NOVOSENSE

NSCSA21xA-Q1
28V, Bi-directional, High-precision Current Sense Amplifier
Datasheet (EN) 1.0

Product Overview

The NSCSA21xA-Q1 series are micropower, precision current sense amplifier with a very wide input common mode range. The NSCSA21xA-Q1 monitors Bidirectional current via the voltage across an external sense resistor. The input common mode voltage range extends from -2V to 28V, with respect to the negative supply voltage (V_-). This allows for the NSCSA21xA-Q1 to be used for both low and high side current-sensing applications.

Four fixed gains are available: 50 V/V, 75 V/V, 100 V/V or 200 V/V. The four gain selections offer flexibility in the choice of the external current-sense resistor. The very low ±5μV (typ) input offset voltage allows small 25mV to 100mV full-scale V_{SHUNT} voltage for very low power loss at full-current measurement.

The NSCSA21xA-Q1 series operates from a single 2.7V to 28V supply, drawing a typical of 260μA of supply current. The operating temperature range is specified from -40°C to 125°C, and the NSCSA21xA-Q1 is offered in a space-saving SC70-6 package.

Key Features

- AEC-Q100 Grade 0 qualified
- Survival Common-Mode Input Range: -28V to 28V
- Supply Voltage Range: 2.7V to 28V
- Low Offset Voltage: ±5μV (Typical)
- Gain Error: ±0.1% (Typical)
- Operate Current: 260μA (Typical)
- Gain Options:
  - NSCSA213A: 50 V/V
  - NSCSA215A: 75 V/V
  - NSCSA214A: 100 V/V
  - NSCSA210A: 200 V/V
- SC70 Package
- ROHS&REACH Compliance

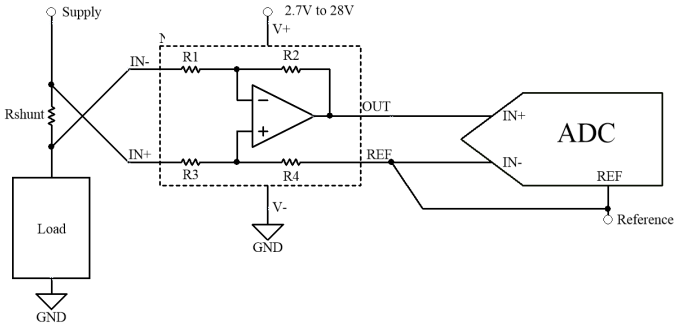
Applications

- Battery Management Systems
- Motor Controls
- Power-System Monitors
- Overcurrent and Fault Detection

Device Information

Part Number	Gain	Package	Body Size
NSCSA213A-Q1SCAR	50	SC70-6	2mm×1.25mm
NSCSA215A-Q1SCAR	75	SC70-6	2mm×1.25mm
NSCSA214A-Q1SCAR	100	SC70-6	2mm×1.25mm
NSCSA210A-Q1SCAR	200	SC70-6	2mm×1.25mm

Typical Application



Part Number	Gain	R1 and R3	R2 and R4
NSCSA213A	50	20kΩ	1MΩ
NSCSA215A	75	13.3kΩ	1MΩ
NSCSA214A	100	10kΩ	1MΩ
NSCSA210A	200	5kΩ	1MΩ

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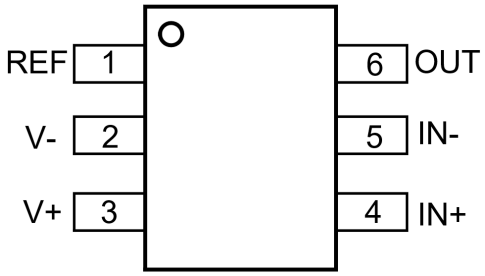
1. Pin Configuration and Functions

SC70-6

Top View



Pin No.	*Symbol*	*Type*	*Function*
1	REF	I	Reference voltage, 0 V to V+
2	V-	GND	Ground
3	V+	Power	Supply voltage, 2.7 V to 28 V
4	IN+	I	Non-inverting Input
5	IN-	I	Inverting input
6	OUT	O	Output voltage

2. Specifications

2.1. Absolute Maximum Ratings

Parameters	Symbol	Min	Max	Unit
Supply Voltage ((V_+) - (V-))	V_S	-0.3	30	V
Supply Voltage ((V_+) - (V-)), pulse for 800ms			36	V
Voltage at IN- and IN+ Pins	V_{IN+}, V_{IN-}	-28	30	V
Voltage at IN- and IN+ Pins, pulse for 800ms			36	V
Voltage at REF Pins	V_{REF}	(V-) - 0.3	30	V
Voltage at Output Pins	V_{OUT}	(V-) - 0.3	(V_+) + 0.3	V
Storage Temperature	T_{stg}	-60	150	°C
Maximum Junction Temperature			150	°C

2.2. ESD Ratings

Ratings		Value	Unit
Electrostatic discharge	● Human body model (HBM), per AEC Q100-002	±3000	V
	● Charged device model (CDM), per AEC Q100-011	±2000	V

2.3. Recommended Operating Conditions

Parameters	Symbol	Min	Typ	Max	Unit
Power Supply Voltage	V_S		5		V
Common-Mode Input Voltage	V_{CM}		12		V
Operation Temperature Range	T_A	-40		125	°C

2.4. Thermal Information

Parameters	Symbol	SC70-6	Unit
Junction-to-ambient thermal resistance	θ_{JA}	179.8	°C/W
Junction-to-case(top) thermal resistance	$\theta_{JC(top)}$	129.4	°C/W
Junction-to-board thermal resistance	θ_{JB}	74.5	°C/W

3. Electrical Characteristics

At T_A = +25°C, V_{SHUNT} = V_{IN+} – $V_{IN–}$, and, V_S = (V+) – (V-) = 5V, V_{IN+} = 12V, V_{SHUNT} = 0mV, and V_{REF} = V_S / 2, unless otherwise noted.

