# 1.2W AUDIO POWER AMPLIFIER WITH ACTIVE-LOW STANDBY MODE

**October 2012**

## GENERAL DESCRIPTION

The IS31AP4991 has been designed for demanding audio applications such as mobile phones and permits the reduction of the number of external components.

It is capable of delivering 1.2W of continuous RMS output power into an 8Ω load @ 5V.

An externally-controlled standby mode reduces the supply current to much less than 1μA. It also includes internal thermal shutdown protection.

The unity-gain stable amplifier can be configured by external gain setting resistors.

## FEATURES

- Operating from $V_{CC}$ = 2.7V ~ 5.5V
- 1.2W output power @ $V_{CC}$ = 5V, THD+N= 1%, f = 1kHz, with 8Ω load
- Ultra-low consumption in standby mode (much less than 1μA)
- 65dB PSRR @217Hz in grounded mode
- Near-zero click-and-pop
- Ultra-low distortion (0.025%@0.5W, 1kHz)
- SOP-8 and MSOP-8 package

## APPLICATIONS

- Mobile phones
- PDAs
- Portable electronic devices
- Notebook computer

## TYPICAL APPLICATION CIRCUIT

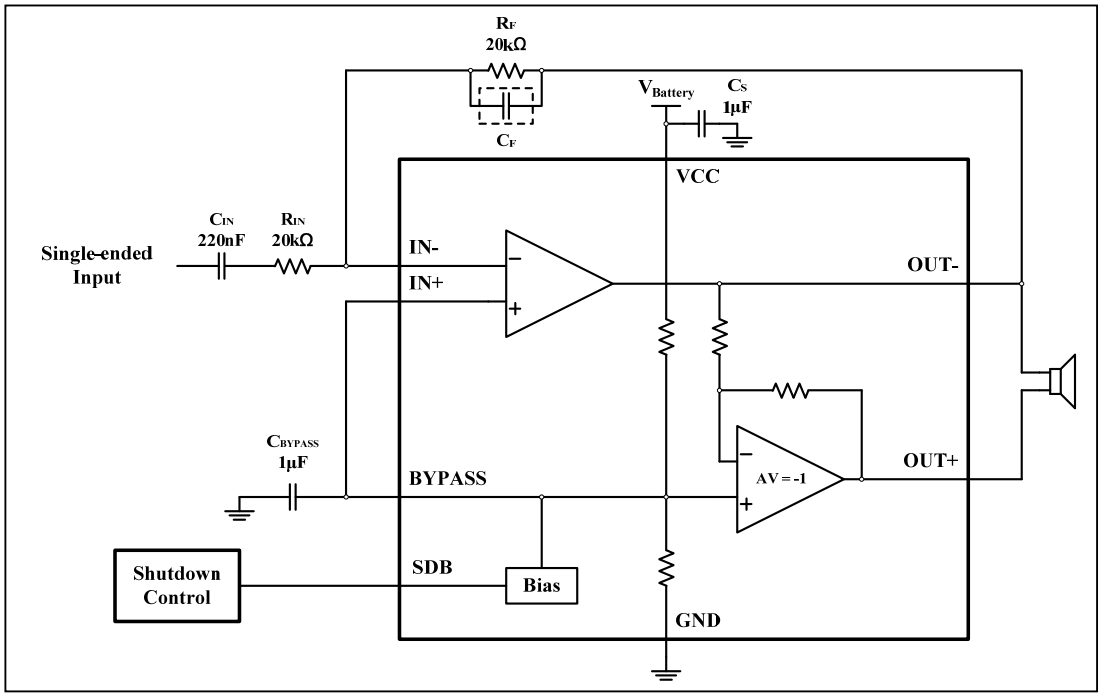



**Figure 1** Typical Application Circuit (Single-ended input)

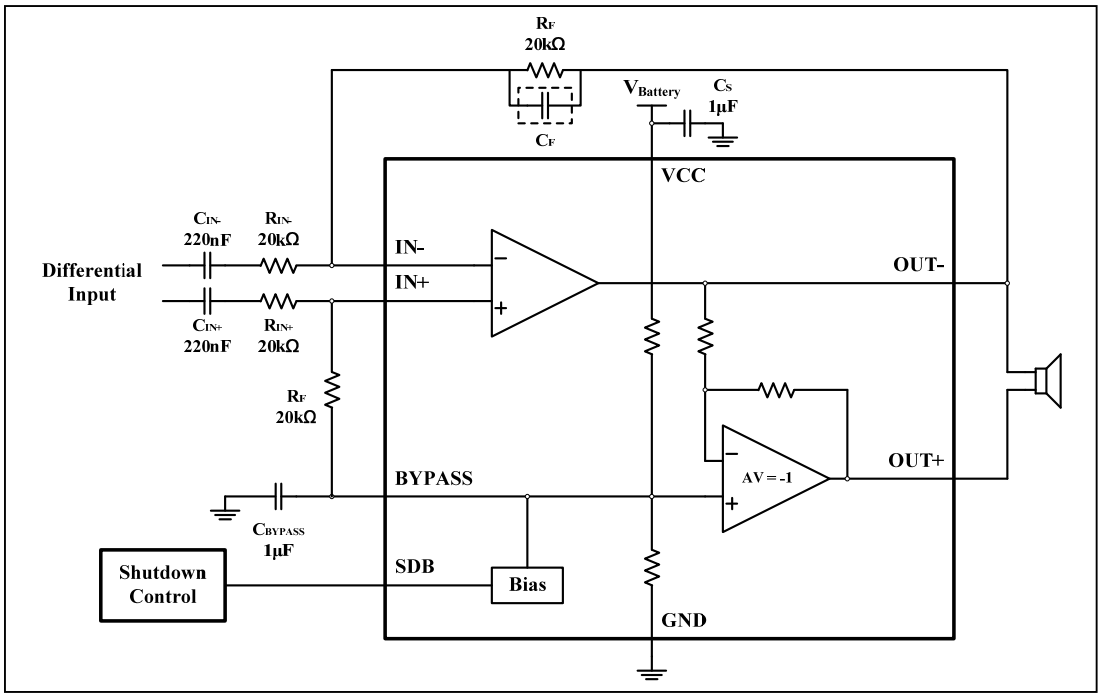
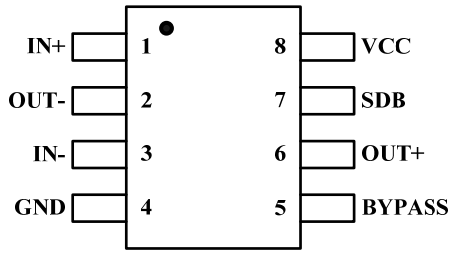
