Low-Noise, Very Low Drift, Precision Voltage Reference

1 FEATURES

- **Low Temperature Drift: 3 ppm/°C(TYP)**
- **High Accuracy: 0.1% Maximum**
- **Low Noise: 7.5 µV_{PP}/V**
- **Low I_Q: 1.1 mA (Typical)**
- **Operating Temperature Range: -40°C to +125°C**
- **High Output Current: ±10 mA**
- **Micro SIZE PACKAGES: SOIC-8(SOP8)**

2 APPLICATIONS

- **Precision Data Acquisition Systems**
- **Semiconductor Test Equipment**
- **Medical Instrumentation**
- **Industrial Process Controls**
- **Pressure and Temperature Transmitters**
- **Lab and Field Instrumentation**

3 DESCRIPTIONS

The RS50XXLV is a family of low-noise, low-drift, very high precision voltage references. These references are capable of both sinking and sourcing current, and have excellent line and load regulation.

Excellent temperature drift (3 ppm/°C) and high accuracy (0.1%) are achieved using proprietary design techniques with 1.1mA(typical) quiescent current. These features, combined with low noise, make the RS50XXLV family ideal for use in high-precision data acquisition systems.

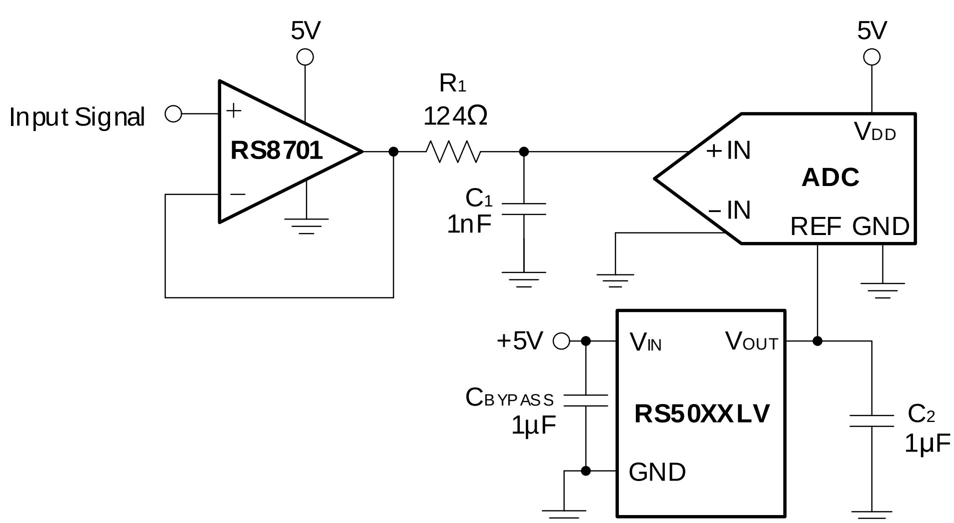
The RS50XXLV is available in Green SOIC-8(SOP8) packages. It operates over an ambient temperature range of -40°C to +125°C.

Device Information (1)

PART NUMBER	PACKAGE	BODY SIZE(NOM)
RS50XXLV	SOIC-8(SOP8)	4.90mm x 3.90mm

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

4 TYPICAL APPLICATION



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5 Revision History

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

VERSION	Change Date	Change Item
A.0	2023/05/30	Preview version completed
A.1	2023/07/28	1. Change RS50XX to RS50XXLV 2. Update TYPICAL APPLICATION on Page 1@RevA.0

6 PACKAGE/ORDERING INFORMATION [1]

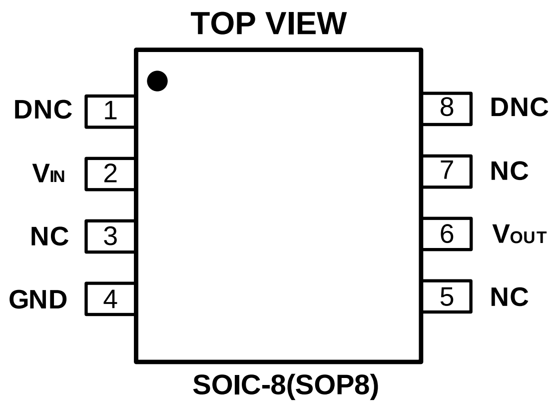
PRODUCT	ORDERING NUMBER	TEMPERATURE RANGE	PACKAGE LEAD	PACKAGE MARKING [2]	PACKAGE OPTION
RS50XXLV	RS5020LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5020LV	Tape and Reel,4000
	RS5025LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5025LV	Tape and Reel,4000
	RS5030LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5030LV	Tape and Reel,4000
	RS5033LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5033LV	Tape and Reel,4000
	RS5040LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5040LV	Tape and Reel,4000
	RS5045LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5045LV	Tape and Reel,4000
	RS5050LVXK	-40°C ~+125°C	SOIC-8(SOP8)	RS5050LV	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.

