General Description

The MD2203 is a dual bridge-connected audio Power ampli-fier which,When connected to a 5V supply, will deliver 2.2W to a 4Ω load (Note1) or 2.5W to a 3Ω load (Note2) with less than 1.0% THD+N. In addition, the headphone input pin allows the amplifiers to operate in single-ended mode when driving stereo headphones.

Boomer audio power amplifiers were designed specifically to provide high quality output power from a surface mount package while requiring few external components.To sim-plify audio system design, the MD2203 combines dual bridge speaker amplifiers and stereo headphone amplifiers on one chip.

The MD2203 features an externally controlled, low-power consumption shutdown mode, a stereo headphone amplifier mode，and thermal shutdown protection. It also utilizes cir-mode,and thermal shutdown protection. It also utilizes cir- cuitry to reduce. “clicks and pops” during device turn-on.

Note1: An MD2203MTE orMD2203LQ that has been properly mounted to a circuit board will deliver 2.2W into 4Ω. The other package options for the MD2203 will deliver 1.1 into 8Ω See the Application Information sections for further information concerning the MD2203MTE and MD2203LQ.

Note2: An MD2203MTE or MD2203LQ that has been properly mounted to a circuit board and forced-air cooled willde liver 2.5W into 3Ω.

KeySpecifications

- P_O at 1% THD+N
- MD2203LQ, 3Ω, 4Ω loads 2.5W(typ), 2.2W(typ)
- MD2203MTE,3Ω,4Ω loads 2.5W(typ), 2.2W(typ)
- MD2203MTE,8Ω loads 1.1W(typ)
- MD2203,8Ω 1.1W(typ)
- Single-ended mode THD+N at 75mW into32Ω 0.5%(max)
- Shutdown current 0.7µA (typ)
- Supply voltage range 2.0Vto5.5V

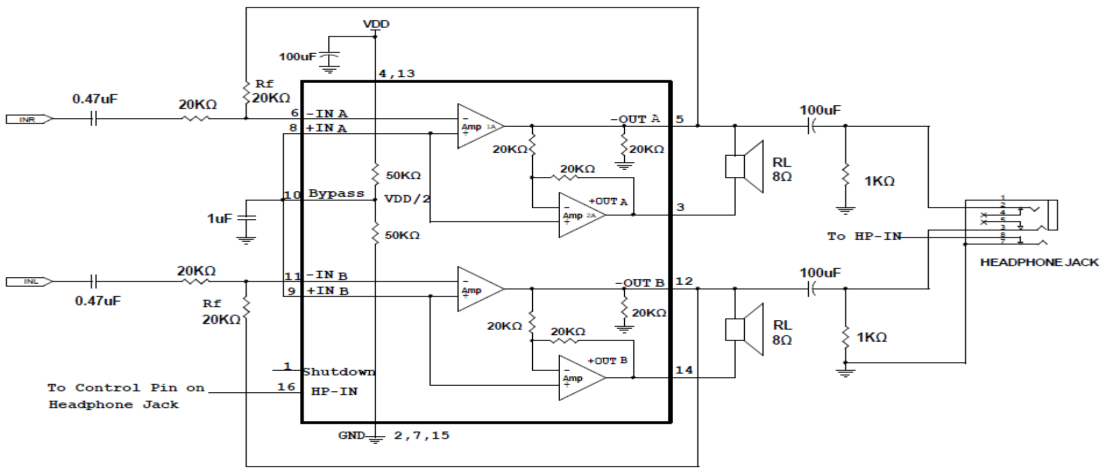
Features

- Stereo headphone amplifier mode
- “Click and pop”suppression circuit
- Unity-gain stable
- Thermal shutdown protection circuitry
- SOIC,TSSOP,exposed-DAP TSSOP,and LLP packages
- Not recommended for new designs.Contact MD Audio Marketing.

