

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

December 2011

### DESCRIPTION

The IS31AP4990D 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 shutdown mode reduces the supply current to 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  $V_{DD} = 2.7V$  to 5.5V
- 1.2W output power @  $V_{DD} = 5V$ , THD+N= 1%,
- $f = 1kHz$ , with 8Ω load
- Ultra-low consumption in shutdown mode (1μA)
- Near-zero pop & click
- Ultra-low distortion
- Unity gain stable
- UTQFN-9L (1.5mm × 1.5mm) package

### APPLICATIONS

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

### TYPICAL APPLICATION CIRCUIT

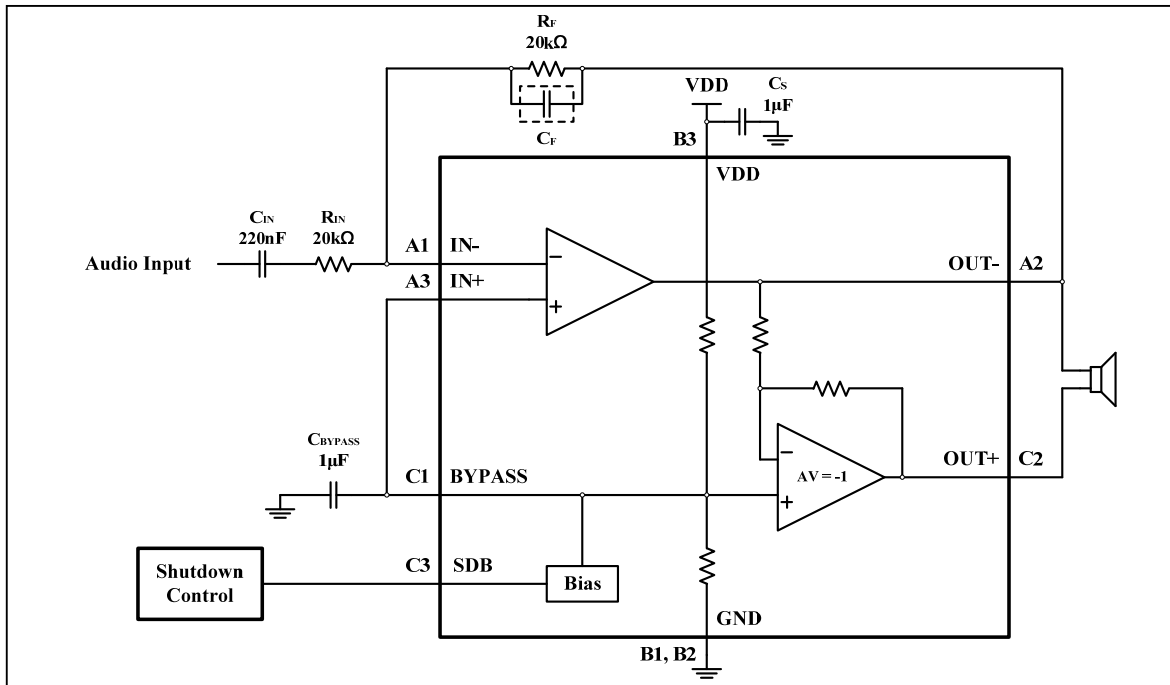


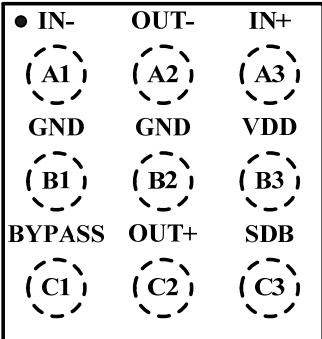
Figure 1 Typical Application Circuit

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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

# IS31AP4990D

## PIN CONFIGURATION

| Package  | Pin Configuration (Top View)                                                      |
|----------|-----------------------------------------------------------------------------------|
| UTQFN-9L |  |