Parameters	Symbol	Condition		Min	Typ	Max	Unit
INPUT							
Common-Mode Input Range	V_{CM}			-2		28	V
Common-Mode Rejection Ratio	CMRR	V_{CM} = -1.5V to 28V T_A = -40°C to 125°C	Gain=50 Gain=75 Gain=100	100	120		dB
			Gain=200	105	126		
Offset Voltage, RTI[1]	V_{OS}	NSCSA213A (Gain=50)			±15	±100	μV
		NSCSA215A (Gain=75)			±15	±70	
		NSCSA214A (Gain=100)			±15	±70	
		NSCSA210A (Gain=200)			±5	±40	
Offset Voltage Drift, RTI [1]	dV_{OS}/dT	T_A = -40°C to 125°C [2]			±0.1	±0.5	μV/°C
Input Bias Current	I_B				10	15	μA
Input offset current	I_{OS}				±0.01		μA
OUTPUT							
Gain Error	GE	V_{SHUNT} = -5mV to 5mV T_A = -40°C to 125°C			±0.1	±0.5	%
Gain Drift		T_A = -40°C to 125°C [2]			±3	±10	ppm/°C
Nonlinearity Error					±0.01		%
Maximum capacitive load		No sustained oscillation			1		nF
VOLTAGE OUTPUT							
Swing to V+		R_L = 10 kΩ to (V-) T_A = -40°C to 125°C			(V+)–0.05	(V+)–0.2	V
Swing to V-		R_L = 10 kΩ to (V-) T_A = -40°C to 125°C			(V-)+5	(V-)+50	mV
FREQUENCY RESPONSE							
Input Voltage-Noise Density		NSCSA213A (Gain=50)			42		$nV/\sqrt{Hz}$
		NSCSA215A (Gain=75)			38		
		NSCSA214A (Gain=100)			36		
		NSCSA210A (Gain=200)			32		
Slew Rate	SR	C_L = 10 pF			2		V/μs
Bandwidth	BW	C_L = 10 pF	Gain=50		200		kHz
			Gain=75		125		
			Gain=100		100		
			Gain=200		50		

[1] RTI means referred to input
[2] Not production tested, guaranteed by characterization results

Electrical Characteristics (continued)

At T_A = +25°C, V_{SHUNT} = V_{IN+} – V_{IN-}, and, V_S = (V+) – (V-) = 5V, V_{IN+} = 12V, V_{SHUNT} = 0mV, and V_{REF} = V_S / 2, unless otherwise noted.

Parameters	Symbol	Condition	Min	Typ	Max	Unit
SUPPLY						
Supply Voltage Range	V_S	T_A = -40°C to 125°C	2.7		28	V
Quiescent Current	I_Q	T_A = +25°C		260		µA
		T_A = -40°C to 125°C			320	
Power Supply Ratio	PSRR	NSCSA213A (Gain=50) NSCSA215A (Gain=75) NSCSA214A (Gain=100)	100	125		dB
		NSCSA210A (Gain=200)	110	135		

4. Typical Performance Characteristics

at T_A = +25°C, V_{SHUNT} = V_{IN+} – $V_{IN–}$, and, V_S = (V+) – (V-) = 5V, V_{IN+} = 12V, V_{SHUNT} = 0mV, and V_{REF} = V_S / 2, unless otherwise noted.