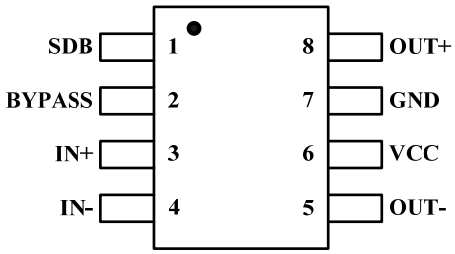



**Figure 2** Typical Application Circuit (Differential input)

## PIN CONFIGURATION

| Package | Pin Configuration (Top View) |
|---|---|
| SOP-8 |   |
| MSOP-8 |   |

## PIN DESCRIPTION

| Pin | No. | | Description |
|---|---|---|---|
| | SOP | MSOP | |
| IN+ | 1 | 3 | Positive input of the first amplifier. |
| OUT- | 2 | 5 | Negative output of the IS31AP4991. Connected to the load and to the feedback resistor $R_F$. |
| IN- | 3 | 4 | Negative input of the first amplifier, receives the audio input signal. Connected to the feedback resistor $R_F$ and to the input resistor $R_{IN}$. |
| GND | 4 | 7 | Ground. |
| BYPASS | 5 | 2 | Bypass capacitor pin which provides the common mode voltage ($V_{CC}$/2). |
| OUT+ | 6 | 8 | Positive output of the IS31AP4991. Connected to the load. |
| SDB | 7 | 1 | The device enters shutdown mode when a low level is applied on this pin. |
| VCC | 8 | 6 | Positive analog supply of the chip. |

## ORDERING INFORMATION

**Industrial Range: -40°C to +85°C**

| Order Part No. | Package | QTY/Reel |
|---|---|---|
| IS31AP4991-GRLS2-TR | SOP-8, Lead-free | 2500 |
| IS31AP4991-SLS2-TR | MSOP-8, Lead-free | 2500 |

