SQ82550 Series

Precision Micropower Shunt Voltage Reference

General Description

The SQ82550 is a high precision, micro power, low temperature drift shunt voltage reference.

The utilization of package level trim technology enables the achievement of better than ±0.1% initial accuracy at 25°C. The device does not require an output capacitor to be stable but tolerates capacitive loads. The SQ82550 supports wide operating current range from I_{RMIN} to 15mA.

The SQ82550 is available in a SOT-23 package and capable of operating within a temperature range of -40 to 125°C.

Features

- Fixed Reverse Breakdown Voltage of 2.5V, 3.3V, 4.096V and 5V.
- Output Voltage Tolerance ±0.1% (Maximum)
- Low output noise (10Hz to 10kHz) 38μVrms (Typical)
- No output Capacitor Required
- Tolerates Capacitive Loads
- Wide Operating Current Range 15mA
- Industrial Temperature Range −40°C to 125°C
- Low Temperature Coefficient ±40 ppm/°C(max)
- Small Package: SOT-23

Applications

- Power Line Monitoring
- Portable, Battery-Powered Equipment
- Data Acquisition Systems
- Instrumentation
- Process Control
- Energy Management
- Product Testing
- Precision Audio Components

Typical Application

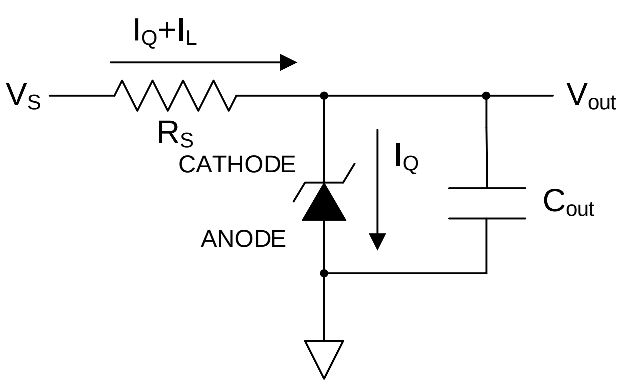


Figure 1. Typical Application

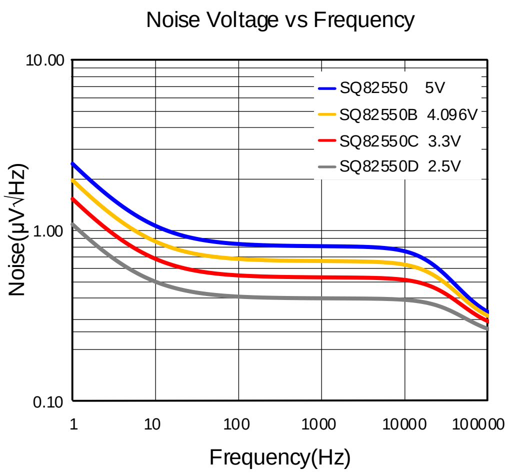


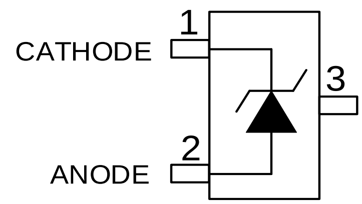
Figure 2. Noise Voltage vs Frequency

Ordering Information

Ordering Part Number	Package Type	Top Mark	Output Voltage
SQ82550AOT	SOT-23	**GTA*xyz***	**5V**
SQ82550BAOT	SOT-23	**GTB*xyz***	**4.096V**
SQ82550CAOT	SOT-23	**GTCxyz**	**3.3V**
SQ82550DAOT	SOT-23	**GTDxyz**	**2.5V**

x = year code, y = week code, z = lot number code

Pinout (Top View)



(SOT-23)

Pin Description

Pin No.	Pin Name	Pin Description
1	CATHODE	Positive pin of the reference.
2	ANODE	Negative pin of the reference, normally connected to ground.
3	NC	This pin must be left floating or connected to pin 2.

Block Diagram

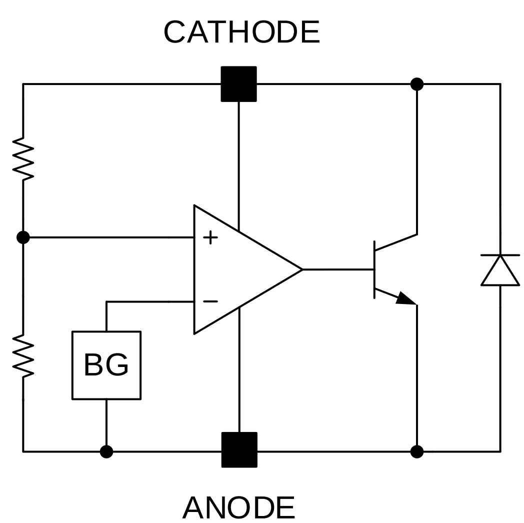


Figure 3. Block Diagram

Absolute Maximum Ratings

Parameter (	Min	Max	Unit
Input Current into CATHODE	-10	20	mA
NC	-0.3	0.3	V
Junction Temperature, Operating	-40	150	°C
Storage Temperature	-65	150	
ESD: HBM (Human Body Model)	± 2000		V
ESD: CDM (Charged Device Model)	± 1000		

