

TMS8203E - Low EMI Stereo Class D Audio Amplifier with DC Volume Control and Headphone

FEATURES

- Supply Voltage from 2.5V to 6.0V
- 3.1W@10% THD Output with a 4Ω Load at 5V Supply
- Filter Free and Low EMI Architecture
- 64 Step DC Volume Control with Hysteresis from -80dB to +24dB
- Programmable Maximum Power Limit to Protect Speaker to Be Damaged
- High Efficiency Up to 90% @1W with an 8Ω Speaker
- Class AB Headphone Amplifier Po=60mW at PVDD=5V, Load=32Ω;
- Shutdown Current <1μA
- Superior Low Noise without Input
- EMI Suppressing by Soft-Driving
- Short Circuit Protection
- Under Voltage Lock-out and Power Down Detection
- Thermal Shutdown
- Available in Space Saving SSOP-24L Packages Pb-Free Package

GENERAL DESCRIPTION

The TMS8203E is a Stereo 3.1W Class D audio power amplifier for driving bridged-tied speakers and includes a Stereo Class AB amplifier for driving headphones. The advanced 64 steps DC volume control minimizes external components allowing simple and accurate volume control over the gain range of +24dB to -80dB.

Advanced EMI suppression technology with soft-driving scheme enables the use of inexpensive ferrite bead filters at the outputs while meeting EMC/EMI requirements for system cost reduction

The outputs are fully protected against shorts to ground, supply, and output-to-output. The short-circuit protection and thermal protection includes an auto recovery feature.

The TMS8203E is available in the power efficient and space saving SSOP-24L package.

APPLICATIONS

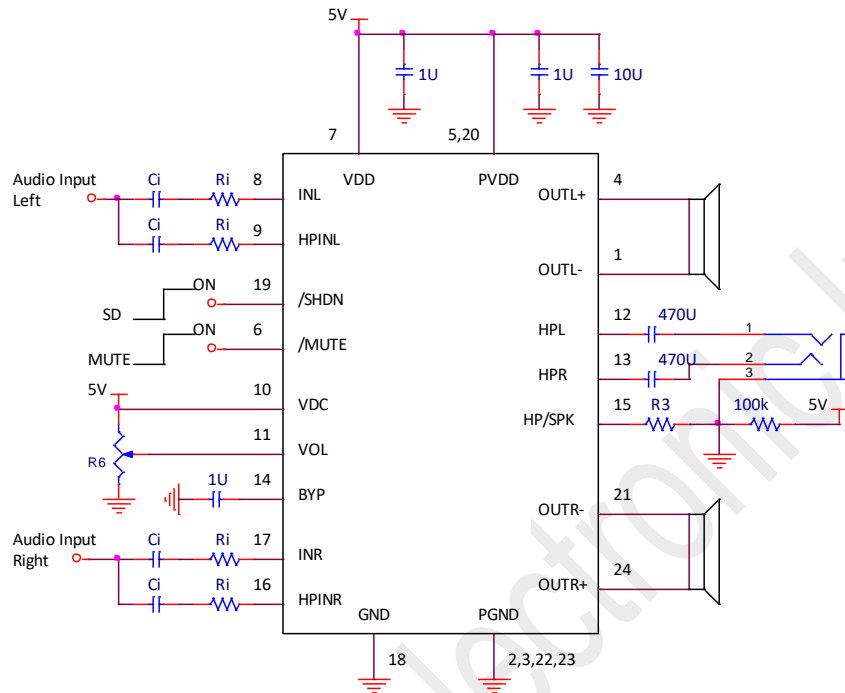
- LCD Monitors and TVs
- Projectors / All-In-One Computers
- Portable / Active Speakers
- Portable DVD Players / Game Machines

ORDERING INFORMATION

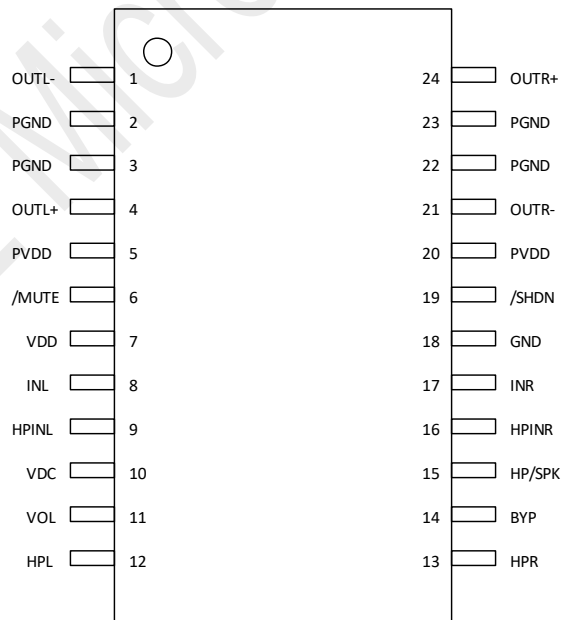
| Part Number | Package | Top Mark | Quantity/ Reel |
|---------------|----------|--------------------|----------------|
| TMS8203EIQ-TR | SSOP-24L | T8203EIQ xxxxxx | 3000 |

- TMS8203E devices are Pb-free and RoHS compliant.

