Low-Noise, Very Low Drift, Precision Voltage Reference

1 FEATURES

- **Low Temperature Drift: 10 ppm/°C(Max)**
- **High Accuracy: 0.05% Maximum**
- **Low Noise: 8μV$_{PP}$/V**
- **Low I$_Q$: 150μA (Typical)**
- **Operating Temperature Range: -40°C to +125°C**
- **High Output Current: ±10 mA**
- **Micro SIZE PACKAGES: SOT23-6**

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 RS34XX 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 (10ppm/°C) and high accuracy (0.05%) are achieved using proprietary design techniques with 150uA(typical) quiescent current. These features, combined with low noise, make the RS34XX family ideal for use in high-precision data acquisition systems.

The RS34XX is available in Green SOT23-6 packages. It operates over an ambient temperature range of -40°C to +125°C.

Device Information [1]

PART NUMBER	PACKAGE	BODY SIZE(NOM)
RS34XX	SOT23-6(6)	1.60mm×2.92mm

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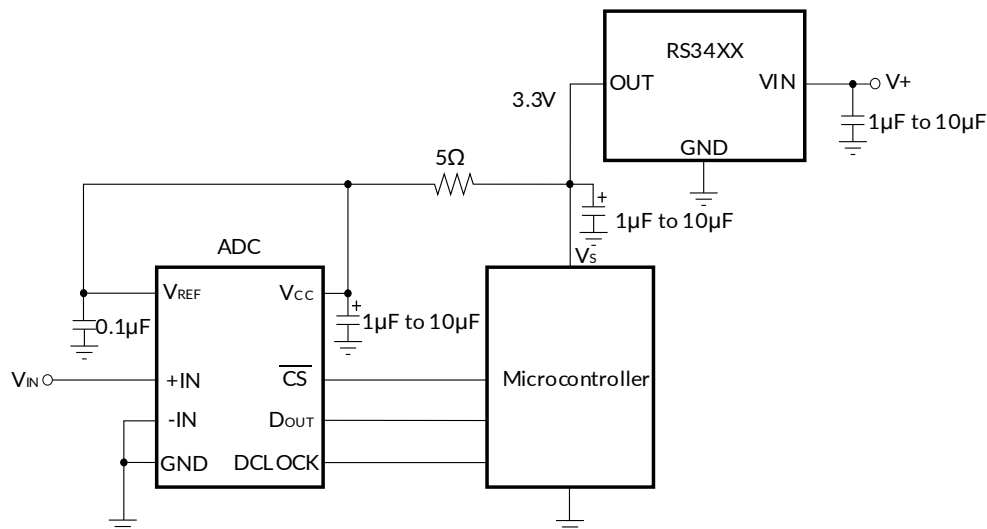
4 TYPICAL APPLICATION

Table of Contents

5 Revision History

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

| VERSION	Change Date	Change Item
A.1	2023/08/22	Initial version completed

6 PACKAGE/ORDERING INFORMATION [1]

PRODUCT	Orderable Device	Package Type	Op Temp(°C)	Device Marking [2]	Package Qty
RS34XX	RS3412XH6-G	SOT23-6	-40°C ~+125°C	3412	Tape and Reel,3000
	RS3420XH6-G	SOT23-6	-40°C ~+125°C	3420	Tape and Reel,3000
	RS3425XH6-G	SOT23-6	-40°C ~+125°C	3425	Tape and Reel,3000
	RS3430XH6-G	SOT23-6	-40°C ~+125°C	3430	Tape and Reel,3000
	RS3433XH6-G	SOT23-6	-40°C ~+125°C	3433	Tape and Reel,3000
	RS3440XH6-G	SOT23-6	-40°C ~+125°C	3440	Tape and Reel,3000
	RS3450XH6-G	SOT23-6	-40°C ~+125°C	3450	Tape and Reel,3000

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)

TOP VIEW

```
GND_F  │ 1 │              │ 6 │  OUT_F

GND_S  │ 2 │              │ 5 │  OUT_S

   EN  │ 3 │              │ 4 │  IN
```
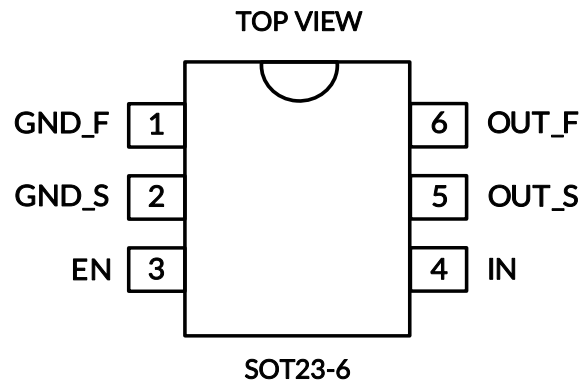
SOT23-6