Thermal Information

Parameter (Note 2)	Value	Unit
θ_{JA} Junction-to-ambient Thermal Resistance	309.5	°C/W
θ_{JC} Junction-to-case (top) Thermal Resistance	122	
θ_{JB} Junction-to-board Thermal Resistance	60	
ψ_{JT} Junction-to-top Characterization Parameter	7	
P_D Power Dissipation T_A = 25°C	280	mW

Recommended Operating Conditions

Parameter (Note 3)	Min	Max	Unit
Input Current into CATHODE	I_{RMIN}	15	mA
Ambient Temperature	-40	125	°C

Electrical Characteristics 5V

I_R = 150 µA, T_A=−40°C to 125°C, unless otherwise specified (Note 4).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	V_R	T_A = 25°C	4.995	5.000	5.005	V
Reverse Breakdown Voltage Tolerance			-25		25	mV
Minimum Operating Current	I_{RMIN}	T_A = 25°C		88	100	µA
				115	125	
Average Reverse Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta T$	I_R = 15 mA		±12	±47	ppm/°C
		I_R = 1 mA		±6	±39	
				±6	±39	
Reverse Breakdown Voltage Changes with Operating Current Change	$\Delta V_R/\Delta I_R$	$I_{RMIN} \le I_R \le$ 1 mA, T_A = 25°C, excluding die temperature change effect	-0.6	0.2	0.8	mV
		$I_{RMIN} \le I_R \le$ 1 mA, excluding die temperature change effect	-0.7	0.6	1.6	
		1mA ≤ I_R ≤ 15mA, T_A = 25°C, excluding die temperature change effect	-3.5	-1	2.5	
		1mA ≤ I_R ≤ 15mA, excluding die temperature change effect	-6	4	11	
Reverse Dynamic Impedance	Z_R	I_R = 1mA, f = 120Hz, I_{AC} = 0.1 I_R		0.5		Ω
Wideband Noise	e_N	10 Hz ≤ f ≤ 10 kHz		80		µV$_{rms}$
Reverse Breakdown Voltage Long Term Stability	ΔV_R	t = 1000hrs		90		ppm
Thermal Hysteresis	V_{HYST}	Full temperature cycle, from 25°C to -40°C, then rise to 125°C and finally back to 25°C		0.8		mV

Electrical Characteristics 4.096V

I_R = 150 μA, T_A=−40°C to 125°C, unless otherwise specified (Note 4).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	V_R	T_A = 25°C	4.092	4.096	4.100	V
Reverse Breakdown Voltage Tolerance			-20.5		20.5	mV
Minimum Operating Current	I_{RMIN}	T_A = 25°C		85	97	μA
				111	128	
Average Reverse Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta T$	I_R = 15 mA		±11	±46	ppm/°C
		I_R = 1 mA		±7	±38	
				±7	±38	
Reverse Breakdown Voltage Changes with Operating Current Change	$\Delta V_R/\Delta I_R$	$I_{RMIN} \le I_R \le$ 1 mA, T_A = 25°C, excluding die temperature change effect	-0.3	0.2	0.7	mV
		$I_{RMIN} \le I_R \le$ 1 mA, excluding die temperature change effect	-0.3	0.5	1.2	
		1mA ≤ I_R ≤ 15mA, T_A = 25°C, excluding die temperature change effect	-3.5	1	5.5	
		1mA ≤ I_R ≤ 15mA, excluding die temperature change effect	-4	3.3	10	
Reverse Dynamic Impedance	Z_R	I_R = 1mA, f = 120Hz, I_{AC} = 0.1 I_R		0.5		Ω
Wideband Noise	e_N	10 Hz ≤ f ≤ 10 kHz		65		μV_{rms}
Reverse Breakdown Voltage Long Term Stability	ΔV_R	t = 1000hrs		85		ppm
Thermal Hysteresis	V_{HYST}	Full temperature cycle, from 25°C to -40°C, then rise to 125°C and finally back to 25°C		0.65		mV

Electrical Characteristics 3.3V

I_R = 150 μA, T_A=−40°C to 125°C, unless otherwise specified (Note 4).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	V_R	T_A = 25°C	3.2967	3.3	3.3033	V
Reverse Breakdown Voltage Tolerance			-16.5		16.5	mV
Minimum Operating Current	I_{RMIN}	T_A = 25°C		83	94	μA
				109	126	
Average Reverse Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta T$	I_R = 15 mA		±11	±39	ppm/°C
		I_R = 1 mA		±7	±39	
				±7	±37	
Reverse Breakdown Voltage Changes with Operating Current Change	$\Delta V_R/\Delta I_R$	$I_{RMIN} \le I_R \le$ 1 mA, T_A = 25°C, excluding die temperature change effect	-0.25	0.2	0.7	mV
		$I_{RMIN} \le I_R \le$ 1 mA, excluding die temperature change effect	-0.5	0.5	1.4	
		1mA ≤ I_R ≤ 15mA, T_A = 25°C, excluding die temperature change effect	-0.3	2.2	4	
		1mA ≤ I_R ≤ 15mA, excluding die temperature change effect	-1.6	4.6	11.7	
Reverse Dynamic Impedance	Z_R	I_R = 1mA, f = 120Hz, I_{AC} = 0.1 I_R		0.4		Ω
Wideband Noise	e_N	10 Hz ≤ f ≤ 10 kHz		51		μV_{rms}
Reverse Breakdown Voltage Long Term Stability	ΔV_R	t = 1000hrs		70		ppm
Thermal Hysteresis	V_{HYST}	Full temperature cycle, from 25°C to -40°C, then rise to 125°C and finally back to 25°C		0.52		mV