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b.) the user assume all such risks; and
c.) potential liability of Integrated Silicon Solution, Inc is adequately protected under the circumstances

## ABSOLUTE MAXIMUM RATINGS *(Note 1)*

| | |
|---|---|
| Supply voltage, $V_{CC}$ | −0.3V ~ +6.0V |
| Voltage at any input pin | −0.3V ~ $V_{CC}$+0.3V |
| Maximum junction temperature, $T_{JMAX}$ | 150°C |
| Storage temperature range, $T_{STG}$ | −65°C ~ +150°C |
| Operating temperature range, $T_A$ | −40°C ~ +85°C |

**Note 1:** Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. These are stress ratings only and functional operation of the device at these or any other condition beyond those indicated in the operational sections of the specifications is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## ELECTRICAL CHARACTERISTICS

The following specifications apply for $C_{IN}$ = 0.22μF, $R_{IN}$ = $R_F$ = 20kΩ, $C_{BYPASS}$ = 1μF, unless otherwise specified. Limits apply for $T_A$ = 25°C. $V_{CC}$=5V (Note 2 or specified)

| Symbol | Parameter | Condition | | Typ. | Limit | Unit |
|---|---|---|---|---|---|---|
| $I_{CC}$ | Quiescent power supply current | $V_{CC}$ = 0V, Io = 0A, no Load | | 4.8 | | mA (max) |
| $I_{STBY}$ | Standby current | $V_{STBY}$ = GND, $R_L$ = ∞ | | | 1 | μA(max) |
| $V_{STBYH}$ | Shutdown voltage input high | $V_{CC}$ = 5.5V | | | 1.4 | V(min) |
| $V_{STBYL}$ | Shutdown voltage input low | $V_{CC}$ = 2.7V | | | 0.4 | V(max) |
| $V_{OS}$ | Output offset voltage | | | | 15 | mV (max) |
| Po | Output power (8Ω) | THD+N = 1%; f = 1kHz | | 1.18 | | W |
| | | THD+N = 10%; f = 1kHz | | 1.46 | | |
| $t_{WU}$ | Wake-up time *(Note 3)* | $C_{BYPASS}$ = 1μF | | 115 | | ms |
| THD+N | Total harmonic distortion+noise *(Note 3)* | Po = 0.5Wrms; f = 1kHz | | 0.025 | | % |
| PSRR | Power supply rejection ratio *(Note 3)* | Vripple p-p = 200mV Input Grounded | f = 217Hz | 65 | | dB |
| | | | f = 1kHz | 77 | | |

The following specifications apply for $C_{IN}$ = 0.22μF, $R_{IN}$ = $R_F$ = 20kΩ, $C_{BYPASS}$ = 1μF, unless otherwise specified. Limits apply for $T_A$= 25°C. $V_{CC}$=3V (Note 2 or specified)

| Symbol | Parameter | Condition | Typ. | Limit | Unit |
|---|---|---|---|---|---|
| $I_{CC}$ | Quiescent power supply current | $V_{CC}$ = 0V, Io = 0A, no Load | 3.8 | | mA(max) |
| $I_{STBY}$ | Standby current | $V_{STBY}$ = GND, $R_L$ = ∞ | | 1 | μA(max) |
| Po | Output power (8Ω) | THD+N = 1%; f = 1kHz | 405 | | mW |
| | | THD+N = 10%; f = 1kHz | 502 | | |
| $t_{WU}$ | Wake-up time *(Note 3)* | $C_{BYPASS}$ = 1μF | 102 | | ms |
| THD+N | Total harmonic distortion+noise *(Note 3)* | Po = 0.3Wrms; f = 1kHz | 0.027 | | % |

**Note 2:** Production testing of the device is performed at 25°C. Functional operation of the device and parameters specified over other temperature range, are guaranteed by design, characterization and process control.

