APA2020

ANPEC

Features

- **Depop Circuitry Integrated**
- **Thermal Shutdown Circuitry Integrated**
- **Output Power at 1% THD+N, V_{DD}=5V**
  - **1.8 W/Ch (typ) into a 4 WLoad**
  - **1.2 W/Ch (typ) into a 8 WLoad**
- **Bridge-Tied Load (BTL) or Single-Ended (SE) Modes Operation**
- **Various 24-Pin Power Packages Available SOP, TSSOP-P**
- **Shutdown Control Mode , I_{DD}= 0.5μA**
- **Lead Free and Green Devices Available (RoHS Compliant)**

Applications
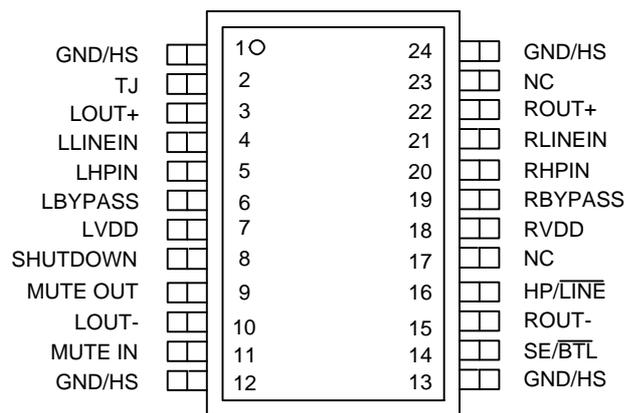
- **Stereo Audio Power Amplifier for Notebook Computer**

General Description

The APA2020 is a stereo bridge-tied audio power amplifier in various 24-pin power packages, including SOP and TSSOP-P. When connecting to a 5V voltage supply, the APA2020 is capable of delivering 1.8W/1.2W of continuous RMS power per channel into 4Ω/8Ω loads with less than 1% THD+N, respectively. The APA2020 simplifies design and frees up board space for other features. The APA2020 also served well in low-voltage applications , which provides 800-mW per channel into 4Ω loads with a 3.3V supply voltage. Both of the depop circuitry and the thermal shutdown protection circuitry are integrated in the APA2020, that reduces pops and clicks noise during power up and when using the shutdown or mute modes and protects the chip from being destroyed by over-temperature failure.
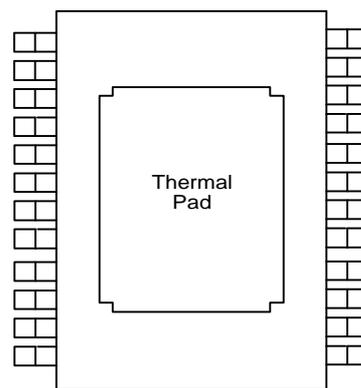
To simplify the audio system design in notebook computer applications, the APA2020 combines a stereo bridge-tied loads ($\overline{BTL}$) mode for speaker drive and a stereo single-end (SE) mode for headphone drive into a single chip, where both modes are easily switched by the SE/$\overline{BTL}$ input control pin signal. For power sensitive applications , the APA2020 also features a shutdown function which keeps the supply current only 0.5 μA (typ).

Pin Configuration

GND/HS	1	24	GND/HS
TJ	2	23	NC
LOUT+	3	22	ROUT+
LLINEIN	4	21	RLINEIN
LHPIN	5	20	RHPIN
LBYPASS	6	19	RBYPASS
LVDD	7	18	RVDD
SHUTDOWN	8	17	NC
MUTE OUT	9	16	HP/$\overline{LINE}$
LOUT-	10	15	ROUT-
MUTE IN	11	14	SE/$\overline{BTL}$
GND/HS	12	13	GND/HS

Top View
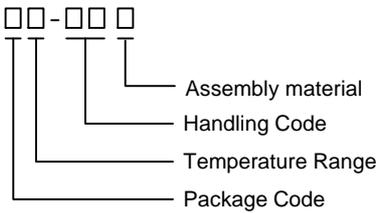
For SOP and TSSOP-P

Thermal Pad

Bottom View

For TSSOP-P Only

ANPEC reserves the right to make changes to improve reliability or manufacturability without notice, and advise customers to obtain the latest version of relevant information to verify before placing orders.

Ordering and Marking Information

APA2020 ☐☐-☐☐☐	Package Code
— Assembly material — Handling Code — Temperature Range — Package Code	K : SOP-24 R : TSSOP-24P Operating Ambient Temperature Range I : - 40 to 85°C Handling Code TR : Tape & Reel Assembly material L : Lead Free Device G : Halogen and Lead Free Device
APA2020 K :	[APA2020 / XXXXX] XXXXX - Date Code
APA2020 R :	[APA2020 / XXXXX] XXXXX - Date Code

Note: ANPEC lead-free products contain molding compounds/die attach materials and 100% matte tin plate termination finish; which are fully compliant with RoHS. ANPEC lead-free products meet or exceed the lead-free requirements of IPC/JEDEC J-STD-020C for MSL classification at lead-free peak reflow temperature. ANPEC defines "Green" to mean lead-free (RoHS compliant) and halogen free (Br or Cl does not exceed 900ppm by weight in homogeneous material and total of Br and Cl does not exceed 1500ppm by weight).

Absolute Maximum Ratings

(Over operating free-air temperature range unless otherwise noted.)

Symbol	Parameter	Rating	Unit
V_{DD}	Supply Voltage	6	V
T_A	Operating Ambient Temperature Range	-40 to 85	°C
T_J	Maximum Junction Temperature	150	°C
T_{STG}	Maximum Lead Storage Temperature Range	-65 to +150	°C
T_S	Maximum Lead Soldering Temperature,10 Seconds	260	°C

Recommended Operating Conditions

Symbol	Parameter		Min.	Typ.	Max.	Unit
V_{DD}	Supply Voltage		3	5	5.5	V
T_A	Operating free-air temperature	V_{DD}=5V, 4-Ω stereo BTL drive, 250mW/Ch average power, with proper PCB design	-20	-	85	°C
		V_{DD}=5V, 3-Ω stereo BTL drive, 2 W/Ch average power, with proper PCB design and 300 CFM forced-air cooling	-20	-	85	
V_{ICM}	Common mode input voltage	V_{DD}=5 V	1.25	-	4.5	V
		V_{DD}=3.3V	1.25	-	2.7	

Thermal Characteristics

Symbol	Parameter	Typical Value	Unit
θ_{JA}	Thermal Resistance from Junction to Ambient in Free Air		°C/W
	SOP-24	65	
	TSSOP-24P	45	

Electrical Characteristics

AC Operating Characteristics , V_{DD}= 5V , T_A= 25°C , R_L= 4Ω (unless otherwise noted)

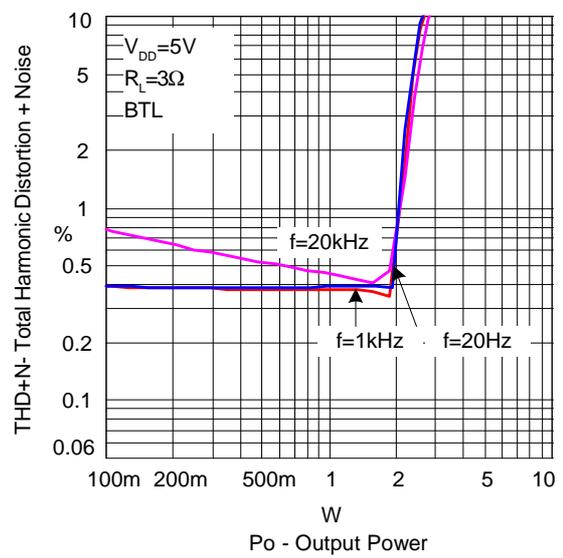| Symbol	Parameter	Test Conditions		APA2020			Unit
				Min.	Typ.	Max.	
P_O	Output Power (Each Channel) (Note 1)	THD+N = 10%, BTL	R_L=4Ω R_L=8Ω	-	2.3 1.5	-	W
		THD+N = 1%, BTL	R_L=4Ω R_L=8Ω	-	1.8 1.2	-	
		THD+N = 10%, SE	R_L=4Ω R_L=8Ω	-	650 400	-	mW
		THD+N = 1%, SE	R_L=4Ω R_L=8Ω	-	500 320	-	
		THD+N = 0.5%, SE	R_L=32Ω	-	90	-	
THD + N	Total Harmonic Distortion Plus Noise	P_O = 1.6W, BTL P_O = 1W, BTL P_O = 78mW, SE	R_L=4Ω R_L=8Ω R_L=32Ω	-	300 150 20	-	m%
		V_i = 1V, R_L =4Ω , A_V = 1		-	10	-	
BOM	Maximum Output Power Bandwidth	A_V = 10, THD+N < 1%		-	>20	-	kHz
	Phase Margin	R_L = 4Ω, BTL		-	72	-	°
		R_L = 4Ω, Open Load		-	71	-	
		R_L = 4Ω, SE		-	52	-	
PSRR	Power Supply Ripple Rejection	f =100 Hz		-	80	-	dB
	Mute Attenuation			-	85	-	dB
Crosstalk	Channel-to-Channel Output Separation			-	85	-	dB
HP/$\overline{LINE}$	Input Separation			-	75	-	dB
	BTL Attenuation in SE Mode			-	80	-	dB
Z_i	Input Impedance			-	2	-	MΩ
S/N	Signal-to-Noise Ratio	P_O = 500 mW, BTL		-	90	-	dB
Vn	Output Noise Voltage			-	80	-	μV(rms)

Note 1 : Output power is measured at the output terminals of the IC at 1 kHz.

Electrical Characteristics (Cont.)