Electrical Characteristics 2.5V

I_R = 150 μA, T_A=−40°C to 125°C, unless otherwise specified (Note 4).

Parameter	Symbol	Test Conditions	Min	Typ	Max	Unit
Reverse Breakdown Voltage	V_R	T_A = 25°C	2.4975	2.500	2.5025	V
Reverse Breakdown Voltage Tolerance			-12.5		12.5	mV
Minimum Operating Current	I_{RMIN}	T_A = 25°C		80	88	μA
				106	115	
Average Reverse Breakdown Voltage Temperature Coefficient	$\Delta V_R/\Delta T$	I_R = 15 mA		±10	±37	ppm/°C
		I_R = 1 mA		±8	±40	
				±8	±40	
Reverse Breakdown Voltage Changes with Operating Current Change	$\Delta V_R/\Delta I_R$	$I_{RMIN} \le I_R \le$ 1 mA, T_A = 25°C, excluding die temperature change effect	-0.4	0.24	0.7	mV
		$I_{RMIN} \le I_R \le$ 1 mA, excluding die temperature change effect	-0.4	0.5	1.2	
		1mA ≤ I_R ≤ 15mA, T_A = 25°C, excluding die temperature change effect	-0.5	2.2	4.4	
		1mA ≤ I_R ≤ 15mA, excluding die temperature change effect	-0.8	4.6	9	
Reverse Dynamic Impedance	Z_R	I_R = 1mA, f = 120Hz, I_{AC} = 0.1 I_R		0.3		Ω
Wideband Noise	e_N	10 Hz ≤ f ≤ 10 kHz		38		μV_{rms}
Reverse Breakdown Voltage Long Term Stability	ΔV_R	t = 1000hrs		110		ppm
Thermal Hysteresis	V_{HYST}	Full temperature cycle, from 25°C to -40°C, then rise to 125°C and finally back to 25°C		0.4		mV

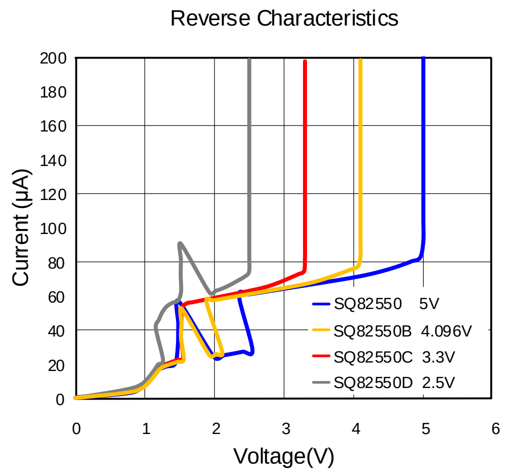
Note 1: Stresses beyond the "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only. Functional operation of the device at these or any other conditions beyond those indicated in the operational sections of the specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

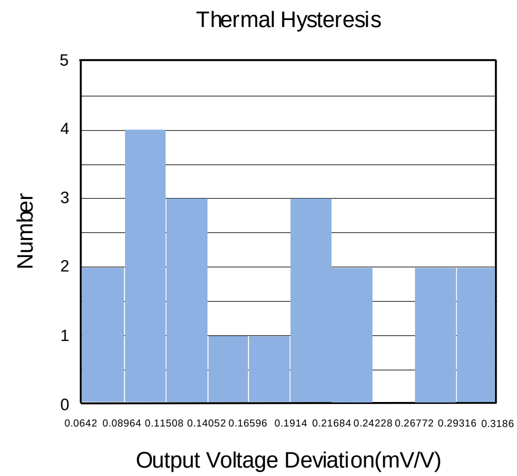
Note 2: θ_{JA} is measured in the natural convection at T_A = 25°C on a low effective single layer thermal conductivity test board of JESD51-3.

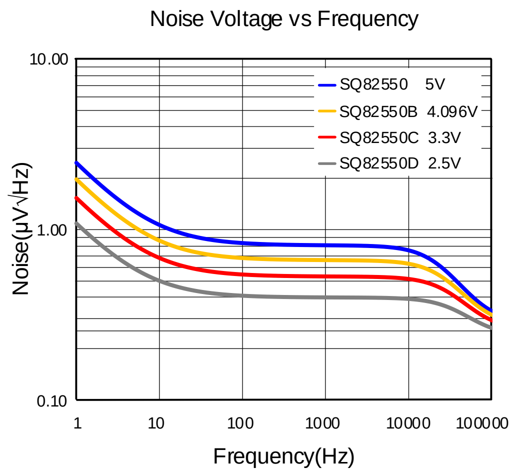
Note 3: The device is not guaranteed to function outside its operating conditions.