## PIN DESCRIPTION

| No.   | Pin    | Function Description                                                                                              |
|-------|--------|-------------------------------------------------------------------------------------------------------------------|
| A1    | IN-    | Negative input of the first amplifier. Connected to the feedback resistor $R_F$ and to the input resistor $R_I$ . |
| A2    | OUT-   | Negative output. Connected to the load and to the feedback resistor $R_F$ .                                       |
| A3    | IN+    | Positive input of the first amplifier.                                                                            |
| B1,B2 | GND    | Ground.                                                                                                           |
| B3    | VDD    | Supply voltage.                                                                                                   |
| C1    | BYPASS | Bypass capacitor pin which provides the common mode voltage ( $V_{DD}/2$ ).                                       |
| C2    | OUT+   | Positive output. Connected to the load.                                                                           |
| C3    | SDB    | The device enters in shutdown mode when a low level is applied on this pin.                                       |



# IS31AP4990D

## ORDERING INFORMATION

Industrial Range: -40°C to +85°C

| Order Part No.       | Package            | QTY/Reel |
|----------------------|--------------------|----------|
| IS31AP4990D-UTLS2-TR | UTQFN-9, Lead-free | 3000     |

# IS31AP4990D

## ABSOLUTE MAXIMUM RATINGS (Note 1)

|                                      |                       |
|--------------------------------------|-----------------------|
| Supply voltage, $V_{DD}$             | -0.3V ~ +6.0V         |
| Voltage at any input pin             | -0.3V ~ $V_{DD}+0.3V$ |
| Junction temperature, $T_{JMAX}$     | -40°C ~ +150°C        |
| Storage temperature range, $T_{stg}$ | -65°C ~ +150°C        |
| Operating temperature ratings        | -40°C ~ +85°C         |
| Power dissipation (Note 2)           | Internally Limited    |

**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.

**Note 2:** The maximum power dissipation must be derated at elevated temperatures and is dictated by  $T_{JMAX}$ ,  $\theta_{JA}$ , and the ambient temperature  $T_A$ . The maximum allowable power dissipation is  $P_{DMAX} = (T_{JMAX} - T_A) / \theta_{JA}$  or the number given in Absolute Maximum Ratings, whichever is lower. For the IS31AP4990D, see power derating curves for additional information.

## ELECTRICAL CHARACTERISTICS

$T_A = -40^\circ\text{C} \sim +85^\circ\text{C}$ ,  $V_{DD} = 2.7V \sim 5.5V$ , unless otherwise noted. Typical value are  $T_A = +25^\circ\text{C}$ .

| Symbol   | Parameter                                  | Condition                                                            | Min.                  | Typ.  | Max. | Unit    |
|----------|--------------------------------------------|----------------------------------------------------------------------|-----------------------|-------|------|---------|
| $V_{DD}$ | Power supply                               |                                                                      | 2.7                   |       | 5.5  | V       |
| $I_{DD}$ | Quiescent current                          | $V_{DD} = 5V$ , $V_{IN} = 0V$ , $I_O = 0A$ , no load                 |                       | 3.8   | 6.4  | mA      |
|          |                                            | $V_{DD} = 3V$ , $V_{IN} = 0V$ , $I_O = 0A$ , no load                 |                       | 2.8   | 5.1  |         |
| $I_{SD}$ | Shutdown current                           | $V_{SDB} = GND$ , no load                                            |                       |       | 1    | $\mu A$ |
| $V_{IH}$ | Shutdown voltage input high                |                                                                      | 1.4                   |       |      | V       |
| $V_{IL}$ | Shutdown voltage input low                 |                                                                      |                       |       | 0.4  | V       |
| $V_{OS}$ | Output offset voltage                      |                                                                      |                       |       | 25   | mV      |
| $P_o$    | Output power (8 $\Omega$ )                 | $V_{DD} = 5V$                                                        | THD+N = 1%, f = 1kHz  | 1.20  |      | W       |
|          |                                            |                                                                      | THD+N = 10%, f = 1kHz | 1.50  |      |         |
|          |                                            | $V_{DD} = 3V$                                                        | THD+N = 1%, f = 1kHz  | 0.418 |      |         |
|          |                                            |                                                                      | THD+N = 10%, f = 1kHz | 0.525 |      |         |
| $t_{WU}$ | Wake-up time (Note 3)                      | $V_{DD} = 5V$ , $C_{BYPASS} = 1\mu F$                                |                       | 115   |      | ms      |
|          |                                            | $V_{DD} = 3V$ , $C_{BYPASS} = 1\mu F$                                |                       | 102   |      |         |
| THD+N    | Total harmonic distortion + noise (Note 3) | $V_{DD} = 5V$ , $P_O = 0.5W_{rms}$ , f = 1kHz                        |                       | 0.23  |      | %       |
|          |                                            | $V_{DD} = 3V$ , $P_O = 0.3W_{rms}$ , f = 1kHz                        |                       | 0.15  |      |         |
| PSRR     | Power supply rejection ratio (Note 3)      | $V_{DD} = 5V$<br>$V_{Ripple\ p-p} = 200mV$<br>Input grounded         | f = 217Hz             | 61    |      | dB      |
|          |                                            |                                                                      | f = 1kHz              | 65    |      |         |
|          |                                            | $V_{DD} = 3.6V, 4.2V$<br>$V_{Ripple\ p-p} = 200mV$<br>Input grounded | f = 217Hz             | 62    |      |         |
|          |                                            |                                                                      | f = 1kHz              | 66    |      |         |