**Note 3:** Guaranteed by design.

## TYPICAL PERFORMANCE CHARACTERISTIC

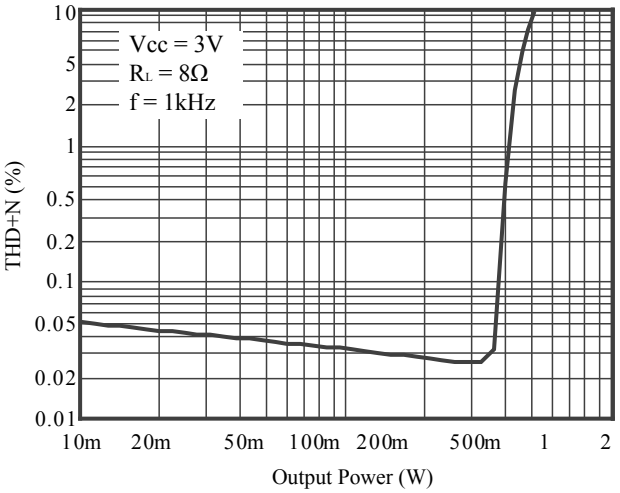



**Figure 3** THD+N vs. Output Power

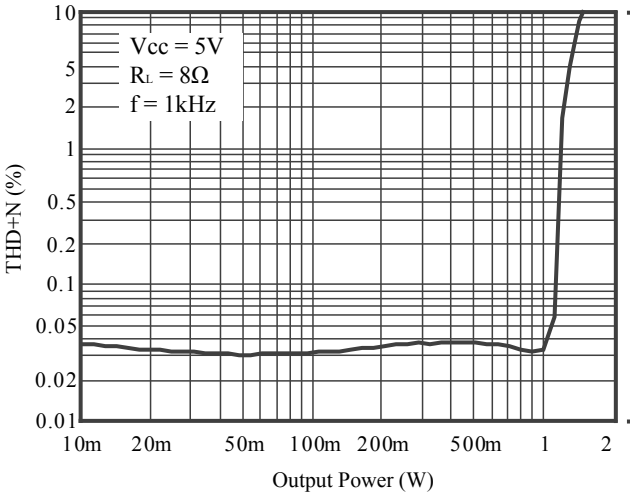



**Figure 4** THD+N vs. Output Power

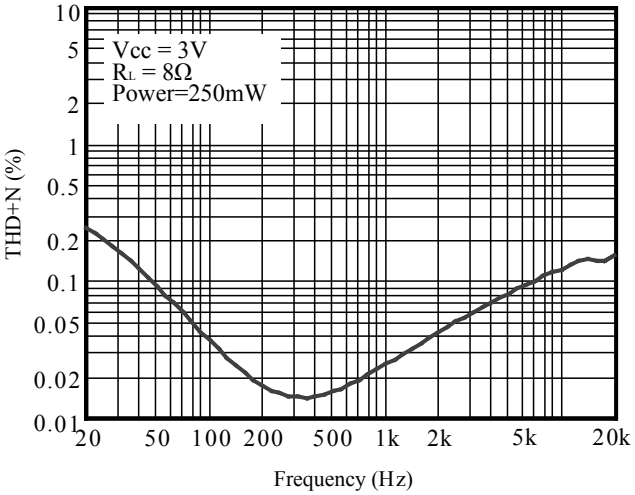



**Figure 5** THD+N vs. Frequency

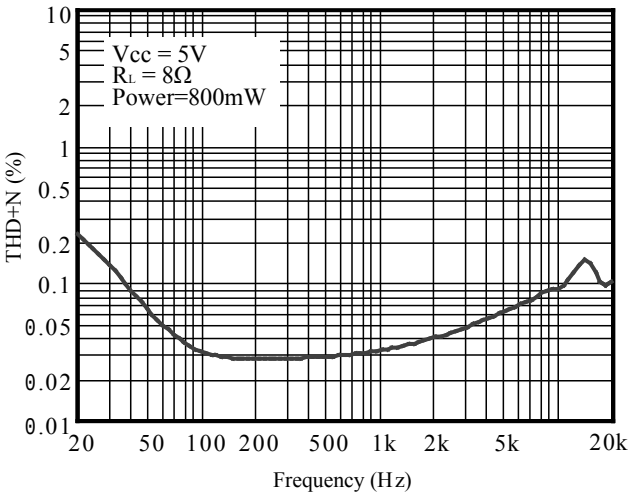



**Figure 6** THD+N vs. Frequency

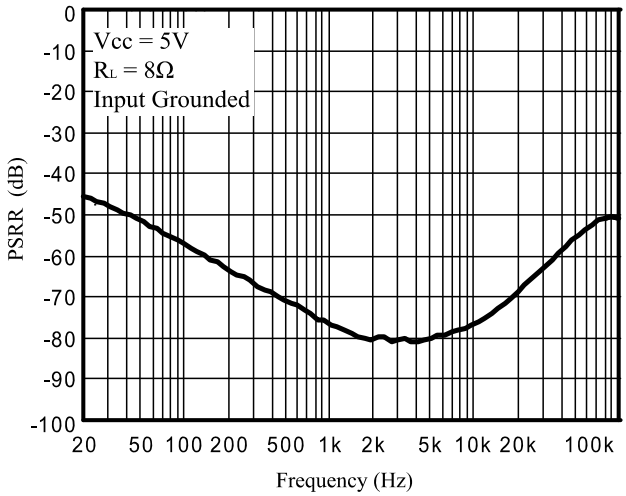



**Figure 7** PSRR vs. Frequency

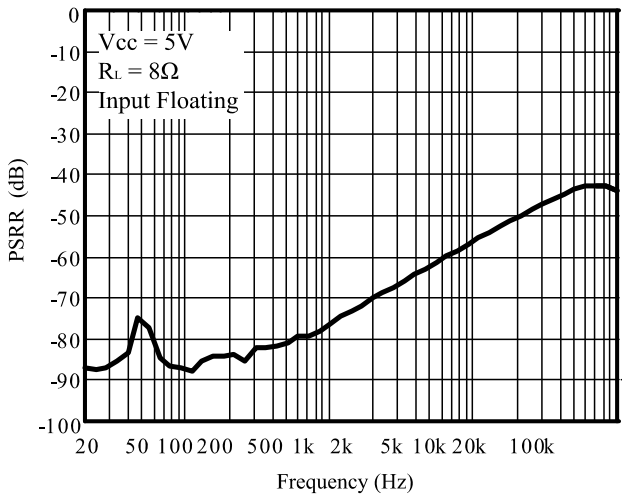



**Figure 8** PSRR vs. Frequency

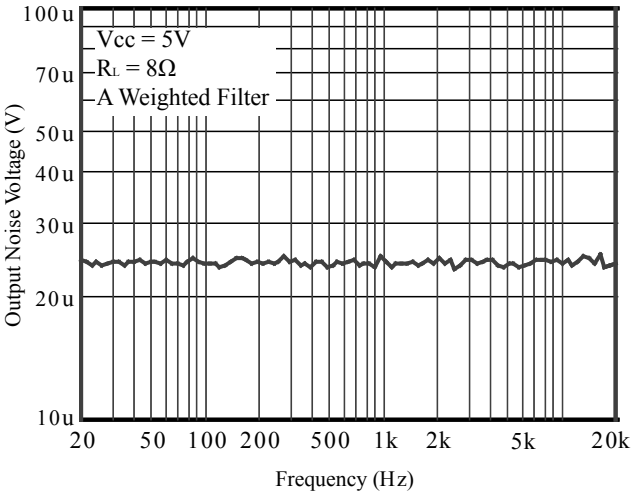



**Figure 9** Noise Floor

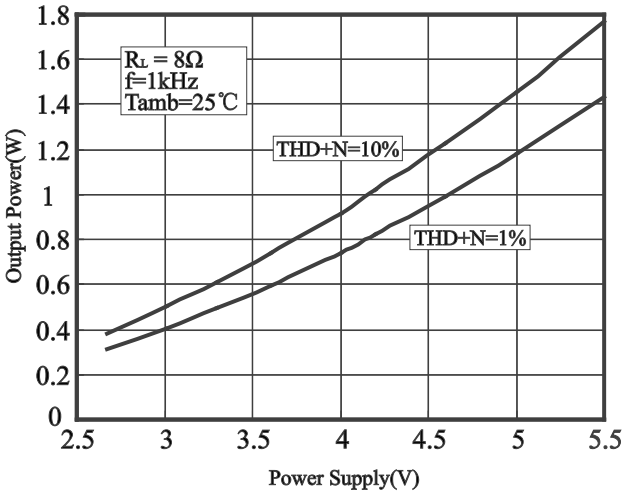



**Figure 10** Output Power vs. Power Supply

## APPLICATION INFORMATION

### BTL CONFIGURATION PRINCIPLE

The IS31AP4991 is a monolithic power amplifier with a BTL output type. BTL (bridge tied load) means that each end of the load is connected to two single-ended output amplifiers. Thus, we have:

Single-ended output 1 = $V_{OUT+}$ = $V_{OUT}$ (V)

Single ended output 2 = $V_{OUT-}$ = -$V_{OUT}$ (V)

and

$V_{OUT}$+ - $V_{OUT-}$ = 2$V_{OUT}$ (V)

The output power is:

$$P_{OUT} = \frac{(2V_{OUT\ RMS})^2}{R_L}$$

For the same power supply voltage, the output power in BTL configuration is four times higher than the output power in single ended configuration.

