

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

### ■ GENERAL DESCRIPTION

The NJU7029 is a dual CMOS operational amplifier with a low noise of  $VNI=13nV/\sqrt{Hz}$  (typ. @ $f=1kHz$ ), Rail-to-Rail output and low operating voltage. It offers a single supply voltage operation from +2.2V to +5.5V, rail-to-rail output swing in both supply rails and input voltage range from ground. Further the NJU7029 has a low bias current of 1pA, which makes it well-suited for current sense amplifiers such as an acceleration sensor, shock sensor and photodiode amplifier. The NJU7029 is available in small surface mount packages of SSOP8, MSOP8 (TVSP8) and an ultra small lead-less package of ESON8 which allows high-density mounting.

### ■ FEATURES

#### Low Noise

- Voltage Noise  $13nV/\sqrt{Hz}$  (typ.) @ $f=1kHz$   
 $3\mu V_{rms}$  (max.) @ $f=100Hz\sim 20kHz$

#### Easy to Use

- Gain Bandwidth 3MHz
- Slew Rate  $1V/\mu s$  (typ.) @ $R_L=50k\Omega$
- $I_{source} / I_{sink}$  200 $\mu A$
- Specified for +5V, +3V and +2.2V operation

#### CMOS Process

- Input Bias Current 1pA (typ.)
- Rail-to-Rail Output

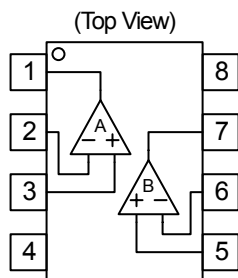
- Offset Voltage 5mV (max.)
- Offset Voltage Drift  $2\mu V/^\circ C$  (typ.)
- Supply Range 2.2V ~ 5.5V
- Supply Current 850 $\mu A$ /all ch (typ.) @ $V_{DD}=+5V$
- Package SSOP8, ESON8

MSOP8 (TVSP8) MEET JEDEC MO-187-DA / THIN TYPE

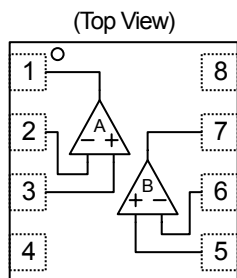
### ■ Application

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

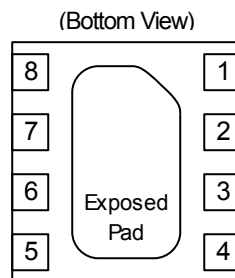
### ■ PIN CONFIGURATION



NJU7029V  
NJU7029RB1



NJU7029KU1



1. A OUTPUT
2. A -INPUT
3. A +INPUT
4. GND(V)
5. B +INPUT
6. B -INPUT
7. B OUTPUT
8.  $V_{DD}$

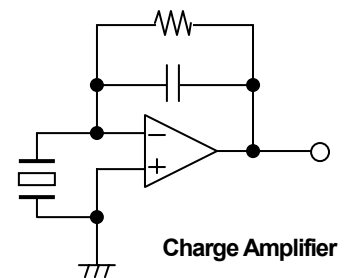
About Exposed Pad

Connect the Exposed Pad on the GND.

### ■ PACKAGE OUTLINE



### ■ Typical Application Circuit



# NJU7029

## ■ 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~+7 (Note1)	V
Differential Input Voltage Range	V <sub>ID</sub>	±7 (Note1)	V
Power Dissipation	P <sub>D</sub>	SSOP8:330 (Note2) MSOP8(TVSP8):410 (Note2) ESON8:360 (Note2)	mW
Operating Temperature Range	T <sub>opr</sub>	-40~+85	°C
Storage Temperature Range	T <sub>stg</sub>	-55~+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)"

Refer to following Figure 1 for a permissible loss when ambient temperature (Ta) is Ta≥25°C.

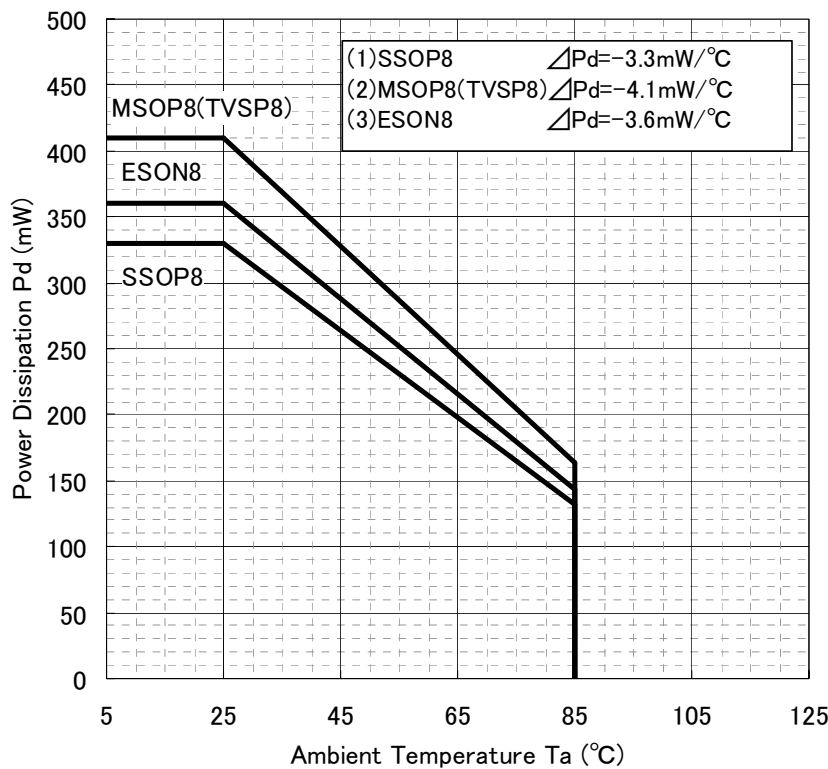


Figure 1 Power Dissipation vs. Ambient Temperature

## ■ OPERATING VOLTAGE (Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Supply Voltage	V <sub>DD</sub>		2.2	-	5.5	V

## ■ +5V ELECTRICAL CHARACTERISTICS

### ●DC CHARACTERISTICS ( $V_{DD}=5V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	$I_{DD}$	No Signal	-	850	1150	$\mu A$
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	-	$\mu V/^\circ C$
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 2.5V, $V_o=2.5V \pm 2V$	65	80	-	dB
Common Mode Rejection Ratio	CMR	$V_{ICM}=0V \sim 4.1V$	65	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 2.5V	4.9	-	-	V
	$V_{OL1}$	$R_L=50k\Omega$ to 2.5V	-	-	0.1	V
Output Voltage2	$V_{OH2}$	$I_{source}=200\mu A$	4.8	-	-	V
	$V_{OL2}$	$I_{sink}=200\mu A$	-	-	0.2	V
Input Common Mode Voltage Range	$V_{ICM}$	CMR $\geq$ 65dB	0	-	4.1	V