Pin Description

PIN SOT23-6	NAME	I/O TYPE [1]	FUNCTION
1	GND_F	G	Ground force connection.
2	GND_S	G	Ground sense connection.
3	EN	I	Enable connection. Enables or disables the device.
4	IN	P	Input supply voltage connection.
5	OUT_S	I	Reference voltage output sense connection.
6	OUT_F	O	Reference voltage output force connection.

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

8 SPECIFICATIONS

8.1 Absolute Maximum Ratings

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

SYMBOL			MIN	MAX	UNIT
IN	Input voltage		-0.3	13	V
EN			-0.3	IN+0.3	V
V_{OUT}	Output voltage		-0.3	5.5	V
I_{SC}	Output short circuit current			20	mA
θ_{JA}	Package thermal impedance [3]	SOT23-6		230	°C/W
T_A	Operating temperature		-40	+125	°C
T_J	Junction temperature [4]		-40	150	
T_{stg}	Storage temperature		-65	150	

(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 $T_{J(MAX)}$, $R_{\theta JA}$, 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.

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	±2000	V
	Charged-Device Model (CDM), ANSI/ESDA/JEDEC JS-002-2018	±1500	V
	Machine Model (MM), JESD22-A115C (2010)	±300	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
IN	Input voltage	V_{OUT}+0.5 [1]	12	V
EN	Enable Voltage	0	IN	V
I_{Load}	Load current	-10	10	mA
T_A	Operating Temperature	-40	125	°C

(1)   Minimum supply voltage for the RS34XX is 4 V.

8.4 ELECTRICAL CHARACTERISTICS

At V_{IN} = 5V, C_{OUT} = 10 µF, C_{IN} =1 µF, I_L = 0 mA, Typical specifications at T_A = 25°C, unless otherwise noted.

PARAMETER			TEST CONDITIONS	MIN	TYP	MAX	UNIT
Output Voltage	V_{OUT}		RS3412		1.2		V
			RS3420		2.048		
			RS3425		2.5		
			RS3430		3.0		
			RS3433		3.3		
			RS3440		4.096		
			RS3450		5.0		
Initial Accuracy	V_{OERR}		All voltage options [1]	-0.05		0.05	%
Temperature Coefficient	TC		T_A = -40°C to +125°C		5	10	ppm/°C
Output Voltage Noise	e_n		f = 0.1Hz to 10Hz		8		µV_{PP}/V
Line Regulation	dV_{OUT}/dV_{IN}		V_{IN} = (V_{OUT} + 0.5) to 12 V		1	4	ppm/V
			V_{IN} = (V_{OUT} + 0.5) to 12 V, T_A = -40°C to +125°C			6	
Load Regulation	dV_{OUT}/dI_{LOAD}		0 mA < I_{LOAD} < 10 mA, V_{IN} = V_{OUT} + 0.5 V [2]		1.5	4	ppm/mA
			0 mA < I_{LOAD} < 10 mA, V_{IN} = V_{OUT} + 0.5 V, T_A = -40°C to +125°C [2]			6	
			0 mA < I_{LOAD} < -10 mA, V_{IN} = V_{OUT} + 0.5 V [2]		2.5	8	
			0 mA < I_{LOAD} < -10 mA, V_{IN} = V_{OUT} + 0.5 V, T_A = -40°C to +125°C [2]			15	
Short-Circuit Current	I_{SC}	Sourcing			23		mA
		Sinking			25		
Long-Term Stability			0 to 1000h @25°C		TBD		ppm
			1000h to 2000h @25°C		TBD		
Thermal Hysteresis			25°C, -40°C, 125°C, 25°C Cycle1		75		ppm
Turn on Settling Time	t_{ON}		To 0.1% with C_L = 1µF		2		ms
Capacitive Load	C_L			1		10	µF
Voltage	V_{IN}		I_{LOAD} = 0, T_A = -40°C to +125°C	V_{OUT}+0.5[1]		12	V
Quiescent Current	I_Q		Active mode, I_{LOAD} = 0, T_A = 25°C		150	200	µA
			Active mode, I_{LOAD} = 0, T_A = -40°C to +125°C			230	
			Shutdown mode, T_A = 25°C		4	10	µA
			Shutdown mode, T_A = -40°C to +125°C			15	
ENABLE Pin Voltage			Voltage reference in active mode (EN = 1), T_A = -40°C to +125°C	1.5			V
			Voltage reference in shutdown mode (EN = 0), T_A = -40°C to +125°C			0.5	
ENABLE Pin Leakage Current	I_{EN}		V_{EN} = V_{IN} = 12V, T_A = 25°C		1.5	3	µA
			V_{EN} = V_{IN} = 12V T_A = -40°C to +125°C			4	

