

## Low Noise, Rail-to-Rail Output Single CMOS Operational Amplifier

### ■ GENERAL DESCRIPTION

The NJU7009 is a CMOS operational amplifier that feature low noise as  $13\text{nV}/\sqrt{\text{Hz}}$  typ. @  $f=1\text{kHz}$ , low operating voltage.

FET input devices provide very low input bias current and suitable for applications uses current signal such as accelerometers, shock sensors and photodiode amplifiers.

### ■ PACKAGE OUTLINE



NJU7009F3

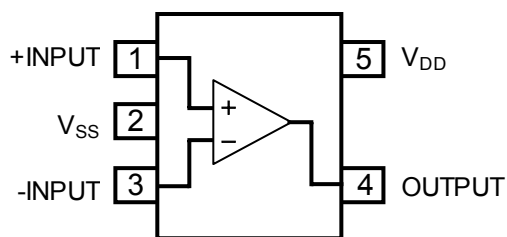
### ■ FEATURES

- |                                |   |
|--------------------------------|---|
| ● Input-Referred Voltage Noise | $13\text{nV}/\sqrt{\text{Hz}}$ Typ. @ $f=1\text{kHz}$<br>$3\mu\text{V}_{\text{rms}}$ max. @ $f=100\text{Hz}\sim 20\text{kHz}$ |
| ● Input Bias Current           | $1\text{pA}$ Typ. @ $T_a=25^\circ\text{C}$  |
| ● Unity Gain Band Width        | $f_T=3\text{MHz}$ Typ.  |
| ● Slew Rate                    | $1\text{V}/\mu\text{s}$ Typ. @ $R_L=50\text{k}\Omega$   |
| ● Rail-to-Rail Output          |   |
| ● Operating Voltage            | 2.2V to 5.5V  |
| ● CMOS Technology              |   |
| ● Small Package                | SC88A [F3 Type] (SC70-5)  |

### ■ Application

- Shock sensors, Accelerometers
- Charge amplifiers
- Photodiode amplifiers
- Low noise signal processing applications
- Microphone amplifiers

### ■ PIN CONFIGURATION



SC88A [Top View]

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

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V <sub>DD</sub>	7	V
Common Mode Input Voltage Range	V <sub>ICM</sub>	-0.3 to 7 (Note 1)	V
Differential Input Voltage Range	V <sub>ID</sub>	±7 (Note 1)	V
Power Dissipation	P <sub>D</sub>	280 [SC88A] (Note 2)	mW
Operating Temperature Range	T <sub>opr</sub>	-40 to +85	°C
Storage Temperature Range	T <sub>stg</sub>	-55 to +125	°C

(Note 1) For supply voltage less than 7V, the absolute maximum input voltage is equal to the supply voltage.

(Note 2) On the PCB " EIA/JEDEC (76.2x114.3x1.6mm, two layers, FR-4) "

## ■ OPERATING VOLTAGE (Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V <sub>DD</sub>	2.2 to 5.5	V

## ■ ELECTRICAL CHARACTERISTICS

### ●DC CHARACTERISTICS (V<sub>DD</sub>=5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I <sub>DD</sub>	No Signal Apply	-	450	600	μA
Input Offset Voltage	V <sub>IO</sub>		-	2	5	mV
Input Offset Voltage Drift	ΔV <sub>io</sub> /ΔT	V <sub>IN</sub> =V <sub>DD</sub> /2 Ta=-40°C~+85°C	-	2	-	μV/deg
Input Bias Current	I <sub>B</sub>		-	1	-	pA
Input Offset Current	I <sub>IO</sub>		-	1	-	pA
Large Signal Voltage Gain	A <sub>v</sub>	R <sub>L</sub> =50kΩ to 2.5V, V <sub>O</sub> =2.5V±2V	65	80	-	dB
Common Mode Rejection Ratio1	CMR1	V <sub>ICM</sub> =0V~4.1V	65	80	-	dB
Common Mode Rejection Ratio2	CMR2	V <sub>ICM</sub> =0V~0.2V	60	80	-	dB
Supply Voltage Rejection Ratio	SVR	2.2V ≤ V <sub>DD</sub> ≤ 5.5V	65	80	-	dB
Output Voltage1	V <sub>OH1</sub>	R <sub>L</sub> =50kΩ to 2.5V	4.9	-	-	V
	V <sub>OL1</sub>	R <sub>L</sub> =50kΩ to 2.5V	-	-	0.1	V
Output Voltage2	V <sub>OH2</sub>	R <sub>L</sub> =10kΩ to 2.5V	4.5	-	-	V
	V <sub>OL2</sub>	R <sub>L</sub> =10kΩ to 2.5V	-	-	0.2	V
Input Common Mode Voltage Range	V <sub>ICM</sub>	CMR ≥ 65dB	0	-	4.1	V

### ●AC CHARACTERISTICS (V<sub>DD</sub>=5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Frequency	f <sub>T</sub>	G <sub>v</sub> =40dB, C <sub>L</sub> =10pF, R <sub>L</sub> =50kΩ to 2.5V	-	3	-	MHz
Equivalent Input Noise Voltage	V <sub>NI</sub>	f=1kHz, G <sub>v</sub> =40dB, R <sub>L</sub> =50kΩ to 2.5V	-	13	-	nV/√Hz
	V <sub>NIrms</sub>	R <sub>L</sub> =50kΩ to 2.5V, G <sub>v</sub> =40dB, BPW=100Hz ~ 20kHz	-	1.7	3	μVrms
Total Harmonic Distortion	THD	G <sub>v</sub> =20dB, R <sub>L</sub> =50kΩ to 2.5V, fin=1kHz, Vout=3Vpp, BPW=400Hz ~ 80kHz	-	0.01	-	%

### ●TRANSIENT CHARACTERISTICS (V<sub>DD</sub>=5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	G <sub>v</sub> =0dB, C <sub>L</sub> =15pF, R <sub>T</sub> =50Ω to 2.5V, R <sub>L</sub> =50kΩ to 2.5V	-	1	-	V/μs

## ■ ELECTRICAL CHARACTERISTICS

### ●DC CHARACTERISTICS ( $V_{DD}=3V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	$I_{DD}$	No Signal Apply	-	330	500	$\mu A$
Input Offset Voltage	$V_{IO}$		-	2	5	mV
Input Offset Voltage Drift	$\Delta V_{IO}/\Delta T$	$V_{IN}=V_{DD}/2$ $T_a=-40^\circ C \sim +85^\circ C$	-	2	-	$\mu V/deg$
Input Bias Current	$I_B$		-	1	-	pA
Input Offset Current	$I_{IO}$		-	1	-	pA
Large Signal Voltage Gain	$A_V$	$R_L=50k\Omega$ to 1.5V, $V_O=1.5V \pm 1V$	65	80	-	dB
Common Mode Rejection Ratio1	CMR1	$V_{ICM}=0V \sim 2.1V$	65	80	-	dB
Common Mode Rejection Ratio2	CMR2	$V_{ICM}=0V \sim 0.2V$	60	80	-	dB
Supply Voltage Rejection Ratio	SVR	$2.2V \leq V_{DD} \leq 5.5V$	65	80	-	dB
Output Voltage1	$V_{OH1}$	$R_L=50k\Omega$ to 1.5V	2.9	-	-	V
	$V_{OL1}$	$R_L=50k\Omega$ to 1.5V	-	-	0.1	V
Input Common Mode Voltage Range	$V_{ICM}$	CMR $\geq 65dB$	0	-	2.1	V