Note 4: Production tested at 25˚C. Limits are guaranteed by design, test or statistical correlation.

Typical Performance Characteristics

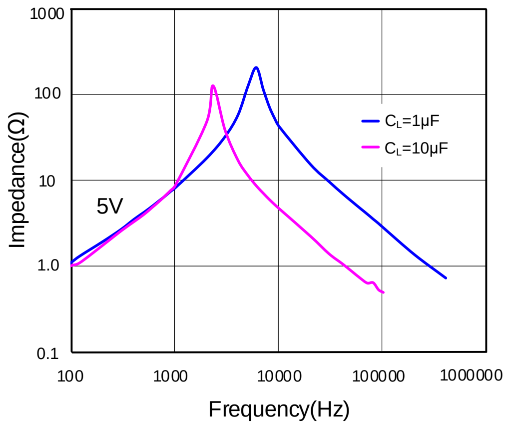




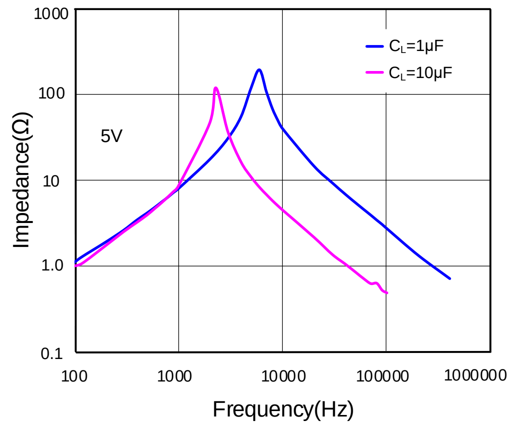


SQ82550 5V

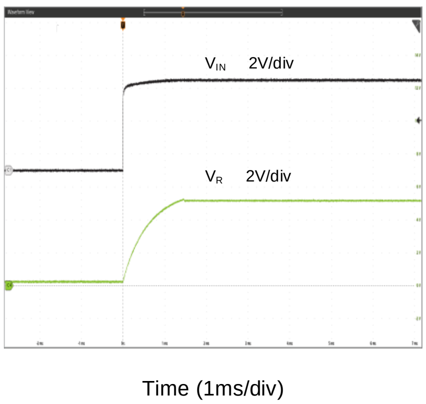
Output Impedance vs Frequency
(I_R=250μA, I_{AC}=0.1I_R)



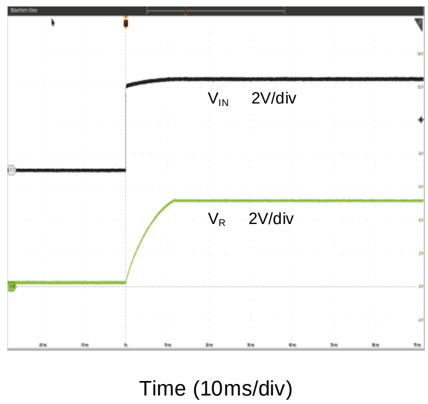
Output Impedance vs Frequency
(I_R=1mA, I_{AC}=0.1I_R)



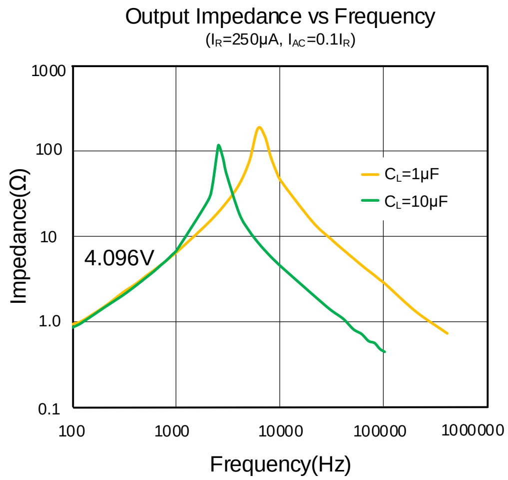
Input Voltage Step Response-5V
(C_L=1μF, I_R=1mA)