(1) Minimum supply voltage for the RS34XX is 4 V.
(2) 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} = V_{EN} = 12 V, I_L = 0 mA, C_L = 10 µF, C_{IN} = 1 µF (unless otherwise noted).
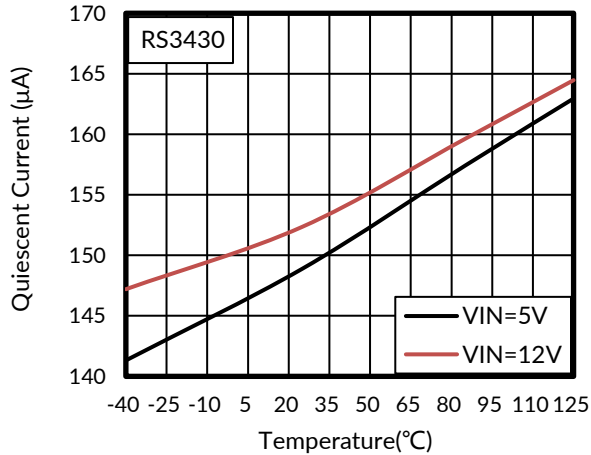
Figure 1. V_{IN} vs I_Q over Temperature
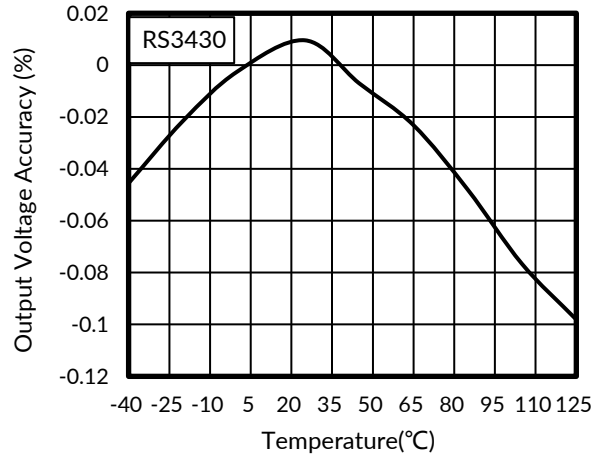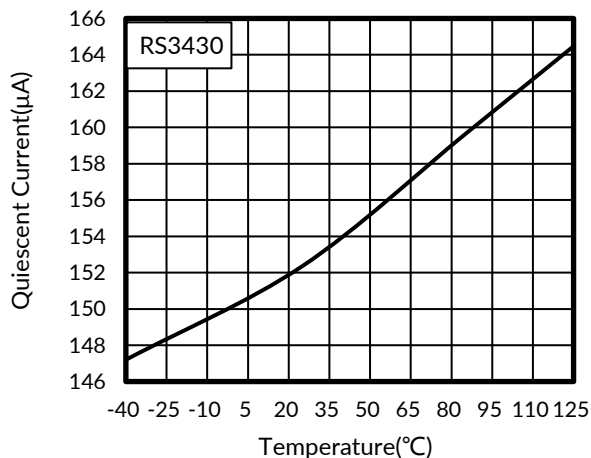
Figure 2. Output Voltage Accuracy vs Temperature
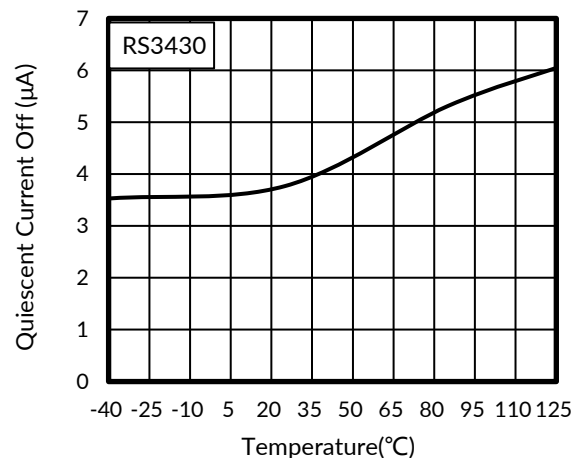
Figure 3. Quiescent Current vs Temperature

