering section. Because this circuit limits only short-term transients, many applications are satisfied with a 10Ω resistor along with conventional Zener diodes of the lowest power rating that can be found. This combination uses the least amount of board space.

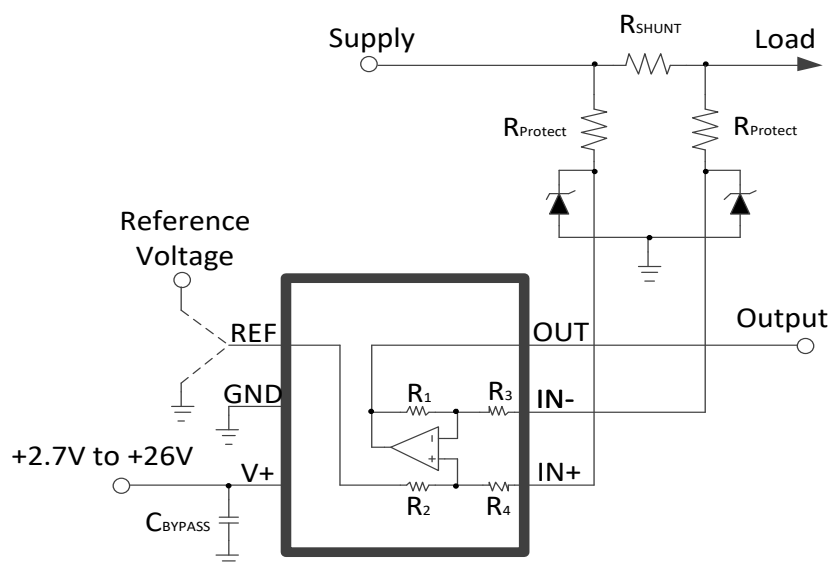


Figure 18. WA3199 Transient Protection Using Dual Zener Diodes

In the event that low-power zeners do not have sufficient transient absorption capability and a higher power transzorb must be used, the most package-efficient solution then involves using a single transzorb and back-to-back diodes between the device inputs. The most space-efficient solutions are dual series-connected diodes in a single SOT-523 or SOD-523 package. This method is shown in Figure 18.

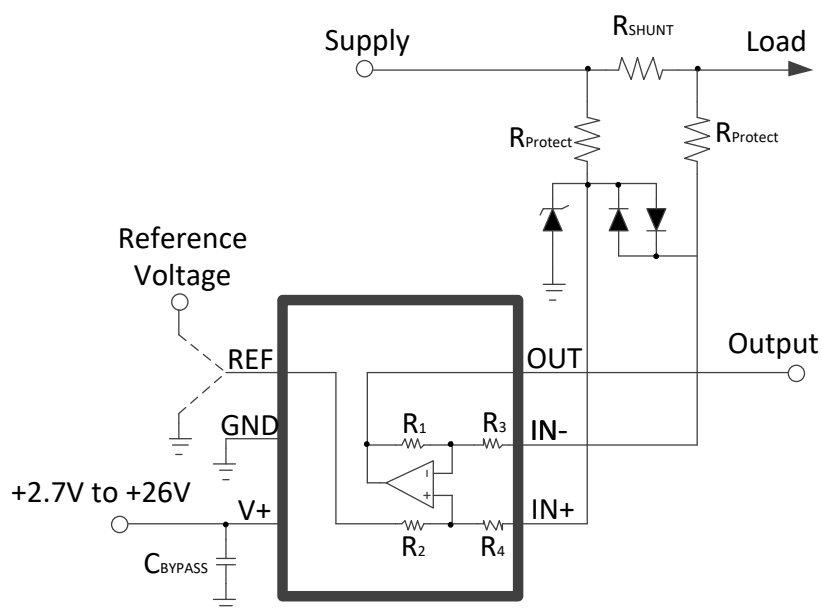


Figure 19. WA3199 Transient Protection Using a Single Transzorb and Input Clamps

12. Application Information

Note: The information in the Applications section below is not part of WAY-ON's product specifications and WAY-ON does not guarantee its accuracy or completeness. The customer is responsible for determining the suitability of the component for its intended use and should verify and test its design implementation to confirm system functionality.

