AN1965
APPLICATION NOTE

DISSIPATED POWER AND HEAT SINK DIMENSIONING IN AUDIO AMPLIFIERS ICS

All STMicroelectronics Audio Amplifiers are thermally protected, the schemes and the modes of operation can be different, but the purpose is always the same, to prevent long-term thermal stress to the device.

The Amplifiers can be assembled in different packages , suitable to be mounted with traditional heat sink or soldered on a PCB with a dissipating copper are on board.
For both the rules to be followed in the dimensioning of the suitable heat sink thermal resistance are the same.

In the following it will be explained what are the parameters involved in the power dissipation and how to dimension an heat sink able to deliver the rated output power avoiding to activate the thermal protection during normal operation.

1 POWER DISSIPATION :

In the most part of ST datasheets are shown the characterization curves showing the Dissipated Power (P_d) vs Output Power (P_o) for various Supply Voltages and Load Impedances.
When these curves are not present , the maximum dissipated power of the I_c , can be estimated using the equations contained in TABLE 1 for the Single Ended and for the Bridge configurations.

Table 1.

	SINGLE ENDED	BRIDGE
Pd (max)	$\frac{V_{cc}^2}{2\pi^2 Rl}$	$\frac{2V_{cc}^2}{\pi^2 Rl}$

Where V_{cc}: total Supply Voltage
Rl : Load Impedance
The obtained values are valid for Mono amplifiers, for Stereo and Multichannel Amplifiers the result must be multiplied as consequence.

The max dissipated power occurs in correspondence of the maximum undistorted output signal applied to the load , this happens for a distortion of about THD = 0.2% .
If this value had been used in the heat sink dimensioning calculations, surely the IC will never go into thermal protection also under severe continuous sine wave tests conditions, but the resulting heat sink dimensions and cost would be excessive.
So it is advisable to use the estimated dissipation given by a normal listening output power.
In order to calculate this so called "Average Listening Dissipated Power" we can proceed in

two different ways, that give similar results.

1.1 Gaussian Noise Test:

On the market are available test CD's containing Gaussian Noise traces that can be used to define the Listening Dissipated Power.
You can proceed as follows:

– Apply the Gaussian Noise signal to the Amplifier input terminals, regulating the level in such a way that the max Audio Signal Peaks observed with an Oscilloscope placed across the load start to clip.
– With an Audio Analyzer measure the average P_{out}. In this conditions measure the V_{cc} and I_{cc} (Pin) and making the difference is obtained the Listening Average Dissipated Power.

As approximation the measured value it will be about a 40% less respect the Maximum Dissipated Power calculated with the equations in Table 1.

1.2 Theoretical Calculation:

Using as Audio source a typical CD music, normally the user will regulate the level in such a way to listen the loudest part of the musical program without distortion.
Considering as maximum listening level a signal at THD = 0.5% (loudest part), it will come out that the average listening level will be at about 12dB below (factor 15.85).
So using the Dissipation and the THD vs P_{out} Curves shown in the Datasheet it will be simple to evaluate the Listening Average Dissipated Power.

$$P_{0avlistening} = \frac{P_{out}(THD = 0.5\%)}{15.85} \quad [1]$$

2 DETERMINING THE CORRECT HEAT SINK RTH:

In order to determine the suitable heat sink R_{th}, it's necessary to know a certain number of quantities coming from the IC and the application characteristics:

a) Average Listening dissipated power ($P_{dav\ listening}$)
b) Max. ambient temperature (T_{amb})
c) Thermal Resistance Junction to case (R_{thj-c})
d) Max. Junction Temperature or Thermal Protection Threshold (T_j)
e) Thermal Resistance Case to Heat sink (R_{thc-s}) due to the coupling medium.

The Average Listening dissipated power is calculated as shown in section 1.
The Maximum ambient temperature is dictated by the particular environment where the IC is used, normally , for consumer Audio applications it ranges from 50°C < $T_{amb(max)}$< 60°C.
The Thermal resistance Junction to case (R_{thj-c}) is specified in the datasheet and depends on the used package and dissipating Silicon Area of the device.
The Thermal protection threshold is usually placed at a temperature close to T_j = 150°C, in some device it could be different (please refer to the interested datasheet).
The thermal resistance due to the coupling medium placed between the IC case and the heat sink (R_{thc-s}), can be 0.2°C/W in case of Thermal Grease or about 0.5°C/W if Silicon Rubber washer is used .

