Basic Design

2014/03/08

Desired max power output

Conditions

Required average SPL at the listening position SPLa: 90 [dB] <=== 90dB represents the SPL threshold above which the ear can be damaged.

Distance between the speaker and listener d: 3 [m]

Sensitivity of the speaker s: 104 [dB/W] (@1m)

Impedance of the speaker R_L: 8 [ohm]

Reflection of the room boundaries are ignored.

Calculation

Pave = $10^{((SPLa+20\log(d)-s)/10)} = 10^{((90+20\log(3)-106)/10)} =$ 0.358 [W]

where Pave is average power output.

Pmax = $(\mathrm{sqrt}(2*Pave*R_L)*10^{(15/20)})^2/(2*R_L) = (\mathrm{sqrt}(2*0.071*8)*10^{(15/20)})^2/(2*8) =$ 11.33 [W]

where Pmax is the desired maximum power output.

Determination

Max power output is determined to be 20[W]. It is a nearly doubled value of Pmax so that distortion will be low enough at Pmax.

Power supply requirements

Conditions

Desired power output P_O: 20 [W]

Dropout voltage of LM3886 V_{od}: 4 [V]

Regulation of the power supply r: 15 [%]

High line condition h: 10 [%]

Voltage drop across diodes V_{BR}: 1 [V]

Calculation

$V_{opeak} = \mathrm{sqrt}(2R_LP_O) =$ 17.89 [V_{peak}]

where V_{opeak} is the peak supply voltage.

$I_{opeak} = \mathrm{sqrt}((2P_O)/R_L) =$ 2.236 [A_{peak}]

where I_{opeak} is the peak supply current.

$V_{min} = V_{opeak}+V_{od} =$ 21.89 [V]

where V_{min} is the minimum supply voltage (the loaded supply voltage).

$V_{max} = V_{min}(1+r/100)(1+h/100) =$ 27.69 [V]

where V_{max} is the maximum supply voltage (no load and high line).

$V_{cc} = V_{min}/(1-r/100) =$ 25.75 [V]

$V_{ee} = -V_{cc} =$ -25.8 [V]

$V_{sec} = (V_{cc}+V_{BR})/sqrt(2) =$ 18.92 [V]

where V_{sec} is the voltage of the secondary winding of the mains transformer.

$I_{max} = sqrt(P_O/R_L) =$ 1.581 [A]

$I_{cc} = I_{max}/2+ 0.3 =$ 1.091 [A]

$I_{sec} = 1.8*I_{cc} =$ 1.963 [A] From Denpa Kagaku Oct. 1980 p.135 $I_{sec} = V_{min}/(3.14*R_L) =$ 0.871 [A]

Determination

Spec of the secondary windings: 20-0-20V, 2.0A x ===> I mistakingly ordered RA200(200VA) that has 20-0-20V, 2.5A x2 to Phoenix on 2014/03/05

The mains transformer's capacity is 160[VA]

From Denpa Kagaku Oct. 1980 p.135

Spec of the secondary windings: 20-0-20V, 1.0A x2

The mains transformer's capacity is 80 [VA] <=== It's just equal to the double of the power output (20W+20W=40W)

Thermal design

Conditions

Max junction temperature T_{Jmax}: 150 [deg-C]

Ambient temperature T_{amb}: 40 [deg-C]

Thermal resistance between the case and the heat sink $Theta_{CS}$: 0.5 [deg/W]

Thermal resistance between the Junction and the case $Theta_{JC}$: 1 [deg/W]

Calculation

$V_T = V_{cc}*2 =$ 51.5 [V]

where V_T is total supply voltage.

$P_{DMAX} = V_T^2/(2*3.14^2R_L) =$ 16.8 [W]

where P_{DMAX} is ?

$V_{opk} = V_T/3.14 =$ 16.39 [V]

$P_{DAVE} = (V_{opk}/R_L)[V_T/3.14-V_{opk}/2] =$ 16.8 [W]

$P_{DAVE} = V_TV_{Opk}/3.14R_L-V_{opk}^2/(2R_L) =$ 16.8 [W]

$Theta_{SA} = [(T_{Jmax}-T_{Amb})-P_{DMAX}(Theta_{Jc}+Theta_{CS})]/P_{DMAX} =$ 5.049 [deg/W]

Determination

The thermal resistance of the heat sink is 5[deg/W]-6[deg/W].
Fischer Elektronik SK68-50-SA: 4.8[K/W], 50x46x33[mm] @364 at RS-online
Or, the case itself is used as the heat sink. At least 150[cm^2] of surface area is required.

Negative feedback design

Conditions

Gain A_V:	13 or	22.28 [dB]	Because LM3886 is stable when A_V is 10 or more.
R_{f1} (feedback resistor)	100 [kohm]		Typically 10k-100k. For low DC offsets at the output, 100k is the best.
The lower pole f_L:	20 [Hz]		
The upper pole f_H:	100 [kHz]		

Calculation

$V_{in} = sqrt(P_O R_L)/A_V =$	0.973 [Vrms]	===> matched with the spec	
$R_i = R_{f1}/(A_V-1) =$	8.333 [kohm]	===>	8.2 [kohm]
$GBWP = A_V * f_H =$	1.3 [MHz]	It smaller than 2.0[MHz] for the LM3886 ===> Good!	
$C_i >= 1/(2*3.14 R_i f_L) =$	0.97 [uF]	===>	1 [uF]