**Note 3:** Guaranteed by design.

## TYPICAL PERFORMANCE CHARACTERISTIC

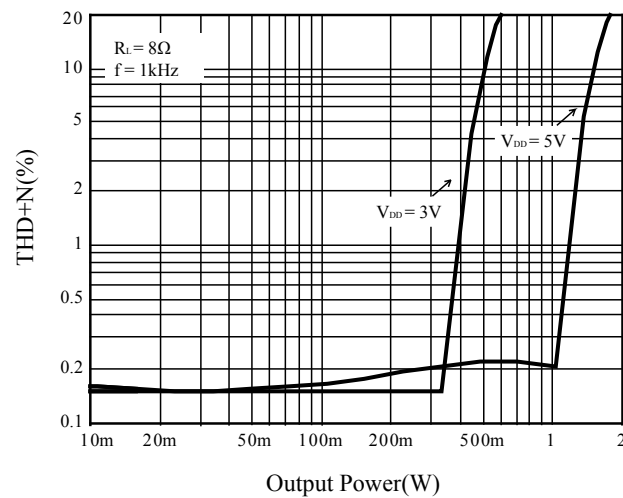


Figure 2 THD+N vs. Output Power

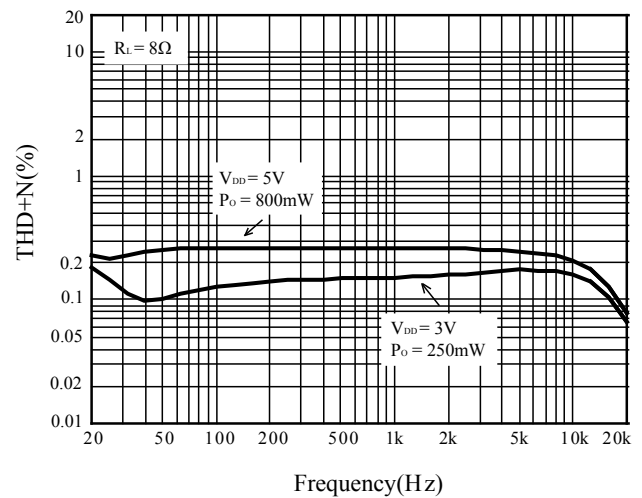


Figure 3 THD+N vs. Frequency

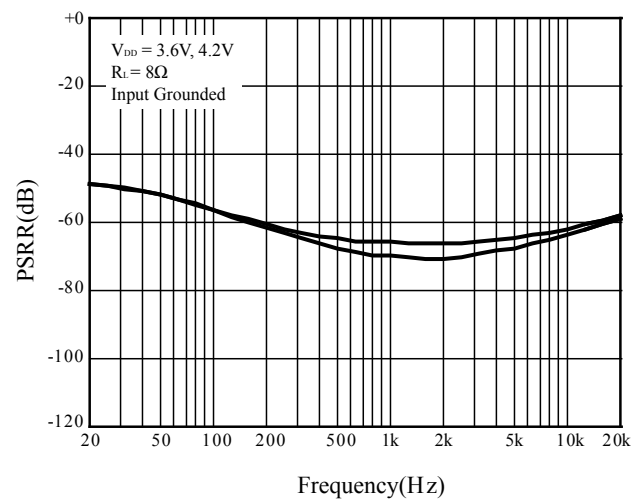