### ●AC CHARACTERISTICS ( $V_{DD}=5V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Frequency	$f_T$	$G_v=40dB$ , $R_L=50k\Omega$ to 2.5V, $C_L=10pF$	-	3	-	MHz
Equivalent Input Noise Voltage	$V_{NI}$	$G_v=40dB$ , $R_L=50k\Omega$ to 2.5V, $f=1kHz$ ,	-	13	-	$nV/\sqrt{Hz}$
	$V_{NIrms}$	$G_v=40dB$ , $R_L=50k\Omega$ to 2.5V BPW=100Hz~20kHz	-	1.7	3	$\mu V_{rms}$
Total Harmonic Distortion	THD	$G_v=20dB$ , $R_L=50k\Omega$ to 2.5V, $f_{in}=1kHz$ , $V_{out}=3V_{pp}$ , BPW=400Hz~80kHz	-	0.01	-	%
Channel separation	CS	$f=1kHz$	-	130	-	dB

### ●TRANSIENT CHARACTERISTICS ( $V_{DD}=5V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	$G_v=0dB$ , $R_T=50\Omega$ to 2.5V, $R_L=50k\Omega$ to 2.5V, $C_L=15pF$	-	1	-	$V/\mu s$

## ■ +3V 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	-	610	950	$\mu A$
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 Ratio	CMR	$V_{ICM}=0V \sim 2.1V$	65	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
Output Voltage2	$V_{OH2}$	$I_{source}=200\mu A$	2.8	-	-	V
	$V_{OL2}$	$I_{sink}=200\mu A$	-	-	0.2	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	$f_T$	$G_v=40dB$ , $R_L=50k\Omega$ to 1.5V, $C_L=10pF$	-	3	-	MHz
Equivalent Input Noise Voltage	$V_{NI}$	$G_v=40dB$ , $R_L=50k\Omega$ to 1.5V, $f=1kHz$	-	13	-	$nV/\sqrt{Hz}$
	$V_{NIrms}$	$G_v=40dB$ , $R_L=50k\Omega$ to 1.5V, $BPW=100Hz \sim 20kHz$	-	1.7	3	$\mu Vrms$
Total Harmonic Distortion	THD	$G_v=20dB$ , $R_L=50k\Omega$ to 1.5V, $f_{in}=1kHz$ , $V_{out}=1V_{pp}$ , $BPW=400Hz \sim 80kHz$	-	0.02	-	%
Channel separation	CS	$f=1kHz$	-	120	-	dB

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

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

## ■ +2.2V 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	-	550	890	$\mu A$
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, $V_o=1.1V \pm 0.5V$	60	80	-	dB
Common Mode Rejection Ratio	CMR	$V_{ICM}=0V \sim 1.3V$	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
Output Voltage2	$V_{OH2}$	$I_{source}=200\mu A$	2.0	-	-	V
	$V_{OL2}$	$I_{sink}=200\mu A$	-	-	0.2	V
Input Common Mode Voltage Range	$V_{ICM}$	CMR $\geq$ 60dB	0	-	1.3	V

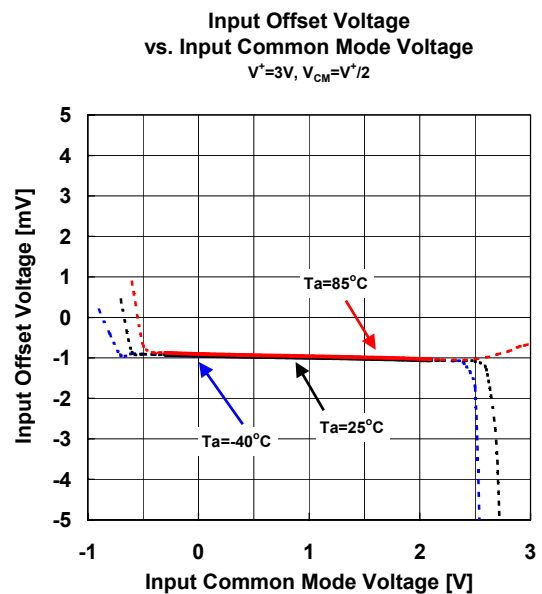
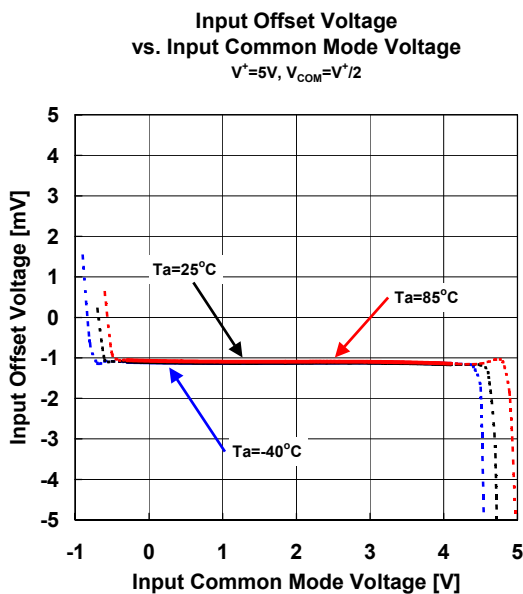
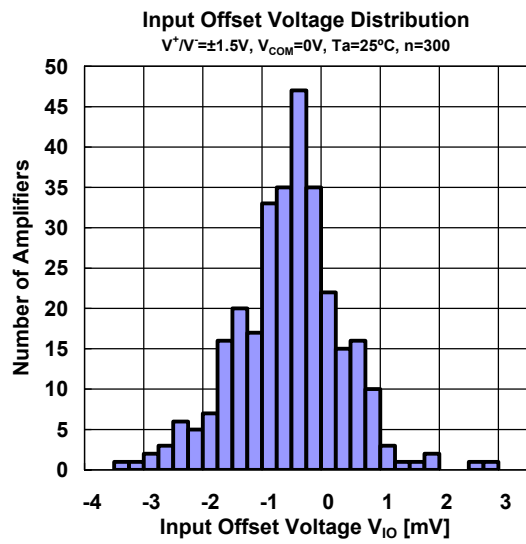
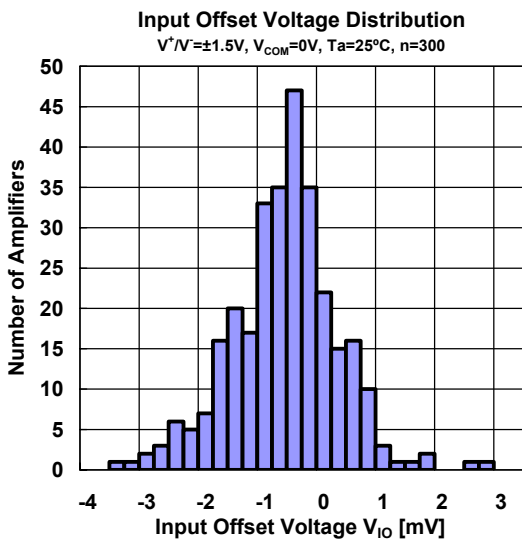
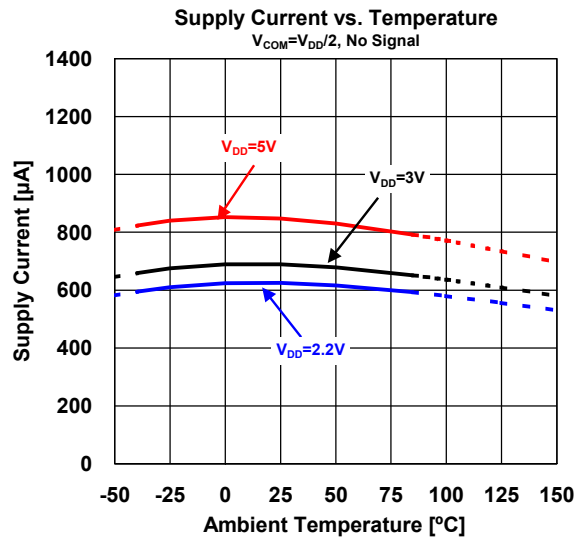
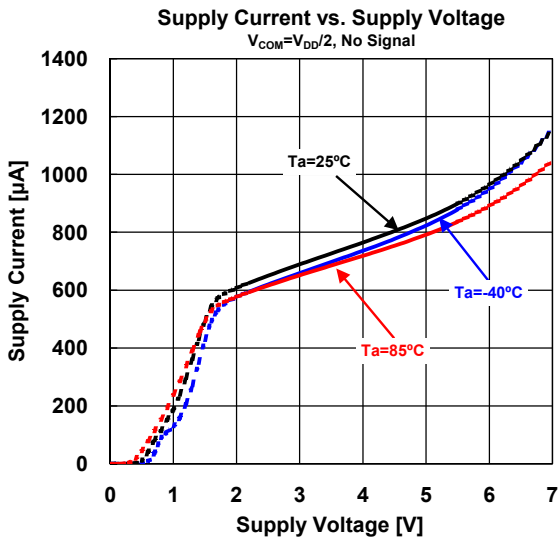
### ●AC CHARACTERISTICS ( $V_{DD}=2.2V$ , $T_a=25^\circ C$ )

