

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

■ GENERAL DESCRIPTION

The NJU7009 is a CMOS operational amplifier that feature low noise as 13nV/√Hz typ. @ f=1kHz, 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

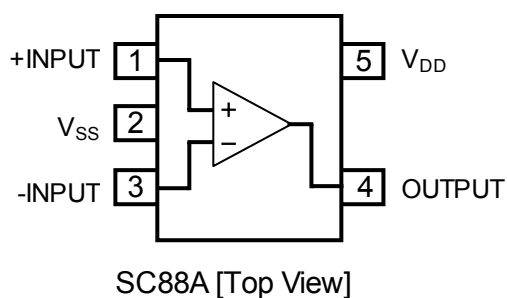
■ FEATURES

- | | |
|--------------------------------|-----------------------------------|
| ● Input-Referred Voltage Noise | 13nV/√Hz Typ. @ f=1kHz |
| ● Input Bias Current | 3μVrms max. @ f=100Hz~20kHz |
| ● Unity Gain Band Width | 1pA Typ. @ Ta=25°C |
| ● Slew Rate | f _T =3MHz Typ. |
| ● Rail-to-Rail Output | 1V/μs Typ. @ R _L =50kΩ |
| ● 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



■ ABSOLUTE MAXIMUM RATINGS (Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V _{DD}	7	V
Common Mode Input Voltage Range	V _{ICM}	-0.3 to 7 (Note 1)	V
Differential Input Voltage Range	V _{ID}	±7 (Note 1)	V
Power Dissipation	P _D	280 [SC88A] (Note 2)	mW
Operating Temperature Range	T _{opr}	-40 to +85	°C
Storage Temperature Range	T _{stg}	-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 _{DD}	2.2 to 5.5	V

■ ELECTRICAL CHARACTERISTICS

●DC CHARACTERISTICS (V_{DD}=5V, Ta=25°C)

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

●AC CHARACTERISTICS (V_{DD}=5V, Ta=25°C)

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

●TRANSIENT CHARACTERISTICS (V_{DD}=5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	G _V =0dB, C _L =15pF, R _T =50Ω to 2.5V, R _L =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	μA
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	μV_{rms}
Total Harmonic Distortion	THD	$G_V=20dB$, $R_L=50k\Omega$ to 1.5V, $f_{in}=1kHz$, $V_{out}=1V_{pp}$, BPW=400Hz ~ 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/ μs

■ 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	μA
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 $\geq 60dB$	0	-	1.3	V

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

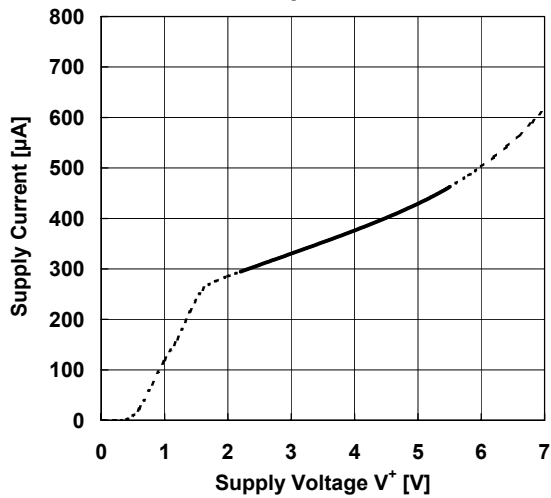
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Frequency	f_T	$G_V=40dB$, $C_L=10pF$, $R_L=50k\Omega$ to 1.1V	-	3	-	MHz
Equivalent Input Noise Voltage	V_{NI}	$f=1kHz$, $G_V=40dB$, $R_L=50k\Omega$ to 1.1V	-	13	-	$nV/\sqrt{Hz}$
	V_{NIrms}	$R_L=50k\Omega$ to 1.1V, $G_V=40dB$, BPW=100Hz ~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

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

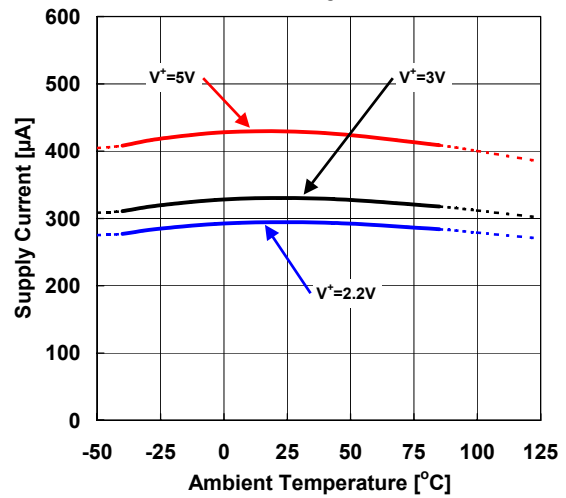
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	$G_V=0dB$, $C_L=15pF$, $R_T=50\Omega$ to 1.1V, $R_L=50k\Omega$ to 1.1V	-	1	-	V/ μs

■ TYPICAL CHARACTERISTICS

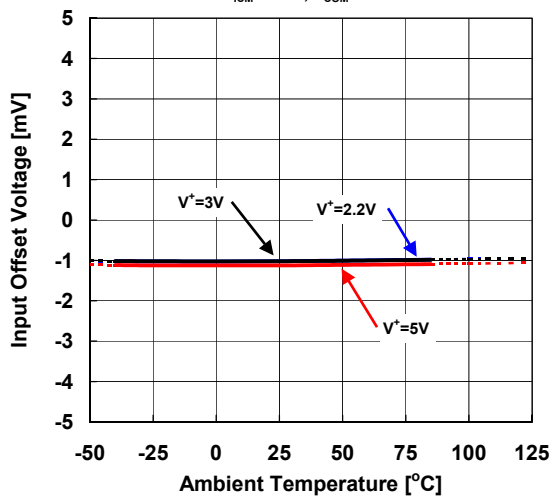
Supply Current vs. Supply Voltage
No Signal, $T_a=25^\circ\text{C}$



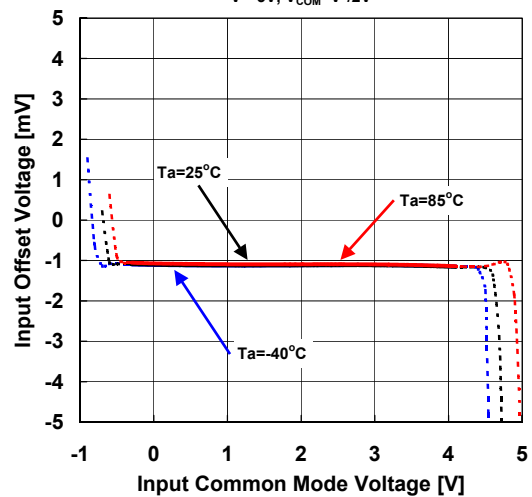
Supply Current vs. Ambient Temperature
(Supply Voltage)
No Signal



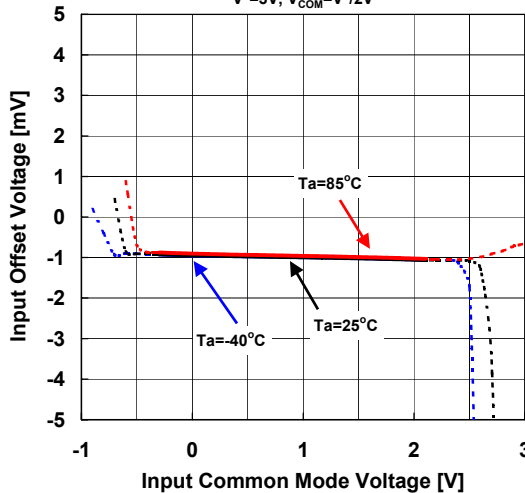
Input Offset Voltage vs. Ambient Temperature
(Supply Voltage)
 $V_{\text{ICM}}=V^+/2\text{V}$, $V_{\text{COM}}=V^+/2\text{V}$



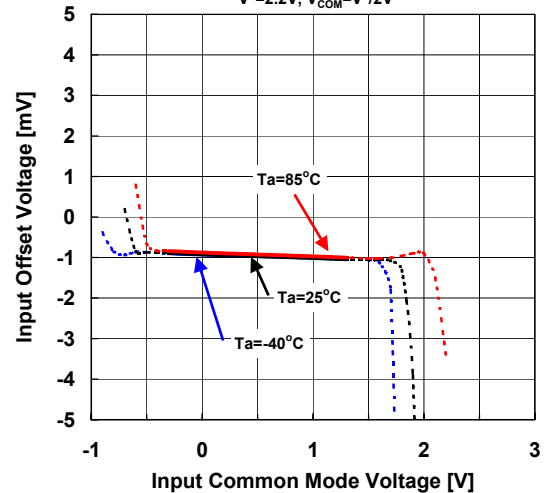
Input Offset Voltage
vs. Input Common Mode Voltage
(Ambient Temperature)
 $V^+=5\text{V}$, $V_{\text{COM}}=V^+/2\text{V}$



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



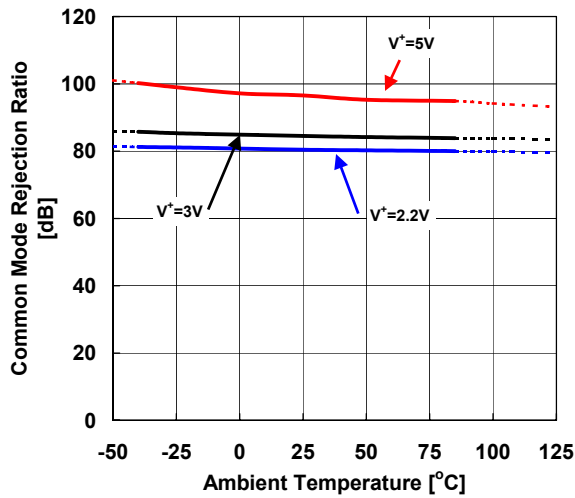
Input Offset Voltage
vs. Input Common Mode Voltage
(Ambient Temperature)
 $V^+=2.2\text{V}$, $V_{\text{COM}}=V^+/2\text{V}$



■ TYPICAL CHARACTERISTICS

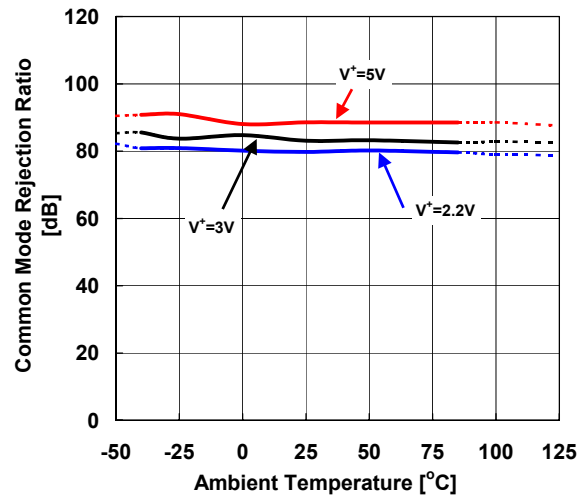
**Common Mode Rejection Ratio1
vs. Ambient Temperature**

$V_{ICM}=0V$ to $V^*-0.9V$, $V_{COM}=V^*/2V$



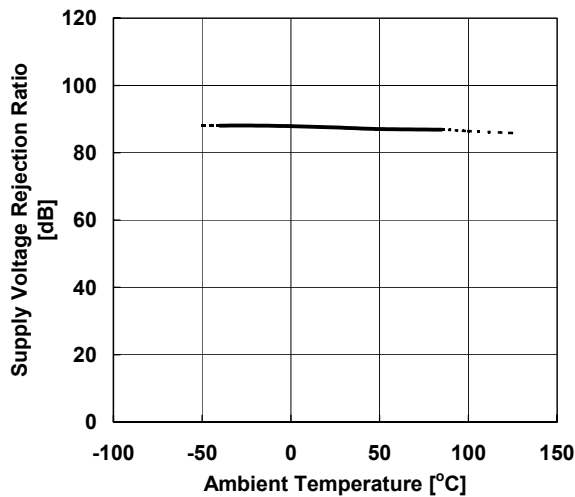
**Common Mode Rejection Ratio2
vs. Ambient Temperature**

$V_{ICM}=0V$ to $0.2V$, $V_{COM}=V^*/2V$



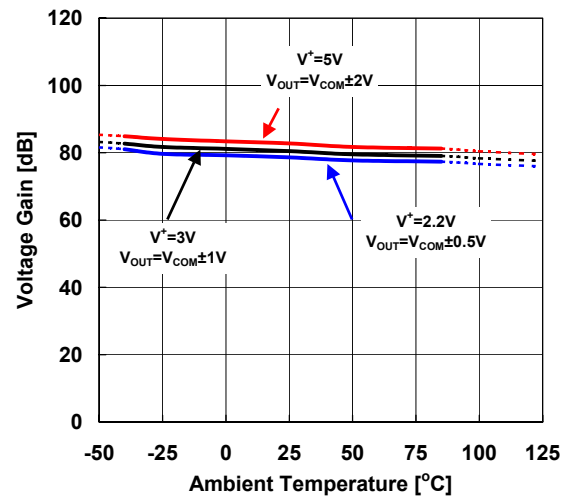
**Supply Voltage Rejection Ratio
vs. Ambient Temperature**

$V^*=2.2V$ to $5.5V$, $V_{ICM}=V^*/2$, $V_{COM}=V^*/2V$



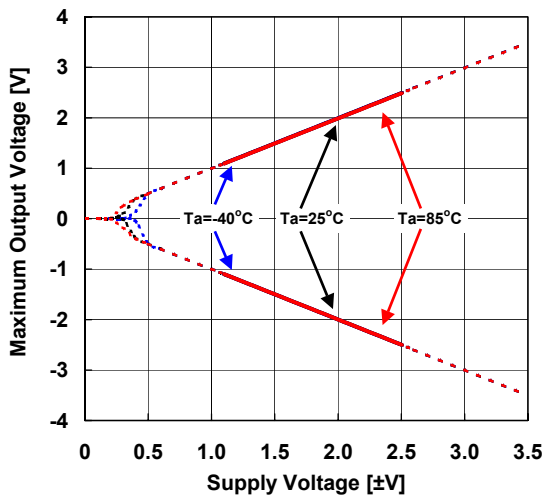
Voltage Gain vs. Ambient Temperature

$V_{COM}=V^*/2V$, $R_L=50k\Omega$ to V_{COM}



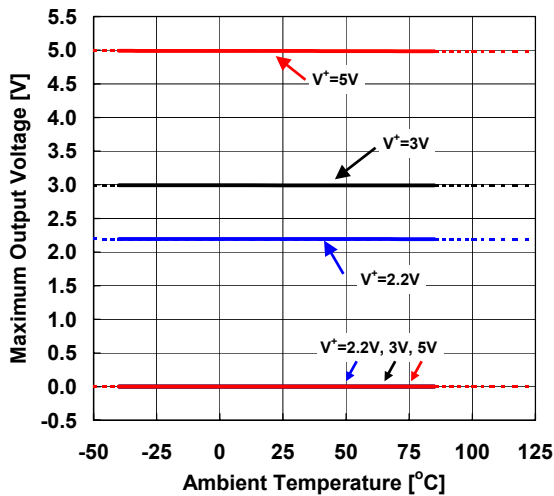
**Maximum Output Voltage vs. Supply Voltage
(Ambient Temperature)**

$V_{IN}=\pm 0.5V$, $V_{COM}=0V$, $R_L=50k\Omega$

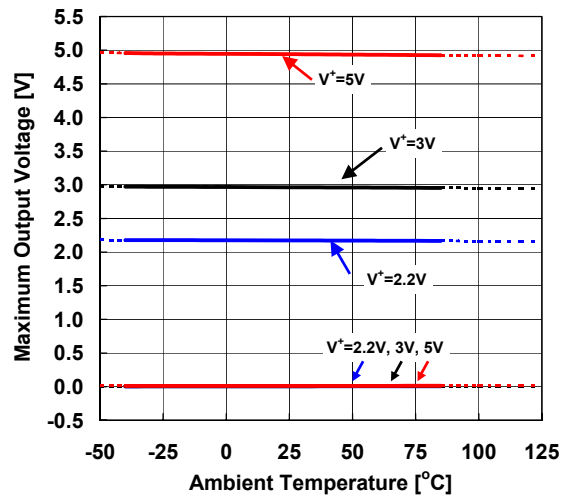


■ TYPICAL CHARACTERISTICS

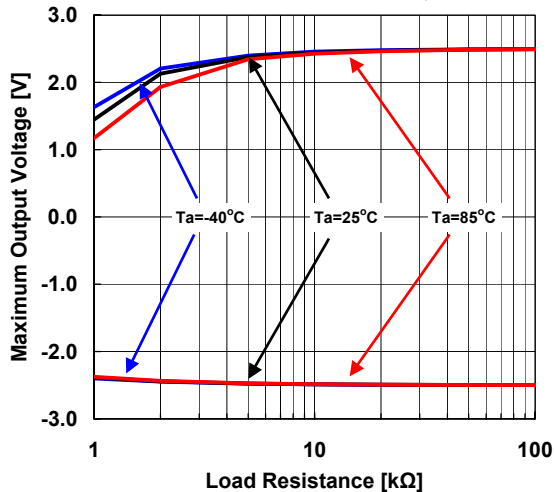
Maximum Output Voltage vs. Ambient Temperature
 $R_L=50k\Omega$ to V_{COM}



