

## 1.5V, 0.29 $\mu$ A, Ultralow Power, Rail-to-Rail Input/Output Single CMOS Operational Amplifier

### FEATURES ( $V^+=5V$ )

- Supply Current: 0.29 $\mu$ A typ.
- Operating Voltage: 1.5V to 5.5V
- Input Offset Voltage: 1mV max.
- Offset Voltage Drift: 0.65 $\mu$ V/ $^{\circ}$ C typ.
- Input Bias Current: 10pA max.
- Unity gain Frequency: 1.1kHz
- Slew Rate: 0.8V/ms
- Rail-to-Rail Input /Output
- RF Noise Immunity
- CMOS Technology
- Package: SOT-23-5  
SC-88A

### APPLICATIONS

- Battery powered Instruments
- Micro power oxygen sensor and gas sensor
- Power line monitoring
- Micropower current sensing
- Healthcare instruments
- Micropower current to Voltage converter

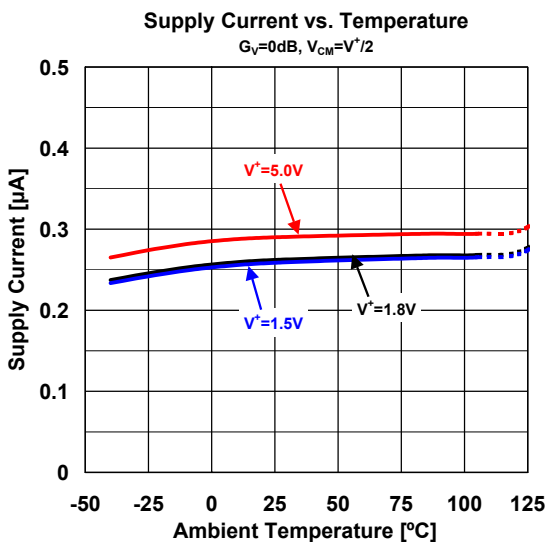
### DESCRIPTION

The NJU77000/NJU77001 are single ultralow power 435nW operational amplifiers designed to extend battery life and performance for portable applications. The operating voltage range of 1.5V to 5.5V and supply current of 0.29 $\mu$ A typical with stable over temperature and input voltage change makes it ideal for micropower oxygen sensors, gas sensors and remote sensor applications.

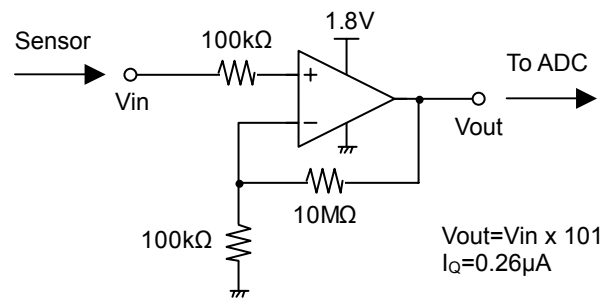
In addition to the ultralow power and low operating voltage, rail-to-rail input and output, input offset voltage of 1mV maximum with 0.65 $\mu$ V/ $^{\circ}$ C drift, input bias current of 10pA maximum and ability to drive 470pF loads, make the NJU77001/NJU77001 ideal when requiring excellent performance in battery powered applications.

The NJU77000 is available in the 5-pin SC-88A package. NJU77001 is available in the 5-pin SOT-23 and SC-88A package. NJU77000 and NJU77001 have difference pin function (see pin configuration). The NJU7700xA have the higher performance and offer guaranteed specifications over the extended temperature range from -40 $^{\circ}$ C to +105 $^{\circ}$ C.

### TYPICAL CHARACTERISTIC



### TYPICAL APPLICATION



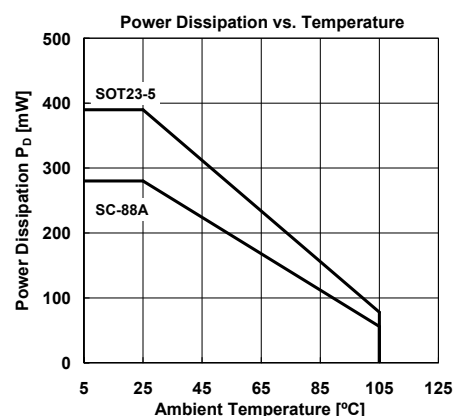
40dB micropower sensor amplifier

## ■ PIN CONFIGURATION / PRODUCT INFORMATION

Pin Function				
	Package	SOT-23-5	SOT-23-5	SC-88A
Product Name	NJU77000F NJU77000AF	NJU77001F NJU77001AF	NJU77001F3 NJU77001AF3	

