# 13μA/ch, Rail-to-Rail Output Dual CMOS Operational Amplifier

## ■ GENERAL DESCRIPTION

**The NJU7027** is a Rail-to-Rail output single supply dual CMOS operational amplifier with a low operating current of 13μA per channel and high RF noise immunity. It offers a single supply voltage operation from +1.8V to +5.5V, rail-to-rail output swing in the rails and input voltage range from ground. Further the NJU7027 has a low bias current of 1pA, which makes it well-suited for a low side current sense amplifier combining with input voltage range from ground. The combination of low voltage operation, low operating current and rail-to-rail output swing makes it well-suited for a wide variety of battery powered applications. The NJU7027 is available in a small surface mount package of MSOP8 (TVSP8) and an ultra small lead-less package of ESON8.

## ■ PACKAGE OUTLINE

**NJU7027RB1**
**(MSOP8 (TVSP8))**

**NJU7027KU1**
**(ESON8)**

## ■ FEATURES

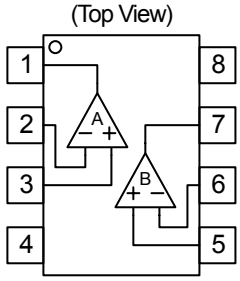
| | |
|---|---|
| •Low Operating Current | 13μA/ch typ. (at $V_{DD}$= 5V), 12μA/ch typ. (at $V_{DD}$= 3V)<br>11μA/ch typ. (at $V_{DD}$= 1.8V) |
| •Low Operating Voltage | Vopr= 1.8V to 5.5V |
| •Rail-to-Rail Output | $V_{OH}$=4.9V min./ $V_{OL}$=0.1V max. (at $V_{DD}$= 5V, $R_L$=100kΩ)<br>$V_{OH}$=4.8V min./ $V_{OL}$=0.2V max. (at $V_{DD}$= 5V, $I_O$=1mA) |
| •Package | MSOP8 (TVSP8) MEET JEDEC MO-187-DA / THIN TYPE ,<br>ESON8(2.0mm x 2.0mm) |
| •RF Noise Immunity | reducing troubles caused by RF noise from mobile phones |
| •CMOS Process | |

## ■ APPLICATION

- •Battery-operated application
- •Battery monitor
- •Current sensor
- •Photodiode amplification

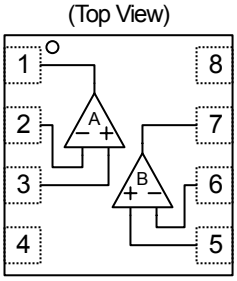
## ■ PIN CONFIGURATION

(Top View)

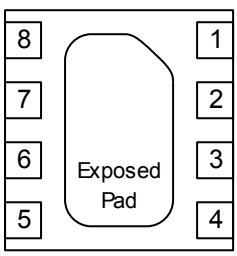



**NJU7027RB1**

(Top View)




(Bottom View)




**NJU7027KU1**

About Exposed Pad
Connect the Exposed Pad on the GND.

**PIN FUNCTION**

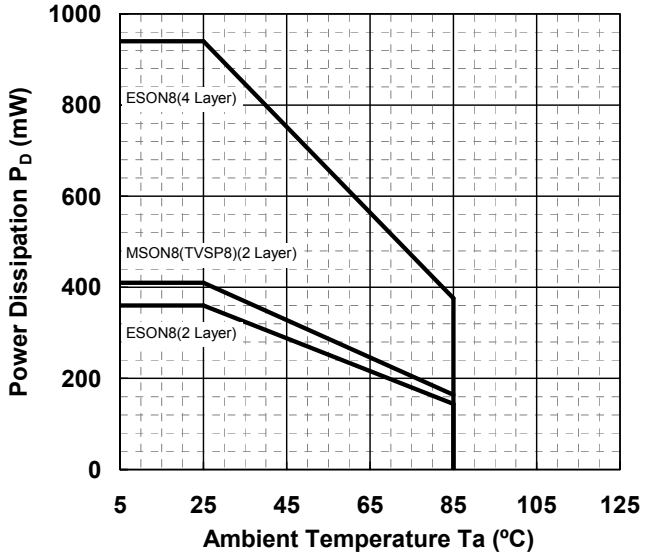
1. A OUTPUT
2. A -INPUT
3. A +INPUT
4. $V_{SS}$
5. B +INPUT
6. B –INPUT
7. B OUTPUT
8. $V_{DD}$

## ■ ABSOLUTE MAXIMUM RATINGS (Ta=25°C, unless otherwise noted.)

| PARAMETER | SYMBOL | RATINGS | UNIT |
|---|---|---|---|
| Supply Voltage | $V_{DD}$ | +7 | V |
| Input Common Mode Voltage | $V_{ICM}$ | $V_{SS}$-0.3 to $V_{DD}$+0.3 | V |
| Differential Input Voltage | $V_{ID}$ | ±7 (Note1) | V |
| Power Dissipation | $P_D$ | (MSOP8 (TVSP8))410 (Note2)<br>(ESON8) 360 (Note2)<br>(ESON8) 940 (Note3) | mW |
| Operating Temperature Range | $T_{opr}$ | -40 to +85 | °C |
| Storage Temperature Range | $T_{stg}$ | -55 to +125 | °C |

(Note1) For supply voltage less than +7V, the absolute maximum rating is equal to the supply voltage.
(Note2) EIA/JEDEC STANDARD Test board (76.2 x 114.3 x 1.6mm, 2 layers, FR-4) mounting.
(Note3) EIA/JEDEC STANDARD Test board (76.2 x 114.3 x 1.6mm, 4 layers, FR-4) mounting.
(Note4) Do not exceed "Power dissipation: $P_D$" in which power dissipation in IC is shown by the absolute maximum rating.
See Figure "Power Dissipation Curve" when ambient temperature is over 25°C.