AC Operating Characteristics , V_{DD}= 3.3V , T_A= 25°C , R_L= 4Ω (unless otherwise noted)

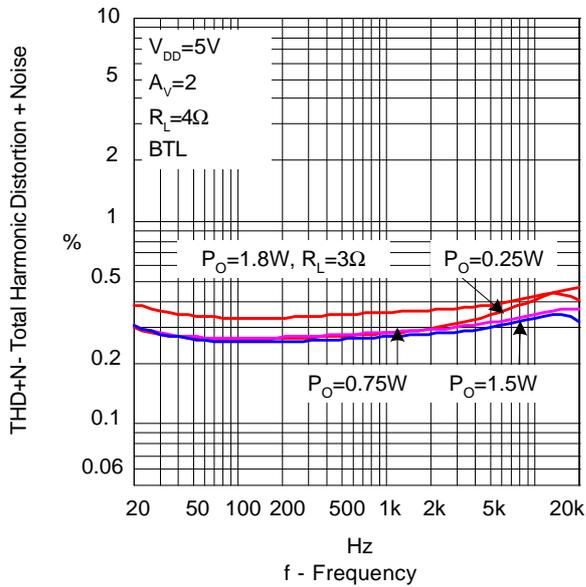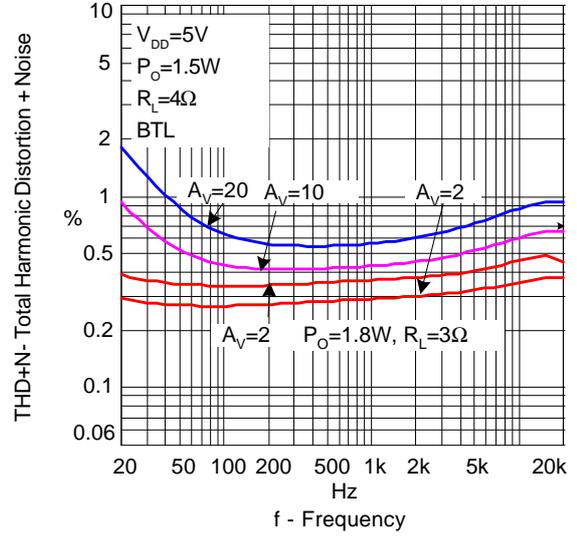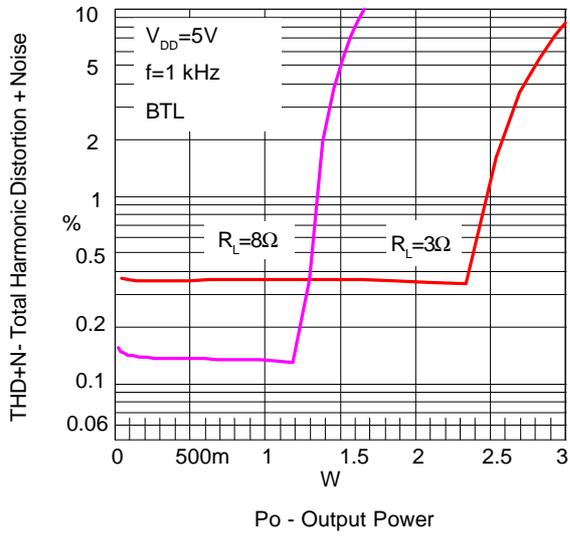| Symbol	Parameter	Test Conditions		APA2020			Unit
				Min.	Typ.	Max.	
P_O	Output Power (Each Channel) [Note 2]	THD+N = 10%, BTL	R_L=4Ω R_L=8Ω	-	1 0.6	-	W
		THD+N = 1%, BTL	R_L=4Ω R_L=8Ω	-	0.8 0.5	-	
		THD+N = 10%, SE	R_L=4Ω R_L=8Ω	-	290 180	-	mW
		THD+N = 1%, SE	R_L=4Ω R_L=8Ω	-	230 140	-	
		THD+N = 0.5%, SE	R_L=32 Ω	-	43	-	
THD + N	Total Harmonic Distortion Plus Noise	P_O = 1.6W, BTL P_O = 1W, BTL P_O = 78mW, SE	R_L=4Ω R_L=8Ω R_L=32Ω	-	270 150 20	-	m%
		V_i = 1V, R_L=4Ω, A_V = 1		-	10	-	
BOM	Maximum Output Power Bandwidth	A_V = 10, THD+N < 1%		-	>20	-	kHz
	Phase Margin	R_L = 4Ω, BTL		-	92	-	°
		R_L = 4Ω, Open Load		-	70	-	
		R_L = 4Ω, SE		-	57	-	
PSRR	Power Supply Ripple Rejection	f =100Hz		-	70	-	dB
	Mute Attenuation			-	85	-	dB
Crosstalk	Channel-to-Channel Output Separation	f =1kHz		-	85	-	dB
HP/$\overline{LINE}$	Input Separation			-	75	-	dB
	BTL Attenuation in SE Mode			-	80	-	dB
Z_i	Input Impedance			-	2	-	MΩ
S/N	Signal-to-Noise Ratio	P_O = 500 mW, BTL		-	90	-	dB
Vn	Output Noise Voltage			-	50	-	µV(rms)

Note 2 : Output power is measured at the output terminals of the IC at 1 kHz.

DC Electrical Characteristic, T_A=25°C

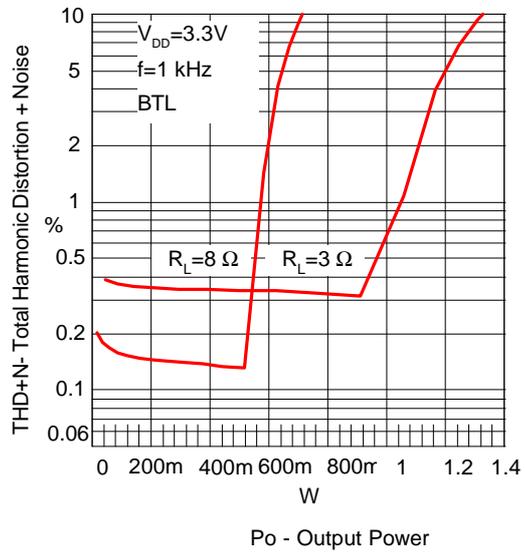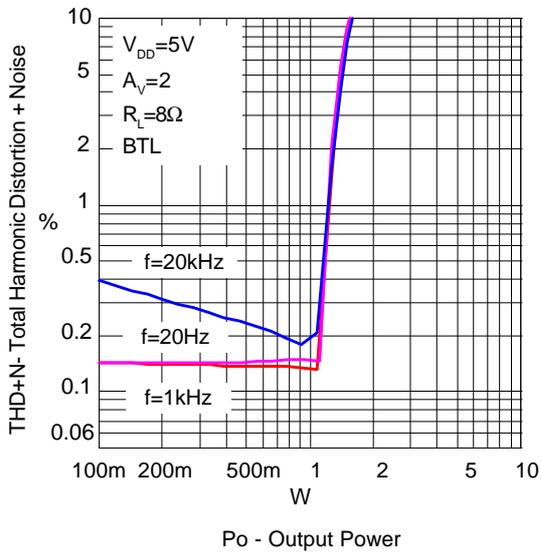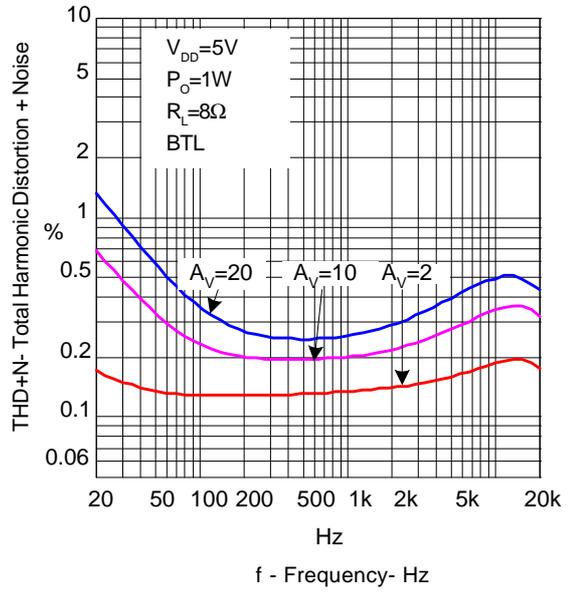| Symbol	Parameter	Test Conditions		APA2020		Unit
				Typ.	Max.	
I_{DD}	Supply Current	V_{DD}=5V	Stereo BTL	8	11	mA
			Stereo SE	4	6.5	mA
		V_{DD}=3.3V	Stereo BTL	7	9	mA
			Stereo SE	3.5	5.6	mA
V_{OS}	DC Differential Output Voltage	V_{DD}=5V, A_V=2 [Note 3]		5	25	mV
$I_{DD\,(MUTE)}$	Supply Current in Mute Mode	V_{DD}=5V		8	11	mA
I_{SD}	Supply Current in Shutdown	V_{DD}=5V		0.5	5	µA

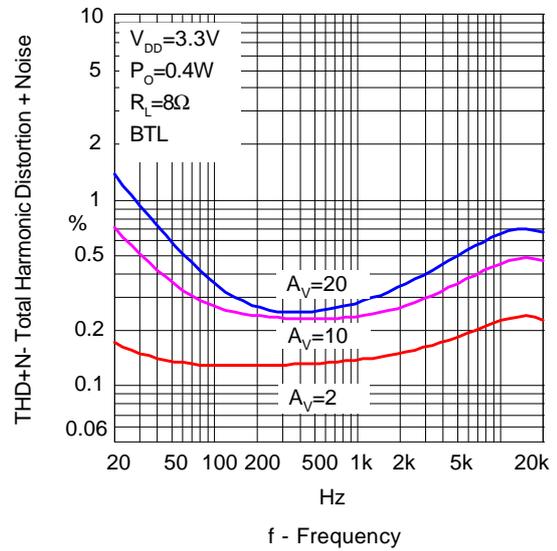Note 3 : at 3V<V_{DD}<5V , the DC output voltage is approximately V_{DD} / 2.

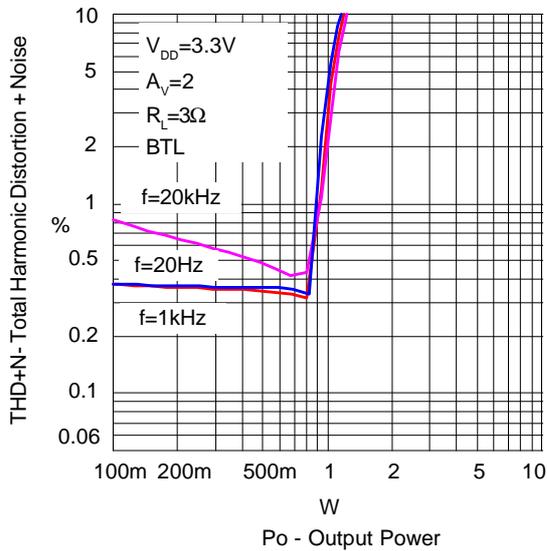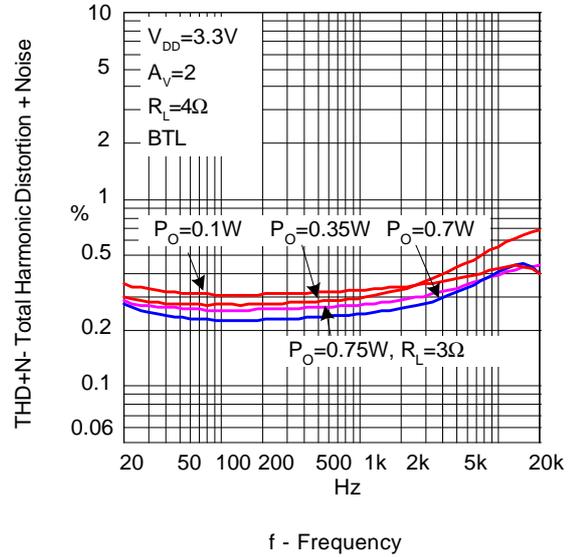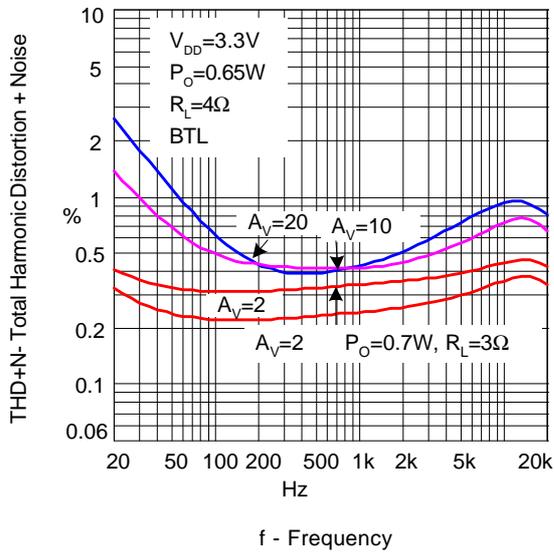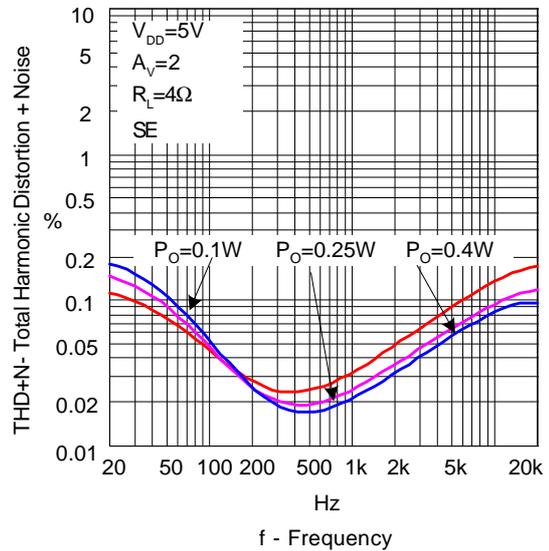## Typical Operating Characteristics
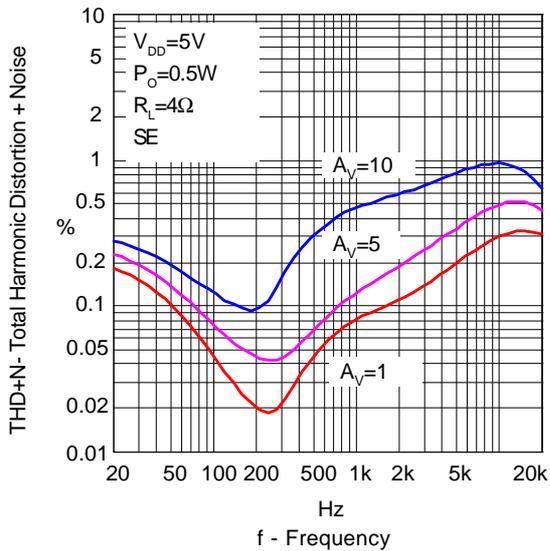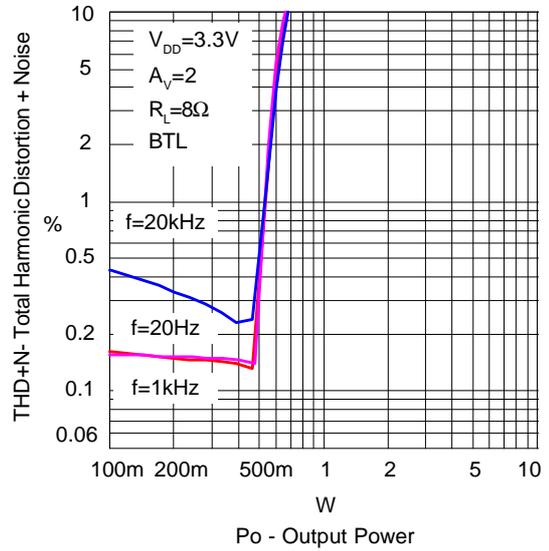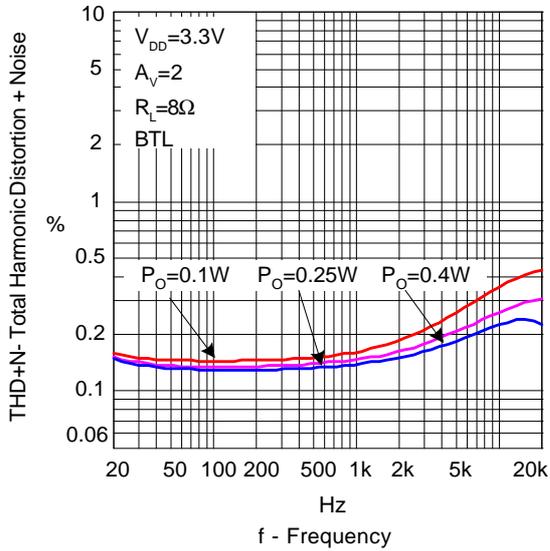

Po - Output Power

f - Frequency

f - Frequency

Po - Output Power
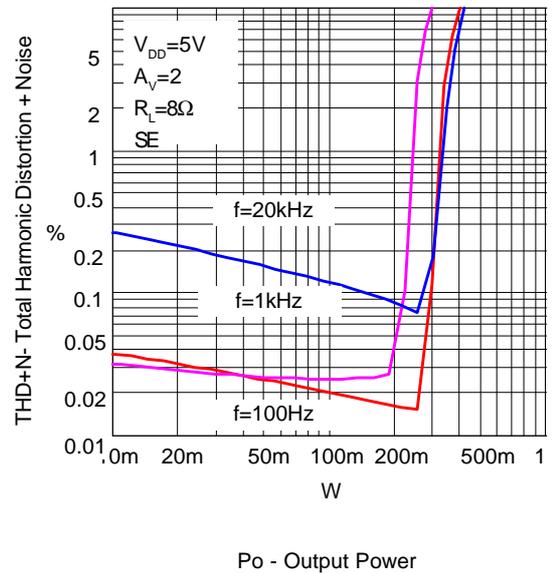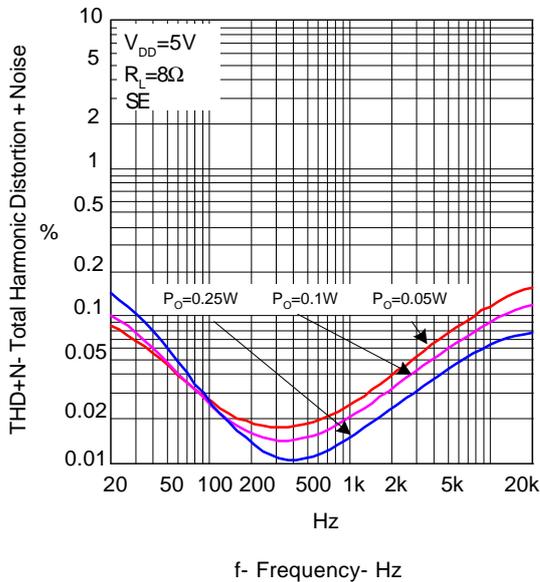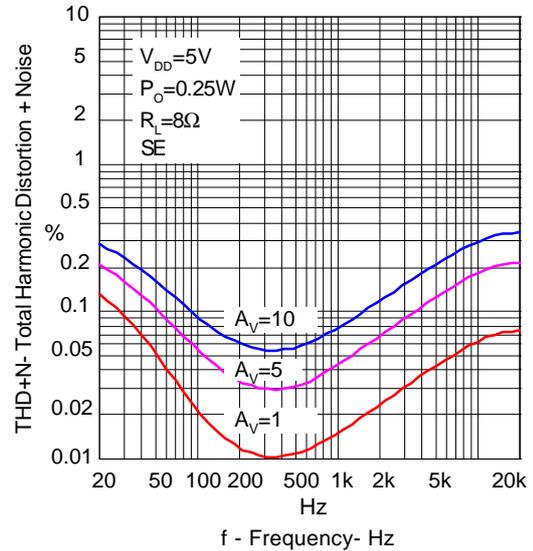
Typical Operating Characteristics (Cont.)

f - Frequency- Hz

f - Frequency- Hz

Po - Output Power

Po - Output Power

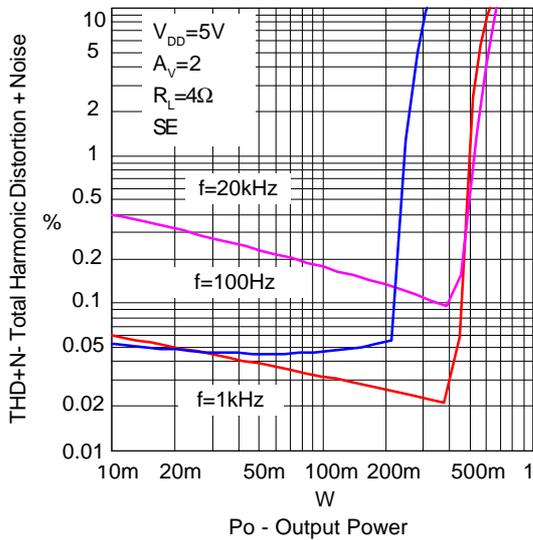## Typical Operating Characteristics (Cont.)

f - Frequency

f - Frequency

Po - Output Power

f - Frequency

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Typical Operating Characteristics (Cont.)

Typical Operating Characteristics (Cont.)

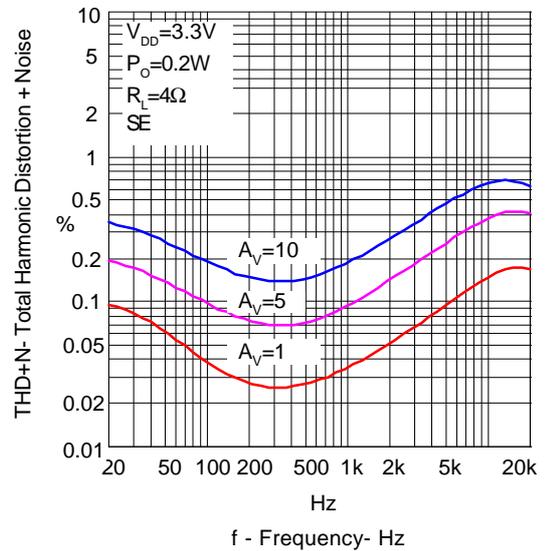Po - Output Power

f - Frequency- Hz

f- Frequency- Hz

Po - Output Power

Typical Operating Characteristics (Cont.)

Po - Output Power

f - Frequency- Hz
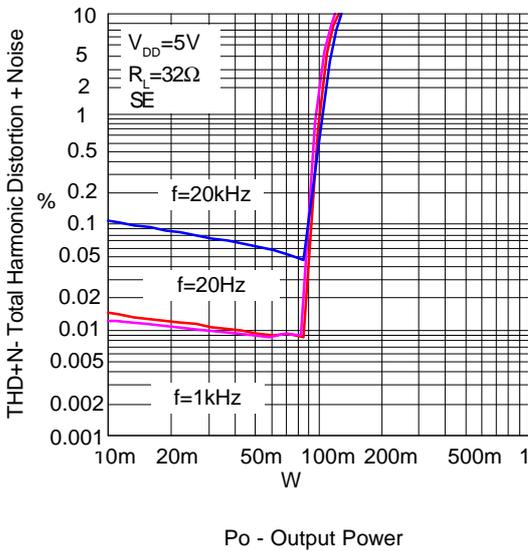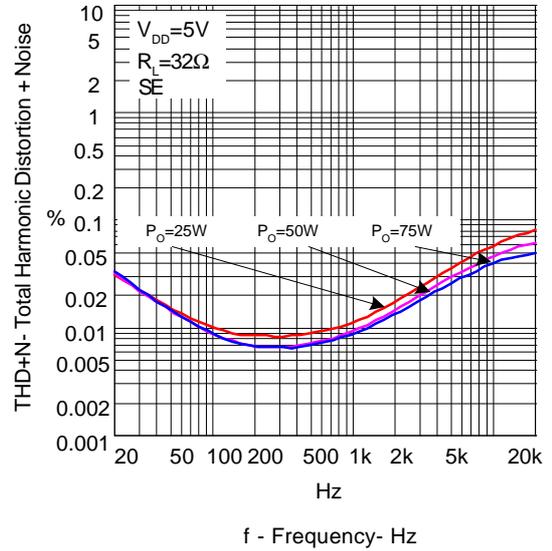

Po - Output Power

f - Frequency- Hz

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Typical Operating Characteristics (Cont.)
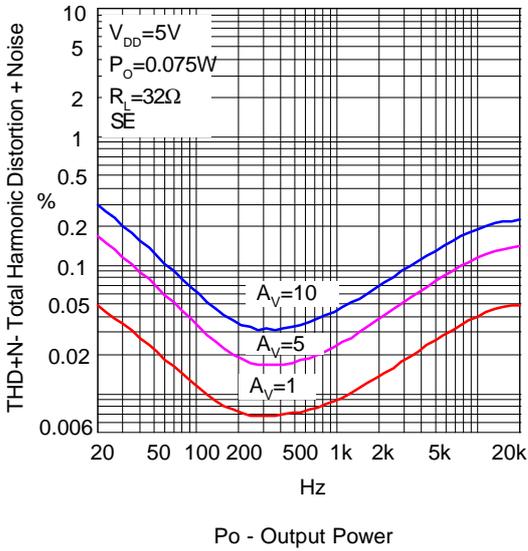

V_{DD}=3.3V
R_L=4Ω
SE

P_O=0.05W P_O=0.1W P_O=0.15W

THD+N- Total Harmonic Distortion + Noise

%

Hz

f - Frequency

V_{DD}=3.3V
A_V=2
R_L=4Ω
SE

f=20kHz

f=1kHz

f=100Hz

THD+N- Total Harmonic Distortion + Noise

%

W

Po - Output Power

V_{DD}=3.3V
P_O=100mW
R_L=8Ω
SE

A_V=10

A_V=5

A_V=1

THD+N- Total Harmonic Distortion + Noise

%

Hz

f - Frequency

V_{DD}=3.3V
R_L=8Ω
SE

P_O=25mW P_O=50mW P_O=100mW
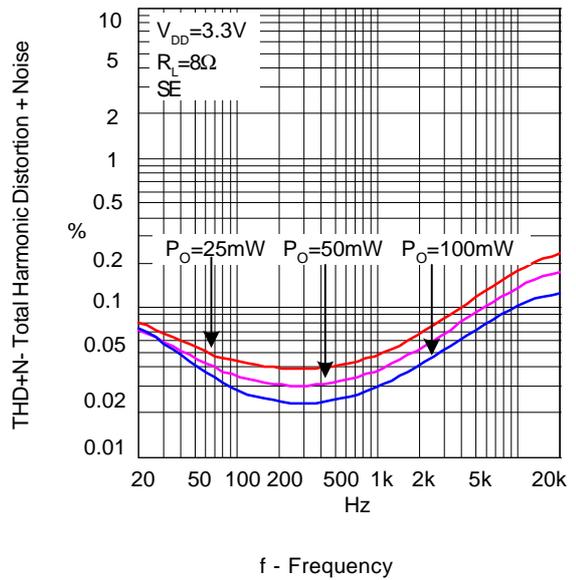
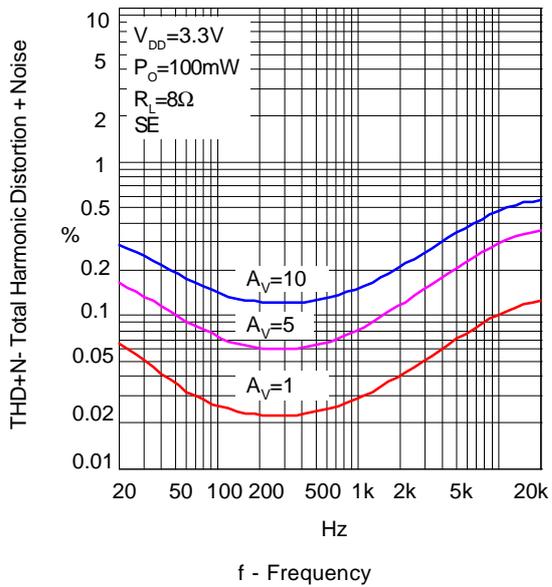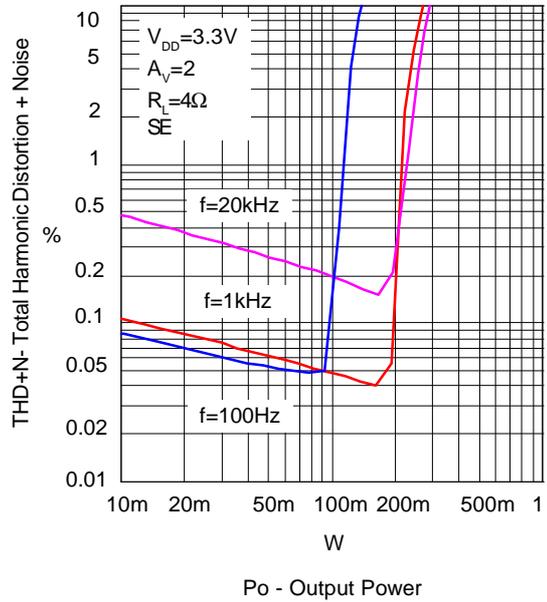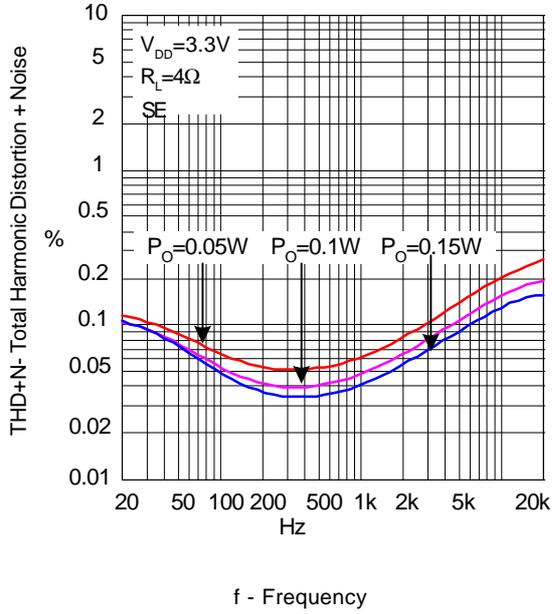THD+N- Total Harmonic Distortion + Noise

%

Hz

f - Frequency

Typical Operating Characteristics (Cont.)

Po - Output Power

f - Frequency

f - Frequency

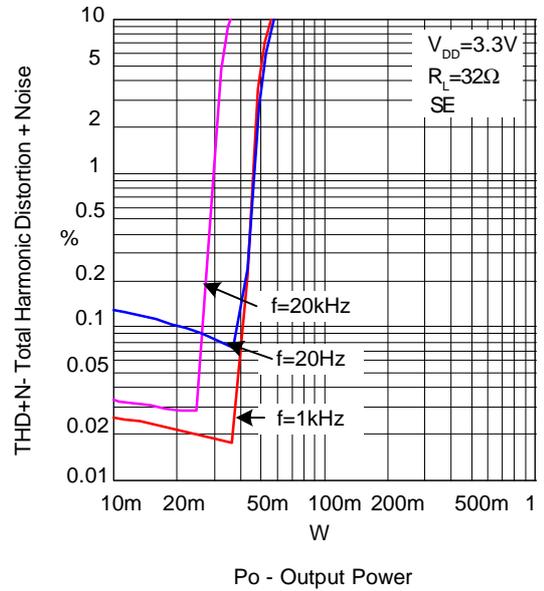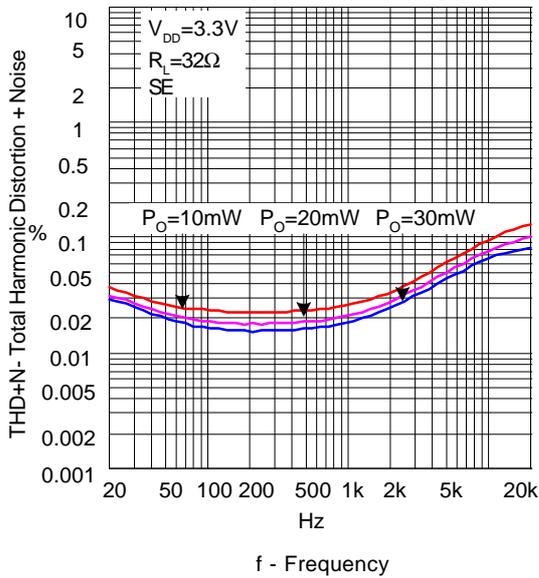Po - Output Power

Typical Operating Characteristics (Cont.)

V_N - Output Noise Voltage - µV

V_O BTL

V_O+SE

V_{DD}=5V
BW=22Hz to 22 kHz

f - Frequency

V_N - Output Noise Voltage - µV

V_O BTL

V_O +SE

V_{DD}=3.3V
BW=22Hz to 22 kHz

f - Frequency

Crosstalk dB

V_{DD}=5V
P_O=1.5W
R_L=4Ω
BTL

Left to Right

Right to Left

f - Frequency

Crosstalk dB

V_{DD}=3.3V
P_O=0.75W
R_L=4Ω
BTL

Left to Right

Right to Left

f - Frequency
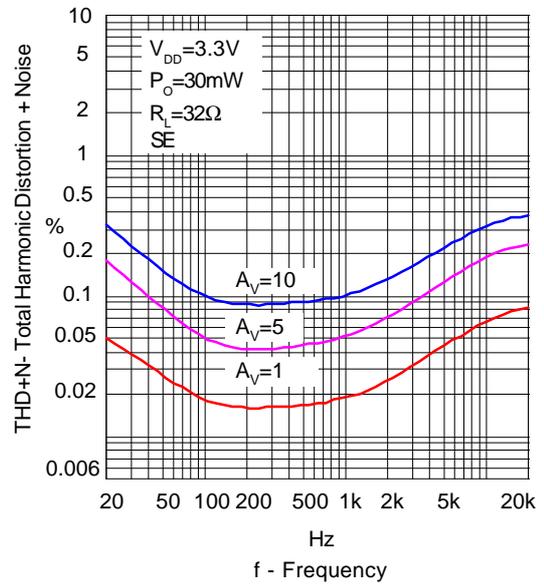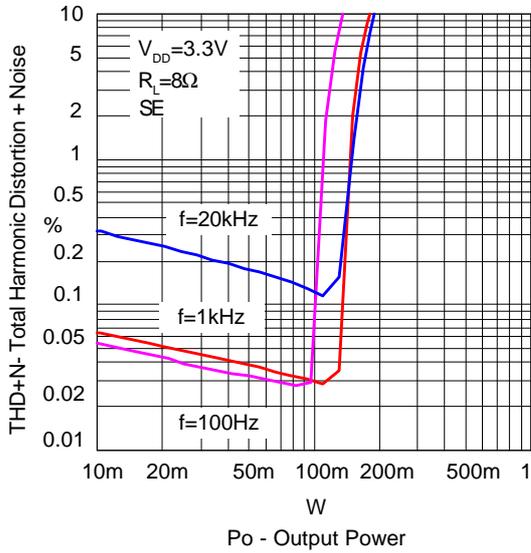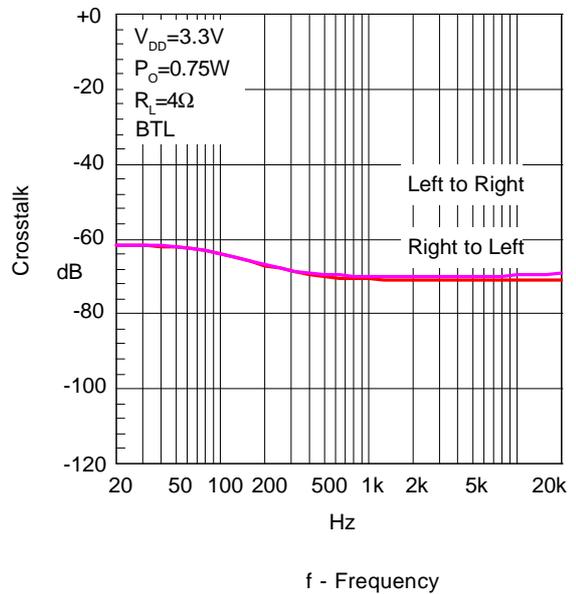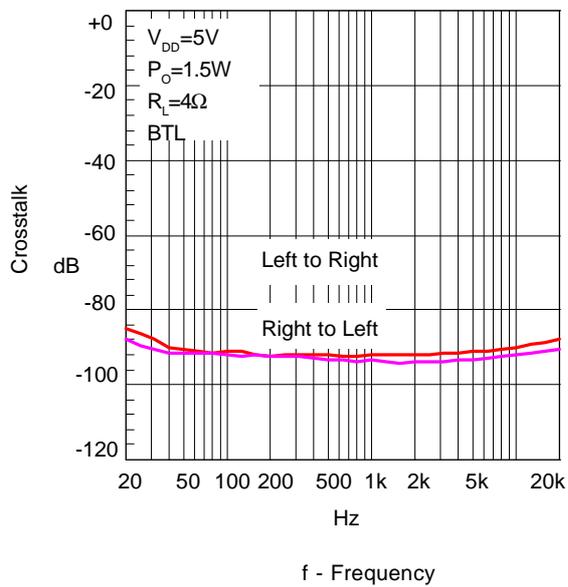
Typical Operating Characteristics (Cont.)

Typical Operating Characteristics (Cont.)

V_{DD}=5V
A_V=1 V/V
P_O=0.5W

Gain

Phase

f- Frequency

V_{DD}=3.3V
A_V=1 V/V
P_O=0.25W

Gain

Phase

f- Frequency

Stereo BTL

Stereo SE

V_{DD} - Supply Voltage - V

THD +N = 1%
BTL

R_L=3Ω

R_L=4Ω
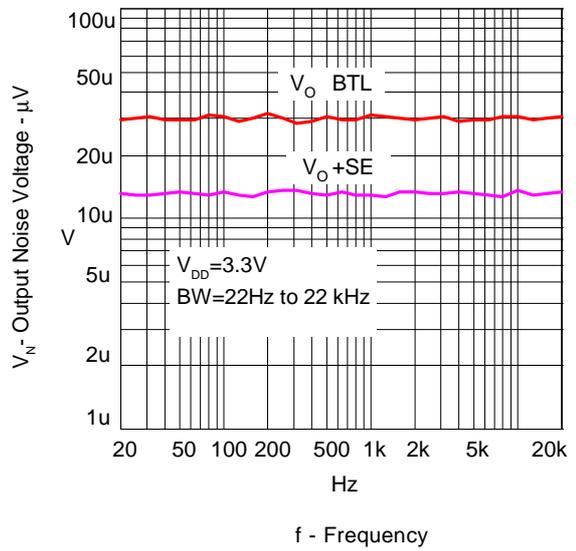
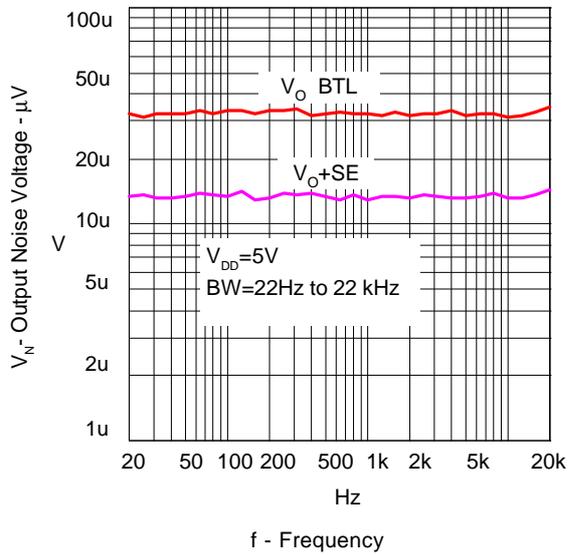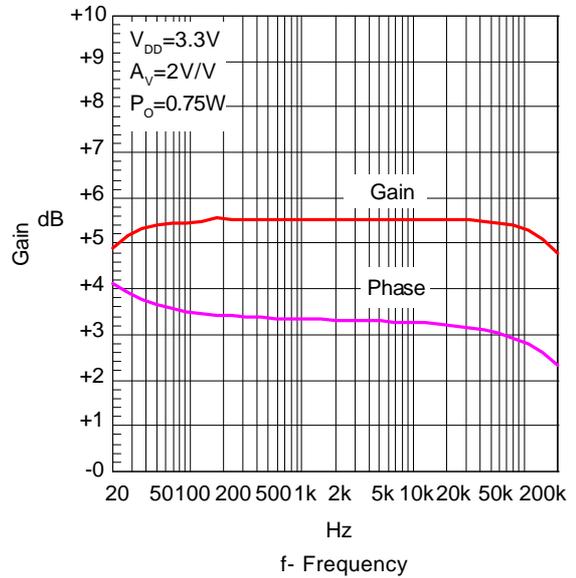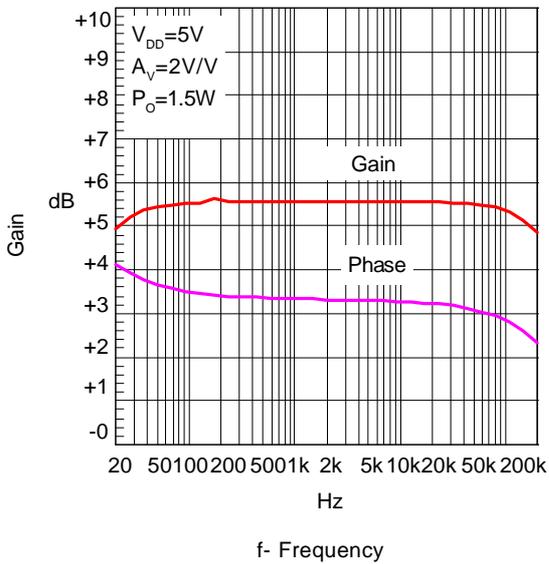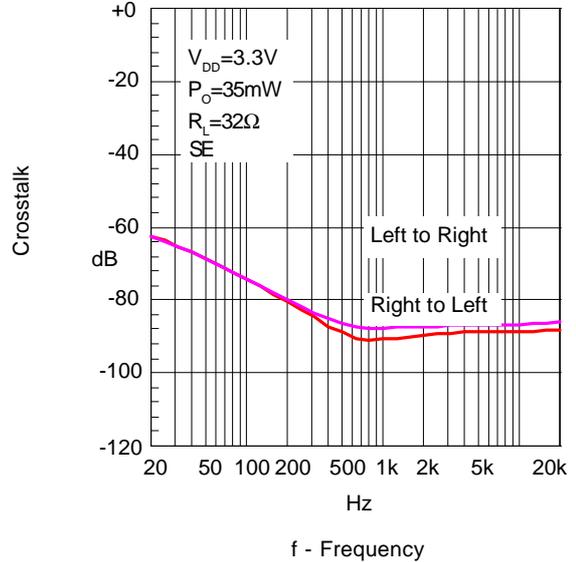R_L=8Ω

V_{DD} - Supply Voltage - V

Typical Operating Characteristics (Cont.)