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Frequency	$f_T$	$G_v=40dB$ , $R_L=50k\Omega$ to 1.1V, $C_L=10pF$	-	3	-	MHz
Equivalent Input Noise Voltage	$V_{NI}$	$G_v=40dB$ , $R_L=50k\Omega$ to 1.1V, $f=1kHz$	-	13	-	$nV/\sqrt{Hz}$
	$V_{NIrms}$	$G_v=40dB$ , $R_L=50k\Omega$ to 1.1V, $BPW=100Hz \sim 20kHz$	-	1.7	3	$\mu Vrms$
Total Harmonic Distortion	THD	$G_v=20dB$ , $R_L=50k\Omega$ to 1.1V, $f_{in}=1kHz$ , $V_{out}=0.5V_{pp}$ , $BPW=400Hz \sim 80kHz$	-	0.02	-	%
Channel separation	CS	$f=1kHz$	-	115	-	dB

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

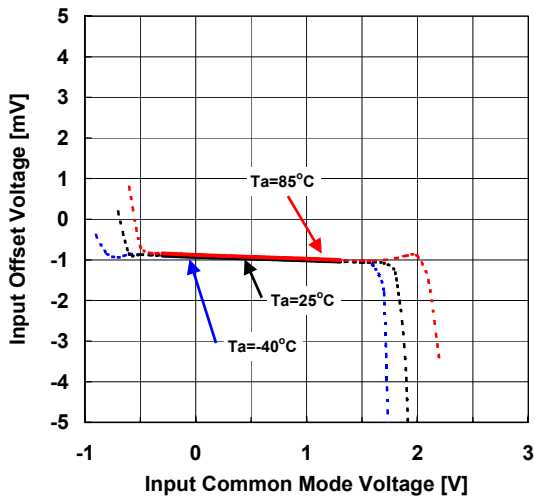
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	$G_v=0dB$ , $R_T=50\Omega$ to 1.1V, $R_L=50k\Omega$ to 1.5V, $C_L=15pF$	-	1	-	$V/\mu s$

## TYPICAL CHARACTERISTICS

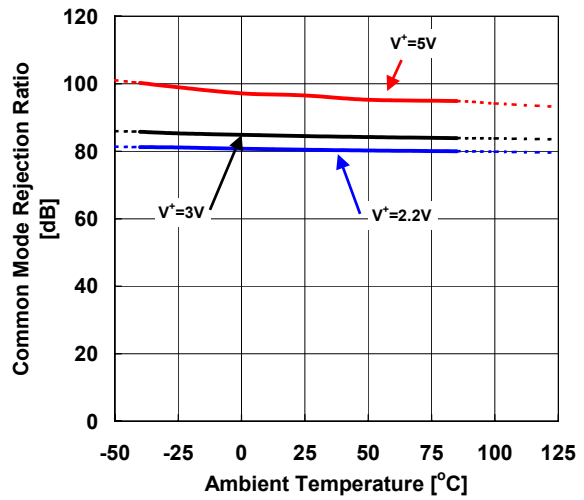


## ■ TYPICAL CHARACTERISTICS

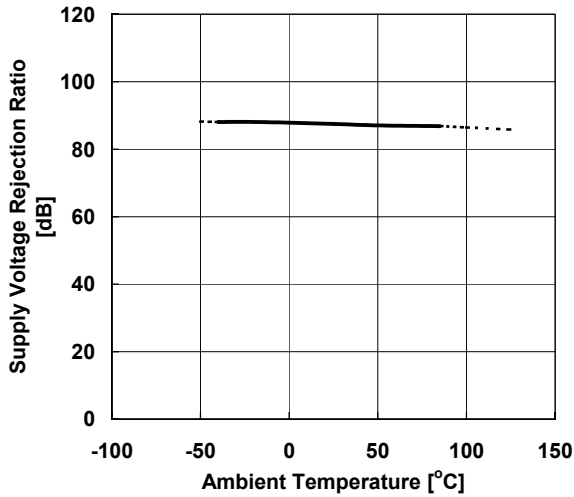
**Input Offset Voltage vs. Input Common Mode Voltage**  
 $V^+ = 2.2V, V_{COM} = V^+/2$



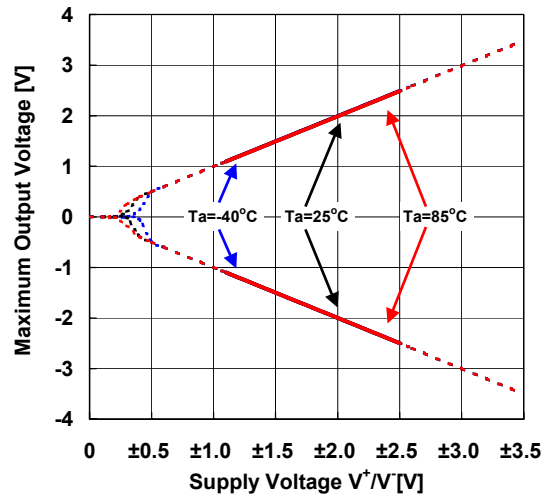
**Common Mode Rejection Ratio vs. Ambient Temperature**  
 $V_{ICM} = 0V \text{ to } V^+ - 0.9V, V_{COM} = V^+/2$



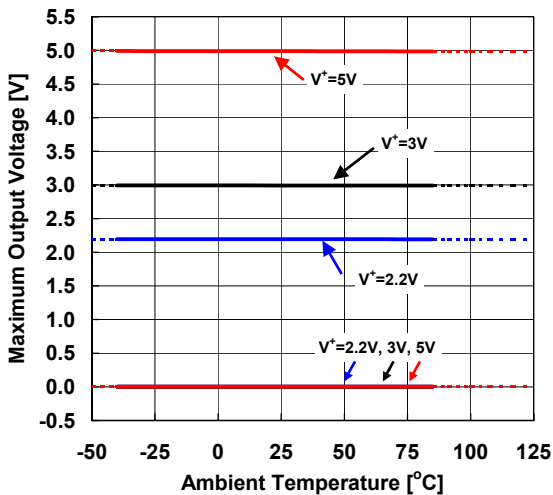
**Supply Voltage Rejection Ratio vs. Ambient Temperature**  
 $V^+ = 2.2V \text{ to } 5.5V, V_{ICM} = V^+/2, V_{COM} = V^+/2$