Figure 4. Quiescent Current Shutdown Mode
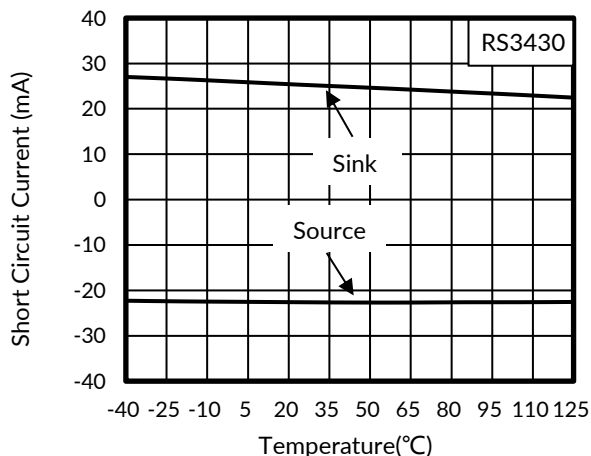
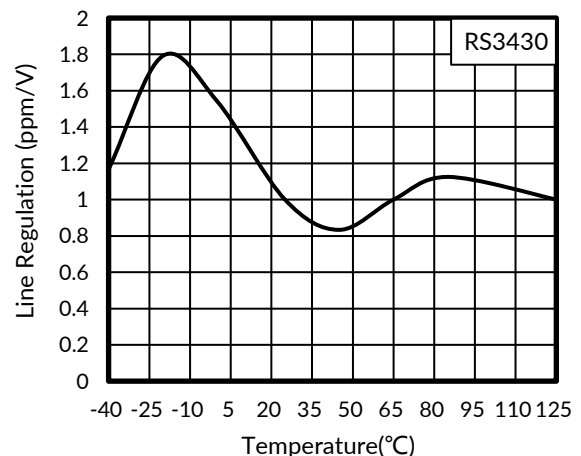**Figure 5. Short Circuit Current vs Temperature**

Figure 6. Line Regulation

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} = V_{EN} = 12 V, I_L = 0 mA, C_L = 10 µF, C_{IN} = 1 µF (unless otherwise noted).
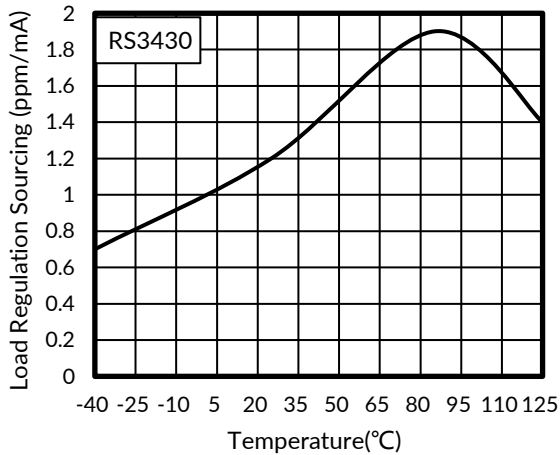

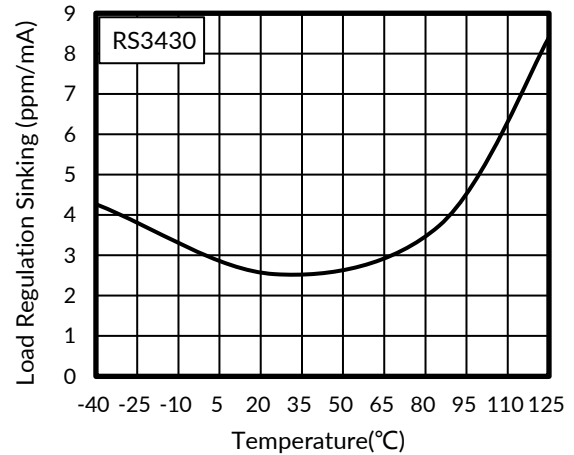**Figure 7. Load Regulation Sourcing**
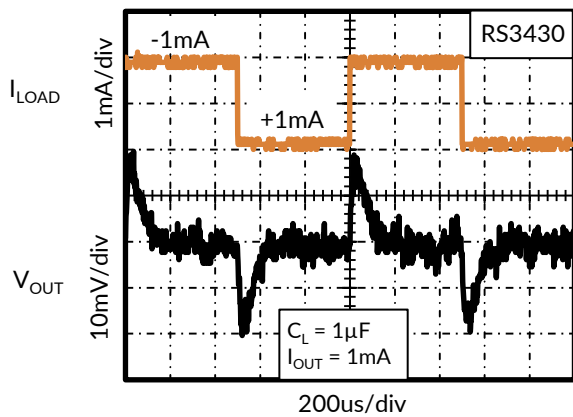

Figure 8. Load Regulation Sinking

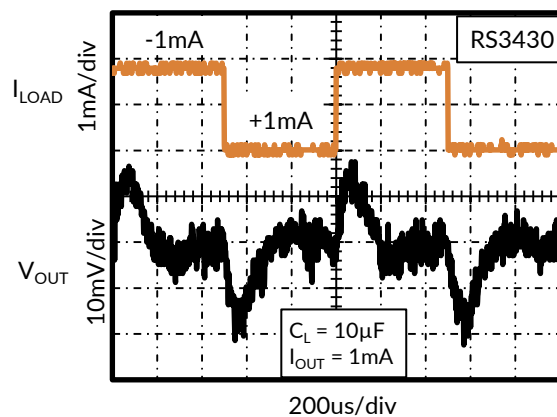**Figure 9. Load Transient**

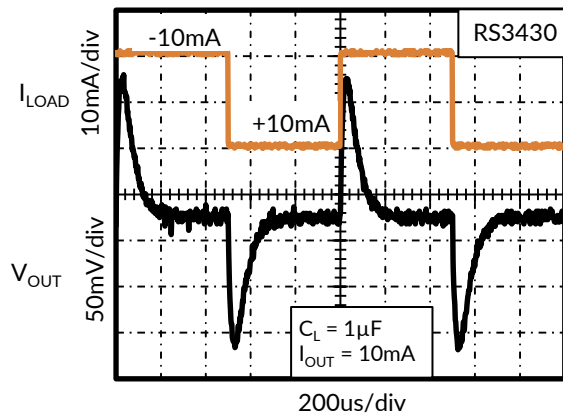

Figure 10. Load Transient
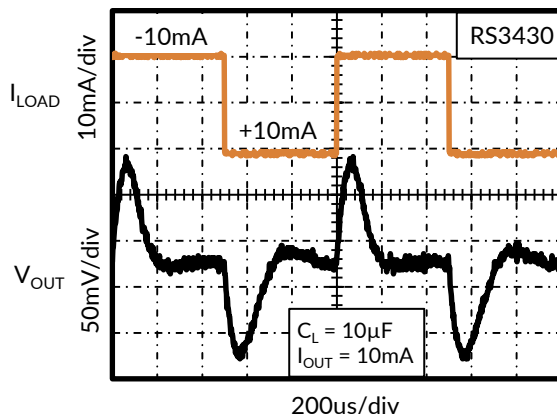

Figure 11. Load Transient

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} = V_{EN} = 12 V, I_L = 0 mA, C_L = 10 µF, C_{IN} = 1 µF (unless otherwise noted).
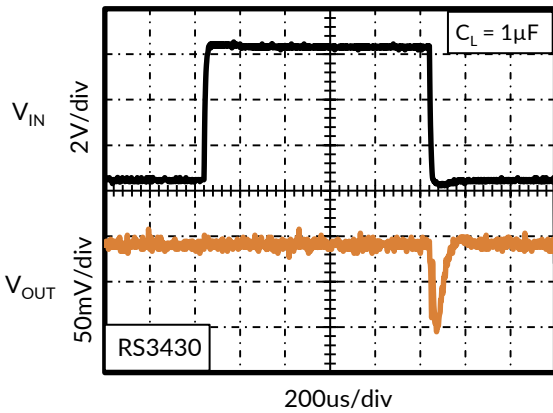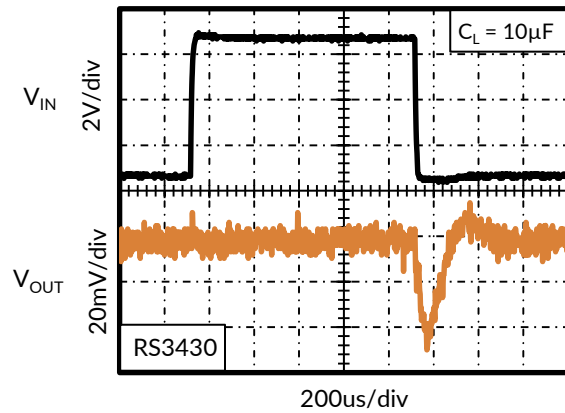
Figure 13. Line Transient

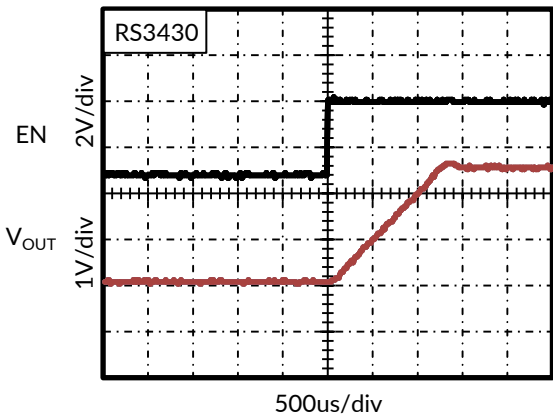**Figure 14. Line Transient**

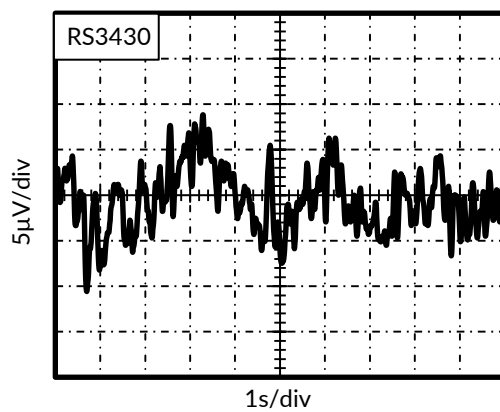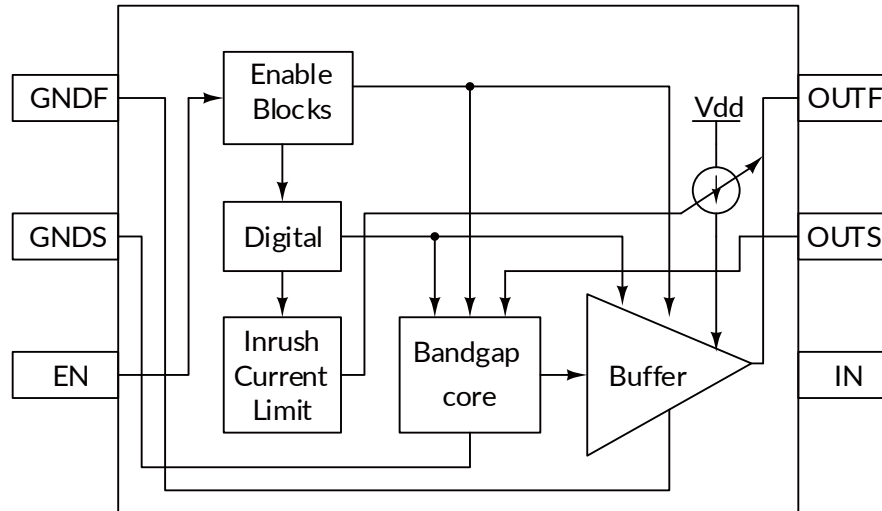**Figure 15. Turn on Time (Enable)**

Figure 16. 0.1-Hz to 10-Hz Noise (VOUT)

9 Detailed Description

9.1 Overview
The RS34XX 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 RS34XX.

9.2 Functional Block Diagram

10 Feature Description

10.1 Temperature Drift

The RS34XX 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.

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

The RS34XX features a maximum drift coefficient of 10 ppm/°C.

10.2 Thermal Hysteresis

Thermal hysteresis for the RS34XX 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 pretemperature 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 RS34XX 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 17 shows the typical connections for the RS34XX. 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.
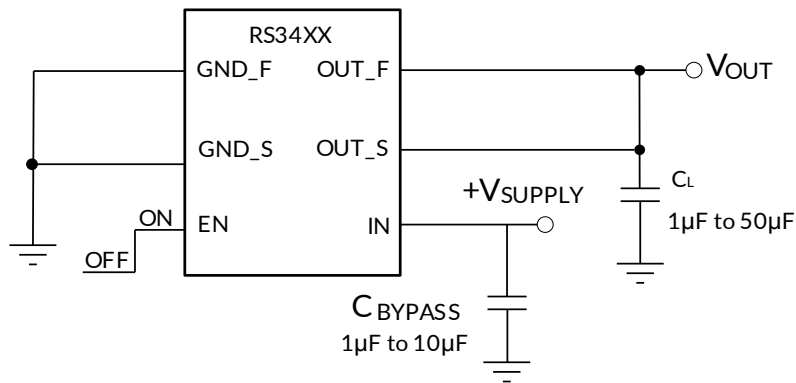

Figure 17. Basic Connections

11.2 Supply Voltage

The RS34XX family of voltage references features extremely low dropout voltage. With the exception of the V_{OUT}<4.0V, which has a minimum supply requirement of 4.0 V, 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 RS34XX and RS8651 can be used to provide a dual-supply reference from a 5V supply. Figure 18 shows the RS3430 used to provide a 3.0V supply reference voltage. The low drift performance of the RS34XX 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.
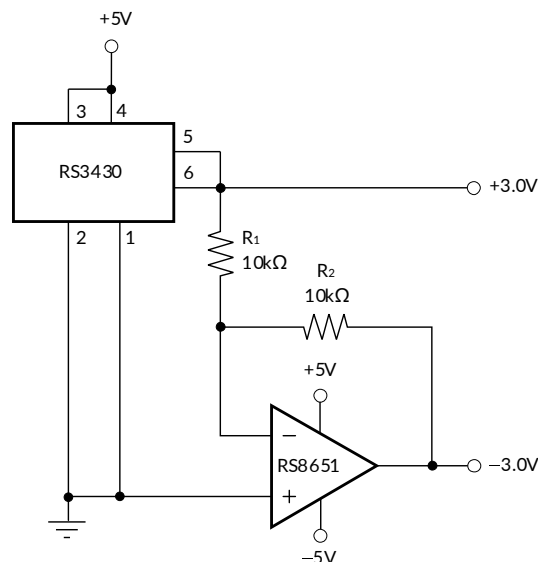

Figure 18. The RS3430 and RS8651 Create Positive and Negative Reference Voltages

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.
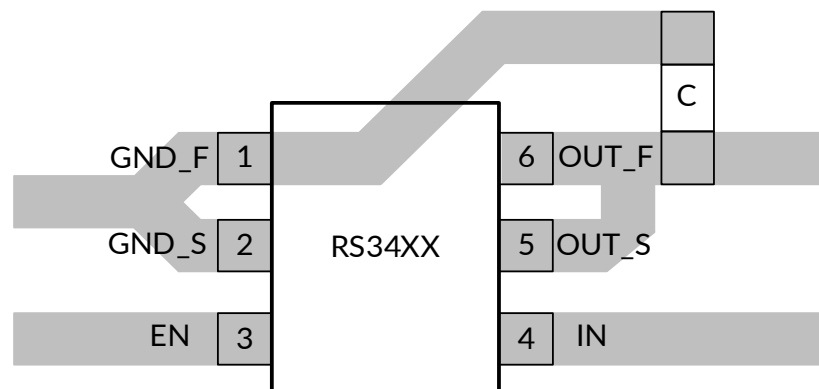
12.2 Layout Example

Figure 19. Layout Example

12.3 Power Dissipation

The RS34XX 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:
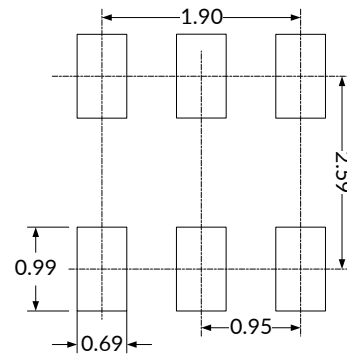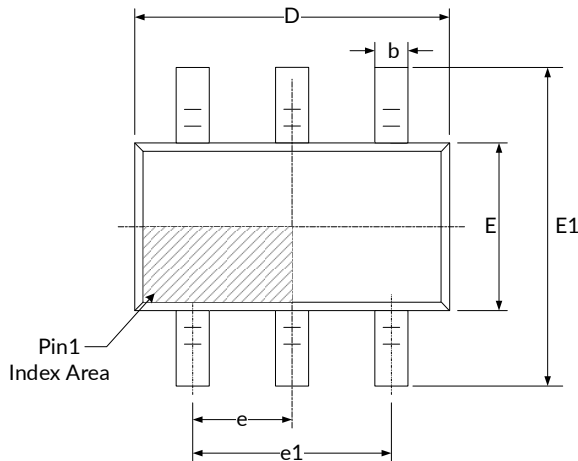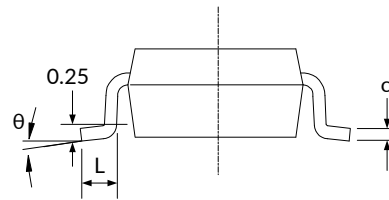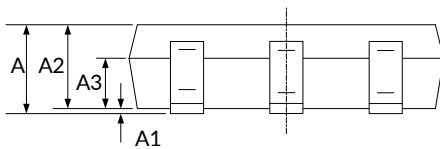
$$T_J = T_A + P_D \times \theta_{JA}$$

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 RS34XX junction temperature must not exceed the absolute maximum rating of 150°C.

13 PACKAGE OUTLINE DIMENSIONS

SOT23-6 [2]

RECOMMENDED LAND PATTERN (Unit: mm)

| Symbol	Dimensions In Millimeters		Dimensions In Inches	
	Min	Max	Min	Max
A [1]		1.250		0.049
A1	0.020	0.110	0.001	0.004
A2	1.000	1.200	0.039	0.047
A3	0.600	0.700	0.024	0.028
b	0.330	0.410	0.013	0.016
c	0.150	0.190	0.006	0.007
D [1]	2.800	3.000	0.110	0.118
E [1]	1.500	1.700	0.059	0.067
E1	2.600	3.000	0.102	0.118
e	0.850	1.050	0.033	0.041
e1	1.800	2.000	0.071	0.079
L	0.350	0.550	0.014	0.022
θ	0°	8°	0°	8°

NOTE:
1. Plastic or metal protrusions of 0.15mm maximum per side are not included.
2. This drawing is subject to change without notice.

14 TAPE AND REEL INFORMATION

REEL DIMENSIONS

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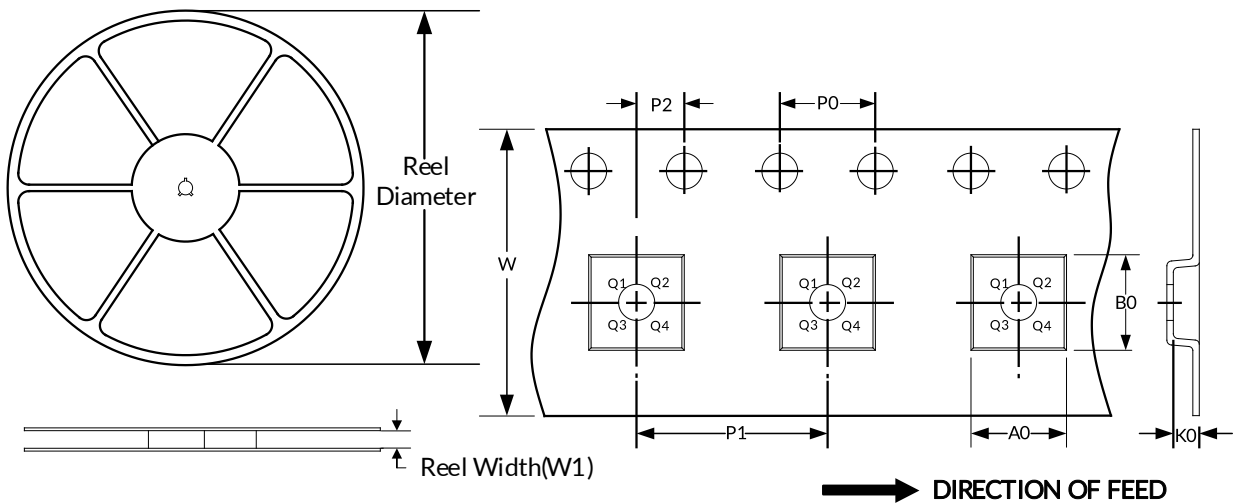
NOTE: The picture is only for reference. Please make the object as the standard.

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
SOT23-6	7"	9.5	3.17	3.23	1.37	4.0	4.0	2.0	8.0	Q3

NOTE:

1. All dimensions are nominal.

2. Plastic or metal protrusions of 0.15mm maximum per side are not included.

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