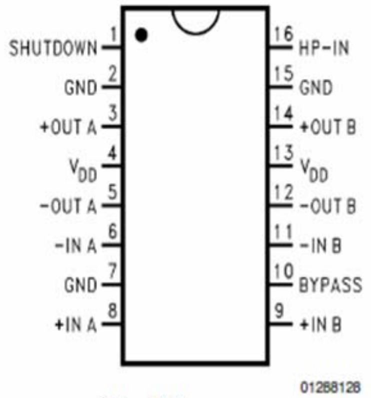
Applications

- Multimedia monitors
- Portable and desktop computers
- Portable televisions

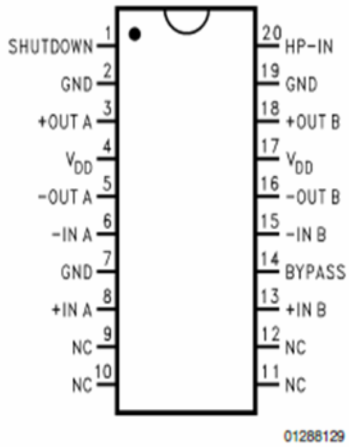
Typical Application



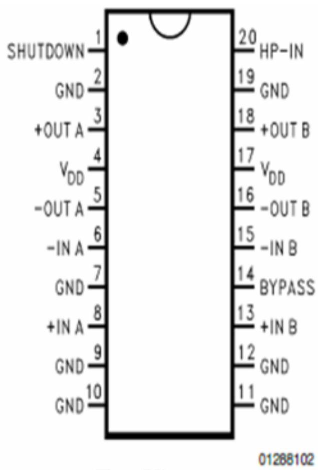
Connection Diagrams



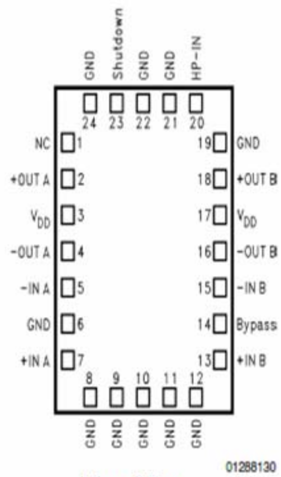
Top View
Order Number MD2203M
See MD Package Number M16B for SO



Top View
Order Number MD2203MT
See MD Package Number MTC20 for TSSOP



Top View
Order Number MD2203MTE
See MD Package Number MXA20A for Exposed-DAP TSSOP



Top View
Order Number MD2203LQ
See MD Package Number LQA24A for Exposed-DAP LLP

***Not recommended for new designs.Contact ID CHIP Audio Marketing.**

Absolute Maximum Ratings (Note3)

If Military/Aerospace specified devices are required, please contact the IDCHIP Sales Office/Distributors for availability and specifications.

Supply Voltage	6.0V
Storage Temperature	-65℃ to +150℃
Input Voltage	-0.3V to V_{DD}+0.3V
Power Dissipation (Note4)	Internally limited
ESD Susceptibility(Note5)	2000V
ESD Susceptibility(Note6)	200V
Junction Temperature	150℃

Solder Information

Small Outline Package

Vapor Phase (60sec.)	215℃
Infrared (15sec.)	220℃

See AN-450 "Surface Mounting and their Effectso Product Reliablilty"for other methods of solderin surface mount devices.

Thermal Resistance

θJC(typ) —M16B	20℃/W
θJA(typ)—M16B	80℃/W
θJC(typ)—MTC20	20℃/W
θJA (typ)—MTC20	80℃/W
θJC (typ) —MXA20A	2℃/W
θJA (typ)—MXA20A	41℃/W(Note7)
θJA (typ)—MXA20A	51℃/W(Note8)
θJA (typ) —MXA20A	90℃/W(Note9)
θJC (typ) —LQ24A	3.0℃/W
θJA (typ) —LQ24A	42℃/W(Note10)

*Not recommended for new designs.Contact IDCHIP Audio marketing.

OperatingRatings

Temperature Range

T_{MIN}≤TA≤T_{MAX}	-40℃≤TA≤85℃
Supply Voltage	2.0V≤ V_{DD} ≤5.5V

Electrical Characteristics for Entire IC (Notes3,11)

The following specifications apply for V_{DD} =5V unless otherwise noted. Limit sapply for T_A =25℃.

Symbol	Parameter	Conditions	MD2203 Typical (Note12)	MD2203 Limit (Note13)	Units (Limits)
V_{DD}	SupplyVoltage			2	V (min)
				5.5	V (max)
I_{DD}	Quiescent PowerS upply Current	V_{IN}=0V,I_O=0A(Note14),HP-IN=0V	11.5	20	mA(max)
				6	mA(min)
		V_{IN}=0V,I_O=0A(Note14),HP-IN=4V	5.8		mA
I_{SD}	Shutdown Current	V_{DD} applied to theSHUTDOWN pin	0.7	2	µA(max)
V_{IH}	Headphone High Input Voltage			4	V(min)
V_{IL}	Headphone Low Input Voltage			0.8	V(max)

Electrical Characteristics for Bridged-Mode Operation (Notes3,11)

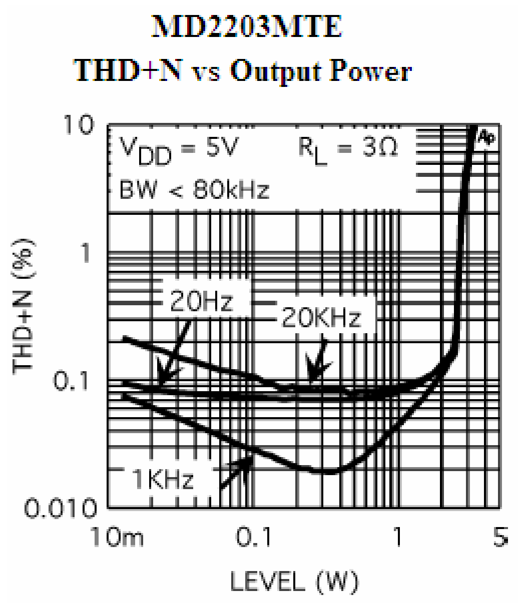
The following specifications apply for V_{DD}=5V unless otherwise specified.Limits apply for T_A=25℃