### ●AC CHARACTERISTICS ( $V_{DD}=3V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Frequency	$f_T$	$G_V=40dB$ , $C_L=10pF$ , $R_L=50k\Omega$ to 1.5V	-	3	-	MHz
Equivalent Input Noise Voltage	$V_{NI}$	$f=1kHz$ , $G_V=40dB$ , $R_L=50k\Omega$ to 1.5V	-	13	-	$nV/\sqrt{Hz}$
	$V_{NIrms}$	$R_L=50k\Omega$ to 1.5V, $G_V=40dB$ , BPW=100Hz ~ 20kHz	-	1.7	3.0	$\mu Vrms$
Total Harmonic Distortion	THD	$G_V=20dB$ , $R_L=50k\Omega$ to 1.5V, $f_{in}=1kHz$ , $V_{out}=1V_{pp}$ , BPW=40Hz ~ 80kHz	-	0.02	-	%

### ●TRANSIENT CHARACTERISTICS ( $V_{DD}=3V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	$G_V=0dB$ , $C_L=15pF$ , $R_T=50\Omega$ to 1.5V, $R_L=50k\Omega$ to 1.5V	-	1	-	$V/\mu s$

## ■ ELECTRICAL CHARACTERISTICS

### ●DC CHARACTERISTICS ( $V_{DD}=2.2V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	$I_{DD}$	No Signal Apply	-	300	470	$\mu A$
Input Offset Voltage	$V_{IO}$		-	2	5	mV
Input Offset Voltage Drift	$\Delta V_{io}/\Delta T$	$V_{IN}=V_{DD}/2$ $T_a=-40^\circ C \sim +85^\circ C$	-	2	-	$\mu V/deg$
Input Bias Current	$I_B$		-	1	-	pA
Input Offset Current	$I_{IO}$		-	1	-	pA
Large Signal Voltage Gain	$A_V$	$R_L=50k\Omega$ to 1.1V, $V_O=1.1V \pm 0.5V$	60	80	-	dB
Common Mode Rejection Ratio1	CMR1	$V_{ICM}=0V \sim 1.3V$	60	80	-	dB
Common Mode Rejection Ratio2	CMR2	$V_{ICM}=0V \sim 0.2V$	60	80	-	dB
Supply Voltage Rejection Ratio	SVR	$2.2V \leq V_{DD} \leq 5.5V$	65	80	-	dB
Output Voltage1	$V_{OH1}$	$R_L=50k\Omega$ to 1.1V	2.1	-	-	V
	$V_{OL1}$	$R_L=50k\Omega$ to 1.1V	-	-	0.1	V
Input Common Mode Voltage Range	$V_{ICM}$	CMR $\geq 60$ dB	0	-	1.3	V

### ●AC CHARACTERISTICS ( $V_{DD}=2.2V$ , $T_a=25^\circ C$ )

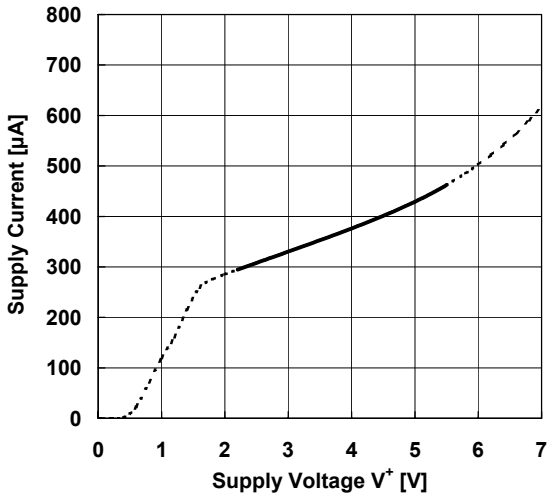
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Frequency	$f_T$	$G_V=40$ dB, $C_L=10$ pF, $R_L=50k\Omega$ to 1.1V	-	3	-	MHz
Equivalent Input Noise Voltage	$V_{NI}$	$f=1$ kHz, $G_V=40$ dB, $R_L=50k\Omega$ to 1.1V	-	13	-	$nV/\sqrt{Hz}$
	$V_{NIrms}$	$R_L=50k\Omega$ to 1.1V, $G_V=40$ dB, BPW=100Hz ~ 20kHz	-	1.7	3.0	$\mu Vrms$
Total Harmonic Distortion	THD	$G_V=20$ dB, $R_L=50k\Omega$ to 1.1V, $f_{in}=1$ kHz, $V_{out}=0.5V_{pp}$ , BPW=400Hz ~ 80kHz	-	0.02	-	%

### ●TRANSIENT CHARACTERISTICS ( $V_{DD}=2.2V$ , $T_a=25^\circ C$ )

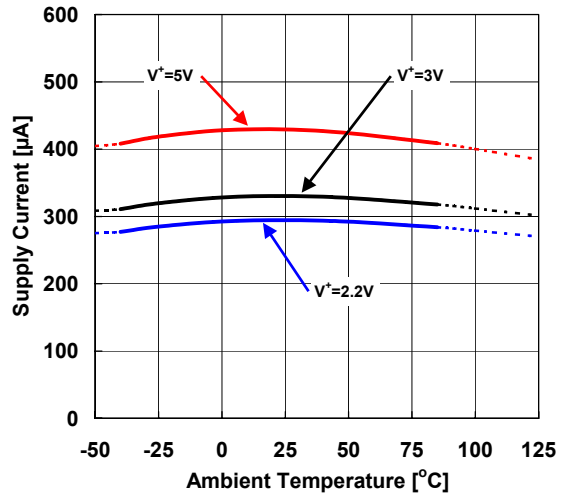
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	$G_V=0$ dB, $C_L=15$ pF, $R_T=50\Omega$ to 1.1V, $R_L=50k\Omega$ to 1.1V	-	1	-	V/ $\mu s$

## ■ TYPICAL CHARACTERISTICS

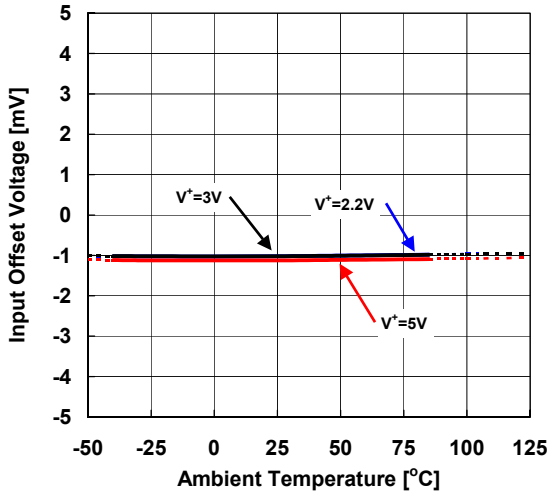
**Supply Current vs. Supply Voltage**  
No Signal,  $T_a=25^\circ\text{C}$