## ■ ABSOLUTE MAXIMUM RATINGS (Ta=25°C)

PARAMETER	SYMBOL	RATING	UNIT
Supply Voltage	$V^+ - V^-$	7	V
Differential Input Voltage <sup>(1)</sup>	$V_{ID}$	$\pm 7$ <sup>(2)</sup>	V
Input Voltage	$V_{IN}$	$V^- - 0.3$ to $V^+ + 0.3$	V
Power Dissipation <sup>(3)</sup>		(2-layer)	
SOT23-5	$P_D$	390	mW
SC-88A		280	
Operating Temperature Range	$T_{opr}$	-40 to +105	°C
Storage Temperature Range	$T_{stg}$	-55 to +125	°C



(1) Differential voltage is the voltage difference between +INPUT and -INPUT.

(2) For supply voltage less than +7V, the absolute maximum rating is equal to the supply voltage.

(3) Power dissipation is the power that can be consumed by the IC at Ta=25°C, and is the typical measured value based on JEDEC condition.

When using the IC over Ta=25°C subtract the value [mW/°C]= $P_D / (T_{stg}(MAX) - 25)$  per temperature.

2-layer: EIA/JEDEC STANDARD Test board (76.2x114.3x 1.6mm, 2layers, FR-4) mounting

## ■ RECOMMENDED OPERATING CONDITIONS (Ta=25°C)

PARAMETER	SYMBOL	CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	$V^+ - V^-$		1.5	-	5.5	V

## ■ ELECTRICAL CHARACTERISTICS

### ● DC CHARACTERISTICS ( $V^+=5V$ , $V^-=0V$ , $V_{CM}=2.5V$ , $T_a=25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITION	NJU77000A NJU77001A			NJU77000 NJU77001			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Supply Current	$I_Q$	No Signal	-	0.29	0.39	-	0.29	0.49	$\mu A$
		$T_a=-40^\circ C$ to $+105^\circ C$	-	-	0.39	-	-	-	
Input Offset Voltage	$V_{IO}$	$V_{CM}=0V$	-	0.35	1	-	0.35	1.8	mV
		$T_a=-40^\circ C$ to $+105^\circ C$	-	0.35	1.2	-	-	-	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	$V_{CM}=0V$ , $T_a=-40^\circ C$ to $+105^\circ C$	-	0.65	17	-	0.65	-	$\mu V/deg$
Input Bias Current	$I_B$	$T_a=-40^\circ C$ to $+105^\circ C$	-10	1	10	-	1	-	pA
			-100	-	100	-	-	-	
Input Offset Current	$I_{IO}$	$T_a=-40^\circ C$ to $+105^\circ C$	-10	1	10	-	1	-	pA
			-100	-	100	-	-	-	
Voltage Gain	$A_V$	$V_{out}=0.5V$ to $4.5V$ , $R_L=100k\Omega$ to $2.5V$	70	100	-	70	100	-	dB
		$T_a=-40^\circ C$ to $+105^\circ C$	70	100	-	-	-	-	
Common-Mode Rejection Ratio	CMR	$V_{CM}=0V$ to $5V$	60	80	-	60	80	-	dB
		$T_a=-40^\circ C$ to $+105^\circ C$	60	80	-	-	-	-	
Supply Voltage Rejection Ratio	SVR	$V^+=1.5V$ to $5.5V$ , $V_{CM}=0V$	70	90	-	70	90	-	dB
		$T_a=-40^\circ C$ to $+105^\circ C$	70	90	-	-	-	-	
Maximum Output Voltage	$V_{OH}$	$R_L=100k\Omega$ to $2.5V$ $T_a=-40^\circ C$ to $+105^\circ C$	4.9	4.95	-	4.9	4.95	-	V
	$V_{OL}$	$R_L=100k\Omega$ to $2.5V$ $T_a=-40^\circ C$ to $+105^\circ C$	-	0.05	0.1	-	0.05	0.1	V
Common-Mode Input Voltage Range	$V_{ICM}$	CMR $\geq 60dB$	0	-	5	0	-	5	V
		$T_a=-40^\circ C$ to $+105^\circ C$	0	-	5	-	-	-	

### ● AC CHARACTERISTICS ( $V^+=5V$ , $V^-=0V$ , $V_{CM}=2.5V$ , $T_a=25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITION	NJU77000A NJU77001A			NJU77000 NJU77001			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Slew Rate	SR	$G_v=0dB$ , $R_L=100k\Omega$ to $2.5V$ , $C_L=20pF$ , $V_{IN}=1V_{pp}$	-	0.8	-	-	0.8	-	V/ms
unity-Gain Frequency	$f_T$	$R_L=100k\Omega$ to $2.5V$ , $C_L=20pF$ , $G_v=20dB$	-	1.1	-	-	1.1	-	kHz
Phase Margin	$\Phi_M$	$R_L=100k\Omega$ to $2.5V$ , $C_L=20pF$	-	60	-	-	60	-	deg
Gain Margin	$G_M$	$R_L=100k\Omega$ to $2.5V$ , $C_L=20pF$	-	30	-	-	30	-	dB
Equivalent Input Noise Voltage	$V_{NI}$	$f=100Hz$	-	600	-	-	600	-	nV/ $\sqrt{Hz}$

## ■ ELECTRICAL CHARACTERISTICS

### ● DC CHARACTERISTICS ( $V^+=1.8V$ , $V=0V$ , $V_{CM}=0.9V$ , $T_a=25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITION	NJU77000A NJU77001A			NJU77000 NJU77001			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Supply Current	$I_Q$	No Signal $T_a=-40^\circ C$ to $+105^\circ C$	-	0.26	0.36	-	0.26	0.46	$\mu A$
			-	-	0.36	-	-	-	
Input Offset Voltage	$V_{IO}$	$V_{CM}=0V$ $T_a=-40^\circ C$ to $+105^\circ C$	-	0.35	1	-	0.35	1.8	mV
			-	0.35	1.2	-	-	-	
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	$V_{CM}=0V$ , $T_a=-40^\circ C$ to $+105^\circ C$	-	0.65	17	-	0.65	-	$\mu V/deg$
Input Bias Current	$I_B$	$T_a=-40^\circ C$ to $+105^\circ C$	-10	1	10	-	1	-	$pA$
			-100	-	100	-	-	-	
Input Offset Current	$I_{IO}$	$T_a=-40^\circ C$ to $+105^\circ C$	-10	1	10	-	1	-	$pA$
			-100	-	100	-	-	-	
Voltage Gain	$A_V$	$V_{out}=0.5V$ to $1.3V$ , $R_L=100k\Omega$ to $0.9V$ $T_a=-40^\circ C$ to $+105^\circ C$	70	100	-	70	100	-	dB
			70	100	-	-	-	-	
Common-Mode Rejection Ratio	CMR	$V_{CM}=0V$ to $1.8V$ $T_a=-40^\circ C$ to $+105^\circ C$	55	80	-	55	80	-	dB
			55	80	-	-	-	-	
Supply Voltage Rejection Ratio	SVR	$V^+=1.5V$ to $5.5V$ , $V_{CM}=0V$ $T_a=-40^\circ C$ to $+105^\circ C$	70	90	-	70	90	-	dB
			70	90	-	-	-	-	
Maximum Output Voltage	$V_{OH}$	$R_L=100k\Omega$ to $0.9V$ $T_a=-40^\circ C$ to $+105^\circ C$	1.7	1.75	-	1.7	1.75	-	V
	$V_{OL}$		-	0.05	0.1	-	0.05	0.1	V
Common-Mode Input Voltage Range	$V_{ICM}$	CMR $\geq 55$ dB $T_a=-40^\circ C$ to $+105^\circ C$	0	-	1.8	0	-	1.8	V
			0	-	1.8	-	-	-	

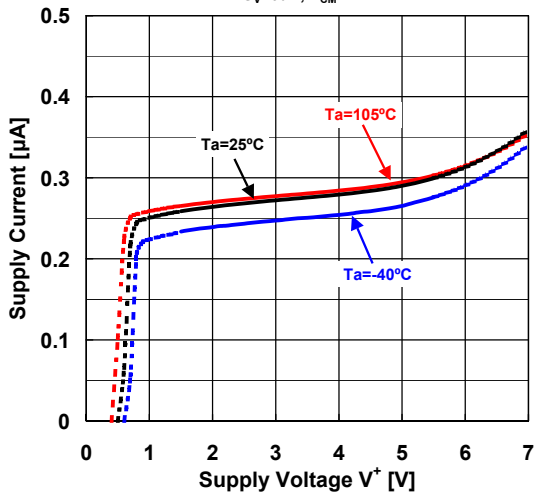
### ● AC CHARACTERISTICS ( $V^+=1.8V$ , $V=0V$ , $V_{CM}=0.9V$ , $T_a=25^\circ C$ , unless otherwise noted.)

PARAMETER	SYMBOL	TEST CONDITION	NJU77000A NJU77001A			NJU77000 NJU77001			UNIT
			MIN.	TYP.	MAX.	MIN.	TYP.	MAX.	
Slew Rate	SR	$G_v=0$ dB, $R_L=100k\Omega$ to $0.9V$ , $C_L=20$ pF, $V_{IN}=1$ Vpp	-	0.7	-	-	0.7	-	V/ms
Unity Gain Frequency	$f_T$	$R_L=100k\Omega$ to $0.9V$ , $C_L=20$ pF, $G_v=20$ dB	-	1.0	-	-	1.0	-	kHz
Phase Margin	$\Phi_M$	$R_L=100k\Omega$ to $0.9V$ , $C_L=20$ pF	-	60	-	-	60	-	deg
Gain Margin	$G_M$	$R_L=100k\Omega$ to $0.9V$ , $C_L=20$ pF	-	30	-	-	30	-	dB
Equivalent Input Noise Voltage	$V_{NI}$	$f=100$ Hz	-	700	-	-	700	-	nV/ $\sqrt{Hz}$

## ■ TYPICAL CHARACTERISTICS

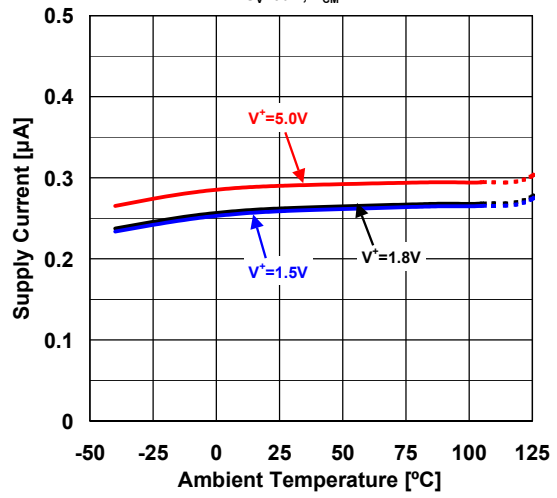
Supply Current vs. Supply Voltage

$G_V=0\text{dB}$ ,  $V_{CM}=V^*/2$



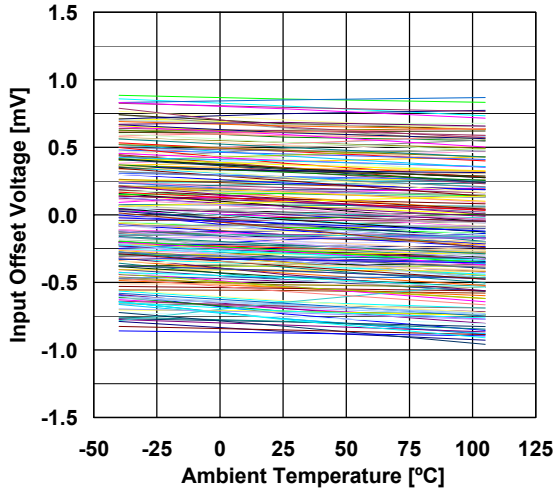
Supply Current vs. Temperature

$G_V=0\text{dB}$ ,  $V_{CM}=V^*/2$



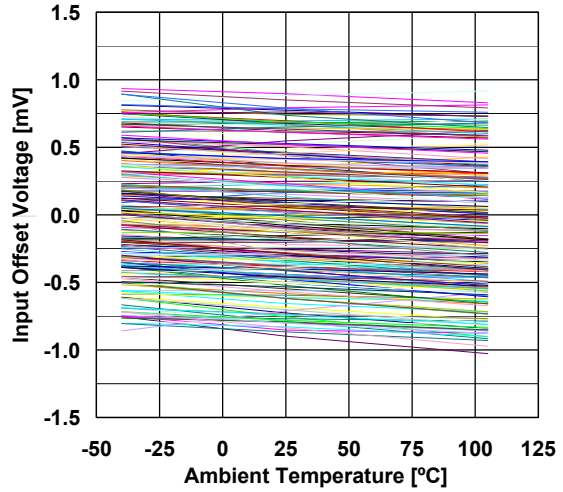
Input Offset Voltage vs. Temperature

$V^*=5.0\text{V}$ ,  $V_{CM}=0\text{V}$ ,  $n=200$



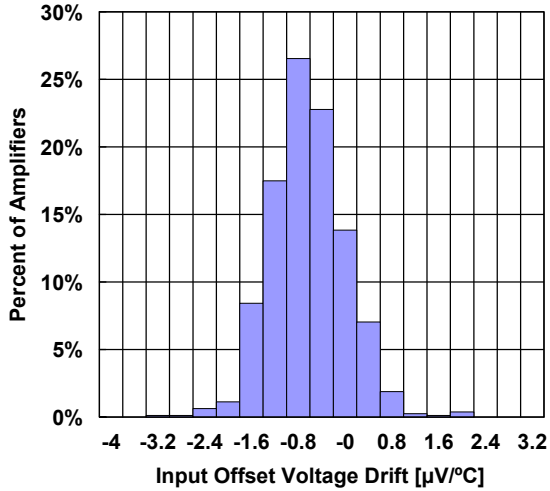
Input Offset Voltage vs. Temperature

$V^*=1.8\text{V}$ ,  $V_{CM}=0\text{V}$ ,  $n=200$



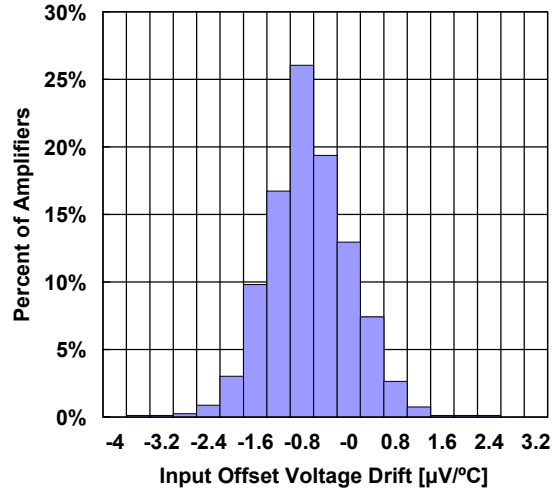
Input Offset Voltage Drift Distribution

$V^*=5.0\text{V}$ ,  $V_{CM}=0\text{V}$ ,  $n=800$



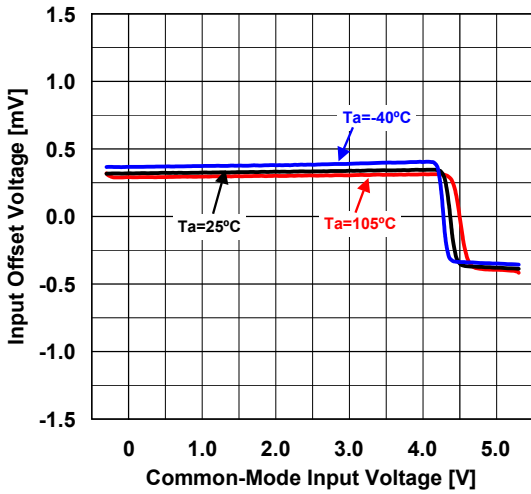
Input Offset Voltage Drift Distribution

$V^*=1.8\text{V}$ ,  $V_{CM}=0\text{V}$ ,  $n=800$

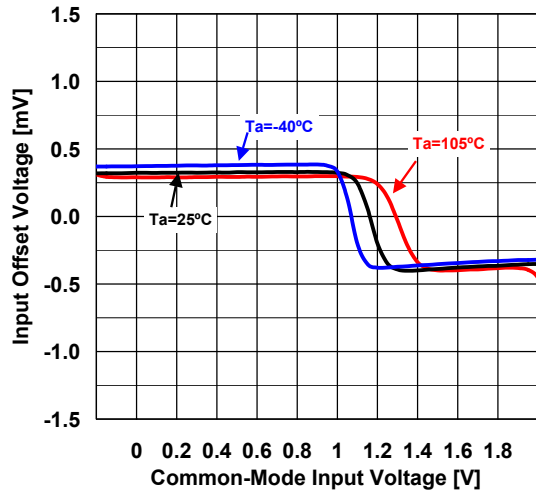


■ TYPICAL CHARACTERISTICS

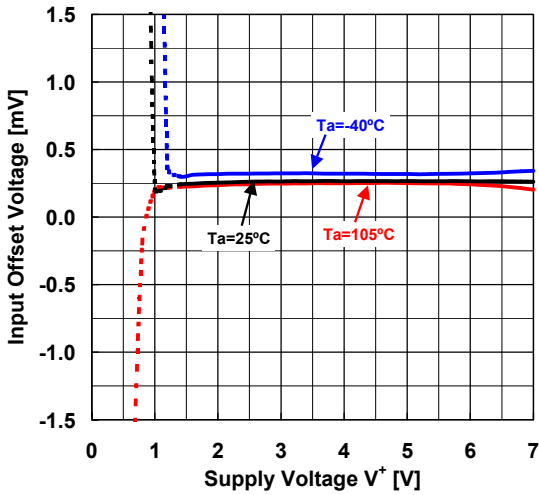
Input Offset Voltage vs. Common-Mode Input Voltage  
 $V^+ = 5.0V$



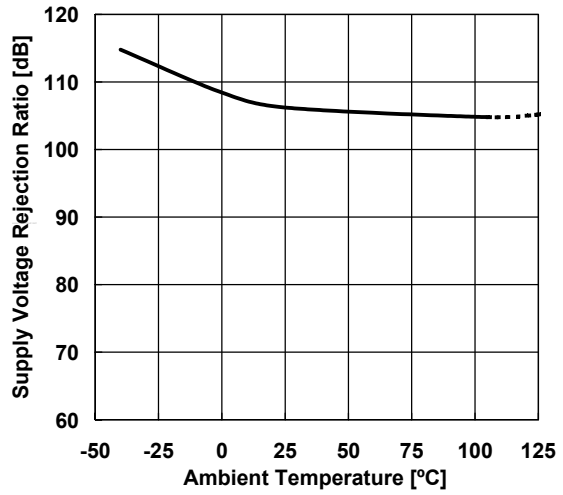
Input Offset Voltage vs. Common-Mode Input Voltage  
 $V^+ = 1.8V$



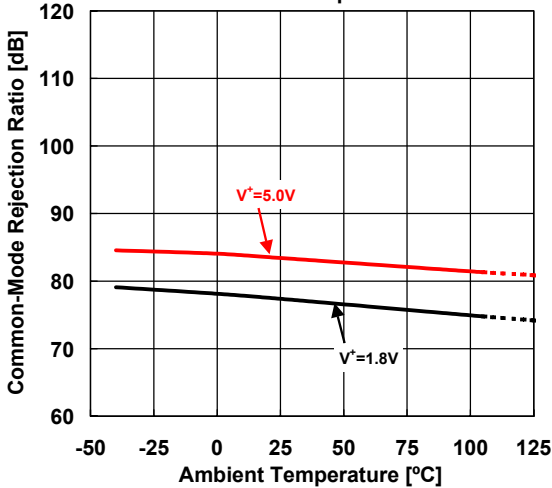
Input Offset Voltage vs. Supply Voltage  
 $V_{CM} = 0V$



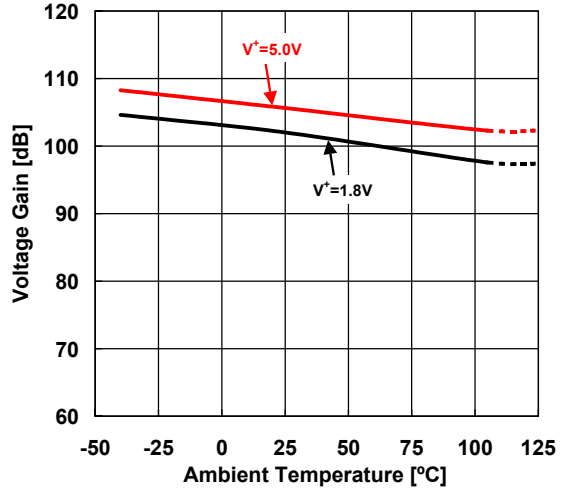
SVR vs. Temperature  
 $V_{CM} = 0V$



CMR vs. Temperature

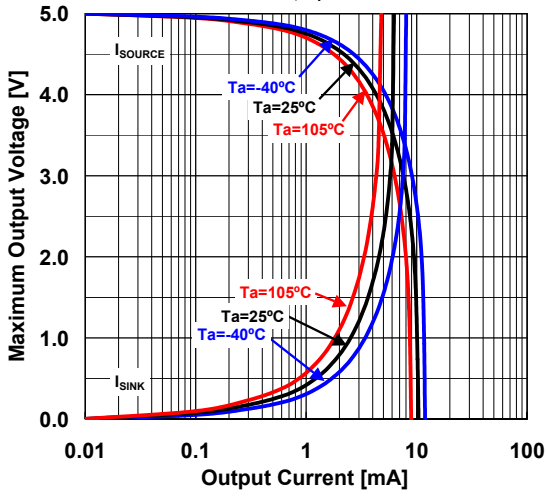


Voltage Gain vs. Temperature  
 $V_{CM} = V^+/2, R_L = 100k\Omega \text{ to } V^+/2$

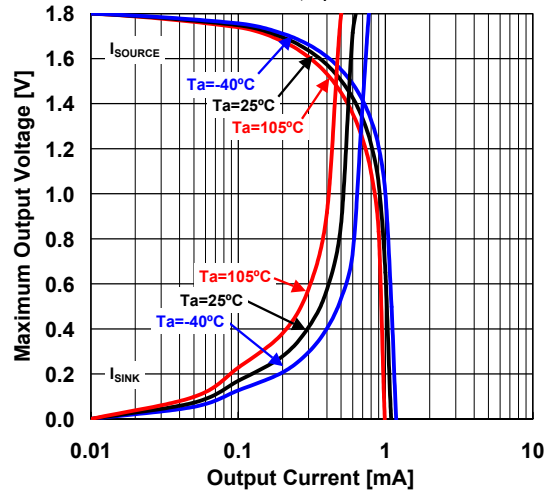


## ■ TYPICAL CHARACTERISTICS

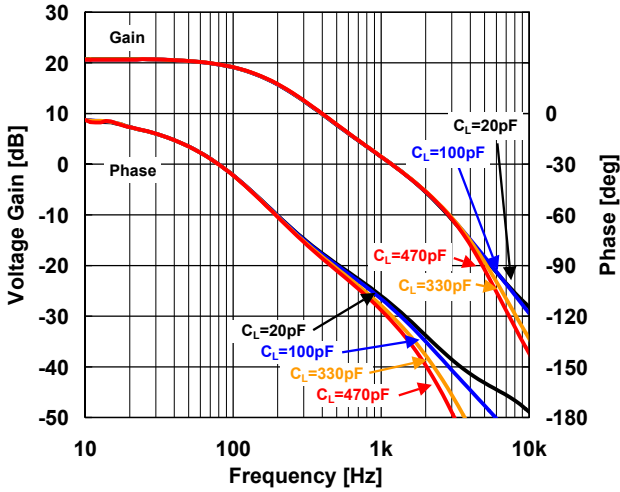
Maximum Output Voltage vs. Output Current  
 $V^+=5.0V, G_V=OPEN$



