Auto-Zero, High Precision Single Operational Amplifier

■GENERAL DESCRIPTION

The NJU7098 is Auto Zero high precision operational amplifiers available in the SOT-23-5 packages. The NJU7098 operates from a single 3V to 10V supply. The NJU7098 of CMOS operational amplifier use Auto Zero techniques to simultaneously provide very low offset voltage, and near-zero drift over temperature (0.05μV/ºC Max.).

The NJU7098 includes a shutdown mode. Under logic control, the amplifiers can be switched from normal operation to a standby. When the $\overline{SHDN}$ pin is connected high, the amplifier is active. Connecting $\overline{SHDN}$ low disables the amplifier.

■PACKAGE OUTLINE

NJU7098F1

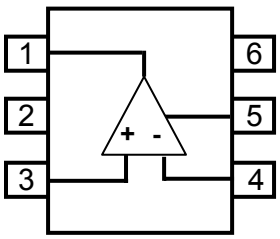
■FEATURES

●Low Offset Voltage Drift	0.05μV/ºC max.
●Low Offset Voltage	15μV max.
●Operating Voltage	+3V to +10V
●High Voltage Gain	140dB typ.
●CMR, SVR	130dB typ.
●Operating Current	0.6mA typ. (at V_{DD}=+5V)
●Output Full-Swing (R_L=10kΩ)	
●Shutdown	
●Ground Sensing	
●Package Outline	SOT-23-6

■APPLICATIONS

●Thermocouple / Thermopile Amplifiers
●Strain Gauge / Pressure sensor Amplifiers
●Load Cell and Bridge Transducer Amplifiers
●High Resolution Data Acquisition
●Precision Current Sensing

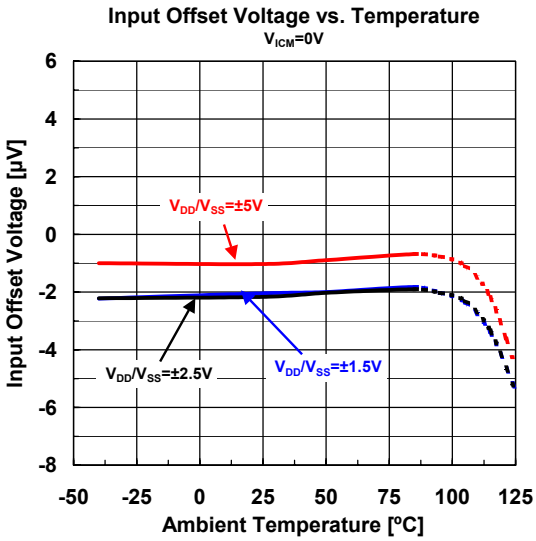
■ PIN CONFIGURATION



NJU7098F1
(Top View)

PIN FUNCTION
1. OUTPUT
2. V_{SS}
3. +INPUT
4. –INPUT
5. $\overline{SHDN}$
6. V_{DD}

■TYPICAL CHARACTERISTICS



■ ABSOLUTE MAXIMUM RATINGS (Ta=25°C)

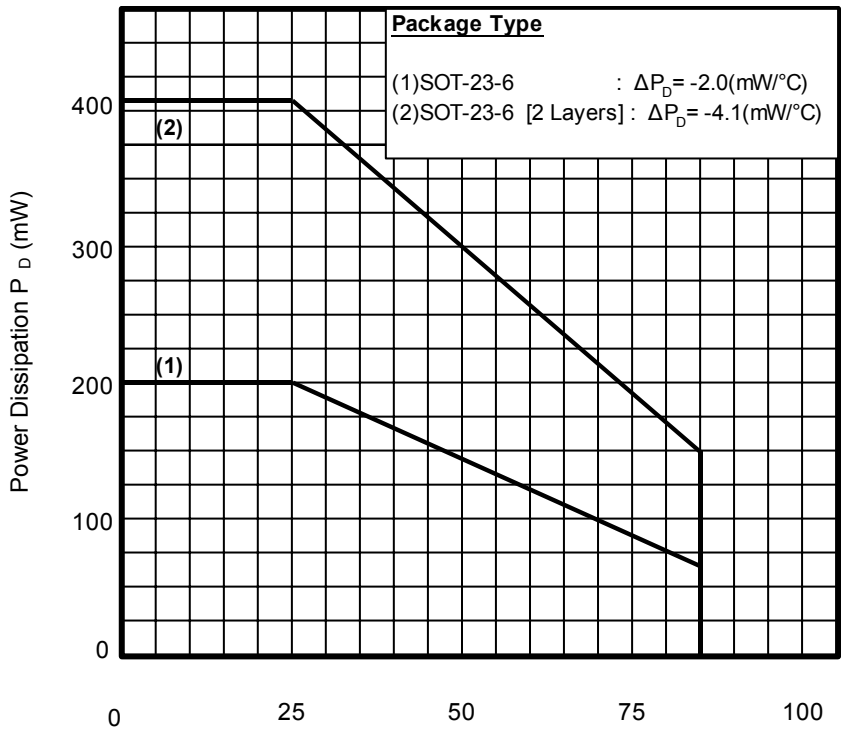
PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{DD}	11	V
Common Mode Input Voltage Range	V_{ICM}	-0.3 to V_{DD}+0.3	V
Differential Input Voltage Range	V_{ID}	±11(Note 1)	V
Power Dissipation	P_D	200 [SOT23-6]	mW
		410 [SOT23-6] (Note 2)	
Operating Temperature Range	T_{opr}	-40 to +85	°C
Storage Temperature Range	T_{stg}	-40 to +125	°C

(Note 1) For supply voltage less than 11V, 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) "

(Note 3) Do not exceed "Power dissipation: P_D" in which power dissipation in IC is shown by the absolute maximum rating. Refer to following Figure 1 for a permissible loss when ambient temperature (Ta) is Ta≥25°C .

Figure 1: Power Dissipation – Ambient Temperature



■ OPERATING VOLTAGE (Ta=-40 to +85°C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{DD}	3 to 10	V

■ ELECTORIC CHARACTERISTICS

● DC CHARACTERISTICS (V_{DD}=+3V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= -40~85°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Current	I_{DD}	R_L=∞, No Signal	-	0.55	1.1	mA
Input Offset Voltage1	$V_{IO}1$	Ta=25°C	-	3	15	μV
Input Offset Voltage2	$V_{IO}2$		-	3	15	μV
Input Offset Voltage Drift	$V_{IO}/\Delta t$		-	-	0.05	μV/°C
Input Bias Current1	I_B1	Ta=25°C	-	15	50	pA
Input Bias Current2	I_B2		-	-	100	pA
Input Offset Curret1	$I_{IO}1$	Ta=25°C			100	pA
Input Offset Current2	$I_{IO}2$				200	pA
Voltage Gain1	A_V1	R_L≥10kΩ, V_o=0.35~2.65V, Ta=25°C	120	140	-	dB
Voltage Gain2	A_V2	R_L≥10kΩ, V_o=0.35~2.65V	115	140	-	dB
Input Common Mode Voltage Range	V_{ICM}	CMR≥110dB	0	-	1.7	V
Common Mode Rejection Ratio1	CMR1	V_{ICM}=0~1.7V, Ta=25°C	110	130		dB
Common Mode Rejection Ratio2	CMR2	V_{ICM}=0~1.7V	110	130		dB
Supply Voltage Rejection Ratio1	SVR1	V_{DD}=3~10V, Ta=25°C	110	130	-	dB
Supply Voltage Rejection Ratio2	SVR2	V_{DD}=3~10V	110	130	-	dB
Maximum Output Voltage1	$V_{OH}1$	R_L=2kΩ to GND	2.85	2.94	-	V
	$V_{OL}1$	R_L=2kΩ to GND	-	1	10	mV
Maximum Output Voltage2	$V_{OH}2$	R_L=10kΩ to GND	2.95	2.98	-	V
	$V_{OL}2$	R_L=10kΩ to GND	-	1	10	mV
Output Source Current	I_{SOURCE}	V_O=2.5V	5	20	-	mA
Output Sink Current	I_{SINK}	V_O=0.5V	3	25	-	mA