Figure 4 PSRR vs. Frequency

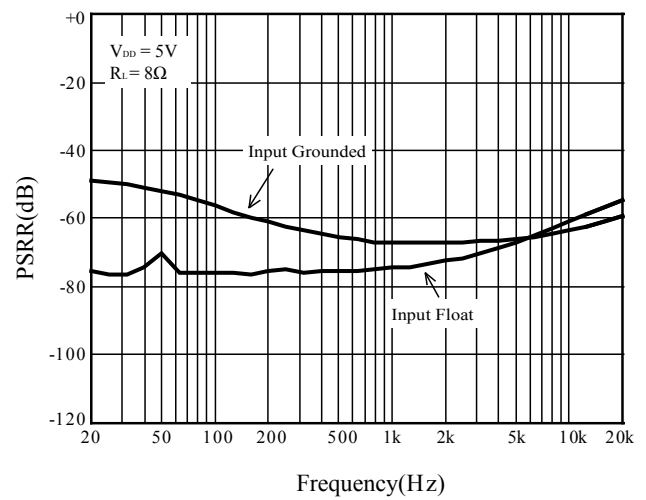


Figure 5 PSRR vs. Frequency

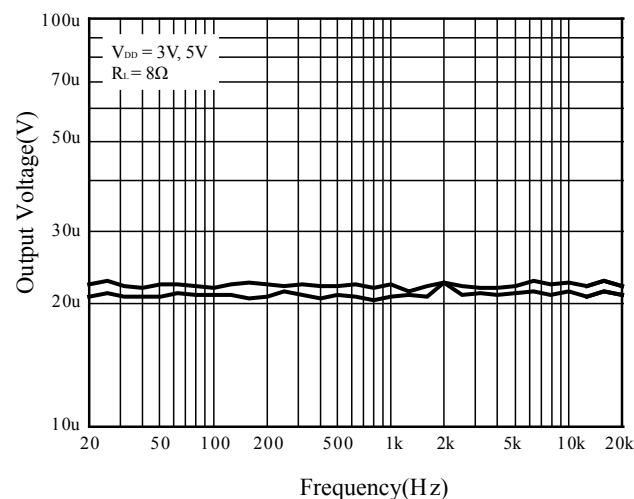


Figure 6 Noise Floor

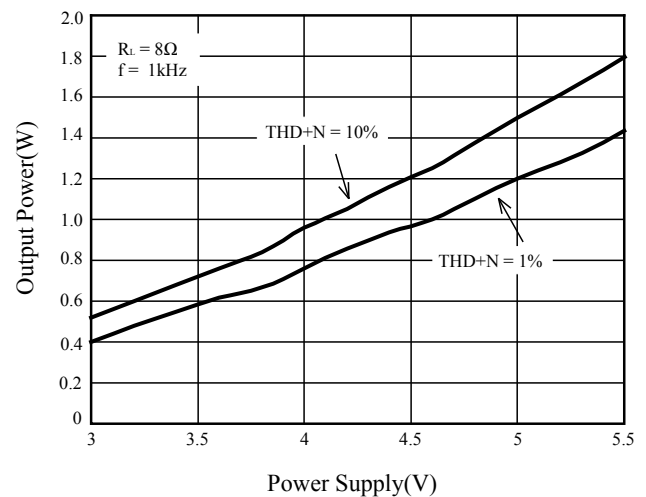
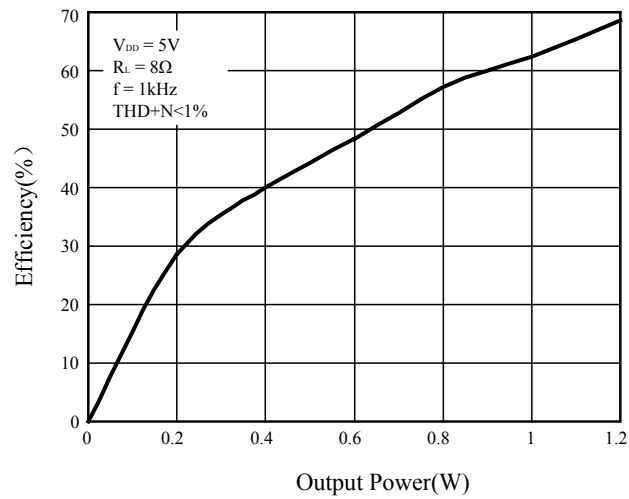