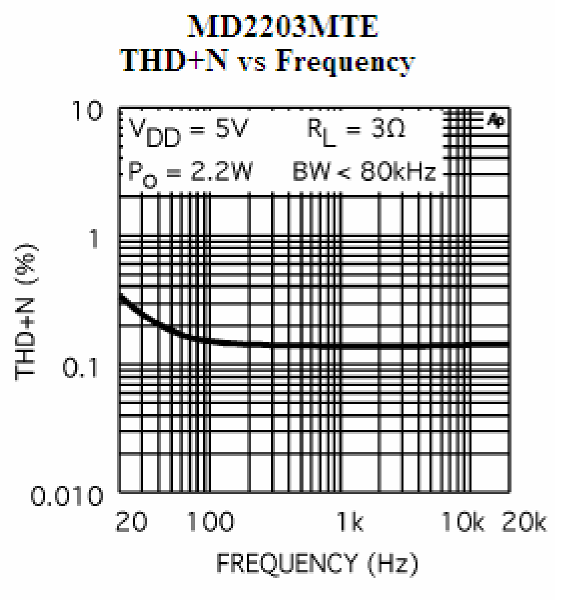
Symbol	Parameter	Conditions	MD2203 Typical Note12)	MD2203 Limit (Note13)	Units (Limits)
V_{OS}	Output Offset Voltage	V_{IN}=OV	5	50	mV(max)
P_O	Output Power (Note15)	THD+N=1%,f=1kHz(Note16)			
		MD2203MTE,R_L=3Ω	2.5		W
		MD2203LQ ,R_L=3Ω-	2.5		W
		MD2203MTE,R_L=4Ω	2.2		W

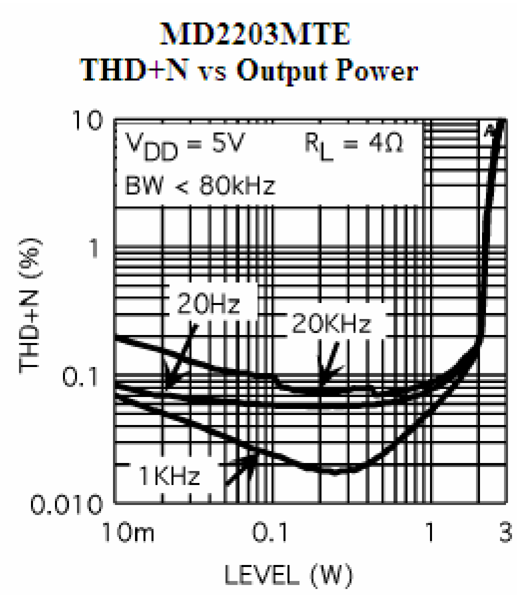
		MD2203LQ ,R_L=4Ω	2.2		W
		MD2203 ,R_L=8Ω	1.1	1.0	W(min)
		THD+N=10%,f=1kHz(Note16)			
		MD2203MTE,R_L=3Ω	3.2		W
		MD2203LQ ,R_L=3Ω	3.2		W
		MD2203MTE,R_L=4Ω	2.7		W
		MD2203LQ ,R_L=4Ω	2.7		W

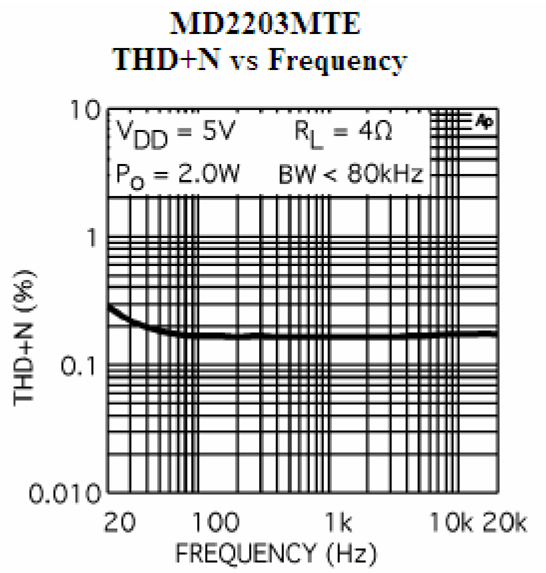
TypicalPerformanceCharacteristics

MTESpecificCharacteristics

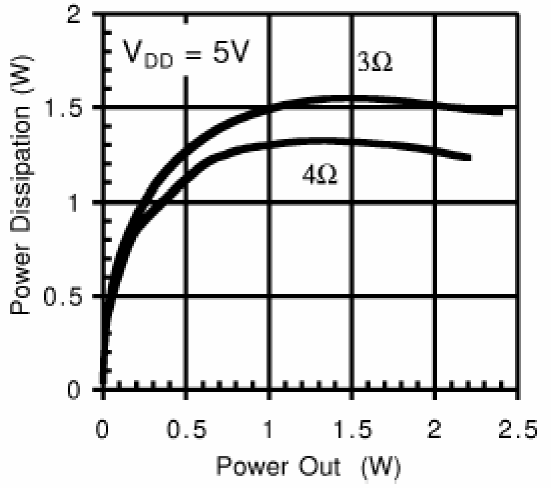




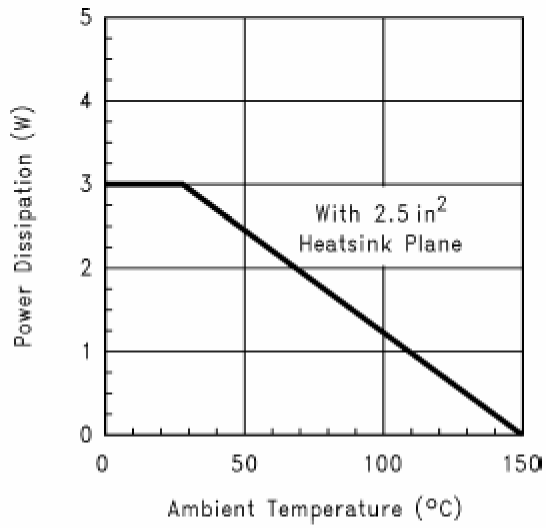




MD2203MTE
Power Dissipation vs Power Output

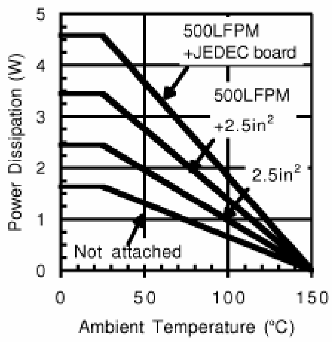


MD2203MTE
Power Derating Curve



Typical Performance Characteristics
MTE Specific Characteristics (Continued)

MD2203MTE(Note 17)
Power Derating Curve



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Note 17: This curve shows the MD2203MTE' thermal dissipation ability at different ambient temperatures given these conditions:

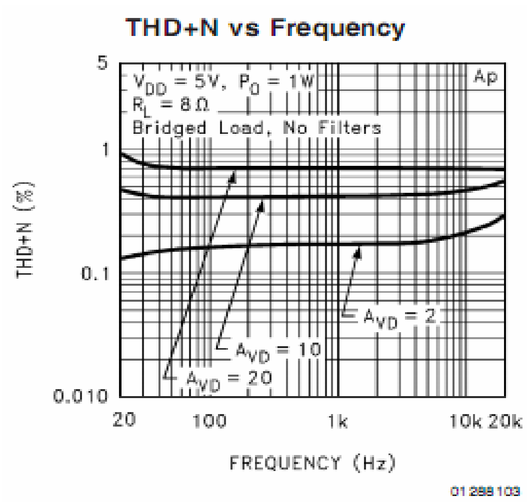
500LFPM + JEDEC board: The part is soldered to a 1S2P 20-lead exposed-DAP TSSOP test board with 500 linear feet per minute of forced-air flow across it.
Board information - copper dimensions: 74x74mm, copper coverage: 100% (buried layer) and 12% (top/bottom layers), 16 vias under the exposed-DAP.

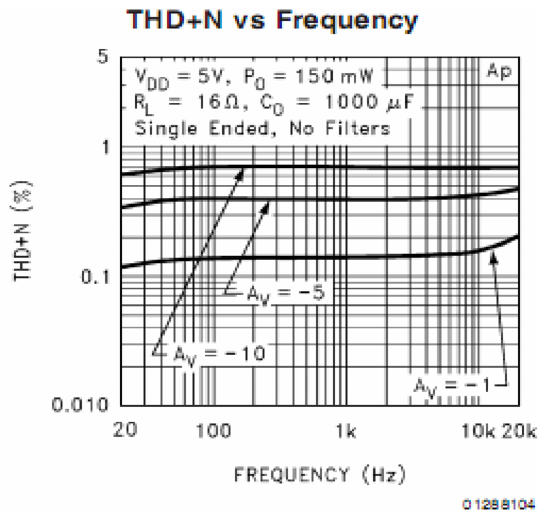
500LFPM + 2.5in^2: The part is soldered to a 2.5in^2, 1 oz. copper plane with 500 linear feet per minute of forced-air flow across it.

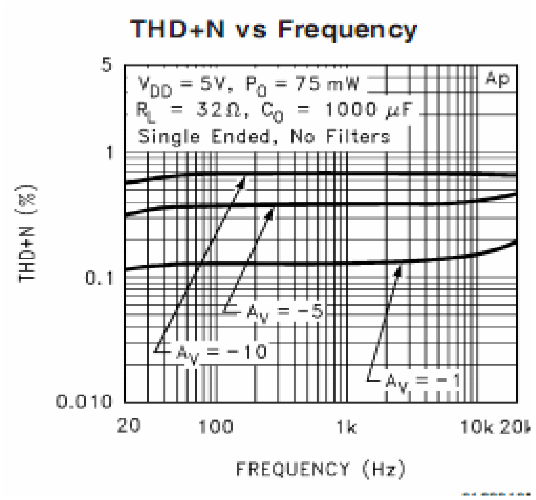
2.5in^2: The part is soldered to a 2.5in^2, 1oz. copper plane.