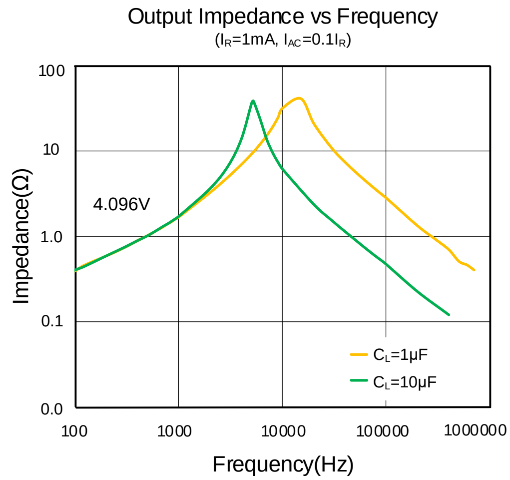


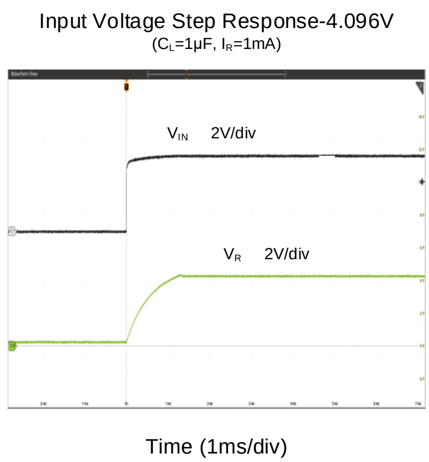
Input Voltage Step Response-5V
(C_L=10μF, I_R=1mA)

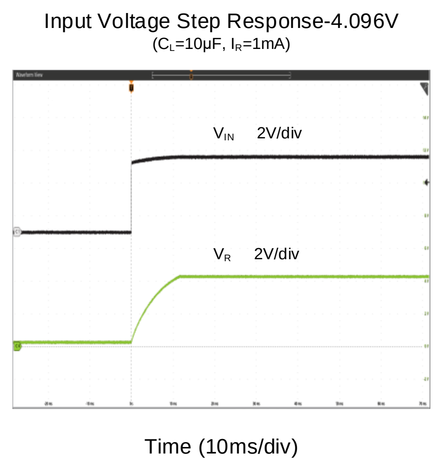


SQ82550B 4.096V



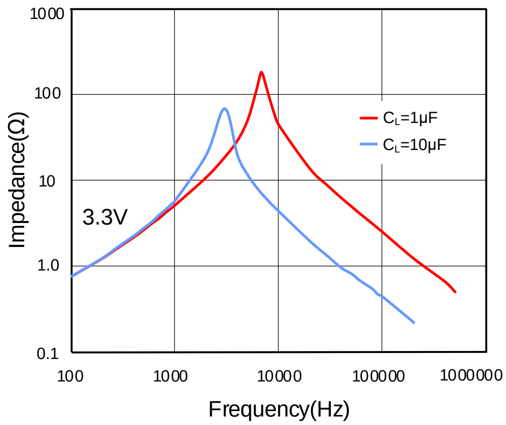




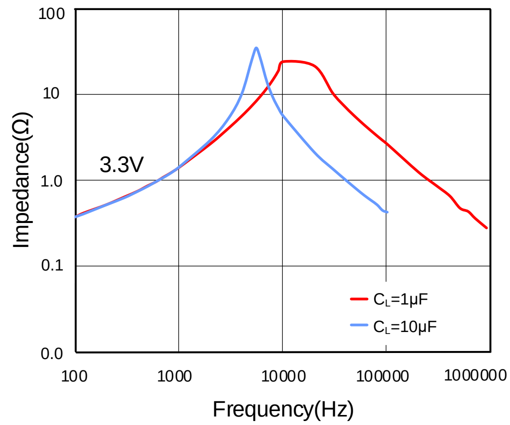


SQ82550C 3.3V

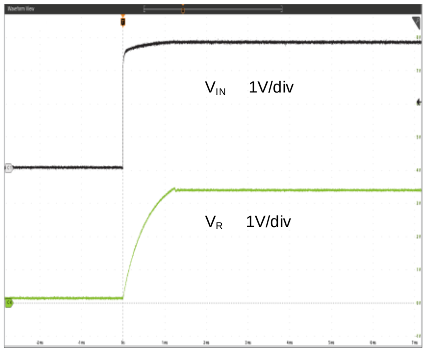
Output Impedance vs Frequency
(I_R=250μA, I_{AC}=0.1I_R)



Output Impedance vs Frequency
(I_R=1mA, I_{AC}=0.1I_R)

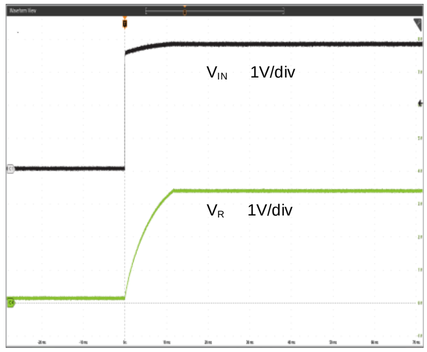


Input Voltage Step Response-3.3V
(C_L=1μF, I_R=1mA)



Time (1ms/div)