● AC CHARACTERISTICS (V_{DD}=+3V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= +25°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Gain Bandwidth Product	GB	R_L=10kΩ	-	2	-	MHz
Phase Margin	Φ_M	R_L=10kΩ, C_L=50pF	-	30	-	deg
Equivalent Input Noise Voltage	V_{NI}	f=10Hz	-	120	-	nV/√Hz
Internal Sampling Frequency	F_S		-	7.5	-	kHz

● TRANSIENT CHARACTERISTICS (V_{DD}=+3V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= +25°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Positive Slew Rate	+SR	A_V=1, V_{IN}=1V_{P-P}, R_L=10kΩ	-	3	-	V/μs
Negative Slew Rate	−SR	A_V=1, V_{IN}=1V_{P-P}, R_L=10kΩ	-	8	-	V/μs

● SHUTDOWN CHARACTERISTICS

(V_{DD}=+3V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= -40~85°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Shutdown Supply Current	I_{DDSHDN}	R_L=∞, $V_{\overline{SHDN}}$=GND, No Signal	-	-	10	μA
Turn On Voltage to Enable Part	V_{SHDNON}	I_{DD}≥300μA	2.5	-	3	V
Turn off Voltage to Disable Part	$V_{SHDNOFF}$	I_{DD}≤10μA	GND	-	0.5	V
Shutdown Bias Current	I_{SHDN}	$V_{\overline{SHDN}}$=GND	-	0.5	3.0	μA

■ ELECTORIC CHARACTERISTICS

● DC CARACTERISTICS (V_{DD}=+5V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= -40~85°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Current	I_{DD}	R_L=∞, No signal	-	0.6	1.2	mA
Input Offset Voltage1	$V_{IO}1$	Ta=25°C	-	3	15	μV
Input Offset Voltage2	$V_{IO}2$		-	3	15	μV
Input Offset Voltage Drift	$V_{IO}/\Delta t$		-	-	0.05	μV/°C
Input Bias Current1	I_B1	Ta=25°C	-	20	50	pA
Input Bias Current2	I_B2		-	-	100	pA
Input Offset Curret1	$I_{IO}1$	Ta=25°C			100	pA
Input Offset Current2	$I_{IO}2$				200	pA
Voltage Gain1	A_V1	R_L≥10kΩ, V_o=1~4V, Ta=25°C	125	140	-	dB
Voltage Gain2	A_V2	R_L≥10kΩ, V_o=1~4V	120	140	-	dB
Input Common Mode Voltage Range	V_{ICM}	CMR≥115dB	0	-	3.5	V
Common Mode Rejection Ratio1	CMR1	V_{ICM}=0~3.5V, Ta=25°C	120	130		dB
Common Mode Rejection Ratio2	CMR2	V_{ICM}=0~3.5V	115	130		dB
Supply Voltage Rejection Ratio1	SVR1	V_{DD}=4~10V, Ta=25°C	115	130	-	dB
Supply Voltage Rejection Ratio2	SVR2	V_{DD}=4~10V	115	130	-	dB
Maximum Output Voltage1	$V_{OH}1$	R_L=2kΩ to GND	4.85	4.94	-	V
	$V_{OL}1$	R_L=2kΩ to GND	-	1	10	mV
Maximum Output Voltage2	$V_{OH}2$	R_L=10kΩ to GND	4.95	4.98	-	V
	$V_{OL}2$	R_L=10kΩ to GND	-	1	10	mV
Output Source Current	I_{SOURCE}	V_O=4.5V	10	30	-	mA
Output Sink Current	I_{SINK}	V_O=0.5V	4	40	-	mA

AC CHARACTERISTICS (V_{DD}=+5V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= +25°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Gain Bandwidth Product	GB	R_L=10kΩ	-	3	-	MHz
Phase Margin	Φ_M	R_L=10kΩ, C_L=50pF	-	30	-	deg
Equivalent Input Noise Voltage	V_{NI}	f=10Hz	-	120	-	nV/√Hz
Internal Sampling Frequency	F_S		-	7.5	-	kHz

● TRANSIENT CHARACTERISTICS (V_{DD}=+5V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= +25°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Positive Slew Rate	+SR	A_V=1, V_{IN}=2V_{P-P}, R_L=10kΩ	-	3	-	V/μs
Negative Slew Rate	−SR	A_V=1, V_{IN}=2V_{P-P}, R_L=10kΩ	-	12	-	V/μs

● SHUTDOWN CHARACTERISTICS

(V_{DD}=+5V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= -40~85°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Shutdown Supply Current	I_{DDSHDN}	R_L=∞, $V_{\overline{SHDN}}$=GND, No Signal	-	-	15	μA
Turn On Voltage to Enable Part	V_{SHDNON}	I_{DD}≥300μA	4.5	-	5	V
Turn off Voltage to Disable Part	$V_{SHDNOFF}$	I_{DD}≤15μA	GND	-	0.5	V
Shutdown Bias Current	I_{SHDN}	$V_{\overline{SHDN}}$=GND	-	2.0	7.0	μA

■ ELECTORIC CHARACTERISTICS

● DC CHARACTERISTICS (V_{DD}=+10V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= -40~85°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Supply Current	I_{DD}	R_L=∞, No Signal	-	0.7	1.5	mA
Input Offset Voltage1	$V_{IO}1$	Ta=25°C	-	3	15	μV
Input Offset Voltage2	$V_{IO}2$		-	3	15	μV
Input Offset Voltage Drift	$V_{IO}/\Delta t$		-	-	0.05	μV/°C
Input Bias Current1	I_B1	Ta=25°C	-	40	200	pA
Input Bias Current2	I_B2		-	-	200	pA
Input Offset Curret1	$I_{IO}1$	Ta=25°C			400	pA
Input Offset Current2	$I_{IO}2$				400	pA
Voltage Gain1	A_V1	R_L≥10kΩ, V_o=1~9V, Ta=25°C	125	140	-	dB
Voltage Gain2	A_V2	R_L≥10kΩ, V_o=1~9V	120	140	-	dB
Input Common Mode Voltage Range	V_{ICM}	CMR≥115dB	0	-	8.5	V
Common Mode Rejection Ratio1	CMR1	V_{ICM}=0~8.5V, Ta=25°C	120	130		dB
Common Mode Rejection Ratio2	CMR2	V_{ICM}=0~8.5V	115	130		dB
Supply Voltage Rejection Ratio1	SVR1	V_{DD}=4~10V, Ta=25°C	115	130	-	dB
Supply Voltage Rejection Ratio2	SVR2	V_{DD}=4~10V	115	130	-	dB
Maximum Output Voltage1	$V_{OH}1$	R_L=2kΩ to GND	9.5	9.94	-	V
	$V_{OL}1$	R_L=2kΩ to GND	-	1	10	mV
Maximum Output Voltage2	$V_{OH}2$	R_L=10kΩ to GND	9.6	9.98	-	V
	$V_{OL}2$	R_L=10kΩ to GND	-	1	10	mV
Output Source Current	I_{SOURCE}	V_O=9.5V	14	40	-	mA
Output Sink Current	I_{SINK}	V_O=0.5V	5	60	-	mA

● AC CHARACTERISTICS (V_{DD}=+10V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= +25°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Gain Bandwidth Product	GB	R_L=10kΩ	-	2	-	MHz
Phase Margin	Φ_M	R_L=10kΩ, C_L=50pF	-	30	-	deg
Equivalent Input Noise Voltage	V_{NI}	f=10Hz	-	120	-	nV/√Hz
Internal Sampling Frequency	F_S		-	7.5	-	kHz

● TRANSIENT CHARACTERISTICS (V_{DD}=+10V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= +25°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Positive Slew Rate	+SR	A_V=1, V_{IN}=2V_{P-P}, R_L=10kΩ	-	4	-	V/μs
Negative Slew Rate	−SR	A_V=1, V_{IN}=2V_{P-P}, R_L=10kΩ	-	14	-	V/μs

