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HM2012

2.1W/ch Stereo Filter-free Class-D Audio Power Amplifier

General Description

The HM2012 is a 2.1W/ch stereo high efficiency filter-free class-D audio power amplifier. The HM2012 can operate from 2.7 to 5.5V supply. When powered with 5V voltage, the HM2012 can deliver 2.1W per channel to dual 4Ω load at 10% THD+N, and also capable of driving 1.5W/ch to dual 8Ω load. The HM2012 is thermally limited in WCSP and may not achieve 2.1W/ch for 4Ω.

As a Class D audio power amplifier, the HM2012 supports 90% high efficiency and -75dB PSRR at 217Hz which make the device ideal for battery-supplied, high quality audio applications. The HM2012 features independent shutdown controls for each channel. The gain can be selected to 6, 12, 18, or 24 dB utilizing the G0 and G1 gain select pins. The HM2012 also features the minimized click-and-pop noise during the turn-on and shutdown.

The HM2012 is manufactured in space-saving QFN-20 (4mm x 4mm) and WCSP-16 (2mm x 2mm) package Applications

Applications

- Mobile phone
- Personal Digital Assistant(PDA)
- Portable gaming device
- Powered speakers
- Notebook computer

Features

- Output power
  - 2.1W/ch into 4Ω at 5V
  - 1.5W/ch into 8Ω at 5V
  - 750mW/ch into 8Ω at 3.6V
- PSRR: -75dB (typical)
- CMRR: -70dB (typical)
- Efficiency up to 90%
- Only two external components required
- Independent shutdown control for each channel
- Short-circuit and thermal protection
- Shutdown current: 1.0μA (typical)
- Power supply range: 2.7V to 5.5V)
- Packaging
  - QFN-20 (4mm x 4mm)
  - WCSP-16 (2mm x 2mm)

Pin Out Diagram

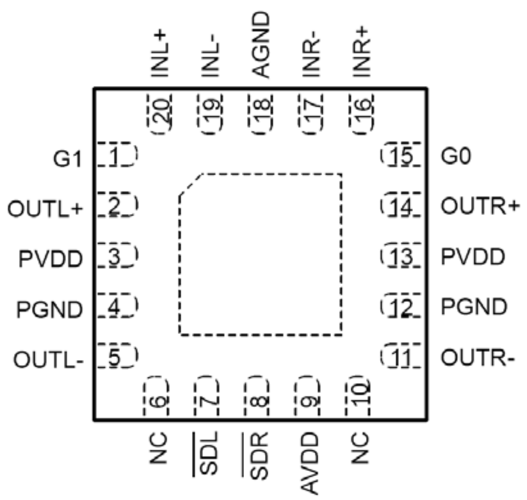


Figure1. QFN 20 Top View

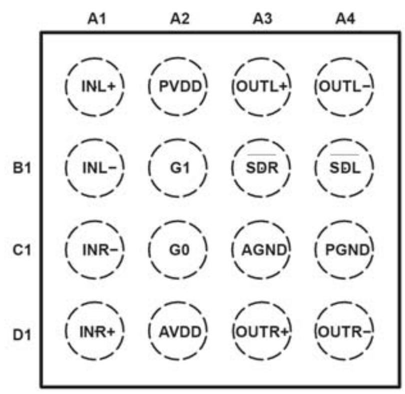


Figure2. WCSP 16 Top View

Ordering Information

P/N	TEMP RANGE	PIN-PACKAGE
HM2012Q	-40°C to +85°C	20 pin QFN
HM2012W	-40°C to +85°C	16 ball WCSP

Note: The HM2012 is thermally limited in WCSP and may not achieve 2.1W/ch for 4Ω.

Absolute Maximum Ratings

Supply Voltage (V_{DD}) in active mode	-0.3 V to 5.5V
Supply Voltage (V_{DD}) in shutdown mode	-0.3 V to 6.0V
Input Voltage (V_I)	-0.3V to V_{DD}+0.3V
Operating Free-air Temperature range (T_A)	-40°C to 85°C
Operating Junction Temperature range (T_J)	-40°C to +125°C
Storage Temperature (T_{STG}) range	-65°C to +150°C

Operation Ratings

Supply Voltage (V_{DD})	2.7V to 5.5V
High Level Input Voltage (V_{IH})	1.3V to VDD
Low Level Input Voltage (V_{IL})	0 to 0.35V
Operating Temperature (T_A)	-40°C to +85°C

Electrical Characteristics

T_A=25°C

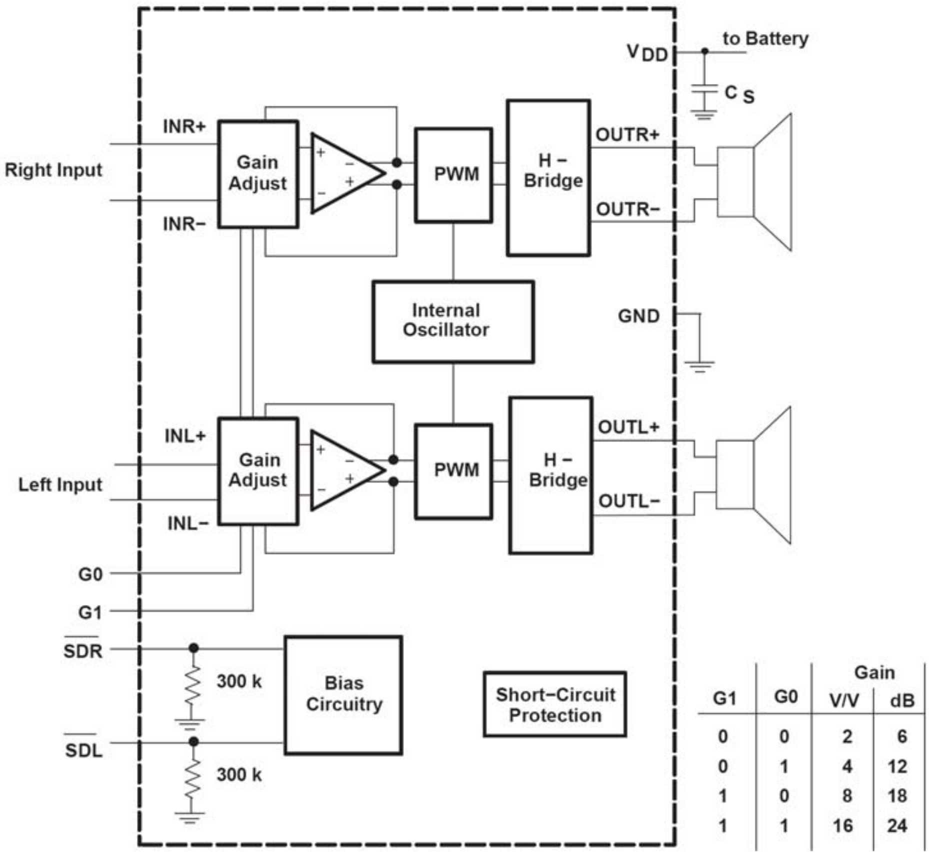
Symbol	Parameter	Test Conditions	Min	Typ	Max	Unit
$\|V_{OO}\|$	Output offset voltage (measured differentially)	Inputs ac grounded, A_V=6dB, V_{DD}=2.7V to 5.5V		5	25	mV
PSRR	Power supply rejection ratio	V_{DD}=2.7V to 5.5V		-75	-55	dB
CMRR	Common mode rejection ratio	Inputs shouted together, V_{DD}=2.7V to 5.5V		-70	-50	dB
$\|I_{IH}\|$	High-level input current	V_{DD}=5.5V, V_I= V_{DD}			50	μA
$\|I_{IL}\|$	Low-level input current	V_{DD}=5.5V, V_I=-0V			5	μA
I_{DD}	Supply current	V_{DD}=5.5V, no load or output filter		7.5	10	mA
		V_{DD}=3.6V, no load or output filter		5.5	8	
$r_{DS(ON)}$	Static Drain-source On-state Resistance	V_{DD}=5.5V		420		mΩ
		V_{DD}=3.6V		520		
	Output impedance in $\overline{\text{SHUTDOWN}}$	$V_{(\overline{SHOUTDOWN})}$=0.35V		2		kΩ
$f_{(SW)}$	Switching frequency	V_{DD}=2.7V to 5.5V	250	300	350	kHZ
	Closed-loop voltage gain	G0, G1=0.35V	5.5	6	6.5	dB
		G0= V_{DD}, G1=0.35V	11.5	12	12.5	
		G0=0.35V, G1= V_{DD}	17.5	18	18.5	
		G0, G1= V_{DD}	23.5	24	24.5	

Operating Characteristics

T_A=25°C, R_L=8Ω

Symbol	Parameter	Test Conditions		Min	Typ	Max	Unit
P_O	Output power (per channel)	THD+N=10%, f=1kHz, R_L=4Ω	V_{DD}=5V		2.1		W
		THD+N=10%, f=1kHz, R_L=8Ω	V_{DD}=5V		1.5		
			V_{DD}=3.6V		0.75		
THD+N	Total harmonic distortion plus noise	V_{DD}=5V, P_O=1W, A_V=6dB, f=1kHz			0.14%		
		V_{DD}=5V, P_O=0.5W, A_V=6dB, f=1kHz			0.10%		
	Channel crosstalk	f=1KHz			-85		dB
k_{SVR}	Supply ripple rejection ratio	V_{DD}=5V, A_V=6dB, f=217Hz			-75		dB
		V_{DD}=3.6V, A_V=6dB, f=217Hz			-70		
Vn	Output voltage noise	V_{DD}=3.6V, f=20 to 20KHz, Inputs ac-grounded, A_V=6dB	No weighting		35		μV
			A weighting		27		
CMRR	Common mode rejection ratio	V_{DD}=3.6V, V_{IC}=1V_{pp}	f=217Hz		-70		dB
Z_I	Input impedance	A_V=6dB			28.1		kΩ
		A_V=12dB			17.3		
		A_V=18dB			9.8		
		A_V=24dB			5.2		
	Start-up time from shutdown	V_{DD}=3.6V			3.5		ms

Block Diagram



G1	G0	Gain V/V	Gain dB
0	0	2	6
0	1	4	12
1	0	8	18
1	1	16	24

Figure3. Block Diagram

Terminal Functions

Terminal			I/O	Description
Name	QFN	WCSP		
INR+	16	D1	I	Right channel positive input
INR-	17	C1	I	Right channel negative input
INL+	20	A1	I	Left channel positive input
INL-	19	B1	I	Left channel negative input
$\overline{SDR}$	8	B3	I	Right channel shutdown terminal (active low)
$\overline{SDL}$	7	B4	I	Left channel shutdown terminal (active low)
G0	15	C2	I	Gain select (LSB)
G1	1	B2	I	Gain select (MSB)
PV_{DD}	3,13	A2	I	Power supply (Must be same voltage as AV_{DD})
AV_{DD}	9	D2	I	Analog supply (Must be same voltage as PV_{DD})
PGND	4,12	C4	I	Power ground
AGND	18	C3	I	Power ground
OUTR+	14	D3	O	Right channel positive differential output
OUTR-	11	D4	O	Right channel negative differential output
OUTL+	2	A3	O	Left channel positive differential output
OUTL-	5	A4	O	Left channel negative differential output
NC	6,10	N/A		No internal connection
Thermal Pad				Connect the thermal pad of QFN or PWP package to PCB GND

Application Information

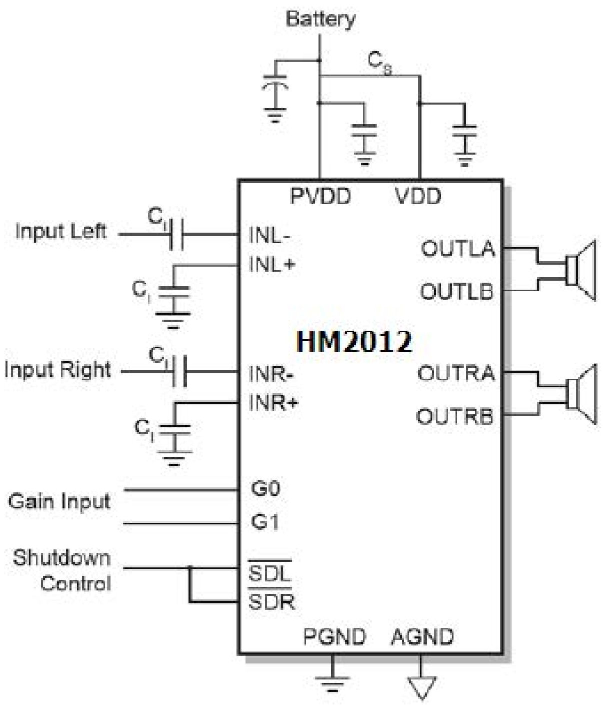


Figure4. Single-ended Input

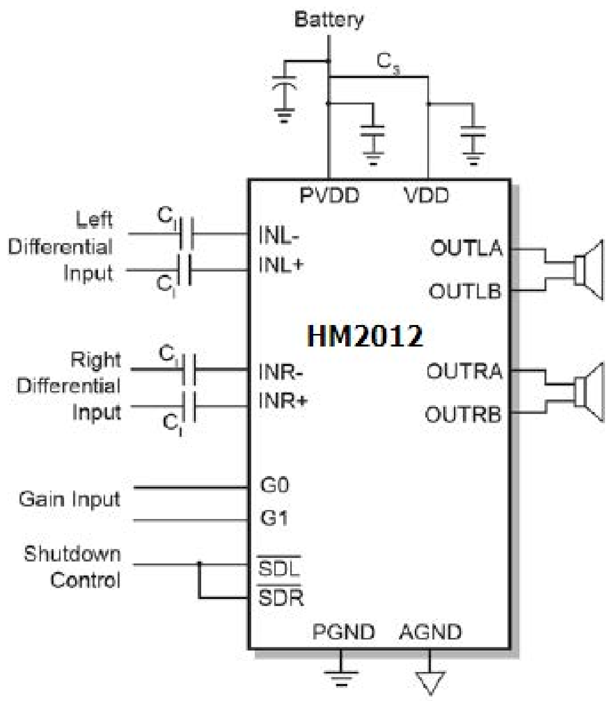


Figure5. Differential Input

Decoupling Capacitor (C_S)

The HM2012 is a high-performance Class-D audio amplifier that requires adequate power supply decoupling to ensure the efficiency is high and total harmonic distortion (THD) is low. For higher frequency transients, spikes, or digital hash on the line a good low equivalent-series-resistance (ESR) ceramic capacitor, typically 1μF, placed as close as possible to the device PV_{DD} lead works best. Placing this decoupling capacitor close to the HM2012 is important for the efficiency of the Class-D amplifier, because any resistance or inductance in the trace between the device and the capacitor can cause a loss in efficiency. For filtering lower-frequency noise signals, a 4.7μF or greater capacitor placed near the audio power amplifier would also help, but it is not required in most applications because of the high PSRR of this device.

Audio Amplifier Gain Setting

The HM2012 features four internally configured gain settings. The device gain is selected through the two gain select pins, G0 and G1. The gain settings are shown in the following table.

G1	G2	Gain (V/V)	Gain (dB)	R_I (KΩ)
0	0	2	6	28.1
0	1	4	12	17.3
1	0	8	18	9.8
1	1	16	24	5.2

Gain Setting Table

Input Capacitors (C_I)

The input capacitors and input resistors form a high-pass filter with the corner frequency, fC, determined in Equation 1.

$$f_c = \frac{1}{(2\pi R_I C_I)} \quad (1)$$

The value of the input capacitor is important to consider as it directly affects the bass (low frequency) performance of the circuit. Speakers in wireless phones cannot usually respond well to low frequencies, so the corner frequency can be set to block low frequencies in this application. Not using input capacitors can increase output offset.

Equation 2 is used to solve for the input coupling capacitance.

$$C_I = \frac{1}{(2\pi R_I f_C)} \quad (2)$$

If the corner frequency is within the audio band, the capacitors should have a tolerance of ±10% or better, because any mismatch in capacitance causes an impedance mismatch at the corner frequency and below.

Operation with DACs and CODECs

In using Class-D amplifiers with CODECs and DACs, sometimes there is an increase in the output noise floor from the audio amplifier. This occurs when mixing of the output frequencies of the CODEC/DAC mix with the switching frequencies of the audio amplifier input stage. The noise increase can be solved by placing a low-pass filter between the CODEC/DAC and audio amplifier. This filters off the high frequencies that cause the problem and allow proper performance.

Filter Free Operation and Ferrite Bead Filters

A ferrite bead filter can often be used if the design is failing radiated emissions without an LC filter and the frequency sensitive circuit is greater than 1MHz. This filter functions well for circuits that just have to pass FCC and CE because FCC and CE only test radiated emissions greater than 30MHz. When choosing a ferrite bead, choose one with high impedance at high frequencies, and very low impedance at low frequencies. In addition, select a ferrite bead with adequate current rating to prevent distortion of the output signal.

Use an LC output filter if there are low frequency (<1MHz) EMI sensitive circuits and/or there are long leads from amplifier to speaker.

Figure 6 shows typical ferrite bead and LC output filters.

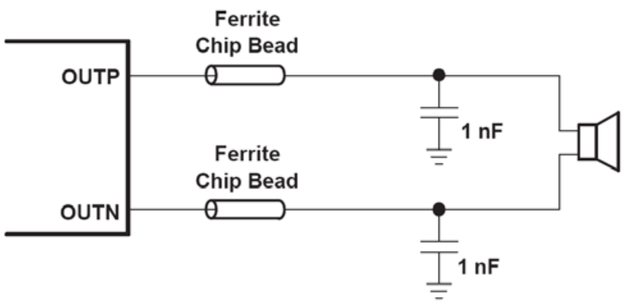
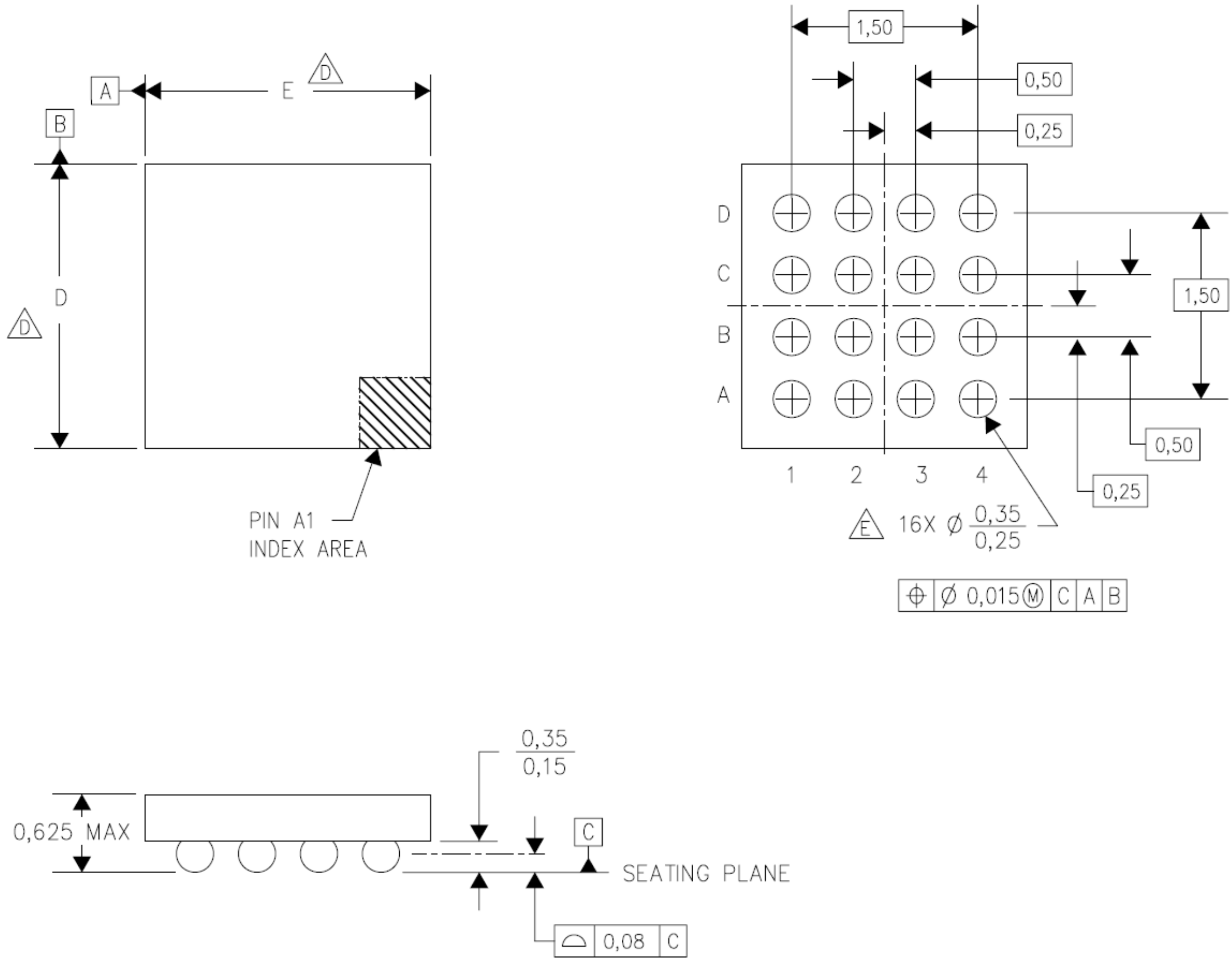