12.1 Unidirectional Operation

The device can be configured to monitor current flowing in one direction (unidirectional) or in both directions (bidirectional) depending on how the REF pin is configured. The most common case is unidirectional where the output is set to ground when no current is flowing by connecting the REF pin to ground, as shown in Figure 20. When the input signal increases, the output voltage at the OUT pin increase.

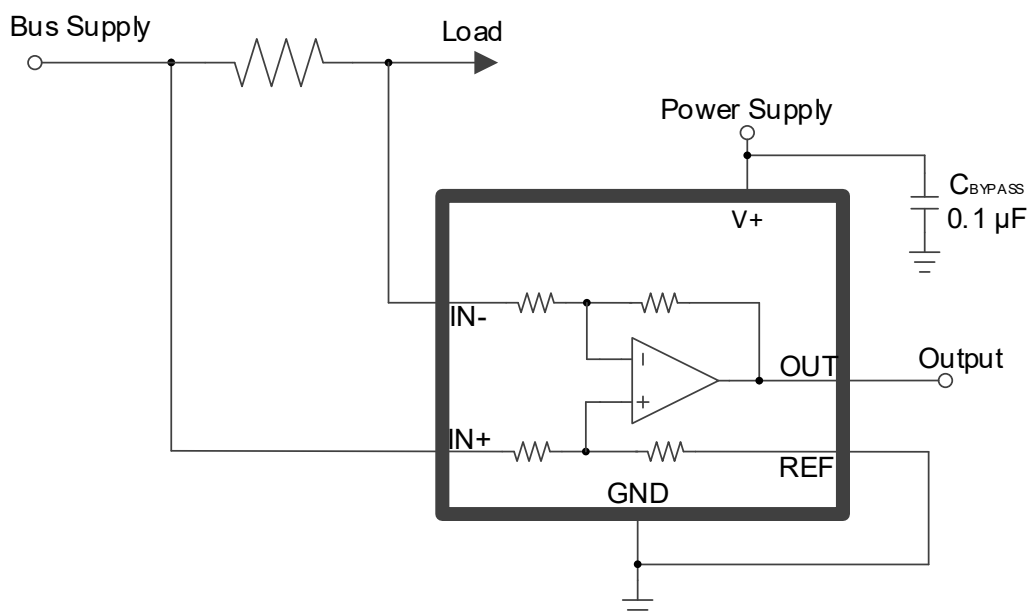


Figure 20. Unidirectional Application Schematic

12.2 Bidirectional Operation

The device is a bidirectional, current-sense amplifier capable of measuring currents through a resistive shunt in two directions, as shown in Figure 21. This bidirectional monitoring is common in applications that include charging and discharging operations where the current flow-through resistor can change directions.