THD +N = 1%
SE
Each Channel

$R_L = 4\Omega$
$R_L = 8\ \Omega$
$R_L = 32\ \Omega$

V_{DD} - Supply Voltage - V

P_O - Output Power - W

THD +N = 1%
BTL
Each Channel

$V_{DD} = 5V$
$V_{DD} = 3.3V$

R_L - Load Resistance- Ω

P_O - Output Power - W

THD +N = 1%
SE
Each Channel

$V_{DD} = 5V$
$V_{DD} = 3.5V$

R_L - Load Resistance- Ω

P_O - Output Power - W

$R_L = 3\Omega$
$R_L = 4\ \Omega$
$R_L = 8\Omega$

$V_{DD} = 5V$
BTL
Each Channel

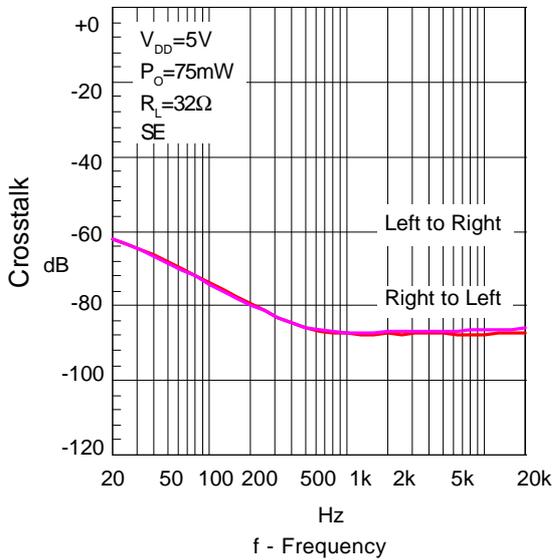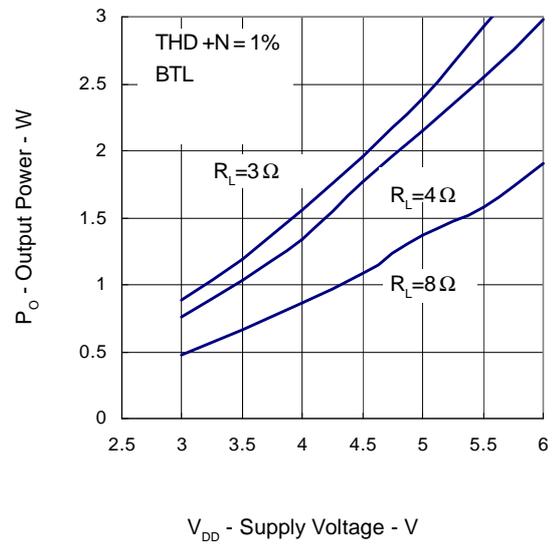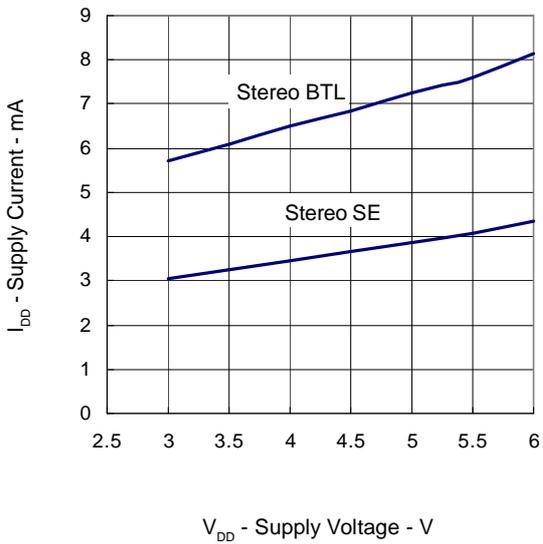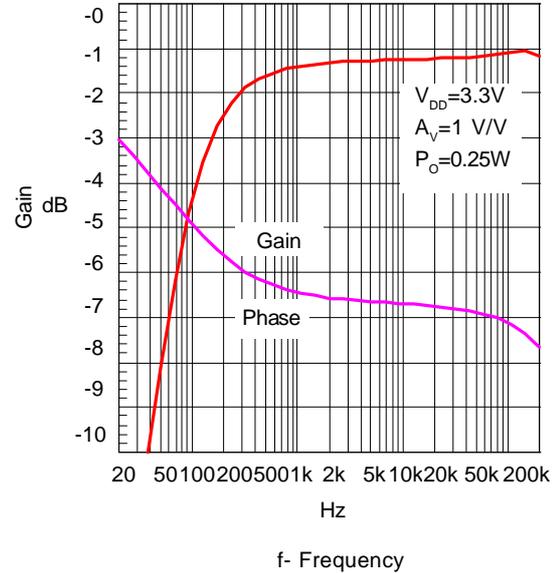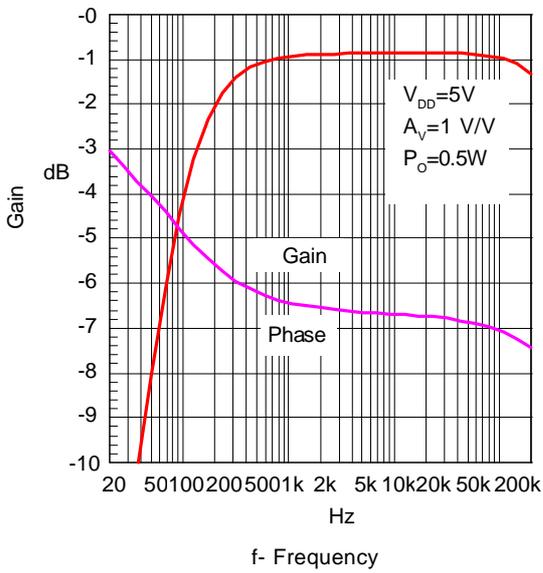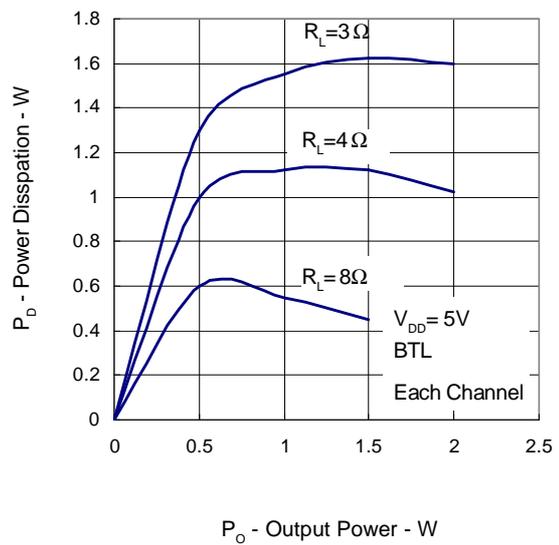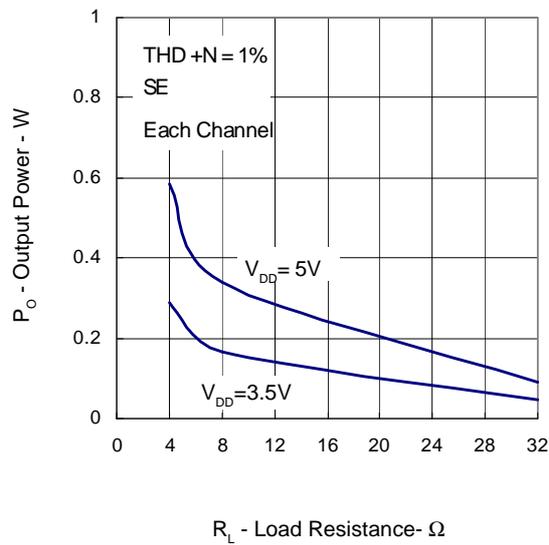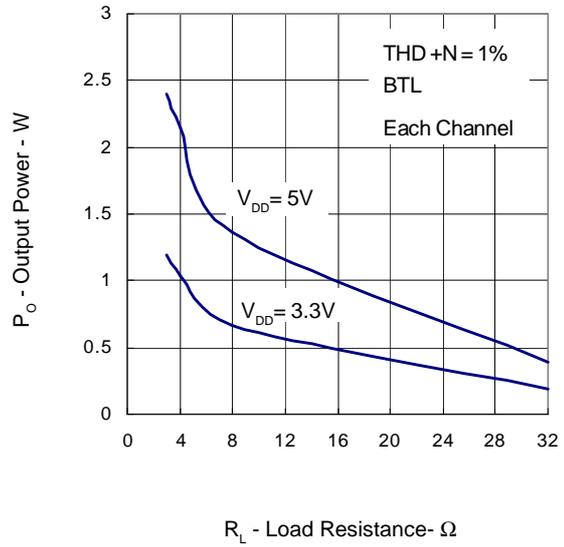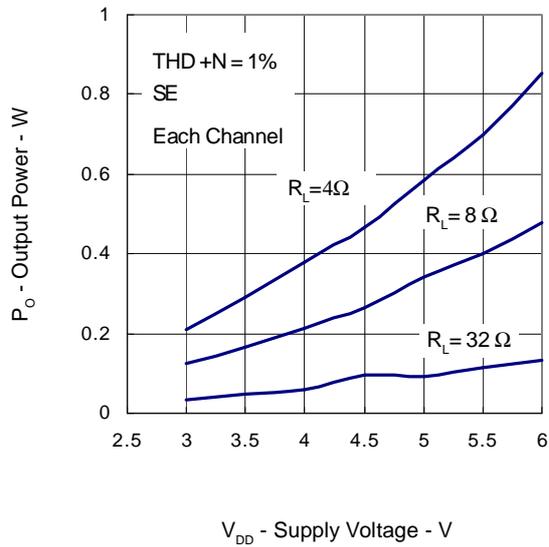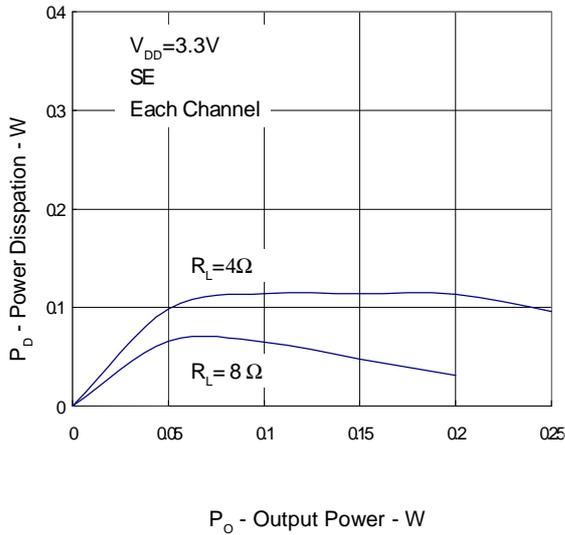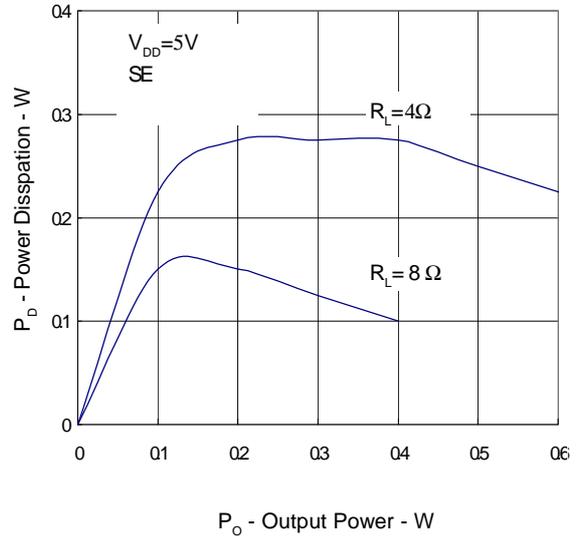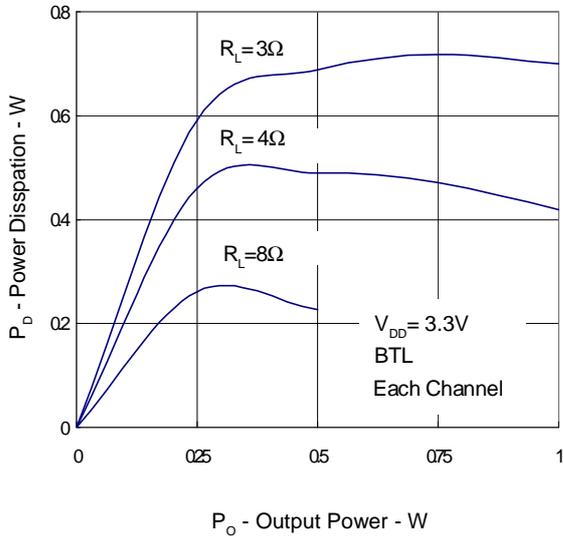P_O - Output Power - W

P_D - Power Disspation - W

Typical Operating Characteristics (Cont.)

P_O - Output Power - W

P_O - Output Power - W

P_O - Output Power - W

Pin Description

| PIN		I/O	FUNCTION
NAME	**NO.**		
GND/HS	1,12, 13,24		Ground connection for circuitry, directly connected to thermal pad (only in TSSOP-P package).
TJ	2	O	Shutdown mode control signal input, sources a current proportional to the junction temperature. This pin should be left unconnected during normal operation. For more information, see the junction temperature measurement section of this document.
LOUT +	3	O	Left channel + output in BTL mode, + output in SE mode.
LLINEIN	4	I	Left channel line input, selected when HP/$\overline{\text{LINE}}$ pin (16) is held low.
LHPIN	5	I	Left channel headphone input, selected when HP/$\overline{\text{LINE}}$ pin (16) is held high.
LBYPASS	6		Connect to voltage divider for left channel internal mid-supply bias.
LVDD	7	I	Supply voltage input for left channel and for primary bias circuits.
SHUTDOWN	8	I	Shutdown mode control signal input, places entire IC in shutdown mode when held high, I_{SD}= 0.5µA.
MUTE OUT	9	O	Follows MUTE in pin (11), provides buffered output.
LOUT -	10	O	Left channel - output in BTL mode, high-impedance state in SE mode.
MUTE IN	11	I	Mute control signal input, hold low for normal operation, hold high to mute.
SE/$\overline{\text{BTL}}$	14	I	Mode control signal input, hold low for BTL mode, hold high for SE mode.
ROUT-	15	O	Right channel - output in BTL mode, high impedance state in SE mode.
HP/$\overline{\text{LINE}}$	16	I	MUX control input, hold high to select headphone inputs (5,20), hold low to select line inputs (4,21).
NC	17,23		No internal connection.
RVDD	18	I	Supply voltage input for right channel.
RBYPASS	19		Connect to voltage divider for right channel internal mild-supply bias.
RHPIN	20	I	Right channel headphone input, selected when HP/$\overline{\text{LINE}}$ pin (16) is held high.
RLINEIN	21	I	Right channel line input, selected when HP/$\overline{\text{LINE}}$ pin (16) is held low.
ROUT+	22	O	Right channel + output in BTL mode, + output in SE mode.