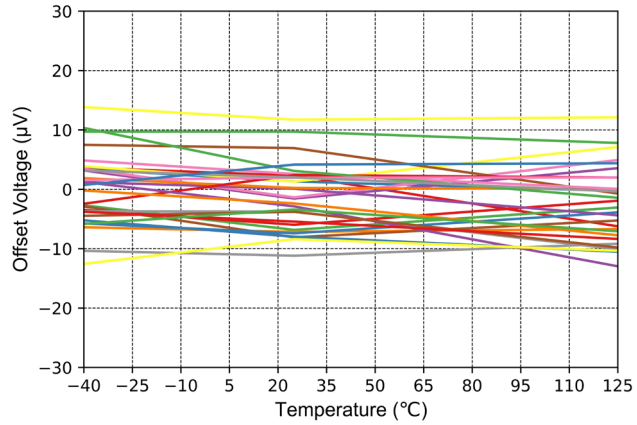


Figure 4-1 Input Offset Voltage vs Temperature

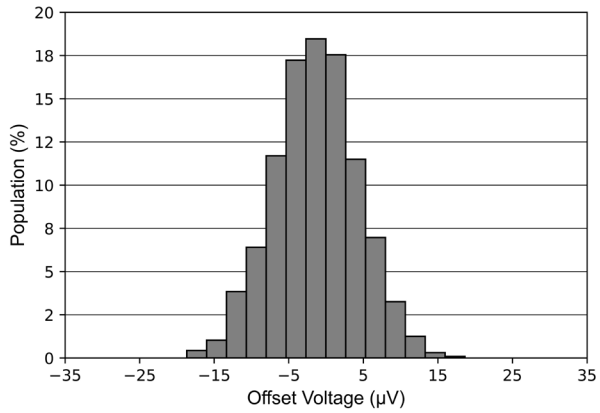


Figure 4-2 Input Offset Voltage Distribution

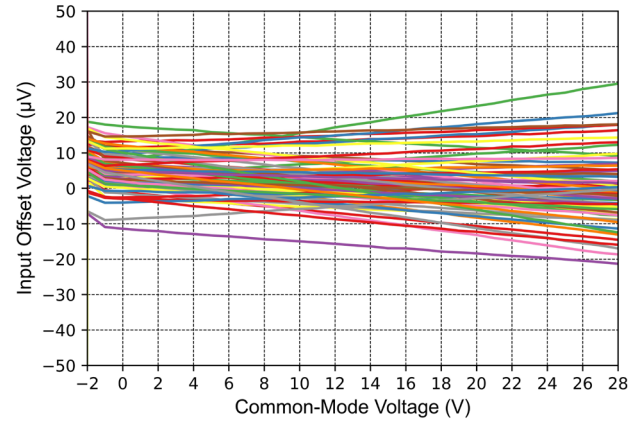


Figure 4-3 Input Offset Voltage vs Common-mode Voltage

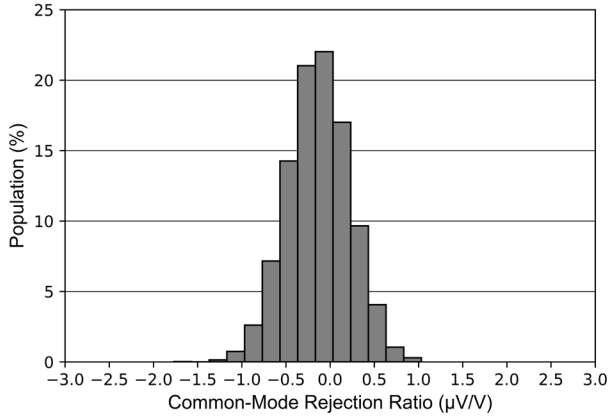


Figure 4-4 Common-Mode Rejection Ratio Distribution

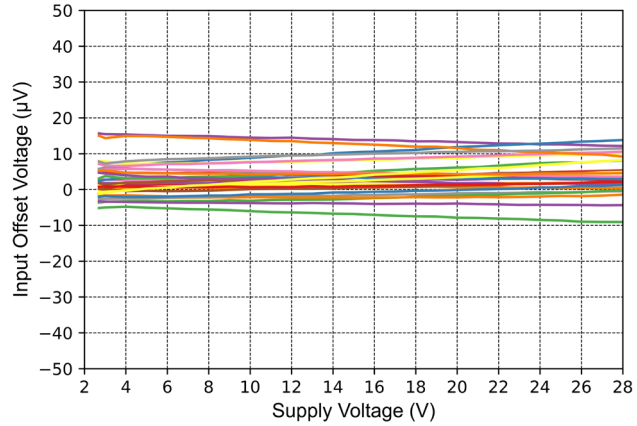


Figure 4-5 Input Offset Voltage vs Supply Voltage

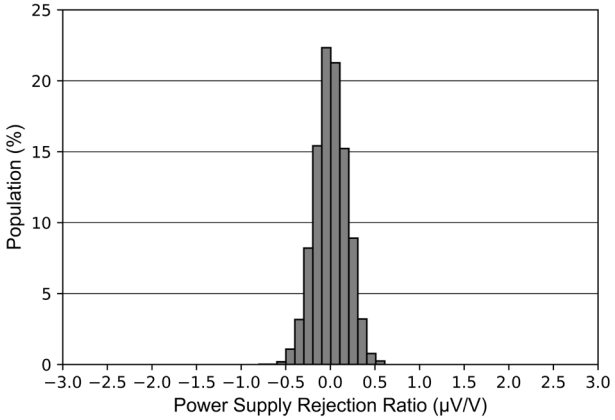


Figure 4-6 Power Supply Rejection Ratio Distribution

Typical Performance Characteristics (continued)

at T_A = +25°C, V_{SHUNT} = V_{IN+} – $V_{IN–}$, and, V_S = (V+) – (V-) = 5V, V_{IN+} = 12V, V_{SHUNT} = 0mV, and V_{REF} = V_S / 2, unless otherwise noted.