TYPICAL APPLICATION



PIN CONFIGURATION



SSOP-24L (Top View)

PIN FUNCTIONS

| Pin No. | Pin Name | Description |
|-----------|----------|---|
| 1 | OUTL- | Negative BTL Of Left Channel Power Amplifier |
| 2,3,22,23 | PGND | Power Ground |
| 4 | OUTL+ | Positive BTL Of Left Channel Power Amplifier |
| 5,20 | PVDD | Power Supply |
| 6 | MUTE | Mute Control Signal Input (Active High, Pull Low Internally) |
| 7 | AVDD | Analog Power Supply |
| 8 | INL | Input of Left Channel Power Amplifier |
| 9 | HPINL | Input of Left Headphone Amplifier |
| 10 | VDC | Analog Power Supply for Volume Control, Connect to AVDD Directly; |
| 11 | VOL | Internal Gain Setting Input (Connect to VDD which Set Max. Gain = +24dB) |
| 12 | HPL | Left Channel Output of Headphone |
| 13 | HPR | Right Channel Output of Headphone |
| 14 | BYP | Bypass pin, connect a capacitance form this pin to GND |
| 15 | HP/SPK | Output Mode Control Input (High for Headphone and Low for Speaker, Pull Low Internally) |
| 16 | HPINR | Input of Right Headphone Amplifier |
| 17 | INR | Input of Right Channel Power Amplifier |
| 18 | GND | Ground |
| 19 | /SHDN | Chip Shutdown Control Input (Active Low, Pull High Internally) |
| 21 | OUTR- | Negative BTL Of Right Channel Power Amplifier |
| 24 | OUTR+ | Positive BTL Of Right Channel Power Amplifier |

ABSOLUTE MAXIMUM RATINGS

| Parameter | Rating | Unit |
|---|------------------------------|------|
| Supply Voltage (PV _{DD} , AV _{DD} , V _{DC}) | 6.5 | V |
| Input Voltage (INL, INR, /SHDN, MUTE, HP/SPK) | -0.3 to V _{DD} +0.3 | V |
| Storage Temperature | -65 to 150 | °C |
| Maximum Junction Temperature | 150 | °C |

ESD RATING

| Items | Description | Value | Unit |
|----------------------|---------------------|-------|------|
| V _{ESD_HBM} | Human Body Model | ±4000 | V |
| V _{ESD_CDM} | Charge Device Model | ±750 | V |

JEDEC specification JS-001

RECOMMENDED OPERATING CONDITIONS

| Symbol | Parameter | Min | Max | Unit |
|------------------|-------------------------------------|-----|-----|------|
| PV _{DD} | Supply Voltage | 2.5 | 6.0 | V |
| T _A | Operating Ambient Temperature Range | -25 | 85 | °C |
| T _J | Junction Temperature Range | -40 | 125 | °C |

ELECTRICAL CHARACTERISTICS

(T_A=25°C, PV_{DD}=5V, C_{IN}=0.22μF, R_L=L(33μH) + R+L(33μH), unless otherwise noted.)