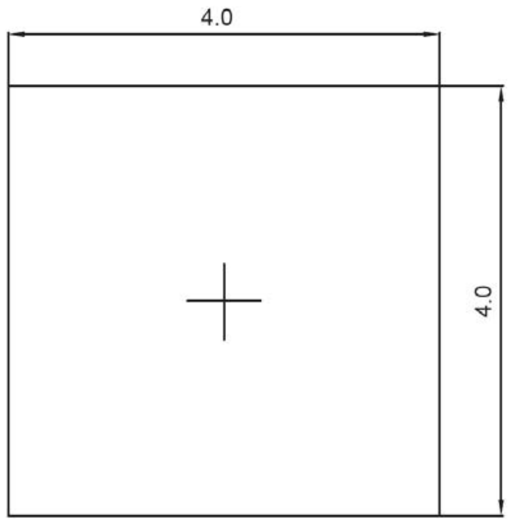
Figure6. Typical ferrite chip bead filter

Mechanical Data

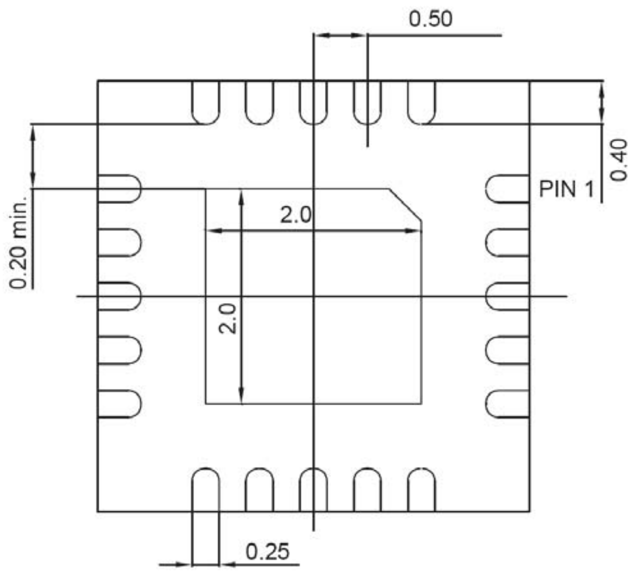
WCSP-16



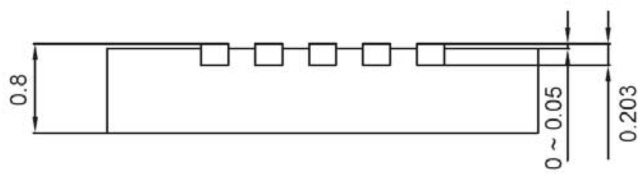
QFN-20



TOP VIEW



BOTTOM VIEW



SIDE VIEW