High-Power & Low-Voltage Stereo Audio Power Amplifier with 3D Surround

■GENERAL DESCRIPTION

The **NJU7085** is a stereo audio power amplifier with surround sound technology for portable applications. No external coupling capacitors are required because of the differential outputs. The closed loop gain is adjusted by two external resistors. And the standby mode control reduces the supply current.

The **NJU7085** contains pop & click noise protection circuitry which eliminates noises during turn-on and turn-off transitions and RF rectification canceling circuitry.

■ PACKAGE OUTLINE

NJU7085SF7

NJU7085V

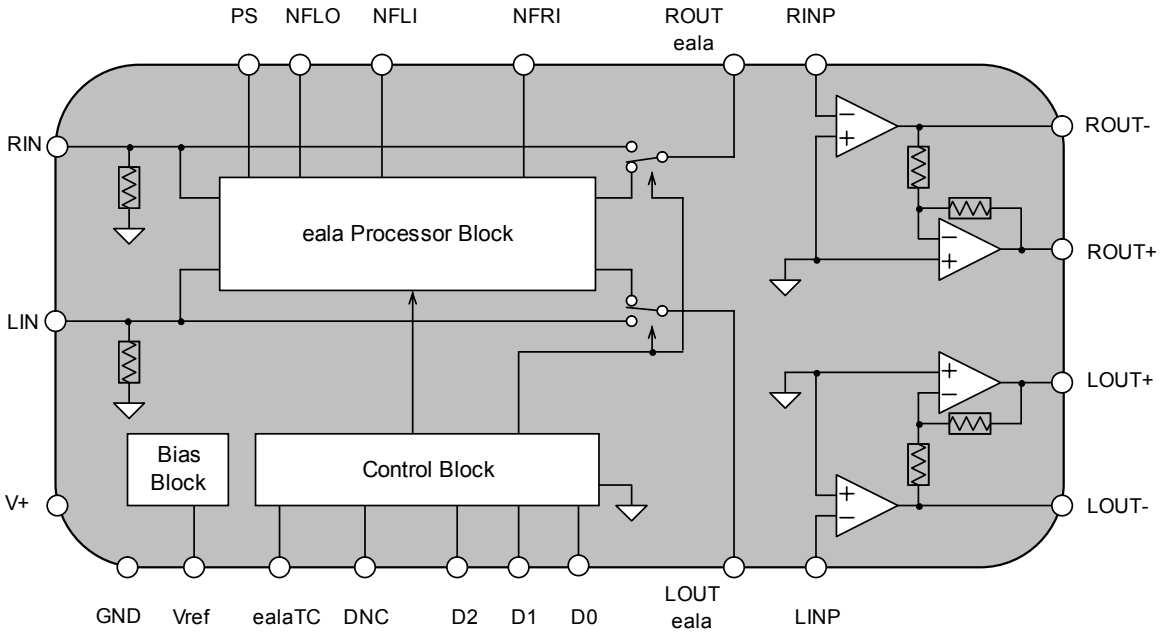
■ APPLICATION

- Portable DVD/TV
- Cradle Speaker
- Mobile-phone/PHS

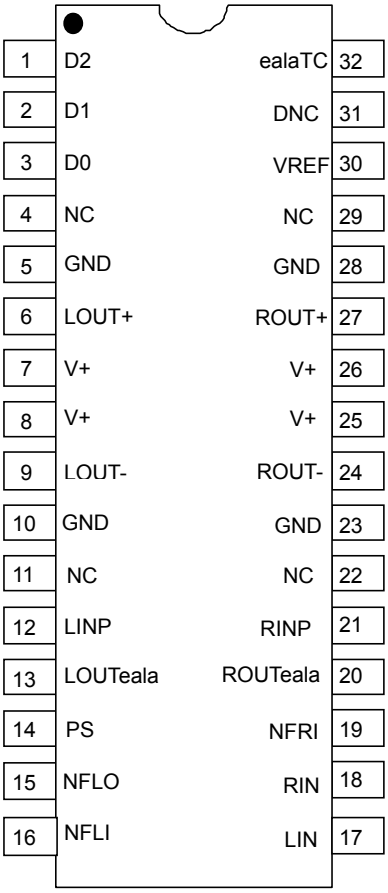
■FEATURES

• Operating Voltage	V^+=2.8 to 5.5V	
• Operating Current	I_{DD1}=4.6 mA typ.	(Mobile mode)
• Supply Current in Power Down Mode	I_{DD4}=2μA max.	(Standby mode)
• Output Power	P_o=400mW/ch typ.	(V^+=3V,R_L=4Ω)
• Low Output Noise	25μVrms typ.	
• Variable Surround Effect by external resistor		
• Standby function		
• Mute Function		
• C-MOS Technology		
• Package Outline	PCSP32F7,SSOP32	

■ BLOCK DIAGRAM



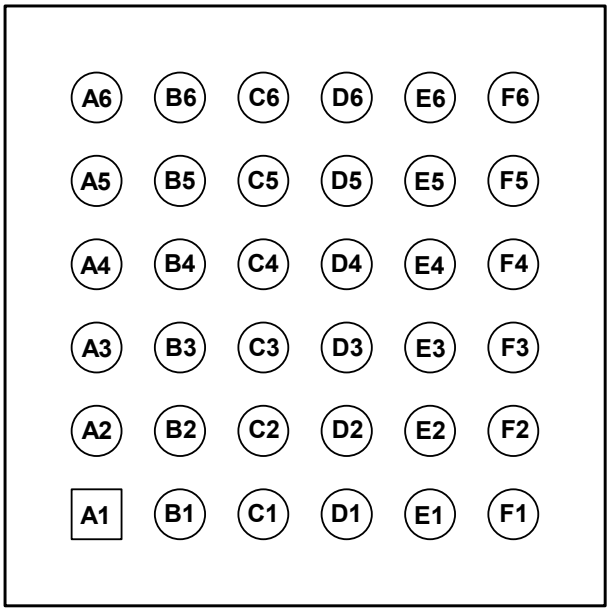
■ PIN CONFIGURATION **(SSOP32)**



No.	Symbol	Function	No.	Symbol	Function
1	D2	Mode Control Switch 2	17	LIN	Lch Input
2	D1	Mode Control Switch 1	18	RIN	Rch Input
3	D0	Mode Control Switch 0	19	NFRI	Filter
4	NC	-	20	ROUTeala	eala processor Rch Output
5	GND	GND	21	RINP	Power Amp Rch Output
6	LOUT+	Lch+ Output	22	NC	-
7	V+	Power Supply	23	GND	GND
8	V+	Power Supply	24	ROUT-	Rch- Output
9	LOUT-	Lch- Output	25	V+	Power Supply
10	GND	GND	26	V+	Power Supply
11	NC	-	27	ROUT+	Rch+ Output
12	LINP	Power Amp Lch Input	28	GND	GND
13	LOUTeala	eala Processor Lch output	29	NC	-
14	PS	Filter	30	VREF	Reference Voltage
15	NFLO	Filter	31	DNC	Do Not Connect
16	NFLI	Filter	32	ealaTC	Filter

*All power supply pin should be connected.

■ PIN CONFIGURATION **(PCSP32F7)**



PCSP32F7 (TOP VIEW)

PCSP32F7											
No.	Symbol	No.	Symbol	No.	Symbol	No.	Symbol	No.	Symbol	No.	Symbol
A1	GND	B1	LOUT+	C1	V+	D1	LOUT-	E1	GND	F1	LOUTeala
A2	D0	B2	NC	C2	NC	D2	NC	E2	LINP	F2	PS
A3	D2	B3	D1	C3	NC	D3	NC	E3	NFLI	F3	NFLO
A4	DNC	B4	ealaTC	C4	NC	D4	NC	E4	RIN	F4	LIN
A5	Vref	B5	NC	C5	NC	D5	NC	E5	ROUTeala	F5	NFRI
A6	GND	B6	ROUT+	C6	V+	D6	ROUT-	E6	GND	F6	RINP

■ **ABSOLUTE MAXIMUM RATINGS** (Ta=25°C)

PARAMETER	SYMBOL	RATINGS	UNIT
Supply Voltage	V^+	+7	V
Power Dissipation	P_D	950*[1] (SSOP32) 1500*[2] (SSOP32) 720*[1] (PCSP32) 1700*[2] (PCSP32)	mW
Output Peak Current	Io	500	mA
Operating Temperature Range	T_{opr}	-40 to +85	°C
Storage Temperature Range	T_{stg}	-40 to +125	°C

*[1] EIA/JEDEC STANDARD Test board (76.2 x 114.3 x 1.6mm, 2layers, FR-4) mounting
*[2] EIA/JEDEC STANDARD Test board (76.2 x 114.3 x 1.6mm, 4layers, FR-4) mounting

Junction Temperature:
Tj = θ_{ja} (Thermal Resistance) x Pd (Power Dissipation on your application) x Ta(Ambient Temperature)
Tj should be less than 0.8 times of the storage maximum temperature.

■ **RECOMMENDED OPERATING VOLTAGE RANGE** (Ta=25°C)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Voltage Range	V^+	-	2.8	3.0	5.5	V

■ **ELECTRICAL CHARACTERISTICS** (Ta=25°C, V^+=3V, Unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Operating Current	I_{DD1}	No signal, R_L=∞, Mobile mode	-	4.6	8.0	mA
	I_{DD2}	No signal, R_L=∞, Mute mode	-	4.6	8.0	mA
	I_{DD3}	No signal, R_L=∞, Charge mode	-	200	400	μA
	I_{DD4}	No signal, R_L=∞, STBY mode	-	-	2.0	μA
Reference Voltage	Vref	-	1.27	1.5	1.72	V

• **AC Characteristics**

(Ta=25°C, V^+=3V, G_V=6dB, V_{IN}=-20dBV, f=1kHz, R_L=4Ω, BW=400Hz to 30kHz, Bypass mode, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Maximum Input Voltage	V_{IM1}	THD=1%	-	-4.0 (630)	-	dBV (mVrms)
	V_{IM2}	THD=1%, f=100Hz, eala mode Lin→Lout, R1+R2=4.7kΩ	-	-21.4 (85)	-	
Output Noise Voltage	V_{NO1}	Rg=0Ω, A-weighted	-	-92 (25.1)	-	dBV (μVrms)
	V_{NO2}	Rg=0Ω, A-weighted, eala mode	-	-90 (31.6)		
Total Harmonic Distortion (THD+N)	THD1	Po=200mW	-	0.1	-	%
	THD2	Po=200mW, eala mode	-	0.1	-	
Bypass Gain	G_{VBYP}	Bypass mode	5.0	6.0	7.0	dB
Surround Gain 1	G_{VSUR1}	V_{IN}=-26dBV, f=100Hz, Lin→Lout, eala mode, R1+R2=4.7kΩ	17.5	20.5	23.5	dB
Surround Gain 2	G_{VSUR2}	f=100Hz, Lin→Lout, eala mode R1+R2=54.7kΩ	6.5	8.5	10.5	dB
Surround Gain 3	G_{VSUR3}	V_{IN}=-26dBV, f=100Hz, Lin→Lout, Mobile mode, R1+R2=4.7kΩ	17.5	20.5	23.5	dB
Surround Gain 4	G_{VSUR4}	f=100Hz,Lin→Lout, Mobile mode, R1+R2=54.7kΩ	6.5	8.5	10.5	dB

• **AC Characteristics**

(Ta=25°C, V^+=3V, G_V=6dB, V_{IN}=-20dBV, f=1kHz, R_L=4Ω, BW=400Hz to 30kHz, Bypass mode, unless otherwise specified)

PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
Output Power	P_o	THD≤2%, Gv=12dB	320	400	-	mW
Power Supply Rejection Raito	PSRR	Vripple=1kHz/100mVrms	-	55	-	dB
Mute Attenuation	MAT1	Mute mode	-	-95	-	dB
	MAT2	STBY mode	-	-130	-	dB
Channel Separation	CS	R_S=600W, V_O=1Vrms, f=1kHz, A-weighted	-	70	-	dB
Input Resistance	R_{IN}	LIN, RIN Terminal	-	100	-	kΩ
	R_{MODE}	Mode Control Terminal	10	-	-	
Output Offset Voltage	V_{OD}	V_{IN}=0V	-60	-	60	mV

• **Mode Control** (Ta=25°C, V^+=3V)

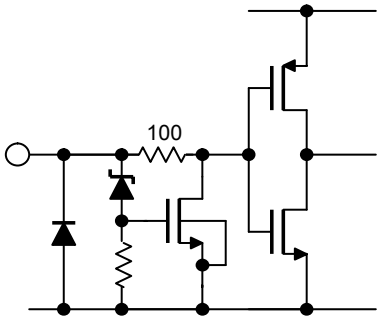
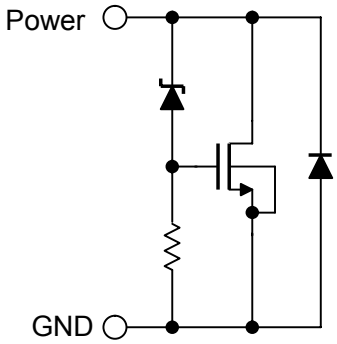
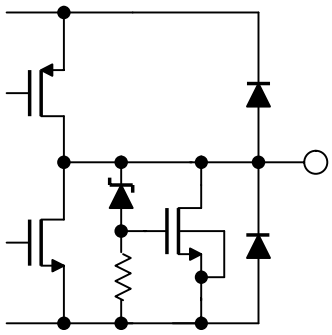
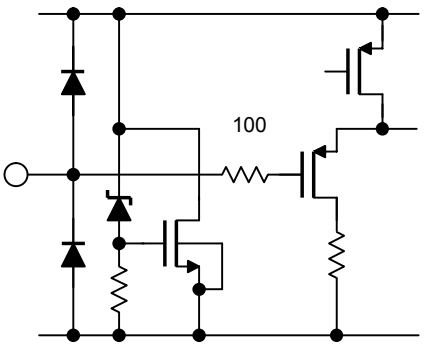
PARAMETER	SYMBOL	TEST CONDITION	MIN.	TYP.	MAX.	UNIT
High Level Input Voltage	V_{IH}	-	$0.7V^+$	-	V^+	V
Low Level Input Voltage	V_{IL}	-	0	-	0.25	

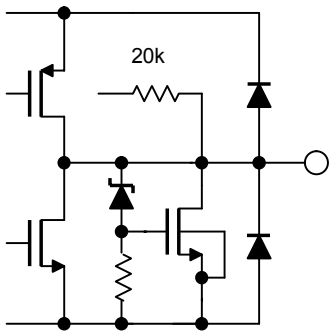
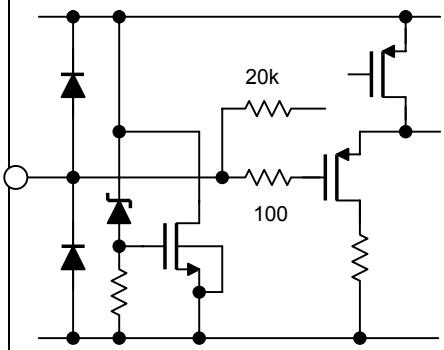
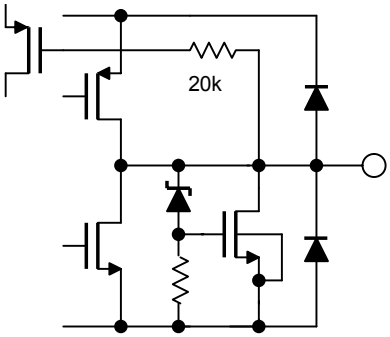
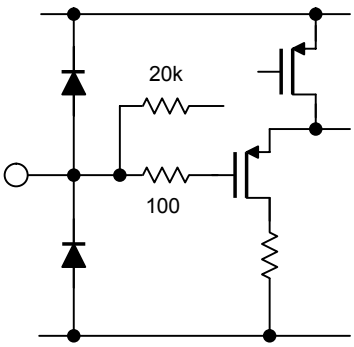
■ **CONTROL TERMINAL EXPLANATION**

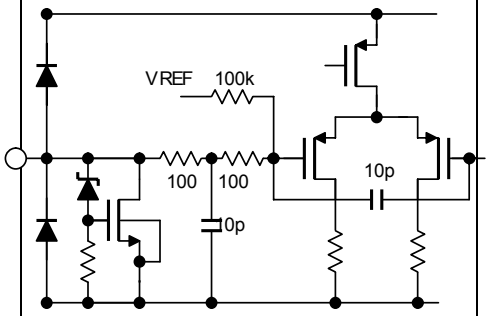
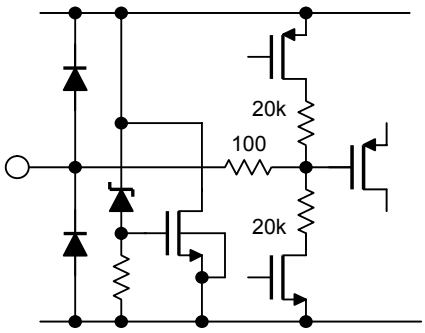
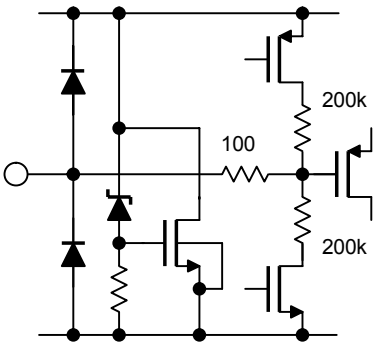
• **MUTE/Standby Mode Control** (MUTE, STBY Terminal)

Operation Mode	D2	D1	D0	NOTE
STBY	L	L	L	IC is non-active
Charge	H	L	L	Reference Voltage Charge mode
MUTE	H	L	H	Non output signal
Bypass	L	H	H	INPUT through
eala	L	L	H	eala-ON
Mobile	H	H	H	eala Mobile-ON
Inhibited Setting	Except for above			-

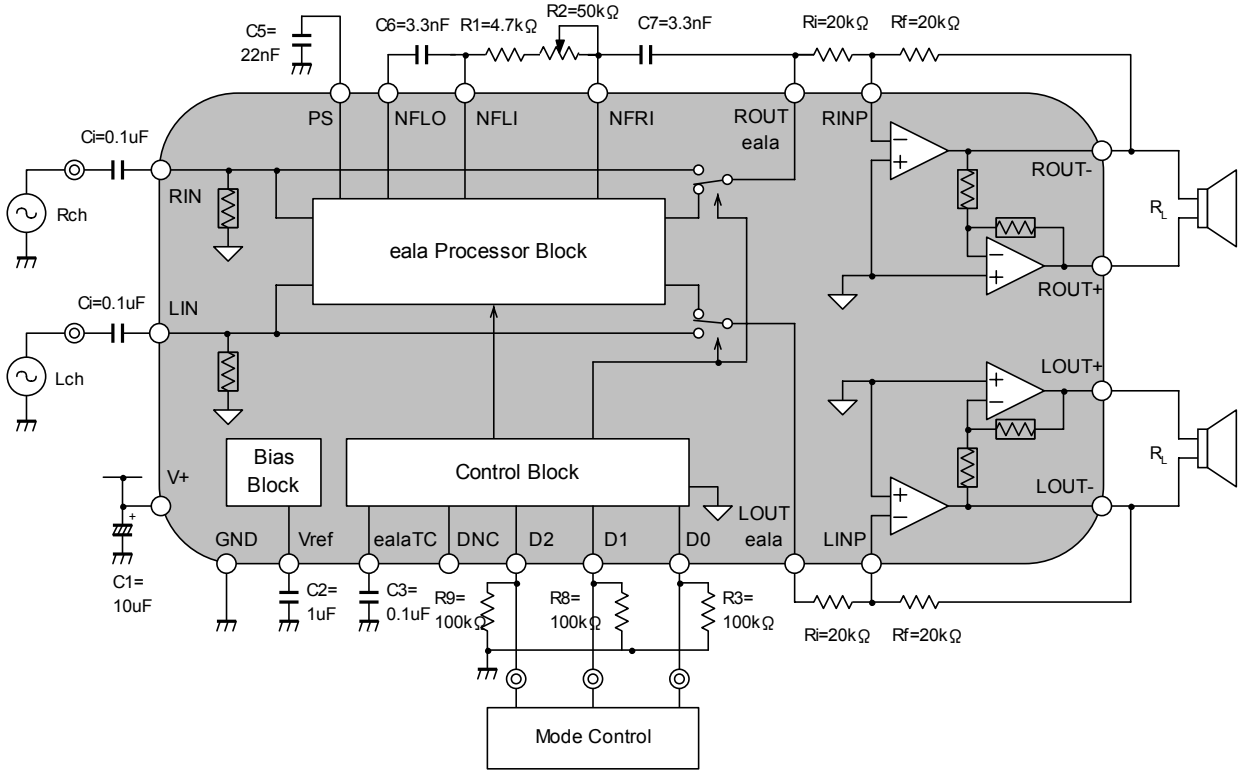
■TERMINAL DESCRIPTION

PIN No. SSOP32	PIN No. PCSP32	SYMBOL	FUNCTION	EQUIVALENT CIRCUIT	TERMINAL DC VOLTAGE
1 2 3	A3 B3 A2	D2 D1 D0	Mode Control Switch		
7,8, 25,26 5,10, 23,28	C1 C6 A1 A6 E1 E6	V+ GND	Power GND		V+ 0
6 9 24 27	B1 D1 D6 B6	LOUT+ LOUT- ROUT- ROUT+	Lch+ Output Lch- Output Rch- Output Rch+ Output		V+/2
12 21	E2 F6	LINP RINP	Lch Input to Power Amp Rch Input to PowerAmp		V+/2

PIN No. SSOP32	PIN No. PCSP32	SYMBOL	FUNCTION	EQUIVALENT CIRCUIT	TERMINAL DC VOLTAGE
13 20	F1 E5	LOUTeala ROUTeala	Lch Input to eala Processer Rch Input to eala Processer		V+/2
14	F2	PS	Filter		V+/2
15	F3	NFLO	Filter		V+/2
16 19	E3 F5	NFLI NFRI	Filter		V+/2

PIN No. SSOP32	PIN No. PCSP32	SYMBOL	FUNCTION	EQUIVALENT CIRCUIT	TERMINAL DC VOLTAGE
17 18	F4 E4	LIN RIN	Lch Input Rch Input		V+/2
30	A5	Vref	Reference Voltage		V+/2
32	B4	ealaTC	Filter		
4,11 22,29	B2,B5 C2,C3, C4,C5 D2,D3 D4,D5	NC	No Connection		
31	A4	DNC	Do Not Connection		

■ APPLICATION CIRCUIT



■APPLICATION NOTES

The **NJU7085** is high power (P_o=400mW/ch typ.) and low operating voltage (2.8V to) stereo audio power amplifier with surround sound technology for cellular phones and portable equipments.

The external coupling capacitors are not necessary because of the differential outputs.

The closed loop gain is set 0 to 43dB by selecting the ratio of Ri to Rf.

The **NJU7085** contains 6-mode:Bypass mode (Input through), eala mode (stereo surround), eala Mobile mode (surround for narrow space speaker), STBY mode (IC is non-active), charge mode (Reference Voltage Charge mode), MUTE mode (Non output signal).

The **NJU7085** includes pop noise protection circuit eliminating noises during turn-on and turn-off transitions.

1.Notice

1.1 The **NJU7085** may be not effective for a sound without the reverberation such as FM and monaural signal source.

1.2 eala Mobile mode may be not effective in the system that speaker distance is more than 20 cm. In this case, we recommend eala mode.

1.3 **NJU7085** includes RF rectification canceling circuit, but please confirm it by an enough examination in your actual application.

2.Operation Outline

Fig.1 shows the block diagram of **NJU7085**.
It consists of eala surround block, power amp block, bias block, thermal shutdown block, control block.
The surround effect can be adjusted with eala effect volume (external resister: R2).
Two external resisters adjust the closed loop gain (Ri, Rf).

The standby function contributes to low consumption by suspecting all circuits.
Charge mode allows start time to shorten because of the external reference capacitor(C2) charged rapidly.
By using external capacitors C2, C3, The **NJU7085** reduces pop noise during turn-on and turn-off transitions.
Please refer to captor 3 detail of Pop noise.

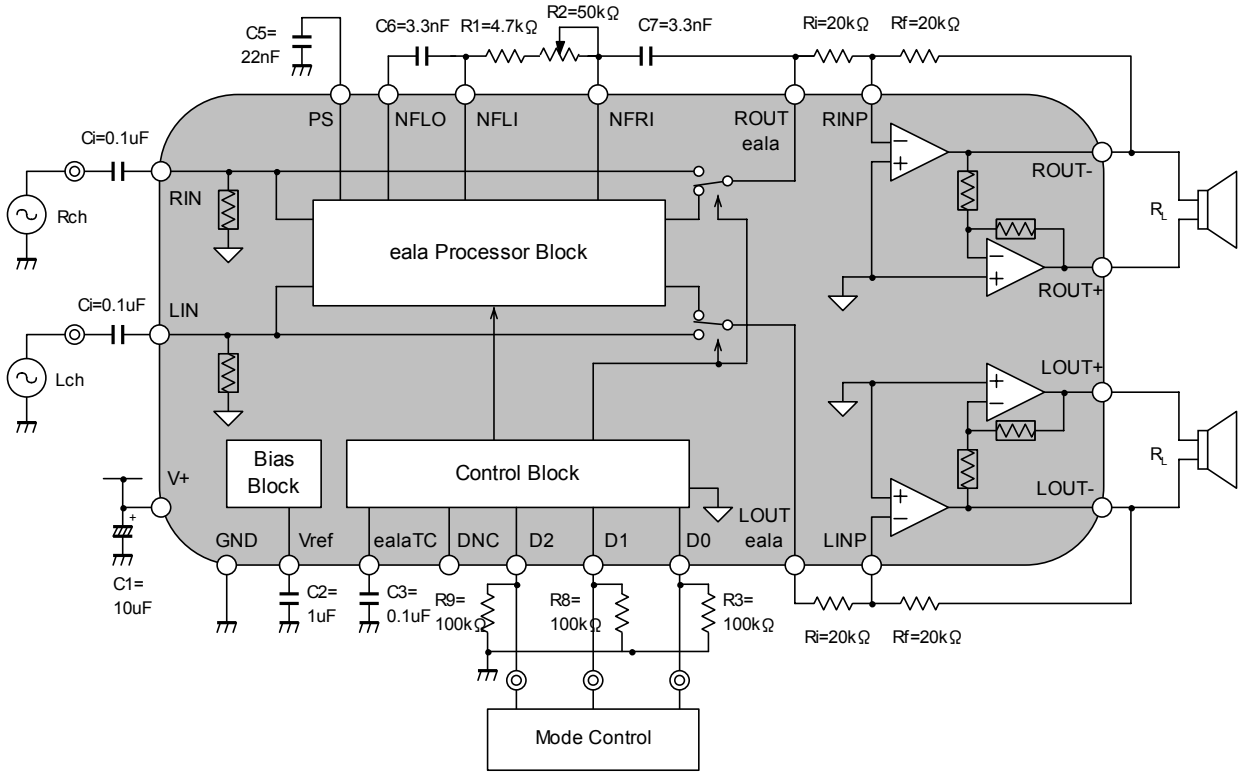


Fig.1 Block Diagram

2.1External parts

2.1.1 power supply bypassing capacitor
Select C1 which is enough good thermal characteristics and high frequency characteristics. The wiring pattern between C1 and IC should be shortened to prevent the generating of wiring resistance.

2.1.2 Input coupling capacitor
The input impedance and input coupling capacitor (Ci) form a high pass filter which limits low frequency response. The input impedance is designed about 100kΩ.

2.1.3 Input resistance (Ri) and feedback resistance (Rf) of power amplifier.
The closed loop gain is adjusted by Ri and Rf .
It is given by the following equation.

$$Gv=20LOG(2Rf/Ri) = 6\ [dB]$$

The closed loop gain should be set from 0dB to +43dB.

2.1.4Reference voltage bypassing capacitor
Reference voltage bypassing capacitor (C2) affects PSRR (See Fig.2).

2.1.5 eala effect volume
The surround effect is able to adjust with eala effect volume (R2).
It is able to replace to fixed resister (R1+R2) if you select constant surround effect.

2.1.6 eala TC capacitor
eala TC capacitor (C3) reduces pop noise at the time of changing the mode setting (Bypass⇔eala, Bypass⇔Mobile, eala ⇔Mobile).
The pop noise becomes smaller with using large capacitor.

2.1.7 PS capacitor
PS capacitor (C5) affects phase characteristics on eala Mobile mode.
In case of canceling L/R sound, it is able to compensate with using small capacitor.

2.1.8 Control terminal (D0,D1,D2) resistance
Control terminal resistances (R3, R8, R9) reduce pop noise at the time of changing mode control.

2.1.9 PSRR (Power Supply Rejection Ratio) vs. C2
Large bypassing capacitor (C2) improves PSRR shown in Fig.2.
But a large input coupling capacitor requires more charge time to reach its quiescent DC voltage.
Select C2 in consideration of PSRR and pop noise.

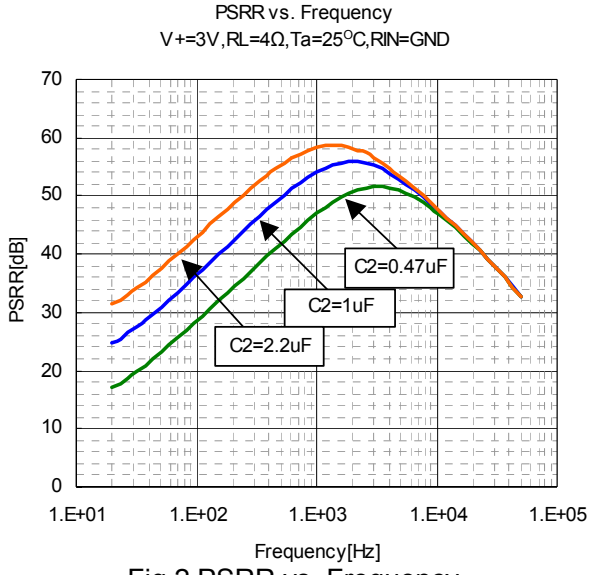


Fig.2 PSRR vs. Frequency

2.2 Operation explanation

2.2.1 Bypass Mode
Fig.2 shows the signal channel at bypass mode.

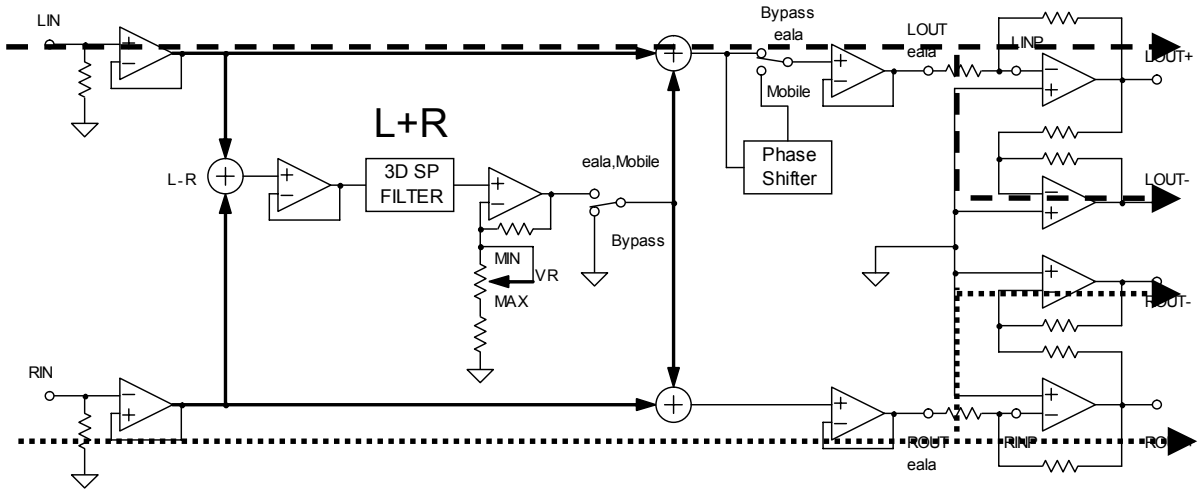


Fig.2 Bypass Mode

2.2.2 eala Mode
Fig.3 shows the signal channel at eala mode.

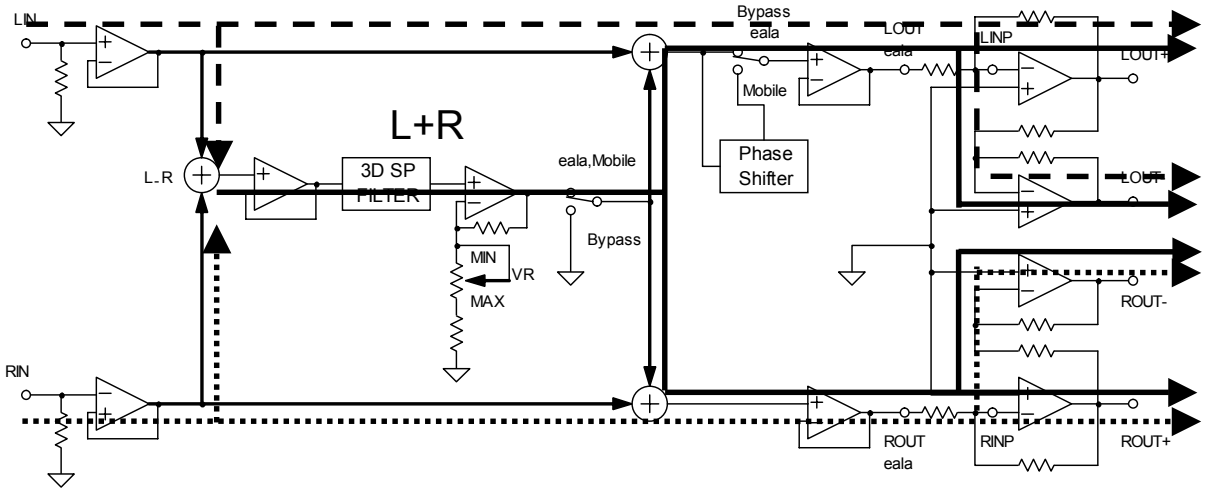


Fig.3 eala Mode

2.2.3 ealaMobile Mode

Fig.4 shows the signal channel at eala Mobile mode.

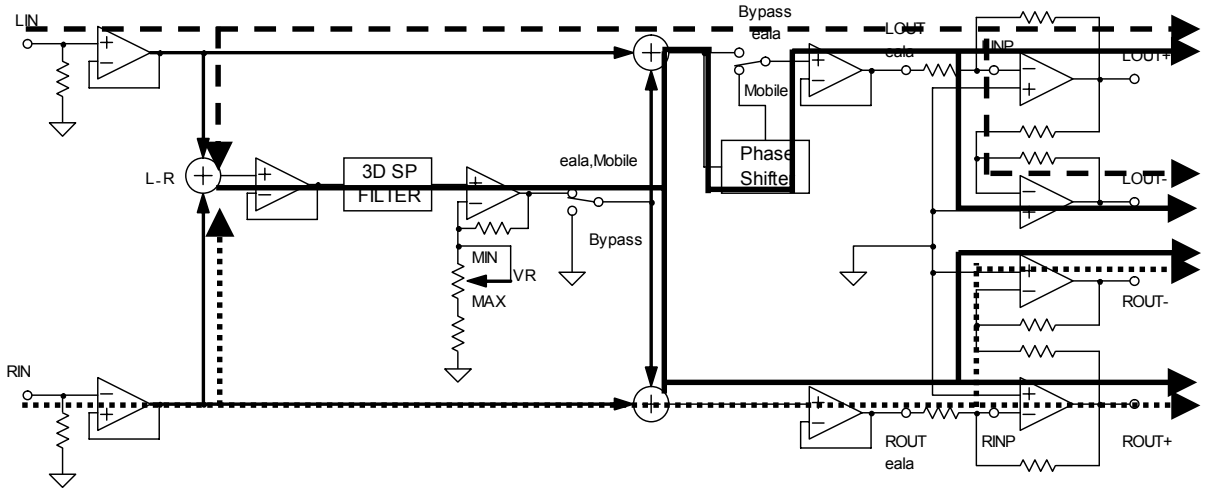


Fig.4 Mobile Mode

3 Power ON/OFF and pop noise during turn-on and turn-off transitions.
The NJU7085 reduces pop noise by using capacitor for charge & discharge.
The following shows tips of reducing pop noise.

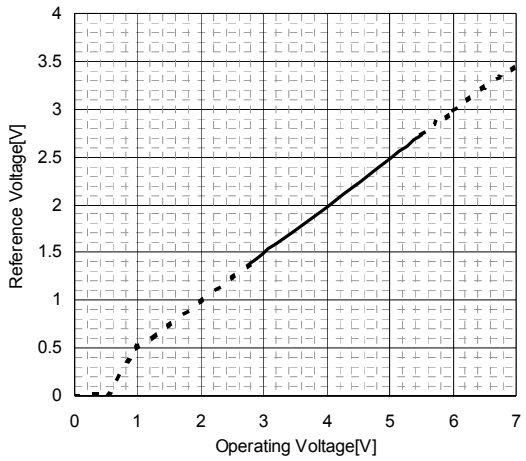
3.1 Power Supply ON/OFF
Power ON/OFF should be changed on the STBY mode (D0,D1,D2=L,L,L)

3.2 STBY → Active (Bypass /eala /Mobile mode)
The recommendation sequence is described as follows.
STBY (L,L,L) → Charge (L,L,H) → MUTE (H,L,H) → each mode
It should be provided the charge time of at least 50 msec for reducing pop noise under application circuit condition (C2=1μF).
The charge time is given by the following equation.
T = 5 x C2 x 100k [S]

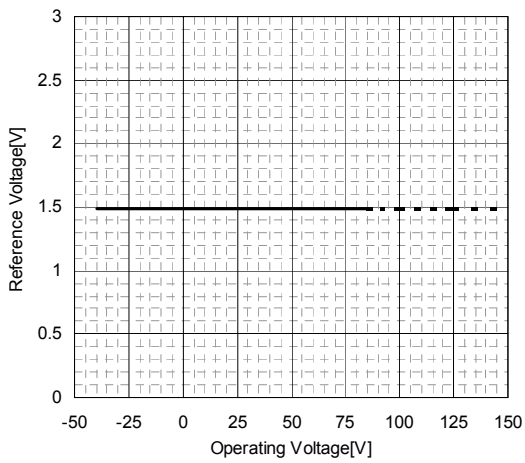
3.3 Active (Bypass /eala /Mobile mode) → STBY
The recommendation sequence is described as follows.
Each mode → Mute (H,L,H) → STBY (L,L,L)

■TYPICAL CHARACTERISTICS

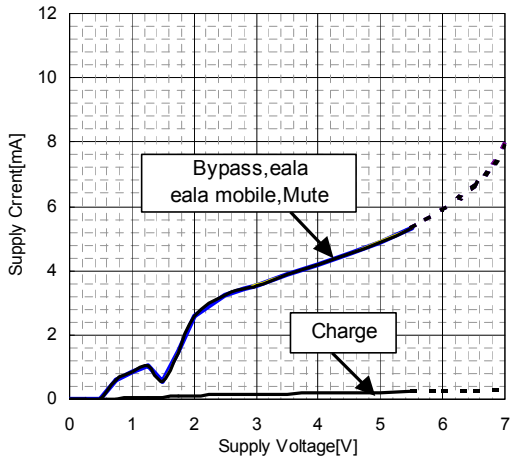
Reference Voltage vs. Operating Voltage
Ta=25°C



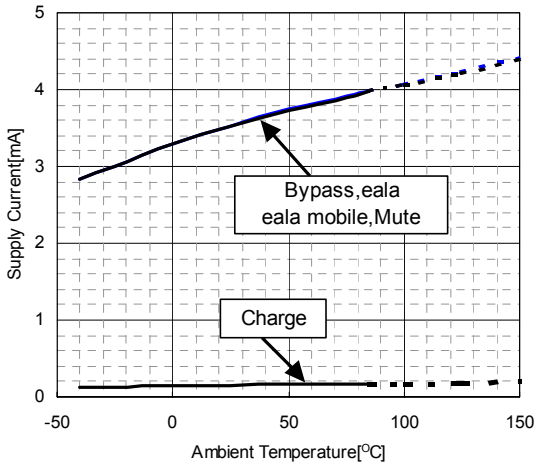
Reference Voltage vs. Ambient Temperature
V+=3V



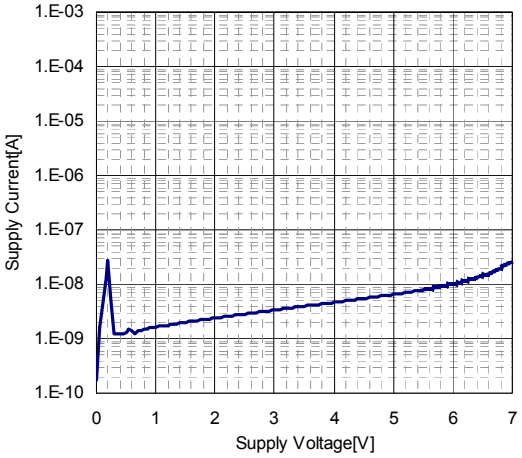
Supply Current vs.Supply Voltage
RL=OPEN, Ta=25°C



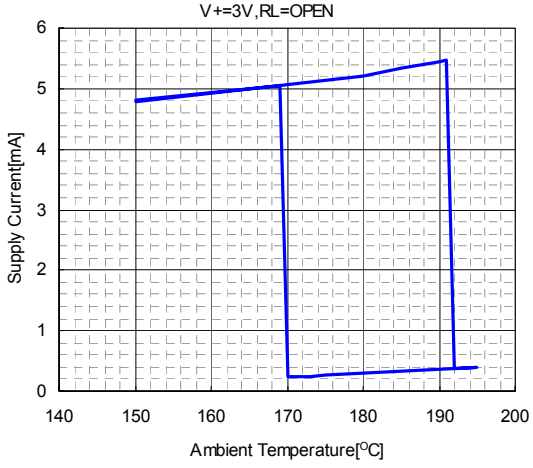
Supply Current vs. Ambient Temperature
V+=3V,Gv=6dB,RL=OPEN



Supply Current vs. Supply Voltage
(STBY mode)

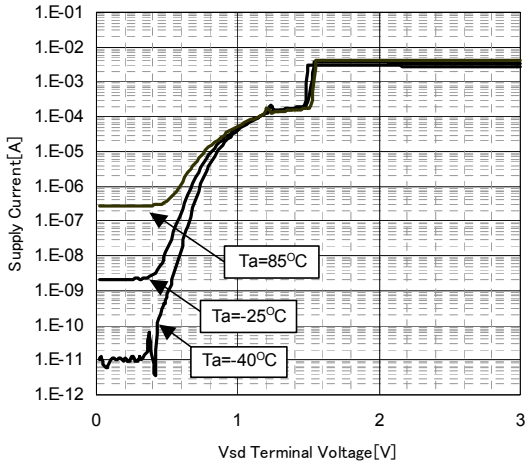


Supply Current vs. Ambient Temperature
(Thermal shutdow n)
V+=3V,RL=OPEN

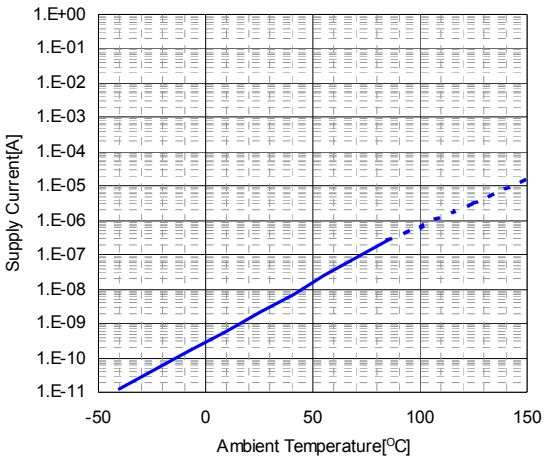


■TYPICAL CHARACTERISTICS

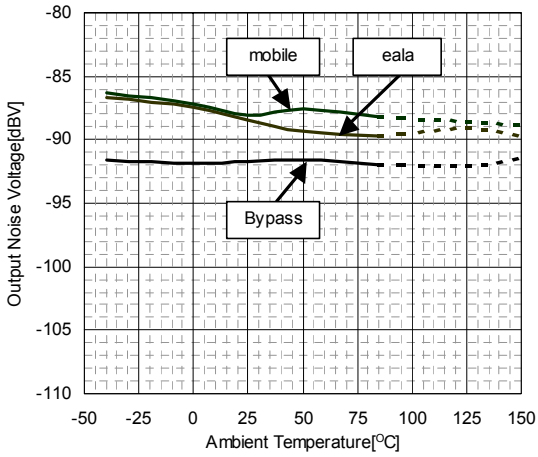
CNT Terminal Voltage vs. Supply Current(Ta)
V+=3V,RL=OPEN



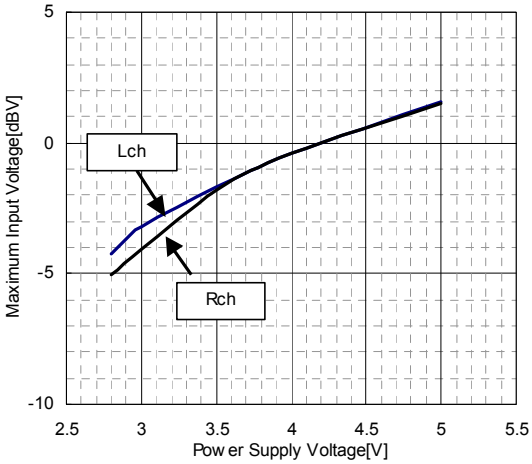
Supply Current vs Ambient Temperature(Shut down)
V+=3V,RL=OPEN,VSD=0.25V



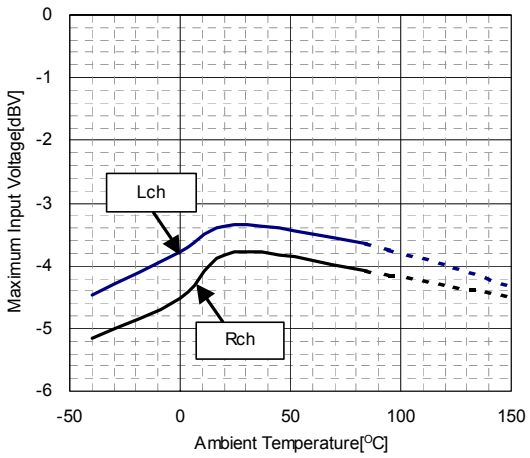
Output Noise Voltage vs. Ambient Temperature
V+=3V、Rg=0Ω、Reff=4.7kΩ、Vout=Lch,A-weighted



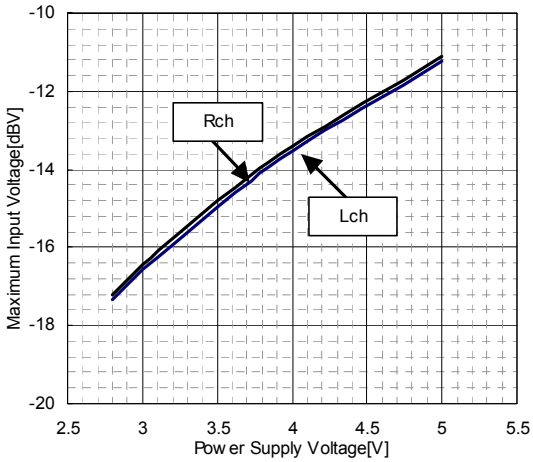
Maximum Input Voltage vs. Power Supply Voltage
RL=4Ω,f=1kHz,THD=1%,Bypass



Maximum Input Voltage vs. Ambient Temperature
V+=3V,RL=4Ω,f=100Hz,THD=1%,Bypass

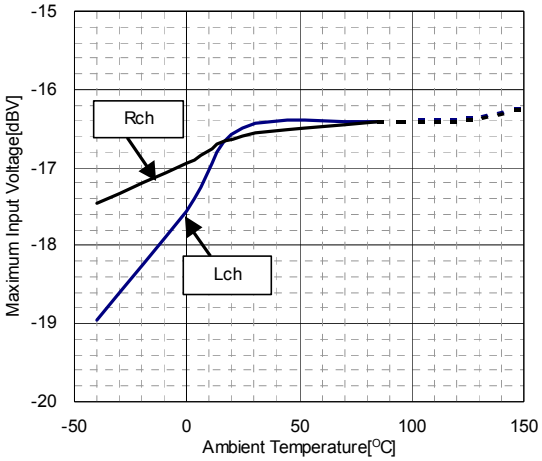


Maximum Input Voltage vs. Power Supply Voltage
RL=4Ω,f=100Hz,Reff=4.7kΩ,THD=1%,eala

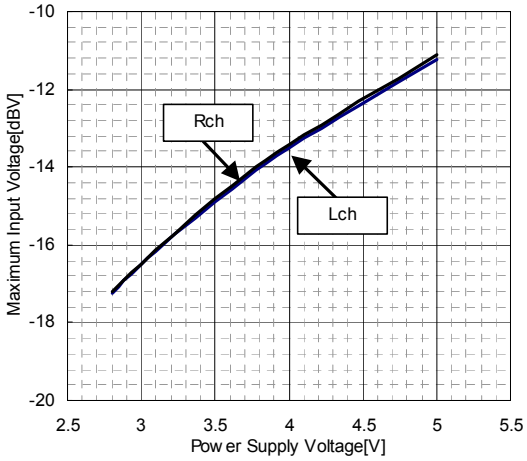


■TYPICAL CHARACTERISTICS

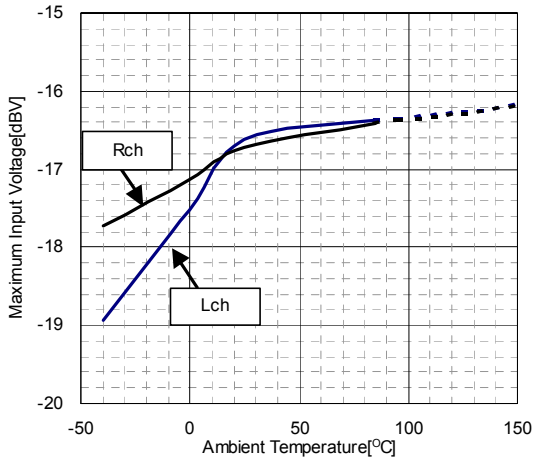
Maximum Input Voltage vs. Ambient Temperature
V+=3V,RL=4Ω,f=100Hz,THD=1%,eala



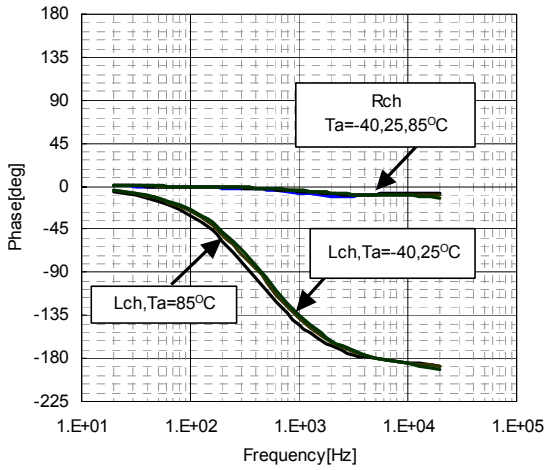
Maximum Input Voltage vs. Power Supply Voltage
RL=4Ω,f=100Hz,Reff=4.7kΩ,THD=1%,mobile



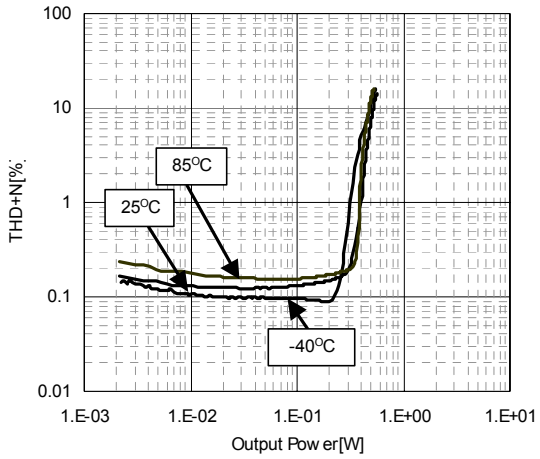
Maximum Input Voltage vs. Ambient Temperature
V+=3V,RL=4Ω,f=100Hz,THD=1%,mobile



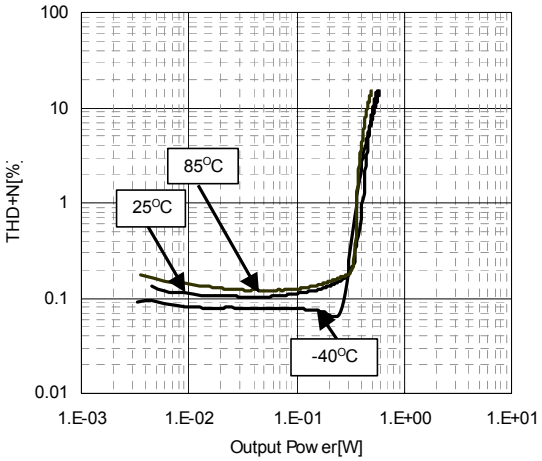
Phase vs, Frequency (Ta)
V+=3V,RL=4Ω,Vin=-20dBV, mobile



THD+N vs. Output Power
V+=3V,Gv=6dB(PA),f=1kHz,RL=4Ω,Vout=Lch,Bypass

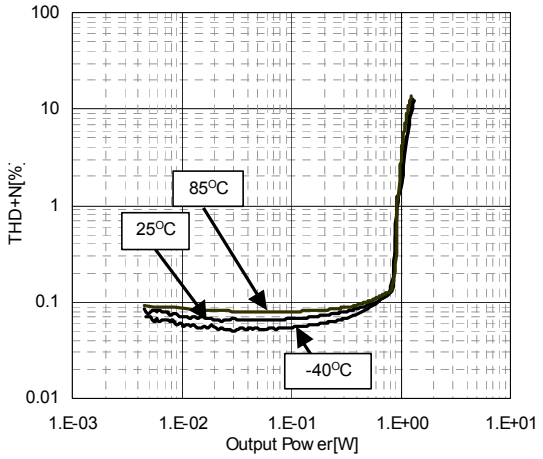


THD+N vs. Output Power
V+=3V,Gv=6dB(PA),f=100Hz,RL=4Ω,Vout=Lch,eala

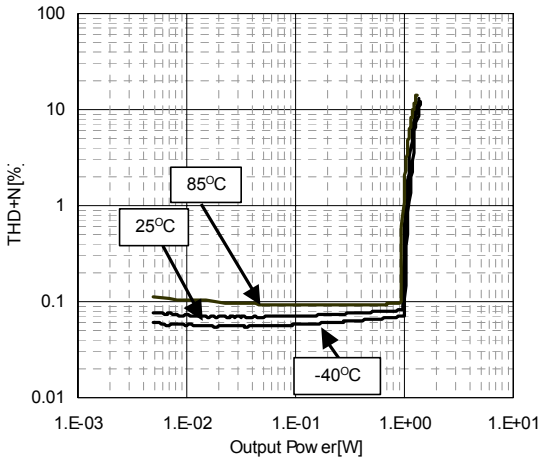


■TYPICAL CHARACTERISTICS

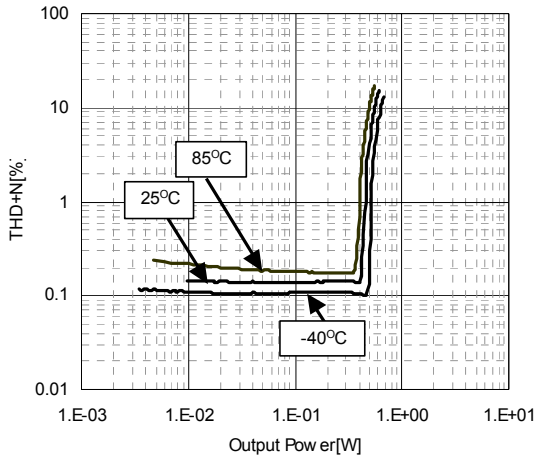
THD+N vs. Output Power
V+=5V,Gv=6dB(PA),f=1kHz,RL=8Ω,Vout=Lch,Bypass



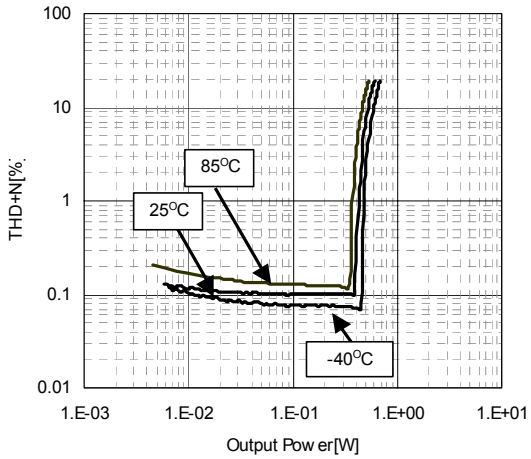
THD+N vs. Output Power
V+=5V,Gv=12dB(PA),f=1kHz,RL=8Ω,Vout=Lch,Bypass



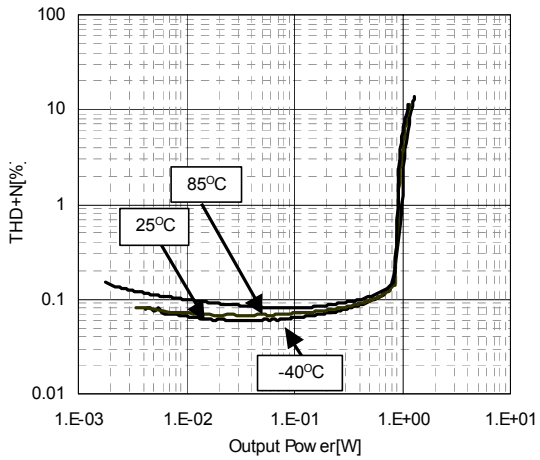
THD+N vs. Output Power
V+=3V,Gv=12dB(PA),f=1kHz,RL=4Ω,Vout=Lch,Bypass



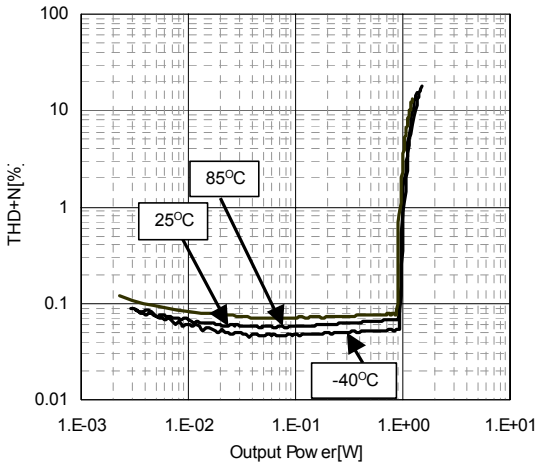
THD+N vs. Output Power
V+=3V,Gv=12dB(PA),f=100Hz,RL=4Ω,Vout=Lch,eala



THD+N vs. Output Power
V+=5V,Gv=6dB(PA),f=100Hz,RL=8Ω,Vout=Lch,eala

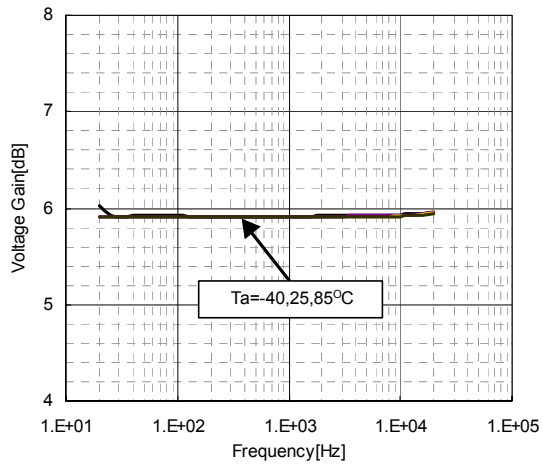


THD+N vs. Output Power
V+=5V,Gv=12dB(PA),f=100Hz,RL=8Ω,Vout=Lch,eala

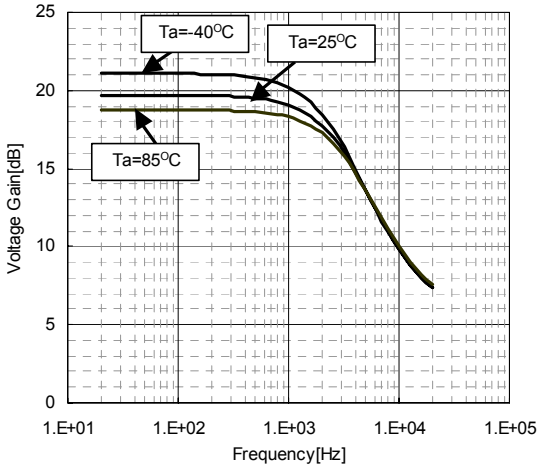


■TYPICAL CHARACTERISTICS

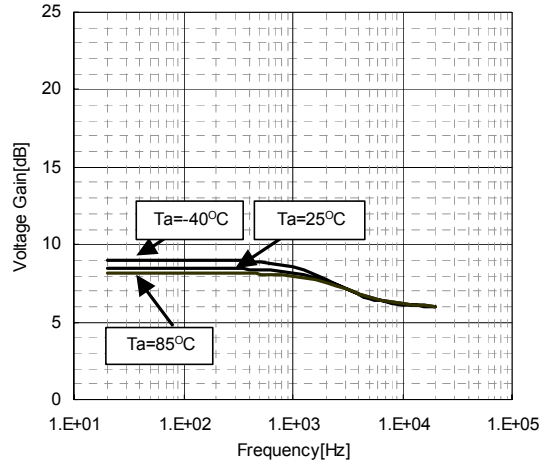
Voltage Gain vs. Frequency(Ta)
V+=3V,RL=4Ω,Vout=Lch,Bypass



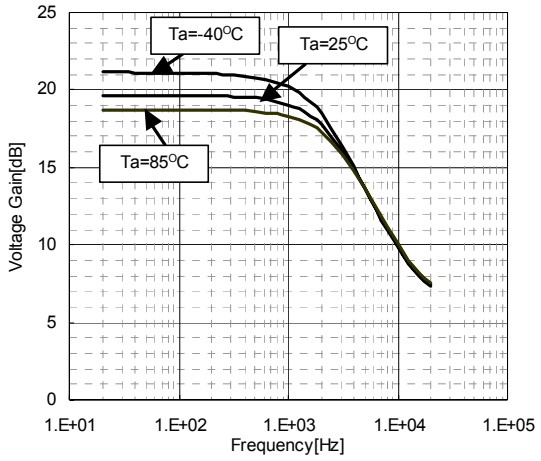
Voltage Gain vs. Frequency(Ta)
V+=3V,RL=4Ω,Reff=4.7kΩ,Vout=Lch,eala



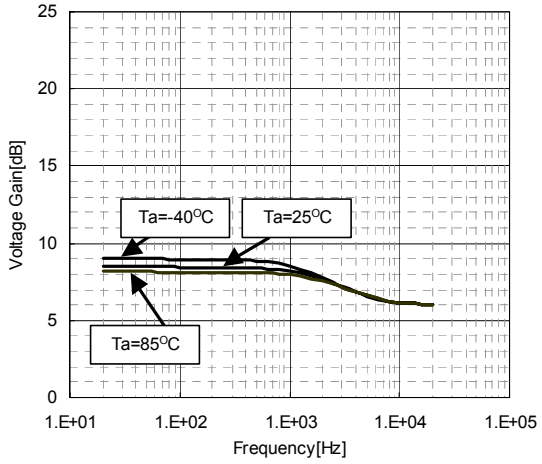
Voltage Gain vs. Frequency(Ta)
V+=3V,RL=4Ω,Reff=54.7kΩ,Vout=Lch,eala



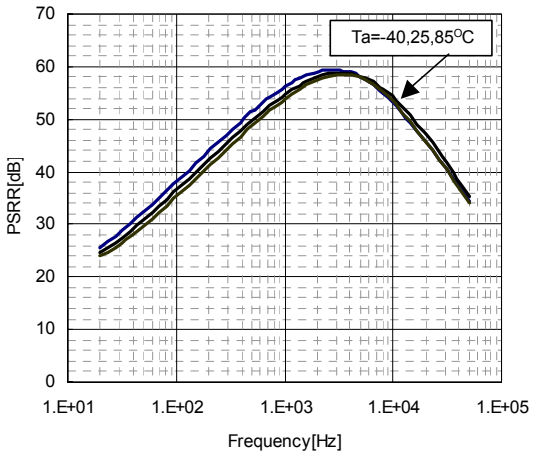
Voltage Gain vs. Frequency(Ta)
V+=3V、RL=4Ω、Reff=4.7kΩ、Vout=Lch、mobile



Voltage Gain vs. Frequency(Ta)
V+=3V、RL=4Ω、Reff=54.7kΩ、Vout=Lch、mobile

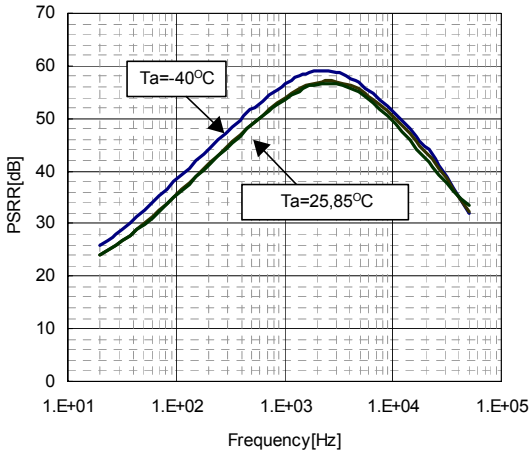


PSRR vs. Frequency(Ta)
V+=5V,RL=8Ω,RIN=GND,Vout=Lch,Bypass

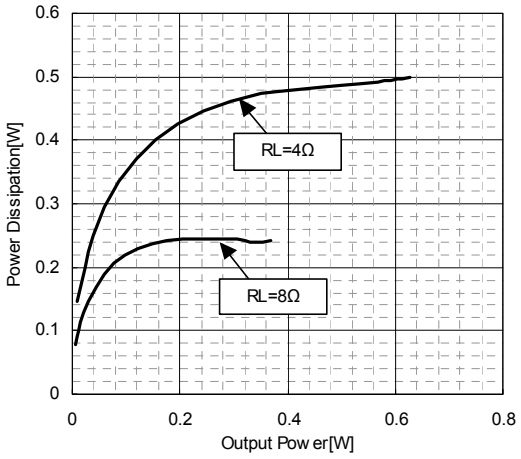


■TYPICAL CHARACTERISTICS

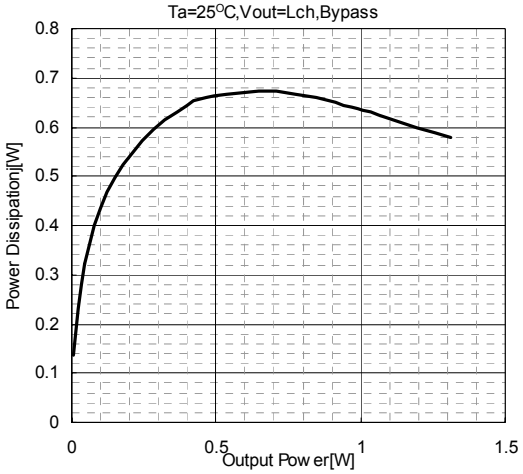
PSRR vs. Frequency(Ta)
V+=3V,RL=4Ω,RIN=GND,Vout=Lch,Bypass



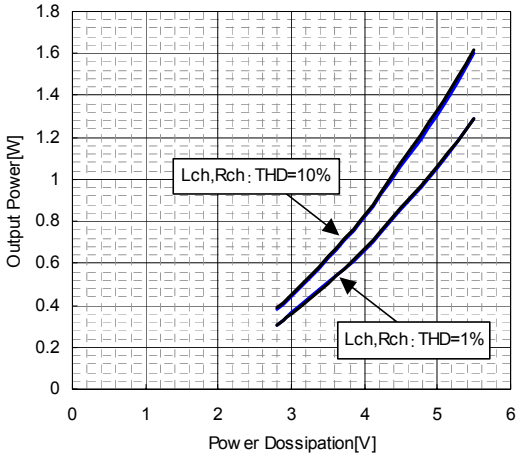
Power Dissipation vs. Output Power
V+=3V,Gv=6dB,f=1kHz,Ta=25°C,Vout=Lch,Bypass



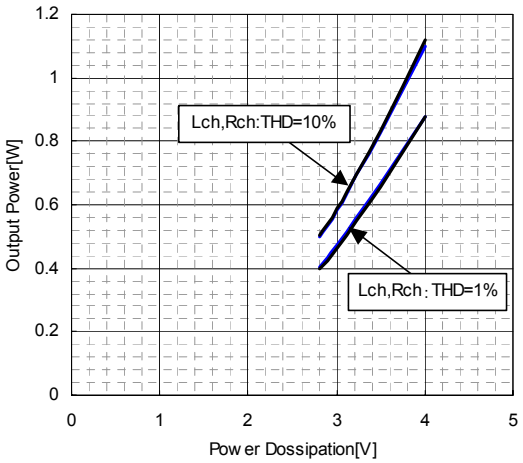
Power Dissipation vs. Output Power
V+=5V,Gv=6dB,RL=8Ω,f=1kHz,
Ta=25°C,Vout=Lch,Bypass



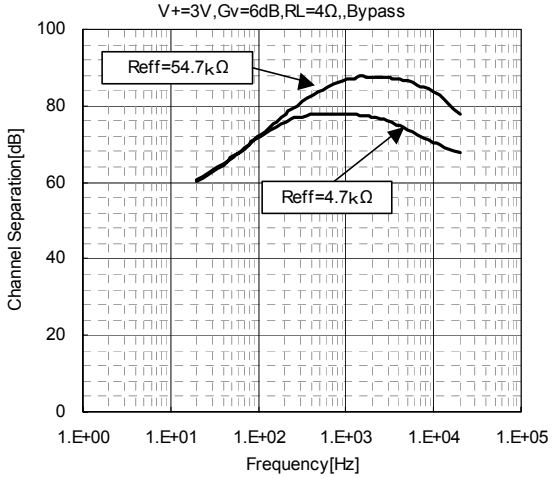
Output Power vs. Power Dissipation
Gv=12dB(PA),f=1kHz,RL=8Ω,Ta=25°C,Bypass



Output Power vs. Power Dissipation
Gv=12dB(PA),f=1kHz,RL=4Ω,Ta=25°C,Bypass



Channel Separation vs. Frequency
Rin→Lout
V+=3V,Gv=6dB,RL=4Ω,,Bypass



■TYPICAL CHARACTERISTICS