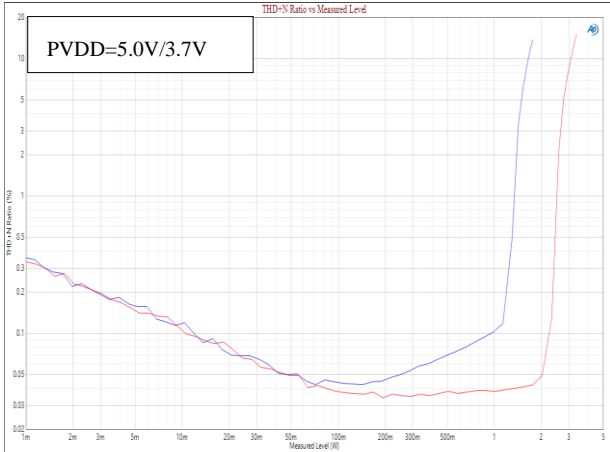
| Symbol | Parameter | Test Conditions | MIN | TYP | MAX | UNIT |
|-------------------------|--------------------------------------|---|------------------------|-----|------|------|
| Class D Mode | | | | | | |
| P _o | Output Power | THD+N=10%, f=1kHz, R _L =4Ω | PV _{DD} =5.0V | | 3.1 | W |
| | | THD+N=1%, f=1kHz, R _L =4Ω | PV _{DD} =5.0V | | 2.45 | |
| | | THD+N=10%, f=1kHz, R _L =8Ω | PV _{DD} =5.0V | | 1.8 | |
| | | THD+N=1%, f=1kHz, R _L =8Ω | PV _{DD} =5.0V | | 1.25 | |
| THD+N | Total Harmonic Distortion Plus Noise | P _o =0.8W, R _L =8Ω | f=1kHz | | 0.03 | % |
| | | P _o =1.6W, R _L =4Ω | f=1kHz | | 0.04 | % |
| Dyn | Dynamic Range | THD=1%, R _L =8Ω | f=1kHz | | 93 | dB |
| CS | Channel Separation | THD=1%, R _L =8Ω | f=1kHz | | -92 | dB |
| V _n | Output Noise | Inputs ac-grounded | No A-weighting | | 115 | μV |
| | | | A-weighting | | 95 | |
| R _{dson} | Drain-to Source On-state Resistor | High Side PMOS, I=500mA | PV _{DD} =5.0V | | 220 | mΩ |
| | | Low Side NMOS, I=500mA | PV _{DD} =5.0V | | 185 | mΩ |
| f _{sw} | Switching Frequency | PV _{DD} =5V | | 350 | | kHz |
| T _{on} | Turn On Time | | | | 400 | mS |
| V _{os} | Offset Voltage | Input ac-ground, PV _{DD} =5V | | 5 | | mV |
| Headphone Output | | | | | | |
| THD+N | Total Harmonic Distortion Plus Noise | P _o =30mW, R _L =32Ω | f=1kHz | | 0.02 | % |
| Dyn | Dynamic Range | THD+N=1%, R _L =32Ω | f=1kHz | | 95 | |
| CS | Channel Separation | THD+N=1%, R _L =32Ω | f=1kHz | | -80 | |
| V _n | Output Noise | Inputs ac-grounded | No A-weighting | | 50 | |
| | | | A-weighting | | 45 | |
| DC Parameters | | | | | | |
| I _Q | Quiescent Current | PV _{DD} =5V | No Load | | 7.5 | mA |
| I _{SD} | Shutdown Current | PV _{DD} =2.5V to 5V | /SHDN=0V | | 1 | μA |
| I _{MUTE} | Mute Current | PV _{DD} =2.5V to 5V | MUTE=0V | | 2 | mA |
| V _{IH} | | PV _{DD} =5V | | 1.2 | | V |
| V _{IL} | | PV _{DD} =5V | | | 0.6 | V |
| OTP | Thermal Protection | | | | 150 | °C |
| | Hysteresis | | | | 40 | °C |

PERFORMANCE CHARACTERISTICS

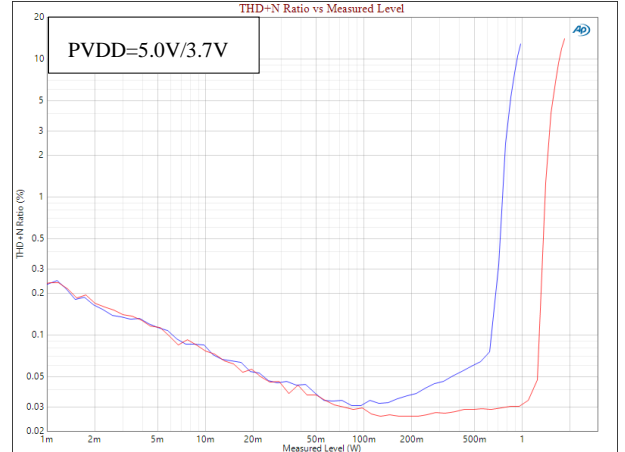
($T_A=25^\circ\text{C}$, $V_{DD}=5\text{V}$, $C_{IN}=0.22\mu\text{F}$, $R_L=L(33\mu\text{H}) + R+L(33\mu\text{H})$, unless otherwise noted.)

Class D Mode

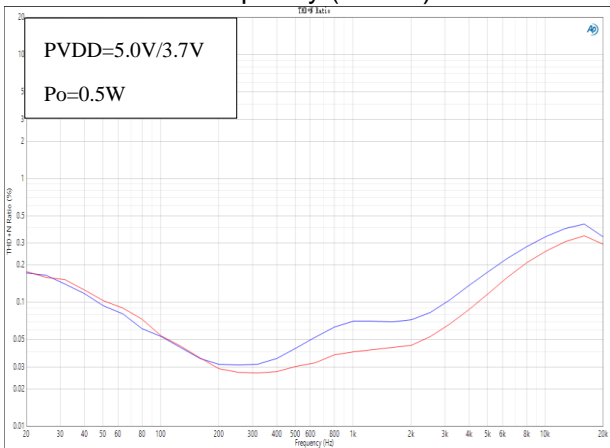
THD+N Vs. Output Power ($R_L=4\Omega$)



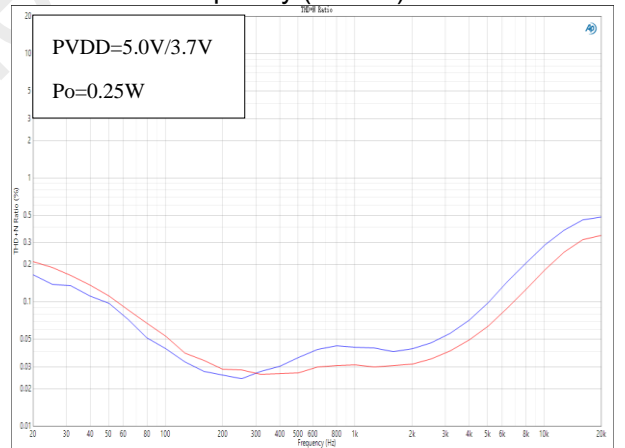
THD+N Vs. Output Power ($R_L=8\Omega$)



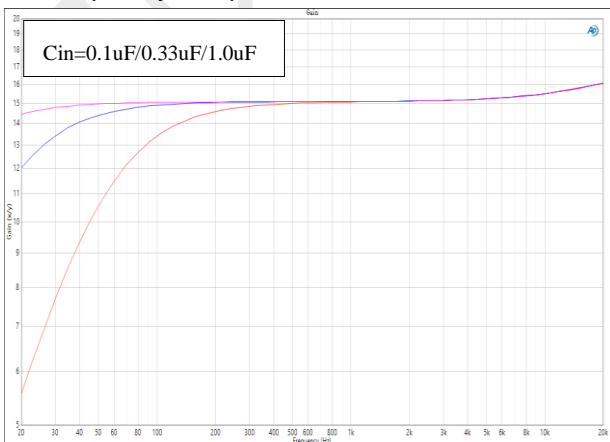
THD+N Vs. Frequency ($R_L=4\Omega$)



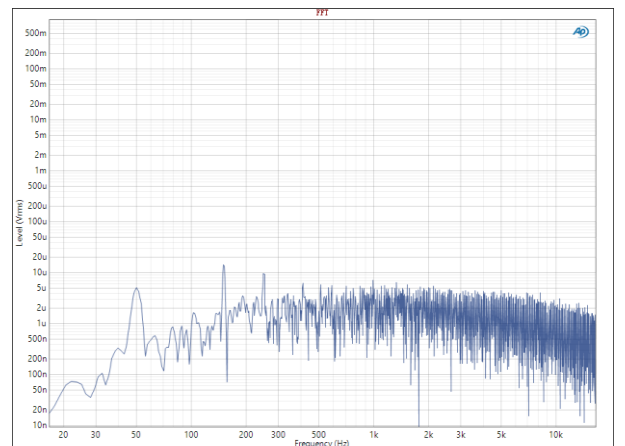
THD+N Vs. Frequency ($R_L=8\Omega$)



Frequency Response



Noise Floor

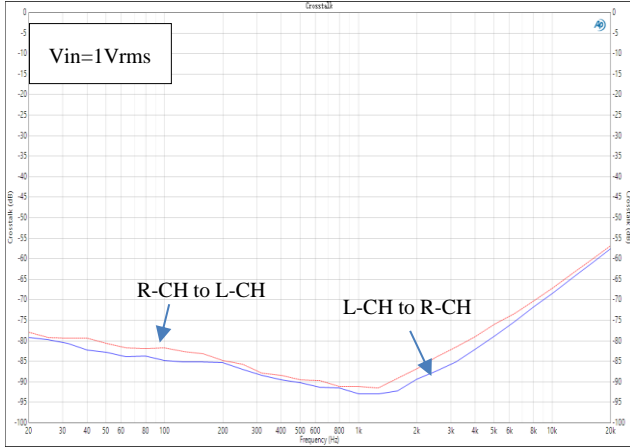


PERFORMANCE CHARACTERISTICS

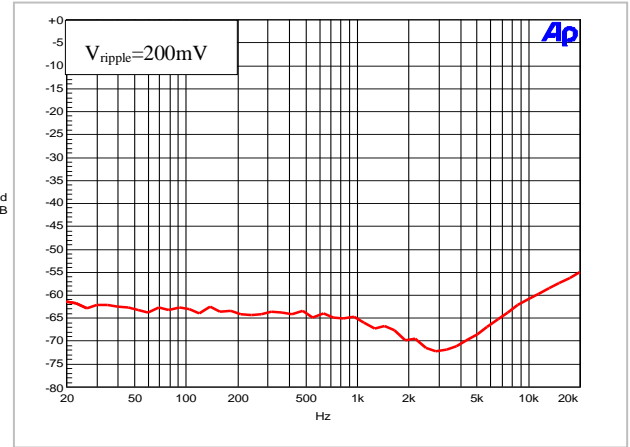
($T_A=25^{\circ}\text{C}$, $V_{DD}=5\text{V}$, $C_{IN}=0.22\mu\text{F}$, $R_L=L(33\mu\text{H}) + R+L(33\mu\text{H})$, unless otherwise noted.)