7 Pin configuration and Functions (Top View)



Pin Description

NAME	PIN	I/O (1)	DESCRIPTION
	SOIC-8(SOP8)		
DNC (2)	1	—	Do not connect
V_{IN}	2	I	Input supply voltage
NC (3)	3,5,7	O	No internal connection
GND	4	G	Ground
V_{OUT}	6	O	Reference voltage output
DNC (2)	8	—	Do not connect

(1) I = Input, O = Output.
(2) DNC = Do not connect.
(3) NC = No internal connection.

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

over operating free-air temperature range (unless otherwise noted) (1)(2)

SYMBOL			MIN	MAX	UNIT
V_{IN}	Supply voltage, V+ to V–		-0.2	8	V
	Output short circuit		-30	30	mA
$θ_{JA}$	Package thermal impedance (3)	SOIC-8(SOP8)		110	°C/W
T_A	Operating temperature		-40	+125	°C
T_J	Junction temperature (4)		-40	150	°C
T_{stg}	Storage temperature		-65	150	°C

(1) Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under *Recommended Operating Conditions* is not implied. Exposure to absolute-maximum-rated conditions for extended periods may affect device reliability.

(2) All voltages are with respect to the GND pin.

(3) The package thermal impedance is calculated in accordance with JESD-51.

(4) The maximum power dissipation is a function of $T_{J(MAX)}$, $R_{θJA}$, and T_A. The maximum allowable power dissipation at any ambient temperature is $P_D = (T_{J(MAX)} - T_A) / R_{θJA}$. All numbers apply for packages soldered directly onto a PCB.

8.2 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), JEDEC EIA/ JESD22 - A114	±3000	V
		Charged-Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2018	±1000	V
		Machine Model (MM), JESD22-A115C (2010)	±200	V

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.

8.3 Recommended Operating Conditions

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

SYMBOL	PARAMETER	MIN	MAX	UNIT
V_{IN}	Input voltage	V_{OUT}+0.5(1)	6	V
I_{Load}	Load current	-10	10	mA

(1) Minimum supply voltage for the RS50XXLV is 4 V.

8.4 ELECTRICAL CHARACTERISTICS

At T_A = 25°C, I_{OUT} = 0 mA, and V_{IN} = 5 V (unless otherwise noted).

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output Voltage	V_{OUT}		RS5020LV		2.048		V
			RS5025LV		2.5		
			RS5030LV		3.0		
			RS5033LV		3.3		
			RS5040LV		4.096		
			RS5045LV		4.5		
			RS5050LV		5.0		
Initial Accuracy			All voltage options (1)	-0.1		0.1	%
Output Voltage Noise			f = 0.1Hz to 10Hz		7.5		$\mu V_{PP}/V$
Output Voltage Temperature Drift (2)	dV_{OUT}/dT		T_A = -40°C to +125°C		3		ppm/°C
Long-Term Stability			0 to 1000 hours		100		ppm
			1000 to 2000 hours		50		
Line Regulation			V_{IN} = (V_{OUT} + 0.5) to 6 V (1)		8		ppm/V
			V_{IN} = (V_{OUT} + 0.5) to 6 V T_A = -40°C to +125°C			15	
Load Regulation	dV_{OUT}/dI_{LOAD}		-10 mA < I_{LOAD} < 10 mA, V_{IN} = V_{OUT} + 0.5 V (3)		2		ppm/mA
			-10 mA < I_{LOAD} < 10 mA, V_{IN} = V_{OUT} + 0.5V T_A = -40°C to 125°C (3)			5	
Thermal Hysteresis	dT		First Cycle		90		ppm
Short-Circuit Current	I_{SC}	Sourcing			25		mA
		Sinking			20		
Turn on Settling Time			To 0.1% with C_L = 1μF		300		μs
Capacitive Load				1		50	μF
Voltage	V_{IN}		I_{LOAD} = 0, T_A = -40°C to +125°C.	V_{OUT}+ 0.5(1)		6	V
Quiescent Current	I_Q		I_{LOAD} = 0, T_A = 25°C		1.1		mA
			I_{LOAD} = 0, T_A = -40°C to +125°C			1.5	

(1) Minimum supply voltage for the RS50XXLV is 4 V.
(2) Box Method used to determine temperature drift.
(3) Typical value of load regulation reflects measurements using force and sense contacts;

8.5 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.

At T_A = 25°C, V_{IN}= 5V, unless otherwise noted.