● SHUTDOWN CHARACTERISTICS

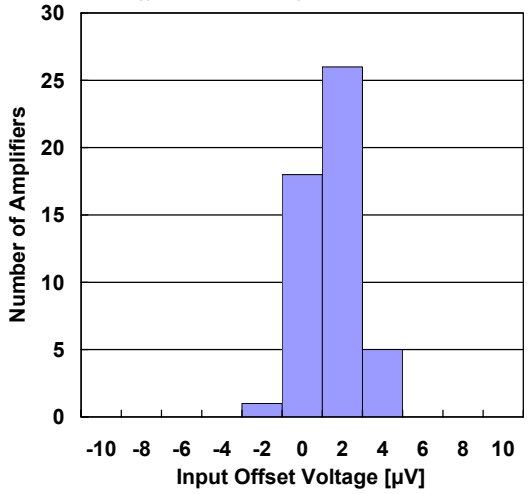
(V_{DD}=+10V, V_{SS}=GND, V_{COM}= V_{DD} /2, $V_{\overline{SHDN}}$= V_{DD}, Ta= -40~85°C unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN	TYP	MAX	UNIT
Shutdown Supply Current	I_{DDSHDN}	R_L=∞, $V_{\overline{SHDN}}$=GND, No Signal	-	-	25	μA
Turn On Voltage to Enable Part	V_{SHDNON}	I_{DD}≥400μA	9.5	-	10	V
Turn off Voltage to Disable Part	$V_{SHDNOFF}$	I_{DD}≤25μA	GND	-	0.5	V
Shutdown Bias Current	I_{SHDN}	$V_{\overline{SHDN}}$=GND	-	7.5	20	μA

■ TYPICAL CHARACTERISTICS

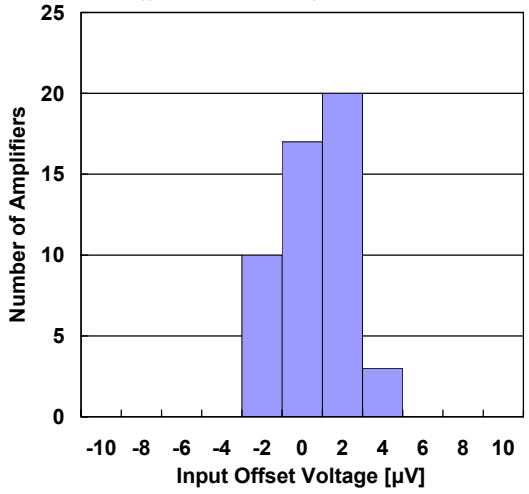
Input Offset Voltage Distribution (V_{DD}/V_{SS}=±5V)

V_{DD}/V_{SS}=±5V, R_F=500kΩ, R_S=50Ω, Gain=80dB, Ta=25ºC



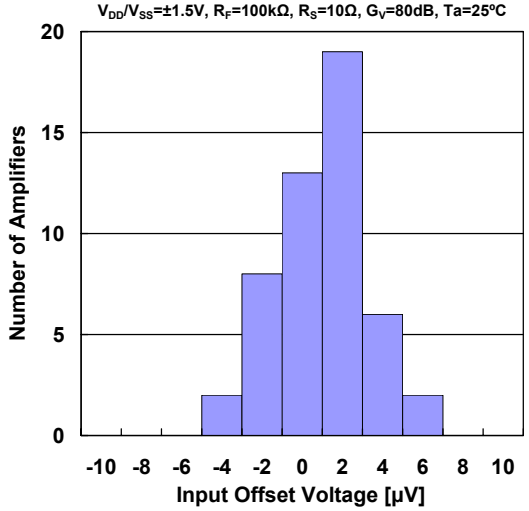
Input Offset Voltage Distribution (V_{DD}/V_{SS}=±2.5V)

V_{DD}/V_{SS}=±2.5V, R_F=500kΩ, R_S=50Ω, G_V=80dB, Ta=25ºC



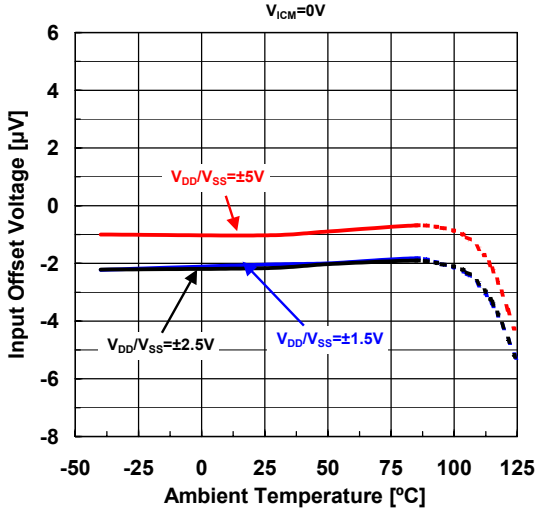
Input Offset Voltage Distribution (V_{DD}/V_{SS}=±1.5V)

V_{DD}/V_{SS}=±1.5V, R_F=100kΩ, R_S=10Ω, G_V=80dB, Ta=25ºC



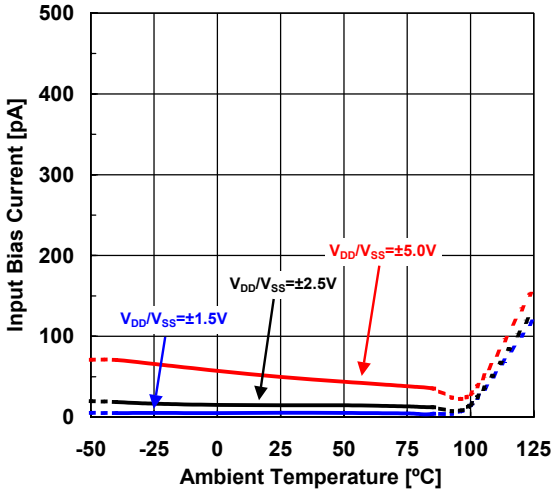
Input Offset Voltage vs. Temperature

V_{ICM}=0V



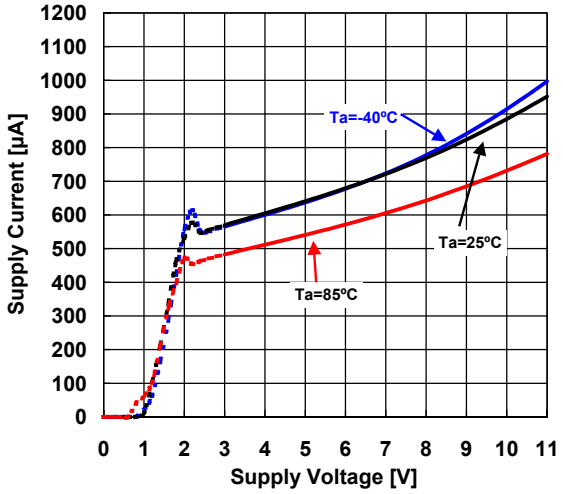
Input Bias Current vs. Temperature

A_V=open, V_{ICM}=0V

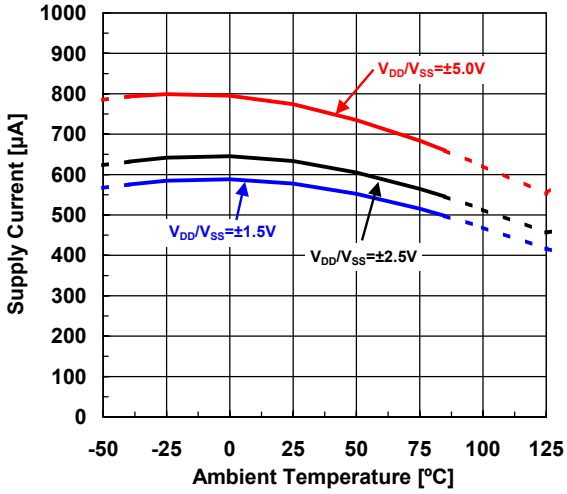


■ TYPICAL CHARACTERISTICS

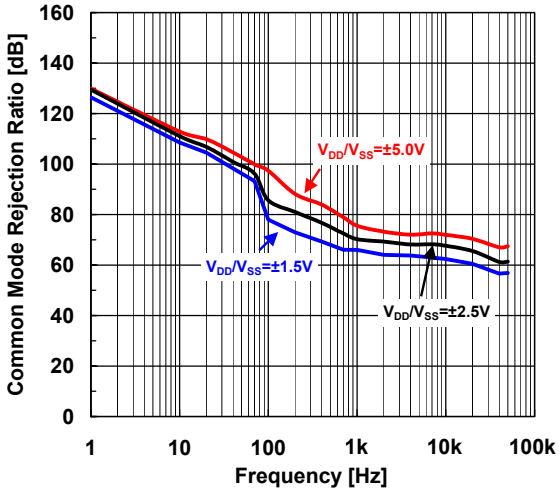
Supply Current vs. Supply Voltage
A_V=0dB