Test Information
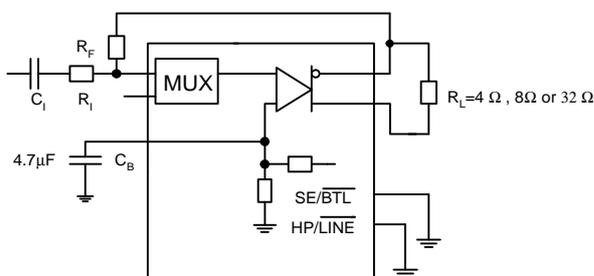
Figure 1. BTL Test Circuit
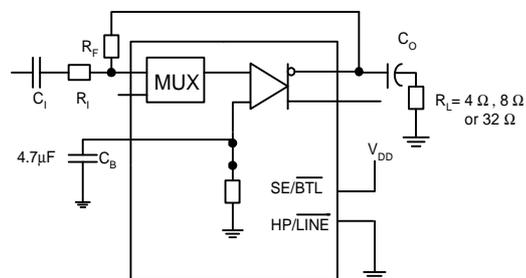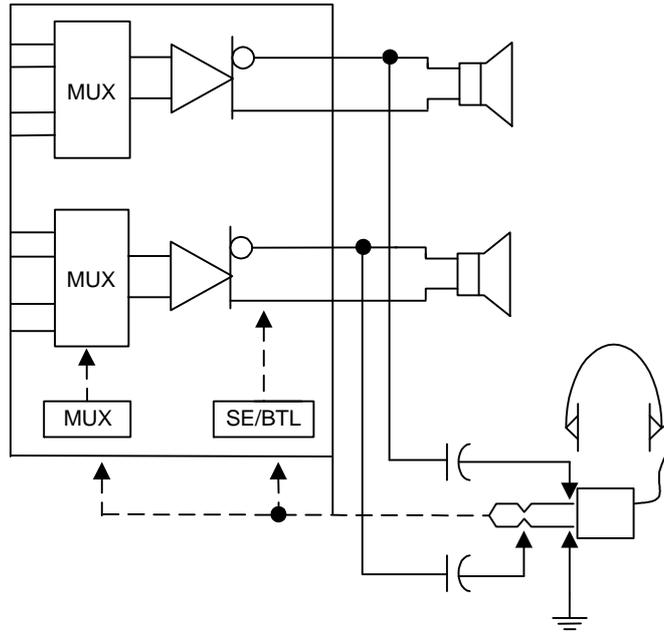

Figure 2. SE Test Circuit

Block Diagram

Figure 3.

Package Information

SOP-24
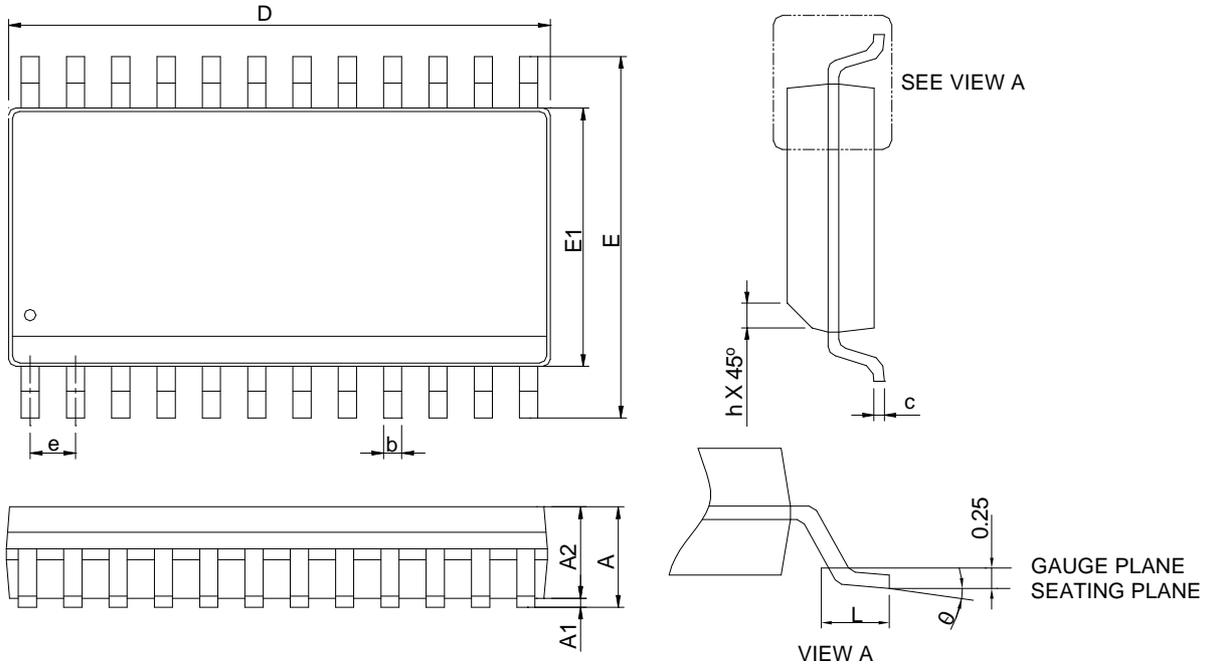
S Y M B O L	SOP-24			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		2.65		0.104
A1	0.10	0.30	0.004	0.012
A2	2.05		0.081	
b	0.31	0.51	0.012	0.020
c	0.20	0.33	0.008	0.013
D	15.20	15.60	0.598	0.614
E	10.10	10.50	0.398	0.413
E1	7.40	7.60	0.291	0.299
e	1.27 BSC		0.050 BSC	
h	0.25	0.75	0.010	0.030
L	0.40	1.27	0.016	0.050
θ	0º	8º	0º	8º

Note : 1. Follow from JEDEC MS-013 AD.

2. Dimension "D" does not include mold flash, protrusions

or gate burrs. Mold flash, protrusion or gate burrs shall not exceed 6 mil per side.

3. Dimension "E" does not include inter-lead flash or protrusions.

Inter-lead flash and protrusions shall not exceed 10 mil per side.

Package Information

TSSOP-24P
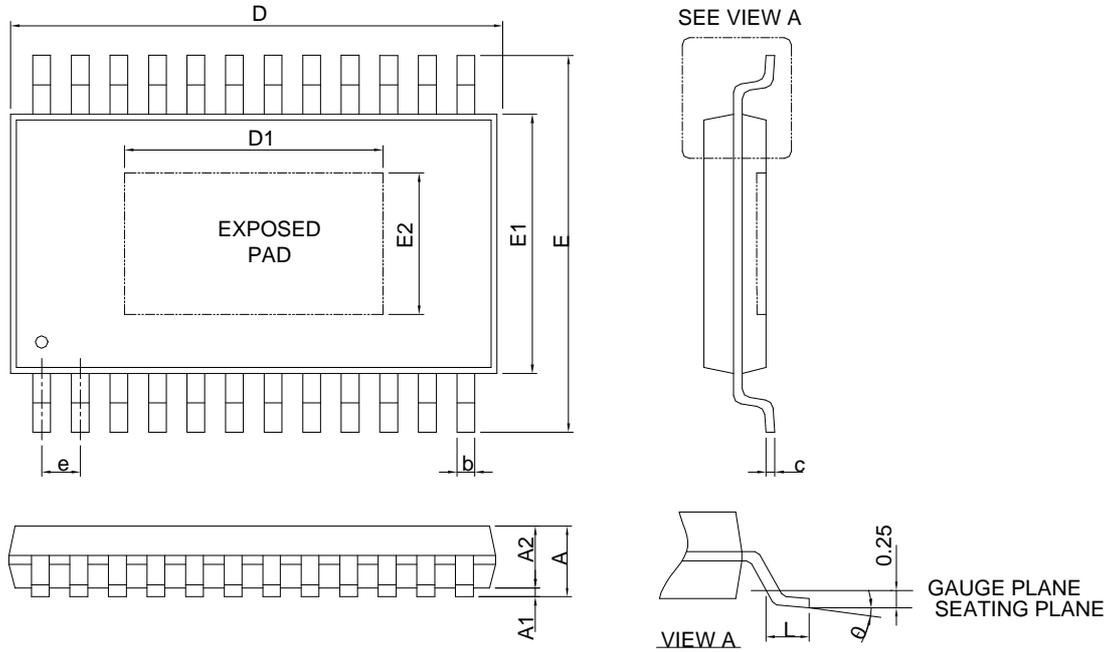
| S Y M B O L	TSSOP-24P			
	MILLIMETERS		INCHES	
	MIN.	MAX.	MIN.	MAX.
A		1.20		0.047
A1	0.05	0.15	0.002	0.006
A2	0.80	1.05	0.031	0.041
b	0.19	0.30	0.007	0.012
c	0.09	0.20	0.004	0.008
D	7.70	7.9	0.303	0.311
D1	3.50	6.00	0.138	0.197
E	6.20	6.60	0.244	0.260
E1	4.30	4.50	0.169	0.177
E2	2.50	3.50	0.098	0.138
e	0.65 BSC		0.026 BSC	
L	0.45	0.75	0.018	0.030
θ	0º	8º	0º	8º

Note : 1. Followed from JEDEC MO-153 ADT.

2. Dimension "D" does not include mold flash, protrusions
   or gate burrs. Mold flash, protrusion or gate burrs shall not
   exceed 6 mil per side.

3. Dimension "E1" does not include inter-lead flash or protrusions.
   Inter-lead flash and protrusions shall not exceed 10 mil per side.