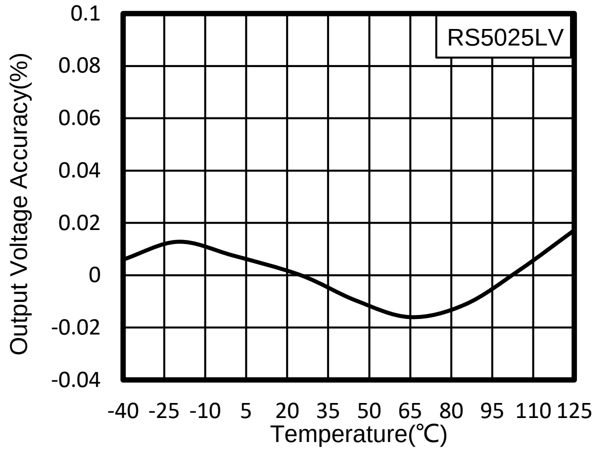


Figure 1. Output Voltage Accuracy vs Temperature

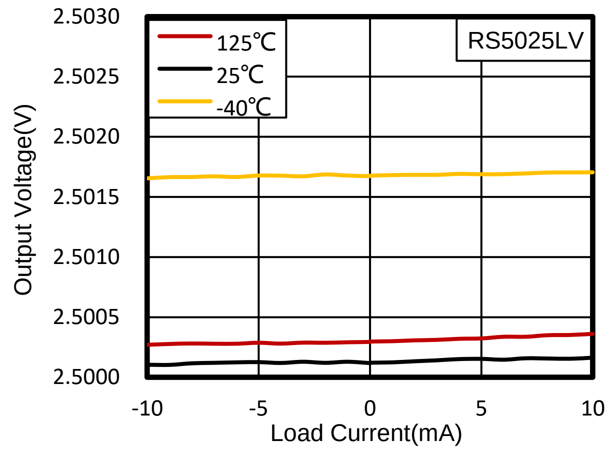


Figure 2. Output Voltage vs Load Current

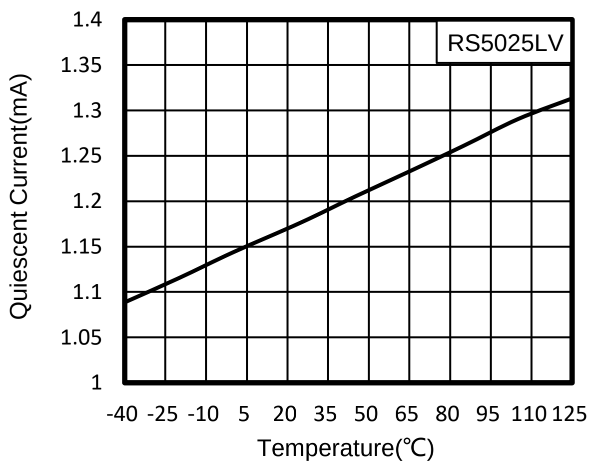


Figure 3. Quiescent Current vs Temperature

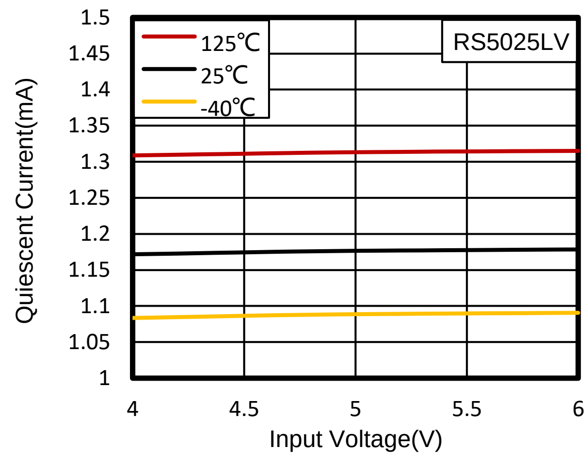


Figure 4. Quiescent Current vs Input Voltage

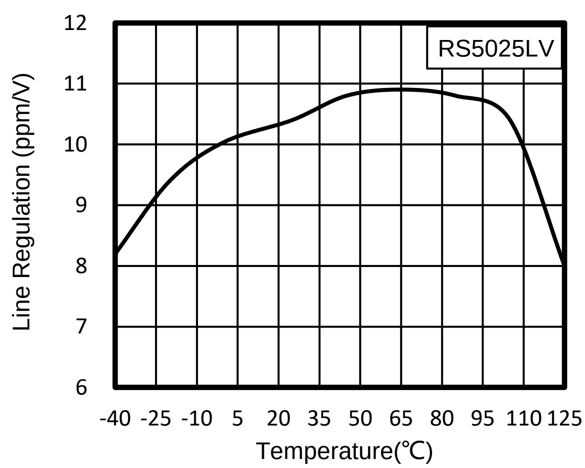


Figure 5. Line Regulation vs Temperature

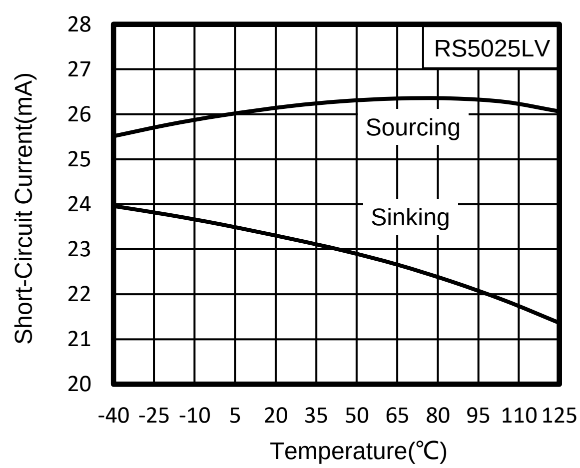


Figure 6. Short Circuit Current vs Temperature

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.
At T_A = 25°C, V_{IN}= 5V, unless otherwise noted.

