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

■ GENERAL DESCRIPTION

The **NJU7028** is a low power, quad CMOS operational amplifier. It is tolerant to RF noise. The NJU7028 can operate from a single-supply voltage of +1.8V to +5.5V. In addition, this amplifier features Rail-to-Rail output and low input bias current (1pA). Because of these features, the NJU7028 is ideal for low-side current sense amplifier. The very low supply current of the NJU7028 (13µA/ch) makes it suitable for battery-operated application.

■ PACKAGE OUTLINE

NJU7028V
(SSOP14)

■ FEATURES

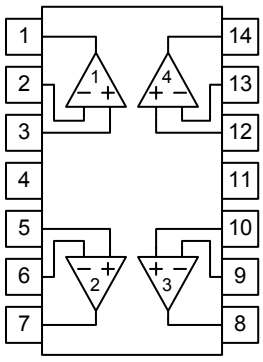
●Low Supply Current	I_{DD}=13µA/ch typ.
●Low Operating Voltage	Vopr= 1.8V to 5.5V
●Rail-to-Rail Output	V_{OH}=4.9V min./ V_{OL}=0.1V max. (at V_{DD}= 5V, R_L=100kΩ)
	V_{OH}=4.8V min./ V_{OL}=0.2V max. (at V_{DD}= 5V, I_O=1mA)
●Enhanced RF Noise Immunity	
●CMOS Process	
●Package	SSOP14

■ APPLICATION

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

■ PIN CONFIGURATION

Top View



Pin Function

1. OUTPUT 1	**8. OUTPUT 3**
2. -INPUT 2	**9. -INPUT 3**
3. +INPUT 2	**10. +INPUT 3**
4. V_{DD}	**11. V_{SS}**
5. +INPUT 2	**12. +INPUT 4**
6. -INPUT 2	**13. -INPUT 4**
7. OUTPUT 2	**14. OUTPUT 4**

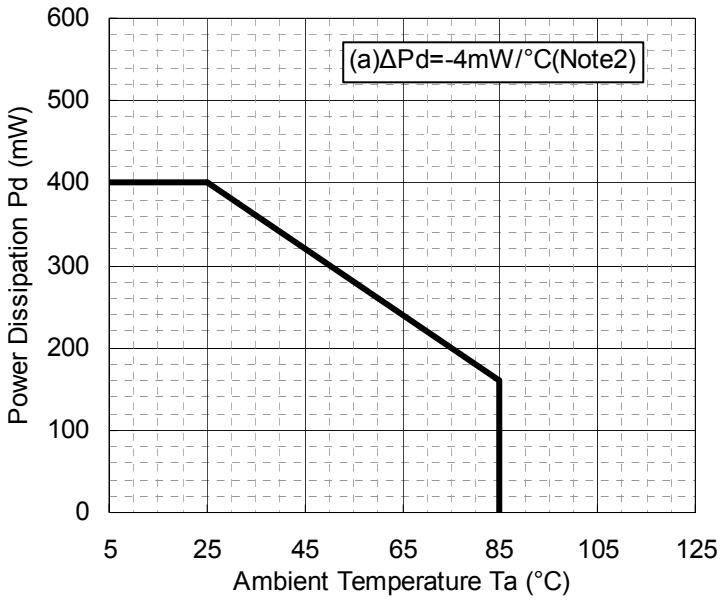
■ **ABSOLUTE MAXIMUM RATINGS** (Ta=25˚C, unless otherwise noted.)

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	400 (Note2)	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 (114.3 x 76.2 x 1.6mm, 2layers, FR-4) mounting.
(Note3) 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.

Figure 1

Power Dissipation Derating Curve



■ **RECOMMENDED OPERATING CONDITION** (Ta=25˚C)

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

■ ELECTRICAL CHARACTERISTICS

●DC CHARACTERISTICS (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	-	48	72	μA
Input Offset Voltage	V_{IO}	V_{IC}=0V, R_S=50Ω	-	0.9	4	mV
Input Offset Voltage drift	$\Delta V_{IO}/\Delta T$		-	1.5	-	μV/ºC
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Open loop gain	A_V	V_O=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 CHARACTERISTICS (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	□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
Slew Rate	SR	G_V=0dB, R_L=100kΩ to 2.5V, C_L=20pF, Vin=3Vpp (1V to 4V) (Note4) (Note5)	-	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 (Note6)	-	5	-	kHz
Total Harmonic Distortion	THD	G_V=6dB, R_F=50kΩ, R_G=50kΩ, C_L=20pF, Vo=4Vpp, f=100Hz (Note6)	-	0.01	-	%

(Note4) Slew rate is defined by the lower value of the rise or fall.