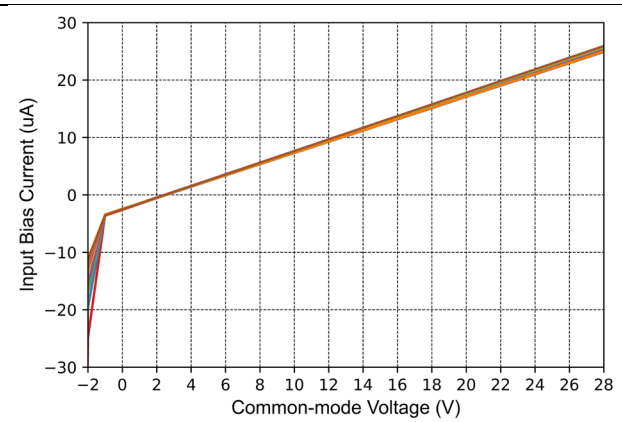


Figure 4-7 Input bias current vs Common-mode Voltage

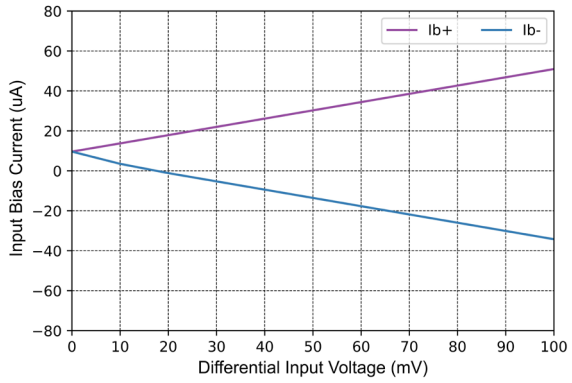


Figure 4-8 Input Bias Current vs Differential Input Voltage

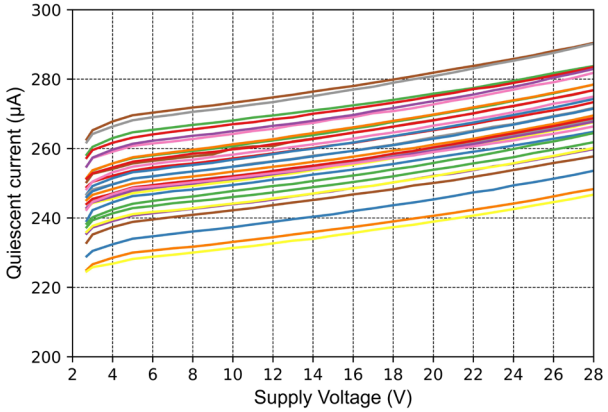


Figure 4-9 Quiescent Current vs Supply Voltage

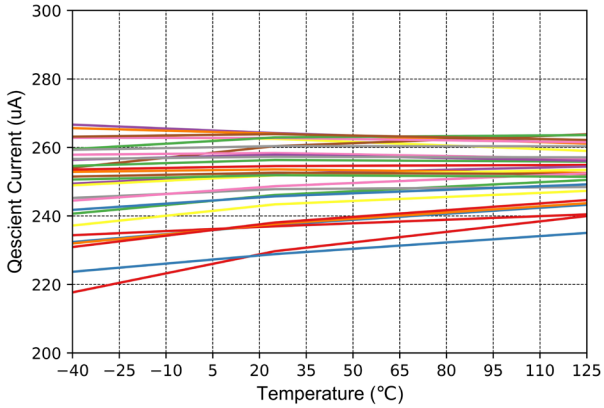


Figure 4-10 Quiescent Current vs Temperature

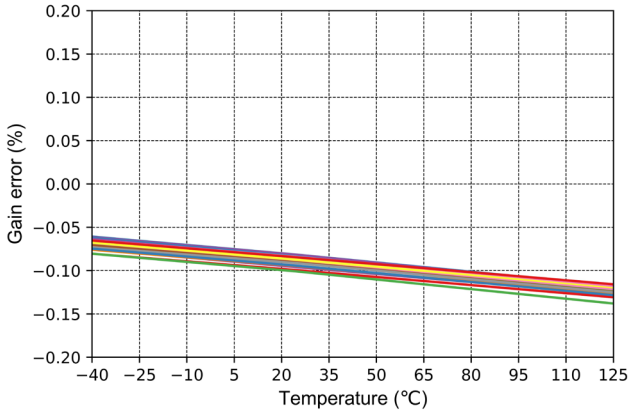


Figure 4-11 Gain Error vs Temperature

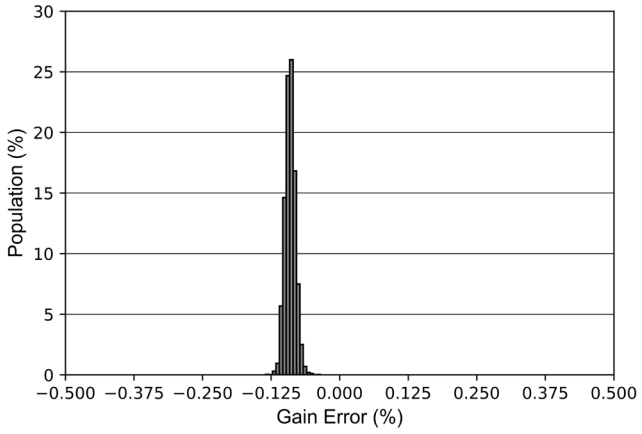


Figure 4-12 Gain Error Distribution

Typical Performance Characteristics (continued)

at T_A = +25°C, V_{SHUNT} = V_{IN+} – $V_{IN–}$, and, V_S = (V+) – (V-) = 5V, V_{IN+} = 12V, V_{SHUNT} = 0mV, and V_{REF} = V_S / 2, unless otherwise noted.