### GAIN IN A TYPICAL APPLICATION SCHEMATIC

The typical application schematic is shown in Figure 1 on page 1.

In the flat region (no $C_{IN}$ effect), the output voltage of the first stage is (in Volts):

$$V_{OUT-} = (-V_{IN})\frac{R_F}{R_{IN}}$$

For the second stage: $V_{OUT+}$ = -$V_{OUT-}$ (V)

The differential output voltage is (in Volts):

$$V_{OUT+} - V_{OUT-} = 2V_{IN}\frac{R_F}{R_{IN}}$$

The differential gain, $G_V$, is given by:

$$G_v = \frac{V_{OUT+} - V_{OUT-}}{V_{IN}} = 2\frac{R_F}{R_{IN}}$$

$V_{OUT-}$ is in phase with $V_{IN}$ and $V_{OUT+}$ is phased 180° with $V_{IN}$. This means that the positive terminal of the loudspeaker should be connected to $V_{OUT+}$ and the negative to $V_{OUT-}$.

### LOW AND HIGH FREQUENCY RESPONSE

In the low frequency region, $C_{IN}$ starts to have an effect. $C_{IN}$ forms with $R_{IN}$ a high-pass filter with a -3dB cut-off frequency. $f_{CL}$ is in Hz.

$$f_{CL} = \frac{1}{2\pi R_{IN} C_{IN}}$$

In the high frequency region, you can limit the bandwidth by adding a capacitor ($C_F$) in parallel with $R_F$. It forms a low-pass filter with a -3dB cut-off frequency. $f_{CH}$ is in Hz.

$$f_{CH} = \frac{1}{2\pi R_F C_F}$$

### DECOUPLING OF THE CIRCUIT

Two capacitors are needed to correctly bypass the IS31AP4991: a power supply bypass capacitor $C_S$ and a bias voltage bypass capacitor $C_{BYPASS}$.

$C_S$ has particular influence on the THD+N in the high frequency region (above 7kHz) and an indirect influence on power supply disturbances. With a value for $C_S$ of 1µF, you can expect THD+N levels similar to those shown in the datasheet.

In the high frequency region, if $C_S$ is lower than 1µF, it increases THD+N and disturbances on the power supply rail are less filtered.

On the other hand, if $C_S$ is higher than 1µF, those disturbances on the power supply rail are more filtered.

$C_{BYPASS}$ has an influence on THD+N at lower frequencies, but its function is critical to the final result of PSRR (with input grounded and in the lower frequency region).

If $C_{BYPASS}$ is lower than 1µF, THD+N increases at lower frequencies and PSRR worsens.

If $C_{BYPASS}$ is higher than 1µF, the benefit on THD+N at lower frequencies is small, but the benefit to PSRR is substantial.

Note that $C_{IN}$ has a non-negligible effect on PSRR at lower frequencies. The lower the value of $C_{IN}$, the higher the PSRR is.

### WAKE-UP TIME ($t_{WU}$)

When the standby is released to put the device on, the bypass capacitor $C_{BYPASS}$ will not be charged immediately. As $C_{BYPASS}$ is directly linked to the bias of the amplifier, the bias will not work properly until the $C_{BYPASS}$ voltage is correct. The time to reach this voltage is called wake-up time or $t_{WU}$ and specified in the electrical characteristics table with $C_{BYPASS}$ = 1µF.

### POP PERFORMANCE

Pop performance is intimately linked with the size of the input capacitor $C_{IN}$ and the bias voltage bypass capacitor $C_{BYPASS}$.

The size of $C_{IN}$ is dependent on the lower cut-off frequency and PSRR values requested. The size of $C_{BYPASS}$ is dependent on THD+N and PSRR values requested at lower frequencies.

Moreover, $C_{BYPASS}$ determines the speed with which the amplifier turns on.