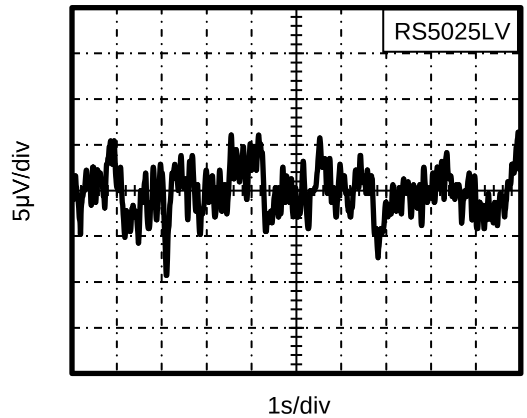


Figure 7. Noise

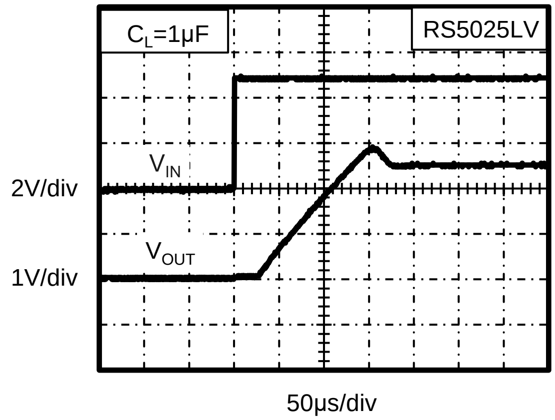


Figure 8. Star-up

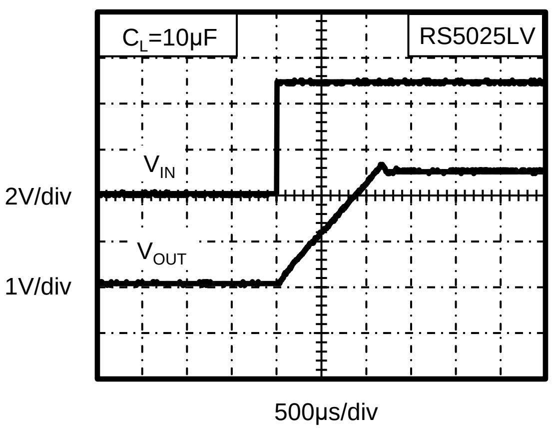


Figure 9. Star-up

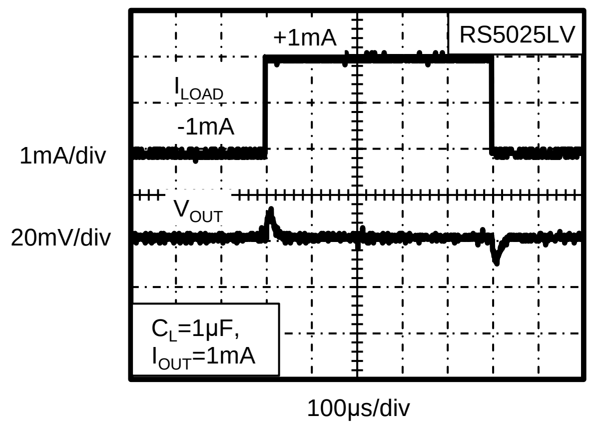


Figure 10. Load Transient

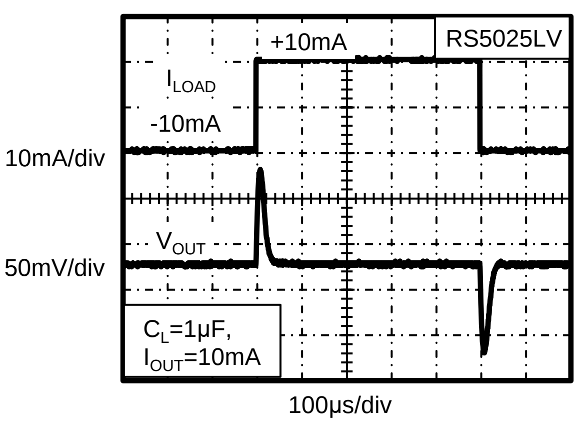


Figure 11. Load Transient

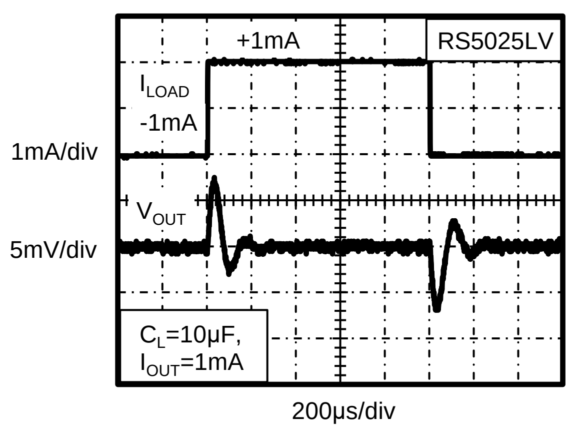


Figure 12. Load Transient

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.
At T_A = 25°C, V_{IN}= 5V, unless otherwise noted.