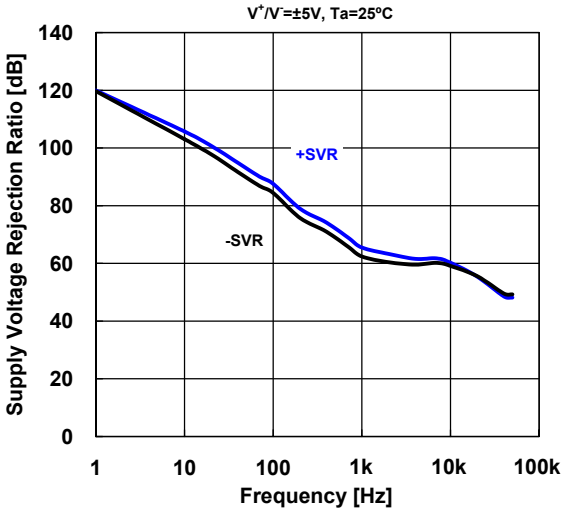
Supply Current vs. Temperature
A_V=0dB



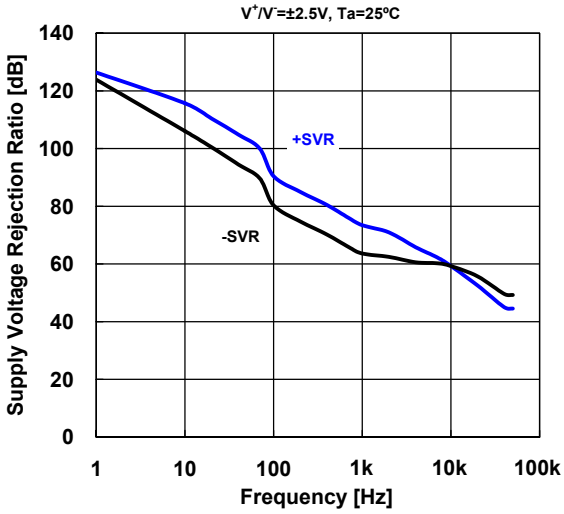
CMR vs. Frequency (Supply Voltage)
R_F=100k, R_S=10, G_V=80dB, Ta=25ºC



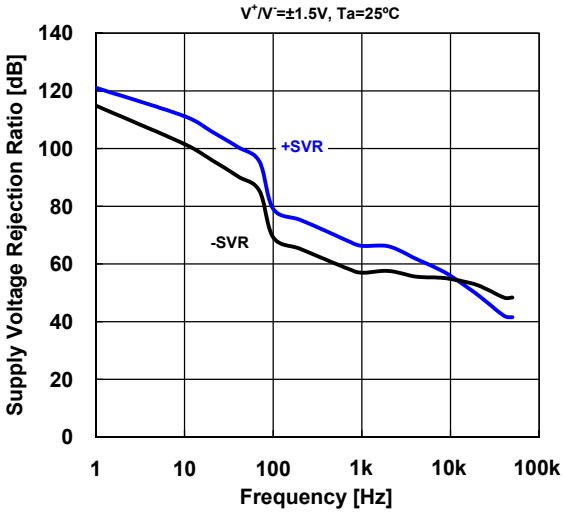
SVR vs. Frequency
V^+/V^-=±5V, Ta=25ºC



SVR vs. Frequency
V^+/V^-=±2.5V, Ta=25ºC

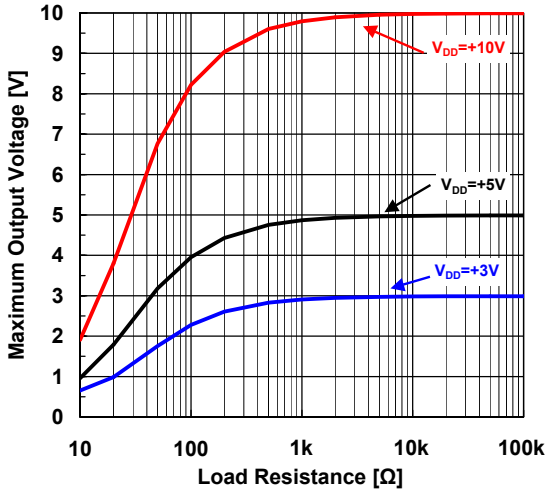


SVR vs. Frequency
V^+/V^-=±1.5V, Ta=25ºC

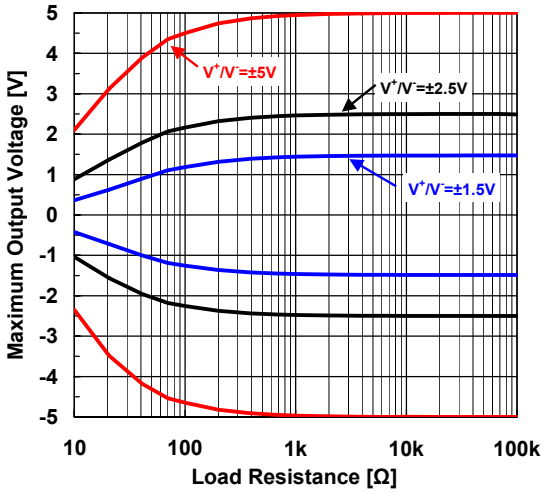


■ TYPICAL CHARACTERISTICS

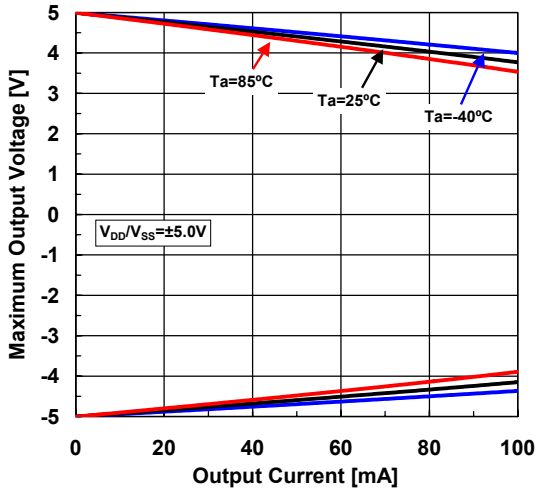
Maximum Output Voltage vs. Load Resistance
(Supply Voltage)
G_V=open, R_L to GND, Ta=25ºC



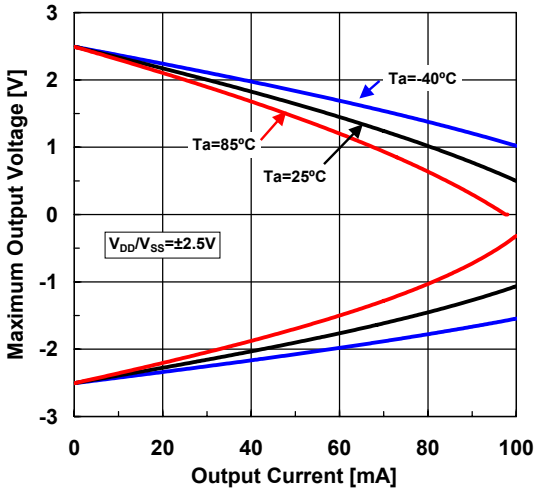
Maximum Output Voltage vs. Load Resistance
(Supply Voltage)
G_V=OPEN, Ta=25ºC



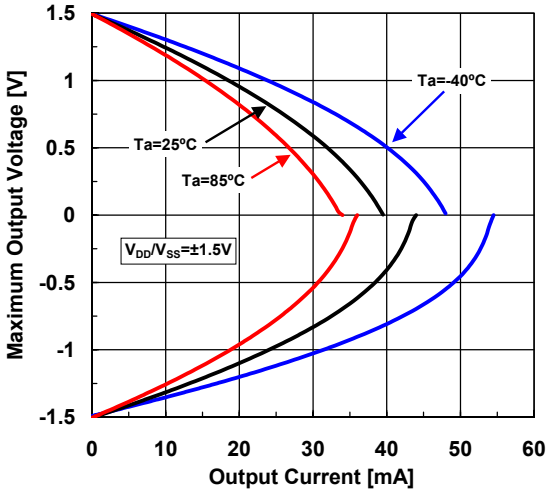
Maximum Output Voltage vs. Output Current
(Temperature)
V_{DD}/V_{SS}=±5.0V, G_V=open,