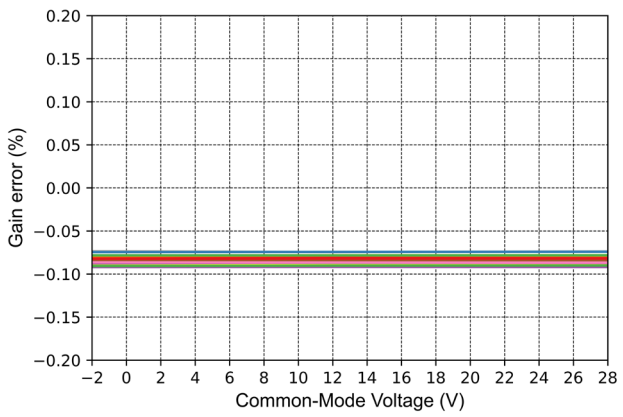


Figure 4-13 Gain Error vs Common-mode Voltage

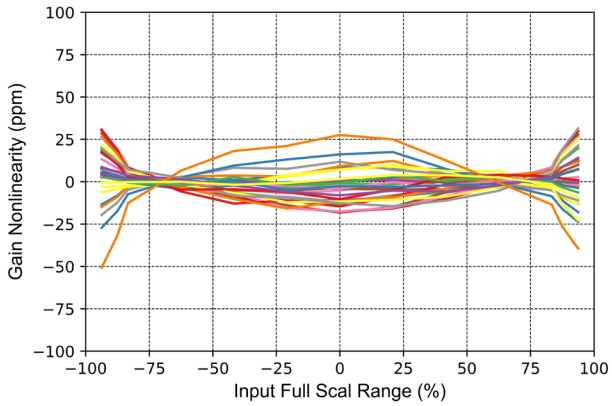


Figure 4-14 Gain Nonlinearity error vs Input Range

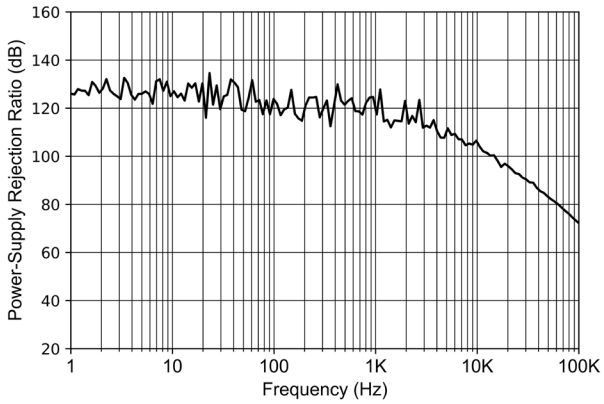


Figure 4-15 Power-Supply Rejection Ratio vs Frequency

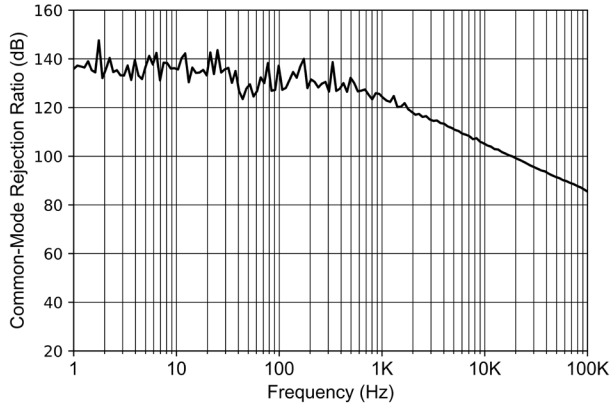


Figure 4-16 Common-Mode Rejection Ratio vs Frequency

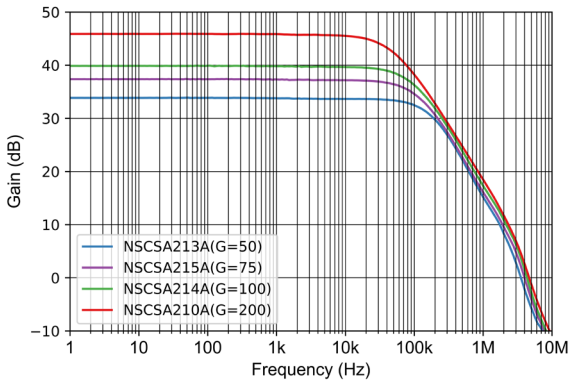


Figure 4-17 Gain vs Frequency

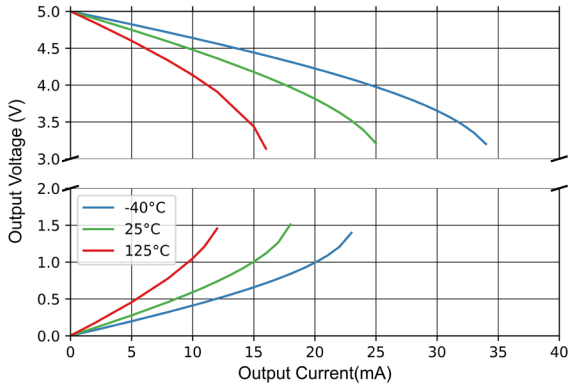


Figure 4-18 Output Voltage vs Output Current

Typical Performance Characteristics (continued)

at T_A = +25°C, V_{SHUNT} = V_{IN+} – $V_{IN–}$, and, V_S = (V+) – (V-) = 5V, V_{IN+} = 12V, V_{SHUNT} = 0mV, and V_{REF} = V_S / 2, unless otherwise noted.

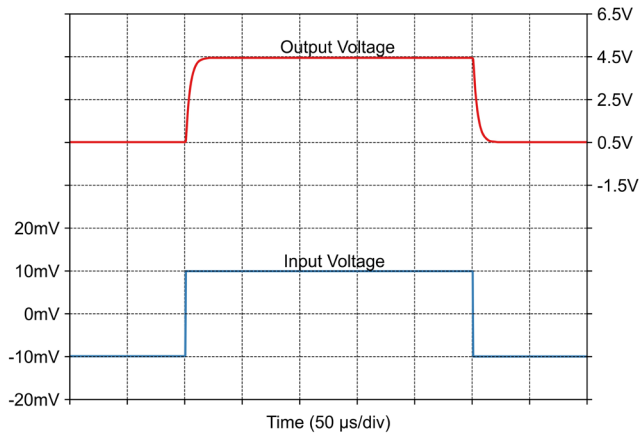


Figure 4-19 Step Response

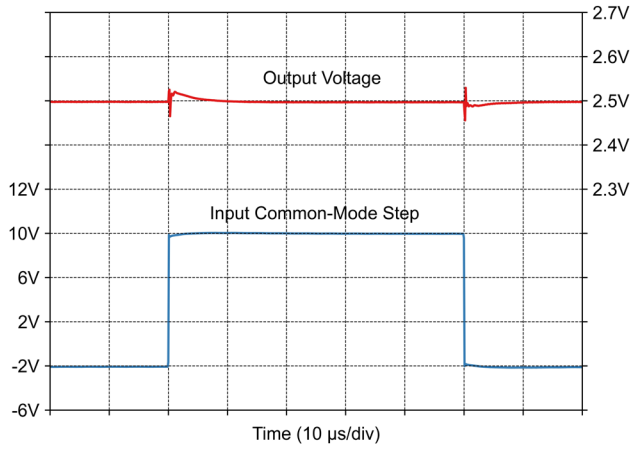


Figure 4-20 Enhanced PWM Rejection

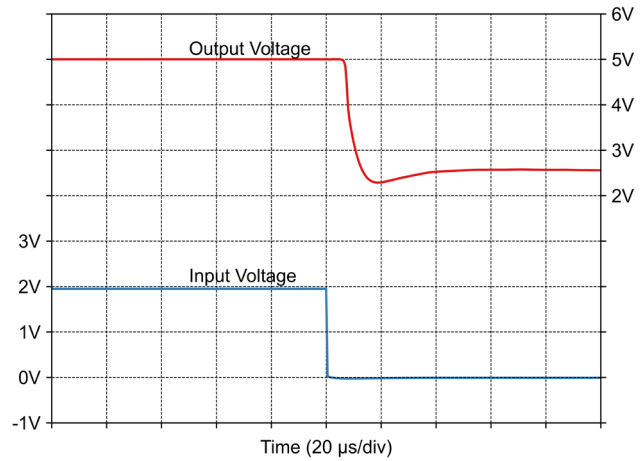


Figure 4-21 Noninverting Differential Input Overload Recovery

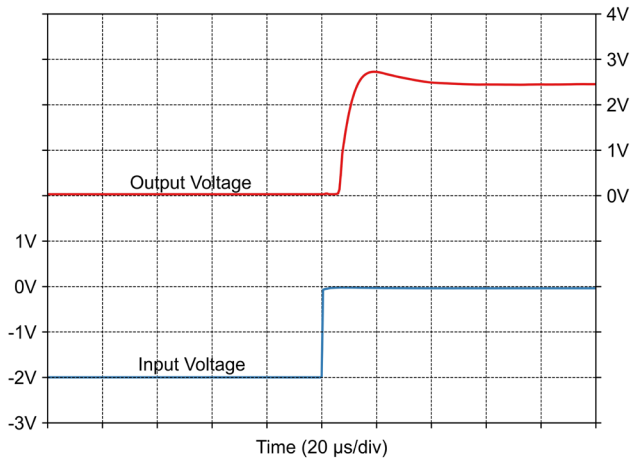


Figure 4-22 Inverting Differential Input Overload Recovery

5. Function Description

5.1. Overview

The NSCSA21xA-Q1 series current sensor amplifiers offer a wide common-mode range from -2V to 28V, this current amplifier protects a main amplifier, 4 precisely matched resistors, oscillator, power on reset circuit, bandgap reference and LDO, and input common mode bias circuit.

The NSCSA21xA-Q1 series are micropower, precision current sense amplifier with a very wide input common mode range. The NSCSA21xA-Q1 monitors Bidirectional current via the voltage across an external sense resistor. The input common mode range extends from -2V to 28V, with respect to the negative supply voltage (V–). This allows for the NSCSA21xA-Q1 to be used for both low and high side current-sensing applications.

Four fixed gains are available: 50 V/V, 75 V/V, 100 V/V or 200 V/V. The four gain selections offer flexibility in the choice of the external current-sense resistor. The very low ±5μV (typ) input offset voltage allows small 25mV to 100mV full-scale V_{SHUNT} voltage for very low power loss at full-current measurement.

The NSCSA21xA-Q1 series operates from a single 2.7V to 28V supply, drawing a typical of 260μA of supply current. The operating temperature range is specified from -40°C to 125°C, and the NSCSA21xA-Q1 is offered in a space-saving SC70-6 package.

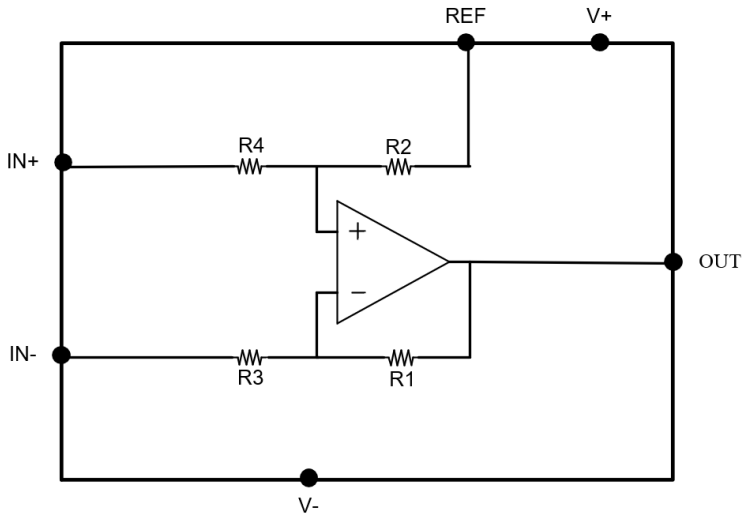


Figure 5-1 NSCSA21xA-Q1 Functional Block Diagram

6. Application Note

6.1. Typical Application Circuit

The NSCSA21xA-Q1 series are bidirectional current-sense amplifier. Figure 6-1 show typical application circuit.

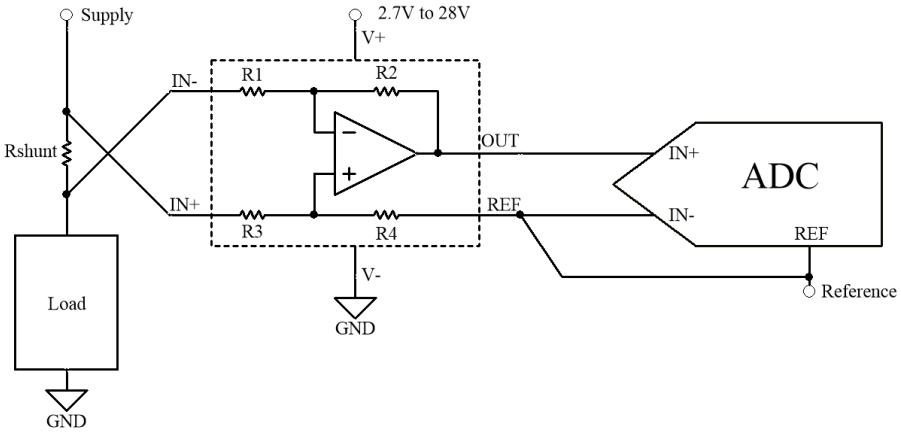
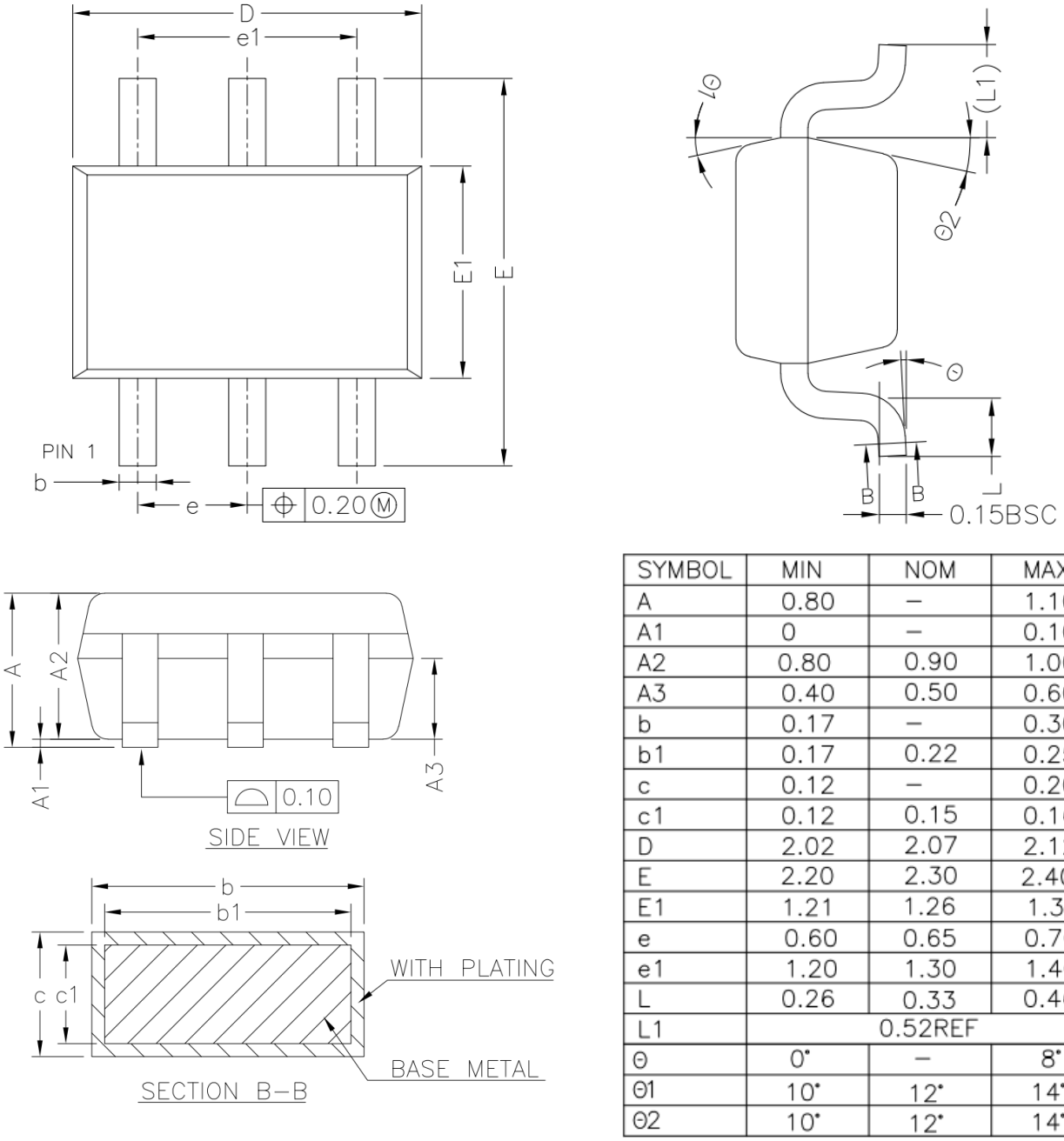