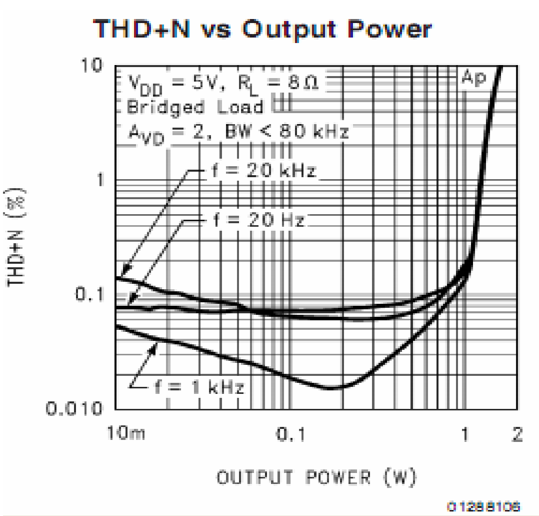
Not Attached: The part is not soldered down and is not forced-air cooled.

Non-MTE Specific Characteristics









External Components Description (Referto Figure1.)	
Components	**Functional Description**
1、 R_i	The Inverting input resistance, along with R_f, set the closed-loop gain .R_i, along with C_i, form a high pass.filter with fc=1/(2πR_i C_i)
2、 C_i	The input coupling capacitor blocks DC voltage at the amplifier's input terminals.C_i Along with R_i,create a high pass filter with fc=1/(2RC).Refer to the section, SELECTING PROPER EXTERNAL COMPONENTS,for an explanation of determining the value of C_i
3、 R_f	The feedback resistance,along with R_i,set the closed-loop gain.
4、 C_s	The supply bypass capacitor. Refer to the POWER SUPPLY BYPASSING section for information about properly placing ,and selecting the value of,this capacitor.
5、 C_B	The capacitor,C_B, filters the half-supply voltage present on the BYPASS pin.Refer to the SELECTING PROPER EXTERNAL COMPONENTS section for information concerning proper placement and selecting's value.