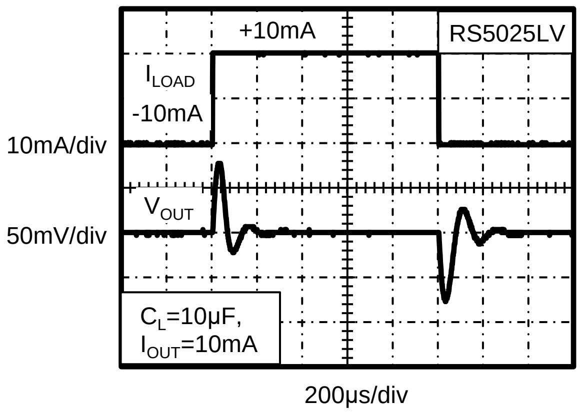


Figure 13. Load Transient

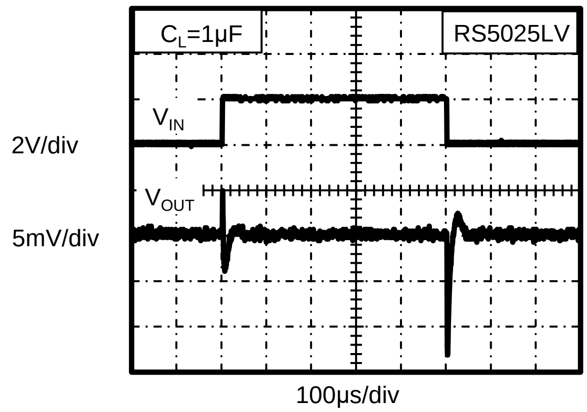


Figure 14. Line Transient

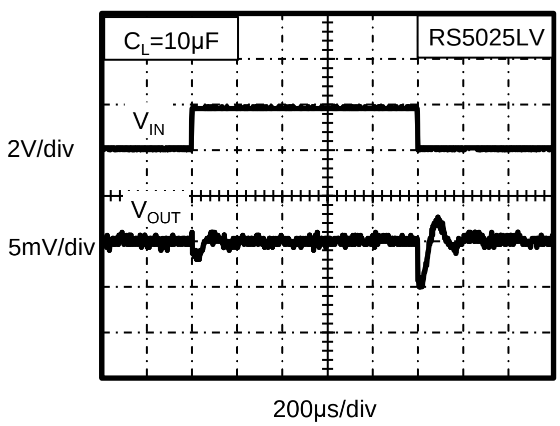


Figure 15. Line Transient

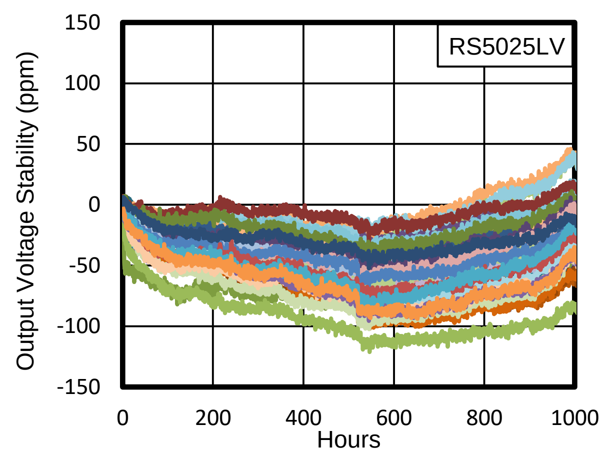


Figure 16. Long - Term Stability (First 1000 hours)

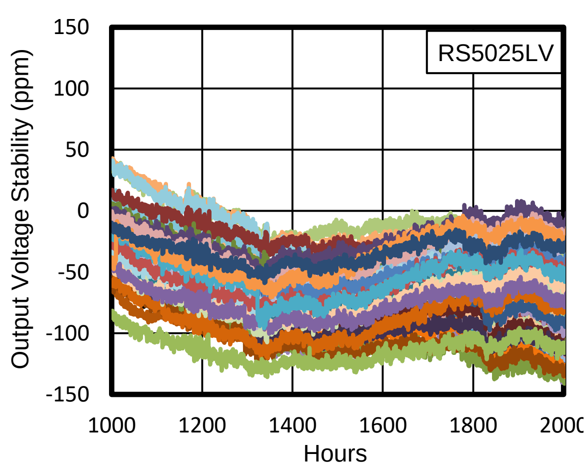


Figure 17. Long - Term Stability (Second 1000 hours)