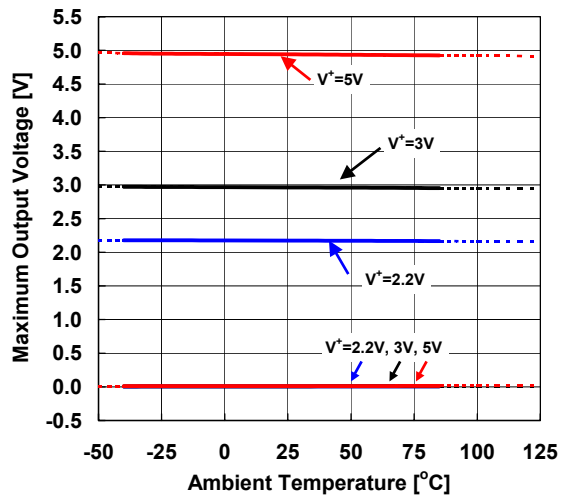
**Maximum Output Voltage vs. Supply Voltage**  
 $V_{IN} = \pm 0.5V, V_{COM} = 0V, R_L = 50k\Omega$



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

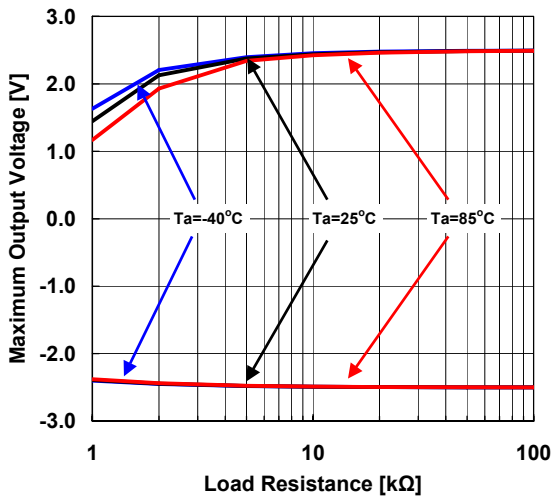


**Maximum Output Voltage vs. Ambient Temperature**  
 $R_L = 10k\Omega \text{ to } V_{COM}$

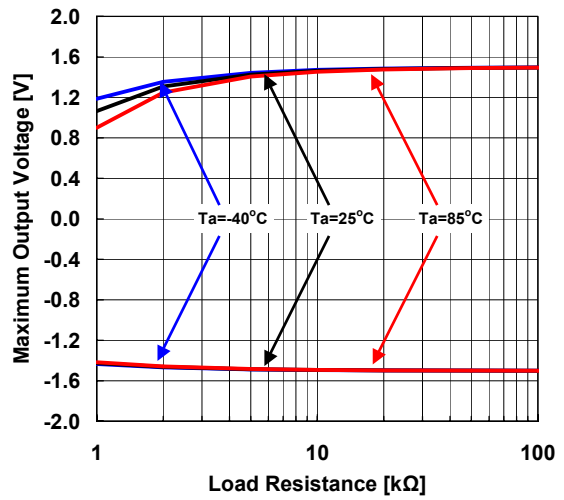


## ■ TYPICAL CHARACTERISTICS

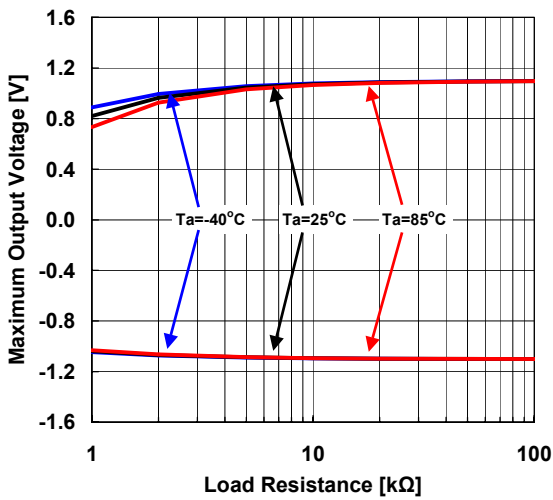
Maximum Output Voltage vs. Load Resistance  
 $V^+V^-=\pm 2.5V, V_{IN}^+=\pm 0.1V, V_{IN}^-=0V, V_{COM}=0V$



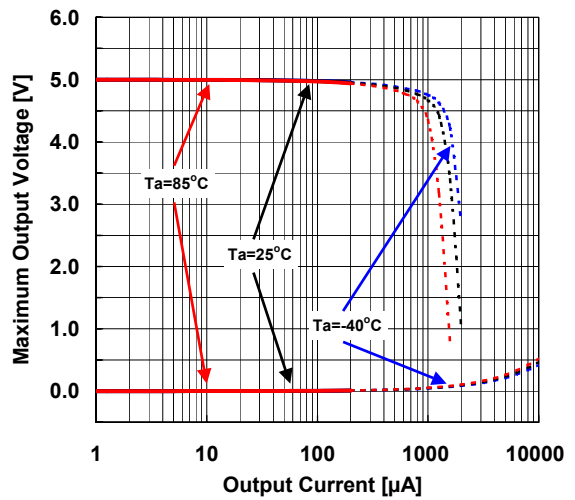
Maximum Output Voltage vs. Load Resistance  
 $V^+V^-=\pm 1.5V, V_{IN}^+=\pm 0.1V, V_{IN}^-=0V, V_{COM}=0V$



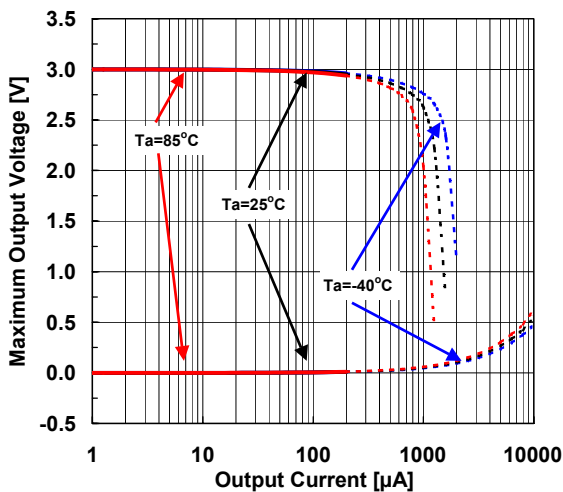
Maximum Output Voltage vs. Load Resistance  
 $V^+V^-=\pm 1.1V, V_{IN}^+=\pm 0.1V, V_{IN}^-=0V, V_{COM}=0V$