(Note5) See figure2-1 for test circuit.

(Note6) See figure2-3 for test circuit.

■ ELECTRICAL CHARACTERISTICS

●DC CHARACTERISTICS (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	-	45	68	μA
Input Offset Voltage	V_{IO}	Vic=0V, R_S=50Ω	-	0.9	4	mV
Input Offset Voltage drift	$\Delta V_{IO}/\Delta T$		-	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 CHARACTERISTICS (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	□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
Slew Rate	SR	G_V=0dB, R_L=100kΩ to 1.5V, C_L=20pF, Vin=1Vpp (1V to 2V) (Note4) (Note5)	-	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 (Note6)	-	8	-	kHz
Total Harmonic Distortion	THD	G_V=6dB, R_F=50kΩ, R_G=50kΩ, C_L=20pF, Vo=2Vpp, f=100Hz (Note6)	-	0.01	-	%

(Note4) Slew rate is defined by the lower value of the rise or fall.

(Note5) See figure2-1 for test circuit.

(Note6) See figure2-3 for test circuit.

■ ELECTRICAL CHARACTERISTICS

●DC CHARACTERISTICS (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	-	43	65	μA
Input Offset Voltage	V_{IO}	Vic=0V, R_S=50Ω	-	0.9	4	mV
Input Offset Voltage drift	$\Delta V_{IO}/\Delta T$		-	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 CHARACTERISTICS (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	□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
Slew Rate	SR	G_V=0dB, R_L=100kΩ to 1.5V, C_L=20pF, Vin=0.5Vpp (0.3V to 0.8V) (Note4) (Note7)	-	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 (Note8)	-	14	-	kHz
Total Harmonic Distortion	THD	G_V=6dB, R_F=50kΩ, R_G=50kΩ, C_L=20pF, Vo=1Vpp, f=100Hz (Note8)	-	0.01	-	%

(Note4) Slew rate is defined by the lower value of the rise or fall.

(Note7) See figure2-2 for test circuit.

(Note8) See figure2-4 for test circuit..

■ MEASUREMENT CIRCUITS

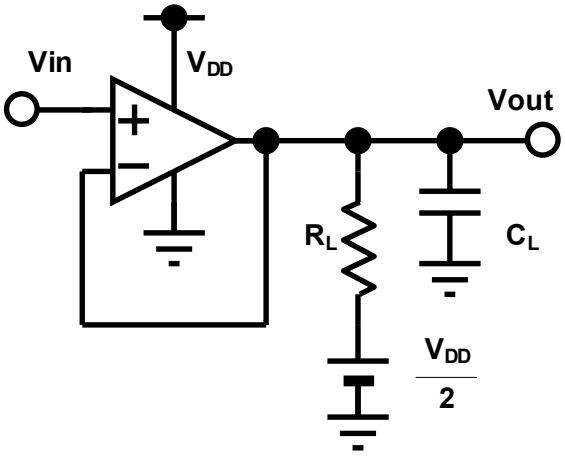


Figure 2-1:Measurement circuit 1

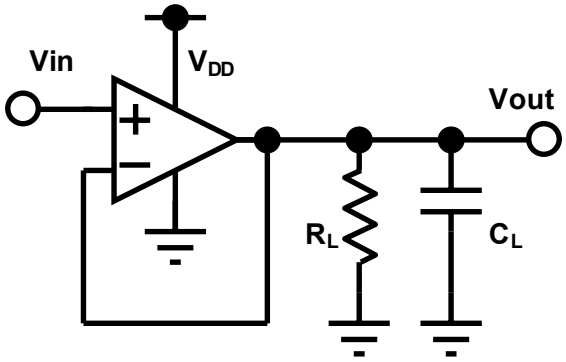


Figure 2-2:Measurement circuit 2

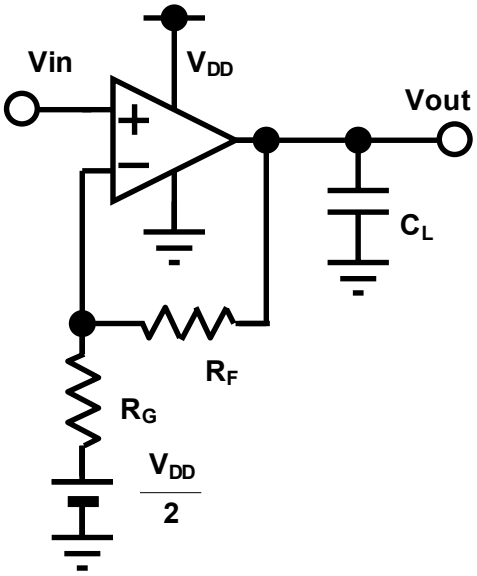


Figure 2-3:Measurement circuit 3

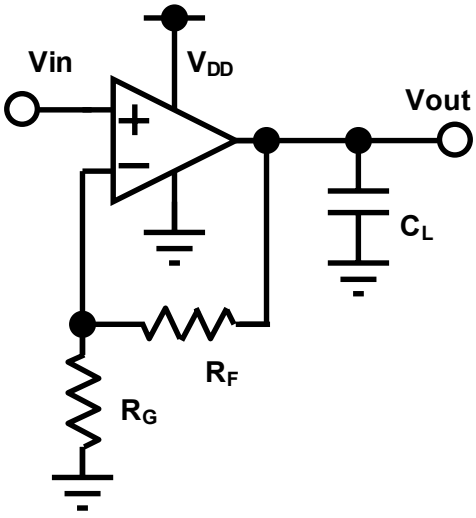
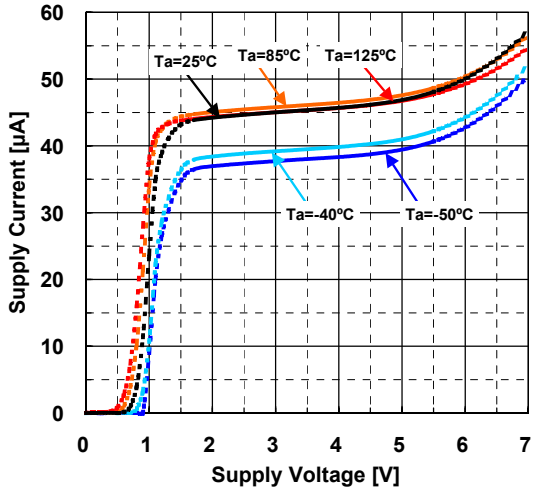


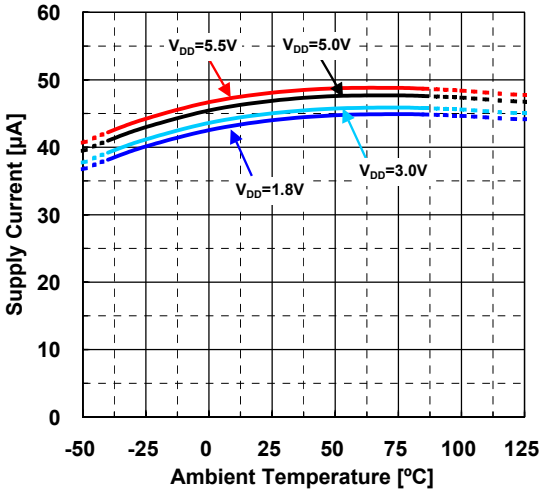
Figure 2-4:Measurement circuit 4

■ TYPICAL CHARACTERISTICS

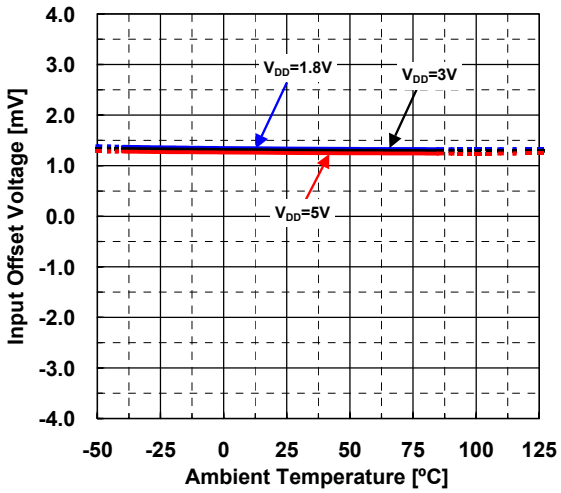
Supply Current vs. Supply Voltage (Temperature)
G_V=0dB