Figure 7 Output Power vs. Power Supply

# IS31AP4990D



**Figure 8** Efficiency vs. Output Power

## APPLICATION INFORMATION

### BTL CONFIGURATION PRINCIPLE

The IS31AP4990D 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:

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

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

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

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,  $G_v$ , in shourt, is given by:

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

$V_{OUT+}$  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 IS31AP4990D: 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 SDB pin 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  $C_{BYPASS} = 1\mu F$ .

### 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.

# IS31AP4990D

## CLASSIFICATION REFLOW PROFILES

| Profile Feature                                                                                                                                                               | Pb-Free Assembly                 |
|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------|
| <b>Preheat &amp; Soak</b><br>Temperature min (T <sub>smin</sub> )<br>Temperature max (T <sub>smax</sub> )<br>Time (T <sub>smin</sub> to T <sub>smax</sub> ) (t <sub>s</sub> ) | 150°C<br>200°C<br>60-120 seconds |
| Average ramp-up rate (T <sub>smax</sub> to T <sub>p</sub> )                                                                                                                   | 3°C/second max.                  |
| Liquidous temperature (T <sub>L</sub> )<br>Time at liquidous (t <sub>L</sub> )                                                                                                | 217°C<br>60-150 seconds          |
| Peak package body temperature (T <sub>p</sub> )*                                                                                                                              | Max 260°C                        |
| Time (t <sub>p</sub> )** within 5°C of the specified classification temperature (T <sub>c</sub> )                                                                             | Max 30 seconds                   |
| Average ramp-down rate (T <sub>p</sub> to T <sub>smax</sub> )                                                                                                                 | 6°C/second max.                  |
| Time 25°C to peak temperature                                                                                                                                                 | 8 minutes max.                   |