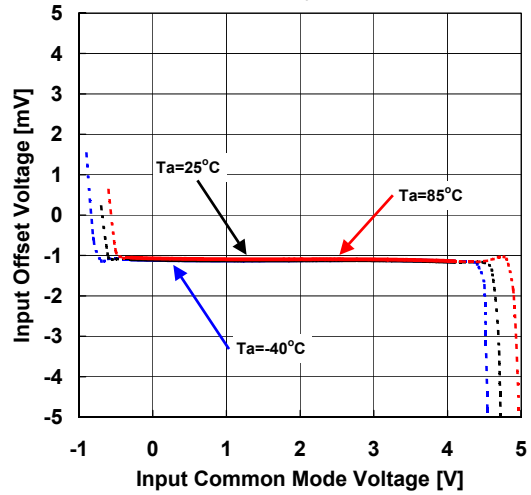
**Supply Current vs. Ambient Temperature**  
(Supply Voltage)  
No Signal



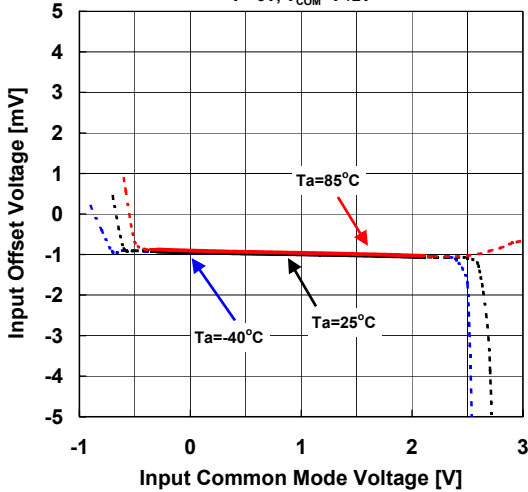
**Input Offset Voltage vs. Ambient Temperature**  
(Supply Voltage)  
 $V_{ICM}=V^+/2V, V_{COM}=V^+/2V$



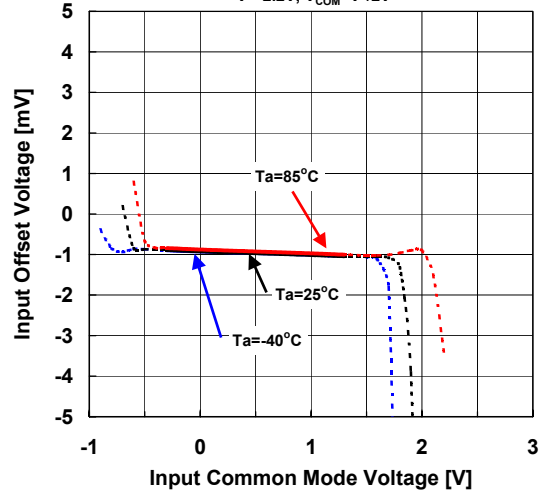
**Input Offset Voltage vs. Input Common Mode Voltage**  
(Ambient Temperature)  
 $V^+=5V, V_{COM}=V^+/2V$



**Input Offset Voltage vs. Input Common Mode Voltage**  
(Ambient Temperature)  
 $V^+=3V, V_{COM}=V^+/2V$

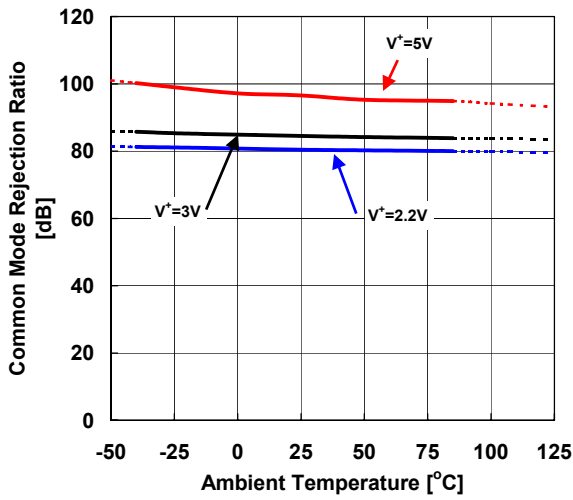


**Input Offset Voltage vs. Input Common Mode Voltage**  
(Ambient Temperature)  
 $V^+=2.2V, V_{COM}=V^+/2V$

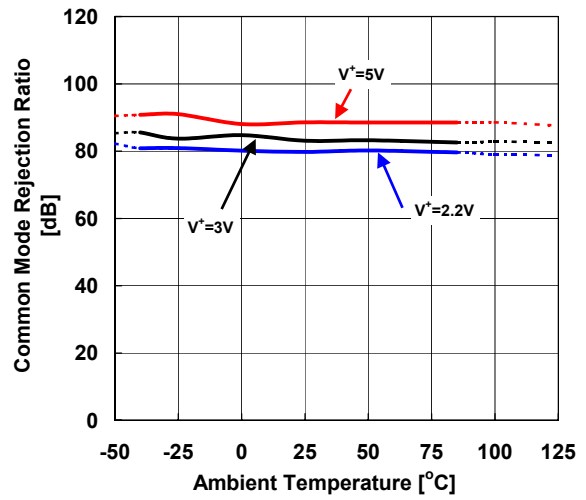


## ■ TYPICAL CHARACTERISTICS

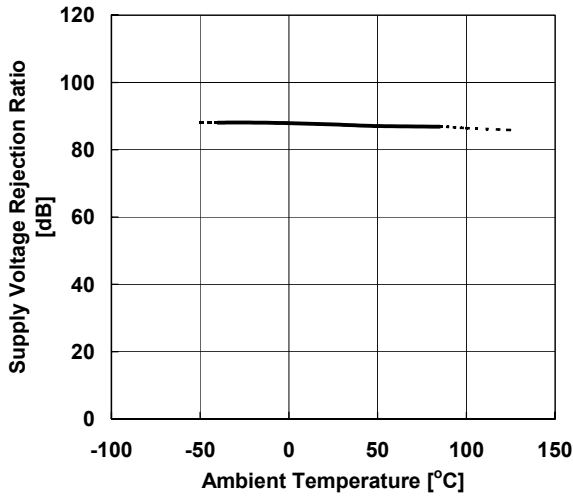
**Common Mode Rejection Ratio1 vs. Ambient Temperature**  
 $V_{ICM}=0V$  to  $V^*-0.9V$ ,  $V_{COM}=V^*/2V$



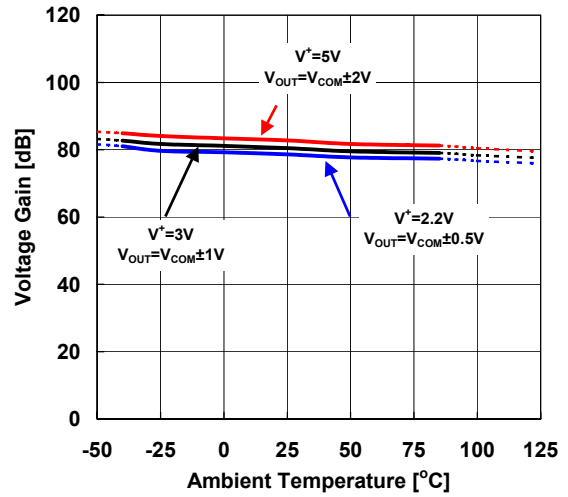
**Common Mode Rejection Ratio2 vs. Ambient Temperature**  
 $V_{ICM}=0V$  to  $0.2V$ ,  $V_{COM}=V^*/2V$



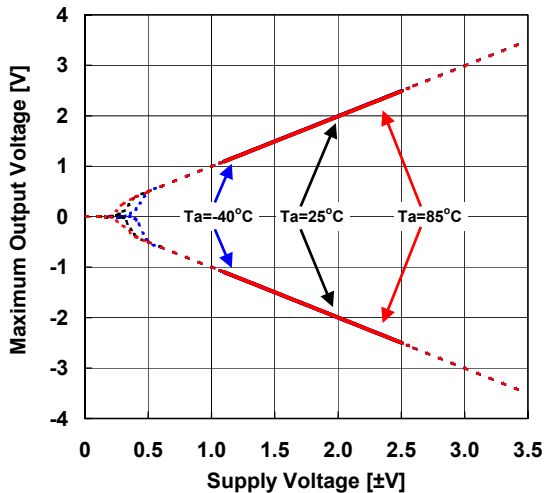
**Supply Voltage Rejection Ratio vs. Ambient Temperature**  
 $V^*=2.2V$  to  $5.5V$ ,  $V_{ICM}=V^*/2$ ,  $V_{COM}=V^*/2V$



**Voltage Gain vs. Ambient Temperature**  
 $V_{COM}=V^*/2V$ ,  $R_L=50k\Omega$  to  $V_{COM}$

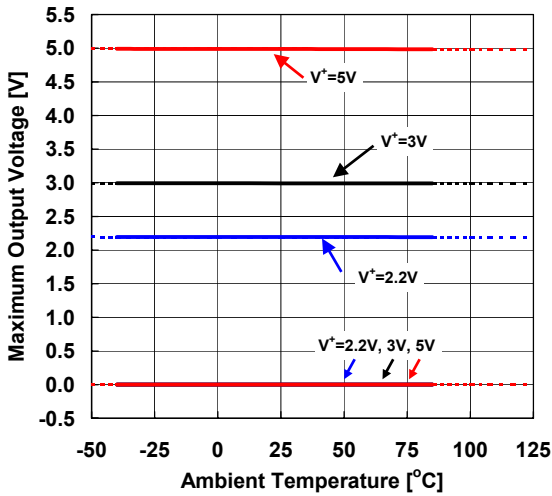


**Maximum Output Voltage vs. Supply Voltage**  
 (Ambient Temperature)  
 $V_{IN}=\pm 0.5V$ ,  $V_{COM}=0V$ ,  $R_L=50k\Omega$

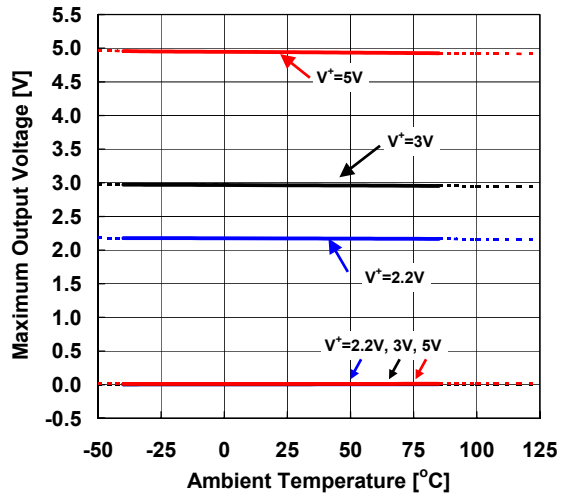


## ■ TYPICAL CHARACTERISTICS

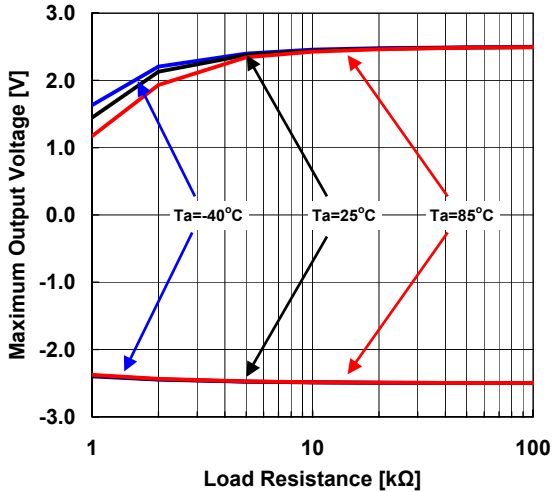
Maximum Output Voltage vs. Ambient Temperature  
 $R_L=50k\Omega$  to  $V_{COM}$



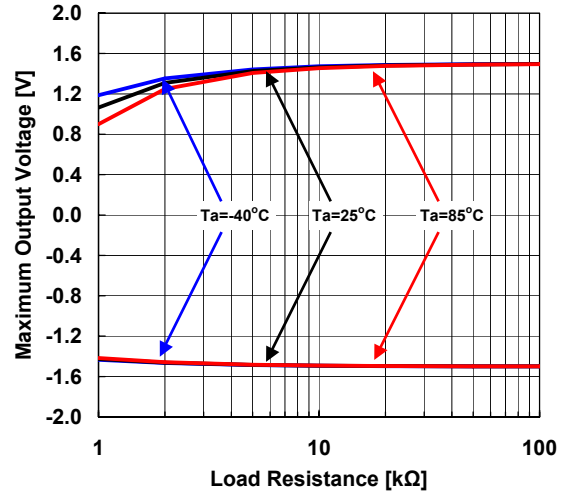
Maximum Output Voltage vs. Ambient Temperature  
 $R_L=10k\Omega$  to  $V_{COM}$



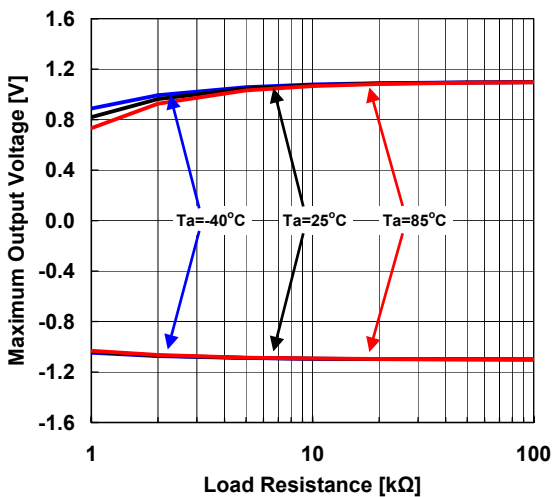
Maximum Output Voltage vs. Load Resistance  
 (Ambient Temperature)  
 $V^*/V=\pm 2.5V, V_{IN}^+=\pm 0.1V, V_{IN}^-=0V, V_{COM}=0V$



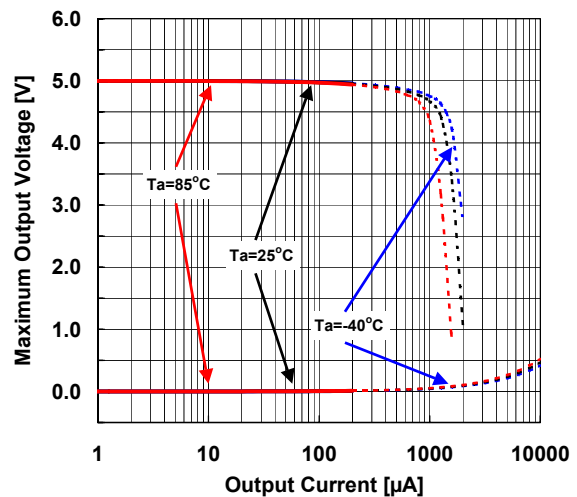
Maximum Output Voltage vs. Load Resistance  
 (Ambient Temperature)  
 $V^*/V=\pm 1.5V, V_{IN}^+=\pm 0.1V, V_{IN}^-=0V, V_{COM}=0V$



Maximum Output Voltage vs. Load Resistance  
 (Ambient Temperature)  
 $V^*/V=\pm 1.1V, V_{IN}^+=\pm 0.1V, V_{IN}^-=0V, V_{COM}=0V$

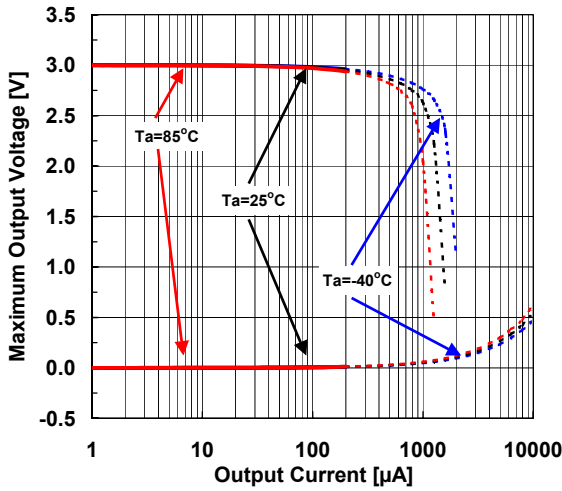


Maximum Output Voltage vs. Output Current  
 (Ambient Temperature)  
 $V^*=5V$

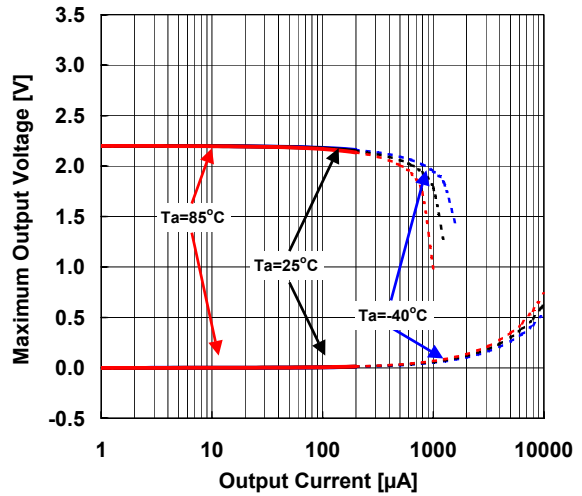


## ■ TYPICAL CHARACTERISTICS

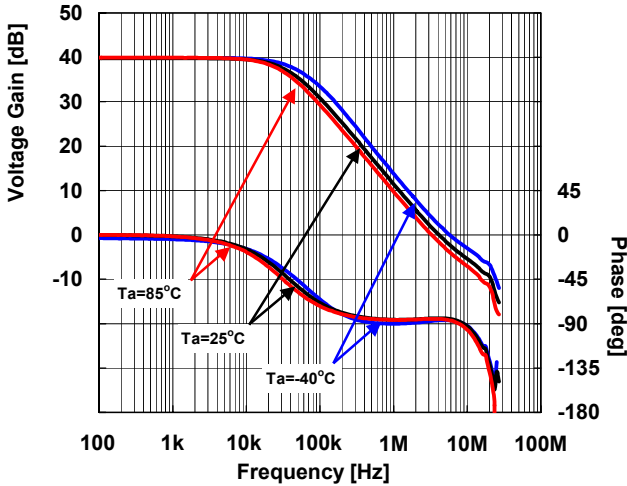
Maximum Output Voltage vs. Output Current  
(Ambient Temperature)  
 $V^+ = 3V$



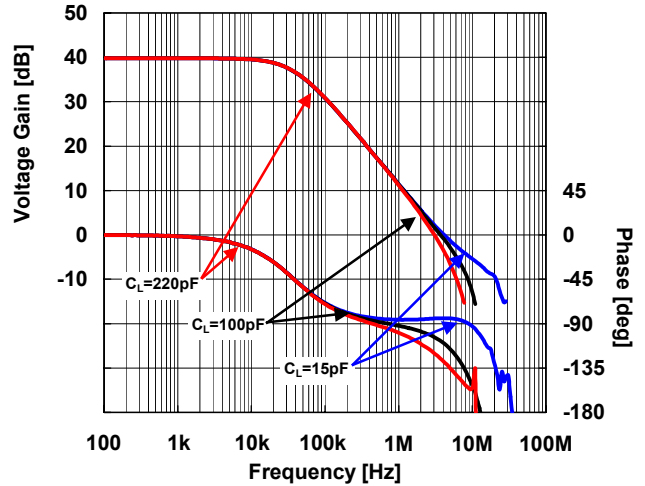
Maximum Output Voltage vs. Output Current  
(Ambient Temperature)  
 $V^+ = 2.2V$



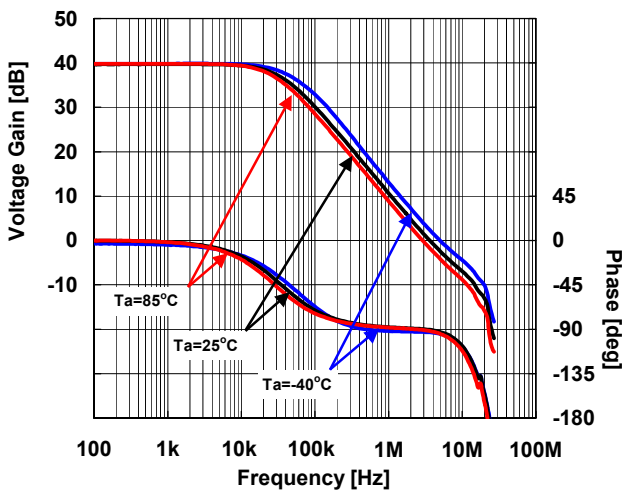
40dB Gain/Phase vs. Frequency (Temperature)  
 $V^+ = 5V, V_{COM} = V^+/2, G_V = 40dB, R_T = 50\Omega, R_L = 50k\Omega, C_L = 15pF$



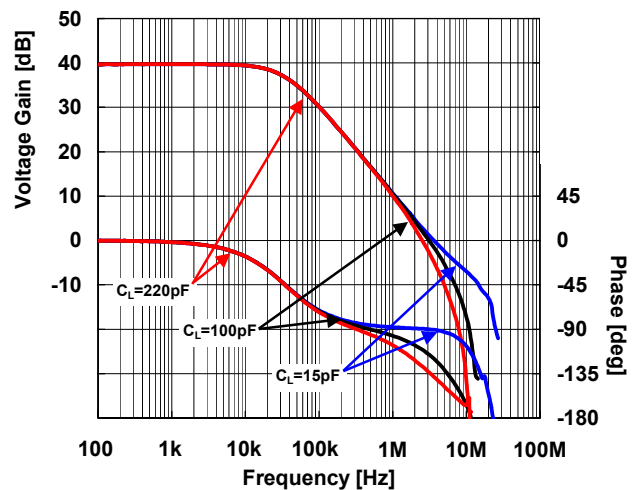
40dB Gain/Phase vs. Frequency (Load Capacitance)  
 $V^+ = 5V, V_{COM} = V^+/2, G_V = 40dB, R_S = 50\Omega, R_L = 50k\Omega, T_a = 25^\circ C$



40dB Gain/Phase vs. Frequency (Temperature)  
 $V^+ = 3V, V_{COM} = V^+/2, G_V = 40dB, R_T = 50\Omega, R_L = 50k\Omega, C_L = 15pF$



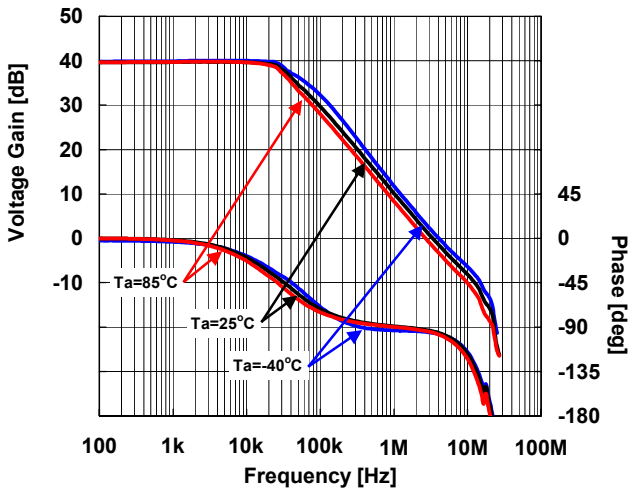
40dB Gain/Phase vs. Frequency (Load Capacitance)  
 $V^+ = 3V, V_{COM} = V^+/2, G_V = 40dB, R_S = 50\Omega, R_L = 50k\Omega, T_a = 25^\circ C$



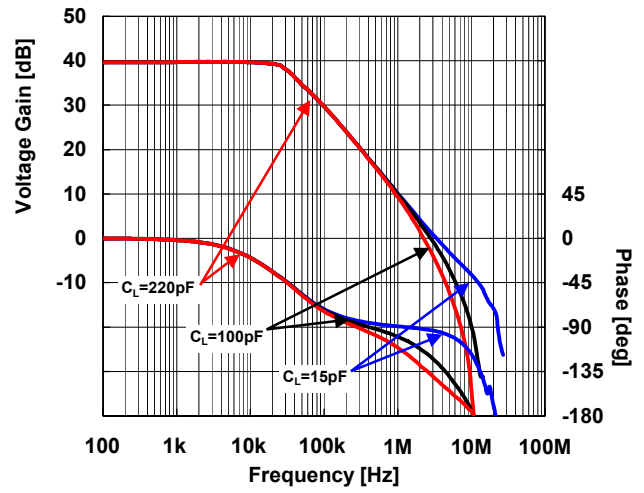


## ■ TYPICAL CHARACTERISTICS

**40dB Gain/Phase vs. Frequency (Temperature)**  
 $V^+ = 2.2V, V_{COM} = V^+/2, G_V = 40dB, R_T = 50\Omega, R_L = 50k\Omega, C_L = 15pF$

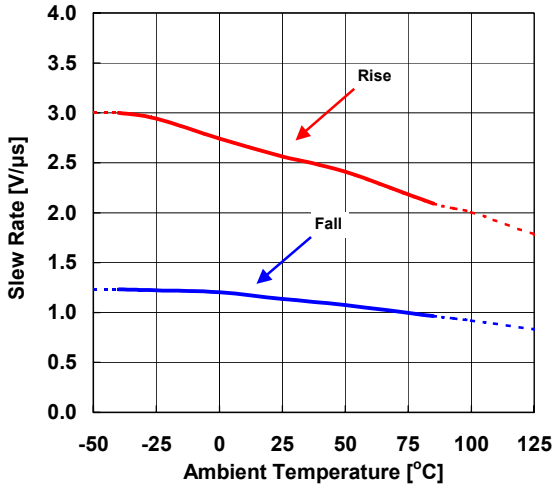


**40dB Gain/Phase vs. Frequency (Load Capacitance)**  
 $V^+ = 2.2V, V_{COM} = V^+/2, G_V = 40dB, R_S = 50\Omega, R_L = 50k\Omega, T_a = 25^\circ C$



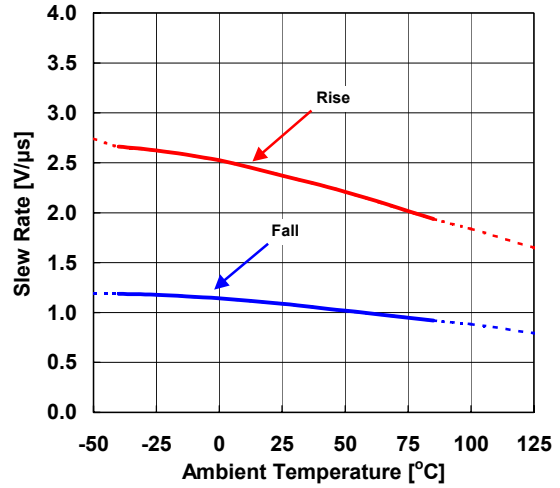
**Slew Rate vs. Ambient Temperature**

$V^+/V^- = \pm 2.5V, G_V = 0dB, R_T = 50\Omega, R_L = 50k\Omega, C_L = 15pF,$   
 $V_{IN} = 2V_{PP}, f_{IN} = 1kHz, V_{COM} = 0V$



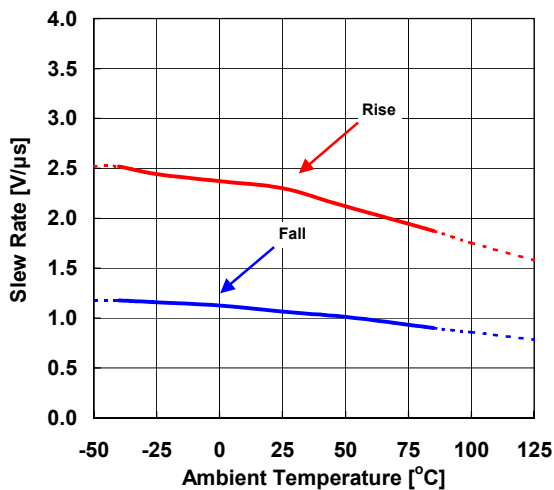
**Slew Rate vs. Ambient Temperature**

$V^+/V^- = \pm 1.5V, G_V = 0dB, R_T = 50\Omega, R_L = 50k\Omega, C_L = 15pF,$   
 $V_{IN} = 1V_{PP}, f_{IN} = 1kHz, V_{COM} = 0V$

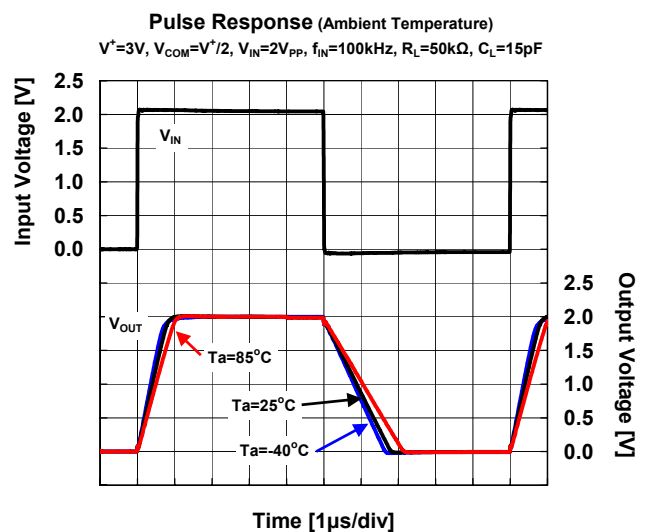
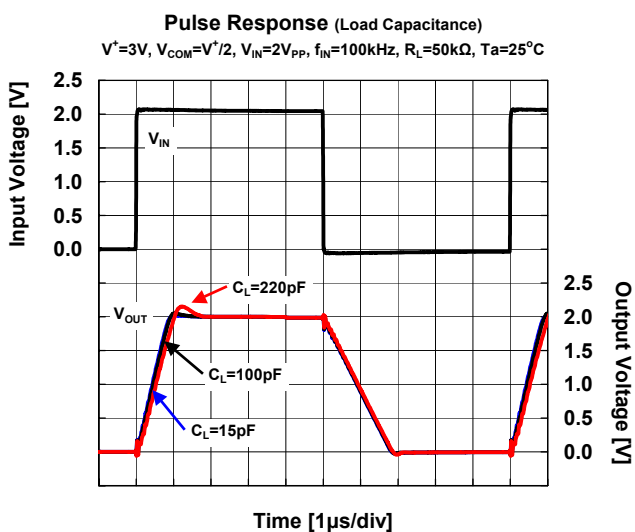
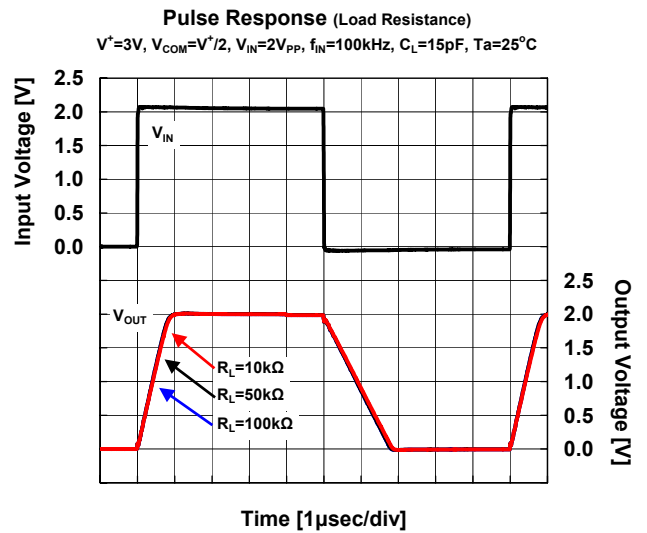
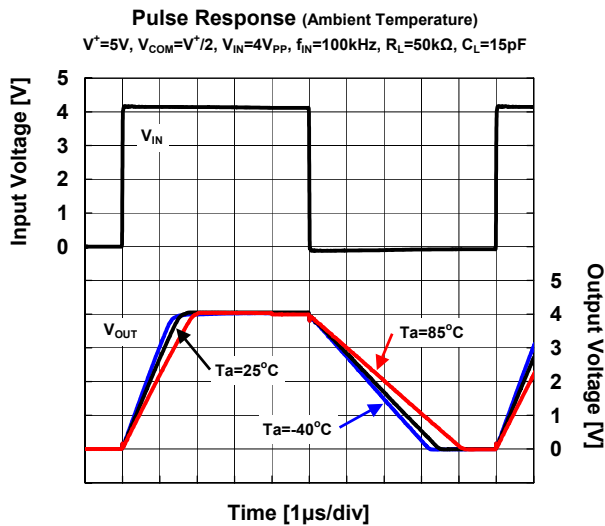
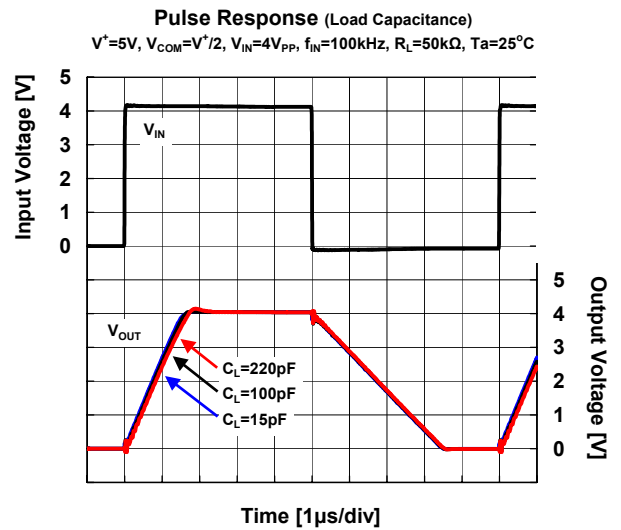
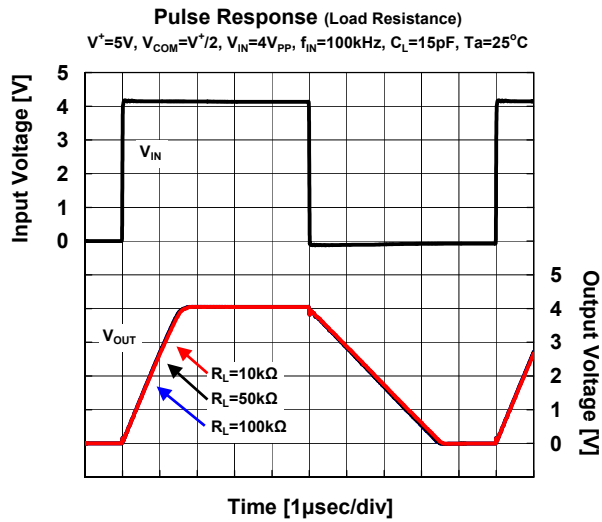


**Slew Rate vs. Ambient Temperature**

$V^+/V^- = \pm 1.1V, G_V = 0dB, R_T = 50\Omega, R_L = 50k\Omega, C_L = 15pF,$   
 $V_{IN} = 1V_{PP}, f_{IN} = 1kHz, V_{COM} = 0V$