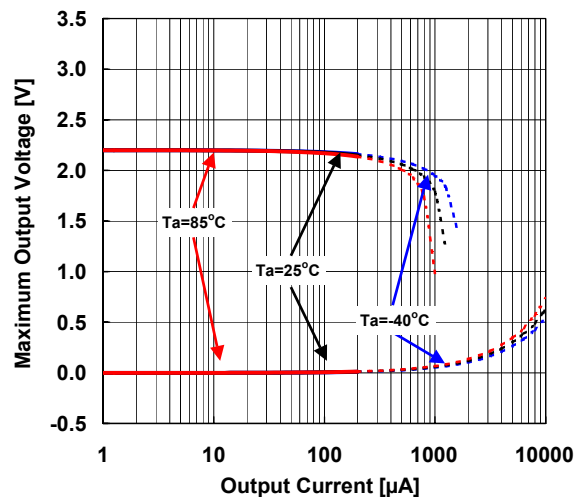
Maximum Output Voltage vs. Output Current  
 $V^+=5V$



Maximum Output Voltage vs. Output Current  
 $V^+=3V$



Maximum Output Voltage vs. Output Current  
 $V^+=2.2V$

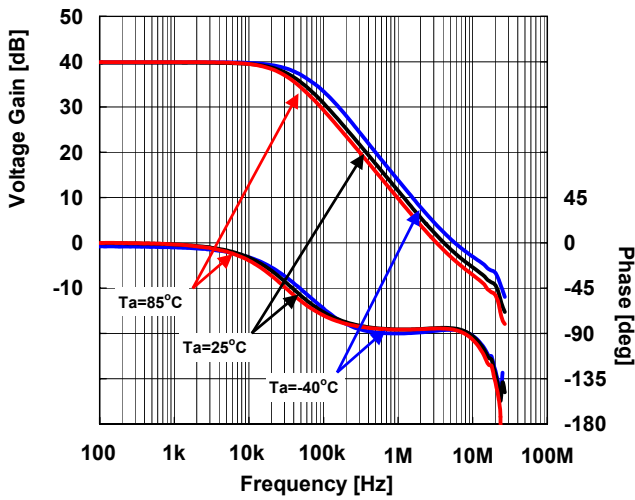




■ TYPICAL CHARACTERISTICS

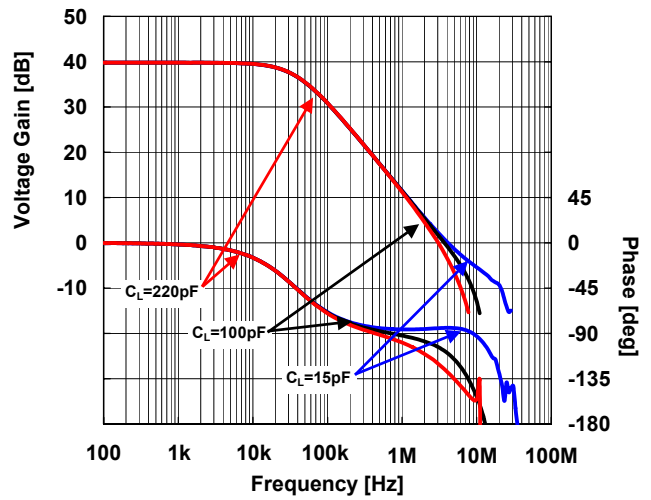
40dB Gain/Phase vs. Frequency

$V^+=5V, V_{COM}=V^+/2, G_V=40dB, R_T=50\Omega, R_L=50k\Omega, C_L=15pF$



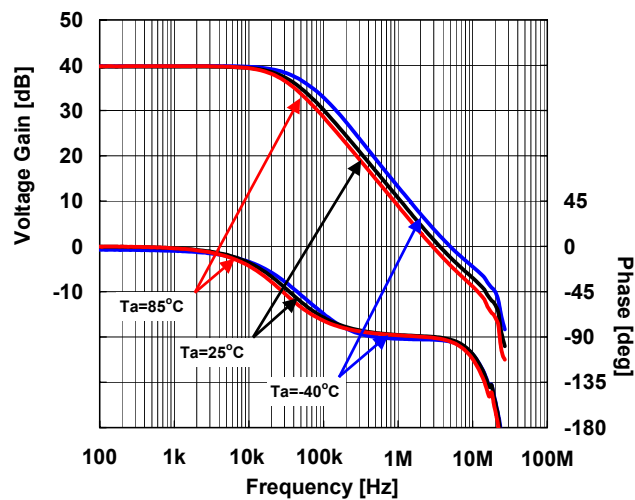
40dB Gain/Phase vs. Frequency

$V^+=5V, V_{COM}=V^+/2, G_V=40dB, R_S=50\Omega, R_L=50k\Omega, T_a=25^\circ C$



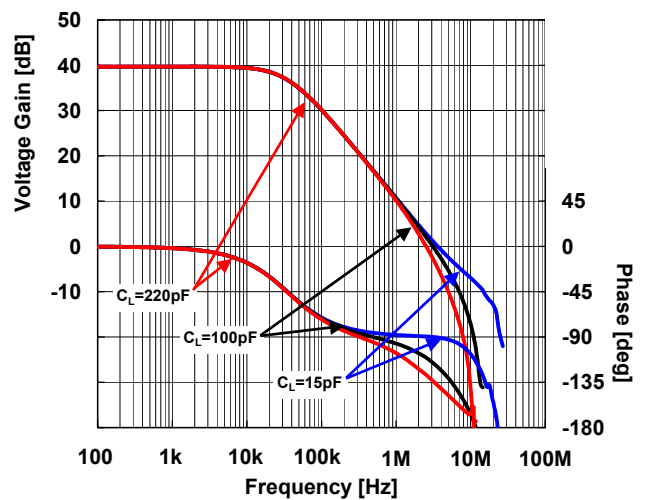
40dB Gain/Phase vs. Frequency

$V^+=3V, V_{COM}=V^+/2, G_V=40dB, R_T=50\Omega, R_L=50k\Omega, C_L=15pF$