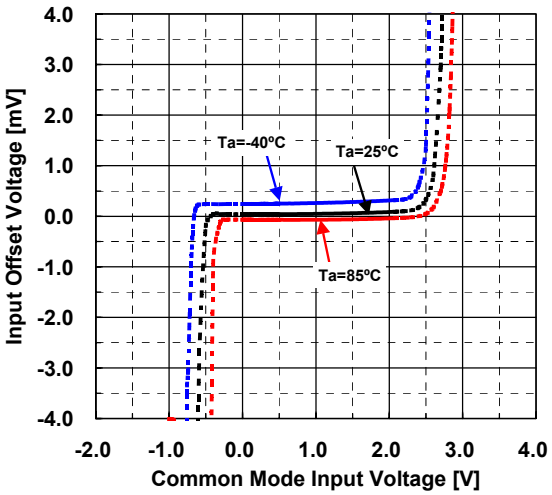
Supply Current vs. Temperature (Supply Voltage)
G_V=0dB



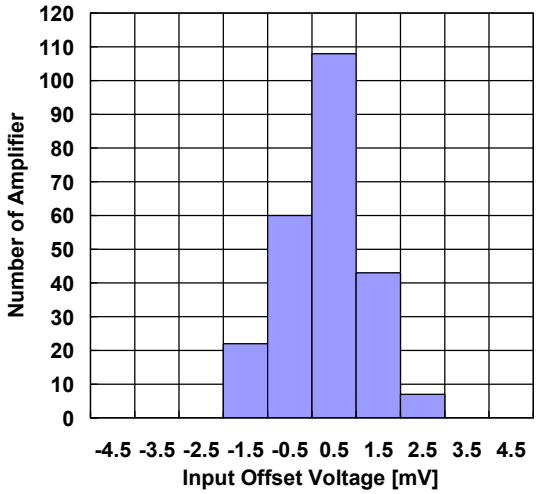
Input Offset Voltage vs. Temperature (Supply Voltage)
V_{ICM}=V_{DD}/2



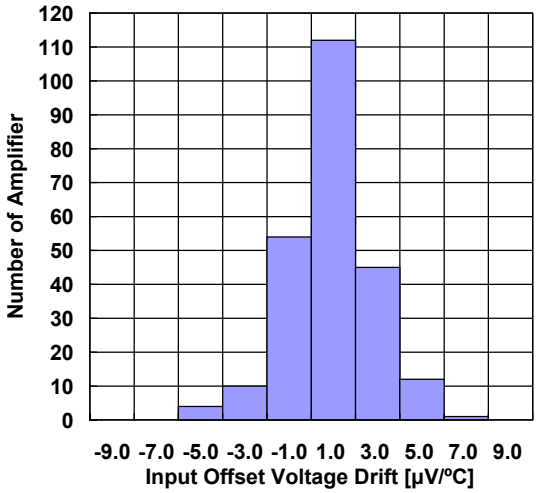
Input Offset Voltage vs. Common Mode Input Voltage (Temperature)
V_{DD}=3V



Input Offset Voltage Distribution
V_{DD}=5V, V_{ICM}=0V, Ta=25ºC, n=240

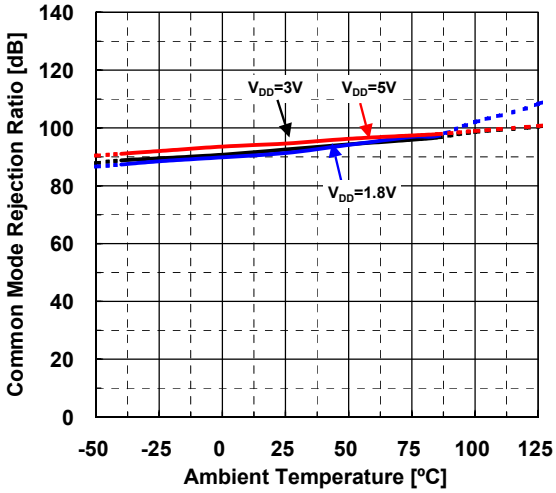


Input Offset Voltage Drift Distribution
V_{DD}=5V, V_{ICM}=0V, Ta=-40 to 85ºC, n=240

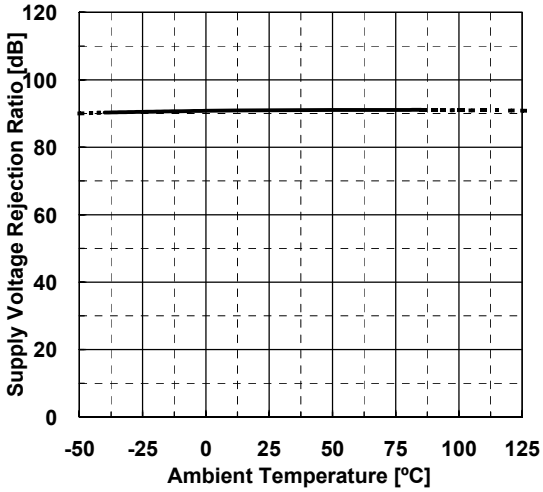


■ TYPICAL CHARACTERISTICS

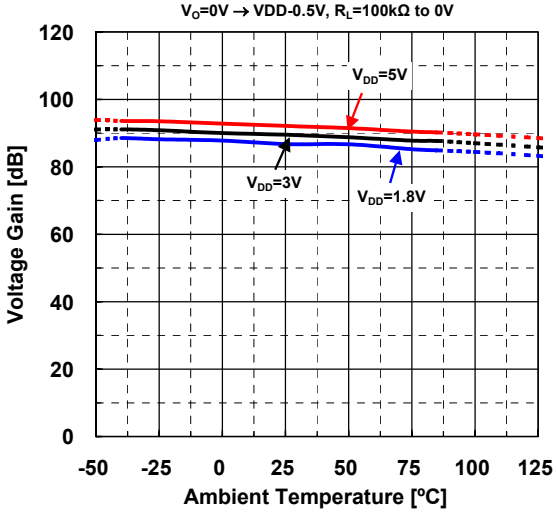
CMR vs. Temperature (Supply Voltage)
V_{ICM}=0V → V_{DD}-0.9V



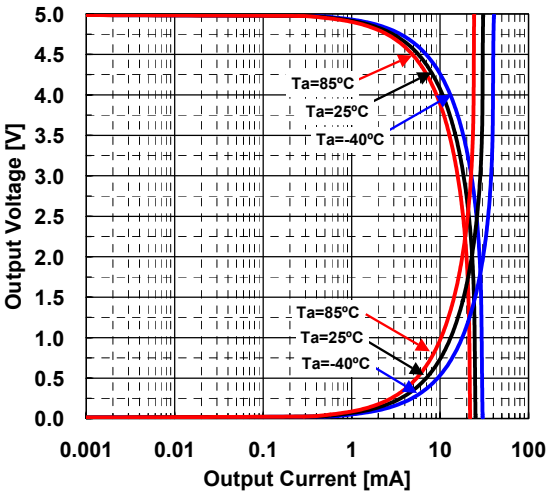
SVR vs. Temperature
V_{DD}=1.8V → 5.5V



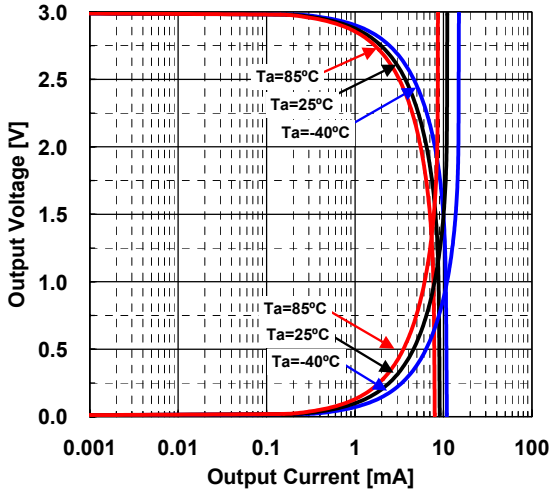
Gain vs. Temperature
V_O=0V → VDD-0.5V, R_L=100kΩ to 0V