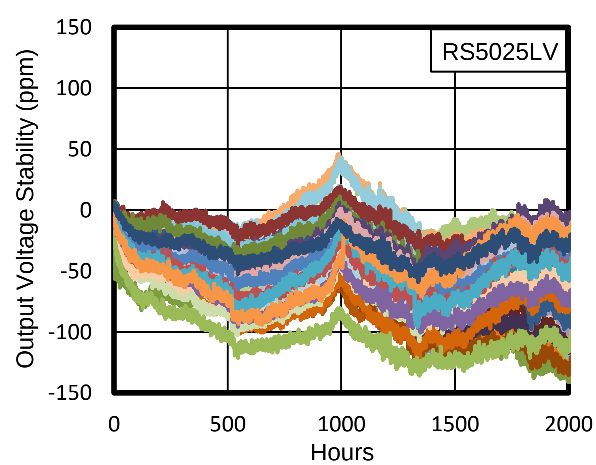


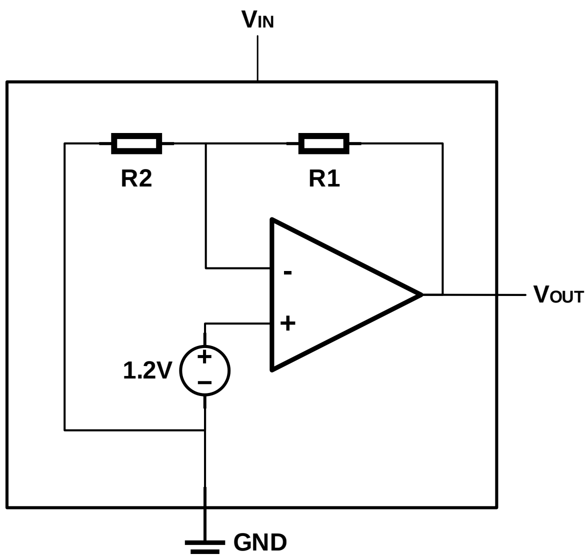
Figure 18. Long - Term Stability (First 2000 hours)

9 Detailed Description

9.1 Overview

The RS50XXLV is family of precision bandgap voltage references that are specifically designed for excellent initial voltage accuracy and drift. See the Functional Block Diagram for a simplified block diagram of the RS50XXLV.

9.2 Functional Block Diagram



10 Feature Description

10.1 Temperature Drift

The RS50XXLV is designed for minimal drift error, which is defined as the change in output voltage over temperature. The drift is calculated using the box method, as described in Equation 1.

$$\text{Drift} = \left(\frac{V_{OUTMAX} - V_{OUTMIN}}{V_{OUT} \times \text{Temp Range}}\right) \times 10^6 (\text{ppm}) \quad (1)$$

The RS50XXLV features a typical drift coefficient of 3 ppm/°C.

10.2 Thermal Hysteresis

Thermal hysteresis for the RS50XXLV is defined as the change in output voltage after operating the device at 25°C, cycling the device through the specified temperature range, and returning to 25°C. Thermal hysteresis can be expressed as Equation 2:

$$V_{HYST} = \left(\frac{|V_{PRE} - V_{POST}|}{V_{NOM}}\right) \bullet 10^6 (\text{ppm})$$

where

- V_{HYST} = thermal hysteresis (in units of ppm).
- V_{NOM} = the specified output voltage.
- V_{PRE} = output voltage measured at 25°C pre-temperature cycling.
- V_{POST} = output voltage measured after the device has been cycled from 25°C through the specified temperature range of -40°C to 125°C and returned to 25°C. (2)

10.3 Noise Performance

Typical 0.1Hz to 10Hz voltage noise for each member of the RS50XXLV family is specified in the Electrical Characteristics table. The noise voltage increases with output voltage and operating temperature. Additional filtering can be used to improve output noise levels, although take care to ensure the output impedance does not degrade performance.

10.4 Long-Term Stability

Due to aging and environmental effects, all semiconductor devices experience physical changes of the semiconductor die and the packaging material over time. These changes and the associated package stress on the die cause the output voltage in precision voltage references to deviate over time. The value of such change is specified on the datasheet by a parameter called the Long-term stability (also known as the Long-Term Drift (LTD)). Equation 3 shows how LTD is calculated. Note that the LTD value will be positive if the output voltage drifts higher over time, negative if the voltage drifts lower over time.

$$\text{LTD(ppm)}|_{t=n} = \frac{(V_{OUT}|_{t=0} - V_{OUT}|_{t=n})}{V_{OUT}|_{t=0}} \times 10^6$$

where

- $\text{LTD(ppm)}|_{t=n}$ = Long-term stability (in units of ppm).
- $V_{OUT}|_{t=0}$ = Output voltage at time = 0 hr.
- $V_{OUT}|_{t=n}$ = Output voltage at time = n hr. (3)

11 Device Functional Modes

11.1 Basic Connections

Figure 19 shows the typical connections for the RS50XXLV. RUNIC recommends a supply bypass capacitor ranging from 1 μF to 10 μF. A minimum 1μF output capacitor (C_L) must be connected from V_{OUT} to GND.

