SHR3425 Low-Drift, Low-Power, Small-Footprint Series Voltage Reference

1 Features

- Initial accuracy: ±0.08% (maximum)
- Temperature coefficient: 3 ppm/°C
- Operating temperature range: −40°C to +125°C
- Output current: ±10 mA
- Low quiescent current: 125 µA
- Ultra-low zero load dropout voltage: 200 mV
- Input voltage: 2.7 ~ 5.5 V
- Output 1/f noise (0.1 Hz to 10 Hz): 15 µVp-p/V
- Long-term stability: 45 ppm/1000 hrs
- Small footprint 6 pin SOT-23 package pinouts:

2 Applications

- Data acquisition systems
- Analog I/O modules
- Field transmitters
- Lab & field instrumentation
- Servo drive control modules
- DC power supply, AC source, electronic load

3 Description

The SHR3425 device is a low temperature drift (3 ppm/°C), low-power, high-precision CMOS voltage reference, featuring ±0.08% initial accuracy, low operating current with power consumption less than 125 µA. This device also offers very low output noise of 15 µVp-p/V, which enables its ability to maintain high signal integrity with high-resolution data converters in noise critical systems. With a small SOT-23 package, SHR3425 offers enhanced specifications and pin-to-pin replacement for MAX607x, REF34xx, ADR34xx and LT1790. The SHR3425 is compatible to most of the ADC and DAC.

Stability and system reliability are further improved by the low output-voltage hysteresis of the device and low long-term output voltage drift. Furthermore, the small size and low operating current of the devices (125 µA) benefit portable and battery-powered applications.

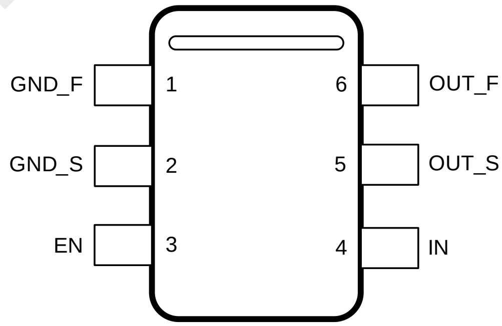
SHR3425 is specified for the wide temperature range of −40°C to +125°C.

Device Information

PART NAME	PACKAGE (PIN)(1)	BODY SIZE (NOM)
SHR3425	SOT-23 (6)	2.92 mm × 1.62 mm

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

PIN Configuration



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4 Revision History

Date	Revision	Notes
01-2024	V1.1	Production Datasheet

5 Pin Configuration and Functions

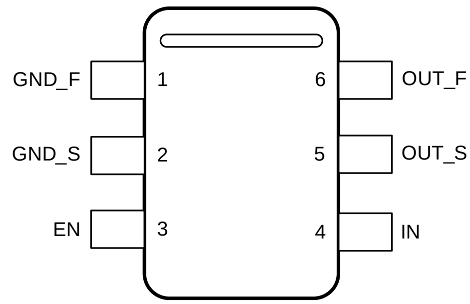

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Figure 1. SHR3425
6-Pin SOT-23
Top View

Table 1. Pin Functions

PIN		TYPE	DESCRIPTION
NAME	PIN		
GND_F	1	Ground	Ground force connection.
GND_S	2	Ground	Ground sense connection.
EN	3	Input	Enable connection. Enables or disables the device.
IN	4	Power	Input supply voltage connection.
OUT_S	5	Input	Reference voltage output sense connection.
OUT_F	6	Output	Reference voltage output force connection.

6 Specifications

6.1 Absolute Maximum Ratings

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

		MIN	MAX	UNIT
Input voltage	IN	-0.3	5.5	V
	EN	-0.3	IN	V
Output voltage	V_{OUT}	-0.3	5.5	V
Output short circuit current	I_{SC}		30	mA
Operating temperature range	T_A	-55	150	℃
Storage temperature range	T_{stg}	-60	150	°C

(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. These are stress ratings only and functional operation of the device at these or any other conditions beyond those specified in the Electrical Characteristics Table is not implied.

6.2 ESD Ratings

			VALUE	UNIT
$V_{(ESD)}$	Electrostatic discharge	Human-body model (HBM), per ANSI/ESDA/ JEDEC JS-001(1)	±2000	V
		Charged-device model (CDM), per JEDEC specification JESD22-C101(2)	±1000	V

(1) JEDEC document JEP155 states that 500-V HBM allows safe manufacturing with a standard ESD control process.
(2) JEDEC document JEP157 states that 250-V CDM allows safe manufacturing with a standard ESD control process.

