NSREF31xx
Precision Low Power SOT23-3L Series Voltage Reference
Datasheet (EN) 1.0

Product Overview

The NSREF31xx is a family of low power, low dropout, precision bandgap references. These designs are available in 3-pin SOT23 package. The NSREF31xx's small size and low power consumption makes them ideal for use in battery-powered systems where there can be wide variations in supply voltage and a need to minimize power dissipation. The NSREF31xx does not require an output compensation capacitor, yet is stable with capacitive loads and can sink or source up to ±10 mA of output current. Unloaded, the NSREF31xx can operate on supplies down to 1 mV above the output voltage. All models are specified over the temperature range of -40°C to +125°C.

Key Features

- Excellent Specified Drift Performance:
  15 ppm/°C (Maximum) from -40°C to +125°C
- Output Noise (0.1 to 10Hz): 22uVpp of NSREF3125
- High Output Current: ±10 mA
- High Accuracy: 0.2% Maximum
- Do Not Require a Load Capacitor to Be Stable
- Low Dropout: 1mV

Applications

- Data Acquisition Systems
- Medical Equipment
- Hand-Held Test Equipment

Device Information

Part Number	Package	Body Size
NSREF3112-DSTR	SOT23-3L	2.9 mm × 1.3 mm
NSREF3120-DSTR		
NSREF3125-DSTR		
NSREF3130-DSTR		
NSREF3133-DSTR		
NSREF3140-DSTR		

Functional Block Diagram

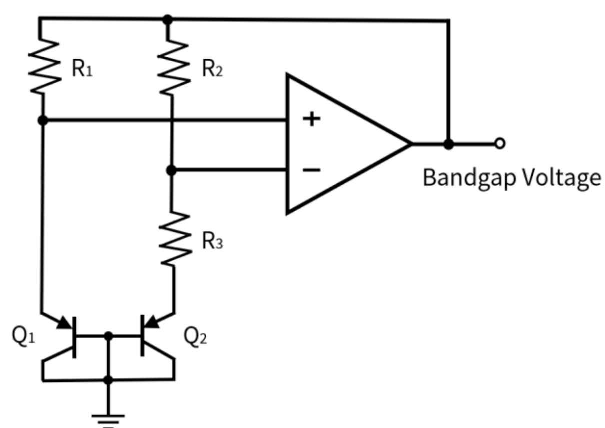

Figure 1 NSREF31xx Functional Block Diagram

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1. Pin Configuration and Functions

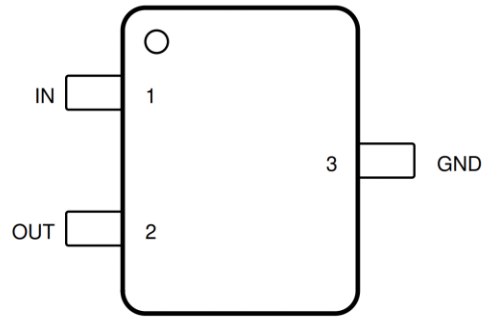

Figure 1.1 NSREF31xx SOT23-3L Package Top View

Table 1.1 NSREF31xx Pin Configuration and Description

PIN No.	***Symbol***	***Function***
1	IN	Input supply voltage
2	OUT	Reference output voltage
3	GND	Ground

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2. Absolute Maximum Ratings

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*
Input supply voltage	V_{IN}			6.5	V
Storage temperature	T_{stg}	-65		150	°C
Ambient temperature	T_A	-40		125	°C
Junction temperature	T_J	-40		150	°C

3. ESD Ratings

	Ratings	*Value*	*Unit*
Electrostatic discharge	Human-body model (HBM), per AEC-Q100-002-RevE ● All pins	±8000	V
	Charged-device model (CDM), per AEC-Q100-011-RevD ● All pins	±2000	V

4. Recommended Operating Conditions

Parameters	*Symbol*	*Min*	*Typ*	*Max*	*Unit*	*Comments*
Input voltage	V_{IN}	1.8		5.5	V	NSREF3112 Only
		V_{OUT} + 0.05		5.5		Except NSREF3112
Load current	I_{LOAD}	-10		10	mA	
Operating temperature	T_A	-40		125	°C	

5. Thermal Information

Parameters	*Symbol*	*SOT23-3L*	*Unit*
Junction-to-ambient thermal resistance	θ_{JA}	298	°C/W
Junction-to-case(top) thermal resistance	$\theta_{JC(top)}$	97	°C/W
Junction-to-board thermal resistance	θ_{JB}	72	°C/W

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6. Electrical Characteristics

T_A =25°C, V_{IN} = 5V and I_{LAOD} = 0mA (Unless otherwise noted) [1]

Parameters	*Symbol*	*Condition*	*Min*	*Typ*	*Max*	*Unit*
NSREF3112 (1.25V)						
Output voltage	V_{OUT}		1.2475	1.25	1.2525	V
Quiescent current	I_Q			135	165	uA
		T_A = –40°C to +125°C			170	
Output voltage noise	$e_{n\ p\text{-}p}$	f = 0.1Hz to 10Hz		9		uV_{pp}
Line regulation		1.8 ≤ V_{IN} ≤ 5.5V		30	90	ppm/V
Turn-on settling time		to 0.1% with C_L = 0		100		us
NSREF3120 (2.048V)						
Output voltage	V_{OUT}		2.044	2.048	2.052	V
Quiescent current	I_Q			140	165	uA
		T_A = –40°C to +125°C			170	
Output voltage noise	$e_{n\ p\text{-}p}$	f = 0.1Hz to 10Hz		20		uV_{pp}
Line regulation		V_{OUT} +0.05V ≤ V_{IN} ≤ 5.5V		25	85	ppm/V
Turn-on settling time		to 0.1% with C_L = 0		250		us
NSREF3125 (2.5V)						
Output voltage	V_{OUT}		2.495	2.5	2.505	V
Quiescent current	I_Q			140	165	uA
		T_A = –40°C to +125°C			170	
Output voltage noise	$e_{n\ p\text{-}p}$	f = 0.1Hz to 10Hz		22		uV_{pp}
Line regulation		V_{OUT} +0.05V ≤ V_{IN} ≤ 5.5V		15	85	ppm/V
Turn-on settling time		to 0.1% with C_L = 0		380		us
NSREF3130 (3.0V)						
Output voltage	V_{OUT}		2.994	3	3.006	V
Quiescent current	I_Q			145	170	uA
		T_A = –40°C to +125°C			175	
Output voltage noise	$e_{n\ p\text{-}p}$	f = 0.1Hz to 10Hz		28		uV_{pp}
Line regulation		V_{OUT} +0.05V ≤ V_{IN} ≤ 5.5V		15	90	ppm/V
Turn-on settling time		to 0.1% with C_L = 0μF		450		us

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Electrical Characteristics(continued)

T_A =25°C, V_{IN} = 5V and I_{LAOD} = 0mA (Unless otherwise noted) [1]

Parameters	Symbol	Condition	Min	Typ	Max	Unit
NSREF3133 (3.3V)						
Output voltage	V_{OUT}		3.294	3.3	3.306	V
Quiescent current	I_Q			145	170	uA
		T_A = –40°C to +125°C			175	
Output voltage noise	$e_{n\ p\text{-}p}$	f = 0.1Hz to 10Hz		31		uV_{pp}
Line regulation		V_{OUT} +0.05V ≤ V_{IN} ≤ 5.5V		25	100	ppm/V
Turn-on settling time		To 0.1% with C_L = 0		550		us
NSREF3140 (4.096V)						
Output voltage	V_{OUT}		4.088	4.096	4.104	V
Quiescent current	I_Q			145	175	uA
		T_A = –40°C to +125°C			175	
Output voltage noise	$e_{n\ p\text{-}p}$	f = 0.1Hz to 10Hz		33		uV_{pp}
Line regulation		V_{OUT} +0.05V ≤ V_{IN} ≤ 5.5V		50	150	ppm/V
Turn-on settling time		To 0.1% with C_L = 0		680		us
NSREF31xx (NSREF3112, NSREF3120, NSREF3125, NSREF3130, NSREF3133, NSREF3140)						
Input supply voltage	V_{IN}	NSREF3112	1.8		5.5	V
		Except NSREF3112	V_{OUT}+0.05		5.5	
Temperature drift [2]	d_{VOUT}/d_T	T_A = -40°C to 125°C		5	15	ppm/°C
Thermal hysteresis		First cycle, T_A cycled from 25°C to 125°C to -40°C to 25°C		100		ppm
Load regulation	$\Delta V_{O(\Delta IL)}$	I_L=0mA to 10mA, V_{IN}=V_{OUT}+0.25V [3]		5	10	uV/mA
		I_L=-10mA to 0mA, V_{IN}=V_{OUT}+0.1V [3]		25	50	
Output current	I_{LOAD}	Guaranteed by Load Regulation	-10		+10	mA
Dropout voltage	V_{IN} – V_{OUT}			1		mV
Short-circuit current	I_{SC}	Sourcing		40		mA
		Sinking		55		
Long-term stability		0 to 1000h at 35°C		100		ppm
		0 to 2000h at 35°C		130		ppm

[1]NSREF31xx series are 100% production tested at T_A = +25°C and are guaranteed by characterization for T_A = T_{MIN} to T_{MAX} as specified.
[2] Box Method used to determine temperature drift.
[3] Minimum supply voltage for the NSREF3112 is 1.8 V.

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7. Typical Performance Characteristics

T_A =25°C, V_{IN} = 5V and I_{LAOD} = 0mA (Unless otherwise noted)

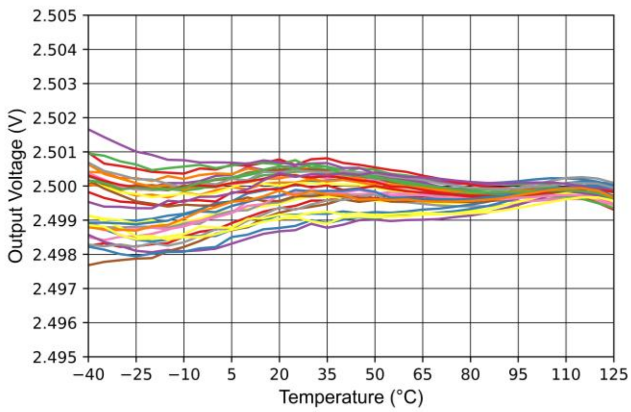

Figure 7.1 Output Voltage vs Temperature

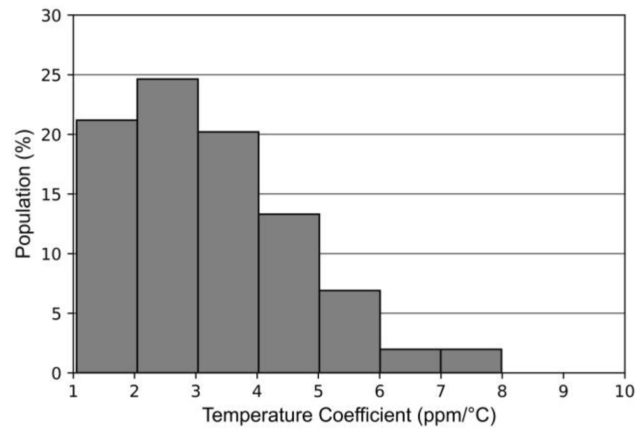

Figure 7.2 Temperature Drift Histogram

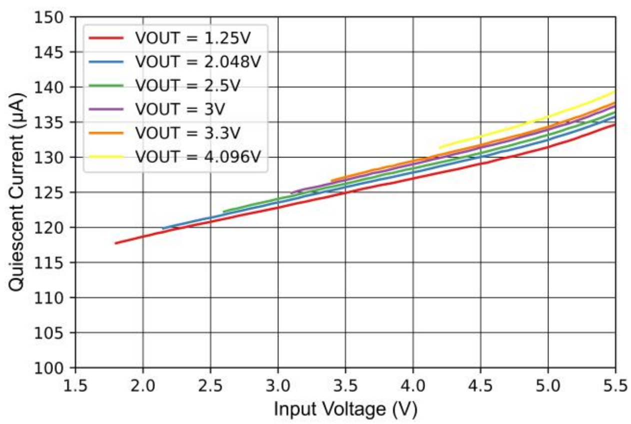

Figure 7.3 Quiescent Current vs Input Voltage

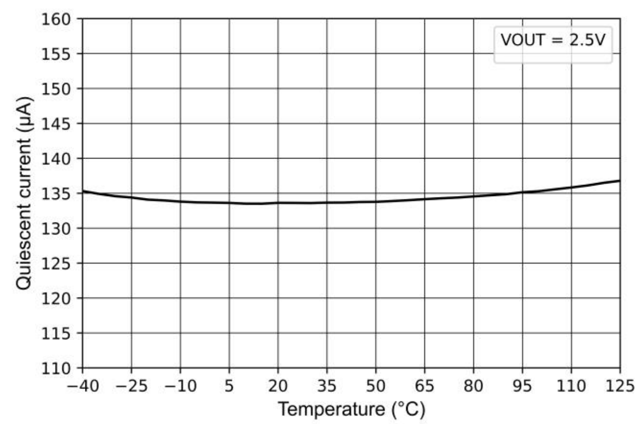

Figure 7.4 Quiescent Current vs Temperature

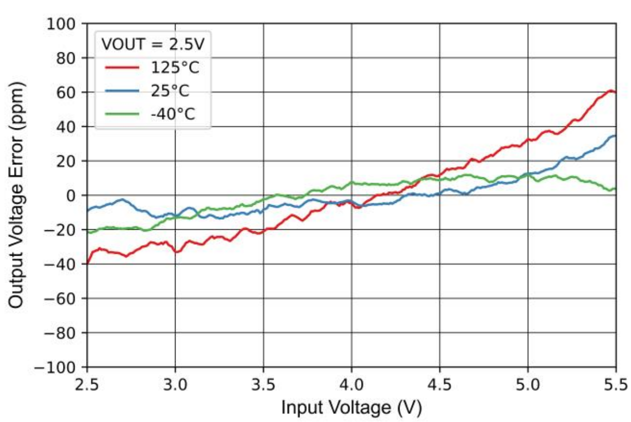

Figure 7.5 Output Voltage Error vs Input Voltage

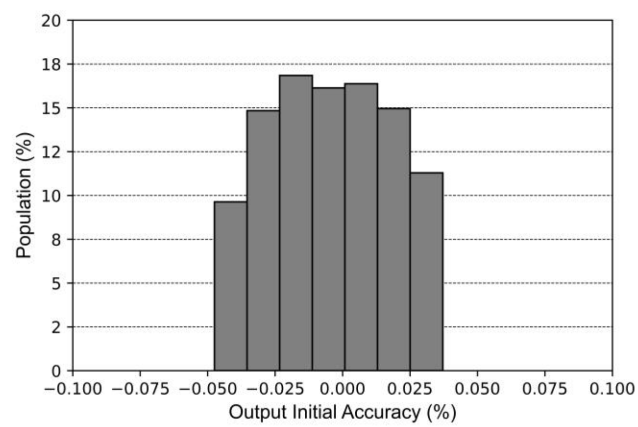

Figure 7.6 Accuracy Distribution

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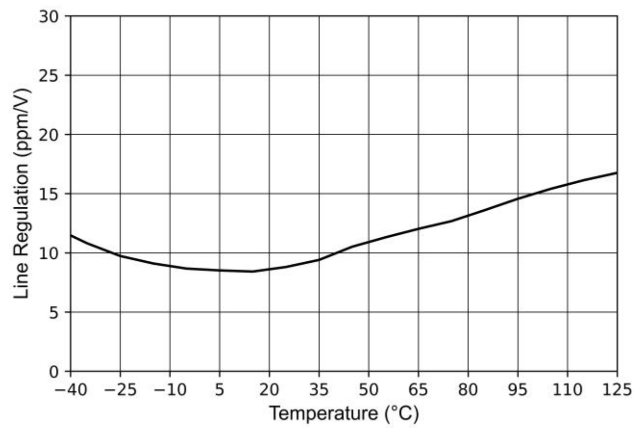

Figure 7.7 Line Regulation vs Temperature

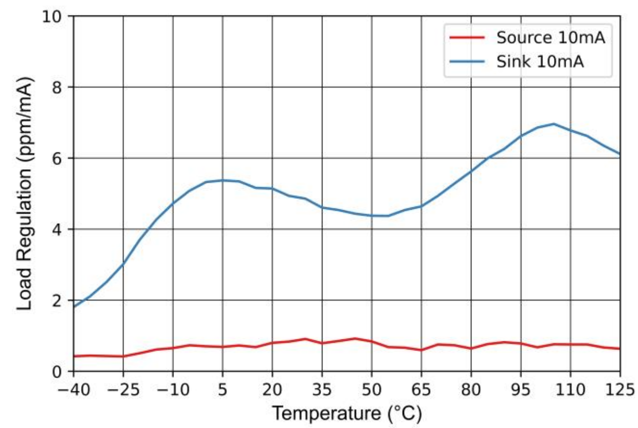

Figure 7.8 Load Regulation vs Temperature

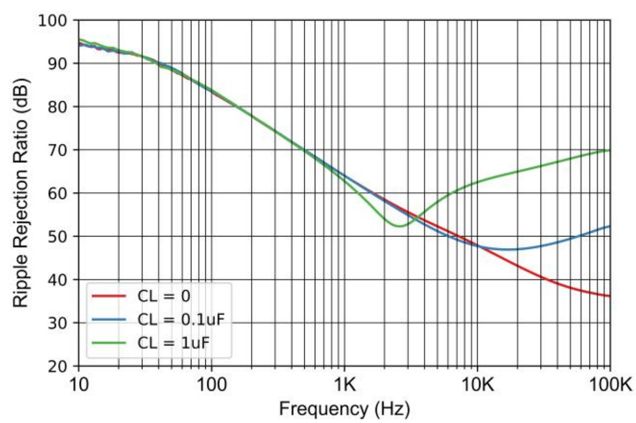

Figure 7.9 Ripple Rejection Ratio vs Frequency

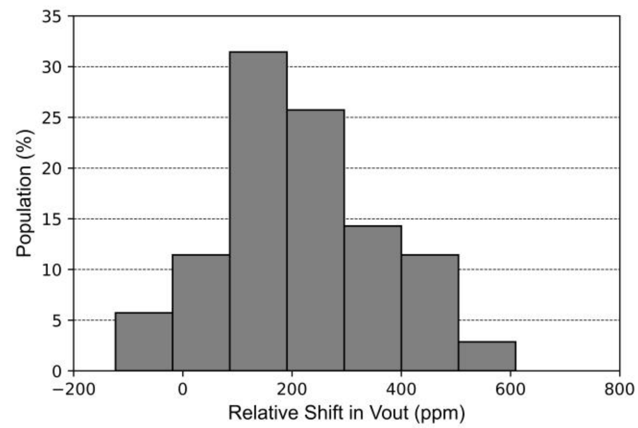

Figure 7.10 Solder Heat Reflow Shift Histogram

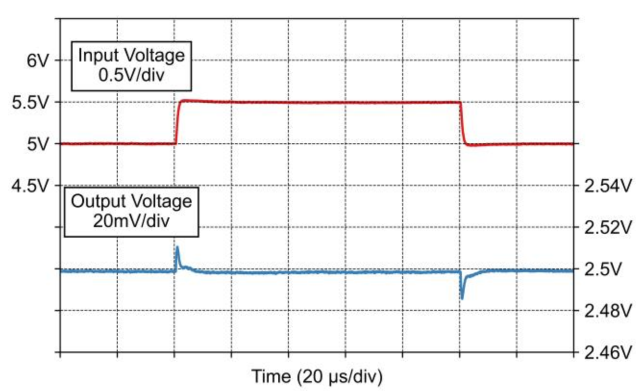

Figure 7.11 Line Transient Response (C_L=0)

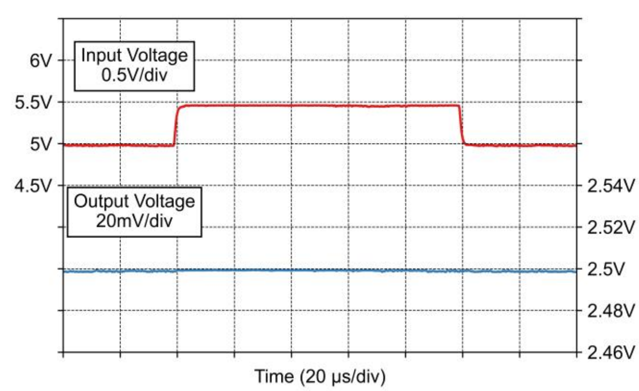

Figure 7.12 Line Transient Response (C_L=1uF)

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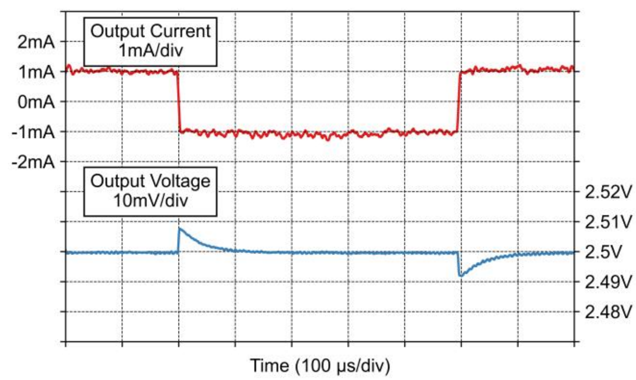

Figure 7.13 Load Transient Response ±1mA (C_L=0)

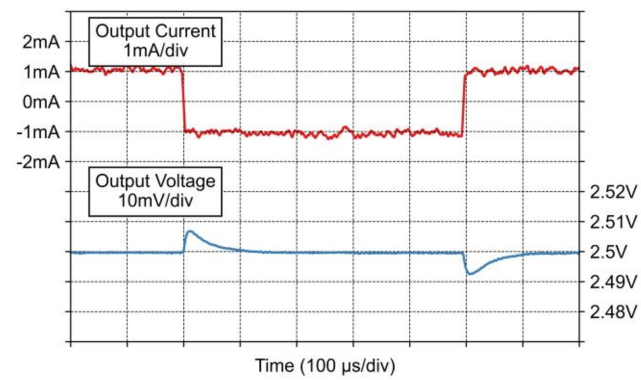

Figure 7.14 Load Transient Response ±1mA (C_L=1uF)

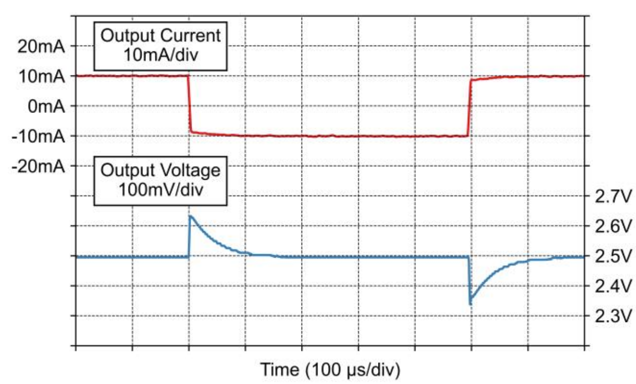

Figure 7.15 Load Transient Response ±10mA (C_L=0)

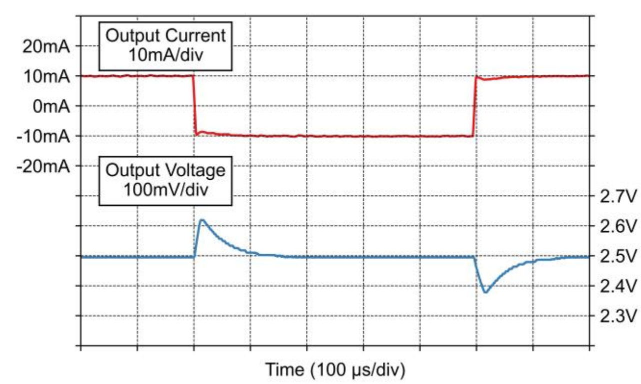

Figure 7.16 Load Transient Response ±10mA (C_L=1uF)

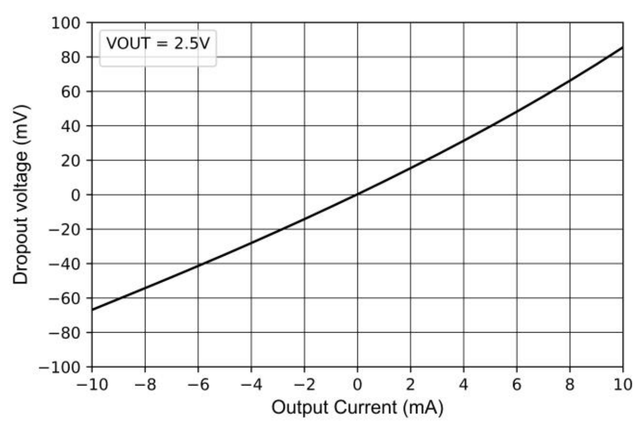

Figure 7.17 Dropout Voltage vs Load Current

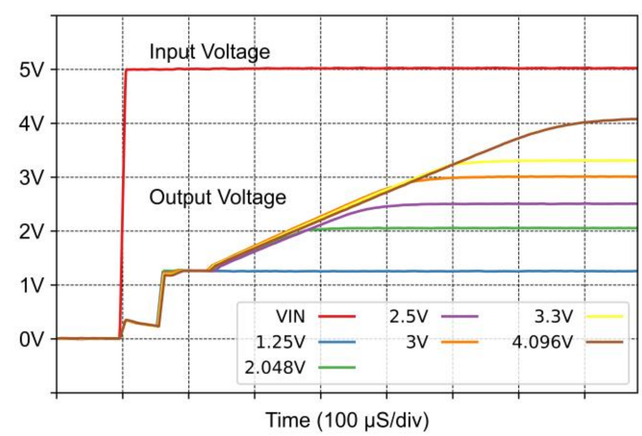

Figure 7.18 Startup Response

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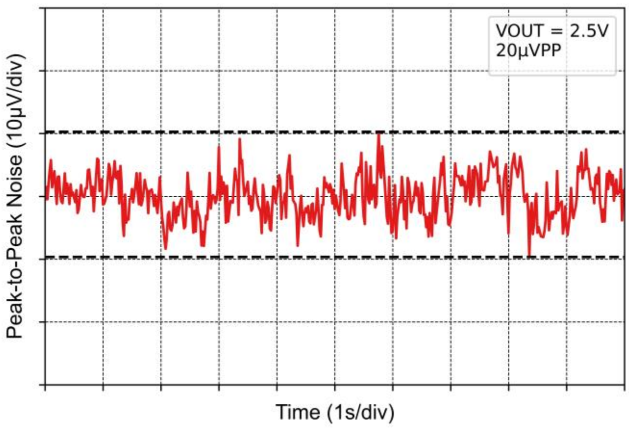

Figure 7.19 0.1Hz to 10Hz Voltage Noise

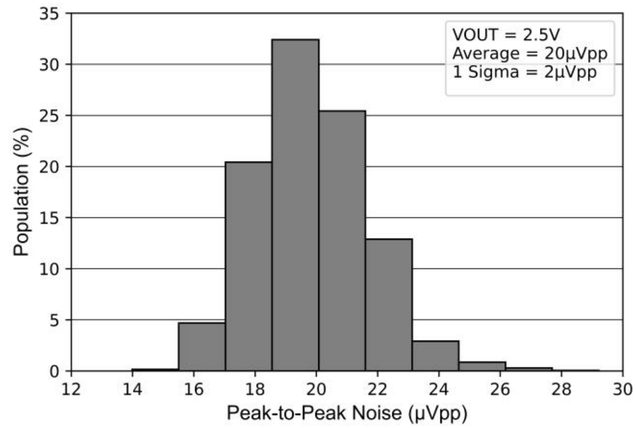

Figure 7.20 0.1Hz to 10Hz Noise Histogram

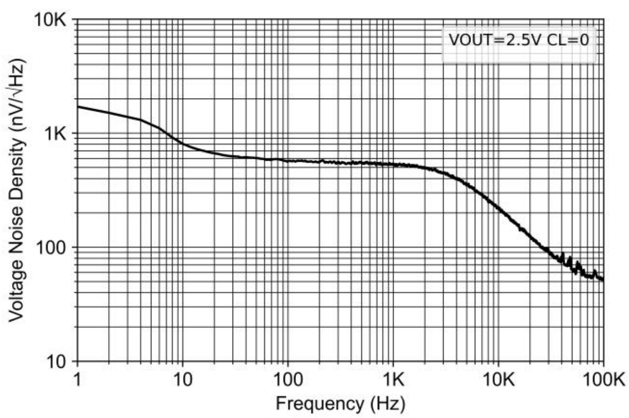

Figure 7.21 Noise Density vs Frequency

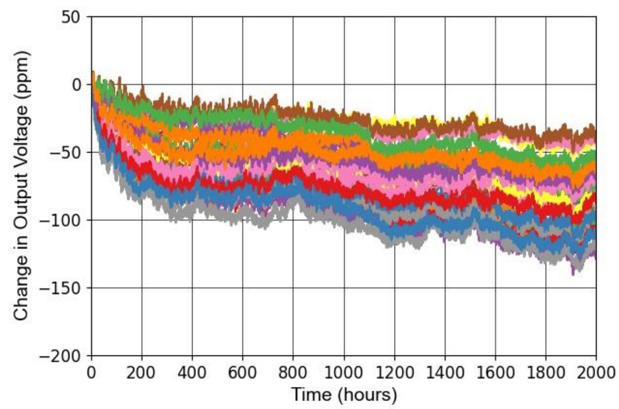

Figure 7.22 Long Term Drift 0 to 2000 hours, T_A=35°C

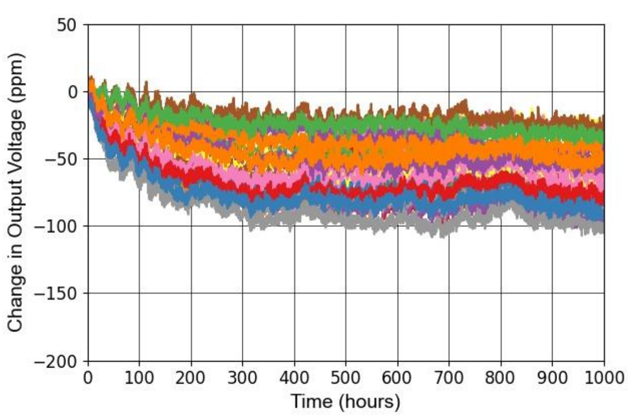

Figure 7.23 Long Term Drift 0 to 1000 hours, T_A=35°C

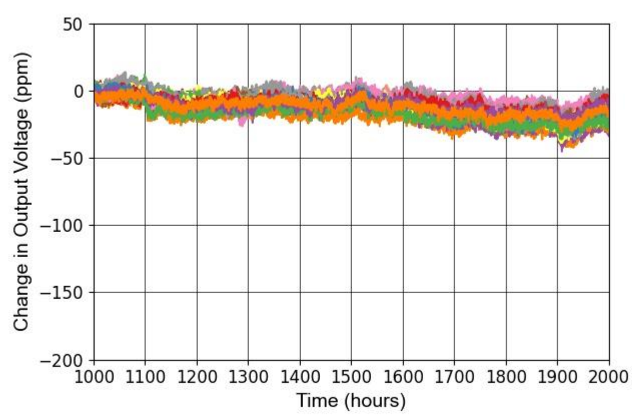

Figure 7.24 Long Term Drift 1000 to 2000 hours, T_A=35°C

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8. Application Information

8.1. Temperature Coefficient

The temperature coefficient is defined as the change in output voltage over temperature. The temperature coefficient is calculated using the box method in which a box is formed by the minimum and maximum values for the nominal output voltage over the operating temperature range. NSREF31xx series have a low maximum temperature coefficient of 15 ppm/°C from –40°C to +125°C.

$$Temperature\ \text{Coefficient} = \left(\frac{(V_{OUT\_MAX} - V_{OUT\_MIN})}{V_{OUT\_NOMINAL} \times \text{Temperature Range}}\right) \times 10^6$$

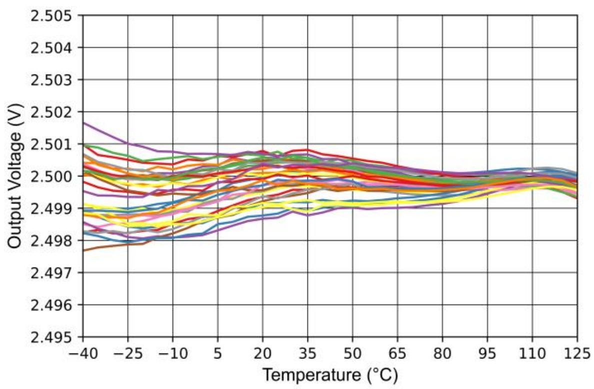

Figure 8.1 Output Voltage vs Temperature

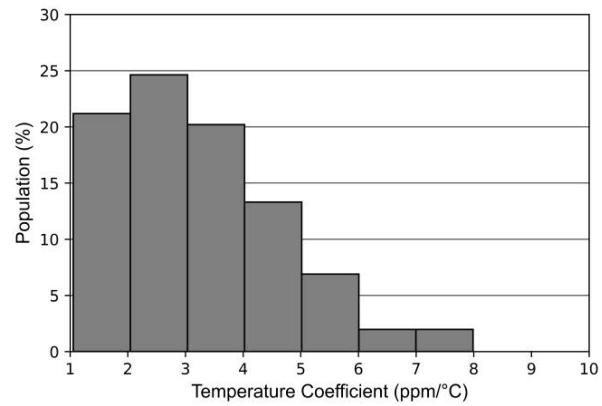

Figure 8.2 Temperature Drift Histogram

The box method specifies limits for the temperature error but does not specify the exact shape and slope of the devices under test. Due to temperature curvature correction to achieve low-temperature drift, the temperature drift is expected to be non-linear. Use for the box method.

8.2. Long-Term Stability

The long-term stability value is tested in a setup that reflects standard PCB board manufacturing practices. The boards are made of standard FR4 material and the board does not have special cuts or grooves around the devices to relieve the mechanical stress of the PCB. The devices and boards in this test do not undergo high temperature burn in post-soldering prior to testing. These conditions replicate real-world system performance and common manufacturing techniques. During the long-term stability testing, the devices under test are maintained at T_A=35°C in an ultra-stable oil bath, their outputs were scanned regularly and measured with an 8.5 digit DVM.

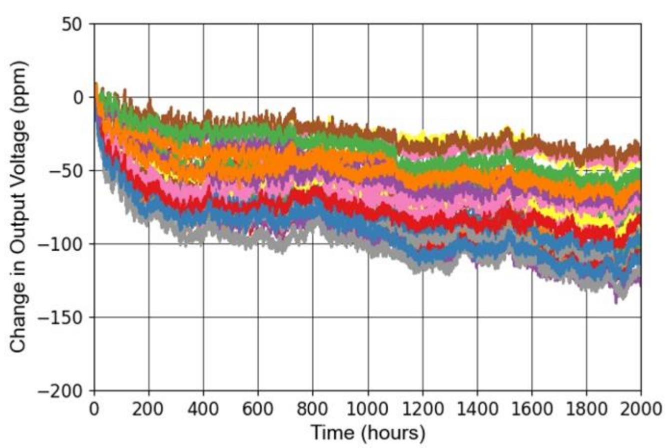

Figure 8.3 Long Term Drift 0 to 2000 hours, T_A=35°C

Figure 8.3 shows that the typical drift value for the NSREF31xx series is 130 ppm from 0 to 2000 hours. It is important to understand that long-term stability is not ensured by design and that the value is typical. The first 250 hours account most drift, Thus, the early life drift is the dominant contributor, whereas the drift after 250 hours is significantly lower.

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8.3. Noise Performance

Flicker noise, also known as 1/f noise, is a low-frequency noise that affects the device output voltage which can affect precision measurements in a data acquisition system. This noise increases proportionally with output voltage and operating temperature. NSREF31xx series peak-to-peak flicker noise is measured with a 2-pole high-pass filter at 0.1Hz and 2-pole low-pass filter at 10Hz, and the test time is 10 seconds. Due to the statistical nature of noise, repeating noise measurements will yield larger and smaller peak values in a given measurement interval. By repeating the measurement for 2000 intervals, each 10 seconds long, it is shown that there are time intervals during which the noise is higher than in a typical single interval, as predicted by statistical theory. For the 1000 interval test, a typical unit will exhibit noise that is less than the typical value listed in the Electrical Characteristics table in more than 80% of all units.

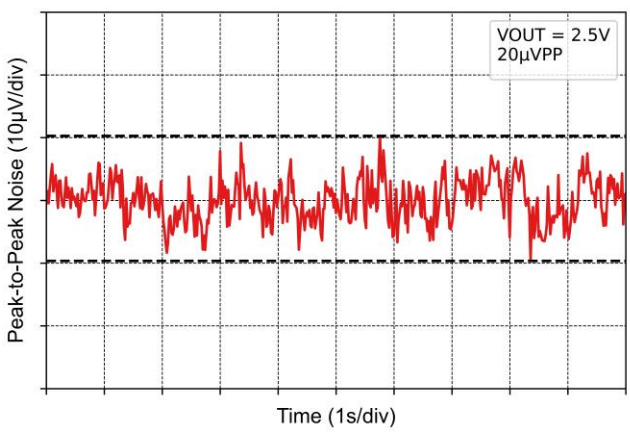

Figure 8.4 0.1Hz to 10Hz Voltage Noise

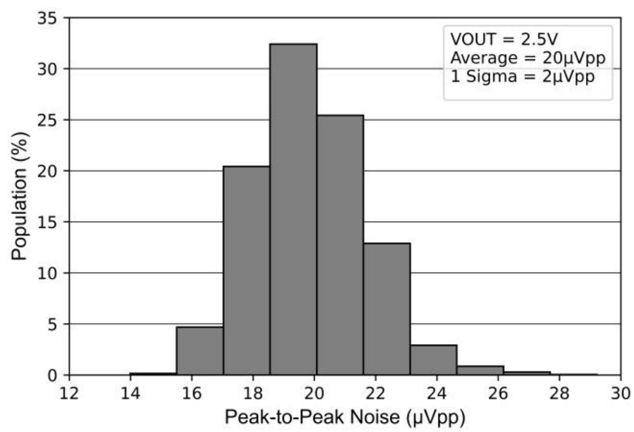

Figure 8.5 0.1Hz to 10Hz Noise Histogram

8.4. Typical Voltage Reference Connection

8.4.1.Input Capacitors

The NSREF31xx series require a 1µF or larger input capacitor located close to IN pin to improve transient response in applications where the supply voltage may fluctuate. Connect an additional 0.1µF capacitor in parallel to reduce high frequency supply noise.

8.4.2.Load Capacitors

The NSREF31xx series does not require any output capacitance for frequency stability, an additional 1µF to 10µF electrolytic or ceramic capacitor can be added to improve transient performance in response to sudden changes in load current, however, doing so increases the turn-on time of the device.

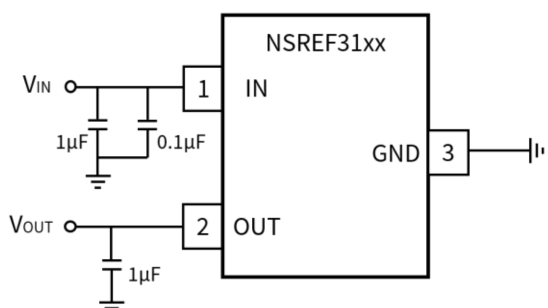

Figure 8.6 The NSREF31xx Typical Application Circuit

8.5. Layout Guidelines

- Connect low-ESR, 0.1-µF ceramic bypass capacitors at IN of the NSREF31xx.
- Connect low-ESR, 1-uF to 10-uF capacitor at OUT of the NSREF31xx.
- Decouple other active devices in the system per the device specifications.
- Using a solid ground plane helps distribute heat and reduces electromagnetic interference (EMI) noise pickup.
- Place the external components as close to the device as possible. This configuration prevents parasitic errors from occurring.

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9. Package Information

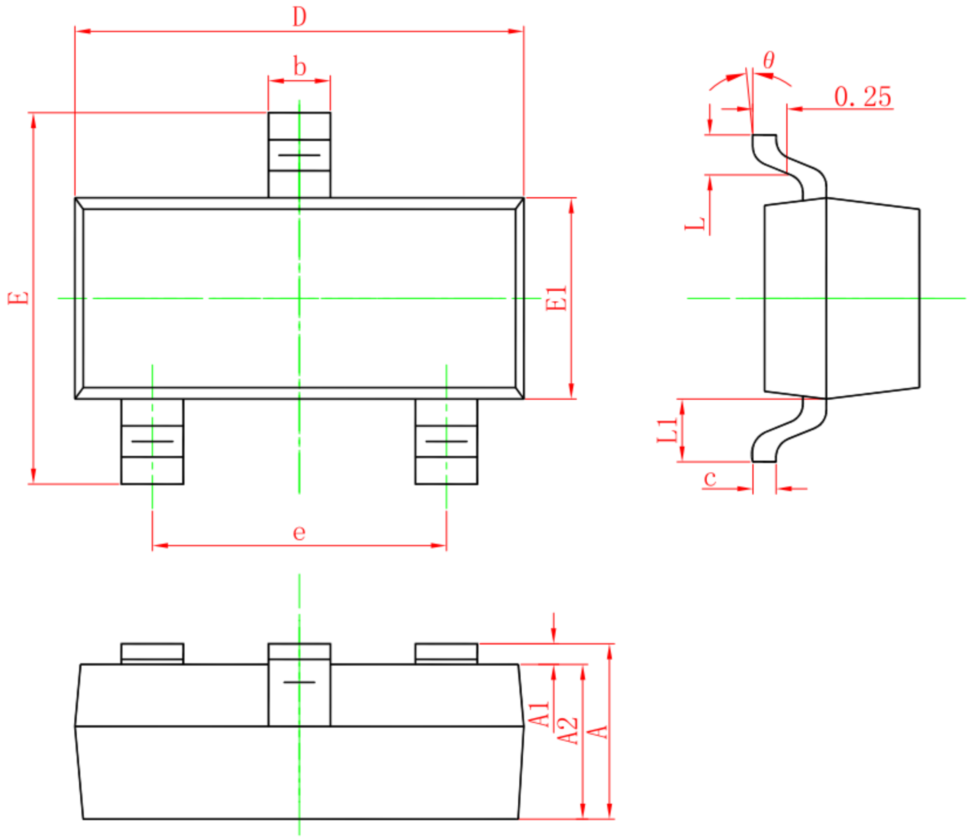

Figure 9.1 SOT23-3L Package Shape and Dimension in millimeters and (inches)

Symbol	Dimensions in Millimeters		Dimensions in Inches	
	Min.	Max.	Min.	Max.
A	1.15Max.		0.045Max.	
A1	0.000	0.100	0.000	0.004
A2	0.900	1.100	0.035	0.043
b	0.300	0.500	0.012	0.020
C	0.132	0.202	0.005	0.008
D	2.800	3.000	0.110	0.118
E	2.250	2.550	0.089	0.100
E1	1.200	1.400	0.047	0.055
e	1.800	2.000	0.071	0.079
L	0.300	0.500	0.012	0.020
L1	0.550 REF.		0.022 REF.	
θ	0°	8°	0°	8°

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10. Ordering Information

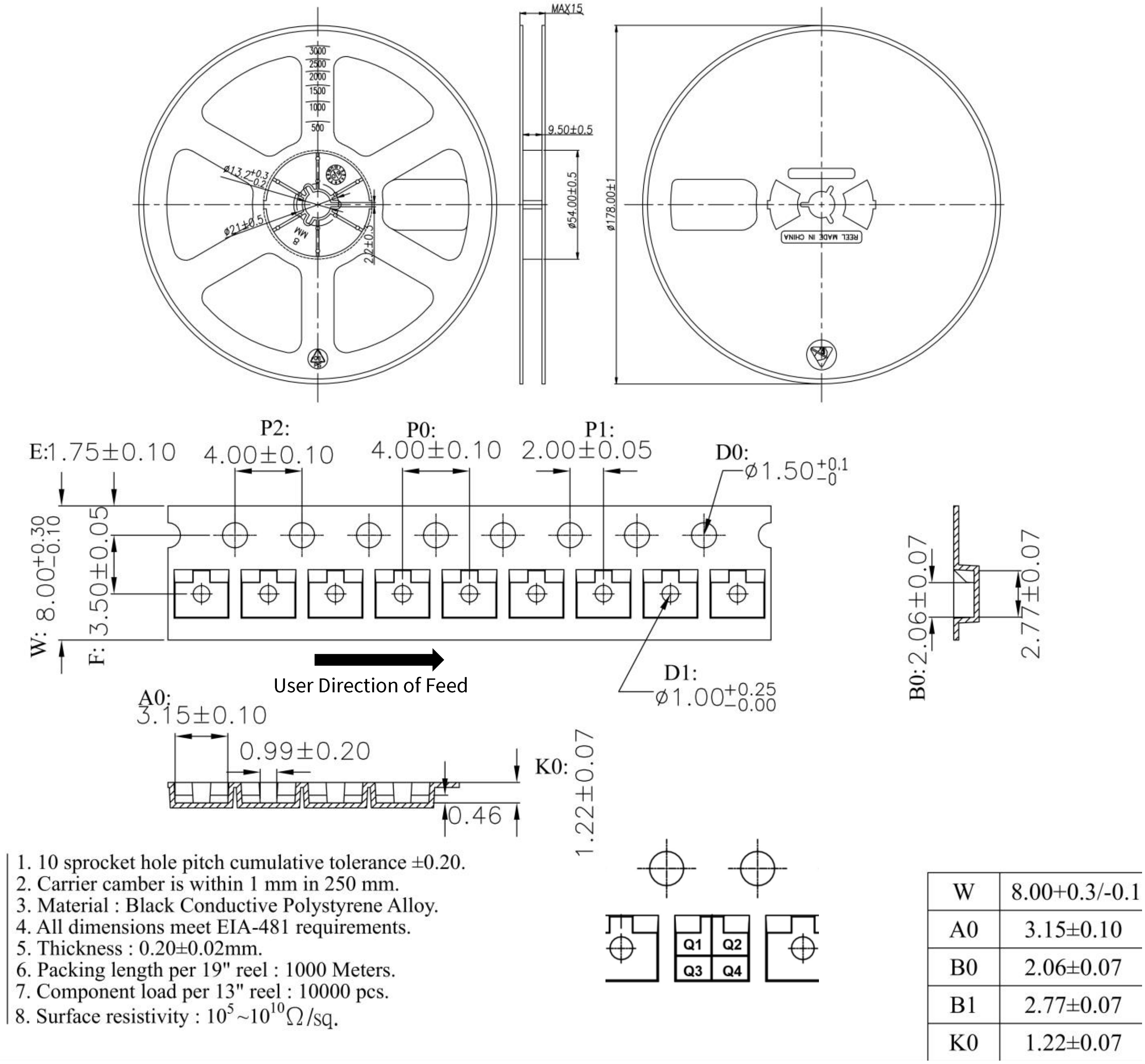
Part Number	*MSL*	*SPQ*	*Marking*	*Temperature*	*Package*
NSREF3112-DSTR	1	3000ea/Reel	3112	-40 to 125°C	SOT23-3L
NSREF3120-DSTR	1	3000ea/Reel	3120	-40 to 125°C	SOT23-3L
NSREF3125-DSTR	1	3000ea/Reel	3125	-40 to 125°C	SOT23-3L
NSREF3130-DSTR	1	3000ea/Reel	3130	-40 to 125°C	SOT23-3L
NSREF3133-DSTR	1	3000ea/Reel	3133	-40 to 125°C	SOT23-3L
NSREF3140-DSTR	1	3000ea/Reel	3140	-40 to 125°C	SOT23-3L

NOTE: All packages are RoHS-compliant with peak reflow temperatures of 260 °C according to the JEDEC industry standard classifications and peak solder temperatures.

11. Documentation Support

Part Number	*Product Folder*	*Datasheet*	*Technical Documents*
NSREF31xx	Click here	Click here	Click here

12. Tape and Reel Information



Device	***Package***	***D1 (mm)***	***W1 (mm)***	***A0 (mm)***	***D0 (mm)***	***D2 (mm)***	***F0 (mm)***	***K0 (mm)***	***P0 (mm)***	***P1 (mm)***	***P2 (mm***	***W (mm)***	***Pin1 Quadrant***
NSREF31xx	SOT23-3L	178	9.5	3.15	1.5	1.0	3.5	1.22	4.0	2.0	4.0	8.0	Q3

13. Revision History

Revision	Description	Date
1.0	Initial Version.	2023/10/15

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