Maximum Output Voltage vs. Output Current
(Temperature)
V_{DD}/V_{SS}=±2.5V, G_V=open,

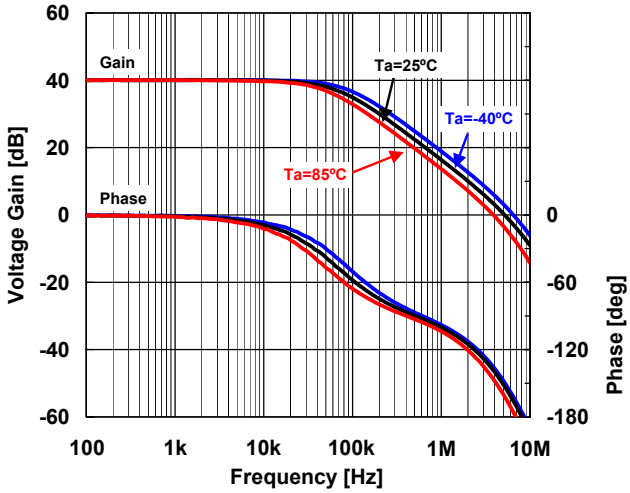


Maximum Output Voltage vs. Output Current
(Temperature)
V_{DD}/V_{SS}=±1.5V, G_V=open,

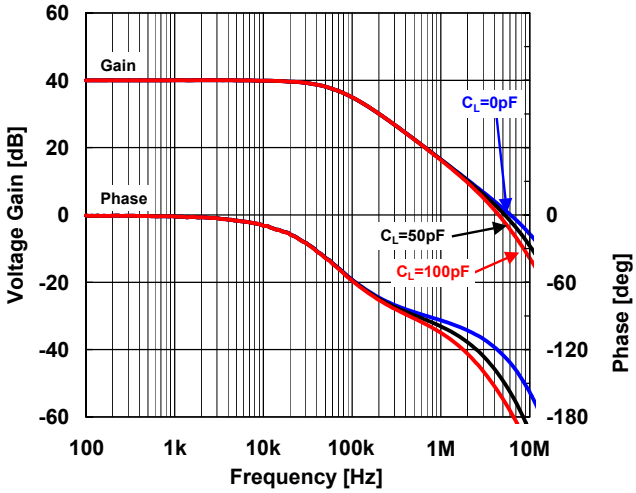


■ TYPICAL CHARACTERISTICS

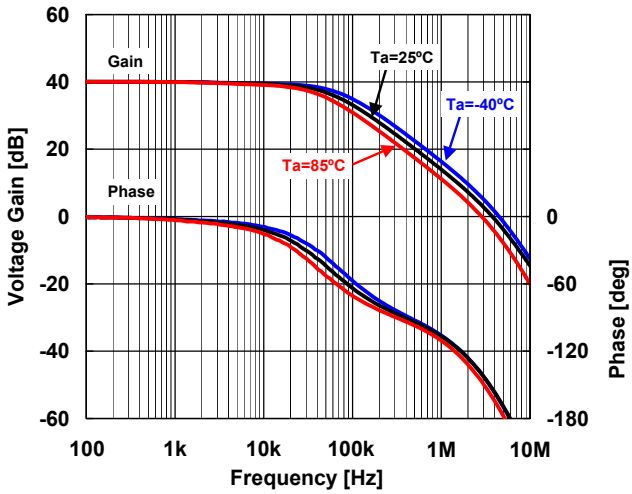
40dBGain/Phase vs. Frequency
(V_{DD}/V_{SS}=±5V, Temperature)
V_{DD}/V_{SS}=±5V, G_V=40dB, R_L=10kΩ, C_L=50pF



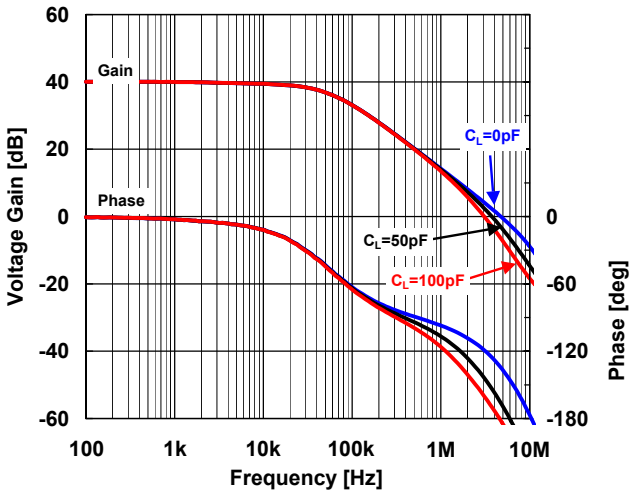
40dBGain/Phase vs. Frequency
(V_{DD}/V_{SS}=±5V, Load Capacitance)
V_{DD}/V_{SS}=±5V, G_V=40dB, R_L=10kΩ, Ta=25°C



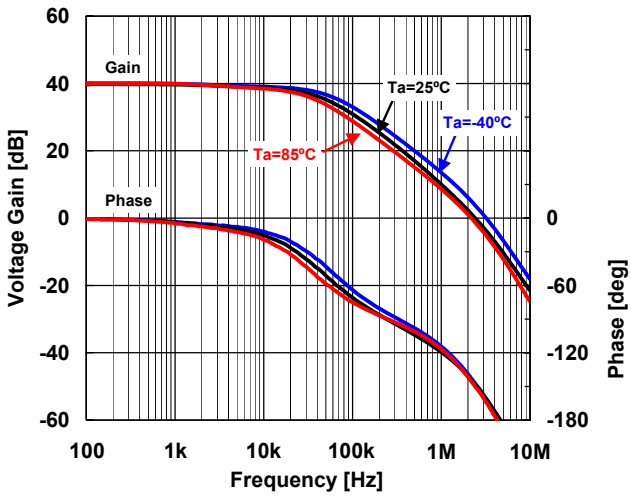
40dBGain/Phase vs. Frequency
(V_{DD}/V_{SS}=±2.5V, Temperature)
V_{DD}/V_{SS}=±2.5V, G_V=40dB, R_L=10kΩ, C_L=50pF



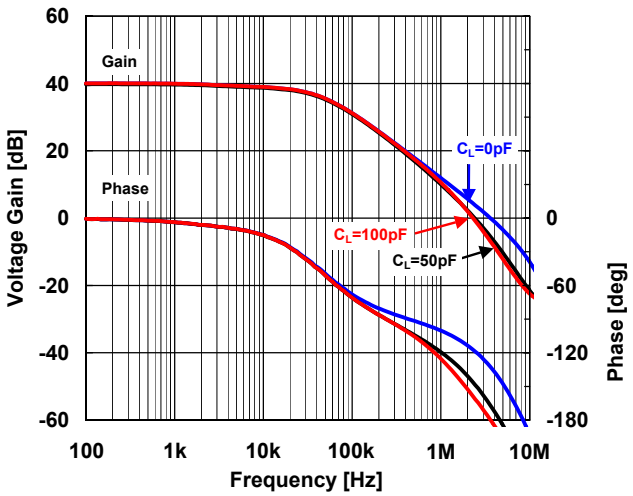
40dBGain/Phase vs. Frequency
(V_{DD}/V_{SS}=±2.5V, Load Capacitance)
V_{DD}/V_{SS}=±2.5V, G_V=40dB, R_L=10kΩ, Ta=25°C



40dBGain/Phase vs. Frequency
(V_{DD}/V_{SS}=±1.5V, Temperature)
V_{DD}/V_{SS}=±1.5V, G_V=40dB, R_L=10kΩ, C_L=50pF