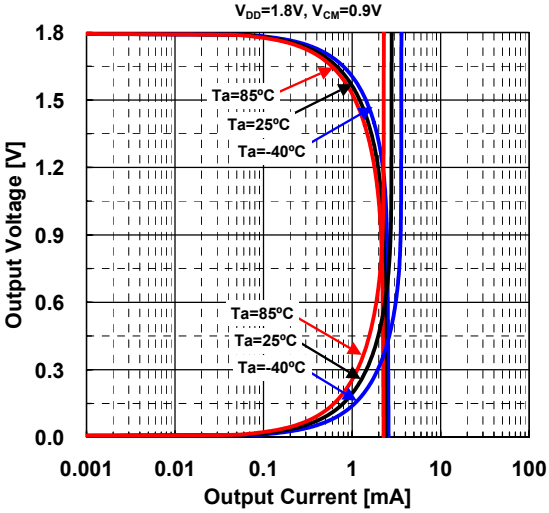
Output Voltage vs. Output Current (Temperature)
V_{DD}=5V, V_{CM}=2.5V



Output Voltage vs. Output Current (Temperature)
V_{DD}=3V, V_{CM}=1.5V

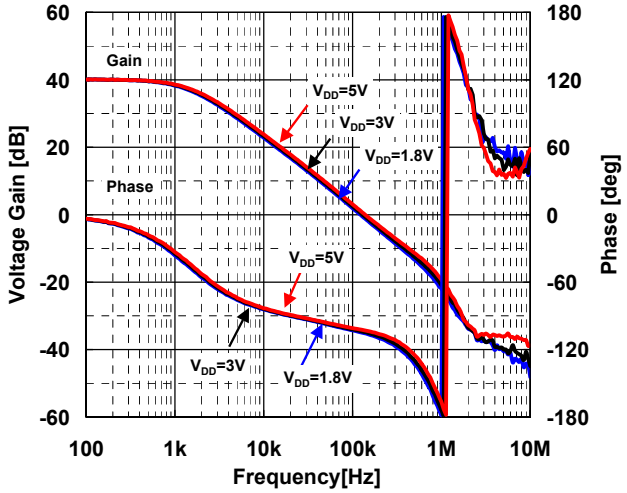


Output Voltage vs. Output Current (Temperature)
V_{DD}=1.8V, V_{CM}=0.9V

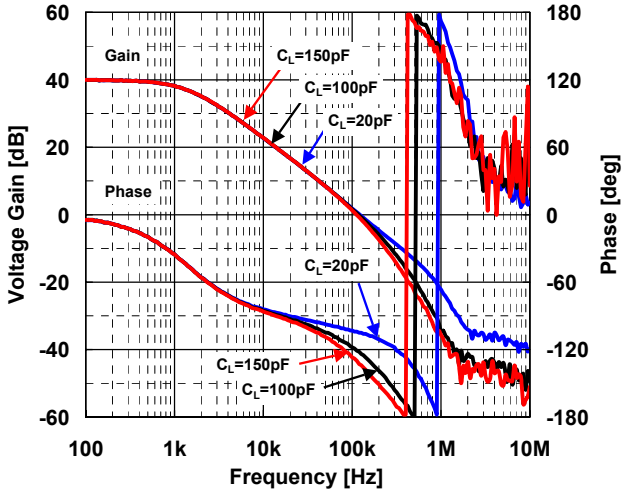


■ TYPICAL CHARACTERISTICS

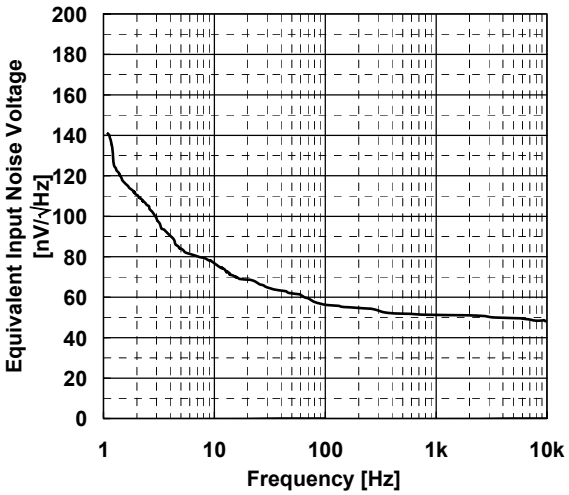
Gain / Phase vs. Frequency
R_F=1MΩ, R_G=10kΩ, R_L=100kΩ, C_L=20pF, Ta=25ºC