Once the above mentioned parameters are known , the suitable heat sink thermal resistance Rths-a can be easily calculated as follows:

$$\text{Heat sink } R_{ths-a} = \frac{T_{jmax} - T_{amb}}{P_{d\ listening}} - R_{thj-c} - R_{thc-s} \qquad [2]$$

3 EXAMPLE 1:

Used device TDA7265 (25W + 25W Stereo Amplifier)
Applicative conditions:

V_{cc} = +/-20V
R_{load} = 2 x 8 ohm
R_{thj-c} = 2°C/W (max)
R_{thc-s} = 0.2°C/W used a thermal grease as thermal coupling medium
$T_{j\ max}$ = 150°C
$T_{amb\ max}$ = 50°C

3.1 Maximum dissipated power (P_{dmax}):

The maximum dissipated power can be calculated via the curves shown in the datasheet (fig.2) or with the equation in Table 1.

$P_{dmax} = [\ 40^2 / 2\pi^2\ 8] = 10.1W$ for each channel
$P_{dmax} = 20.2W$ for Stereo

From the fig.2 we can see that the measured Pdmax is about 19.5W so the two methods give similar results both acceptable for the heat sink dimensioning.
If we use this value for the dimensioning we will obtain an heat sink not suitable for the real applicative conditions in terms of cost and dimensions.

Figure 1. THD vs P_{out}

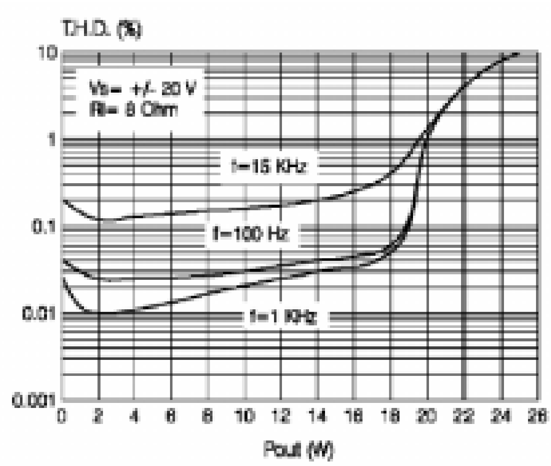
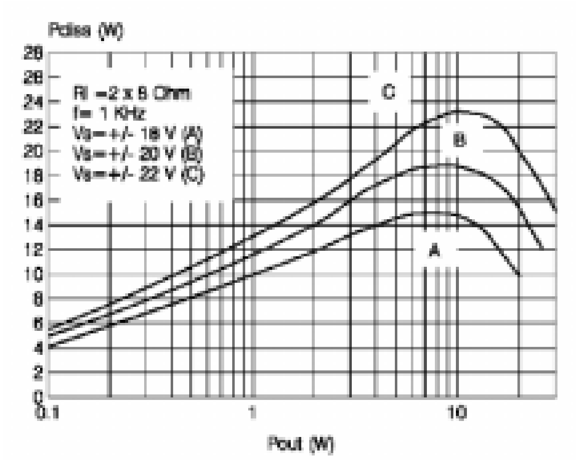


Figure 2. P_d vs P_{out}



As suggested in Section 2 it is advisable to use for the dimensioning the Average Listening Dissipated Power [$\mathbf{P_{dav}}$]. As mentioned in sec 2 we can obtain this value using two methods:

a) Gaussian Noise Test: with this approach we measured a value that is about 40% less respect the P_{dmax} . The measured value is about 12W

b) Theoretical Value: (eq.1)

$$P_{outav} = P_{outmax/}\ 15.85 = 25/\ 15.85 = 1.58W \text{ (for each channel)}$$

Looking at fig.2 this average output power gives a listening dissipated power of P_{dav} = 12W.

So using the two methods the result is the same.

Heat sink dimensioning:

from eq.[2] and using the values given in the applicative conditions it results

$$R_{ths-a} = \frac{150-50}{12} - 2 - 0.2 = 6.1°C/W$$

This is the correct R_{th} value for the heat sink to be used in the application, if we want to take in account some safety margin we can use an heat sink having an Rth of 5°C/W.
If the P_{dmax} have been used for the calculation the resulting heat sink Rth would be 2.8°C/W.

Note : When a PowerDip or PSSO packages are used the procedure is identical , the only difference consists in dimensioning correctly the Dissipating Copper Area on board.
In the datasheet are shown curves showing the R_{thj-a} vs Dissipating copper area.

Table 2. Revision History

Date	Revision	Description of Changes
May 2004	1	First Issue

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