Class D Mode

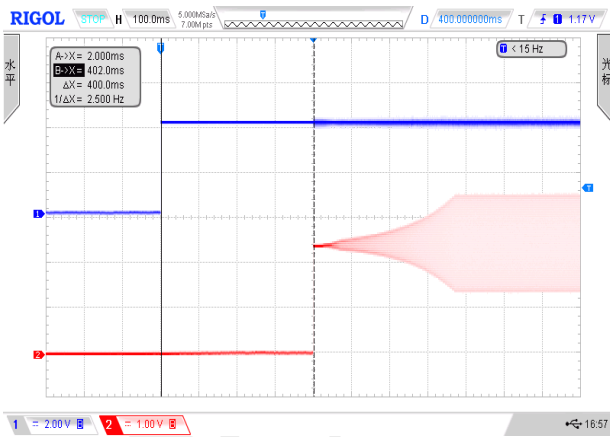
Crosstalk



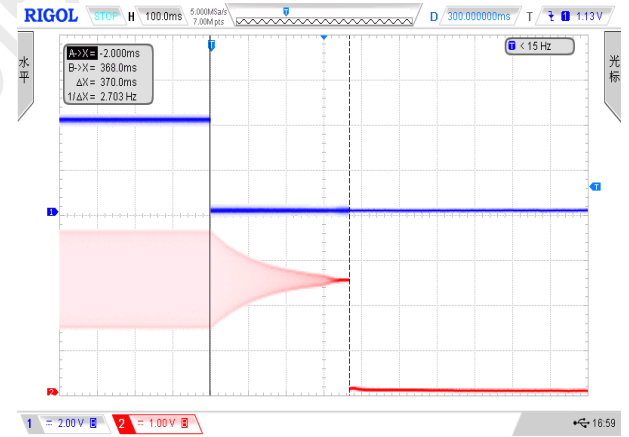
PSRR



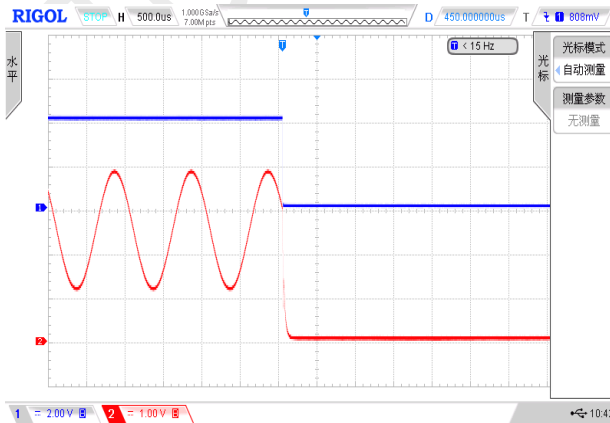
Start-up From EN Response



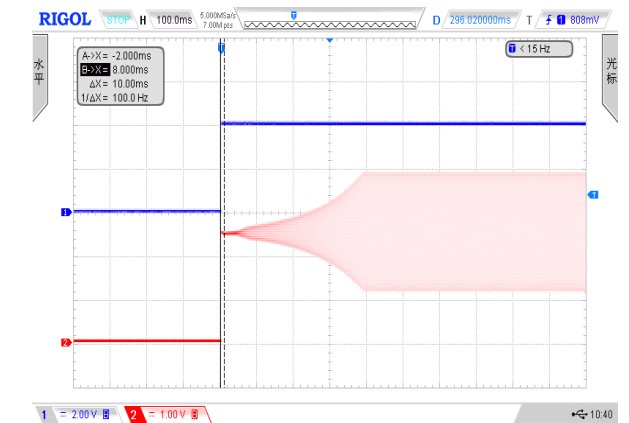
Shutdown Response



Mute-In Response



Mute-Out Response

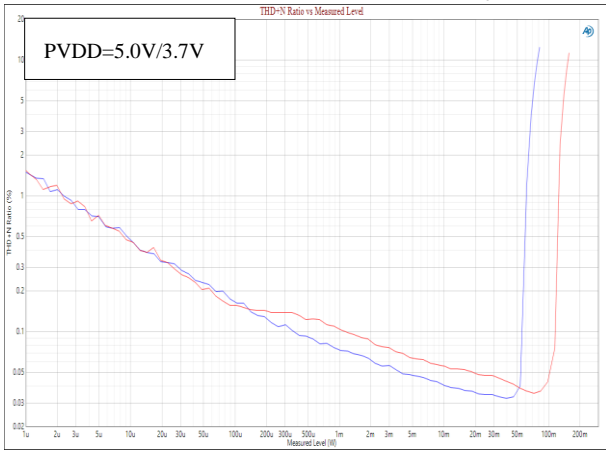


PERFORMANCE CHARACTERISTICS

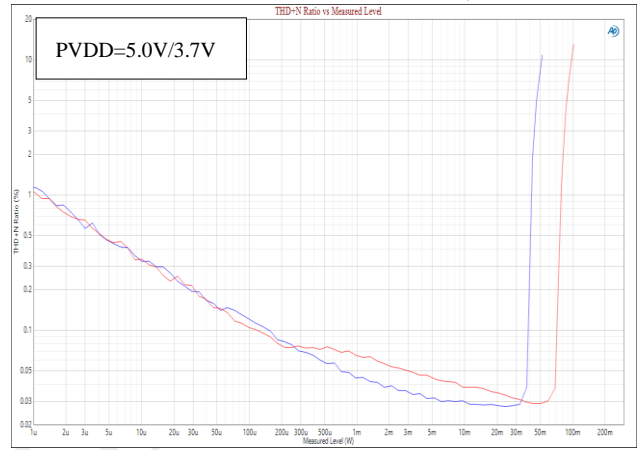