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Carrier Tape & Reel Dimensions

SECTION A-A

SECTION B-B
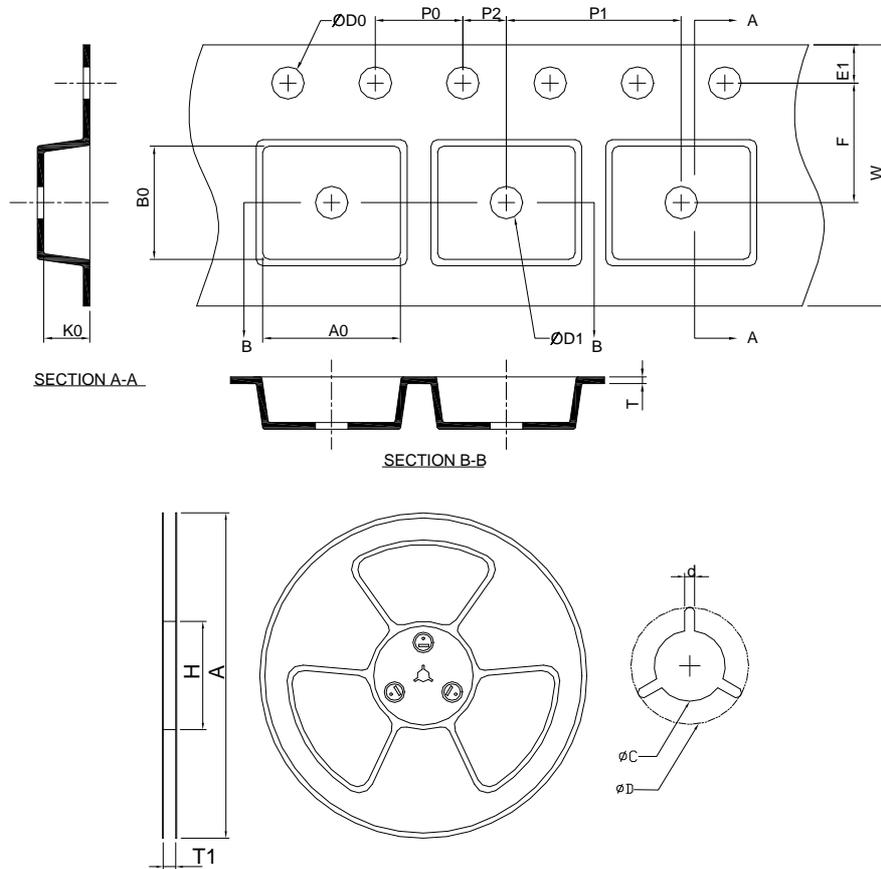
| Application	A	H	T1	C	d	D	W	E1	F
SOP-24	330.0±2.00	50 MIN.	24.4+2.0 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	24.0±0.30	1.75±0.10	11.5±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.0±0.10	12.0±0.10	2.0±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	10.9±0.20	15.80±0.20	3.10±0.20
Application	**A**	**H**	**T1**	**C**	**d**	**D**	**W**	**E1**	**F**
TSSOP-24P	330.0±2.00	50 MIN.	16.4+2.00 -0.00	13.0+0.50 -0.20	1.5 MIN.	20.2 MIN.	16.0±0.30	1.75±0.10	7.50±0.10
	P0	**P1**	**P2**	**D0**	**D1**	**T**	**A0**	**B0**	**K0**
	4.00±0.10	8.00±0.10	2.00±0.10	1.5+0.10 -0.00	1.5 MIN.	0.6+0.00 -0.40	6.9±0.20	8.30.±0.20	1.50±0.20

(mm)

Devices Per Unit

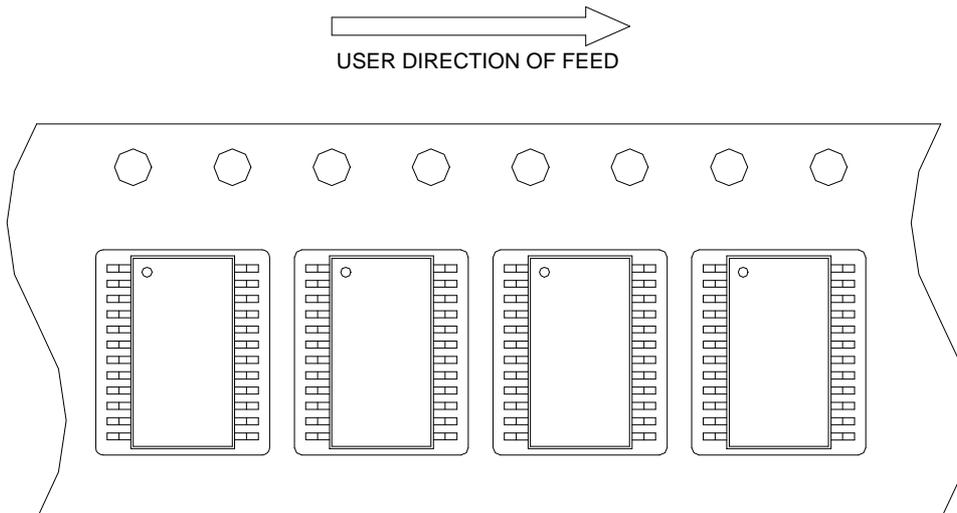| Package Type	Unit	Quantity
SOP-24	Tape & Reel	1000
TSSOP-24P	Tape & Reel	2000

Taping Direction Information

SOP-24

USER DIRECTION OF FEED

TSSOP-24P

USER DIRECTION OF FEED
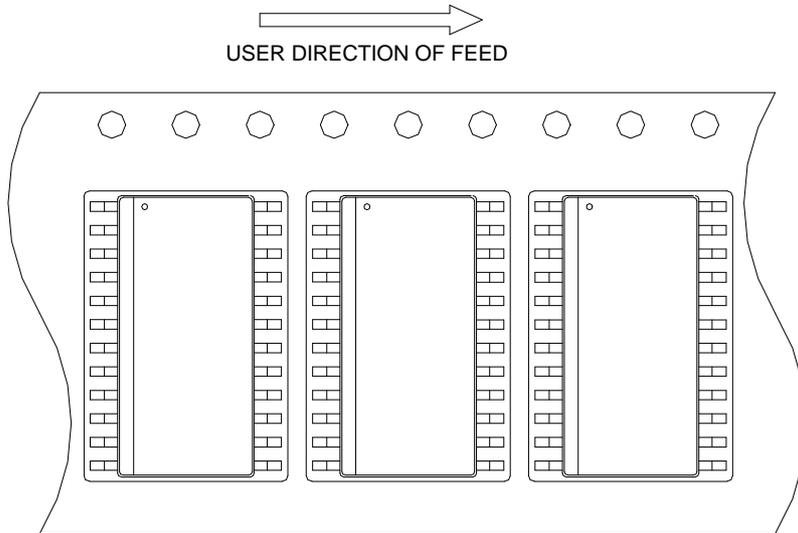
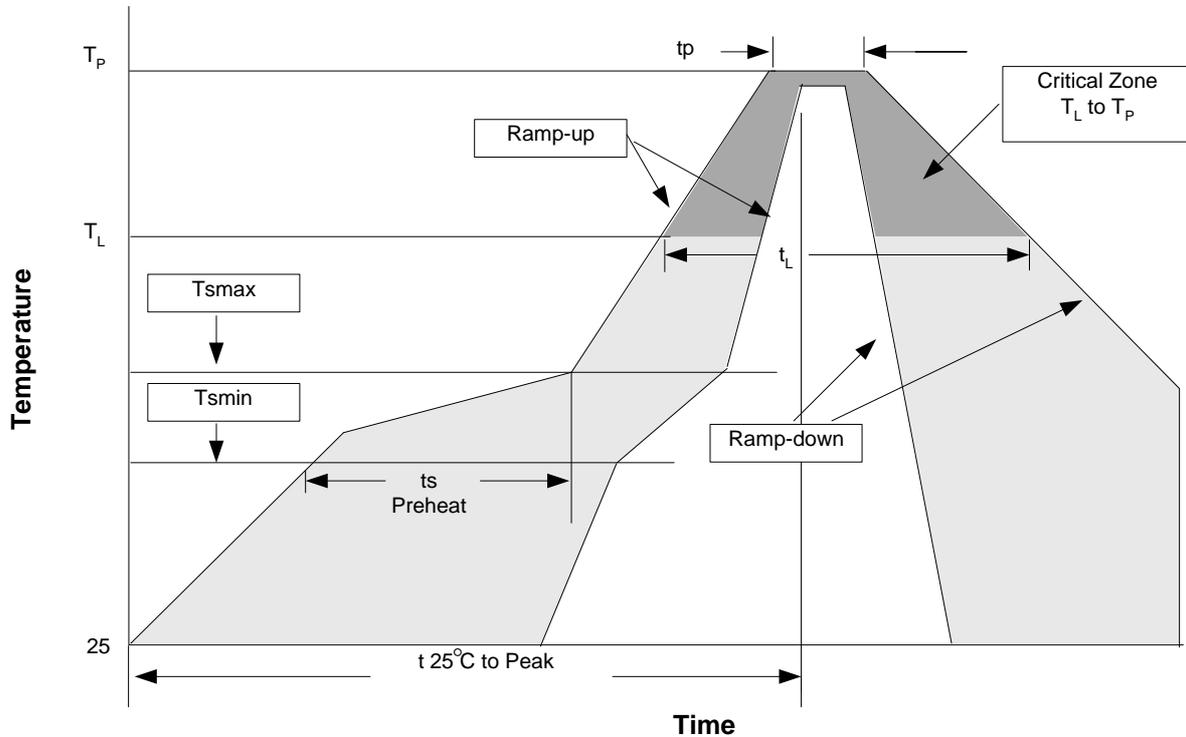## Reflow Condition (IR/Convection or VPR Reflow)

Reliability Test Program

Test item	Method	Description
SOLDERABILITY	MIL-STD-883D-2003	245°C, 5 sec
HOLT	MIL-STD-883D-1005.7	1000 Hrs Bias @125°C
PCT	JESD-22-B,A102	168 Hrs, 100%RH, 121°C
TST	MIL-STD-883D-1011.9	-65°C~150°C, 200 Cycles
ESD	MIL-STD-883D-3015.7	VHBM > 2KV, VMM > 200V
Latch-Up	JESD 78	10ms, 1_{tr} > 100mA

Classification Reflow Profiles

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (T_L to T_P)	3°C/second max.	3°C/second max.
Preheat - Temperature Min (Tsmin) - Temperature Max (Tsmax) - Time (min to max) (ts)	100°C 150°C 60-120 seconds	150°C 200°C 60-180 seconds
Time maintained above: - Temperature (T_L) - Time (t_L)	183°C 60-150 seconds	217°C 60-150 seconds
Peak/Classification Temperature (Tp)	See table 1	See table 2
Time within 5°C of actual Peak Temperature (tp)	10-30 seconds	20-40 seconds
Ramp-down Rate	6°C/second max.	6°C/second max.
Time 25°C to Peak Temperature	6 minutes max.	8 minutes max.

Note: All temperatures refer to topside of the package. Measured on the body surface.

Classification Reflow Profiles (Cont.)

Table 1. SnPb Eutectic Process – Package Peak Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 ^{3}350
<2.5 mm	240 +0/-5°C	225 +0/-5°C
≥2.5 mm	225 +0/-5°C	225 +0/-5°C

Table 2. Pb-free Process – Package Classification Reflow Temperatures

Package Thickness	Volume mm^3 <350	Volume mm^3 350-2000	Volume mm^3 >2000
<1.6 mm	260 +0°C*	260 +0°C*	260 +0°C*
1.6 mm – 2.5 mm	260 +0°C*	250 +0°C*	245 +0°C*
≥2.5 mm	250 +0°C*	245 +0°C*	245 +0°C*
* Tolerance: The device manufacturer/supplier **shall** assure process compatibility up to and including the stated classification temperature (this means Peak reflow temperature +0°C. For example 260°C+0°C) at the rated MSL level.			

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