**Figure1**
**Power Dissipation Derating Curve**




| Pkg. | ΔPd (mW/ºC) | Pd (25ºC) | Pd (85ºC) |
|---|---|---|---|
| MSON8(TVSP8)(2 Layer) | -4.10 | 410 | 164 |
| ESON8(2 Layer) | -3.60 | 360 | 144 |
| ESON8(4 Layer) | -9.40 | 940 | 376 |

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

| PARAMETER | SYMBOL | RATING | UNIT |
|---|---|---|---|
| Supply Voltage | $V_{DD}$ | 1.8 to 5.5 | V |

## ■ ELECTRICAL CHARACTERISTICS

**DC CHARACTER** ($V_{DD}$=5V, $V_{SS}$=0V, Ta=25˚C, unless otherwise noted.)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Supply Current | $I_{DD}$ | No Signal | - | 26 | 40 | μA |
| Input Offset Voltage | $V_{IO}$ | Vic=0V, $R_S$=50Ω | - | 0.9 | 4 | mV |
| Input Offset Voltage drift | ΔVio/ΔT | | - | 1.5 | - | μV/ºC |
| Input Bias Current | $I_B$ | | - | 1 | - | pA |
| Input Offset Current | $I_{IO}$ | | - | 1 | - | pA |
| Open loop gain | $A_V$ | Vo=0.5V to 4.5V, $R_L$=100kΩ to 2.5V | 70 | 90 | - | dB |
| Common Mode Rejection Ratio | CMR | $V_{ICM}$=0V to 4.1V | 65 | 80 | - | dB |
| Supply Voltage Rejection Ratio | SVR | $V_{DD}$=1.8V to 5.5V | 70 | 90 | - | dB |
| Maximum Output Voltage 1 | $V_{OH}$1 | $R_L$=100kΩ to 2.5V | 4.9 | 4.95 | - | V |
| | $V_{OL}$1 | $R_L$=100kΩ to 2.5V | - | 0.05 | 0.1 | V |
| Maximum Output Voltage 2 | $V_{OH}$2 | $R_L$=100kΩ to 0V | 4.9 | 4.95 | - | V |
| | $V_{OL}$2 | $R_L$=100kΩ to 0V | - | 0.02 | 0.05 | V |
| Maximum Output Voltage 3 | $V_{OH}$3 | Isource=1mA | 4.8 | 4.85 | - | V |
| | $V_{OL}$3 | Isink=1mA | - | 0.15 | 0.2 | V |
| Common Mode Input Voltage Range | $V_{ICM}$ | CMR≥65dB | 0 | - | 4.1 | V |

**AC CHARACTER** ($V_{DD}$=5V, $V_{SS}$=0V, Ta=25˚C, unless otherwise noted.)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Gain Bandwidth Product | GBW | $R_L$=100kΩ to 2.5V, $C_L$=20pF, f=10kHz | - | 160 | - | kHz |
| Phase Margin | $\phi_M$ | $R_L$=100kΩ to 2.5V, $C_L$=20pF | - | 80 | - | deg |
| Gain Margin | $G_M$ | $R_L$=100kΩ to 2.5V, $C_L$=20pF | - | 15 | - | dB |
| Equivalent Input Noise Voltage | $e_n$ | f=1kHz | - | 50 | - | nV/√Hz |
| Channel Separation | CS | f=1kHz | - | 120 | - | dB |
| Slew Rate | SR | $G_V$=0dB, $R_L$=100kΩ to 2.5V, $C_L$=20pF, Vin=3Vpp (1V to 4V) (Note5), (Note6) | - | 0.05 | - | V/us |
| Power Bandwidth | PBW | $G_V$=6dB, $R_F$=50kΩ, $R_G$=50kΩ, $C_L$=20pF, Vin=2.5Vpp (1.25V to 3.75V), Vo≥4.8Vpp (Note7) | - | 5 | - | kHz |
| Total Harmonic Distortion | THD | $G_V$=6dB, $R_F$=50kΩ, $R_G$=50kΩ, $C_L$=20pF, Vo=4Vpp, f=100Hz (Note7) | - | 0.01 | - | % |

(Note5) Slew rate is defined by the lower value of the rise or fall.

(Note6) See figure2-1 for test circuit.

(Note7) See figure2-3 for test circuit.