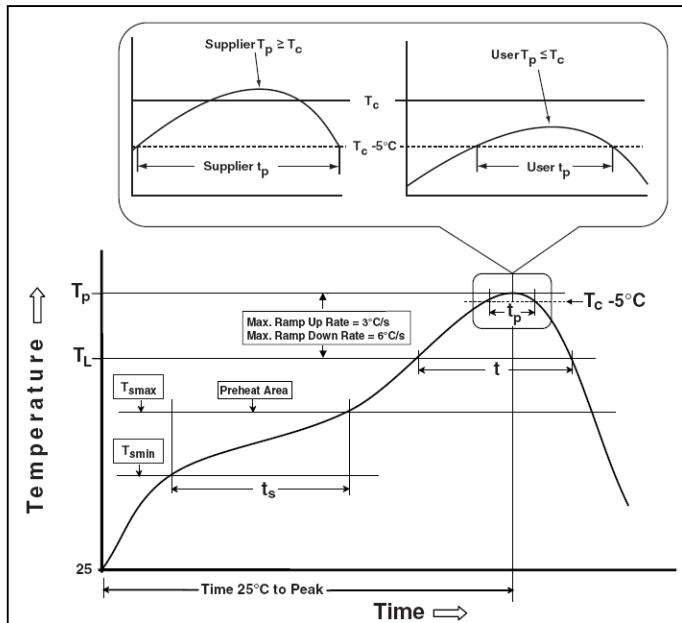
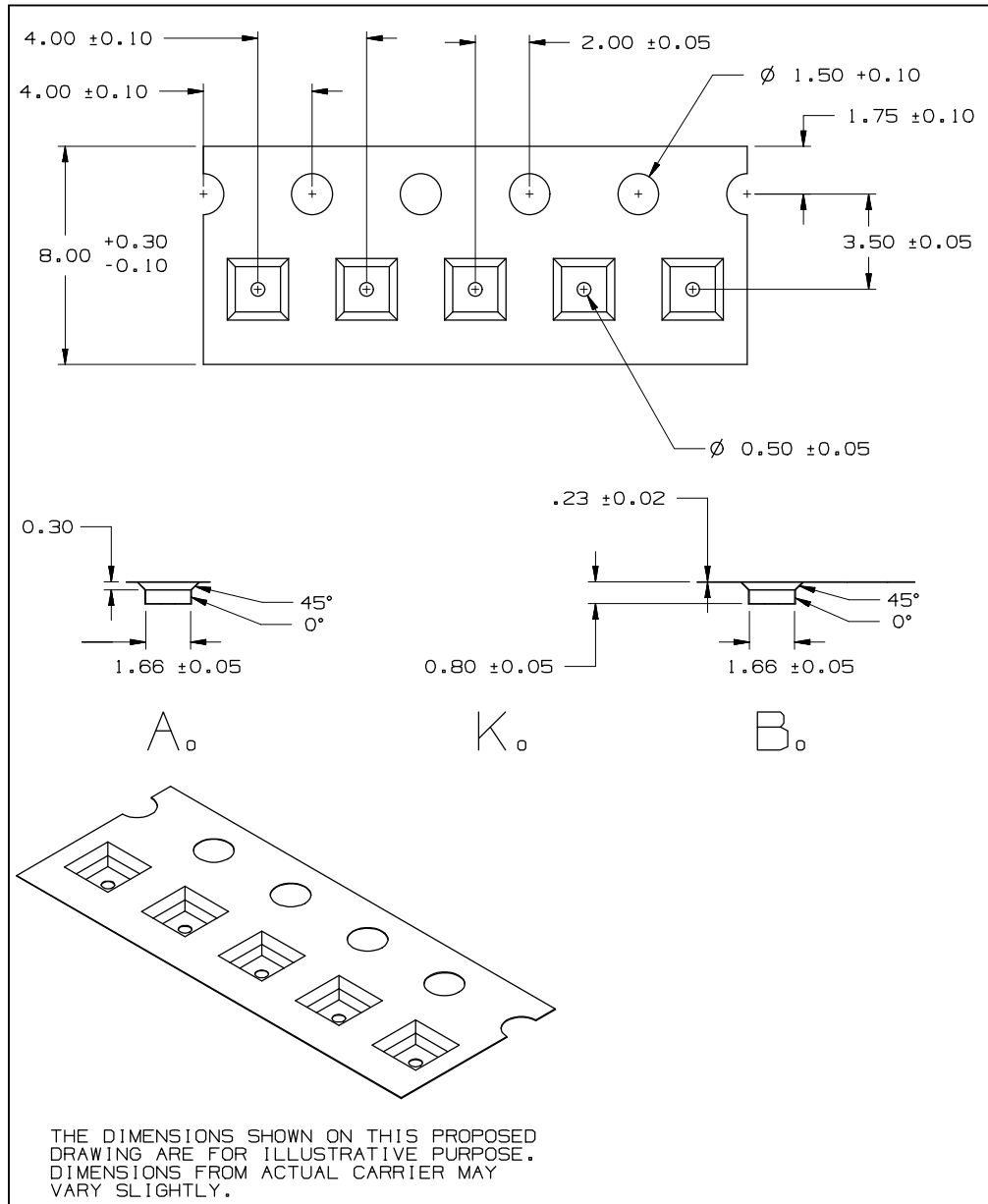


Figure 9 Classification Profile

## TAPE AND REEL INFORMATION



**Note:** All dimensions in millimeters unless otherwise stated.

# IS31AP4990D

## PACKAGING INFORMATION

### UTQFN-9L