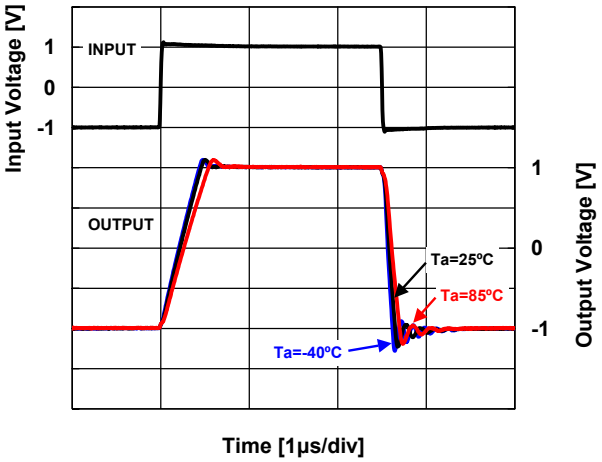


40dBGain/Phase vs. Frequency
(V_{DD}/V_{SS}=±1.5V, Load Capacitance)
V_{DD}/V_{SS}=±1.5V, G_V=40dB, R_L=10kΩ, Ta=25°C



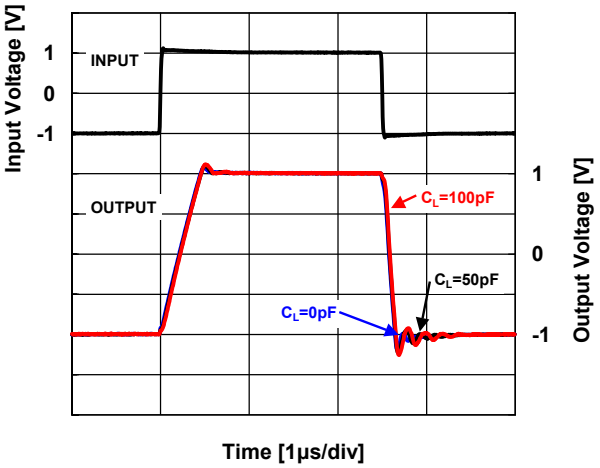
■ TYPICAL CHARACTERISTICS

Pulse Response (V_{DD}/V_{SS}=±5V, Temperature)
V_{DD}/V_{SS}=±5.0V, G_V=0dB, f=100kHz,
V_{IN}=±1V, R_L=10kΩ, C_L=50pF



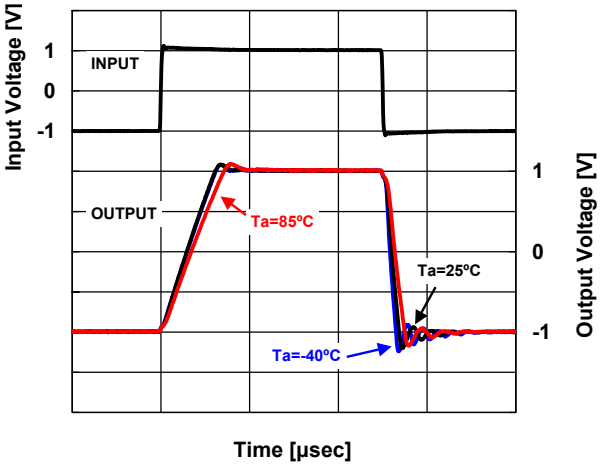
Time [1µs/div]

Pulse Response (V_{DD}/V_{SS}=±5V, Load Capacitance)
V_{DD}/V_{SS}=±5.0V, G_V=0dB, f=100kHz,
V_{IN}=±1V, R_L=10kΩ, Ta=25°C



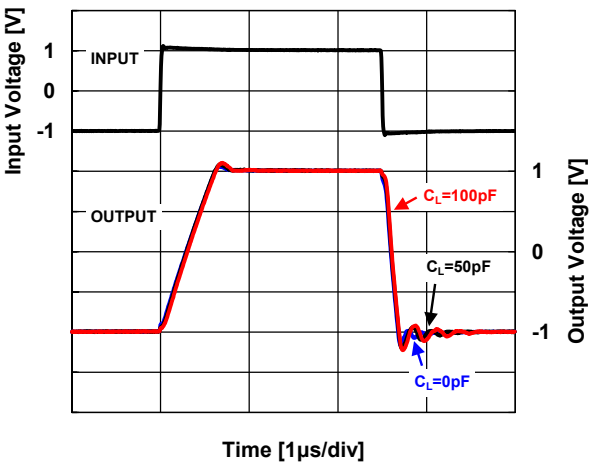
Time [1µs/div]

Pulse Response (V_{DD}/V_{SS}=±2.5V, Temperature)
V_{DD}/V_{SS}=±2.5V, G_V=0dB, f=100kHz,
V_{IN}=±1V, R_L=10kΩ, C_L=50pF



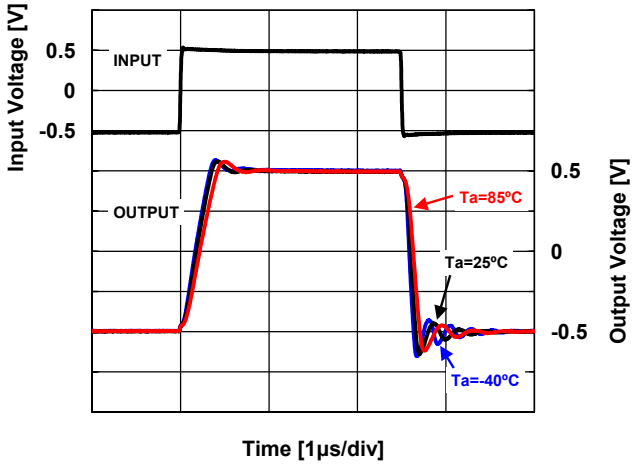
Time [µsec]

Pulse Response (V_{DD}/V_{SS}=±2.5V, Load Capacitance)
V_{DD}/V_{SS}=±2.5V, G_V=0dB, f=100kHz,
V_{IN}=±1V, R_L=10kΩ, Ta=25°C



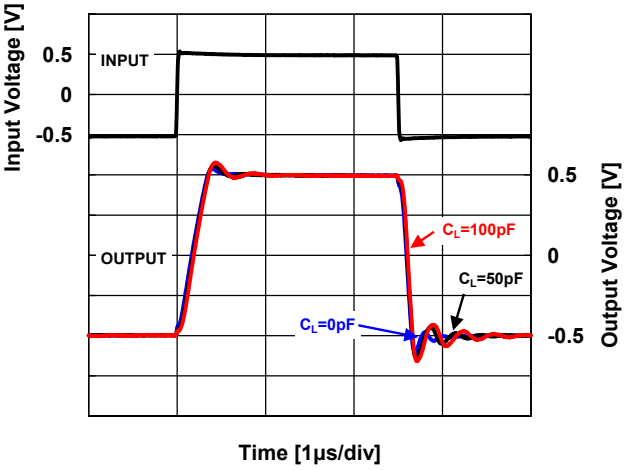
Time [1µs/div]

Pulse Response (V_{DD}/V_{SS}=±1.5V, Temperature)
V_{DD}/V_{SS}=±1.5V, G_V=0dB, f=100kHz,
V_{IN}=±0.5V, R_L=10kΩ, C_L=50pF



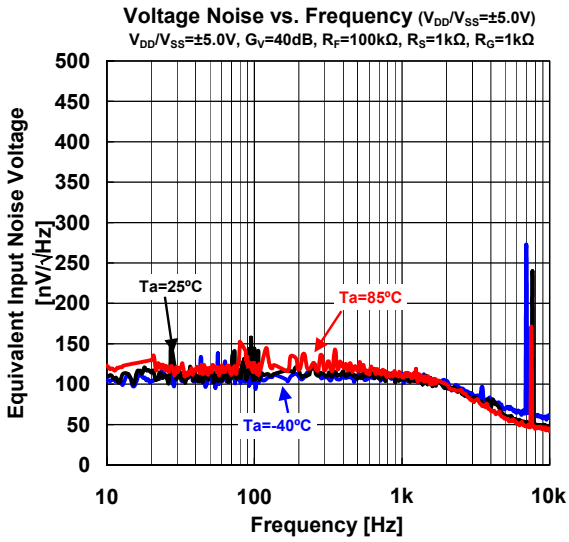
Time [1µs/div]