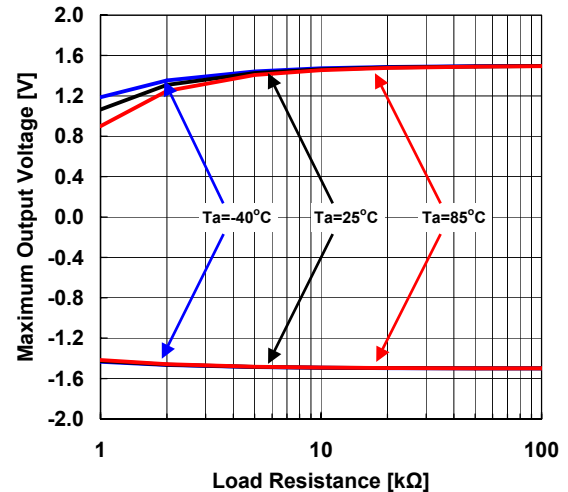
Maximum Output Voltage vs. Ambient Temperature
 $R_L=10k\Omega$ to V_{COM}



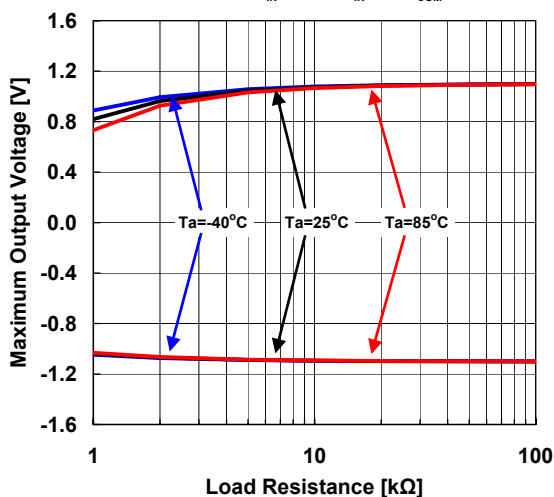
Maximum Output Voltage vs. Load Resistance
 (Ambient Temperature)
 $V^*/V=\pm 2.5V$, $V_{IN}^+=\pm 0.1V$, $V_{IN}=0V$, $V_{COM}=0V$



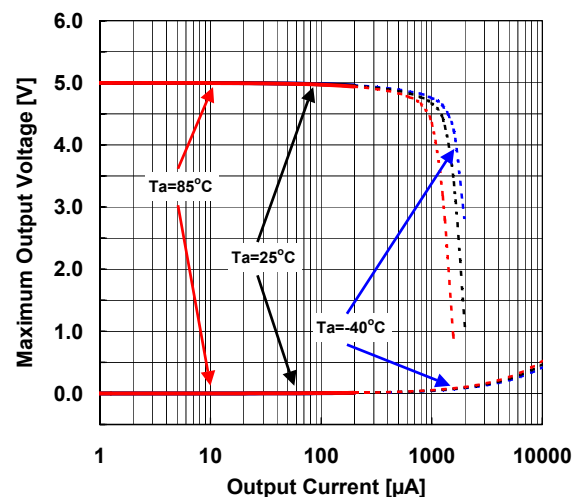
Maximum Output Voltage vs. Load Resistance
 (Ambient Temperature)
 $V^*/V=\pm 1.5V$, $V_{IN}^+=\pm 0.1V$, $V_{IN}=0V$, $V_{COM}=0V$



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

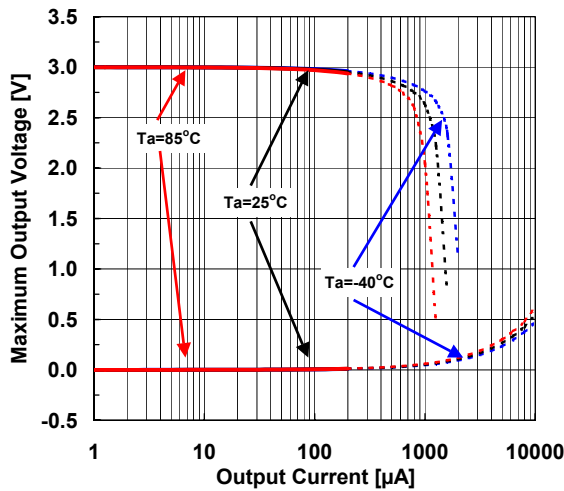


Maximum Output Voltage vs. Output Current
 (Ambient Temperature)
 $V^*=5V$

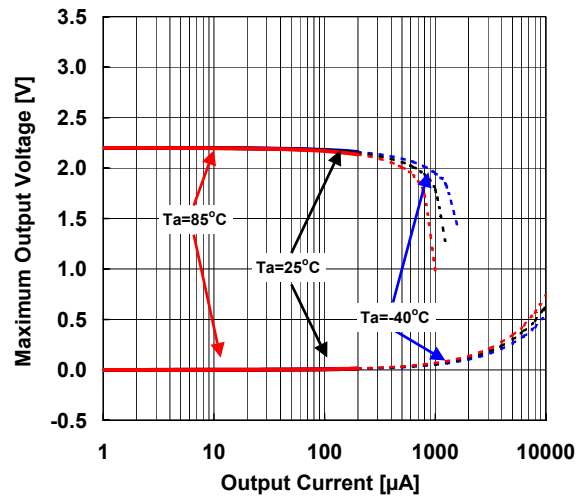


■ TYPICAL CHARACTERISTICS

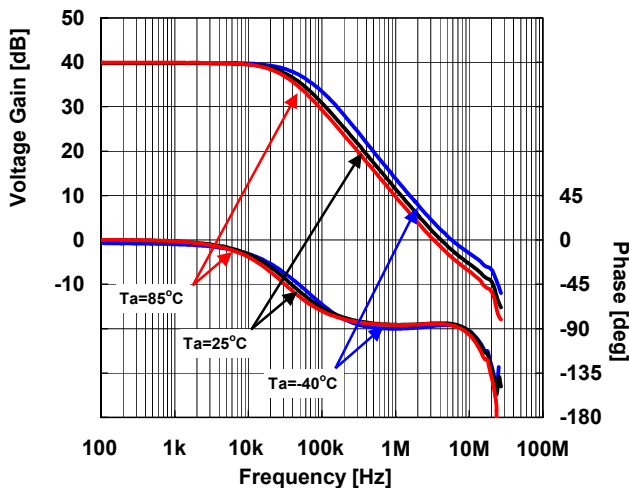
Maximum Output Voltage vs. Output Current
(Ambient Temperature)
 $V^+=3V$