Application Information

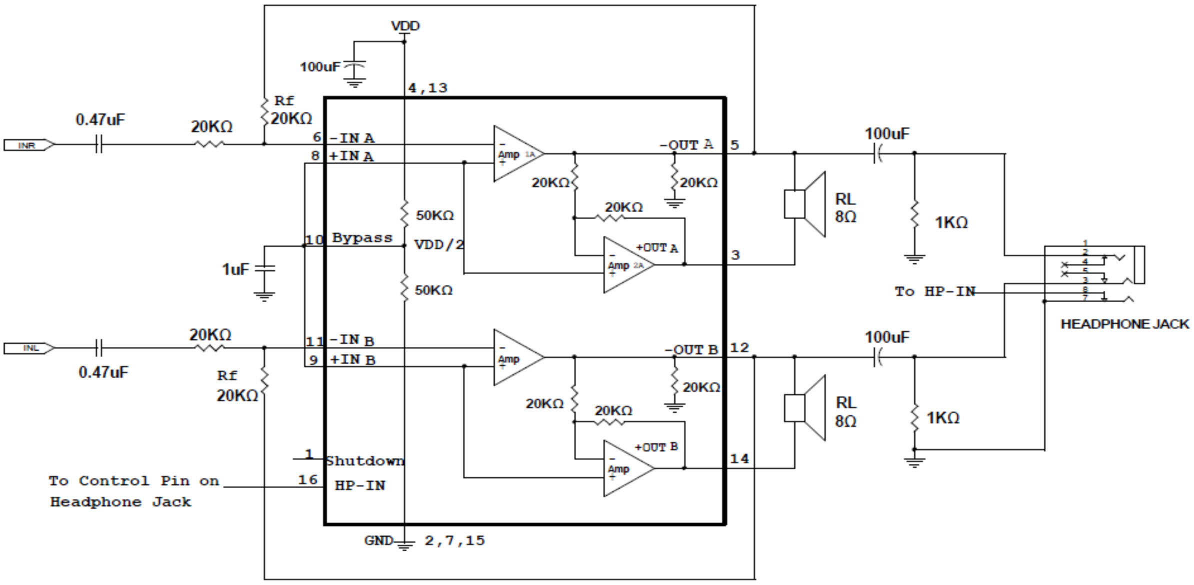
EXPOSED-DAP PACKAGE PCB MOUNTING CONSIDERATIONS

The MD2203's exposed-DAP (die attach paddle) package (MTE and LQ) provide a low thermal resistance between the die and the PCB to which the part is mounted and soldered.This allows rapid heatt ransfer from the die to the surround-ing PCB copper traces, ground plane and,finally,surround-ing air.The result is a low voltage audio power amplifier that produces 2.2W at≤1% THD with a 4Ω load.This high power is achieved through careful consideration of necessary ther-mal design. Failing too ptimize thermal design may compro-mise the MD2203's high power performance and activatunwanted,though necessary, thermal shutdown protection.The MTE and LQ packages must have their DAPs soldered to a copper pad on the PCB.The DAP's PCB copper pad is connected to a large plane of continuous unbroken copper.This plane forms a thermal mass and heat sink and radiation area. Place the heat sink area on either outsid eplane in the case of a two-sided PCB, or on an inner layer of a board with more than two layers.Connect the DAP copper pad to the inner layer or backside copper heat sink area with 32(4x8) (MTE) or 6(3x2) (LQ) vias. The via diameter should be 0.012in-0.013in with a 1.27mm pitch.Ensure efficient ther-mal conductivity by plating-through and solder-filling the vias Best thermal performance is achieved with the largest prac-tical copper heat sink area.If the heatsink and amplifier share the same PCB layer, a nominal 2.5in^2(min) area is necessary for 5V operation with a 4Ω load.Heatsink areas not placed on the same PCB layer as the MD2203 should be 5in^2 (min) for the same supply voltage and load resistance. The last two area recommendations apply for 25 ℃ cambient temperature. Increase the area to compensate for ambient temperatures above25 ℃ .In systems using cooling fans,the MD2203MTE can take advantage of forced air cooling.With an air flow rate of 450 linear-feet per minute and a 2.5in^2 exposed copper or 5.0in^2 inner layer copper plane heatsink,the MD2203MTE can continuously drive a 3Ω load to full power. The MD2203LQ achieves the same output power leve lwithout forced air cooling.In all circumstances and conditions,the junction temperature must be held below 150℃to prevent activating the MD2203's thermal shutdow protection.The MD2203's power de-rating curve in the Typi-cal Performance Characteristics shows the maximum power dissipation versus temperature.Example PCB layouts for the exposed-DAP TSSOP and LLP packages are shown in the Demonstration Board Layout section.Further de-tailed and specific information concerning PCB layout,fabri-cation,and mounting an LLP package is available from National Semiconductor's package Engineering Group When contacting them,ask for"Preliminary Application Note for the Assembly of the LLP Package on a Printed Circuit Board,Revision A dated 7/14/00."

PCB LAYOUT AND SUPPLY REGULATION CONSIDERATIONS FOR DRIVING 3Ω AND 4Ω LOADS

Power dissipated by a load is a function of the voltage swing across the load and the load's impedance.As load imped-ance decreases,load dissipation becomes increasingly de-pendent on the interconnect(PCB trace and wire)resistance between the amplifier output pins and the load's connections.Residual trace resistance causes a voltage drop,which results in power dissipated in the trace and not in the load as desired.For example,0.1Ω trace resistance reduces the output power dissipated by a 4Ω load from 2.1W to 2.0W. This problem of decreased load dissipation is exacerbated as load impedance decreases.Therefore,to maintain the highest load dissipation and widest output voltages wing, PCB traces that connect the output pins to a load must be as wide as possible.Poor power supply regulation adversely affects maximum output power.A poorly regulated supply's output voltag decreases with increasing load current.Reduced supply voltage causes decreased headroom,output signal clipping, and reduced output power.Even with tightly regulated sup-plies,trace resistance creates the same effects as poor supply regulation.Therefore,making the power supply traces as wide as possible helps maintain full output voltage swing.

Application Information (continued)



BRIDGE CONFIGURATION EXPLANATION

As shown in Figure1,the MD2203 consists of two pairs of operational amplifiers,forming a two-channel(channel A and channel B)stereo amplifier.(Though the following discusses channel A,it applies equally to channel B.)External resistors R_f and R_i set the closed-loop gain of Amp1A,whereas two internal 20kΩ resistors set Amp2A's gain at-1.The MD2203 drives a load,such as a speaker,connected between the two amplifier outputs,-OUTA and+OUTA.Figure1 shows that Amp1A's output servesas Amp2A's input.This results in both amplifiers producing signals iden-tical in magnitude,but 180° out of phase.Taking advantage of this phase difference,a load is placed between-OUTA and+OUTA and driven differentially(commonly referred to as"bridge mode").This results in a differential gain of

$$A_{VD}=2\times(R_f/R_i) \qquad (1)$$

Bridge mode amplifiers are different from single-ended am-plifiers that drive loads connected between a single amplifi-er;s output and ground.For a given supply voltage,bridg mode has a distinct advantage over the single-ended con-figuration:its differential output doubles the voltage swing across the load.This produces four times the output power when compared to a single-ended amplifier under the same conditions.This increase in attainable output power as-sumes that the amplifier is not current limited o that channel A's and channel B's outputs at half-supply.This eliminates the coupling capacitor that single supply,single-ended amplifiers require.Eliminating an output coupling ca- pacitor in a single-ended configuration forces a single-supply amplifier's half-supply bias voltage across the load.This increases internal IC power dissipation and may perma-
nently damage loads such as speakers.