## ■ ELECTRICAL CHARACTERISTICS

**DC CHARACTER** ($V_{DD}$=3V, $V_{SS}$=0V, Ta=25˚C, unless otherwise noted.)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Supply Current | $I_{DD}$ | No Signal | - | 24 | 36 | μA |
| Input Offset Voltage | $V_{IO}$ | Vic=0V, $R_S$=50Ω | - | 0.9 | 4 | mV |
| Input Offset Voltage drift | ΔVio/ΔT | | - | 1.5 | - | μV/ºC |
| Input Bias Current | $I_B$ | | - | 1 | - | pA |
| Input Offset Current | $I_{IO}$ | | - | 1 | - | pA |
| Open loop gain | $A_V$ | Vo=0.5V to 2.5V, $R_L$=100kΩ to 1.5V | 70 | 90 | - | dB |
| Common Mode Rejection Ratio | CMR | $V_{ICM}$=0V to 2.1V | 65 | 80 | - | dB |
| Supply Voltage Rejection Ratio | SVR | $V_{DD}$=1.8V to 5.5V | 70 | 90 | - | dB |
| Maximum Output Voltage 1 | $V_{OH}$1 | $R_L$=100kΩ to 1.5V | 2.9 | 2.95 | - | V |
| | $V_{OL}$1 | $R_L$=100kΩ to 1.5V | - | 0.05 | 0.1 | V |
| Maximum Output Voltage 2 | $V_{OH}$2 | $R_L$=100kΩ to 0V | 2.9 | 2.95 | - | V |
| | $V_{OL}$2 | $R_L$=100kΩ to 0V | - | 0.02 | 0.05 | V |
| Maximum Output Voltage 3 | $V_{OH}$3 | Isource=1mA | 2.8 | 2.85 | - | V |
| | $V_{OL}$3 | Isink=1mA | - | 0.15 | 0.2 | V |
| Common Mode Input Voltage Range | $V_{ICM}$ | CMR≥65dB | 0 | - | 2.1 | V |

**AC CHARACTER** ($V_{DD}$=3V, $V_{SS}$=0V, Ta=25˚C, unless otherwise noted.)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Gain Bandwidth Product | GBW | $R_L$=100kΩ to 1.5V, $C_L$=20pF, f=10kHz | - | 150 | - | kHz |
| Phase Margin | $\phi_M$ | $R_L$=100kΩ to 1.5V, $C_L$=20pF | - | 80 | - | deg |
| Gain Margin | $G_M$ | $R_L$=100kΩ to 1.5V, $C_L$=20pF | - | 15 | - | dB |
| Equivalent Input Noise Voltage | $e_n$ | f=1kHz | - | 50 | - | nV/√Hz |
| Channel Separation | CS | f=1kHz | - | 115 | - | dB |
| Slew Rate | SR | $G_V$=0dB, $R_L$=100kΩ to 1.5V, $C_L$=20pF, Vin=1Vpp (1V to 2V) (Note5), (Note6) | - | 0.05 | - | V/us |
| Power Bandwidth | PBW | $G_V$=6dB, $R_F$=50kΩ, $R_G$=50kΩ, $C_L$=20pF, Vin=1.5Vpp (0.75V to 2.25V), Vo≥2.8Vpp (Note7) | - | 8 | - | kHz |
| Total Harmonic Distortion | THD | $G_V$=6dB, $R_F$=50kΩ, $R_G$=50kΩ, $C_L$=20pF, Vo=2Vpp, f=100Hz (Note7) | - | 0.01 | - | % |

(Note5) Slew rate is defined by the lower value of the rise or fall.

(Note6) See figure2-1 for test circuit.

(Note7) See figure2-3 for test circuit.

## ■ ELECTRICAL CHARACTERISTICS

**DC CHARACTER** ($V_{DD}$=1.8V, $V_{SS}$=0V, Ta=25˚C, unless otherwise noted.)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Supply Current | $I_{DD}$ | No Signal | - | 22 | 34 | μA |
| Input Offset Voltage | $V_{IO}$ | Vic=0V, $R_S$=50Ω | - | 0.9 | 4 | mV |
| Input Offset Voltage drift | ΔVio/ΔT | | - | 1.5 | - | μV/ºC |
| Input Bias Current | $I_B$ | | - | 1 | - | pA |
| Input Offset Current | $I_{IO}$ | | - | 1 | - | pA |
| Open loop gain | $A_V$ | Vo=0.5V to 2.5V, $R_L$=100kΩ to 0.9V | 70 | 90 | - | dB |
| Common Mode Rejection Ratio | CMR | $V_{ICM}$=0V to 0.9V | 65 | 80 | - | dB |
| Supply Voltage Rejection Ratio | SVR | $V_{DD}$=1.8V to 5.5V | 70 | 90 | - | dB |
| Maximum Output Voltage 1 | $V_{OH}$1 | $R_L$=100kΩ to 0.9V | 1.7 | 1.75 | - | V |
| | $V_{OL}$1 | $R_L$=100kΩ to 0.9V | - | 0.05 | 0.1 | V |
| Maximum Output Voltage 2 | $V_{OH}$2 | $R_L$=100kΩ to 0V | 1.7 | 1.75 | - | V |
| | $V_{OL}$2 | $R_L$=100kΩ to 0V | - | 0.02 | 0.05 | V |
| Maximum Output Voltage 3 | $V_{OH}$3 | Isource=0.5mA | 1.5 | 1.55 | - | V |
| | $V_{OL}$3 | Isink=0.5mA | - | 0.25 | 0.3 | V |
| Common Mode Input Voltage Range | $V_{ICM}$ | CMR≥65dB | 0 | - | 0.9 | V |