Maximum Output Voltage vs. Output Current  
 $V^+=1.8V, G_V=OPEN$

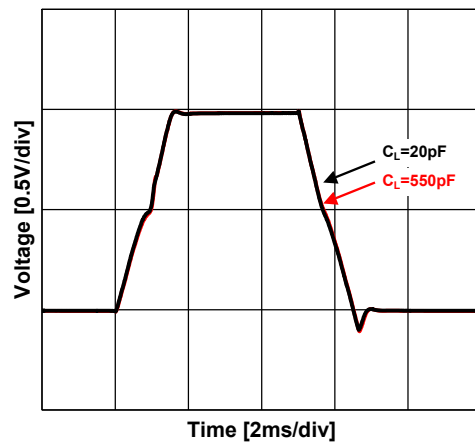


Voltage Gain/Phase vs. Frequency  
 $V^+=5.0V, G_V=20dB, T_a=25^\circ C$

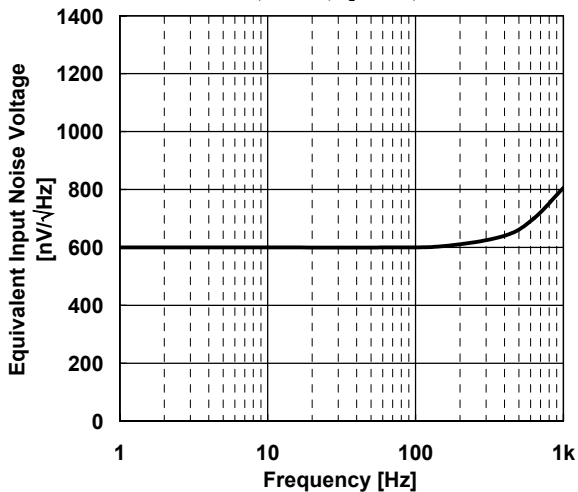


Pulse Response

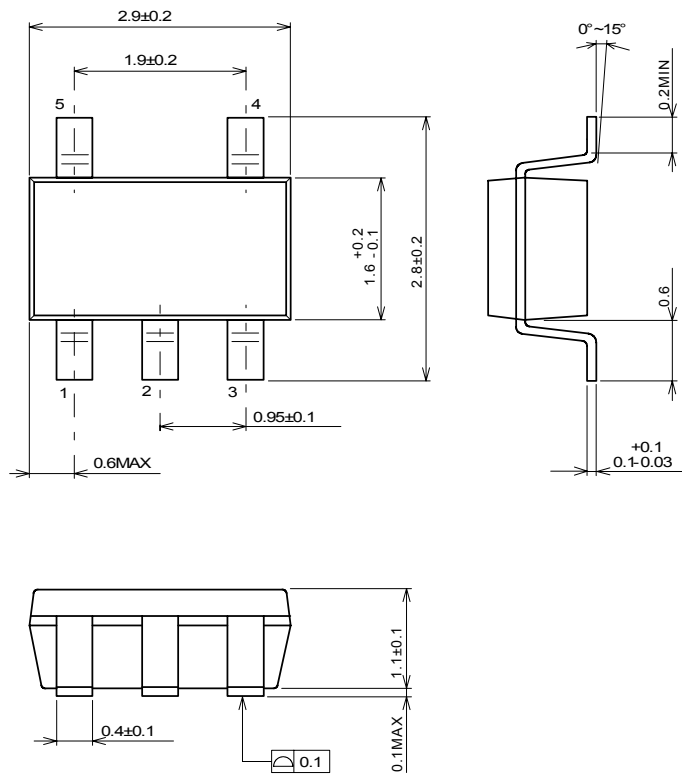
$V^+=5.0V, G_V=0dB, R_L=100k\Omega \text{ to } 2.5V, T_a=25^\circ C$



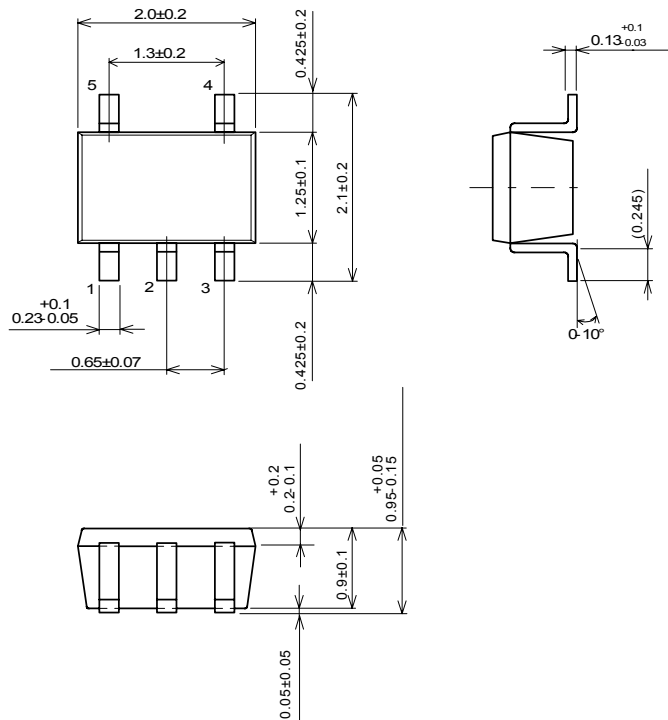
Voltage Noise vs. Frequency  
 $V^+=5.0V, G_V=0dB, R_L=100k\Omega, T_a=25^\circ C$



## ■ PACKAGE DIMENSIONS



**SOT-23-5 Package**



**SC-88A Package**

**[CAUTION]**  
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