Figure 6-1 Typical Application Circuit

7. Package Information



SYMBOL	MIN	NOM	MAX
A	0.80	–	1.10
A1	0	–	0.10
A2	0.80	0.90	1.00
A3	0.40	0.50	0.60
b	0.17	–	0.30
b1	0.17	0.22	0.25
c	0.12	–	0.20
c1	0.12	0.15	0.16
D	2.02	2.07	2.12
E	2.20	2.30	2.40
E1	1.21	1.26	1.31
e	0.60	0.65	0.70
e1	1.20	1.30	1.40
L	0.26	0.33	0.46
L1	0.52REF		
θ	0°	–	8°
θ1	10°	12°	14°
θ2	10°	12°	14°

Figure 7-1 SC70-6 Package Shape and Dimension in millimeters

8. Order Information

Part Number	*Gain*	*Temperature*	*MSL*	*Package Type*	*SPQ*
NSCSA213A-Q1SCAR	50	-40 to 125°C	MSL1	SC70-6	3000
NSCSA215A-Q1SCAR	75	-40 to 125°C	MSL1	SC70-6	3000
NSCSA214A-Q1SCAR	100	-40 to 125°C	MSL1	SC70-6	3000
NSCSA210A-Q1SCAR	200	-40 to 125°C	MSL1	SC70-6	3000

9. Tape and Reel Information

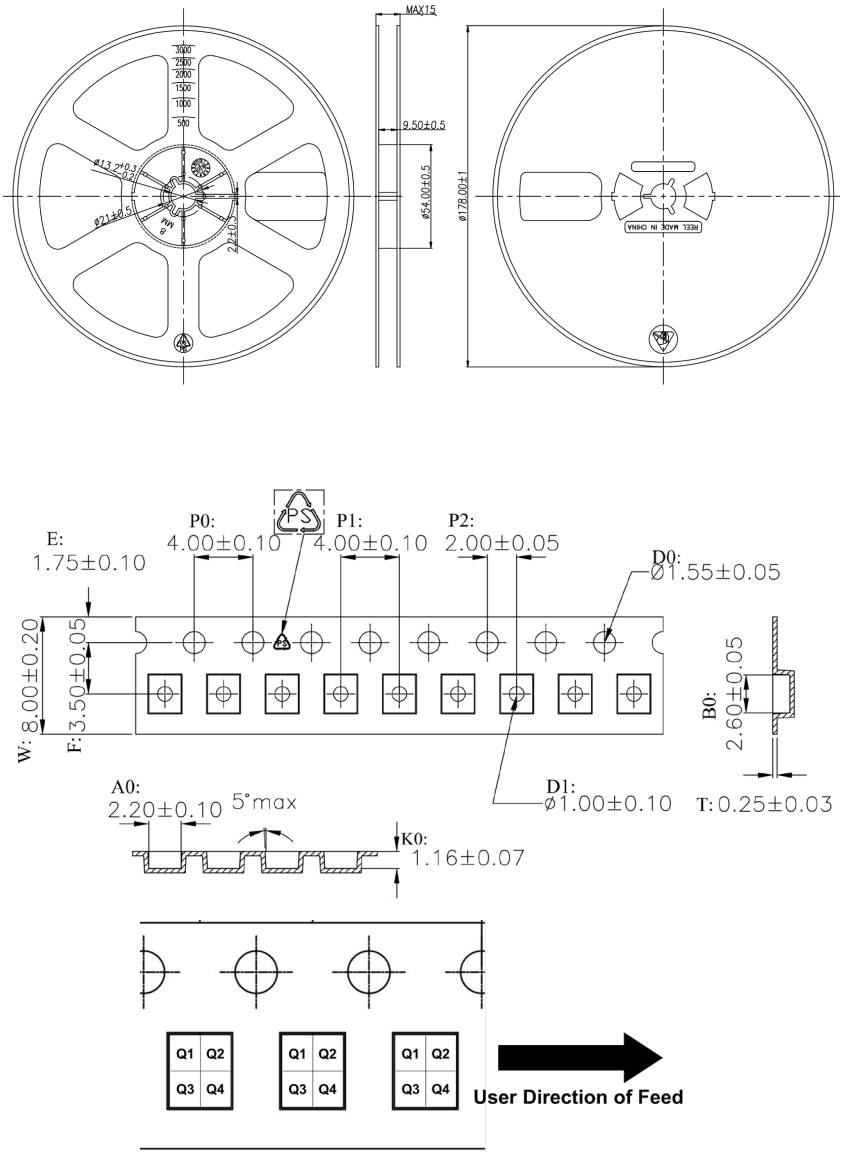


Figure 9-1 Tape and Reel Information of SC70-6

Device	Reel Diameter	Reel Width	W	A0	B0	P0	P1	P2	K0	D0	D1	PIN1 Quadrant
NSCSA213A -Q1SCAR	178	9.5	8.0	2.2	2.6	4.0	4.0	2.0	1.16	1.55	1.0	Q3
NSCSA215A -Q1SCAR	178	9.5	8.0	2.2	2.6	4.0	4.0	2.0	1.16	1.55	1.0	Q3
NSCSA214A -Q1SCAR	178	9.5	8.0	2.2	2.6	4.0	4.0	2.0	1.16	1.55	1.0	Q3
NSCSA210A -Q1SCAR	178	9.5	8.0	2.2	2.6	4.0	4.0	2.0	1.16	1.55	1.0	Q3

10. Revision History

Revision	*Description*	*Date*
1.0	Initial Version	2025/8

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