POWER DISSIPATION

Power dissipation is a major concern when designing a successful single-ended or bridged amplifier.Equation(2) states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and drivinga specified output load

$$P_{DMAX}=(V_{DD})^2/(2\pi^2R_L) \text{ Single-Ended} \qquad (2)$$

However,a direct consequence of the increased power de-livered to the load by a bridge amplifier is higher internal power dissipation for the same conditions. The MD2203 has two operational amplifiers perchannel.Themaximum internal power dissipation per channel operating in the bridge mode is four times that of a single-ended ampli-fier.From Equation(3),assuming a 5V power supply and an 4Ω load,the maximum single channel power dissipation is 1.27W or 2.54W for stereo the output signal is not clipped.To ensure minimum output sig-nal clipping when choosing an amplifier's closed-loop gain,refer to the Audio Power Amplifier Design section.

Another advantage of the differential bridge output is no net DC voltage across the load.This is accomplished by biasing operation.

$P_{DMAX} = 4x(V_{DD}) / (2\pi^2 R_L)$ BridgeMode

ApplicationInformation (Continued)

sents a tradeoff:as the size of C_B increases,the turn-on time increases.There is a linear relationship between the size of C_B and the turn-on time.Here are som etypical turn-on times for various values of C_B

C_B	T_{ON}
0.01μF	20ms
0.1μF	200ms
0.22μF	440ms
0.47μF	940ms
1.0μF	2sec

In order eliminate"clicks and pops",all capacitors must be discharged before turn-on.Rapidly switching V_{DD} may not allow the capacitors tofully discharge,which may cause "clicks and pops".In a single-ended configuration,the output is coupled to the load by C_{OUT} This capacitor usually has a high value.C_{OUT}, discharges throug hinternal 20KΩ resistors Depending on the size of C_{OUT} the discharge time constant can be relatively large.To reduce transients in single-ended mode,an external 1kΩ -5kΩ resistor can be placed in parallel with the internal 20kΩ resistor.The tradeoff for using this resistor is increased quiescent current.

NO LOAD STABILITY

The MD2203 may exhibit low level oscillation when the load resistance is greater than 10kΩ.This oscillation only occurs as the output signal swings near the supply voltages.Pre-vent this oscillation by connecting a 5kΩ between the output pins and ground.

AUDIO POWER AMPLIFIER DESIGN

Audio Amplifier Design:Driving 1W into an 8 Load

The following are the desired operational parameters:

Power Output:	1Wrms
Load Impedance:	8Ω
Input Level:	1Vrms

easily met by the commonly used 5V supply voltage.The additional voltage creates the benefit of headroom,allowing the MD2203 to produce peak output power in excess of 1W without clipping or other audible distortion.The choice of supply voltage must also not create a situation that violates maximum power dissipation as explained above in the Power Dissipation section. After satisfying the MD2203's power dissipation require-ments, the minimum differential gain is found using Equation(10).

$$AVD \geq \sqrt{(P_O R_L)} / (V_{IN}) = V\text{ orms}/V\text{ inrms} \quad (10)$$

Thus,a minimum gain of 2.83 allows the MD2203's to reach full output swing and maintain low noise and THD+N perfor--mance.For this example,let A_{VD}=3.

The amplifier,s overall gain is set using the input(R_i) and feedback (R_f) resistors.With the desired input impedance set at 20kΩ,the feedback resistor is found using Equation(11).

$$R_f/R_i = A_{VD}/2 \quad (11)$$

The value of R_f is30kΩ.

The last step in this design example is setting the amplifier's -3dB frequency bandwidth.To achieve the desired ±0.25dB pass band magnitude variation limit,the low frequency re-sponse must extend to at least one-fifth the lower bandwidth limit and the high frequency response must extend to at least five times the upper bandwidth limit.The gain variation for both response limits is 0.17dB,well within the ±0.25dB desired limit.The results are an

$$f_L = 100Hz/5 = 20Hz \quad (12)$$

and an $FH = 20KHz \times 5 = 100KHz$ (13)

As mentioned in the External Components section,R_i and C_i create a highpass filter that sets the amplifier's lower bandpassfrequency limit.Find the coupling capacitor's value using Equation(12).

$$Ci \geq \frac{1}{2\pi R_i fc}$$

The result is

Input Impedance: Ω20k

Bandwidth: 100Hz-20kHz±0.25 dB

The design begins by specifying the minimum supply voltage necessary to obtain the pecified output power.One way to find the minimum supply voltage is to use the Output Power vs Supply Voltage curve in the Typical Performance Char-acteristics section.Another way,using Equation(4),is tocalculate the peak output voltage necessary to achieve the desired output power for a given load impedance.To ac-count for the amplifier's dropout voltage,two additional volt-ages,based on the Dropout Voltage vs Supply Voltage in the Typical Performance Characteristics curves,must be added to the result obtained by Equation(8).The result in Equation(9).