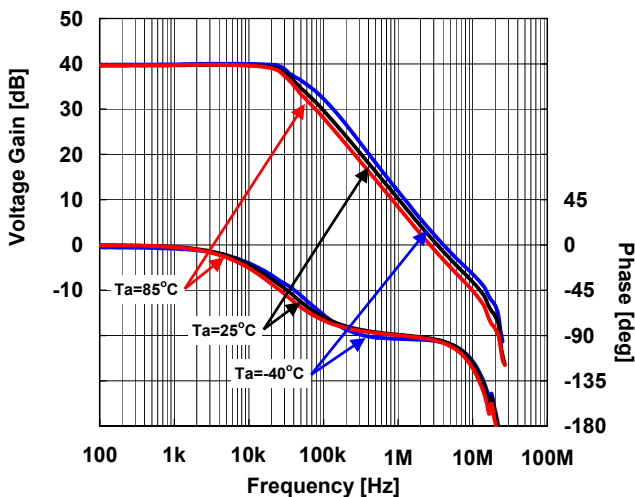
40dB Gain/Phase vs. Frequency

$V^+=3V, V_{COM}=V^+/2, G_V=40dB, R_S=50\Omega, R_L=50k\Omega, T_a=25^\circ C$



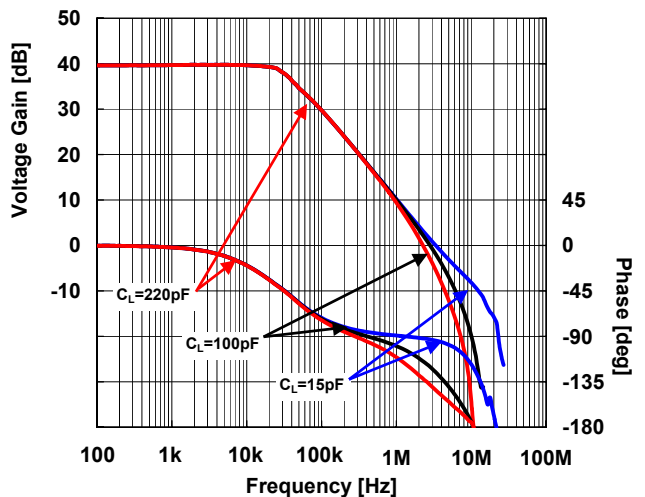
40dB Gain/Phase vs. Frequency

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

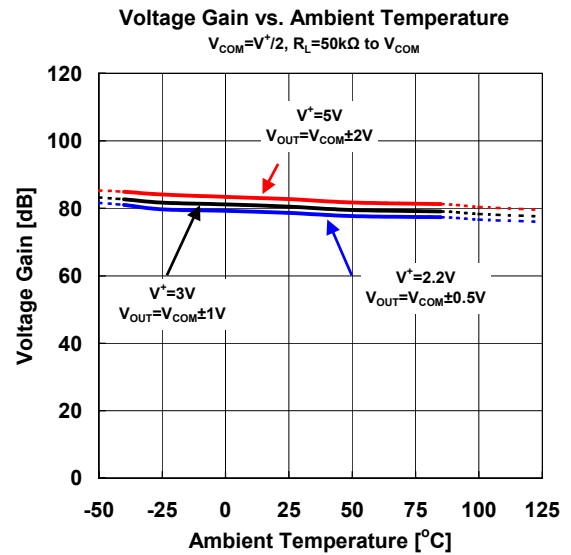
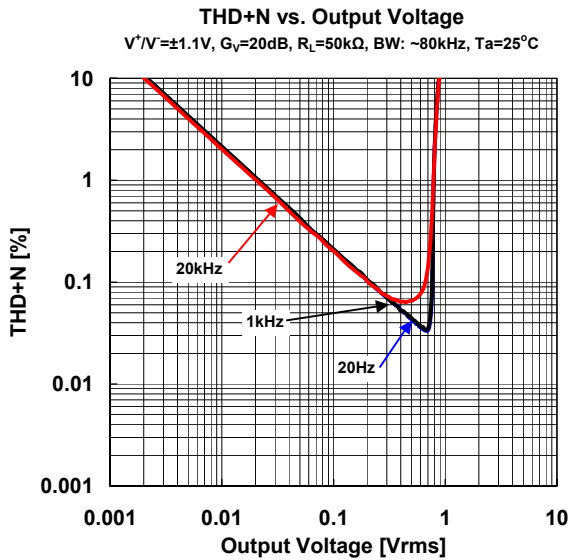
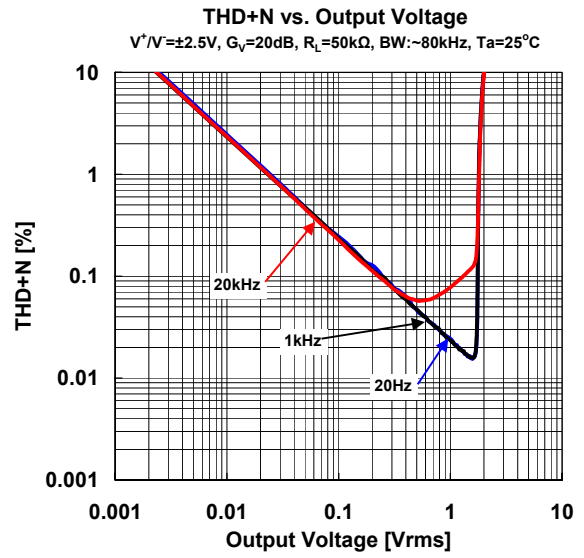
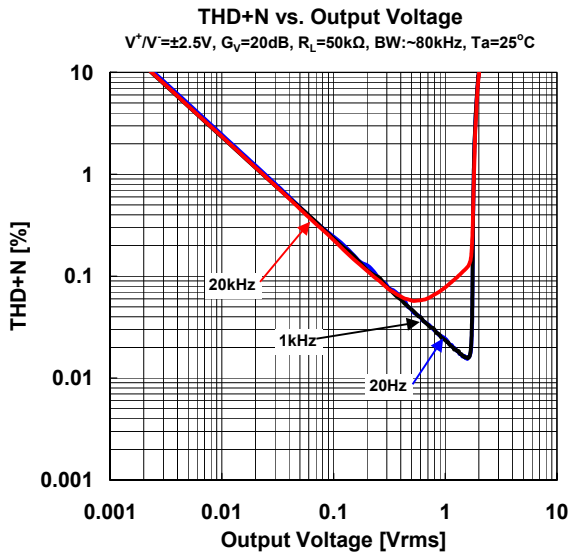


40dB Gain/Phase vs. Frequency

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



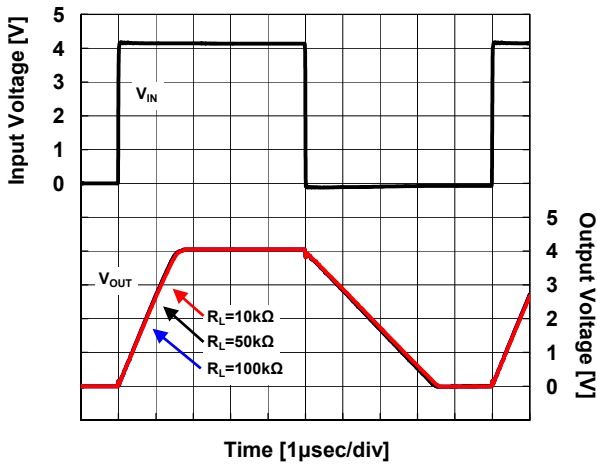
## ■ TYPICAL CHARACTERISTICS



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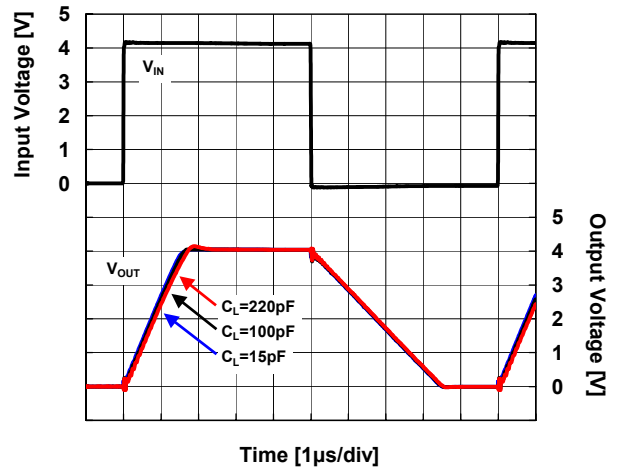
### Pulse Response

$V^+=5V, V_{COM}=V^+/2, V_{IN}=4V_{PP}, f_{IN}=100kHz, C_L=15pF, T_a=25^\circ C$



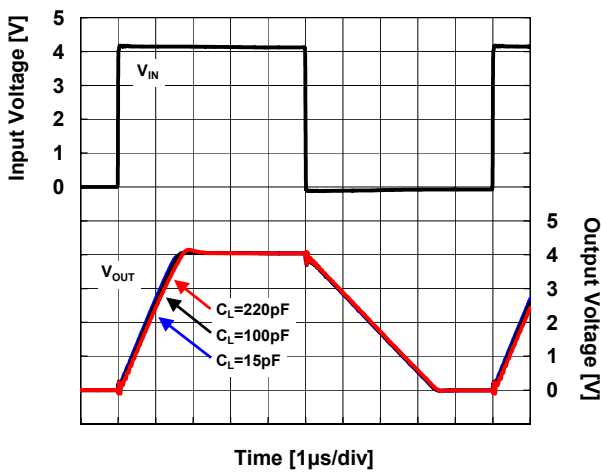
### Pulse Response

$V^+=5V, V_{COM}=V^+/2, V_{IN}=4V_{PP}, f_{IN}=100kHz, R_L=50k\Omega, T_a=25^\circ C$



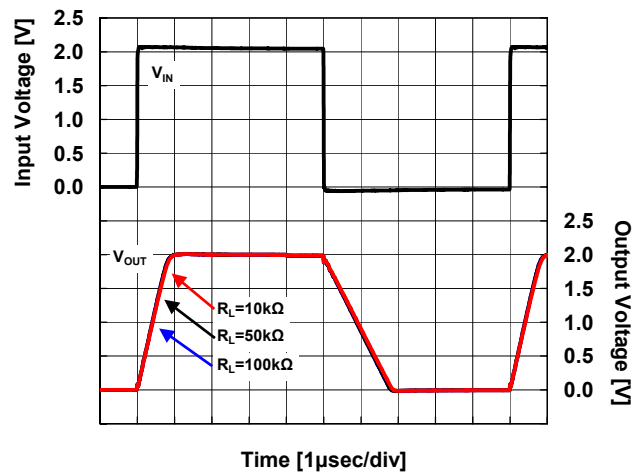
### Pulse Response

$V^+=5V, V_{COM}=V^+/2, V_{IN}=4V_{PP}, f_{IN}=100kHz, R_L=50k\Omega, T_a=25^\circ C$



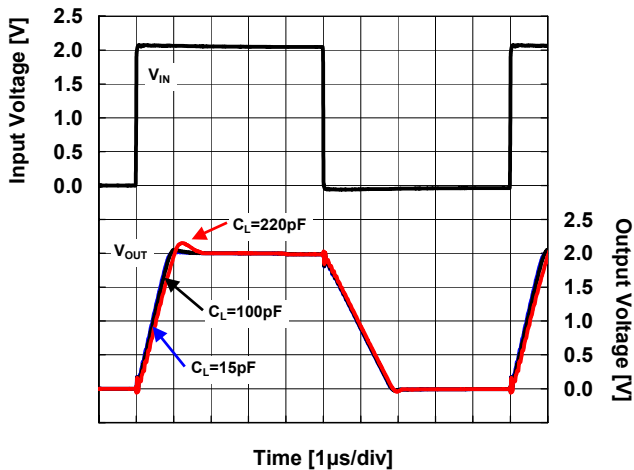
### Pulse Response

$V^+=3V, V_{COM}=V^+/2, V_{IN}=2V_{PP}, f_{IN}=100kHz, C_L=15pF, T_a=25^\circ C$



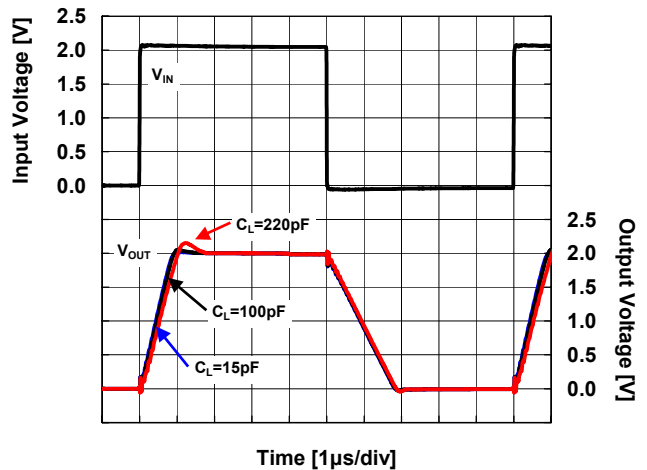
### Pulse Response

$V^+=3V, V_{COM}=V^+/2, V_{IN}=2V_{PP}, f_{IN}=100kHz, R_L=50k\Omega, T_a=25^\circ C$



### Pulse Response

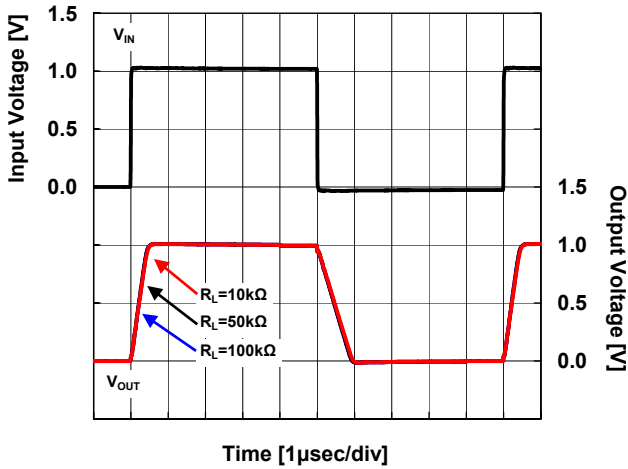
$V^+=3V, V_{COM}=V^+/2, V_{IN}=2V_{PP}, f_{IN}=100kHz, R_L=50k\Omega, T_a=25^\circ C$