**CLASSIFICATION REFLOW PROFILES**

| Profile Feature | Pb-Free Assembly |
|---|---|
| **Preheat & Soak**<br>Temperature min (Tsmin)<br>Temperature max (Tsmax)<br>Time (Tsmin to Tsmax) (ts) | 150°C<br>200°C<br>60-120 seconds |
| Average ramp-up rate (Tsmax to Tp) | 3°C/second max. |
| Liquidous temperature (TL)<br>Time at liquidous (tL) | 217°C<br>60-150 seconds |
| Peak package body temperature (Tp)* | Max 260°C |
| Time (tp)** within 5°C of the specified classification temperature (Tc) | Max 30 seconds |
| Average ramp-down rate (Tp to Tsmax) | 6°C/second max. |
| Time 25°C to peak temperature | 8 minutes max. |

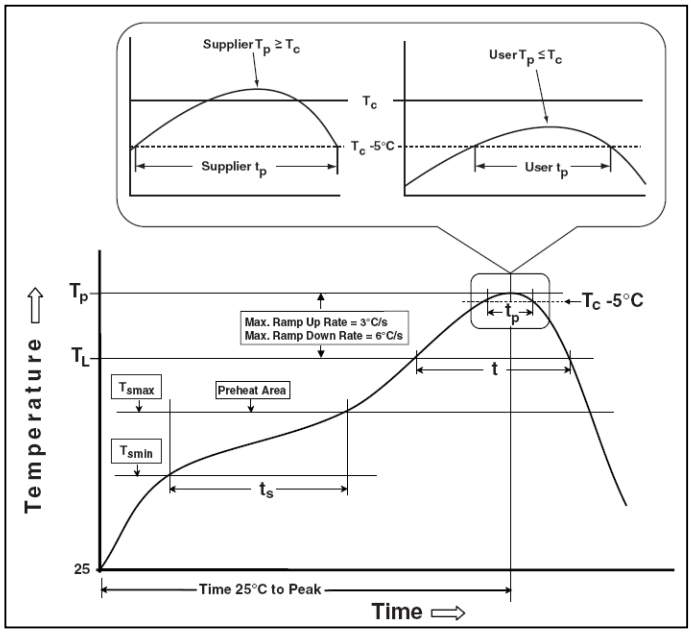
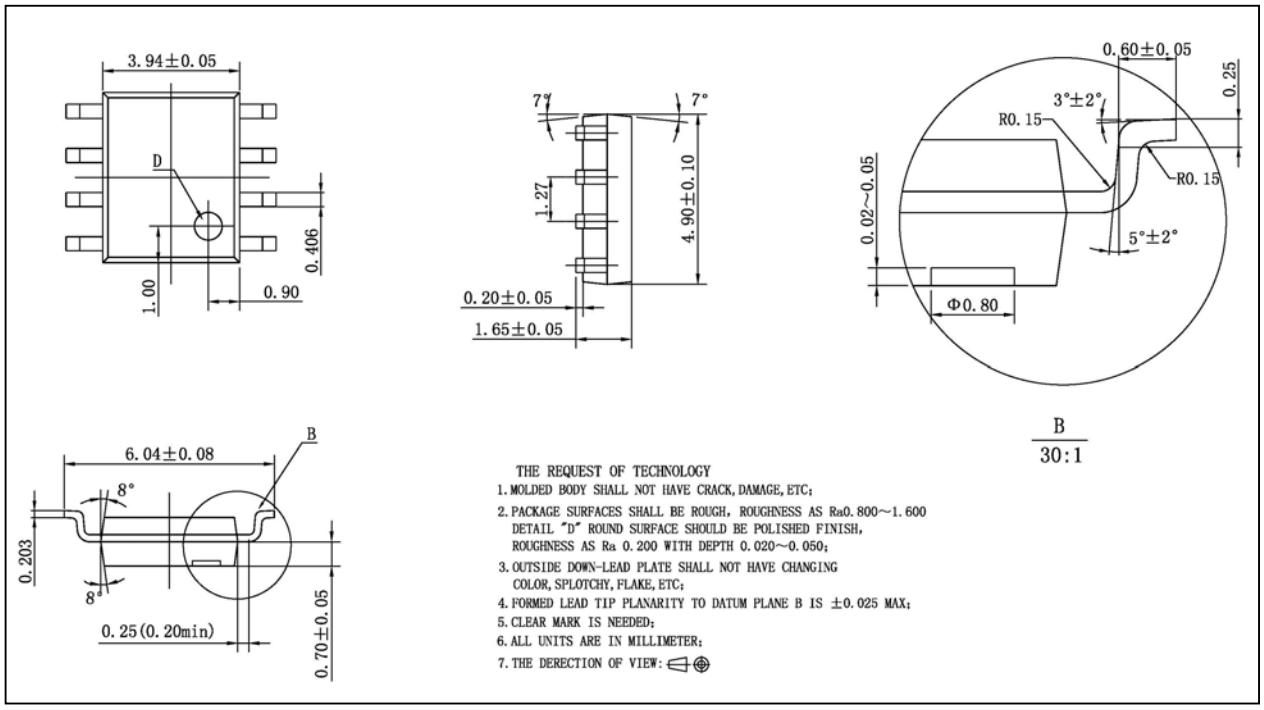