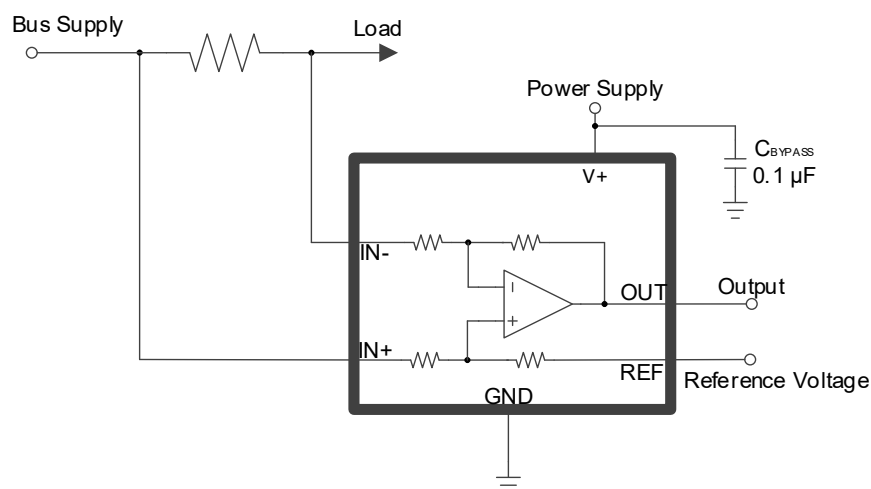


Figure 21. Bidirectional Application Schematic

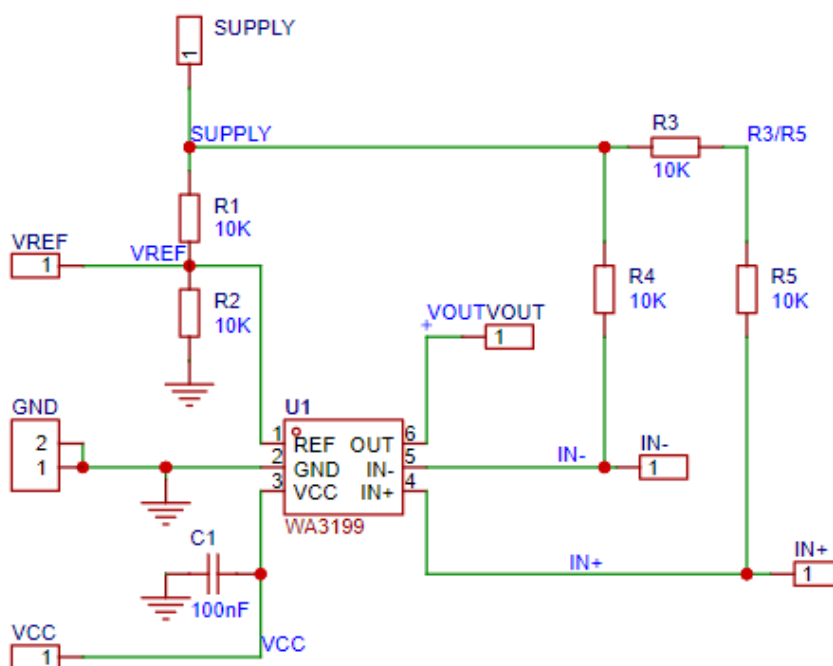
13. Evaluation Modules

Evaluation Modules (EVMs) are available to help evaluate initial circuit performance. We have evaluation modules for different packages, you can contact us to get the evaluation module or schematic.

The module names are listed in the following table.

Name	Package	Evaluation Module
WA3199	SOT363	WAYON OPA_EVM-SOT363_V1.0

13.1 Schematic

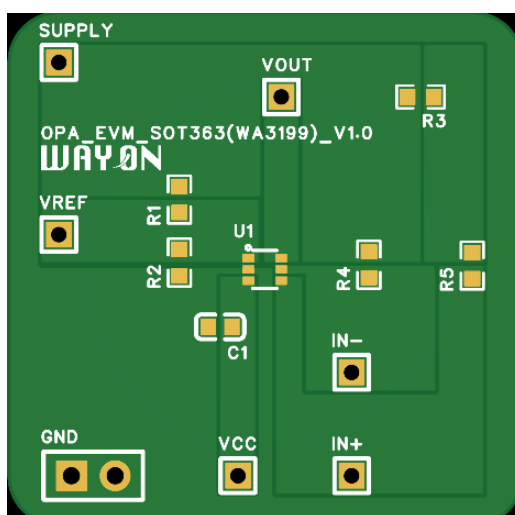


13.2 Layout

Layout Guidelines

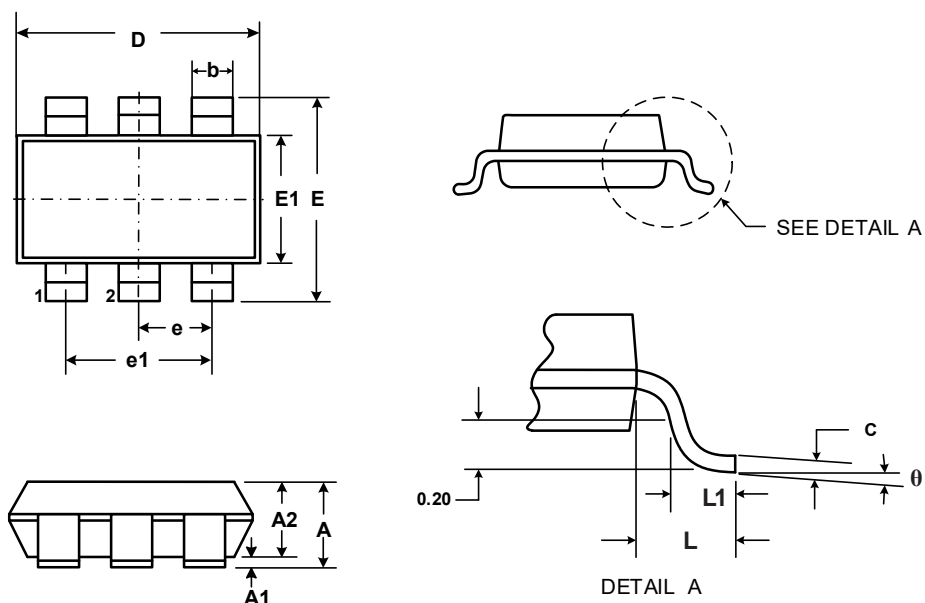
1. Connect low-ESR, 0.1 μ F ceramic bypass capacitors between each supply pin and ground, placed as close to the device as possible.
2. Separate grounding for analog and digital portions.
3. Run the input traces as far away from the supply or output traces as possible.
4. Place the external components as close to the device as possible.
5. Keep the length of input traces as short as possible.