**AC CHARACTER** ($V_{DD}$=1.8V, $V_{SS}$=0V, Ta=25˚C, unless otherwise noted.)

| PARAMETER | SYMBOL | TEST CONDITION | MIN. | TYP. | MAX. | UNIT |
|---|---|---|---|---|---|---|
| Gain Bandwidth Product | GBW | $R_L$=100kΩ to 0.9V, $C_L$=20pF, f=10kHz | - | 140 | - | kHz |
| Phase Margin | $\phi_M$ | $R_L$=100kΩ to 0.9V, $C_L$=20pF | - | 80 | - | deg |
| Gain Margin | $G_M$ | $R_L$=100kΩ to 0.9V, $C_L$=20pF | - | 15 | - | dB |
| Equivalent Input Noise Voltage | $e_n$ | f=1kHz | - | 50 | - | nV/√Hz |
| Channel Separation | CS | f=1kHz | - | 110 | - | dB |
| Slew Rate | SR | $G_V$=0dB, $R_L$=100kΩ to 1.5V, $C_L$=20pF, Vin=0.5Vpp (0.3V to 0.8V) (Note5), (Note8) | - | 0.05 | - | V/us |
| Power Bandwidth | PBW | $G_V$=6dB, $R_F$=50kΩ, $R_G$=50kΩ, $C_L$=20pF, Vin=0.9Vpp (0V to 0.9V), Vo≥1.6Vpp (Note9) | - | 14 | - | kHz |
| Total Harmonic Distortion | THD | $G_V$=6dB, $R_F$=50kΩ, $R_G$=50kΩ, $C_L$=20pF, Vo=1Vpp, f=100Hz (Note9) | - | 0.01 | - | % |

(Note5) Slew rate is defined by the lower value of the rise or fall.

(Note8) See figure2-2 for test circuit.

(Note9) See figure2-4 for test circuit..