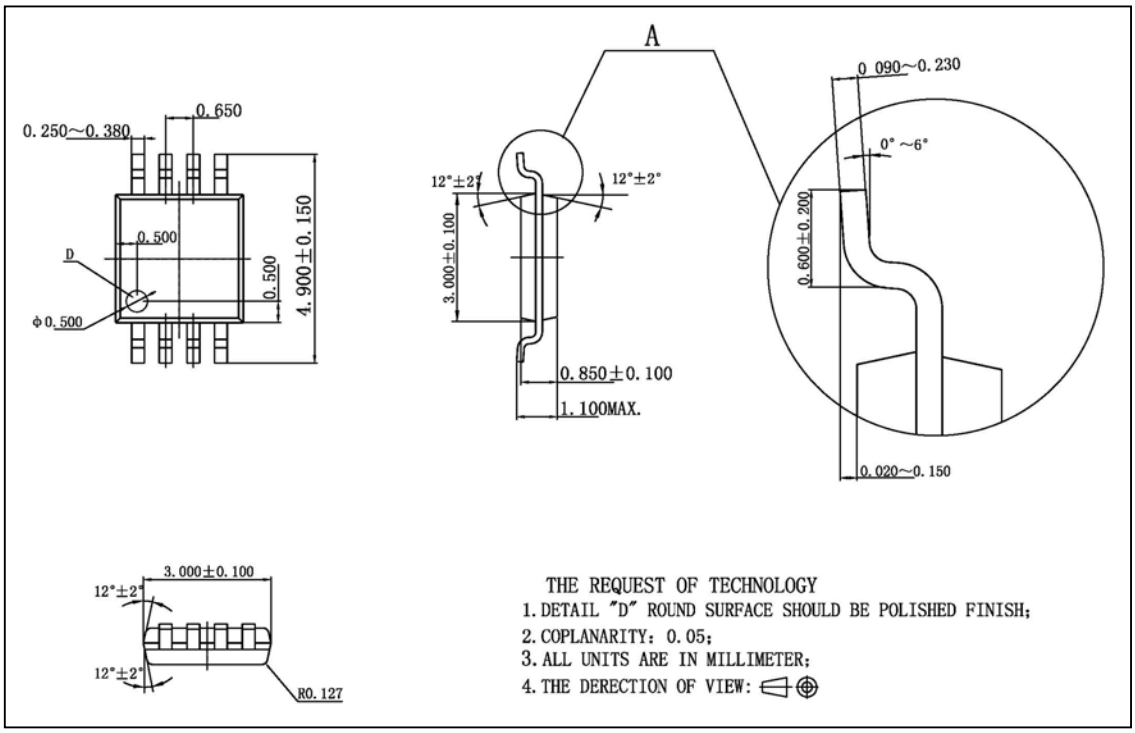

**Figure 11** Classification Profile

## PACKAGE INFORMATION

### SOP-8



**MSOP-8**


A
0.650
0.250~0.380
0.500
D
0.500
4.900±0.150
φ0.500
12°±2°
12°±2°
3.000±0.100
0.850±0.100
1.100MAX.
0.090~0.230
0°~6°
0.600±0.200
0.020~0.150
3.000±0.100
12°±2°
12°±2°
R0.127
THE REQUEST OF TECHNOLOGY
1. DETAIL "D" ROUND SURFACE SHOULD BE POLISHED FINISH;
2. COPLANARITY: 0.05;
3. ALL UNITS ARE IN MILLIMETER;
4. THE DERECTION OF VIEW: