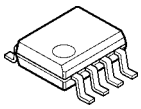
High Output Current, Rail-to-Rail Input/Output Single CMOS Operational Amplifier with Shutdown

■GENERAL DESCRIPTION

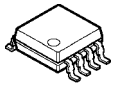
The NJU7045 is a Rail-to-Rail Input/Output single CMOS operational amplifier with a low operating voltage from 2.2V to 5.5V and shutdown function which offers low power operation.

It offers a high output current of 40mA (at VDD=3V) which is higher than our conventional CMOS operational amplifiers, low operating current of 350μA (typ. active) and 0.9μA (typ. at shut down), low voltage operation, low input bias current of 1pA and ground sensing, which is suitable for various applications. The NJU7045 is available in 8-lead small surface mount packages of SOP8 JEDEC 150mil, MSOP8 (TVSP8) and a 6-lead tiny package of SOT-23-6.

■PACKAGE OUTLINE



NJU7045E
(SOP8)



NJU7045RB1
(MSOP8(TVSP8))

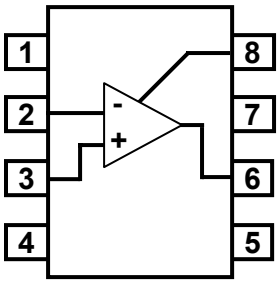
NJU7045F1
(SOT-23-6)

■ FEATURES

●Operating Voltage:		2.2V to 5.5V
●Rail-to-Rail Input/Output		
●High Output Current:		40mA at V_O=0V
●Input Offset Voltage:		V_{IO}=10mV max.
●Wide Input Common Mode		Voltage Range:V_{SS} to V_{DD}
●Operating Current:	(Active)	I_{DD}=350μA typ. (at V_{DD}=3V)
	(Shutdown)	I_{DD}=0.9μA typ. (at V_{DD}=2.2V to 5.5V)
●High Input Impedance:		1TΩ Typ.
●Low Input Bias Current:		I_{IB}=1pA typ.
●Ground Sensing		
●Tiny Package:		SOP8 JEDEC 150mil
		MSOP8 (TVSP8) MEET JEDEC MO-187-DA / THIN TYPE
		SOT-23-6

■ PIN CONFIGURATION

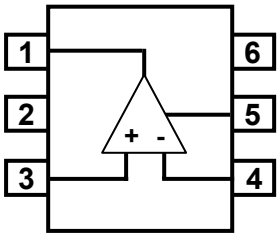
(Top View)



NJU7045E
NJU7045RB1

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

(Top View)



NJU7045F1

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

■ ABSOLUTE MAXIMUM RATINGS

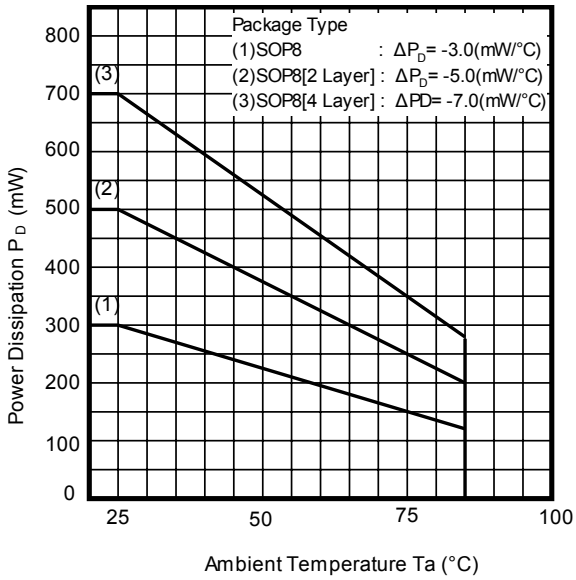
PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{DD}	7	V
Common Mode Input Voltage Range	V_{ICM}	0 to 7 (Note 1)	V
Differential Input Voltage Range	V_{ID}	±7	V
Power Dissipation	P_D	300 [SOP8] 500 [SOP8] (Note 2) 700 [SOP8] (Note 3) 320 [MSOP8(TVSP8)] 410 [MSOP8(TVSP8)] (Note 2) 540 [MSOP8(TVSP8)] (Note 3) 200 [SOT-23-6] 410 [SOT-23-6] (Note 2) 580 [SOT-23-6] (Note 3)	mW
Output Current	I_O	±75 [TVSP8, SOT-23-6]	mA
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 (76.2x 114.3x 1.6mm, two layers, FR-4) "

(Note 3) On the PCB " EIA/JEDEC (76.2x 114.3x 1.6mm, four layers, FR-4) "

FIGURE 1. Power Dissipation vs. Ambient Temperature



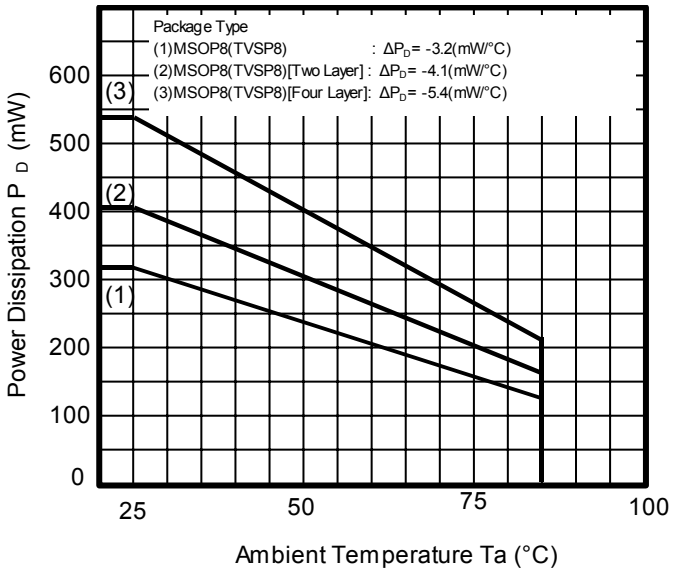
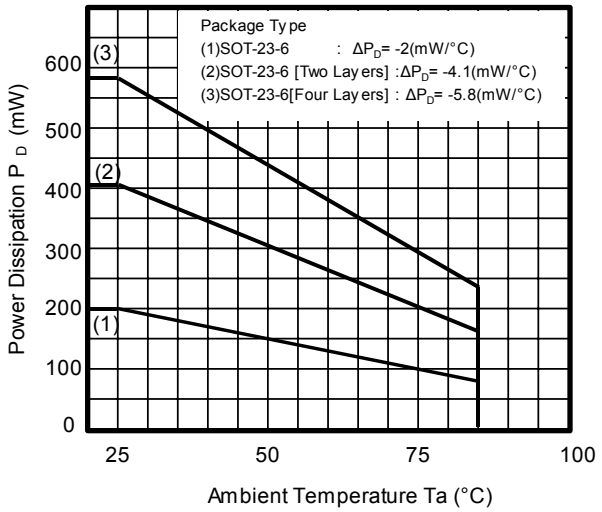


FIGURE 1-2. Power Dissipation vs. Ambient Temperature

(Note 4)

Please do not exceed "Power Dissipation (PD)" the power dissipation in IC is absolutely indicated to be in the maximum rating.

See the figure "Power Dissipation vs. Ambient Temperature" for information on temperature derating of this device.



■ **OPERATING VOLTAGE** (Ta=25˚C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V_{DD}	2.2 to 5.5	V

■STATE DEFINITION OF NJU7045 OPERATION

●"State of NJU7045 Operation" vs. "Turn-on/off Control Voltage V_{SD}" (2.2V ≤ V_{DD} ≤ 5.5V, Ta=25˚C)

State Definition	CONTROL CONDITION	State of NU7045 Operation
Amplifier Operating	$V_{SD}=V_{IH}$	Amplifier is active.
Shutdown	$V_{SD}=V_{IL}$	The output impedance is high, output signal is muted and the supply current is reduced.

■ELECTRICAL CHARACTERISTICS [Enable/Shutdown Control Information]

●Turn-on/off Control Voltage Range for SHDN Pin (2.2V ≤ V_{DD} ≤ 5.5V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Turn-on Voltage to Enable part	V_{IH}	(Note 5)	V_{DD} x 0.7	-	V_{DD}	V
Turn-off Voltage	V_{IL}	(Note 5)	0	-	V_{DD} x 0.3	V

(Note 5) The SHDN pin can't be left unconnected.

●DC CHARACTERISTICS of "SHDN Pin" (2.2V ≤ V_{DD} ≤ 5.5V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Input Bias Current of SHDN Pin	I_{BSD}	0 ≤ V_{SD} ≤ V_{DD}	-	-	±2	μA

●Turn-on/off Time (2.2V ≤ V_{DD} ≤ 5.5V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Amplifier Turn-off Time	T_{OFF}	T_{VSDHL} ≤ 100ns FIGURE 2,3	-	1	-	μs
Amplifier Turn-on Time	T_{ON}	T_{VSDLH} ≤ 100ns FIGURE 2,3	-	10	-	μs

FIGURE 2. T_{OFF}/T_{ON} CONDITION

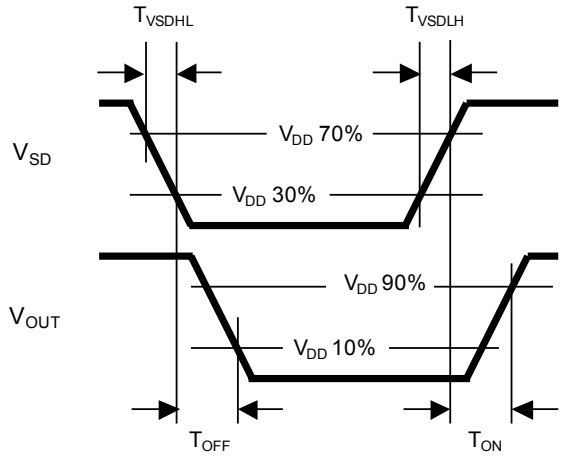
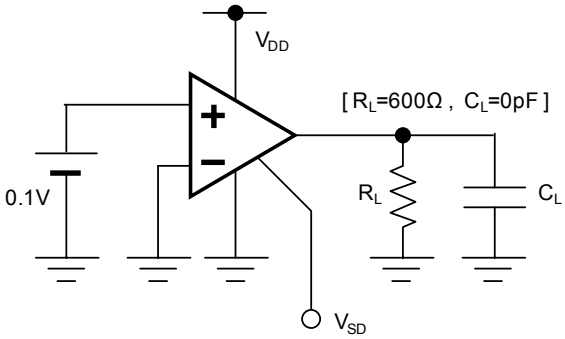


FIGURE 3. T_{OFF}/T_{ON} TEST CIRCUIT



■ELECTRICAL CHARACTERISTICS [Shutdown Characteristics]

●DC CHARACTERISTICS (2.2V ≤ V_{DD} ≤ 5.5V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Leak Current	I_{LEAK}	FIGURE 4	-	-	±3	μA
Operating Current	I_{DDSD}	No Signal Apply, No Load, V_{SD} ≤ 0.2V	-	-	0.9	μA

●AC CHARACTERISTICS (2.2V ≤ V_{DD} ≤ 5.5V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Mute Level	MUTE	V_{IN}=1V_{PP}, f=1kHz, FIGURE 5	-	-100	-	dB

FIGURE 4. LEAK CURRENT TEST CIRCUIT

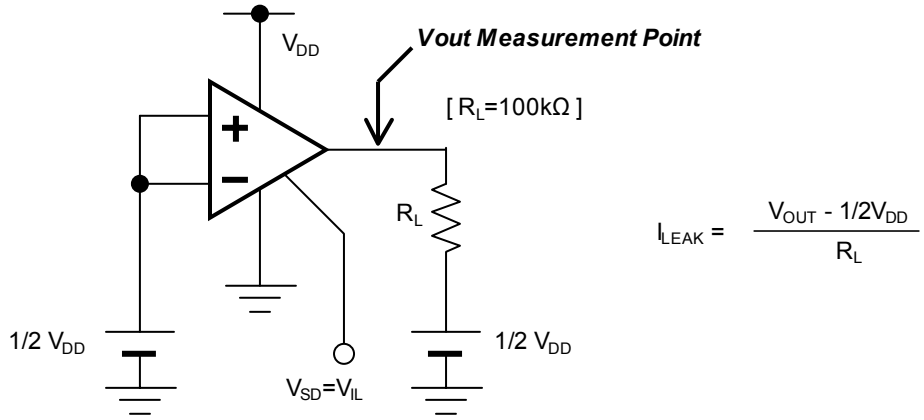
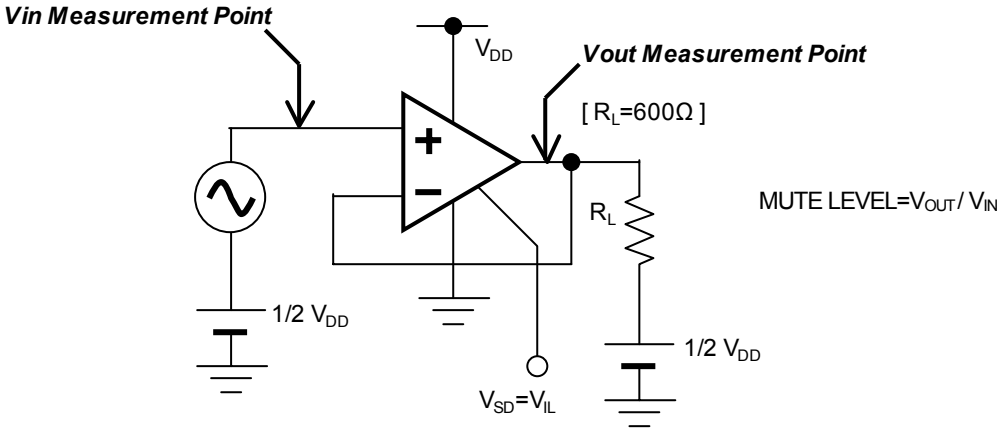


FIGURE 5. MUTE LEVEL TEST CIRCUIT



■ELECTRICAL CHARACTERISTICS [Amplifier Operating]

●DC CHARACTERISTICS (V_{DD}=5V, 3.5V ≤ V_{SD} ≤ 5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I_{DD}	No signal Apply, V_{SD}=V_{DD}	-	450	700	μA
Input Offset Voltage	V_{IO}		-	-	10	mV
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Large Signal Voltage Gain	A_V	R_L=10kΩ to 2.5V, Vo=2.5V±2.4V	70	90	-	dB
Common Mode Rejection Ratio	CMR	CMR+: 2.5V ≤ V_{CM} ≤ 5V CMR-: 0V ≤ V_{CM} ≤ 2.5V (Note 6)	44	60	-	dB
Supply Voltage Rejection Ratio	SVR	4.0V ≤ V_{DD} ≤ 5.5V, V_{CM}=V_{DD}/2, V_{SD}=V_{DD}	55	85	-	dB
Output Voltage1	V_{OH}1	R_L=10kΩ to 2.5V	4.95	-	-	V
	V_{OL}1	R_L=10kΩ to 2.5V	-	-	0.05	V
Output Voltage2	V_{OH}2	R_L=600Ω to 2.5V	4.9	-	-	V
	V_{OL}2	R_L=600Ω to 2.5V	-	-	0.10	V
Output Source Current	I_{SOURCE}	V_O=2.5V	70	-	-	mA
Output Sink Current	I_{SINK}	V_O=2.5V	70	-	-	mA
Input Common Mode Voltage Range	V_{ICM}	CMR ≥ 44dB	0	-	5	V

(Note 6) CMR is represented by either CMR+ or CMR- has lower value.

●AC CHARACTERISTICS (V_{DD}=5V, 3.5V ≤ V_{SD} ≤ 5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Bandwidth	GB	R_L=10kΩ to 2.5V	-	0.8	-	MHz
Total Harmonic Distortion	THD	f=1kHz, V_{IN}=1Vpp, A_V=0dB	-	0.05	-	%
Equivalent Input Noise Voltage	V_{NI}	f=1kHz	-	40	-	nV/√Hz

●TRANSIENT CHARACTERISTICS (V_{DD}=5V, 3.5V ≤ V_{SD} ≤ 5V, Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	R_L=10kΩ to 2.5V	-	0.8	-	V/μs

■ELECTRICAL CHARACTERISTICS [Amplifier Operating]

●DC CHARACTERISTICS (V_{DD}=3V, 2.1V ≤ V_{SD} ≤ 3V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I_{DD}	No signal Apply, V_{SD}=V_{DD}	-	350	600	μA
Input Offset Voltage	V_{IO}		-	-	10	mV
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Large Signal Voltage Gain	A_V	R_L=10kΩ to 1.5V, Vo=1.5V±1.4V	70	90	-	dB
Common Mode Rejection Ratio	CMR	CMR+: 1.5V ≤ V_{CM} ≤ 3V CMR-: 0V ≤ V_{CM} ≤ 1.5V (Note 7)	42	60	-	dB
Supply Voltage Rejection Ratio	SVR	2.7V ≤ V_{DD} ≤ 4.0V, V_{CM}=V_{DD}/2, V_{SD}=V_{DD}	50	80	-	dB
Output Voltage1	V_{OH}1	R_L=10kΩ to 1.5V	2.95	-	-	V
	V_{OL}1	R_L=10kΩ to 1.5V	-	-	0.05	V
Output Voltage2	V_{OH}2	R_L=600Ω to 1.5V	2.9	-	-	V
	V_{OL}2	R_L=600Ω to 1.5V	-	-	0.10	V
Output Source Current	I_{SOURCE}	V_O=1.5V	30	40	-	mA
Output Sink Current	I_{SINK}	V_O=1.5V	30	40	-	mA
Input Common Mode Voltage Range	V_{ICM}	CMR ≥ 42dB	0	-	3	V

(Note 6) CMR is represented by either CMR+ or CMR- has lower value.

●AC CHARACTERISTICS (V_{DD}=3V, 2.1V ≤ V_{SD} ≤ 3V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Bandwidth	GB	R_L=10kΩ to 1.5V	-	0.8	-	MHz
Total Harmonic Distortion	THD	f=1kHz, V_{IN}=1Vpp, A_V=0dB	-	0.05	-	%
Equivalent Input Noise Voltage	V_{NI}	f=1kHz	-	40	-	nV/√Hz

●TRANSIENT CHARACTERISTICS (V_{DD}=3V, 2.1V ≤ V_{SD} ≤ 3V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	R_L=10kΩ to 1.5V	-	0.7	-	V/μs

■ELECTRICAL CHARACTERISTICS [Amplifier Operating]

●DC CHARACTERISTICS (V_{DD}=2.2V, 1.54V ≤ V_{SD} ≤ 2.2V, Ta=25˚C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I_{DD}	No Signal Apply, $V_{SD}=V_{DD}$	-	300	500	μA
Input Offset Voltage	V_{IO}		-	-	10	mV
Input Bias Current	I_B		-	1	-	pA
Input Offset Current	I_{IO}		-	1	-	pA
Large Signal Voltage Gain	A_V	R_L=10kΩ to 1.1V, Vo=1.1V±1.0V	70	90	-	dB
Common Mode Rejection Ratio	CMR	CMR+: 1.1V ≤ V_{CM} ≤ 2.2V CMR-: 0V ≤ V_{CM} ≤ 1.1V (Note 7)	30	60	-	dB
Supply Voltage Rejection Ratio	SVR	2.2V ≤ V_{DD} ≤ 2.7V, $V_{CM}=V_{DD}/2$, $V_{SD}=V_{DD}$	45	70	-	dB
Output Voltage1	$V_{OH}1$	R_L=10kΩ to 1.1V	2.15	-	-	V
	$V_{OL}1$	R_L=10kΩ to 1.1V	-	-	0.05	V
Output Voltage2	$V_{OH}2$	R_L=600Ω to 1.1V	2.1	-	-	V
	$V_{OL}2$	R_L=600Ω to 1.1V	-	-	0.1	V
Output Source Current	I_{SOURCE}	V_O=1.1V	10	15	-	mA
Output Sink Current	I_{SINK}	V_O=1.1V	10	15	-	mA
Input Common Mode Voltage Range	V_{ICM}	CMR ≥ 30dB	0	-	2.2	V

(Note 7) CMR is represented by either CMR+ or CMR- has lower value.

●AC CHARACTERISTICS (V_{DD}=2.2V, 1.54V ≤ V_{SD} ≤ 2.2V, Ta=25˚C)

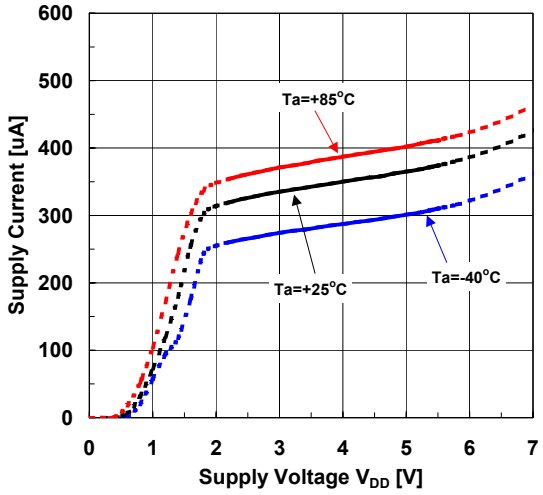
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Unity Gain Bandwidth	GB	R_L=10kΩ to 1.1V	-	0.8	-	MHz
Total Harmonic Distortion	THD	f=1kHz, V_{IN}=1Vpp, A_V=0dB	-	0.05	-	%
Equivalent Input Noise Voltage	V_{NI}	f=1kHz	-	40	-	nV/√Hz

●TRANSIENT CHARACTERISTICS (V_{DD}=2.2V, 1.54V ≤ V_{SD} ≤ 2.2V, Ta=25˚C)

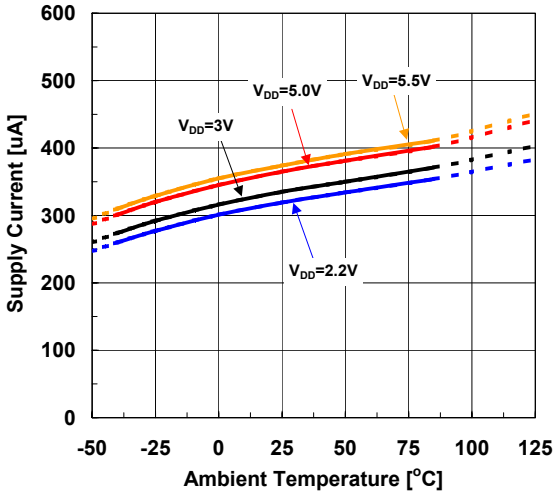
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Slew Rate	SR	R_L=10kΩ to 1.1V	-	0.6	-	V/μs

■TYPICAL CHARACTERISTICS

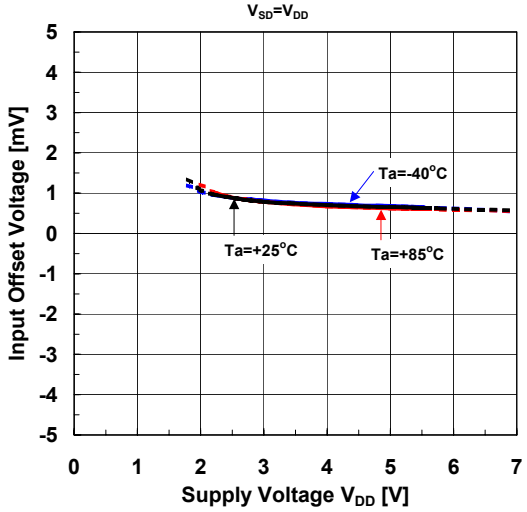
Supply Current vs. Supply Voltage (Temperature)
G_V=0dB, $V_{SD}=V_{DD}$



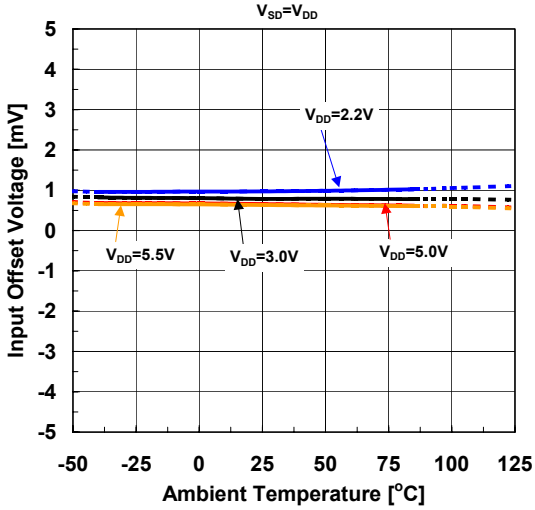
Supply Current vs. Ambient Temperature (Supply Voltage)
G_V=0dB, $V_{SD}=V_{DD}$



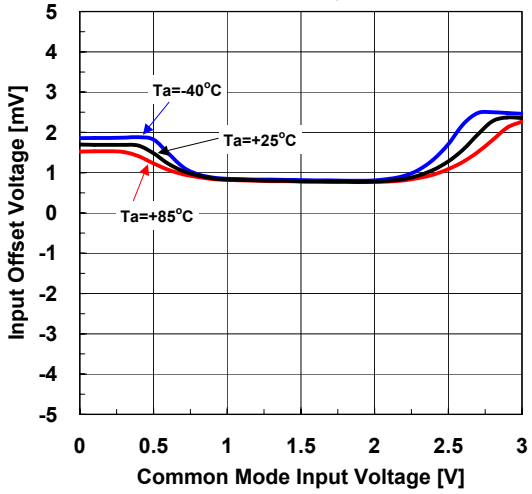
Input Offset Voltage vs. Supply Voltage (Temperature)
$V_{SD}=V_{DD}$



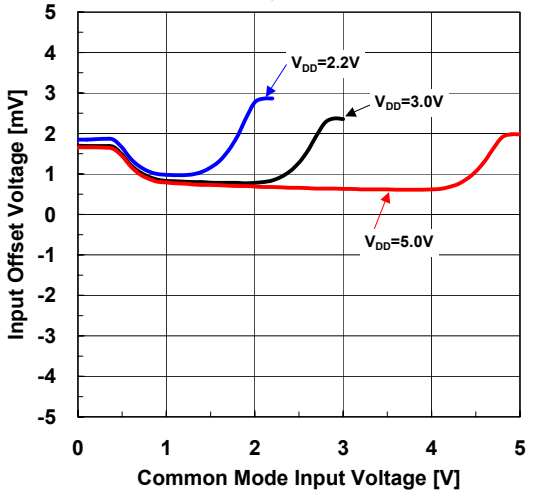
Input Offset Voltage vs. Ambient Temperature (Supply Voltage)
$V_{SD}=V_{DD}$



Input Offset Voltage vs. Common Mode Input Voltage (Temperature, V_{DD}=3V)
V_{DD}=3V, R_L=10kΩ, $V_{SD}=V_{DD}$

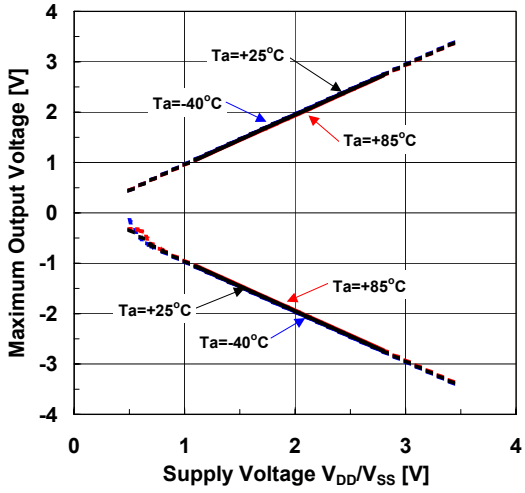


Input Offset Voltage vs. Common Mode Input Voltage (Supply Voltage)
R_L=10kΩ, $V_{SD}=V_{DD}$, Ta=25°C

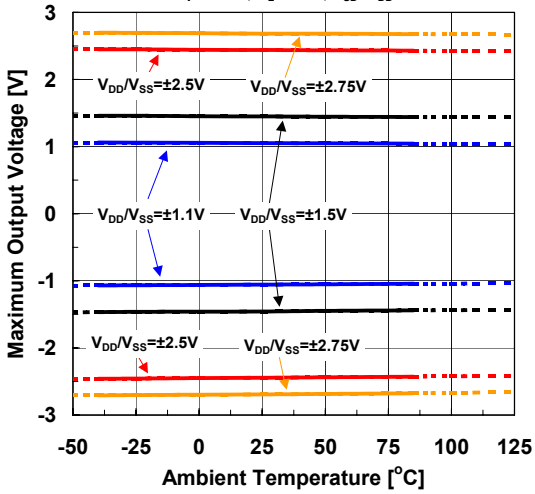


■TYPICAL CHARACTERISTICS

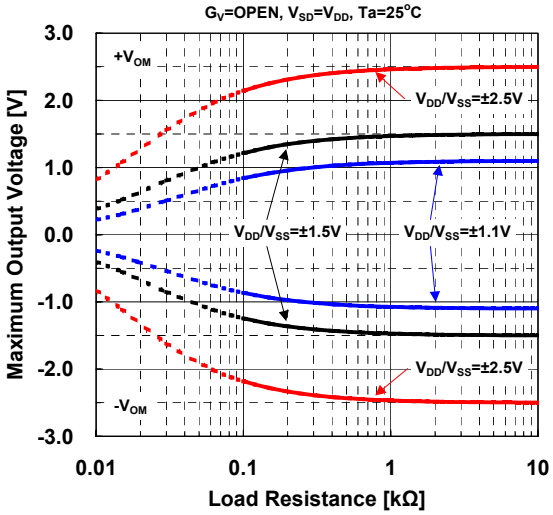
Maximum Output Voltage vs. Supply Voltage
(Temperature)
G_V=OPEN, R_L=600Ω, V_{SD}=V_{DD}



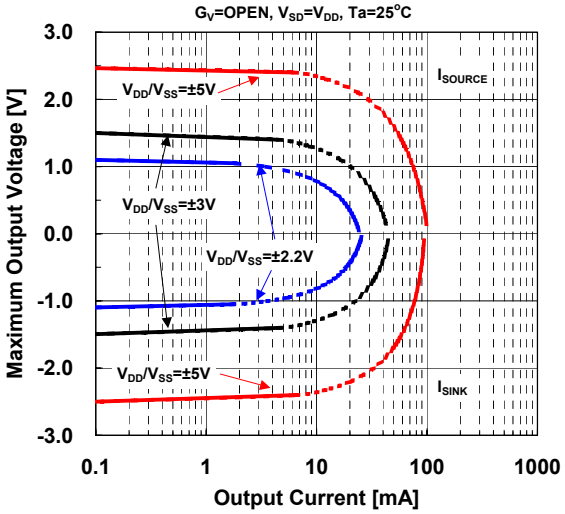
Maximum Output Voltage
vs. Ambient Temperature (Supply Voltage)
G_V=OPEN, R_L=600Ω, V_{SD}=V_{DD}



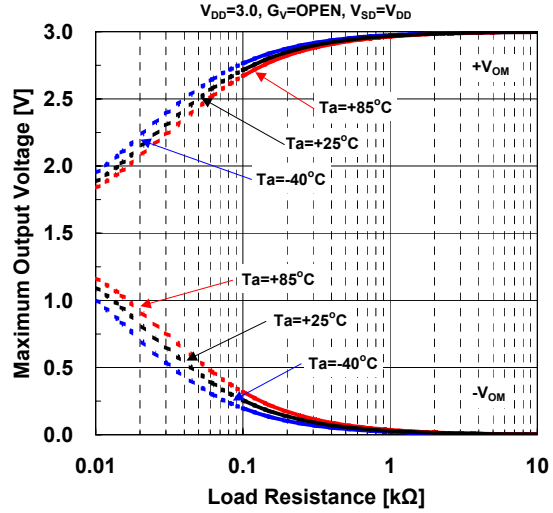
Maximum Output Voltage vs. Load Resistance
(Temperature)
G_V=OPEN, V_{SD}=V_{DD}, Ta=25°C



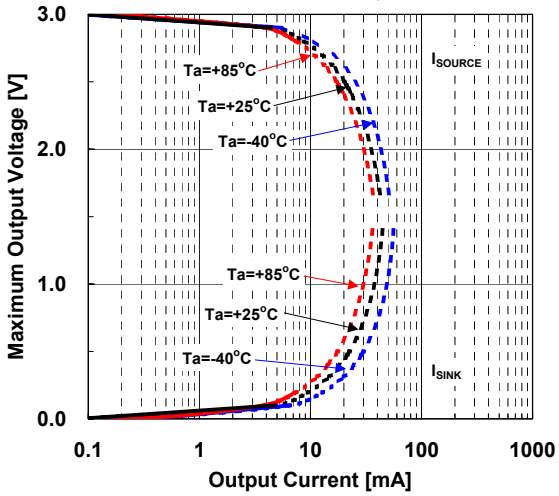
Maximum Output Voltage vs. Output Current
(Supply Voltage)
G_V=OPEN, V_{SD}=V_{DD}, Ta=25°C



Maximum Output Voltage vs. Load Resistance
(Temperature, V_{DD}=3V)
V_{DD}=3.0, G_V=OPEN, V_{SD}=V_{DD}



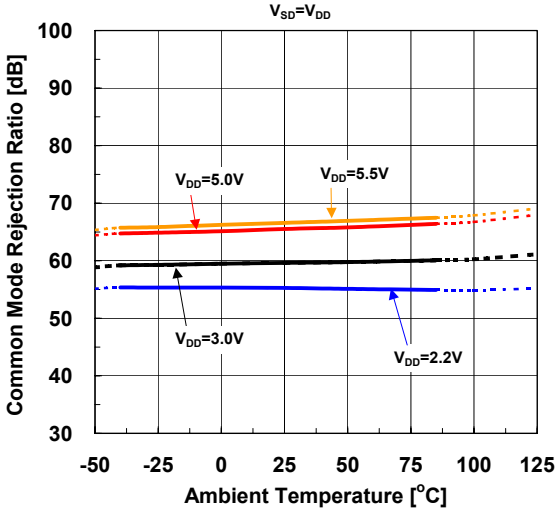
Maximum Output Voltage vs. Output Current
(Temperature, V_{DD}=3V)
V_{DD}=3.0V, G_V=OPEN, V_{SD}=V_{DD}



■TYPICAL CHARACTERISTICS

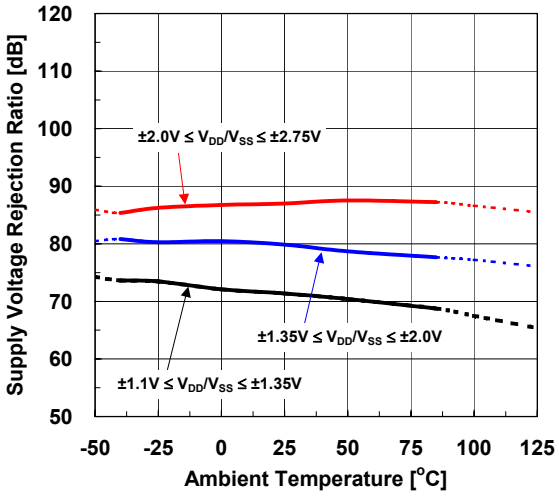
Common Mode Rejection Ratio vs. Ambient Temperature (Supply Voltage)

$V_{SD}=V_{DD}$



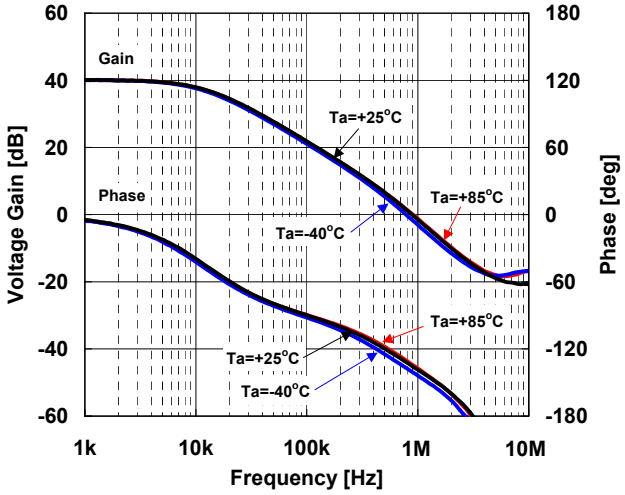
Supply Voltage Rejection Ratio vs. Ambient Temperature (Supply Voltage)

$V_{SD}=V_{DD}$



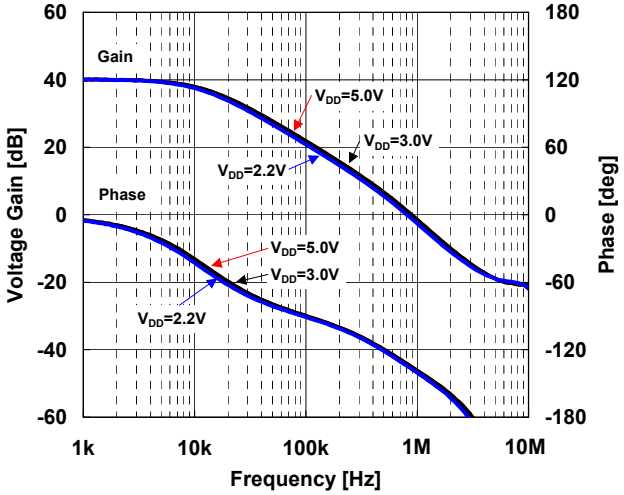
Gain/Phase vs. Frequency (Temperature)