## ■ MEASUREMENT CIRCUITS

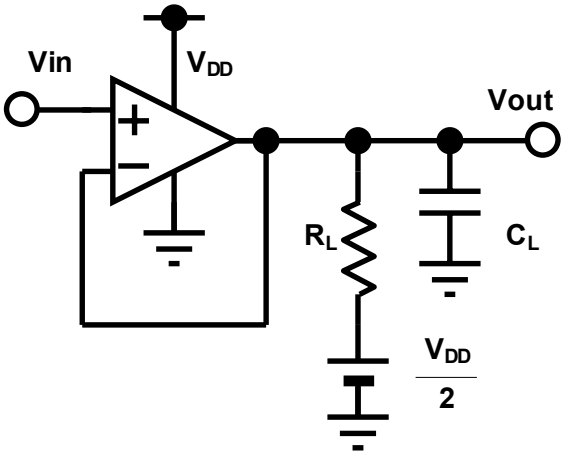



Figure 2-1:Measurement circuit 1

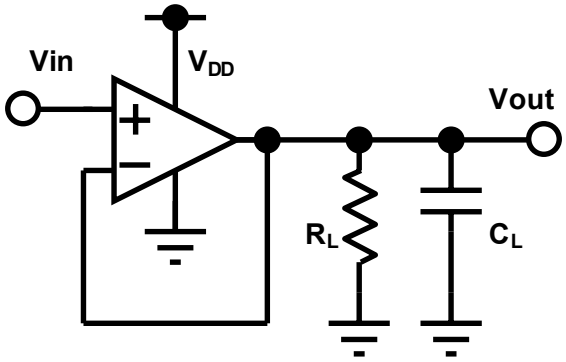



Figure 2-2:Measurement circuit 2

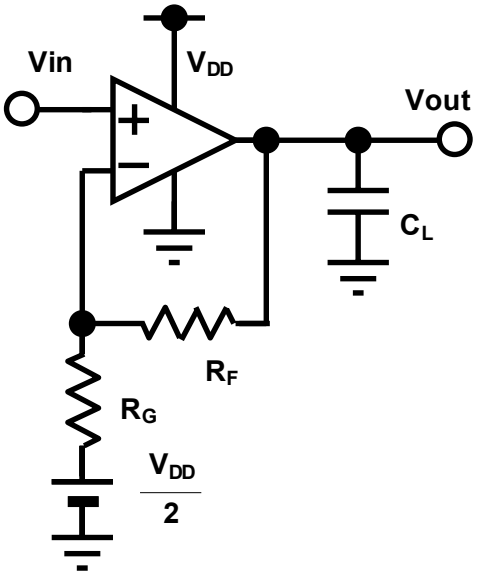



Figure 2-3:Measurement circuit 3

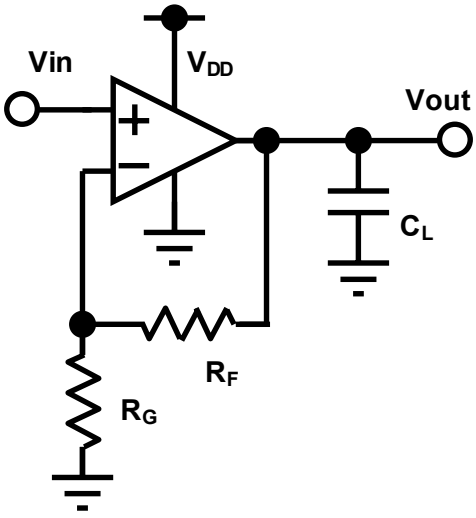
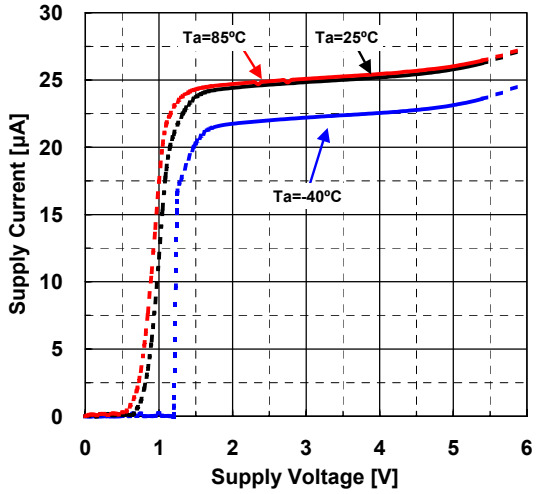


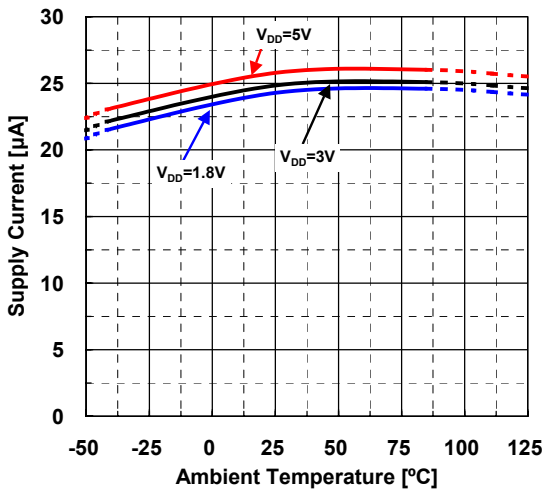

Figure 2-4:Measurement circuit 4

## ■ TYPICAL CHARACTERISTICS

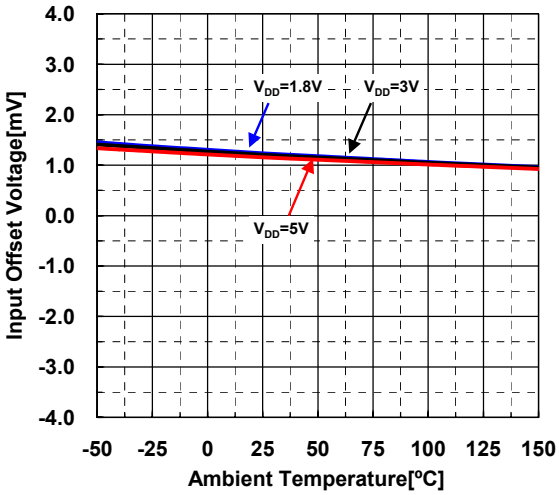
Supply Current vs. Supply Voltage
$G_V$=0dB