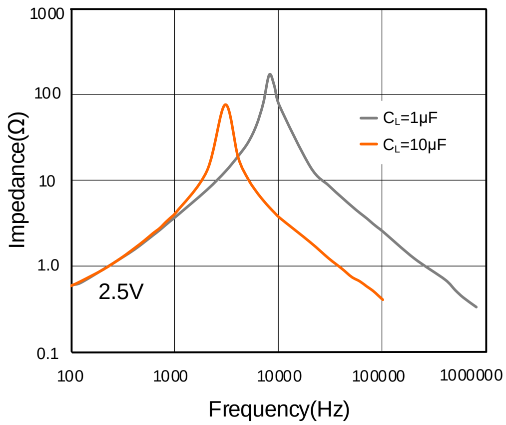
Input Voltage Step Response-3.3V
(C_L=10μF, I_R=1mA)



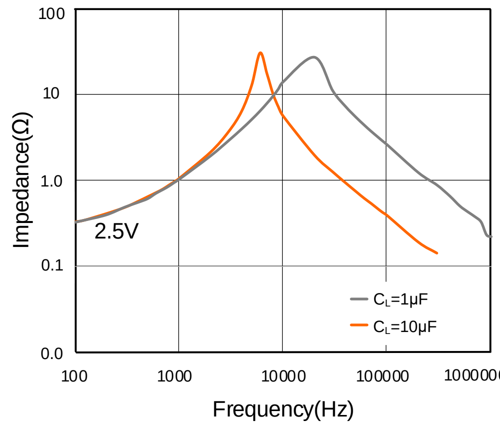
Time (10ms/div)

SQ82550D 2.5V

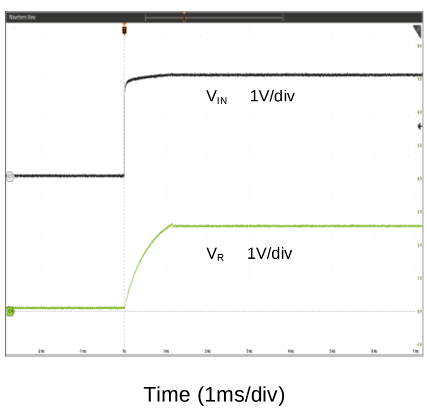
Output Impedance vs Frequency
(I_R=250μA, I_{AC}=0.1I_R)



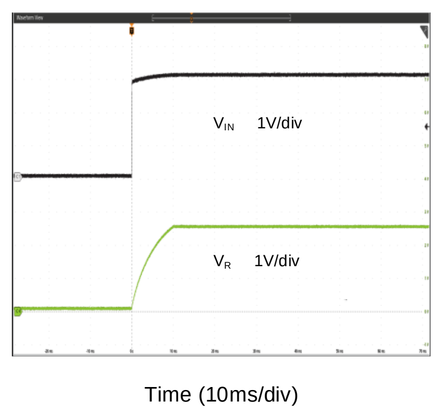
Output Impedance vs Frequency
(I_R=1mA, I_{AC}=0.1I_R)



Input Voltage Step Response-2.5V
(C_L=1μF, I_R=1mA)



Input Voltage Step Response-2.5V
(C_L=10μF, I_R=1mA)



Functional Description

The SQ82550 is a high precision, micro power, low temperature drift shunt voltage reference which is available in SOT-23 package.

The utilization of package level trim technology enables the achievement of better than ±0.1% initial accuracy at 25°C. The device does not require an output capacitor to be stable but tolerates capacitive loads.

In order to enhance the design flexibility, the devices can provide different options of fixed reverse breakdown voltages, including 2.5V, 3.3V, 4.096V, and 5V. All versions of the SQ82550 provide a maximum current capability of 15mA. It is recommended to either leave the NC pin unconnected or connect it to the ANODE pin.

Minimum Operation Current

As a shunt reference, the SQ82550 requires a minimum operation current that flows into CATHODE to keep the output voltage stable. The value of the minimum operation current varies with the fixed output voltage and the environment temperature. See Electrical Characteristics Table for more details.
It is recommended to provide enough margin for the operating current when selecting components and account for the input voltage changes, resistor tolerance and load current range for the target application. See Application Information Section for more details.

Output Capacitance

The SQ82550 does not require an output capacitor to be stable but tolerates capacitive loads. The output capacitor improves the performance at higher frequencies. See Output Impedance versus Frequency waveform for more details.

Application Information

As Figure 4 typical application diagram shows, a series resistor (R_S) is needed to limit the total input current. The total input current is divided into two parts: the load current (I_L) and the SQ82550 bias operation current (I_Q). The value of R_S is determined by the supply voltage (V_S), I_L, I_Q, and the reverse breakdown voltage of the SQ82550 (V_R). The formula for calculating R_S is shown below:

$$R_S = \frac{V_S - V_R}{I_L + I_Q}$$

Since the load current and supply voltage may vary, it is important for R_S to have a low enough value to ensure that the SQ82550 will receive at least the minimum required current (I_{RMIN}), even when operating with the lowest supply voltage and highest load current. The formula for calculating maximum R_S is shown below:

$$R_{SMAX} < \frac{V_{SMIN} - V_{RMAX}}{I_{LMAX} + I_{QMAX}}$$

Conversely, when the supply voltage is at its maximum value and the load current is at its minimum, the R_S should have a large enough value to limit the current flowing through the SQ82550 to a value below its maximum operating current of 15mA. The formula for calculating minimum R_S is as follows:

$$R_{SMIN} > \frac{V_{SMAX} - V_{RMIN}}{I_{LMIN} + I_{QMIN}}$$

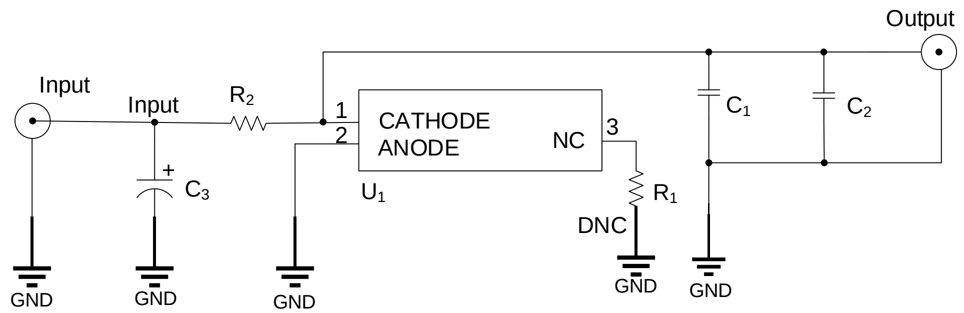
It is recommended to leave enough margin for I_Q when calculating R_S. For example, choose I_{QMAX} as 10mA and I_{QMIN} as 3mA. In this case, the SQ82550 will operate correctly with the bias currents in the range of 3mA to 10mA, independent of how the supply voltage V_S and load current I_L change.

Ensure the power dissipation of resistor is below its nominal value. The formula for calculating the power dissipation of the resistor RS is shown below:

$$P_S = (V_S - V_R) * (I_L + I_Q)$$

Once the nominal value of resistor R_S is determined, it is recommended to check the accuracy and temperature drift coefficient of the resistor, which influence the actual value of resistor.

Application Schematic



BOM List

Designator	Description	Part Number	Manufacturer
U_1	Shunt voltage reference	SQ82550	Silergy
C_1	0805, 10uF/25V		
C_2	DNC		
C_3	0805, 1uF/25V		
Input, Output	SMB Straight Connector		
R_1	DNC		
R_2	0603, 510Ω		

Layout Design

Noise on the power supply input to the R_S has a discernible impact on the output noise performance. To mitigate this effect, using a 0.1µF or higher ceramic bypass capacitor can improve the noise performance.

Place R_S as close to the CATHODE as possible. If input and output capacitors are used, the capacitors should be placed as close to the SQ82550 as possible, as shown in figure 4.

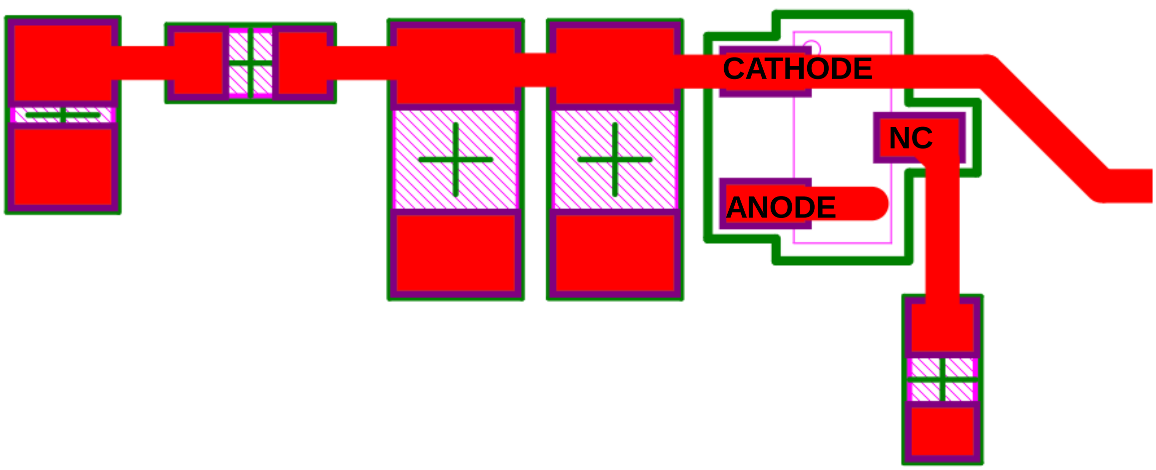
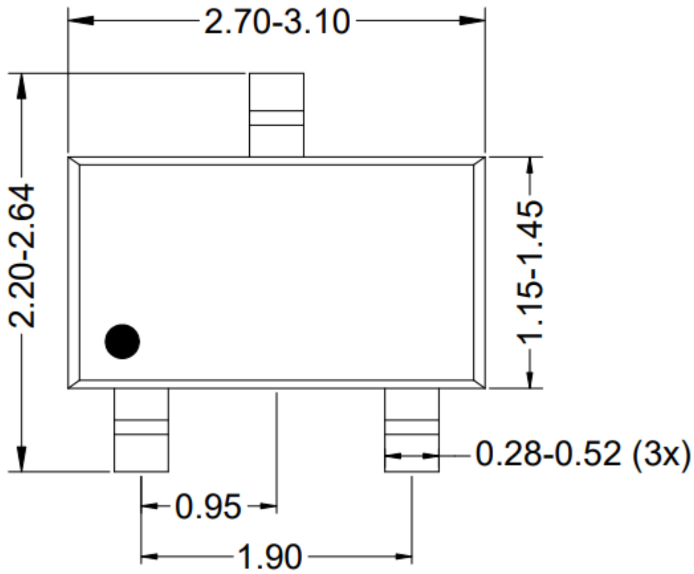
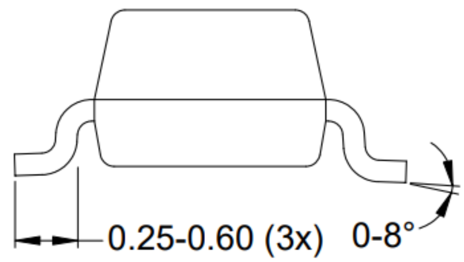