V_{DD}=5.0V, V_{in}=-30dBm, G_V=40dB, R_L=10kΩ, R_F=100kΩ, R_G=1kΩ, C_L=3pF, $V_{SD}=V_{DD}$



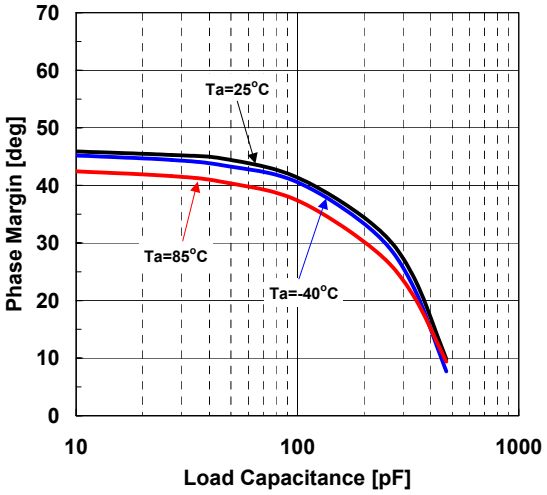
Gain/Phase vs. Frequency (Supply Voltage)

V_{in}=-30dBm, G_V=40dB, R_L=10kΩ, R_F=100kΩ, R_G=1kΩ, C_L=3pF, $V_{SD}=V_{DD}$, Ta=25°C



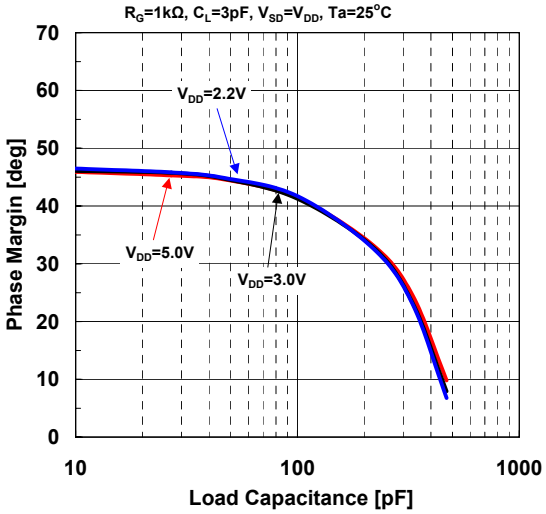
Phase Margin vs. Load Capacitance (Temperature)

V_{DD}=5.0V, V_{in}=-30dBm, G_V=40dB, R_L=10kΩ, R_F=100kΩ, R_G=1kΩ, C_L=3pF, $V_{SD}=V_{DD}$



Phase Margin vs. Load Capacitance (Supply Voltage)

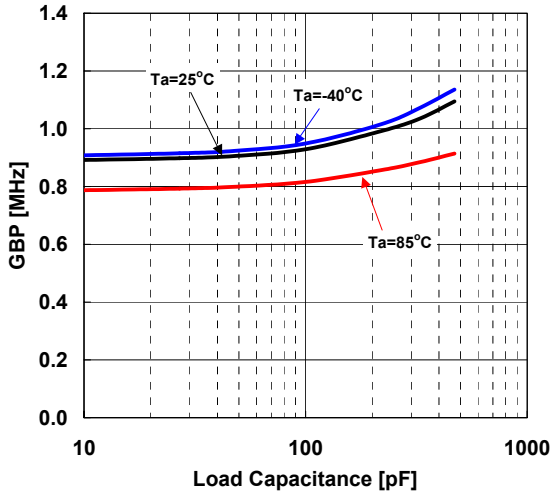
V_{in}=-30dBm, G_V=40dB, R_L=10kΩ, R_F=100kΩ, R_G=1kΩ, C_L=3pF, $V_{SD}=V_{DD}$, Ta=25°C



■TYPICAL CHARACTERISTICS

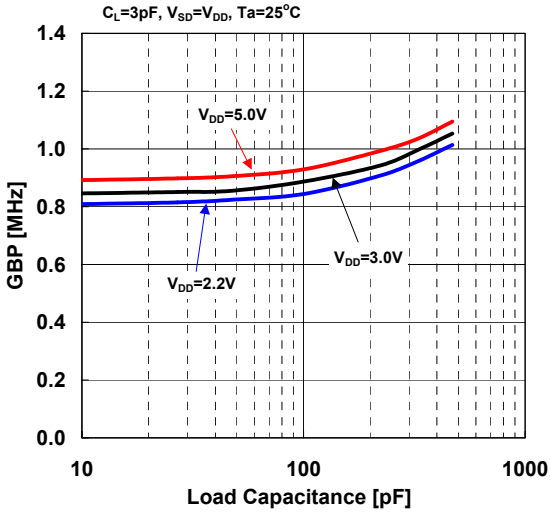
GBP vs. Load Capacitance (Temperature)

V_{DD}=5.0V, V_{in}=-30dBm, G_V=40dB, R_L=10kΩ, R_F=100kΩ, R_G=1kΩ, C_L=3pF, V_{SD}=V_{DD}



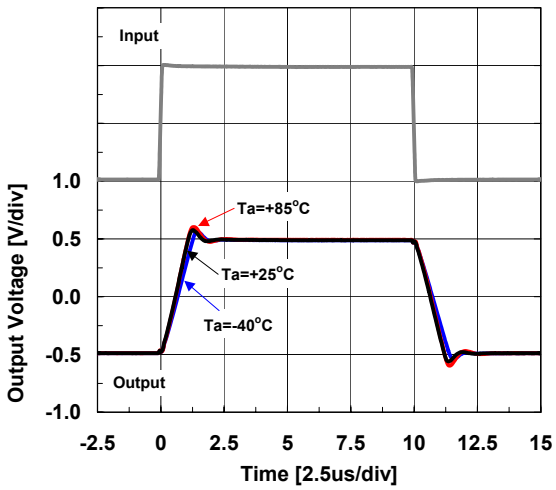
GBP vs. Load Capacitance (Supply Voltage)

V_{in}=-30dBm, G_V=40dB, R_L=10kΩ, R_F=100kΩ, R_G=1kΩ, C_L=3pF, V_{SD}=V_{DD}, Ta=25°C



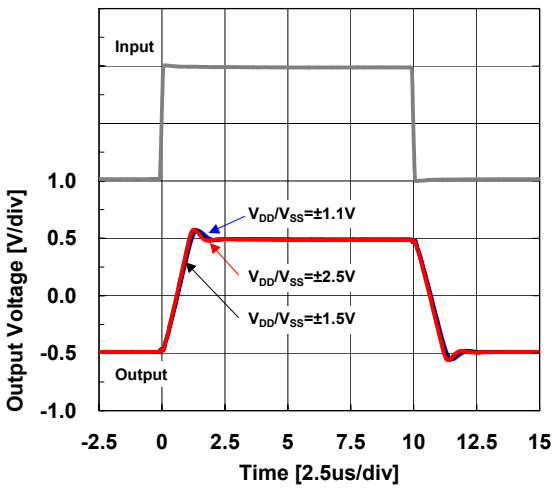
Pulse Response (Temperature)

V_{DD}/V_{SS}=±2.5V, V_{in}=1V_{p-p}, G_V=0dB, R_L=10kΩ, C_L=15pF, V_{SD}=V_{DD}



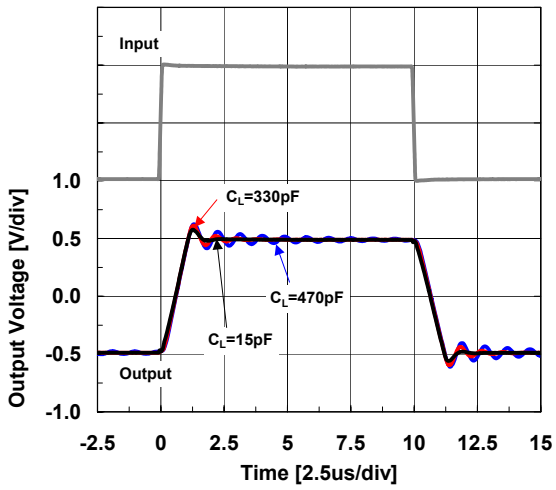
Pulse Response (Supply Voltage)

V_{in}=1V_{p-p}, G_V=0dB, R_L=10kΩ, C_L=15pF, V_{SD}=V_{DD}, Ta=25°C



Pulse Response (Load Capacitance)

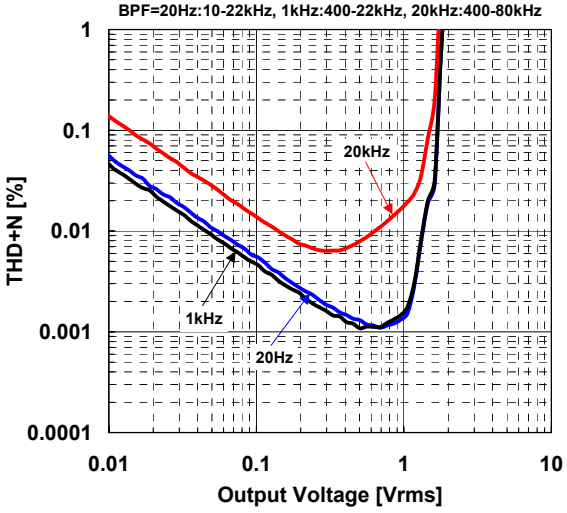
V_{DD}/V_{SS}=±2.5V, V_{in}=1Vp-p, G_V=0dB, R_L=10kΩ, V_{SD}=V_{DD}, Ta=25°C



■TYPICAL CHARACTERISTICS

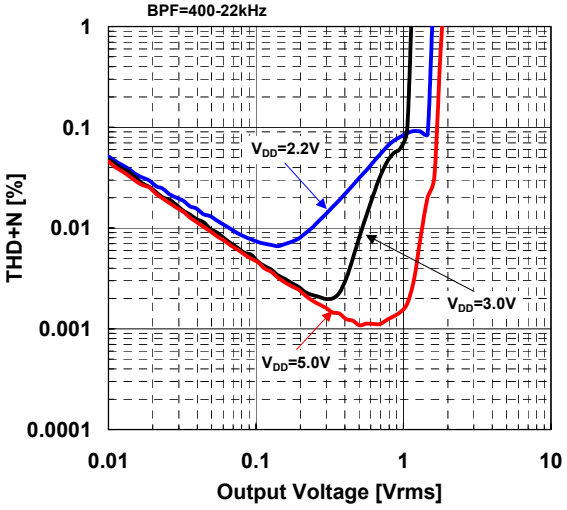
THD+N vs. Output Voltage (Frequency)

V_{DD}=5.0V, G_V=0dB, R_L=10kΩ, V_{SD}=V_{DD}, Ta=25°C,
BPF=20Hz:10-22kHz, 1kHz:400-22kHz, 20kHz:400-80kHz



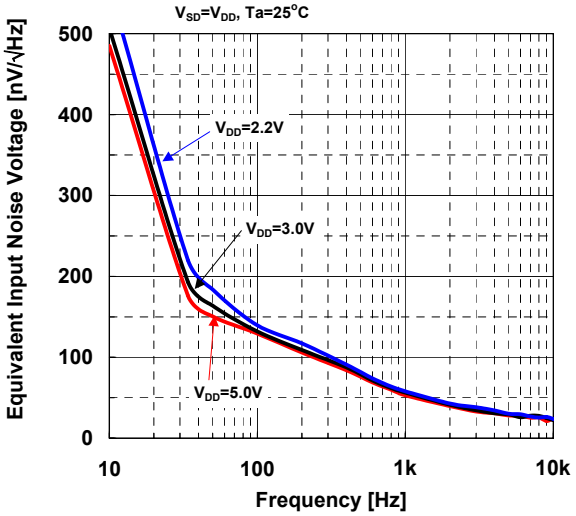
THD+N vs. Output Voltage (Supply Voltage)

f_{in}=1kHz, G_V=0dB, R_L=10kΩ, V_{SD}=V_{DD}, Ta=25°C,
BPF=400-22kHz



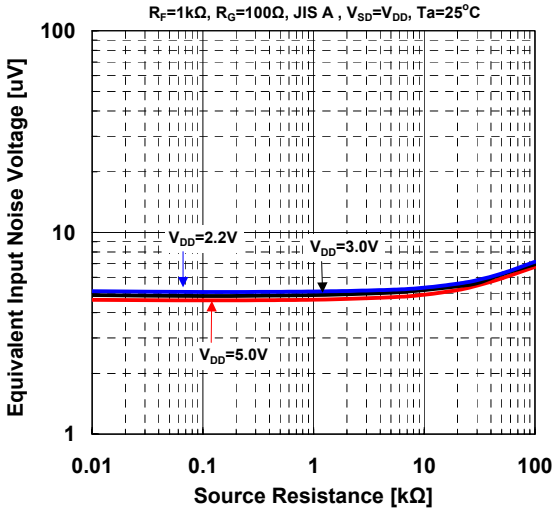
Equivalent Input Noise Voltage vs. Frequency
(Supply Voltage)

G_V=40dB,R_G=100kΩ, R_F=10kΩ, R_S=600Ω,
V_{SD}=V_{DD}, Ta=25°C



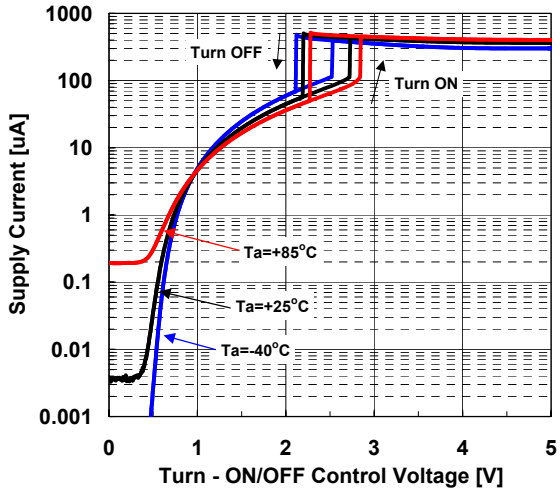
Equivalent Input Noise Voltage vs. Source Resistance
(Supply Voltage)

R_F=1kΩ, R_G=100Ω, JIS A , V_{SD}=V_{DD}, Ta=25°C

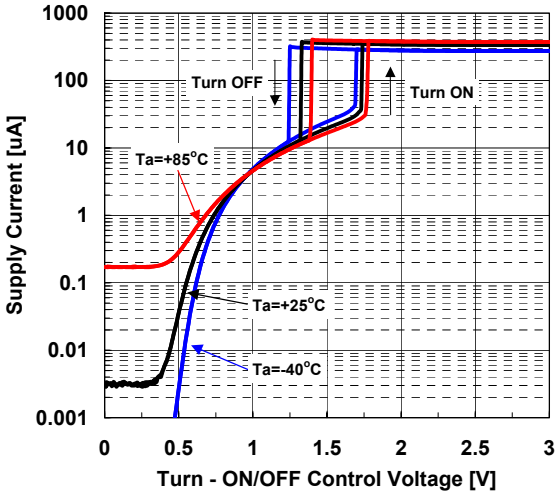


■TYPICAL CHARACTERISTICS

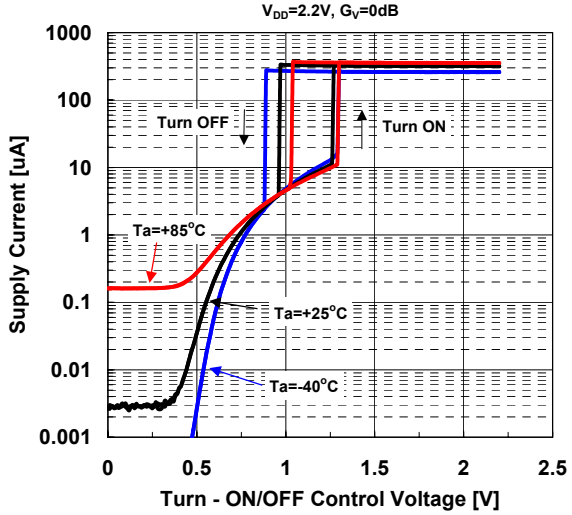
Supply Current vs. Turn - ON/OFF Control Voltage
(Temperature, V_{DD}=5V)
V_{DD}=5.0V, G_V=0dB



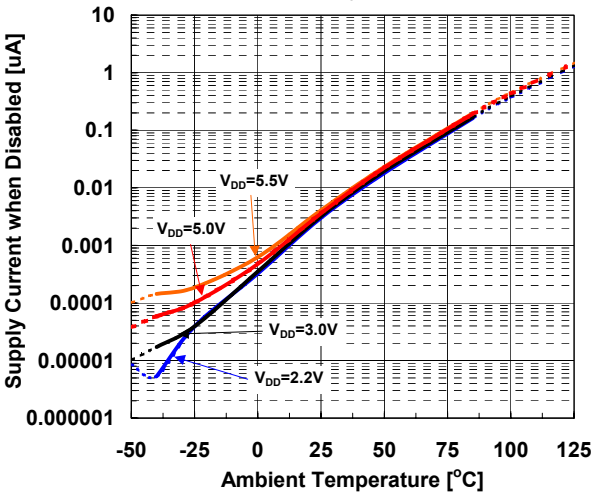
Supply Current vs. Turn - ON/OFF Control Voltage
(Temperature, V_{DD}=3V)
V_{DD}=3.0V, G_V=0dB



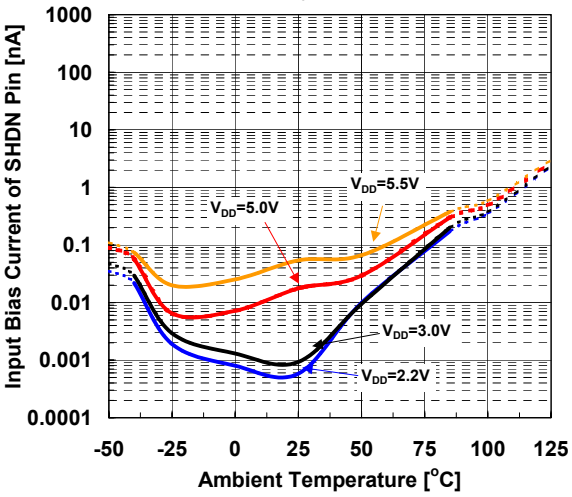
Supply Current vs. Turn - ON/OFF Control Voltage
(Temperature, V_{DD}=2.2V)
V_{DD}=2.2V, G_V=0dB



Supply Current when Disabled
vs. Ambient Temperature
G_V=0dB, V_{SD}=0.2V



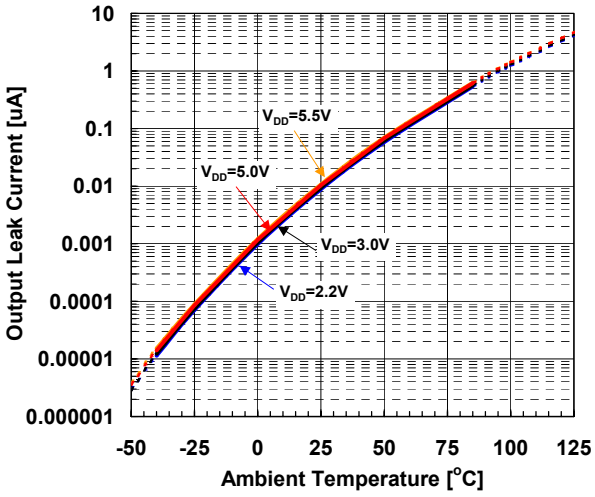
Input Bias Current of SHDN Pin
vs. Ambient Temperature
V_{SD}=V_{DD}



■TYPICAL CHARACTERISTICS

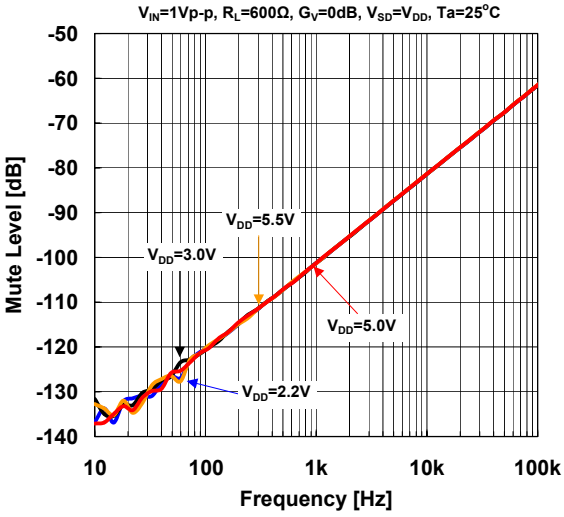
Output Leak Current vs. Ambient Temperature

V_{ICM}=1/2V_{DD}, V_{OUT}=1/2V_{DD}, G_V=OPEN, V_{SD}=GND



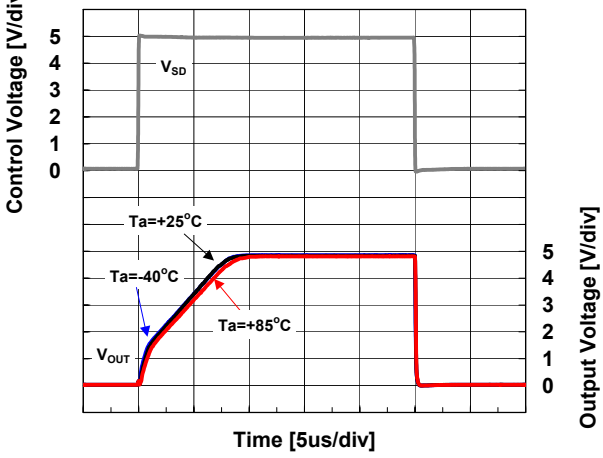
Mute Level vs. Frequency

V_{IN}=1Vp-p, R_L=600Ω, G_V=0dB, V_{SD}=V_{DD}, Ta=25°C



SHDN Pulse Response (Temperature)

V_{DD}=5V, V_{SD}=5V_{p-p}, f=20kHz, G_V=OPEN, R_L=600Ω



SHDN Pulse Response (Supply Voltage)

V_{SD}=5V_{p-p}, f=20kHz, G_V=OPEN, R_L=600Ω, Ta=25°C