($T_A=25^\circ\text{C}$, $V_{DD}=5\text{V}$, $C_{IN}=0.22\mu\text{F}$, unless otherwise noted.)

Headphone Mode

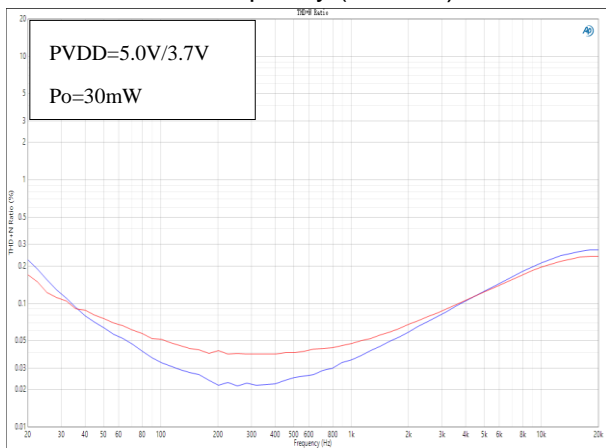
THD+N Vs. Output Power ($R_L=16\Omega$)



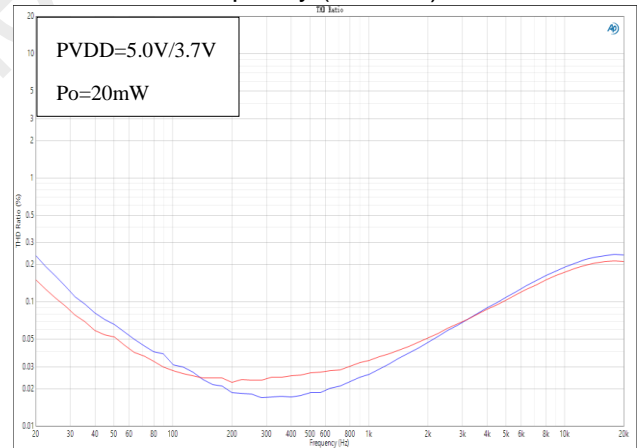
THD+N Vs. Output Power ($R_L=32\Omega$)



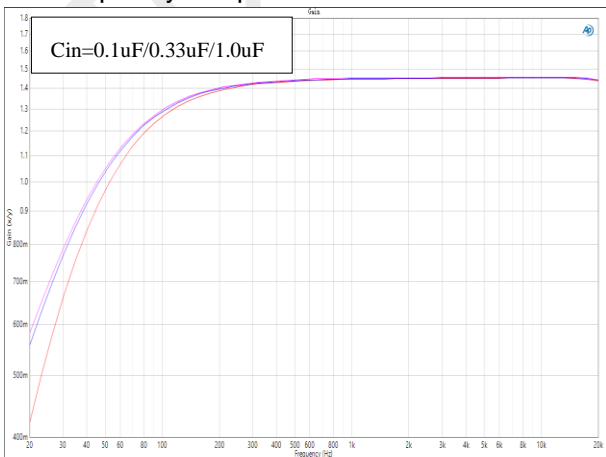
THD+N Vs. Frequency ($R_L=16\Omega$)



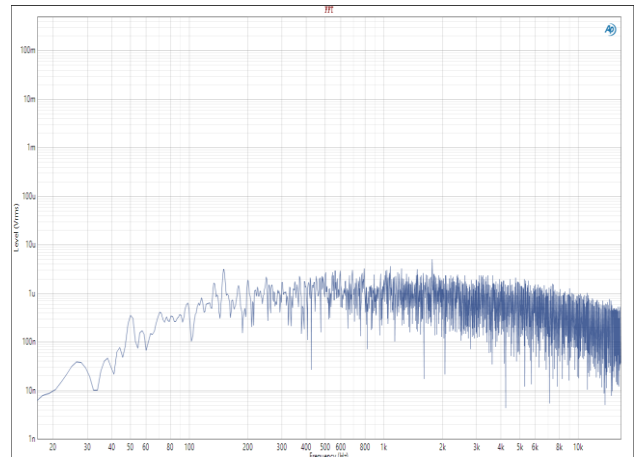
THD+N Vs. Frequency ($R_L=32\Omega$)