6.3 Recommended Operating Conditions

over operating ambient temperature range (unless otherwise noted)

		MIN	NOM	MAX	UNIT
IN	Input voltage	V_{OUT}+ V_{DO} (1)		5.5	V
EN	Enable voltage	0		IN	V
I_L	Output current	-10		10	mA
T_A	Operating Temperature	-40	25	125	℃

(1) V_{DO} = Dropout voltage

6.4 Thermal Information

THERMAL METRIC		SOT23-6	UNIT
$R_{\theta JA}$	Junction-to-ambient thermal resistance	131	°C/W
$R_{\theta JC(top)}$	Junction-to-case (top) thermal resistance	83	°C/W

6.5 Electrical Characteristics

At $V_{IN} = V_{OUT} + V_{DO}$, C_L = 1 µF, C_{IN} = 0.1 µF, I_L = 0 mA, minimum and maximum specifications at T_A = –40℃ to 125℃;

Typical specifications at T_A = 25℃ (Unless otherwise noted).

PARAMETER		TEST CONDITIONS		MIN	TYP	MAX	UNIT
ACCURACY AND DRIFT							
	Output voltage	T_A = 25℃			2.500		V
	Output voltage accuracy	T_A = 25℃		-0.08		+0.08	%
	Output voltage temperature coefficient (1)	-40°C ≤ T_A ≤ 125°C			3	8	ppm/℃
LINE & LOAD REGULATION							
$\Delta V_O/\Delta V_{IN}$	Line Regulation	$V_{IN} = V_{OUT} + V_{DO}$ (2) to 5.5 V			15		ppm/V
$\Delta V_O/\Delta I_L$	Load Regulation	I_L = 0 mA to 10mA, V_{IN} = V_{OUT}+ V_{DO} (3)	T_A = 25°C, Sourcing		5		ppm/mA
		I_L = 0 mA - 10mA, V_{IN} = V_{OUT}+ V_{DO}	T_A = 25°C, Sinking		20		
I_{SC}	Short circuit current	V_{OUT} = 0 V at T_A = 25°C			30		mA
NOISE							
e_{np-p}	Low frequency noise	0.1Hz ≤ f ≤ 10Hz			15		µV_{P-P}/V
e_n	Integrated wide band noise	10Hz ≤ f ≤ 10kHz			40		µV_{rms}
LONG TERM STABILITY AND HYSTERESIS							
	Long-term stability	SOT23-6 Package	0 to 1000h at 25°C		45		ppm
	Output voltage thermal hysteresis	SOT23-6 Package	25°C, –40°C,125°C, 25°C Cycle 1		120		ppm
			25°C, –40°C,125°C, 25°C Cycle 2		60		
TURN-ON TIME							
t_{ON}	Turn-on time	0.1% of output voltage settling, C_L = 10 µF			5		ms
CAPACITIVE LOAD							

C_L	Stable output capacitor range	–40°C ≤ TA ≤ 125°C	0.1		10	µF
POWER SUPPLY						
V_{IN}	Input voltage		$V_{OUT} + V_{DO}$		5.5	V
I_L	Output current capacity	$V_{IN} = V_{OUT} + V_{DO}$ to 5.5 V	-10		10	mA
I_Q	Quiescent current	Active mode		125		µA
		Shutdown mode		4		
V_{EN}	ENABLE pin voltage	Voltage reference in active mode (EN = 1)	0.6 × IN			V
		Voltage reference in shutdown mode (EN = 0)			0.5	
V_{DO}	Dropout voltage	I_L = 0 mA		160		mV
		I_L = 10 mA		250		
I_{EN}	ENABLE pin leakage current	$V_{EN} = V_{IN}$ = 5.5V		0.1		µA

(1) Temperature drift is specified according to the box method.
(2) V_{DO} for line regulation test is 300 mV.
(3) V_{DO} for load regulation test is 500 mV.

6.6 Typical Characteristics

At T_A = 25°C, V_{IN} = V_{EN} = 5.0V, I_L=0mA, C_L=1µF, C_{IN} = 0.1µF (unless otherwise noted).

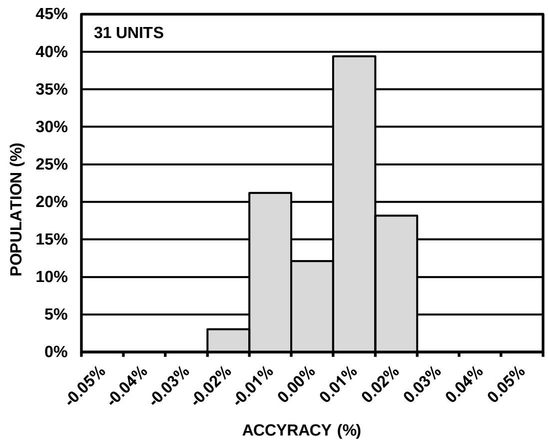


Figure 2: Initial Accuracy

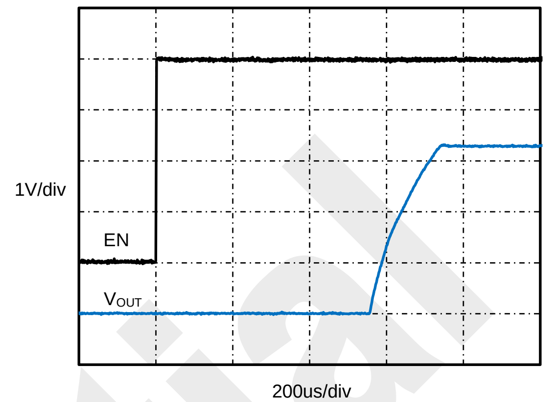


Figure 3: Turnon Time(Enable)