Layout Example:



14. Package Information

SOT 363



SYMBOL	DIMENSIONS IN MILLIMETERS	
	MIN	MAX
A	0.90	1.10
A1	0.00	0.10
A2	0.90	1.00
b	0.15	0.35
c	0.10	0.15
D	2.00	2.20
E1	1.15	1.35
E	2.15	2.45
e	0.65 TYP	
e1	1.20	1.40
L	0.525 REF	
L1	0.26	0.46
θ	0°	8°

15. Ordering Information

PART NUMBER	PACKAGE	PACKING QUANTITY
WA3199-A1C60R	SOT363	3k/Reel
WA3199-A2C60R	SOT363	3k/Reel

Contact Information

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WAYON website: <http://www.way-on.com>

For additional information, please contact your local Sales Representative.

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Product Specification Statement

1.The product specification aims to provide users with a reference regarding various product parameters, performance, and usage. It presents certain aspects of the product's performance in graphical form and is intended solely for users to select product and make product comparisons, enabling users to better understand and evaluate the characteristics and advantages of the product. It does not constitute any commitment, warranty, or guarantee.

2.The product parameters described in the product specification are numerical values, characteristics, and functions obtained through actual testing or theoretical calculations of the product in an independent or ideal state. Due to the complexity of product applications and variations in test conditions and equipment, there may be slight fluctuations in parameter test values. WAYON shall not guarantee that the actual performance of the product when installed in the customer's system or equipment will be entirely consistent with the product specification, especially concerning dynamic parameters. It is recommended that users consult with professionals for product selection and system design. Users should also thoroughly validate and assess whether the actual parameters and performance when installed in their respective systems or equipment meet their requirements or expectations. Additionally, users should exercise caution in verifying product compatibility issues, and WAYON assumes no responsibility for the application of the product.

3.WAYON strives to provide accurate and up-to-date information to the best of our ability. However, due to technical, human, or other reasons, WAYON cannot guarantee that the information provided in the product specification is entirely accurate and error-free. WAYON shall not be held responsible for any losses or damages resulting from the use or reliance on any information in these product specifications. WAYON reserves the right to revise or update the product specification and the products at any time without prior notice, and the user's continued use of the product specification is considered an acceptance of these revisions and updates. Prior to purchasing and using the product, users should verify the above information with WAYON to ensure that the product specification is the most current, effective, and complete. If users are particularly concerned about product parameters, please consult WAYON in detail or request relevant product test reports. Any data not explicitly mentioned in the product specification shall be subject to separate agreement.

4.Users are advised to pay attention to the parameter limit values specified in the product specification and maintain a certain margin in design or application to ensure that the product does not exceed the parameter limit values defined in the product specification. This precaution should be taken to avoid exceeding one or more of the limit values, which may result in permanent irreversible damage to the product, ultimately affecting the quality and reliability of the system or equipment.

5.The design of the product is intended to meet civilian needs and is not guaranteed for use in harsh environments or precision equipment. It is not recommended for use in systems or equipment such as medical devices, aircraft, nuclear power, and similar systems, where failures in these systems or equipment could reasonably be expected to result in personal injury. WAYON shall assume no responsibility for any consequences resulting from such usage.

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