Frequency Response



Noise Floor



APPLICATION INFORMATION

Input Capacitors (Ci)

In the typical application, an input capacitor, Ci, is required to allow the amplifier to bias the input signal to the proper DC level for optimum operation. In this case, Ci and the minimum input impedance Ri form a high-pass filter with the corner frequency determined in the following equation:

$$f_c = \frac{1}{(2\pi R_i C_i)}$$

It is important to consider the value of Ci as it directly affects the low frequency performance of the circuit. For example, when Ri is 10kΩ and the specification calls for a flat bass response are down to 150Hz. Equation is reconfigured as followed:

$$C_i = \frac{1}{(2\pi R_i f_c)}$$

When input resistance variation is considered, the Ci is 112nF, so one would likely choose a value of 150nF. A further consideration for this capacitor is the leakage path from the input source through the input network (Ci, Ri + Rf) to the load. This leakage current creates a DC offset voltage at the input to the amplifier that reduces useful headroom, especially in high gain applications. For this reason, a low-leakage tantalum or ceramic capacitor is the best choice. When polarized capacitors are used, the positive side of the capacitor should face the amplifier input in most applications as the DC level is held at VDD/2, which is likely higher than the source DC level. Please note that it is important to confirm the capacitor polarity in the application.

Decoupling Capacitor (CS)

The TMS8203E is a high-performance CMOS audio amplifier that requires adequate power supply decoupling to ensure the output total harmonic distortion (THD) as low as possible. Power supply decoupling also prevents the oscillations causing by long lead length between the amplifier and the speaker.

The optimum decoupling is achieved by using two different types of capacitors that target on different types of noise on the power supply leads. For higher frequency transients, spikes, or digital hash on the line, a good low Equivalent-Series-Resistance (ESR) ceramic capacitor, typically 1μF, is placed as close as possible to the device PVDD pin for the best operation. For filtering lower frequency noise signals, a large ceramic capacitor of 10μF or greater placed near the audio power amplifier is recommended.

How to Reduce EMI

Most applications require a ferrite bead filter for EMI elimination shown at Figure 1. The ferrite filter reduces EMI around 1MHz and higher. When selecting a ferrite bead, choose one with high impedance at high frequencies, but low impedance at low frequencies.

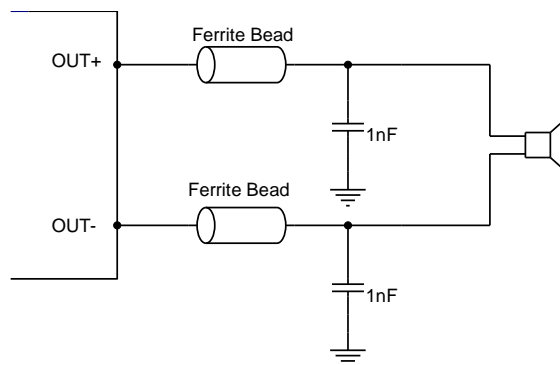


Figure 1: Ferrite Bead Filter to Reduce EMI

APPLICATION INFORMATION

Under Voltage Lock-out (UVLO)

The TMS8203E incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.3V or below, the TMS8203E goes into a state of shutdown, and the device comes out of its shutdown state and restore to normal function only when VDD higher than 2.5V.

Short Circuit Protection (SCP)

The TMS8203E has short circuit protection circuitry on the outputs to prevent the device from damage when output-to-output shorts, output-to-VDD shorts or output-to-GND shorts occur. When a short circuit occurs, the device immediately goes into shutdown state. Once the short is removed, the device will be reactivated.

DC Volume Control

The TMS8203E integrated 64-step DC volume control—apply DC voltage on the VOL pin to set the amplifier’s gain. Below table shows the gain versus voltage of VOL pin.