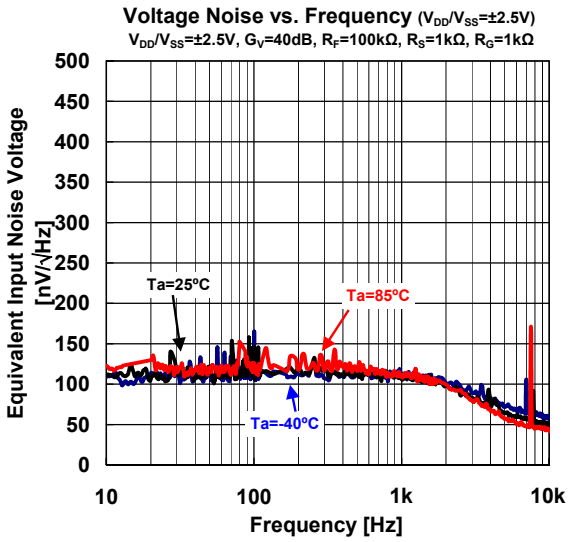
Pulse Response (V_{DD}/V_{SS}=±1.5V, Load Capacitance)
V_{DD}/V_{SS}=±1.5V, G_V=0dB, f=100kHz,
V_{IN}=±0.5V, R_L=10kΩ, Ta=25°C

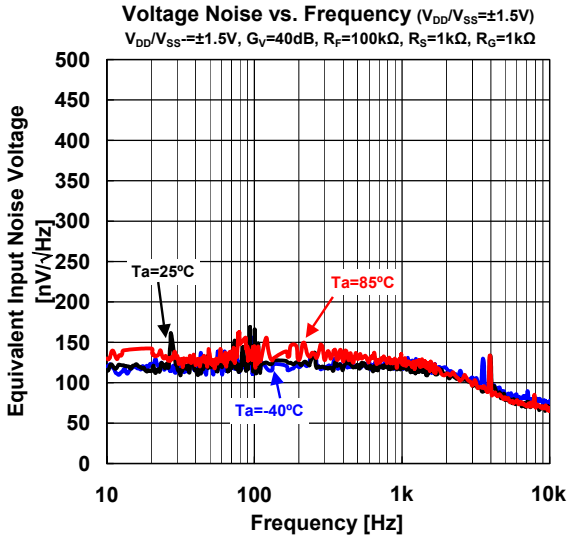


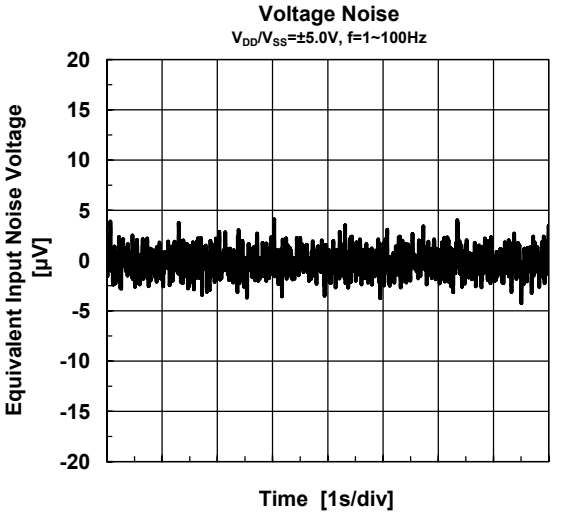
Time [1µs/div]

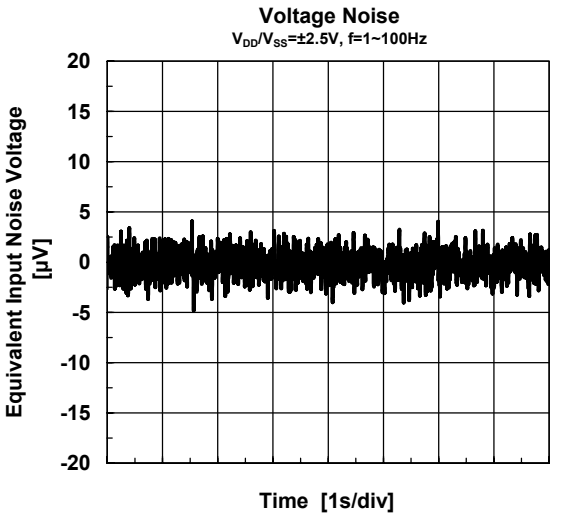
■ TYPICAL CHARACTERISTICS

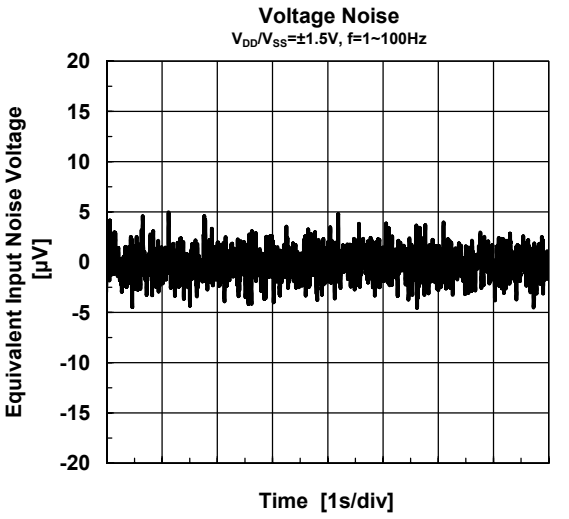




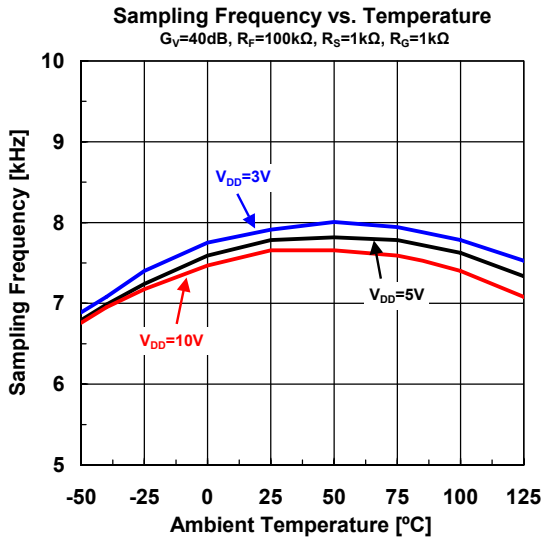


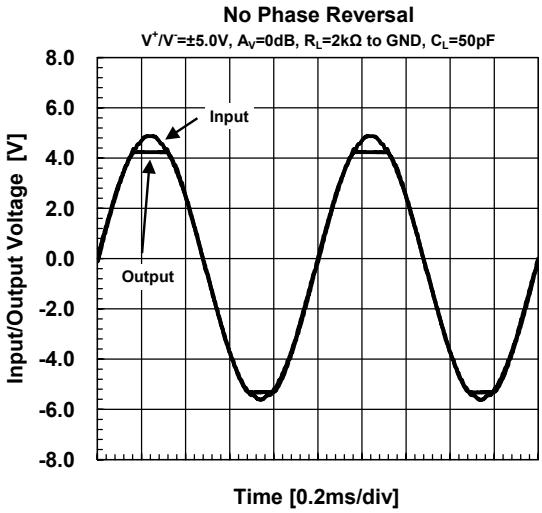


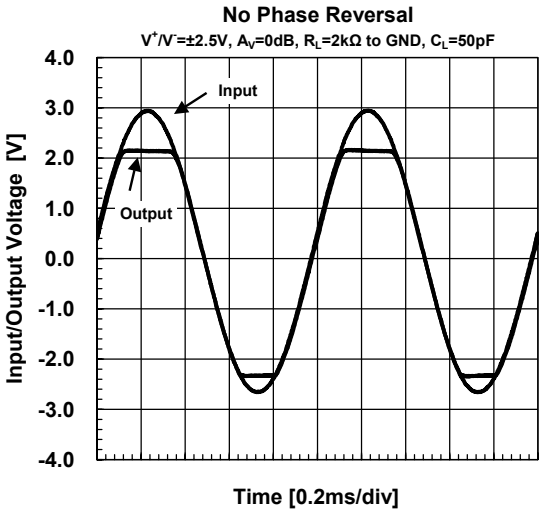


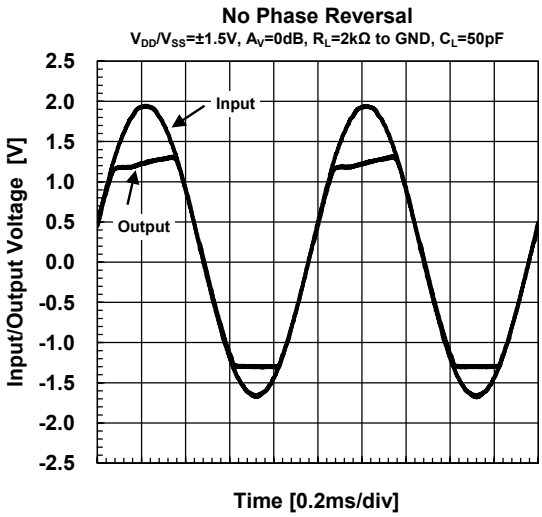


■ TYPICAL CHARACTERISTICS





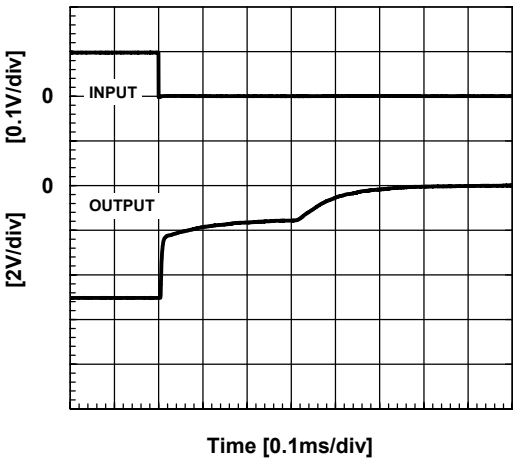




■ TYPICAL CHARACTERISTICS

Positive Overload Recovery Response

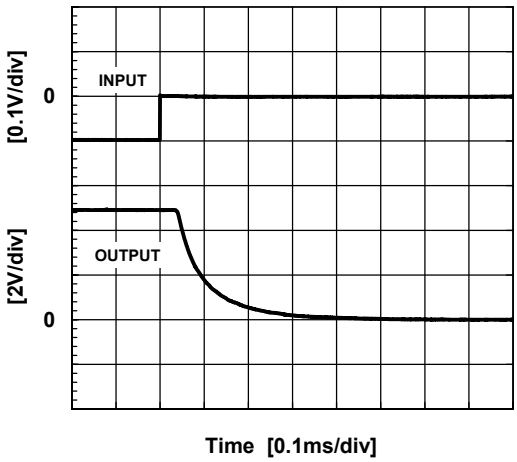
V^+/V^-=±5.0V,
A_V=100, R_1=1kΩ, R_2=100kΩ



Time [0.1ms/div]

Negative Overload Recovery Response

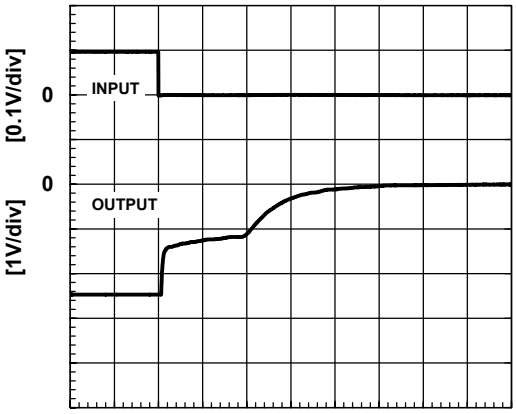
V^+/V^-=±5.0V, A_V=100, R_1=1kΩ, R_2=100kΩ



Time [0.1ms/div]

Positive Overload Recovery Response

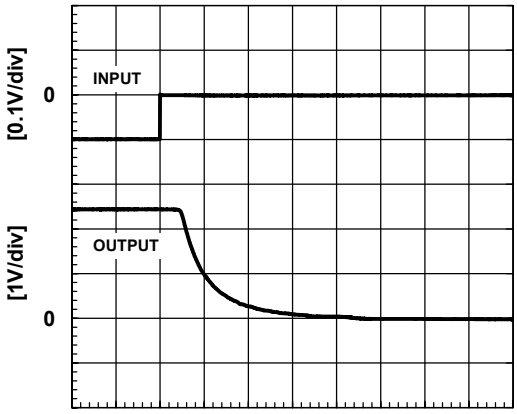
V^+/V^-=±2.5V, A_V=100, R_1=1kΩ, R_2=100kΩ



Time [0.1ms/div]

Negative Overload Recovery Response

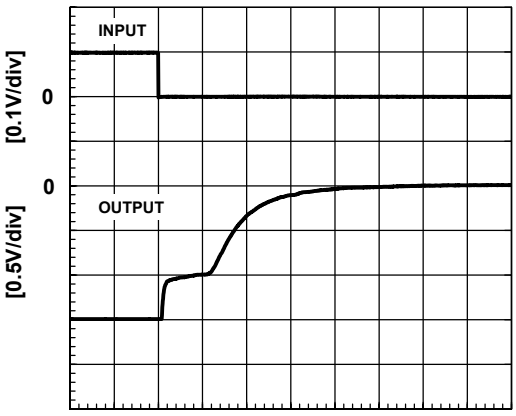
V^+/V^-=±2.5V, A_V=100, R_1=1kΩ, R_2=100kΩ



Time [0.1ms/div]

Positive Overload Recovery Response

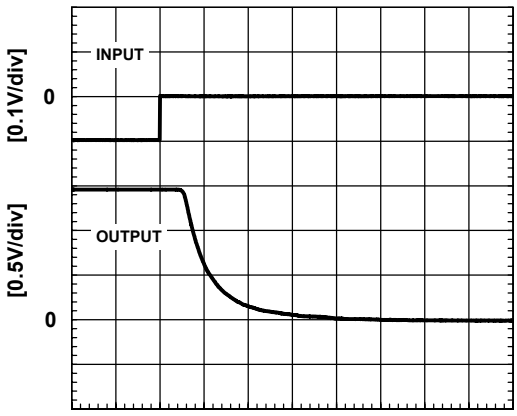
V^+/V^-=±1.5V, A_V=100, R_1=1kΩ, R_2=100kΩ



Time [0.1ms/div]

Negative Overload Recovery Response

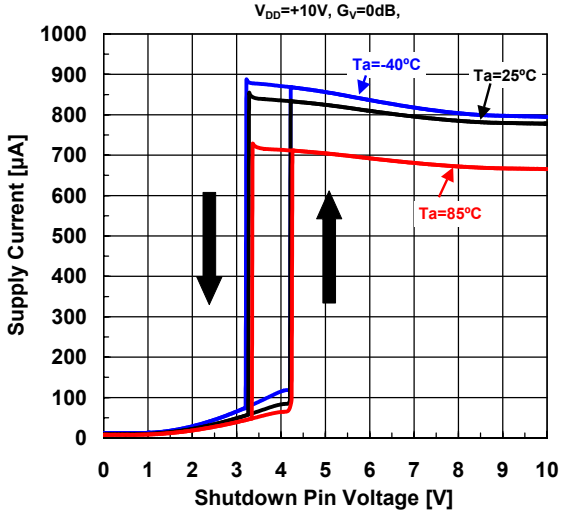
V^+/V^-=±1.5V, A_V=100, R_1=1kΩ, R_2=100kΩ



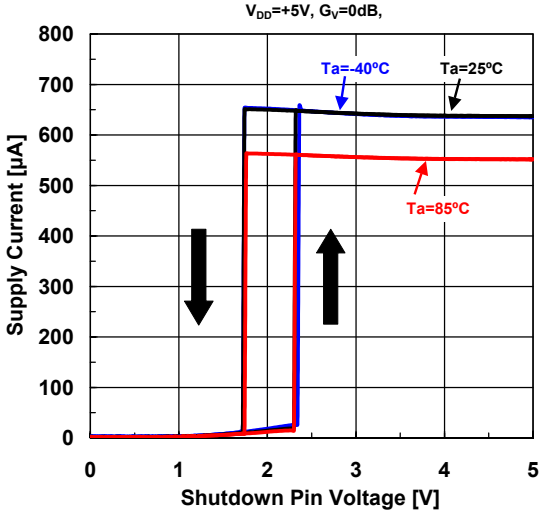
Time [0.1ms/div]

■ TYPICAL CHARACTERISTICS

Supply Current vs. Shutdown Pin Voltage
(Temperature)
V_{DD}=+10V, G_V=0dB,



Supply Current vs. Shutdown Pin Voltage
(Temperature)
V_{DD}=+5V, G_V=0dB,



Supply Current vs. Shutdown Pin Voltage
(Temperature)
V_{DD}=+3V, G_V=0dB,