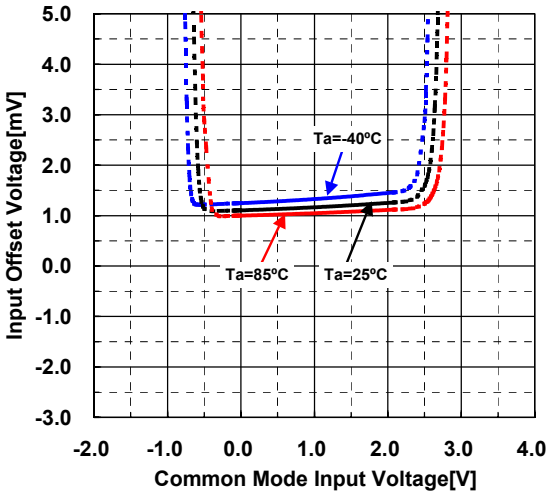

Supply Current vs. Temperature
$G_V$=0dB



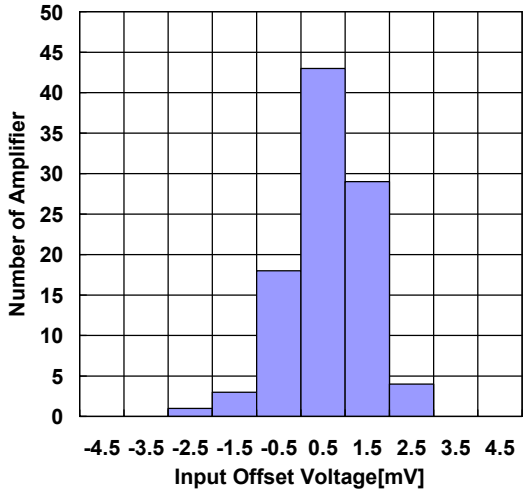

Input Offset Voltage vs. Temperature
$V_{ICM}=V_{DD}/2$



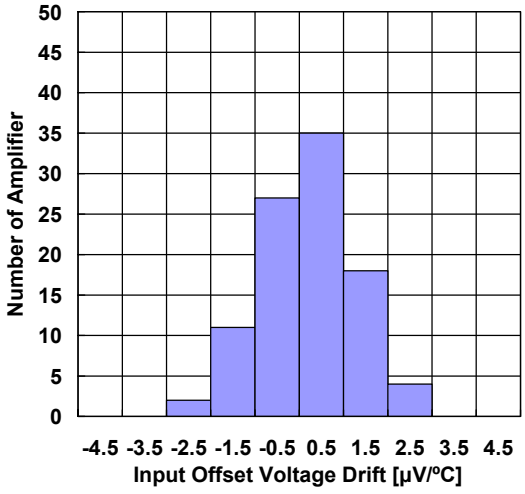

Input Offset Voltage vs.
Common Mode Input Voltage
$V_{DD}$=3V




Input Offset Voltage Distribution
$V_{DD}$=3V, $V_{ICM}$=0V, Ta=25°C, n=100

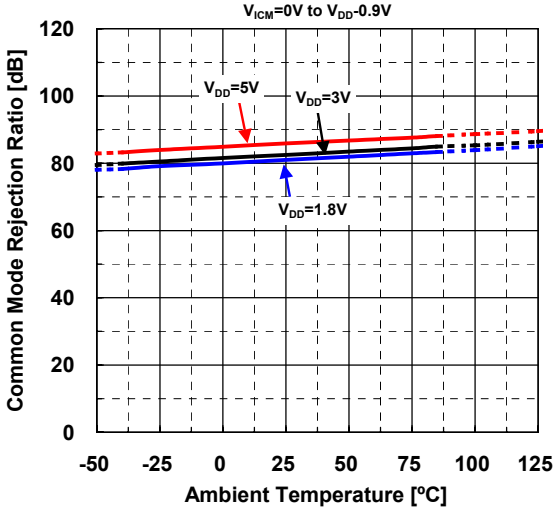



Input Offset Voltage Drift Distribution
$V_{DD}$=3V, $V_{ICM}$=0V, Ta=-40 to 85°C, n=100

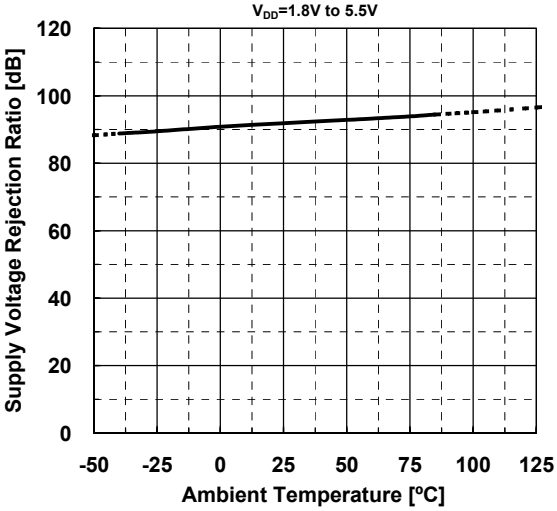


## ■ TYPICAL CHARACTERISTICS

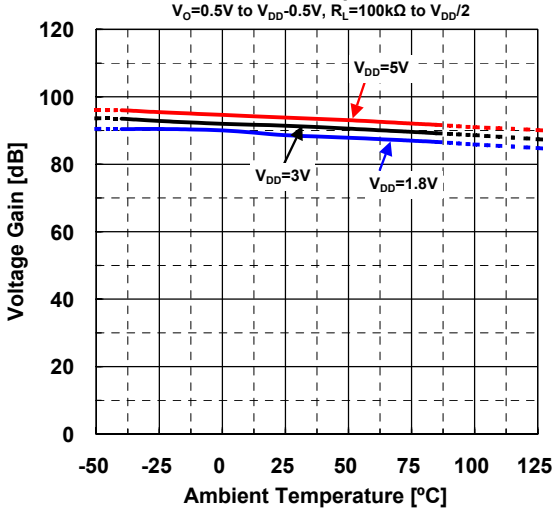
CMR vs. Temperature
$V_{ICM}$=0V to $V_{DD}$-0.9V



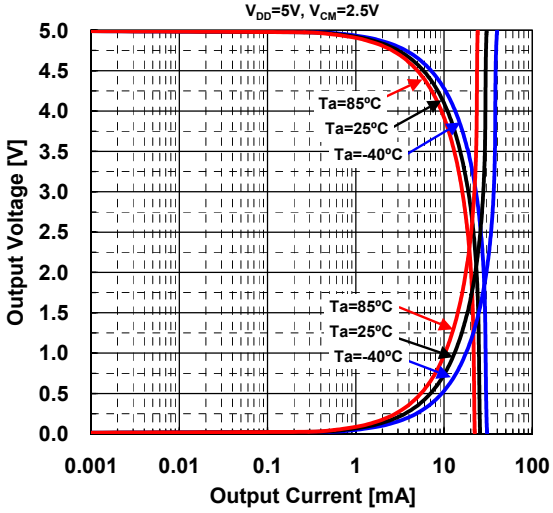

SVR vs. Temperature
$V_{DD}$=1.8V to 5.5V



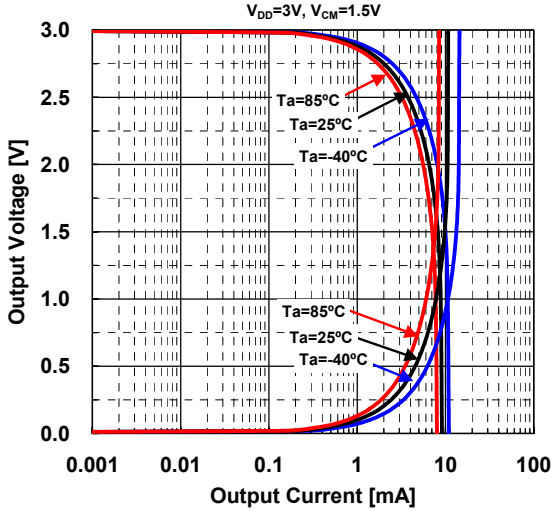

Gain vs. Temperature
$V_O$=0.5V to $V_{DD}$-0.5V, $R_L$=100kΩ to $V_{DD}$/2



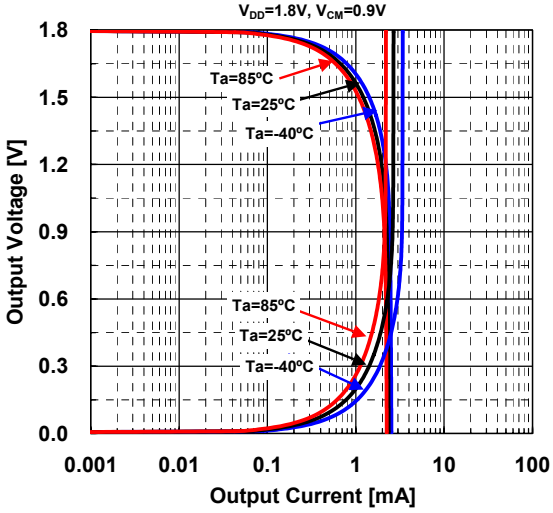

Output Voltage vs. Output Current
$V_{DD}$=5V, $V_{CM}$=2.5V




Output Voltage vs. Output Current
$V_{DD}$=3V, $V_{CM}$=1.5V



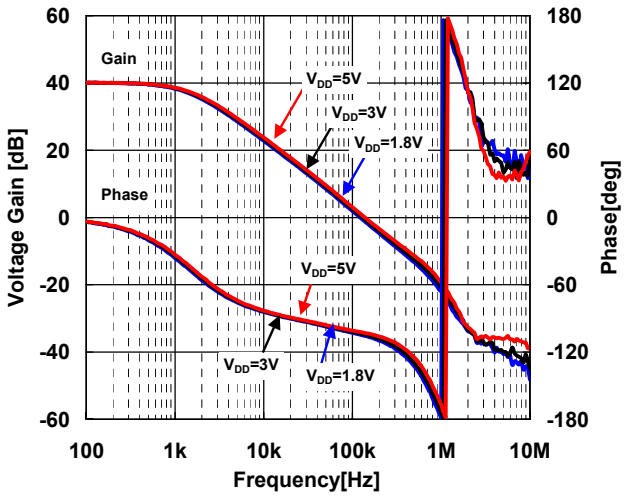

Output Voltage vs. Output Current
$V_{DD}$=1.8V, $V_{CM}$=0.9V



## ■ TYPICAL CHARACTERISTICS

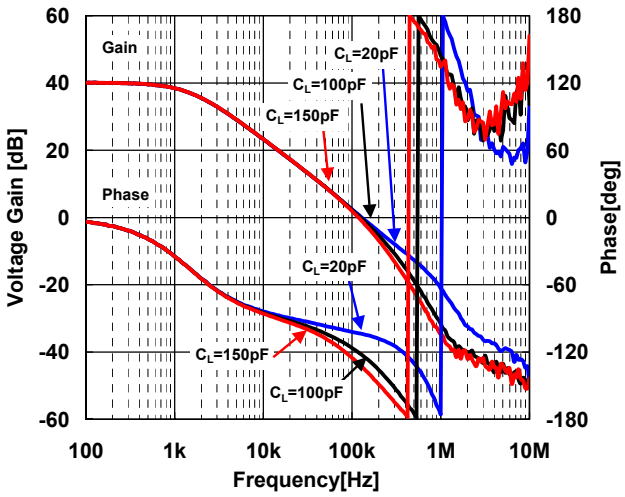
Gain/Phase vs. Frequency

$R_F$=1MΩ, $R_G$=1KΩ, $R_L$=100KΩ, $C_L$=20pF, Ta=25°C



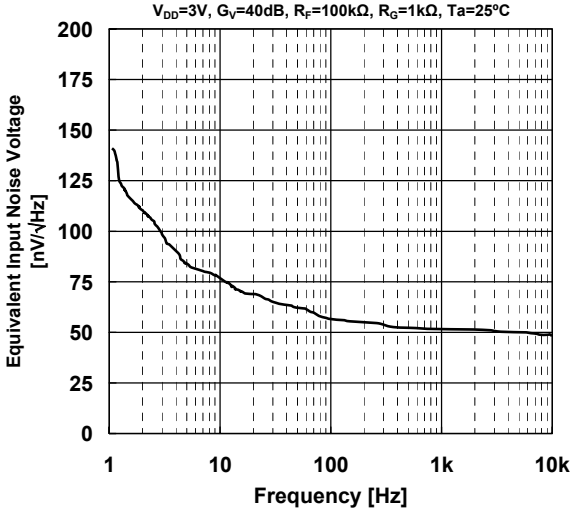

Gain/Phase vs. Frequency

$V_{DD}$=3V, $R_F$=1MΩ, $R_G$=1kΩ, $R_L$=100kΩ, Ta=25°C




Voltage Noise vs. Frequency

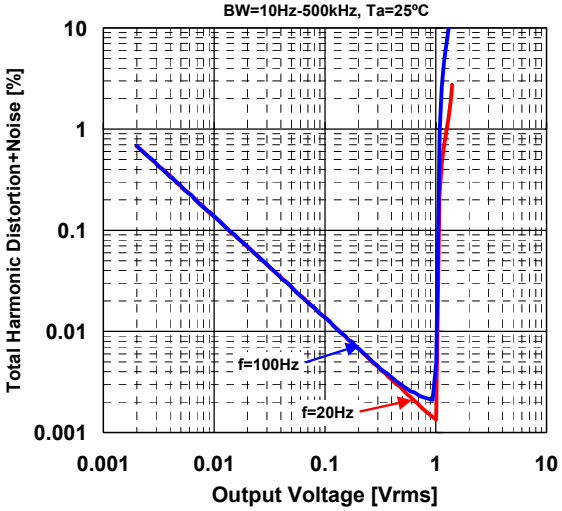
$V_{DD}$=3V, $G_V$=40dB, $R_F$=100kΩ, $R_G$=1kΩ, Ta=25°C




THD+Noise vs. Output Voltage

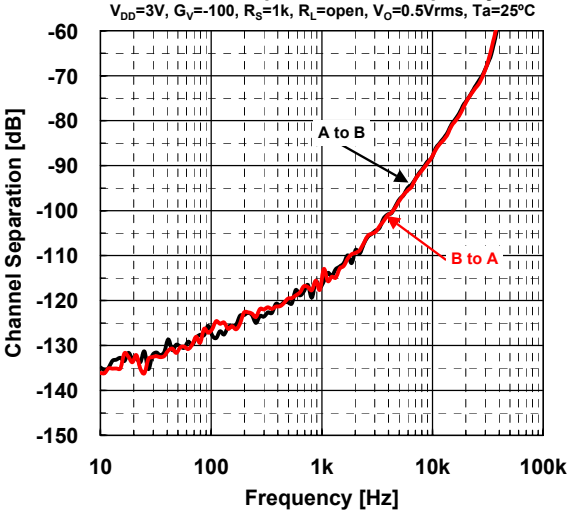
$V_{DD}$=3V, Gv=6dB, $R_F$=50kΩ, $C_L$=20pF

BW=10Hz-500kHz, Ta=25°C




Channel Separation vs. Frequency

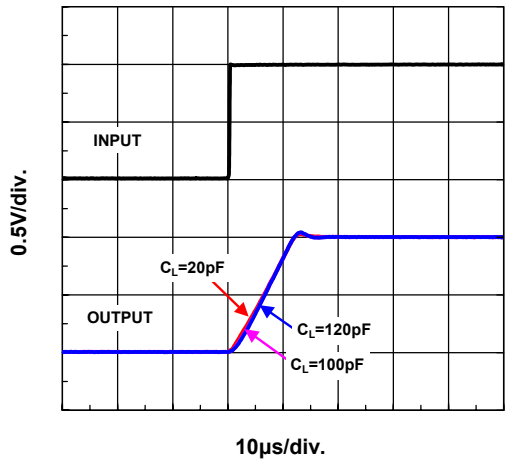
$V_{DD}$=3V, $G_V$=-100, $R_S$=1k, $R_L$=open, $V_O$=0.5Vrms, Ta=25°C



## ■ TYPICAL CHARACTERISTICS

**Pulse Response**

$V_{DD}$=3V, Gv=0dB, $R_L$=100kΩ, Ta=25ºC




**Pulse Response**

$V_{DD}$=3V, Gv=0dB, $R_L$=100kΩ, Ta=25ºC