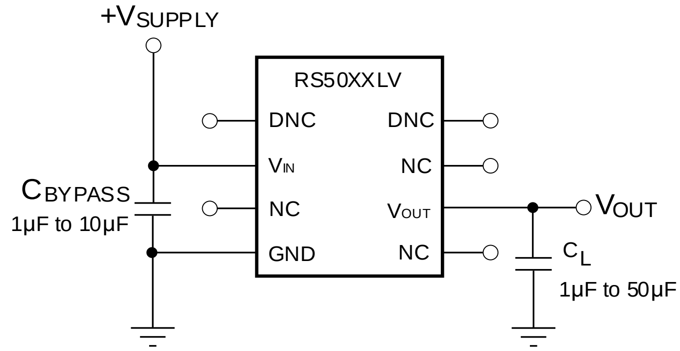


Figure 19. Basic Connections

11.2 Supply Voltage

The RS50XXLV family of voltage references features extremely low dropout voltage. With the exception of the RS5020LV, which has a minimum supply requirement of 4V, these references can be operated with a supply of 500 mV more than the output voltage in an unloaded condition.

11.3 Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the RS50XXLV and RS8651 can be used to provide a dual-supply reference from a 5V supply. Figure 20 shows the RS5025LV used to provide a 2.5V supply reference voltage. The low drift performance of the RS50XXLV complements the low offset voltage and zero drift of the RS8651 to provide an accurate solution for split-supply applications. Take care to match the temperature coefficients of R_1 and R_2.

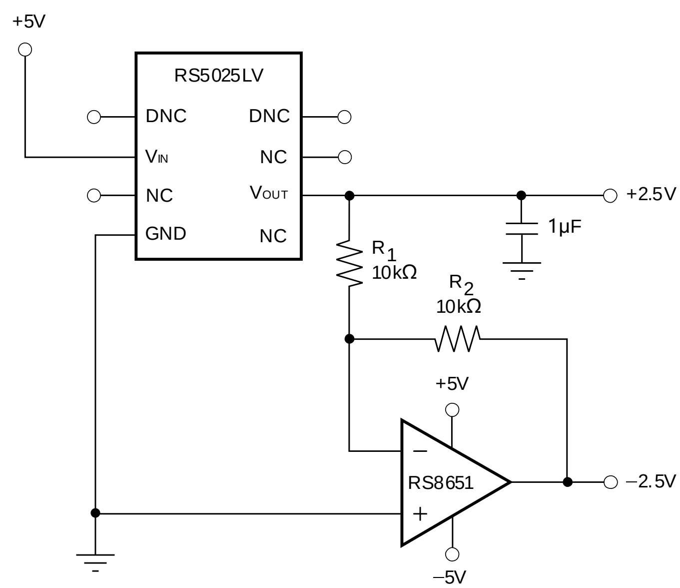


Figure 20. The RS5025LV and RS8651 Create Positive and Negative Reference Voltages

12 Layout

12.1 Layout Guidelines

- Place the power-supply bypass capacitor as closely as possible to the supply and ground pins. The recommended value of this bypass capacitor is from 1 μF to 10 μF. If necessary, additional decoupling capacitance can be added to compensate for noisy or high-impedance power supplies.
- Place a 1μF noise filtering capacitor between the NR pin and ground.
- The output must be decoupled with a 1μF to 50μF capacitor. A resistor in series with the output capacitor is optional. For better noise performance, the recommended ESR on the output capacitor is from 1 Ω to 1.5 Ω.
- A high-frequency, 1μF capacitor can be added in parallel between the output and ground to filter noise and help with switching loads as data converters.

12.2 Layout Example

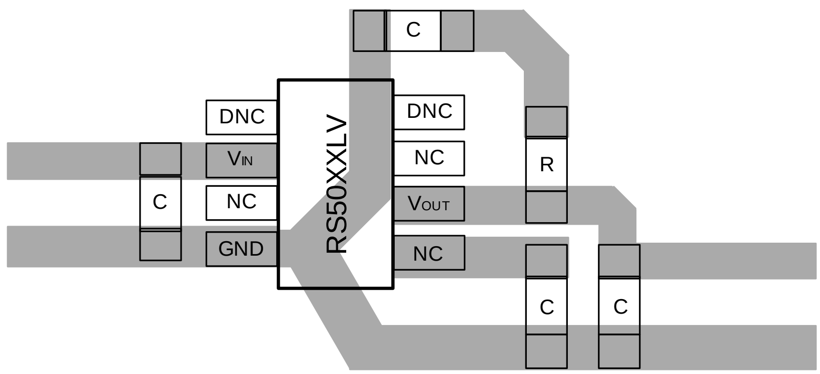


Figure 21. Layout Example

12.3 Power Dissipation

The RS50XXLV family is specified to deliver current loads of ±10 mA over the specified input voltage range. The temperature of the device increases according to Equation 4:

$T_J = T_A + P_D \times \theta_{JA}$

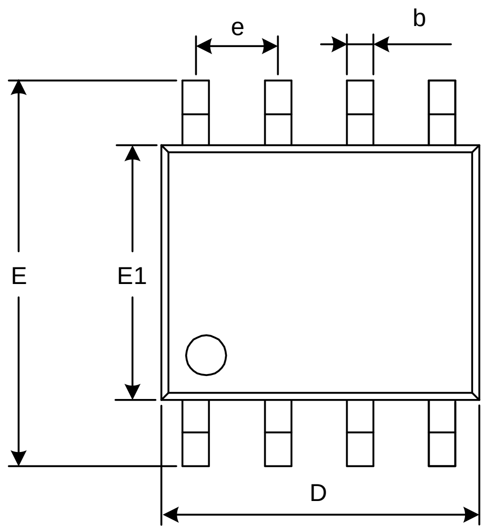
where

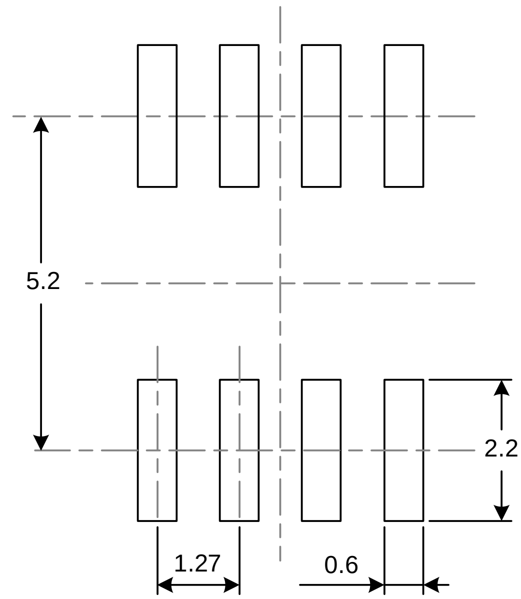
- T_J = Junction temperature (°C)
- T_A = Ambient temperature (°C)
- P_D = Power dissipated (W)
- θ_{JA} = Junction-to-ambient thermal resistance (°C/W) (4)

The RS50XXLV junction temperature must not exceed the absolute maximum rating of 150°C.

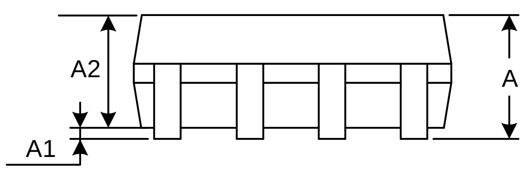
13 PACKAGE OUTLINE DIMENSIONS

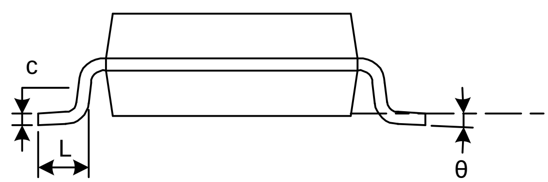
SOIC-8(SOP8) (3)





RECOMMENDED LAND PATTERN (Unit: mm)





Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A (1)	1.350	1.750	0.053	0.069
A1	0.100	0.250	0.004	0.010
A2	1.350	1.550	0.053	0.061
b	0.330	0.510	0.013	0.020
c	0.170	0.250	0.007	0.010
D (1)	4.800	5.000	0.189	0.197
e	1.270 (BSC) (2)		0.050 (BSC) (2)	
E	5.800	6.200	0.228	0.244
E1 (1)	3.800	4.000	0.150	0.157
L	0.400	1.270	0.016	0.050
θ	0°	8°	0°	8°

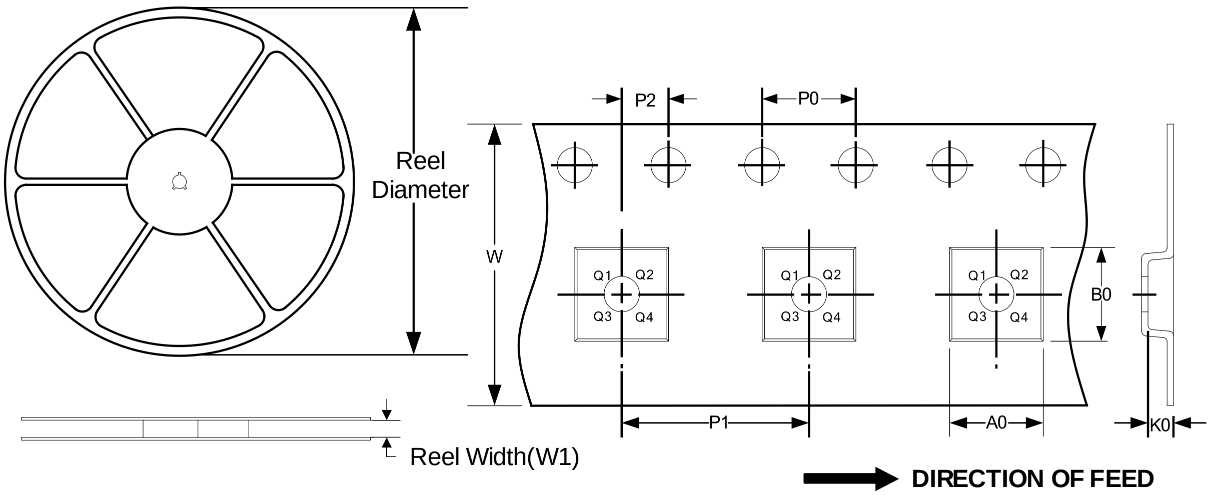
NOTE:

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.

14 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
SOIC-8(SOP8)	13’’	12.4	6.40	5.40	2.10	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.

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