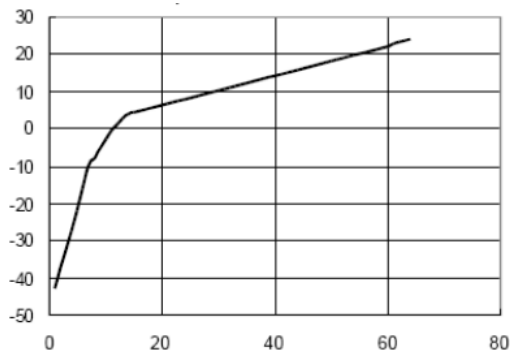


Figure 2: Class D Gain vs. VOL Voltage

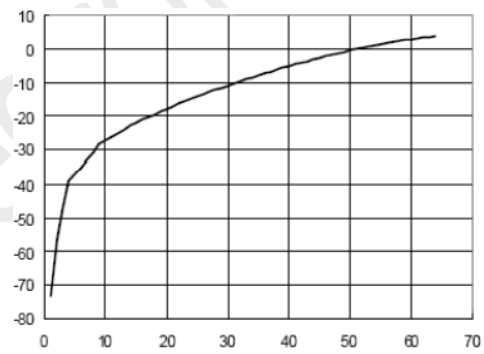


Figure 3: Class AB Gain vs. VOL Voltage

HP/SPK Operation

In order to control the speaker and headphone switch, the TMS8203E contains detection circuitry: When HP/SPK is logic low, speaker (Class D) activates; when logic high, headphone (Class AB) activates. This pin is pulled low internally.

Over Temperature Protection (OTP)

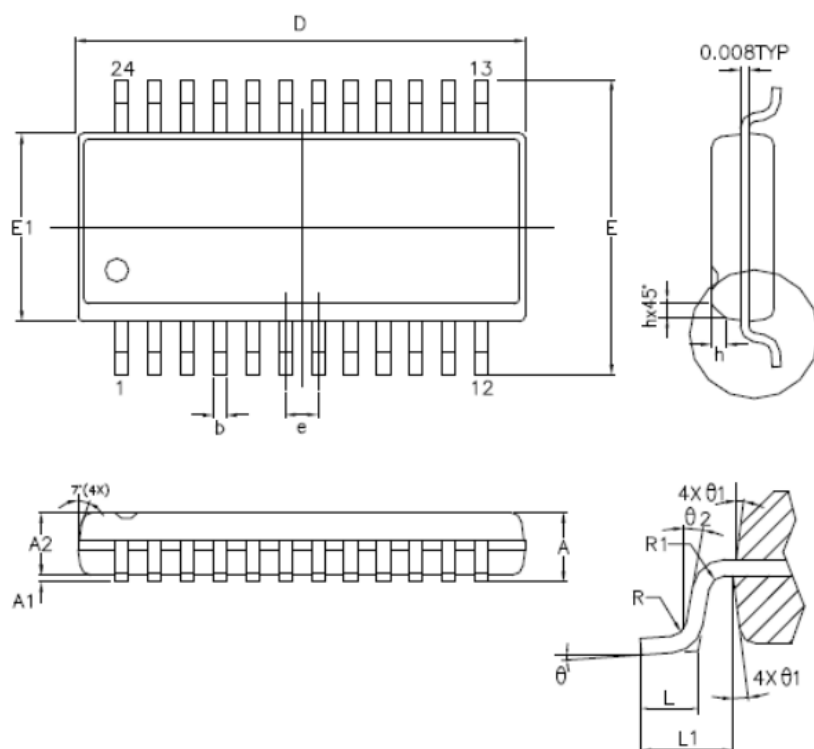
Thermal protection on the TMS8203E prevents the device from damage when the internal die temperature exceeds 150°C. There is a 15°C tolerance on this trip point from device to device. Once the die temperature exceeds the set point, the device will enter the shutdown state and the outputs are disabled. This is not a latched fault. The thermal fault is cleared once the temperature of the die decreased by 40°C. This large hysteresis will prevent motor boating sound well and the device begins normal operation at this point with no external system interaction.

POP and Click Circuitry

The TMS8203E contains circuitry to minimize turn-on and turn-off transients or “click and pops”, where turn-on refers to either power supply turn-on or device recover from shutdown mode. When the device is turned on, the amplifiers are internally muted. An internal current source ramps up the internal reference voltage. The device will remain in mute mode until the reference voltage reach half supply voltage, 1/2 VDD. As soon as the reference voltage is stable, the device will begin full operation. For the best power-off pop performance, the amplifier should be set in shutdown mode prior to removing the power supply voltage.

PACKAGE INFORMATION

SSOP-24L



| SYMBOLS | MIN. | NOM. | MAX. |
|------------|-----------|-------|-------|
| A | 0.053 | 0.061 | 0.069 |
| A1 | 0.004 | - | 0.010 |
| A2 | 0.049 | 0.057 | 0.065 |
| b | 0.008 | 0.010 | 0.012 |
| D | 0.335 | 0.341 | 0.347 |
| E | 0.228 | 0.236 | 0.244 |
| E1 | 0.150 | 0.154 | 0.158 |
| e | - | 0.025 | - |
| L | 0.016 | 0.033 | 0.050 |
| L1 | 0.041 REF | | |
| R | 0.003 | - | - |
| R1 | 0.003 | - | - |
| h | 0.010 | 0.015 | 0.020 |
| θ | 0° | 4° | 8° |
| θ_1 | 5° | 10° | 15° |
| θ_2 | 0° | - | - |

UNIT : INCH

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