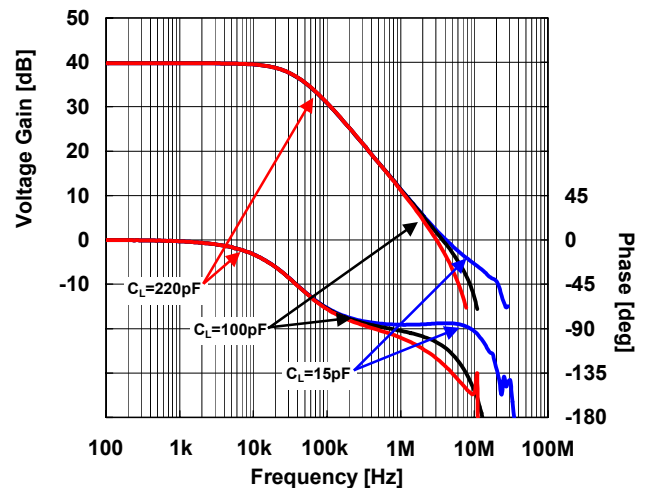
Maximum Output Voltage vs. Output Current
(Ambient Temperature)
 $V^+=2.2V$



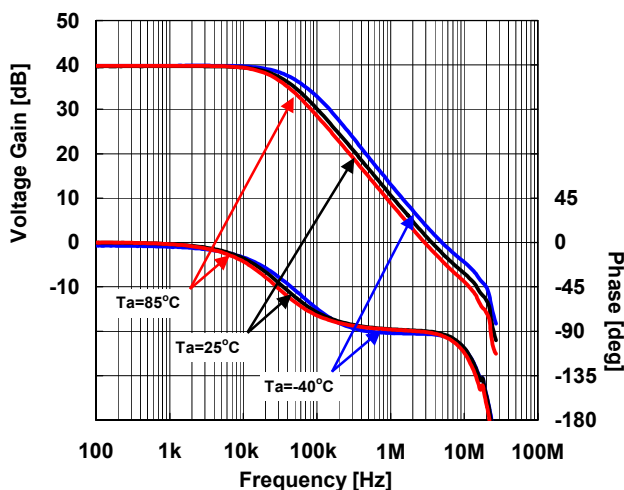
40dB Gain/Phase vs. Frequency (Temperature)
 $V^+=5V$, $V_{COM}=V^+/2$, $G_V=40dB$, $R_T=50\Omega$, $R_L=50k\Omega$, $C_L=15pF$



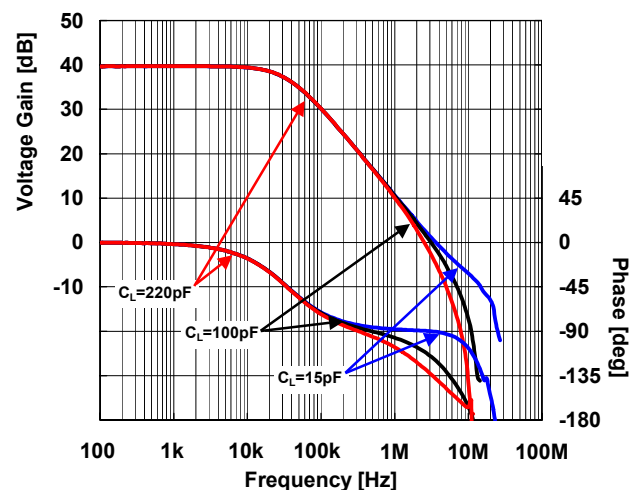
40dB Gain/Phase vs. Frequency (Load Capacitance)
 $V^+=5V$, $V_{COM}=V^+/2$, $G_V=40dB$, $R_S=50\Omega$, $R_L=50k\Omega$, $T_a=25^\circ C$



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



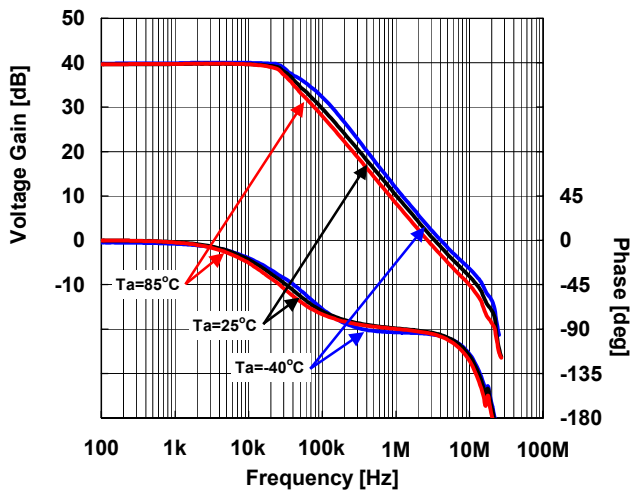
40dB Gain/Phase vs. Frequency (Load Capacitance)
 $V^+=3V$, $V_{COM}=V^+/2$, $G_V=40dB$, $R_S=50\Omega$, $R_L=50k\Omega$, $T_a=25^\circ C$



■ TYPICAL CHARACTERISTICS

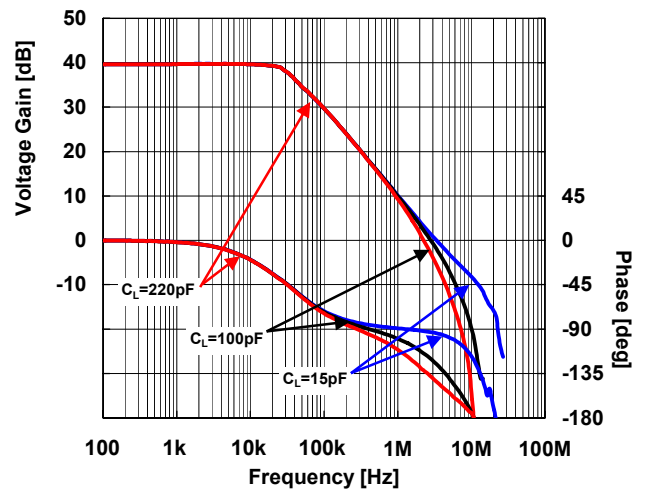
40dB Gain/Phase vs. Frequency (Temperature)

$V^+=2.2V$, $V_{COM}=V^+/2$, $G_V=40dB$, $R_T=50\Omega$, $R_L=50k\Omega$, $C_L=15pF$



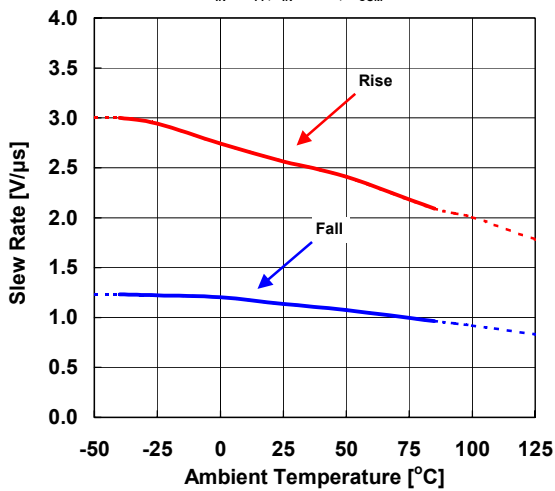
40dB Gain/Phase vs. Frequency (Load Capacitance)

$V^+=2.2V$, $V_{COM}=V^+/2$, $G_V=40dB$, $R_S=50\Omega$, $R_L=50k\Omega$, $T_a=25^\circ C$



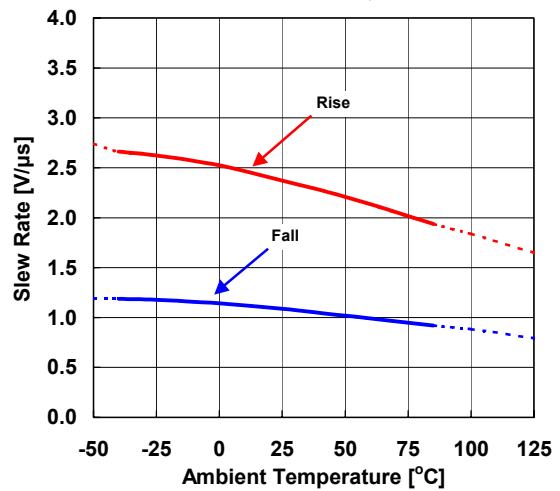
Slew Rate vs. Ambient Temperature

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



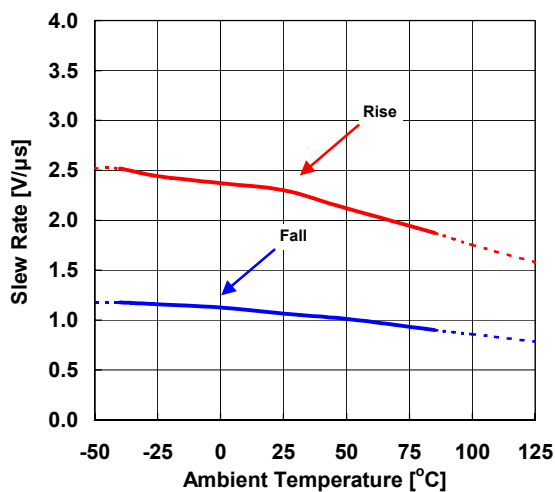
Slew Rate vs. Ambient Temperature

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

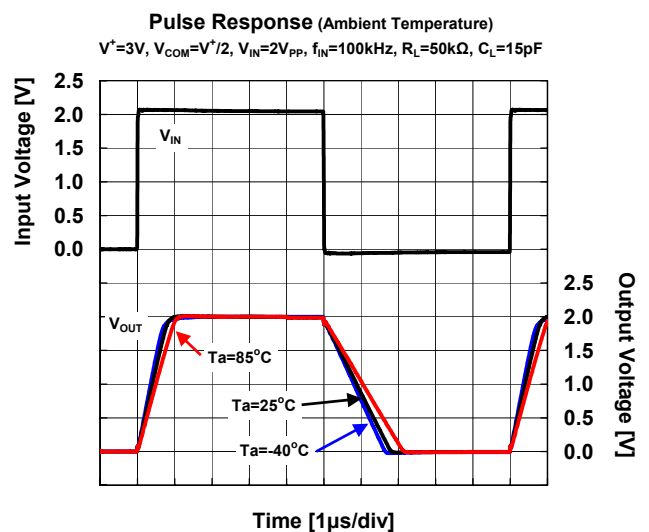
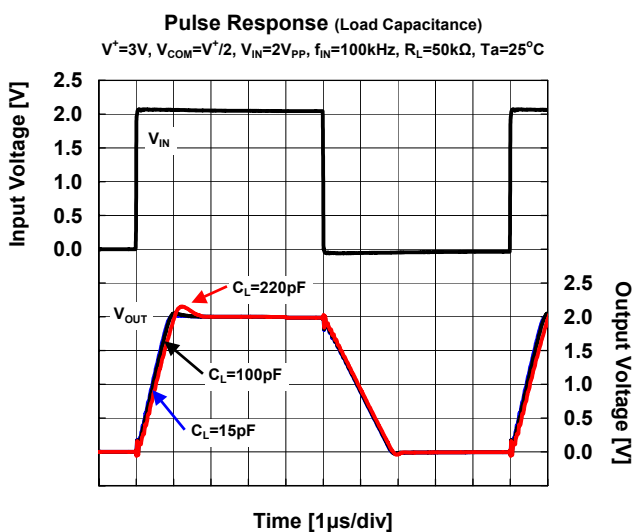
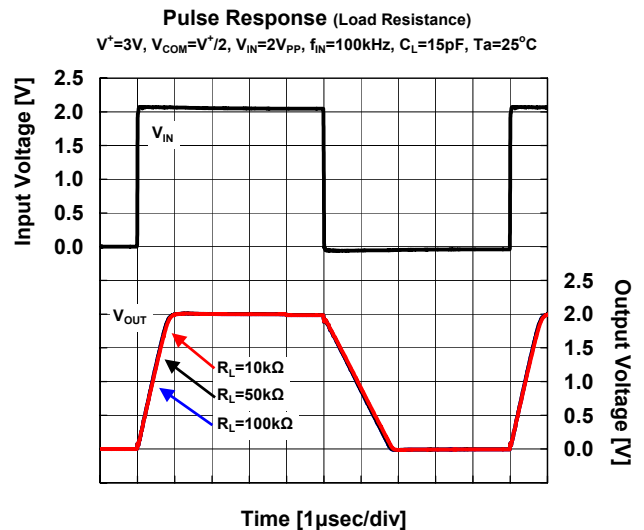
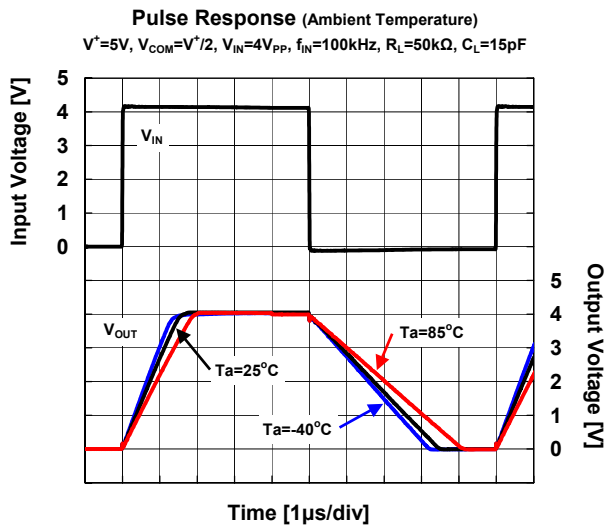
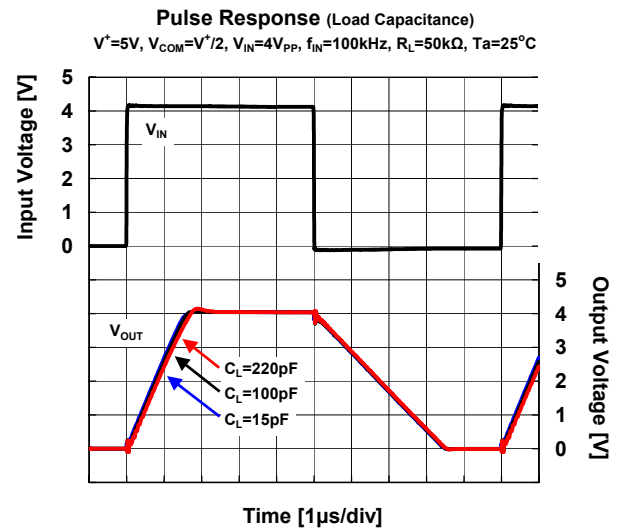
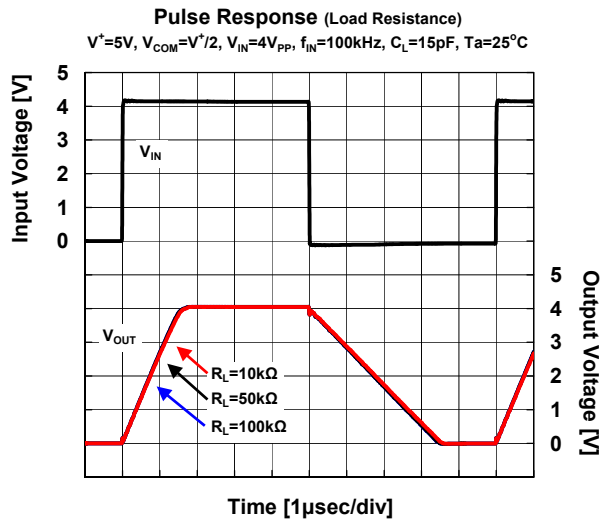


Slew Rate vs. Ambient Temperature

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

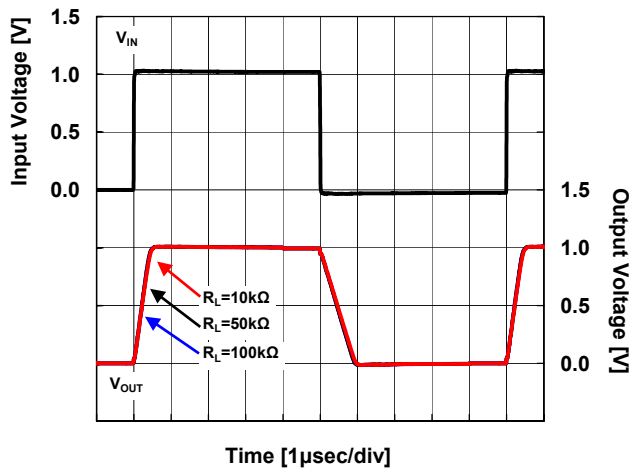


■ TYPICAL CHARACTERISTICS

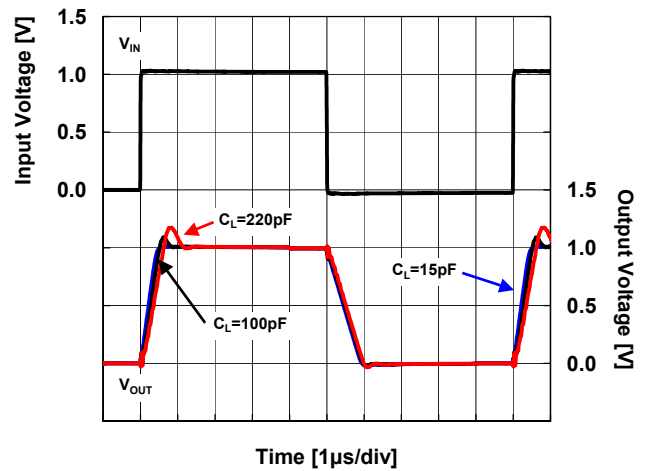


■ TYPICAL CHARACTERISTICS

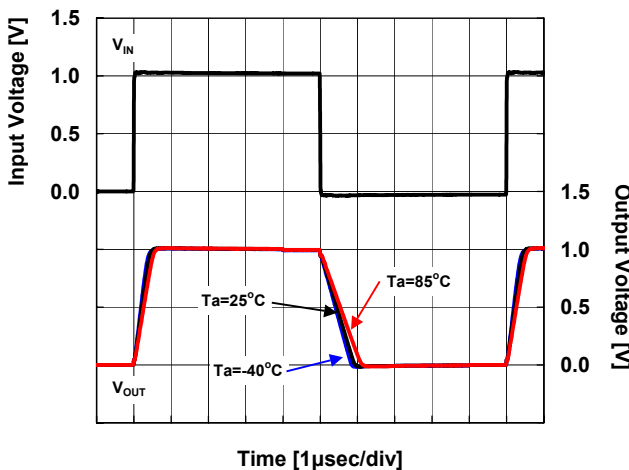
Pulse Response (Load Resistance)
 $V^+=2.2V$, $V_{COM}=V^+/2$, $V_{IN}=1V_{PP}$, $f_{IN}=100kHz$, $C_L=15pF$, $T_a=25^\circ C$



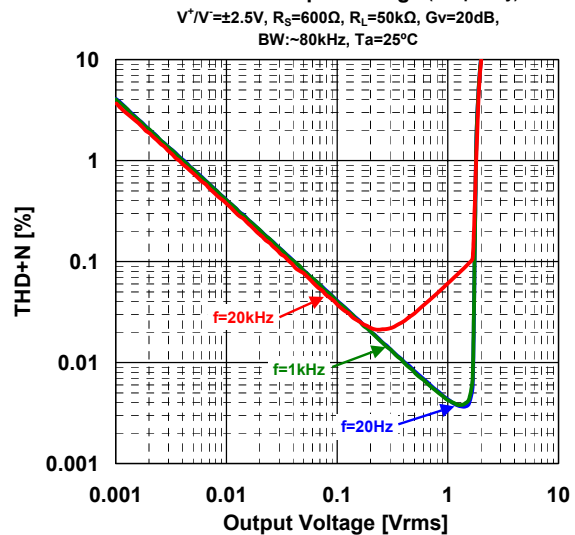
Pulse Response (Load Capacitance)
 $V^+=2.2V$, $V_{COM}=V^+/2$, $V_{IN}=1V_{PP}$, $f_{IN}=100kHz$, $R_L=50k\Omega$, $T_a=25^\circ C$



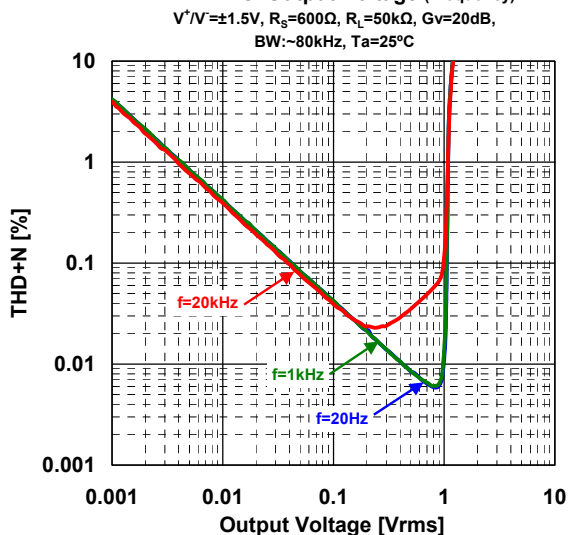
Pulse Response (Ambient Temperature)
 $V^+=2.2V$, $V_{COM}=V^+/2$, $V_{IN}=1V_{PP}$, $f_{IN}=100kHz$, $R_L=50k\Omega$, $C_L=15pF$



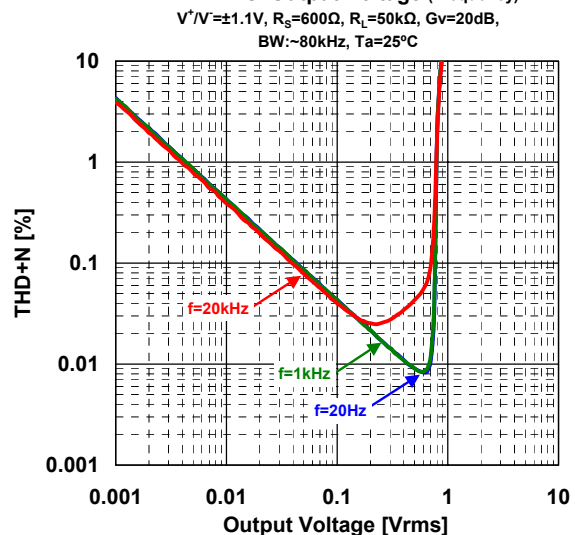
THD+N vs. Output Voltage (Frequency)



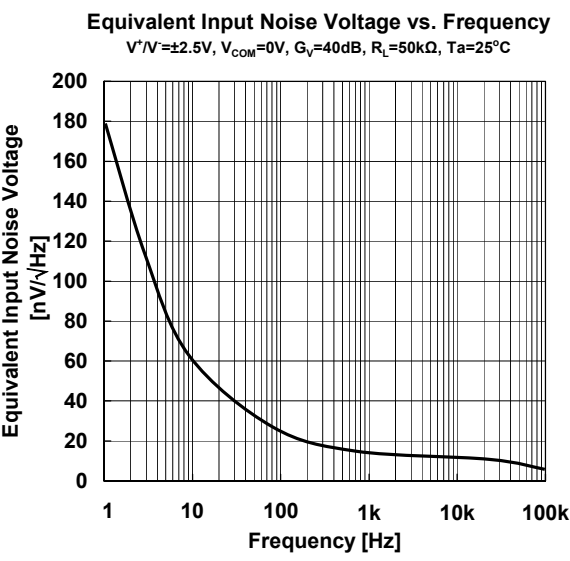
THD+N vs. Output Voltage (Frequency)



THD+N vs. Output Voltage (Frequency)



■ TYPICAL CHARACTERISTICS



[CAUTION]
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