Figure 5. Layout Recommendation

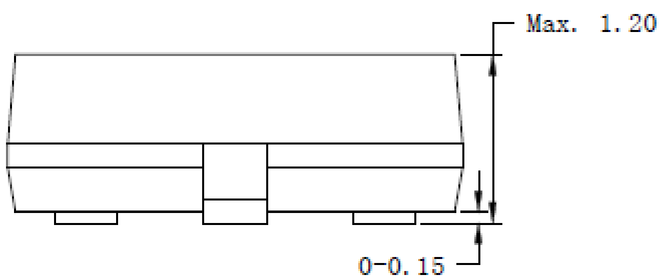
SOT-23 Package Outline Drawing



Top view



Side view A



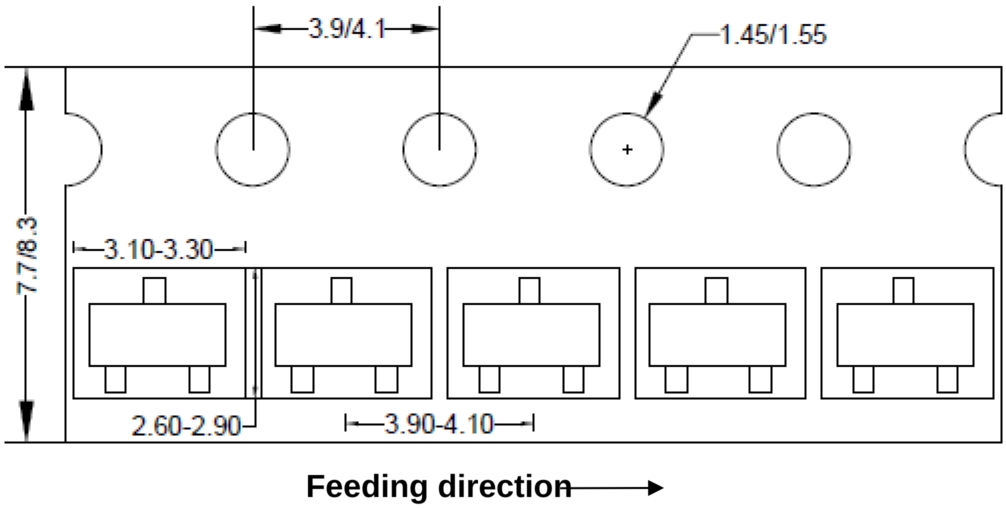
Side view B

Notes: **All dimension in millimeter and exclude mold flash & metal burr.**

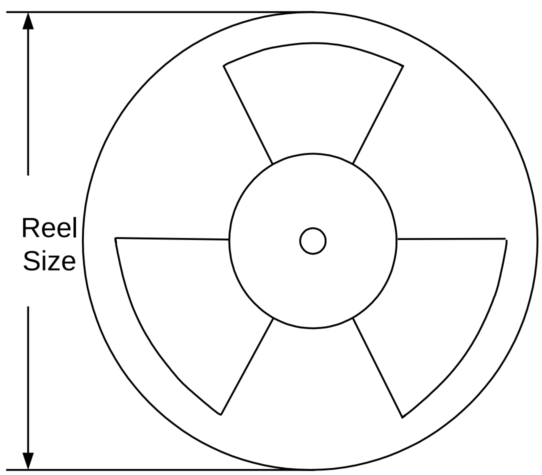
Taping & Reel Specification

1. Taping Orientation

SOT-23



2. Carrier Tape & Reel Specification for Packages



Package types	Tape width (mm)	Pocket pitch(mm)	Reel size (Inch)	Trailer length(mm)	Leader length (mm)	Qty per reel
SOT-23	8	4	7"	400	400	3000

3. Others: NA

Revision History

The revision history provided is for informational purposes only and is believed to be accurate; however, it is not warrantied. Please make sure that you have the latest revision.

Date	Revision	Change
Feb. 2, 2024	Revision 1.0	Initial Release

IMPORTANT NOTICE

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