## ■ TYPICAL CHARACTERISTICS

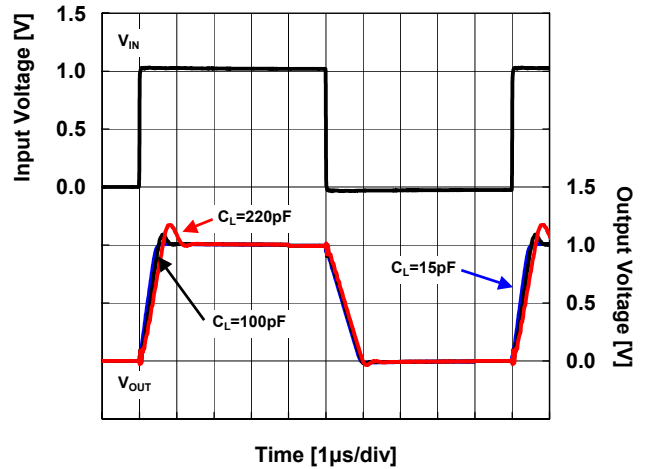
**Pulse Response**

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



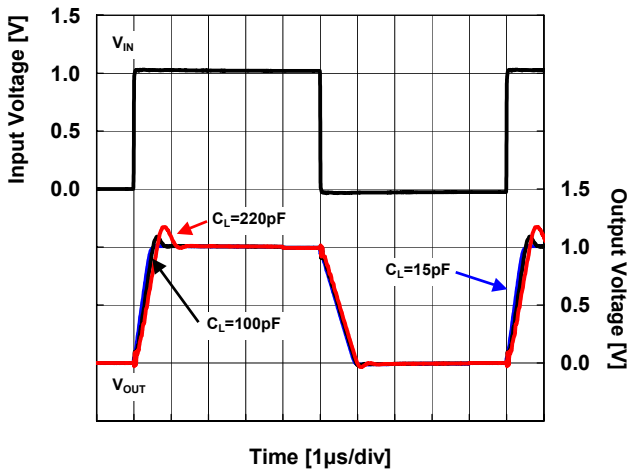
**Pulse Response**

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



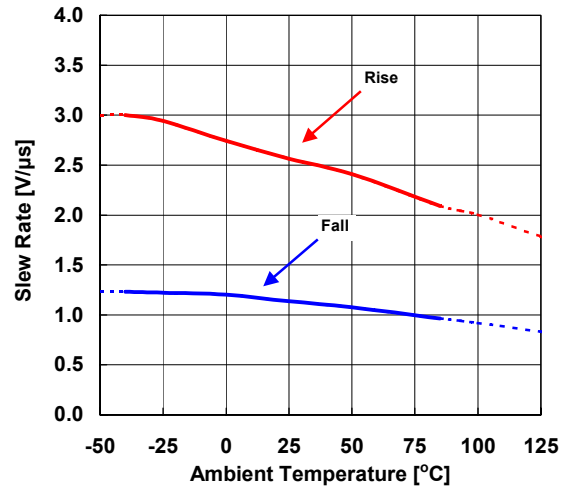
**Pulse Response**

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



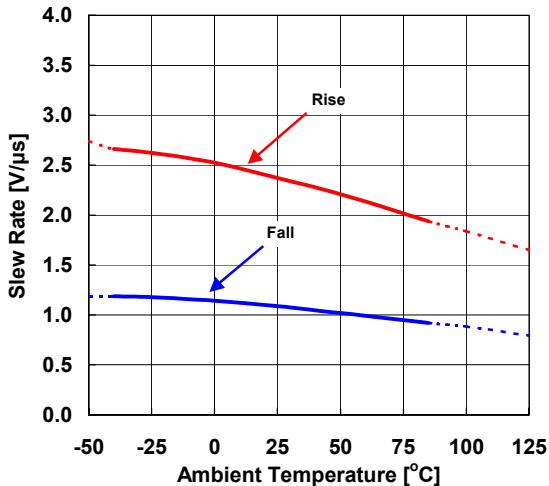
**Slew Rate vs. Ambient Temperature**

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



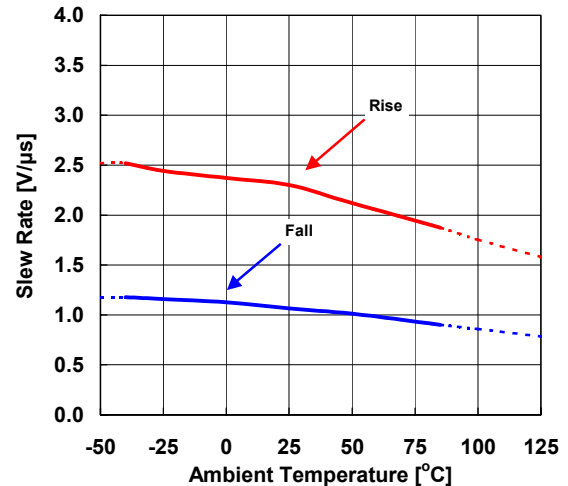
**Slew Rate vs. Ambient Temperature**

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

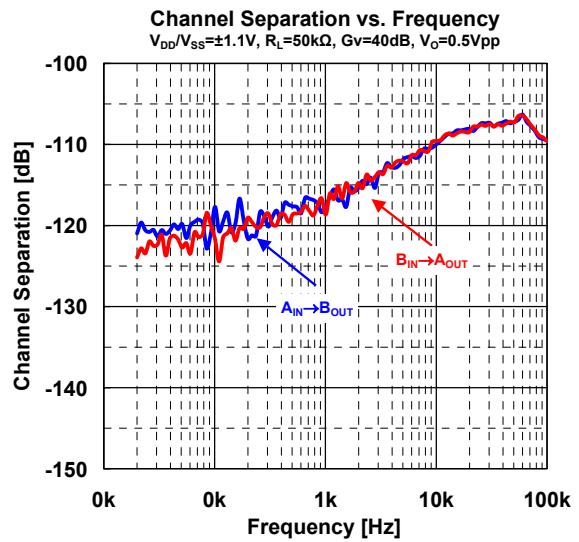
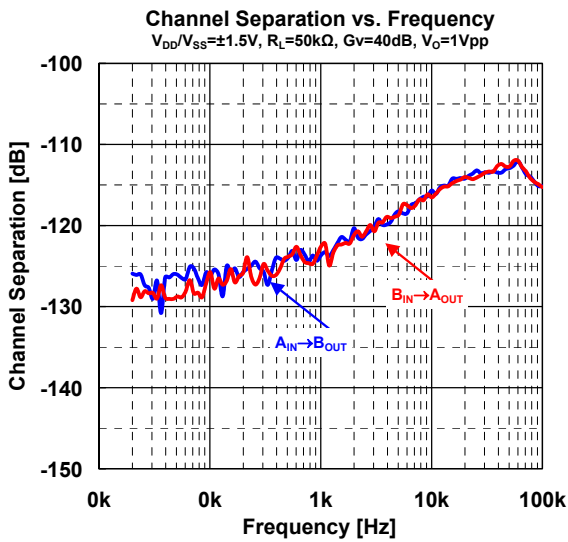
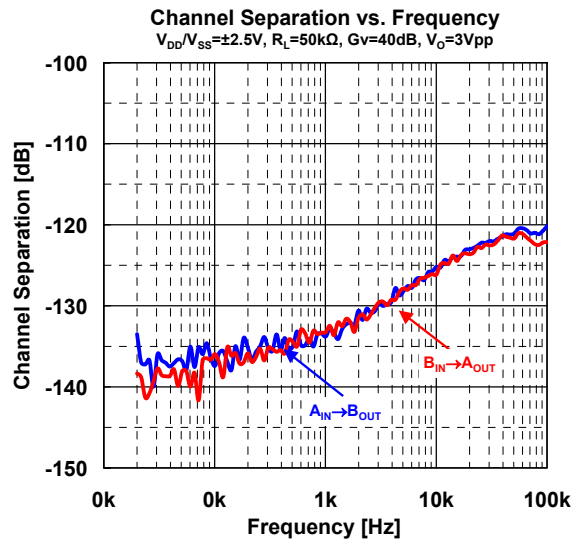
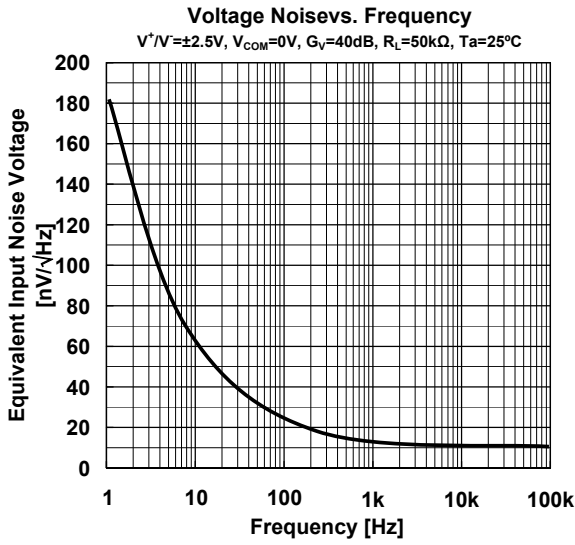


**Slew Rate vs. Ambient Temperature**

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



## ■ TYPICAL CHARACTERISTICS



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