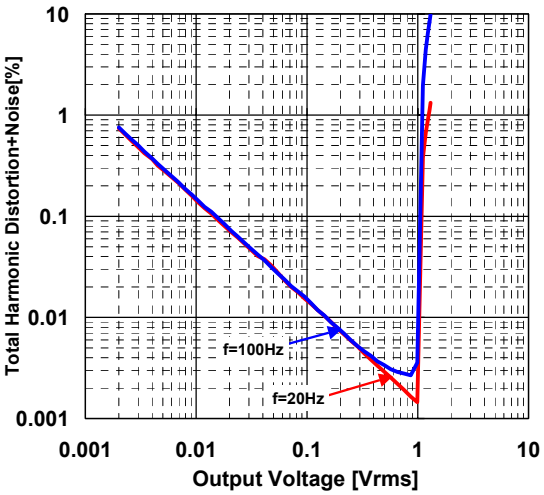
Gain / Phase vs. Frequency (Load Capacitance)
V_{DD}=3V, R_F=1MΩ, R_G=10kΩ, R_L=100kΩ, Ta=25ºC



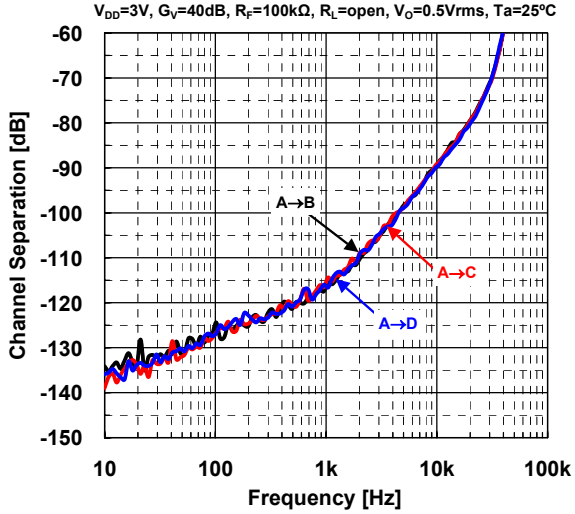
Voltage Noise vs. Frequency
V_{DD}=3V, G_V=40dB, R_F=100kΩ, R_G=1kΩ, Ta=25ºC



THD+Noise vs. Output Voltage
V_{DD}=3V, Gv=6dB, R_F=50kΩ, C_L=20pF
BW=10Hz-500kHz, Ta=25ºC

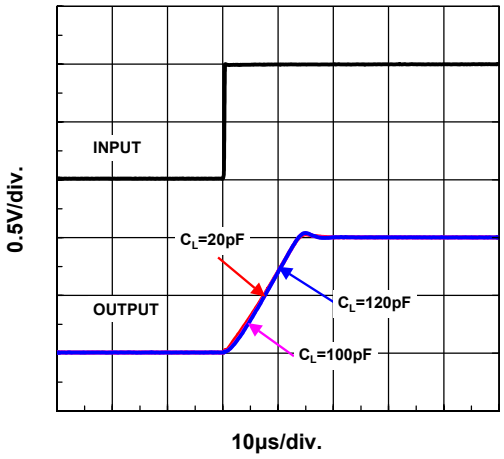


Channel Separation vs. Frequency
V_{DD}=3V, G_V=40dB, R_F=100kΩ, R_L=open, V_O=0.5Vrms, Ta=25ºC



■ TYPICAL CHARACTERISTICS

Pulse Response (Load Capacitance)
V_{DD}=3V, Gv=0dB, R_L=100kΩ, Ta=25ºC



Pulse Response (Load Capacitance)
V_{DD}=3V, Gv=0dB, R_L=100kΩ, Ta=25ºC