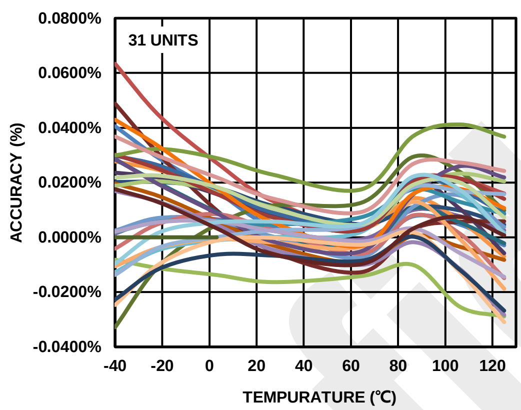


Figure 4: Output Voltage Accuracy vs. Temperature

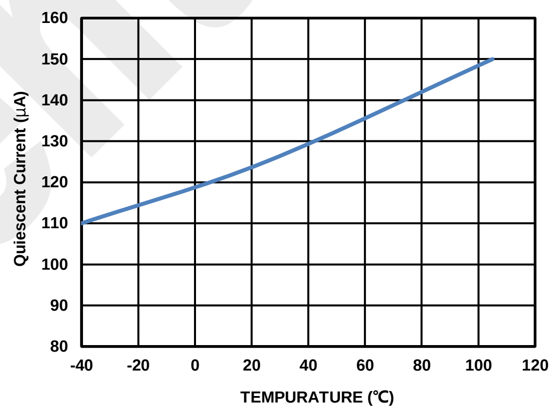


Figure 5: Quiescent Current vs. Temperature

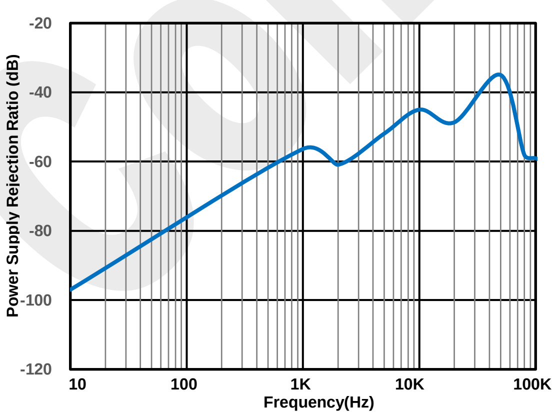


Figure 6: Power-Supply Rejection Ratio vs. Frequency

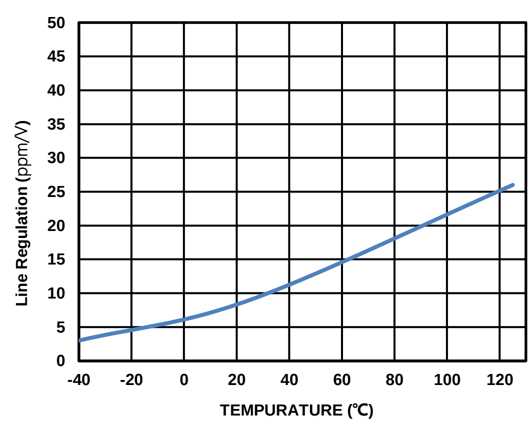


Figure 7: Line Regulation vs. Temperature

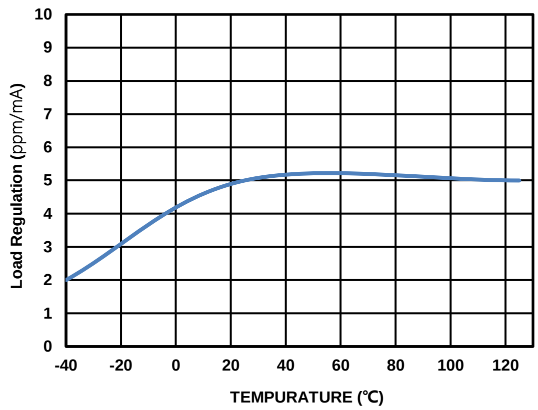


Figure 8: Load Regulation Sourcing