$$Vopeak = \sqrt{(2R_L P_O)} \qquad (8)$$

$$V_{DD} \geqslant (V_{OUTPEAK} + (V_{ODTOP} + V_{ODBOT})) \qquad (9)$$

The Output Power vs Supply Voltage graph for an 8Ω loadindicates a minimum supply voltage of 4.6V.This is

$$1/(2\pi * 20k\Omega * 20Hz) = 0.398\mu F \qquad (4)$$

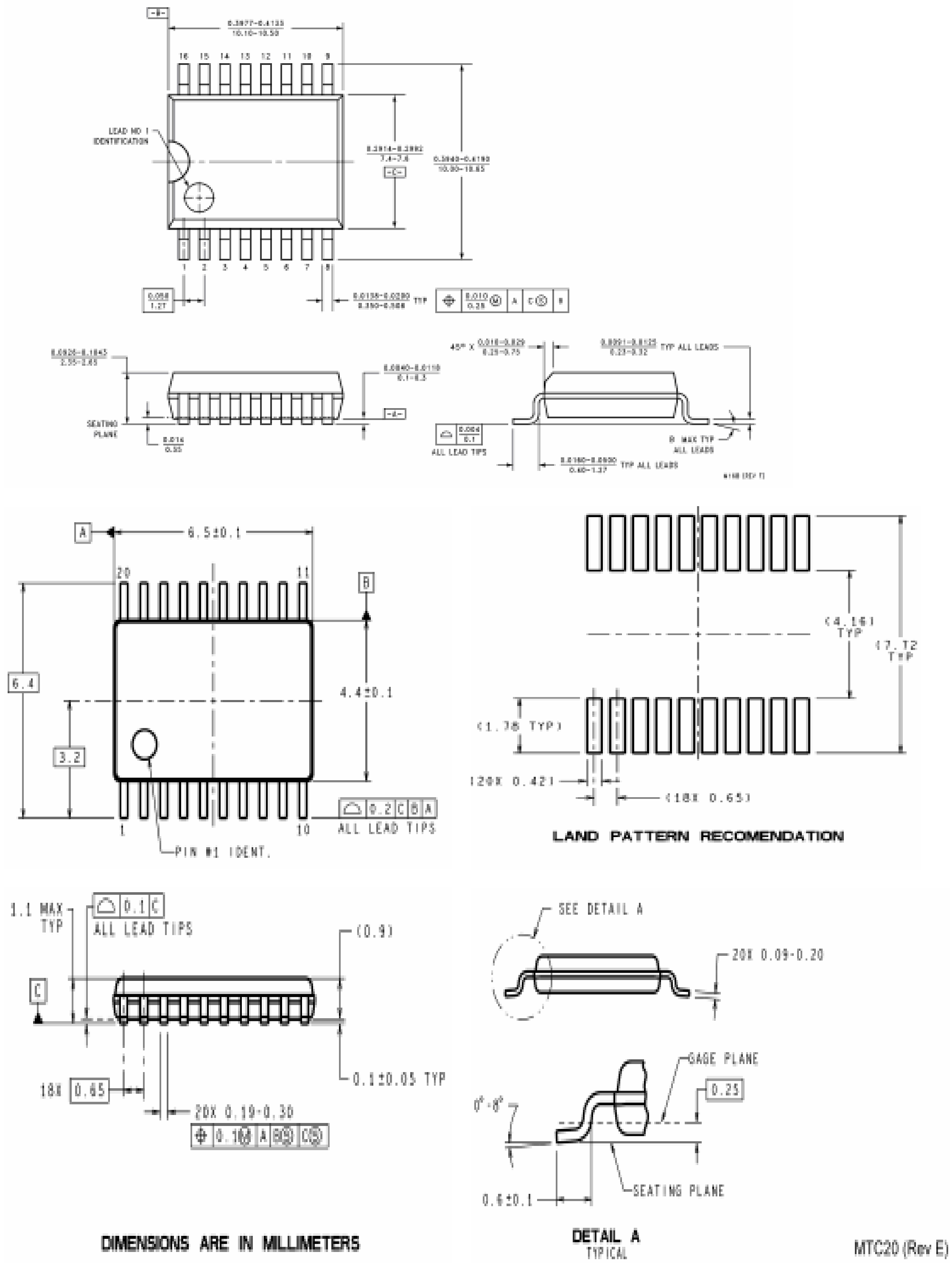
Use a 0.39μF capacitor,the closest standard value

The product of the desired high frequency cutoff(100kHz in this example) and the differential gain,A_{VD}=3 and f_H =100KHZ,the closed-loop gain bandwidth product (GBWP) is 3.5MHz G. this margin,the amplifier can be used in designs that require more differential gain while avoidingperformance -lrestricting bandwidth limitations.

RECOMMENDED PRINTED CIRCUIT BOARD LAYOUT

Figures3 through 6 show the recommended two-layer PC board layout that is optimized for the 20-pin MTE-packaged MD2203 and associated external components.Figures 7 through11show the recommended four-layer PC board layout that is optimized for the 24-pin LQ-packaged MD2203 and associated external components.These circuits are de-signed for use with an external 5V supply and 4Ω speakers.These circuit boards are easy to use.Apply 5V and ground to the board's VDD and GND pads,respectively.Connect 4Ω speakers between the board's –OUTA and +OUTA and OUTB and+OUTB pads.

Physical Dimensions inches (millimeters) unless otherwise noted



20-Lead Molded PKG,TSSOP,JEDEC,4.4mm BODY WIDTH

Order Number MD2203 MT

MD Package Number MTC20