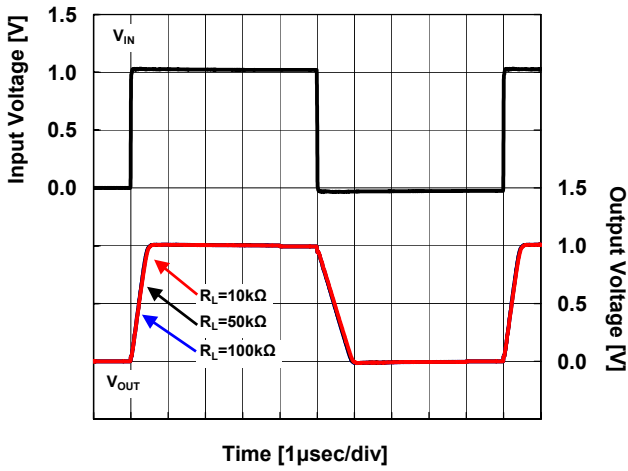


## ■ TYPICAL CHARACTERISTICS

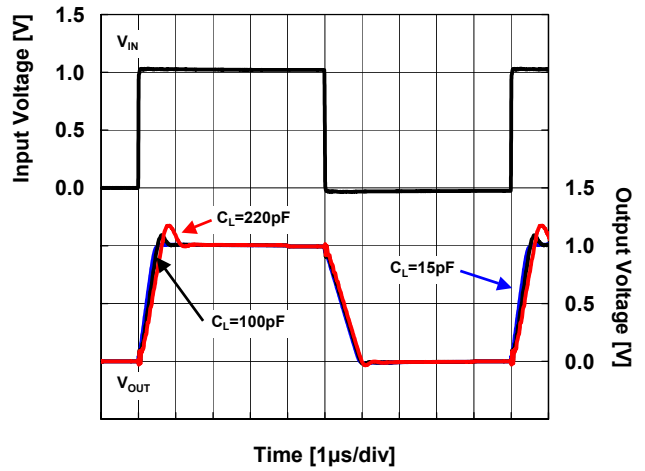


## ■ TYPICAL CHARACTERISTICS

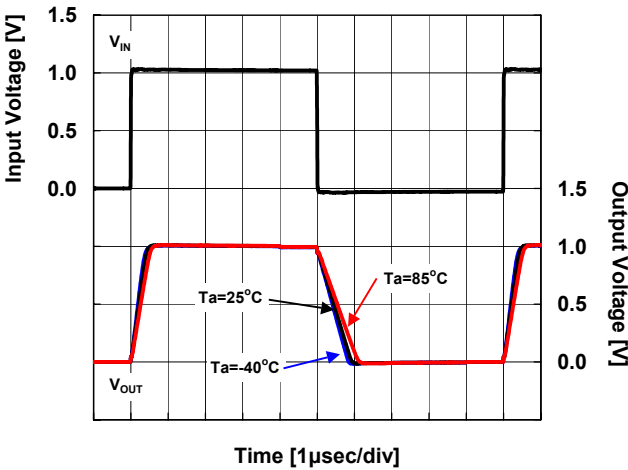
**Pulse Response (Load Resistance)**  
 $V^+ = 2.2V, V_{COM} = V^+/2, V_{IN} = 1V_{PP}, f_{IN} = 100kHz, C_L = 15pF, T_a = 25^\circ C$



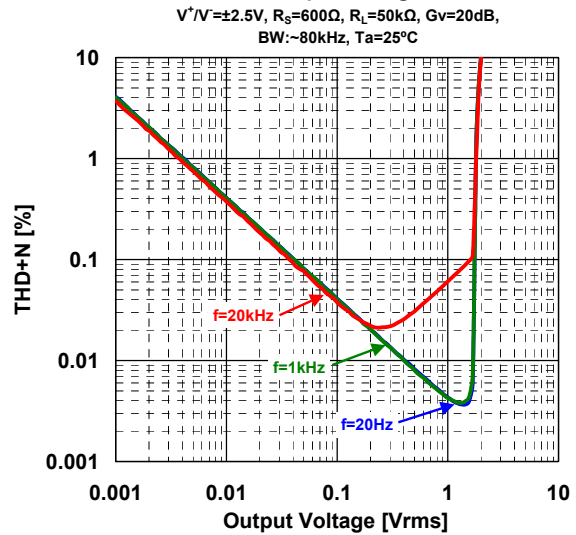
**Pulse Response (Load Capacitance)**  
 $V^+ = 2.2V, V_{COM} = V^+/2, V_{IN} = 1V_{PP}, f_{IN} = 100kHz, R_L = 50k\Omega, T_a = 25^\circ C$



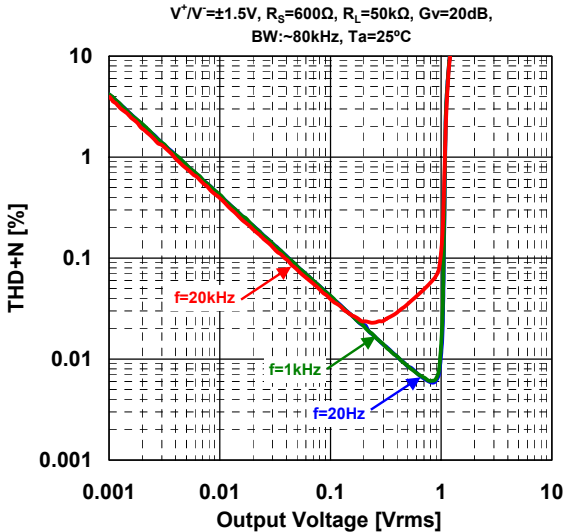
**Pulse Response (Ambient Temperature)**  
 $V^+ = 2.2V, V_{COM} = V^+/2, V_{IN} = 1V_{PP}, f_{IN} = 100kHz, R_L = 50k\Omega, C_L = 15pF$



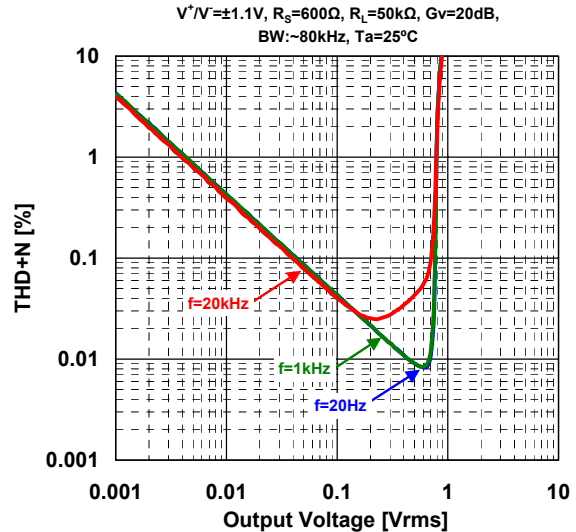
**THD+N vs. Output Voltage (Frequency)**



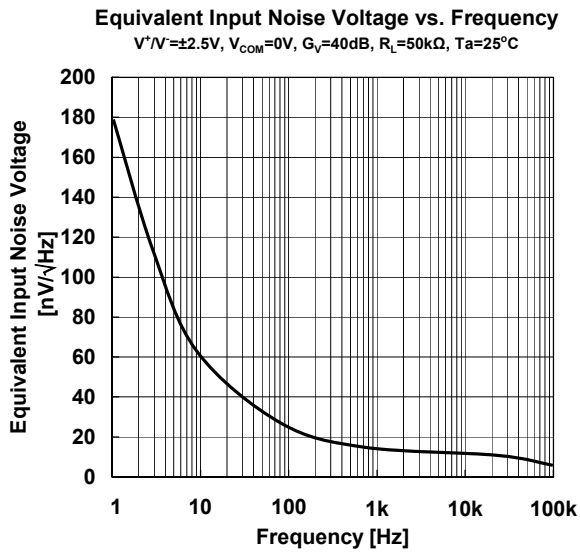
**THD+N vs. Output Voltage (Frequency)**



**THD+N vs. Output Voltage (Frequency)**



## ■ TYPICAL CHARACTERISTICS



[CAUTION]  
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