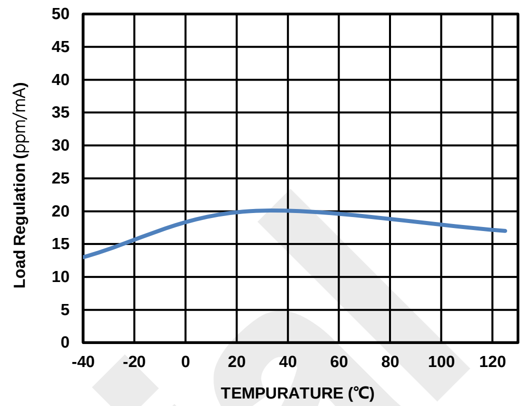


Figure 9: Load Regulation Sinking

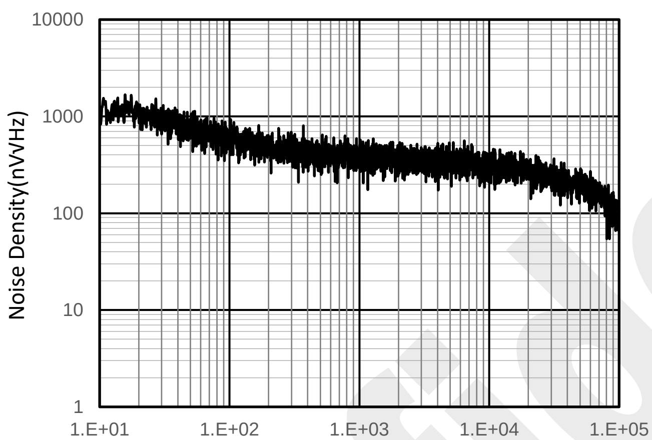
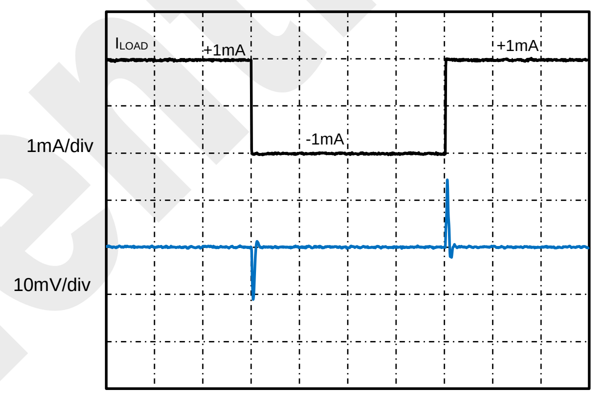
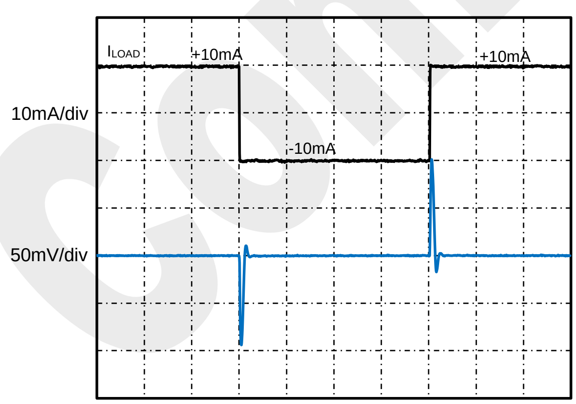


Figure 10: Noise Performance 1Hz to 100kHz



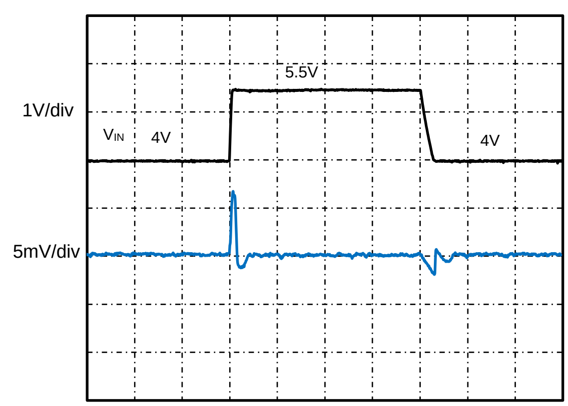
250us/div
(C_L=1uF, I_{OUT}=1mA)

Figure 11: Load Transient



250us/div
(C_L=1uF, I_{OUT}=10mA)

Figure 12: Load Transient



250us/div
(C_L=1uF)

Figure 13: Line Transient

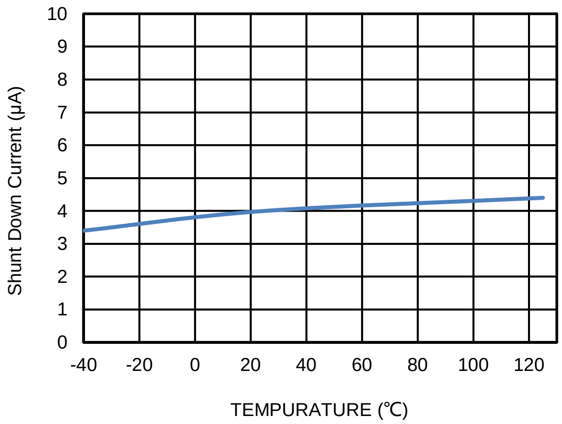


Figure 14: Shunt Down Current vs. Temperature

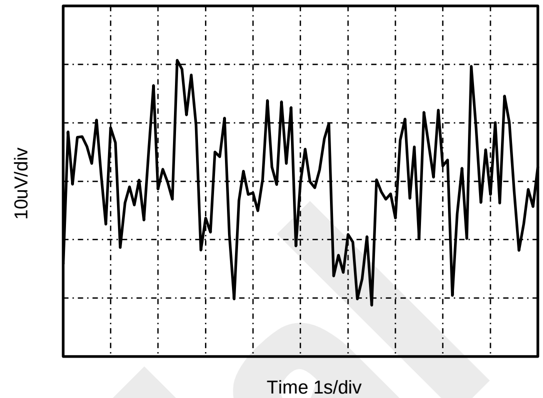


Figure 15: 0.1-Hz to 10-Hz Noise(V_{OUT}=3.3V)

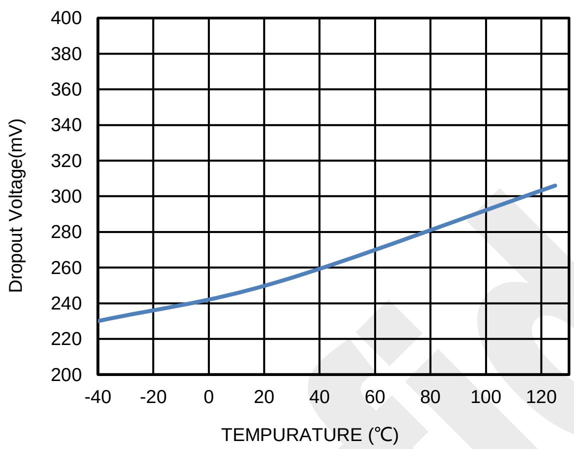


Figure 16: Dropout Voltage(I_{OUT}=10mA)

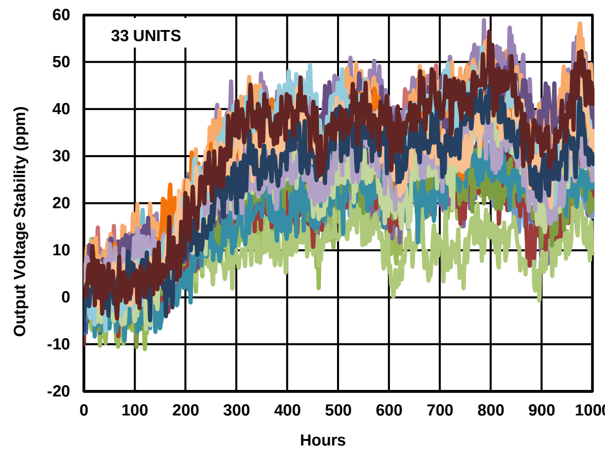


Figure 17: Long Term Stability – 1000 Hours

7 Parameter Measurement Information

7.1 Long-Term Stability

One of the key parameters of the SHR3425 references is long-term stability. Typical characteristic expressed as: Figure 17 show the typical drift value for the SHR3425 is 45 ppm from 0 to 1000 hours. This parameter is characterized by measuring 33 units at regular intervals for a period of 1000 hours. It is important to understand that long-term stability is not ensured by design and that the output from the device may shift beyond the typical 30 ppm specification at any time. For systems that require highly stable output voltages over long periods of time, the designer should consider burning in the devices prior to use to minimize the amount of output drift exhibited by the reference over time.

7.2 Power Dissipation

The SHR3425 voltage references are capable of source and sink up to 10 mA of load current across the rated input voltage range. However, when used in applications subject to high ambient temperatures, the input voltage and load current must be carefully monitored to ensure that the device does not exceeded its maximum power dissipation rating. The maximum power dissipation of the device can be calculated with Equation 1:

$$T_J = T_A + P_D \times R_{\theta JA} \quad (1)$$

where

- P_D is the device power dissipation

- T_J is the device junction temperature
- T_A is the ambient temperature
- $R_{\theta JA}$ is the package (junction-to-air) thermal resistance

Because of this relationship, acceptable load current in high temperature conditions may be less than the maximum current-sourcing capability of the device. In no case should the device be operated outside of its maximum power rating because doing so can result in premature failure or permanent damage to the device.

7.3 Noise Performance

Typical 0.1-Hz to 10-Hz voltage noise can be seen in Figure 18 . Device noise increases with output voltage and operating temperature. Additional filtering can be used to improve output noise levels, although care must be taken to ensure the output impedance does not degrade ac performance. Peak-to-peak noise measurement setup is shown in Figure 18.

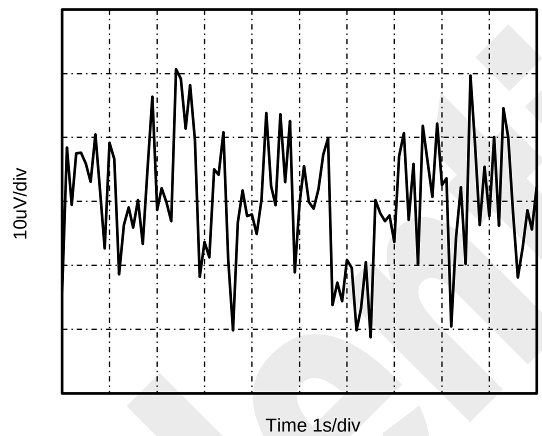


Figure 18: 0.1-Hz to 10-Hz Noise(V_{OUT}=3.3V)

8 Detailed Description

8.1 Overview

The SHR3425 is family of low-noise, precision bandgap voltage references that are specifically designed for excellent initial voltage accuracy and drift. The Section 8.2 is a simplified block diagram of the SHR3425 showing basic band-gap topology.

8.2 Functional Block Diagram

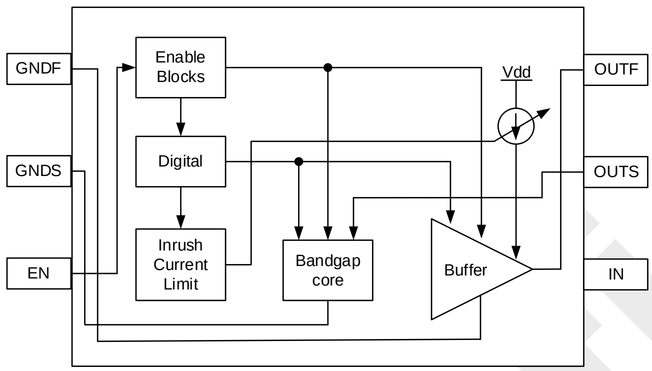


Figure 19: Functional Block Diagram

8.3 Feature Description

8.3.1 Supply Voltage

The SHR3425 family of references features an extremely low dropout voltage. For loaded conditions, a typical dropout voltage versus load is shown on the front page. The SHR3425 features a low quiescent current that is extremely stable over changes in both temperature and supply. The typical room temperature quiescent current is 125 μA, and the maximum quiescent current over temperature is just 150 μA. Supply voltages below the specified levels can cause the SHR3425 to momentarily draw currents greater than the typical quiescent current. Use a power supply with a fast rising edge and low output impedance to easily prevent this issue.

8.3.2 Low Temperature Drift

The SHR3425 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 by Equation 2. For this equation, V_{REF} is V_{OUT} which is the output voltage seen at the junction of OUT_F and OUT_S.

$$\text{Drift} = \left(\frac{V_{REF(MAX)} - V_{REF(MIN)}}{V_{REF(25℃)} \times \text{Temperature Range}} \right) \times 10^6 \qquad (2)$$

8.3.3 Load Current

The SHR34xx family is specified to deliver a current load of ±10 mA per output. The device temperature increases according to Equation 3:

$$T_J = T_A + P_D \times R_{\theta JA} \qquad (3)$$

where

- T_J = junction temperature (°C)
- T_A = ambient temperature (°C)
- P_D = power dissipated (W), and
- $R_{\theta JA}$ = junction-to-ambient thermal resistance (°C/W)

The SHR3425 maximum junction temperature must not exceed the absolute maximum rating of 150°C.

8.4 Device Functional Modes

8.4.1 EN Pin

When the EN pin of the SHR3425 is pulled high, the device is in active mode. The device must be in active mode for normal operation. The SHR3425 can be placed in a low-power mode by pulling the enable pin low. When in shutdown mode, the output of the device becomes high impedance and the quiescent current of the device reduces to 4 µA in shutdown mode. The EN pin must not be pulled higher than VIN supply voltage. See the Section 6.5for logic high and logic low voltage levels.

8.4.2 Negative Reference Voltage

For applications requiring a negative and positive reference voltage, the SHR3425 can be used to provide a dual-supply reference from a 5V supply. Figure 20: SHR3425 Create Positive and Negative Reference Voltages shows the SHR3425 used to provide a 3.3V supply reference voltage. Take care to match the temperature coefficients of R1 and R2.

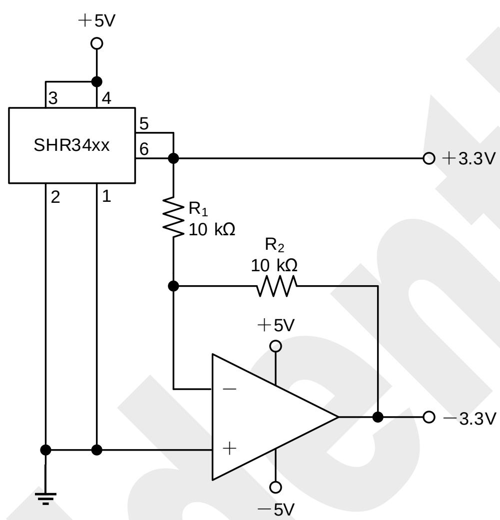


Figure 20: SHR3425 Create Positive and Negative Reference Voltages

9 Power Supply Recommendations

The SHR3425 family of references feature an extremely low-dropout voltage.These references can be operated with a supply of only 250 mV above the output voltage.Sensilicon recommends a supply bypass capacitor ranging between 0.1 µF to 10 µF.

10 Layout

10.1 Layout Guidelines

Figure 21 illustrates an example of a PCB layout for a data acquisition system using the SHR3425.Some key considerations are:

- Connect low-ESR,0.1-µF ceramic bypass capacitors at IN,OUT_F,VOUT of the SHR3425.
- Decouple other active devices in the system per the device specifications.
- Using a solid ground plane helps distribute heat and reduce electromagnetic interference(EMI)noise pickup.
- Place the external components as close to the device as possible. This configuration prevents parasitic errors (such as the Seebeck effect)from occurring.
- Do not run sensitive analog traces in parallel with digital traces. Avoid crossing digital and analog traces if possible, and only make perpendicular crossings when absolutely necessary.

10.2 Layout Example

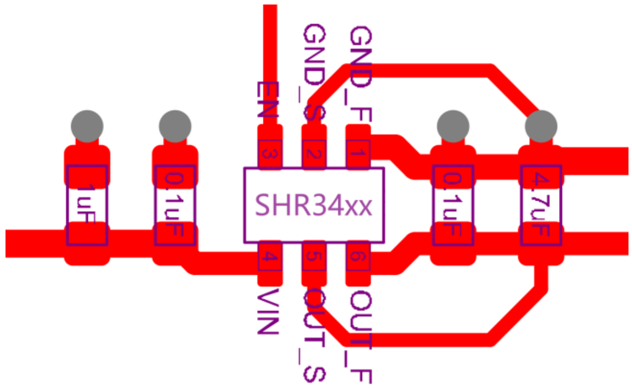
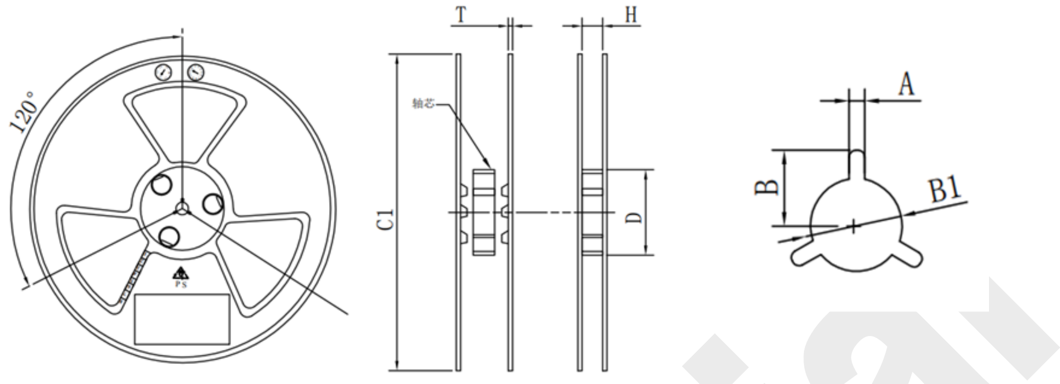
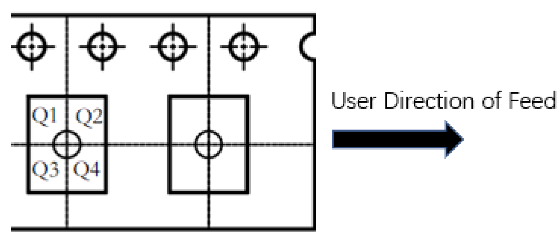


Figure 21: SHR3425 PCB Layout Example

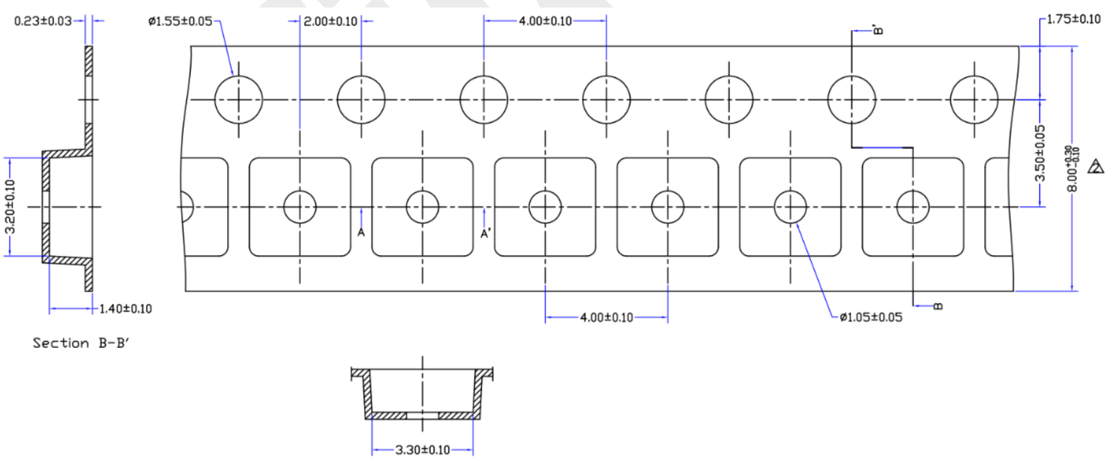
11 Tape and Reel Information



C1	178±1
H	8.4+1/-0
A	2.2±0.5
B	∅13.5±0.2
T	1.2±0.2
D	∅60±0.5
SPQ	300
Part Number	SHR34XX
Pin1 Quadrant	Q3



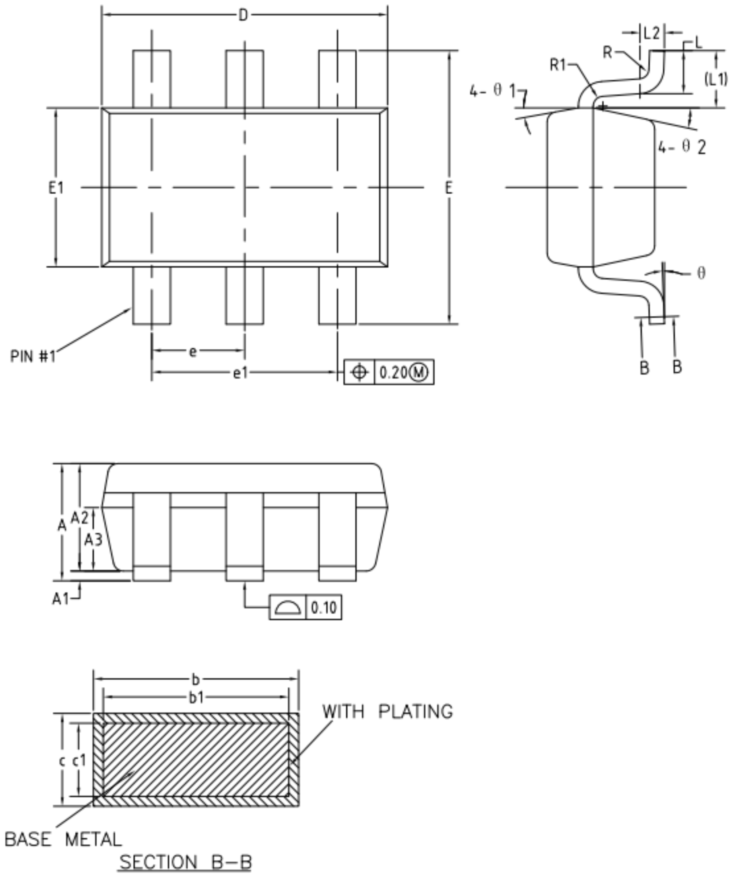
Note: Q1~Q4 is Pocket Quadrants



Section B-B'

Section A-A'

12 Package Information



COMMON DIMENSIONS
(UNITS OF MEASURE=MILLIMETER)

SYMBOL	MIN	NOM	MAX
A	–	–	1.25
A1	0	–	0.15
A2	1.00	1.10	1.20
A3	0.60	0.65	0.70
b	0.34	–	0.45
b1	0.34	0.38	0.41
c	0.12	–	0.20
c1	0.12	0.15	0.16
D	2.826	2.926	3.026
E	2.60	2.80	3.00
E1	1.526	1.626	1.700
e	0.90	0.95	1.00
e1	1.80	1.90	2.00
L	0.30	0.40	0.60
L1		0.59REF	
L2		0.25BSC	
R	0.05	–	0.20
R1	0.05	–	0.20
θ	0°	–	8°
θ 1	8°	10°	12°
θ 2	10°	12°	14°

13 Ordering Guide

Orderable Device	Package	Package Qty	Op Temp (°C)	MSL	RoHS (Pb Free)
SHR3425SST6IR	SOT23-6	3000	-40 to 125°C	Level 1	Yes
SHR3425SST6IT	SOT23-6	250	-40 to 125°C	Level 1	Yes