ft2012

2.7W/ch Stereo Filter-free Class-D Audio Power Amplifier（Rev.2.2）

General Description

The ft2012 is a 2.7W/ch stereo high efficiency filter-free class-D audio power amplifier. The ft2012 can operate from 2.7 to 5.5V supply. When powered with 5V voltage, the ft2012 can deliver 2.7W per channel to dual 4Ω load at 10% THD+N, and also capable of driving 1.5W/ch to dual 8Ω load. The ft2012 is thermally limited in WCSP and may not achieve 2.7W/ch for 4Ω.

As a Class D audio power amplifier, the ft2012 supports 90% high efficiency and -75dB PSRR at 217Hz which make the device ideal for battery-supplied, high quality audio applications. The ft2012 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 ft2012 also features the minimized click-and-pop noise during the turn-on and shutdown.

The ft2012 is manufactured in space-saving QFN-20 (4mm x 4mm) and WCSP-16 (2mm x 2mm) package

Features

- Output power
  - 2.7W/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
- thermal protection
- Shutdown current: 0.1μA (typical)
- Power supply range: 2.7V to 5.5V
- Packaging
  - QFN-20 (4mm x 4mm)
  - WCSP-16 (2mm x 2mm)

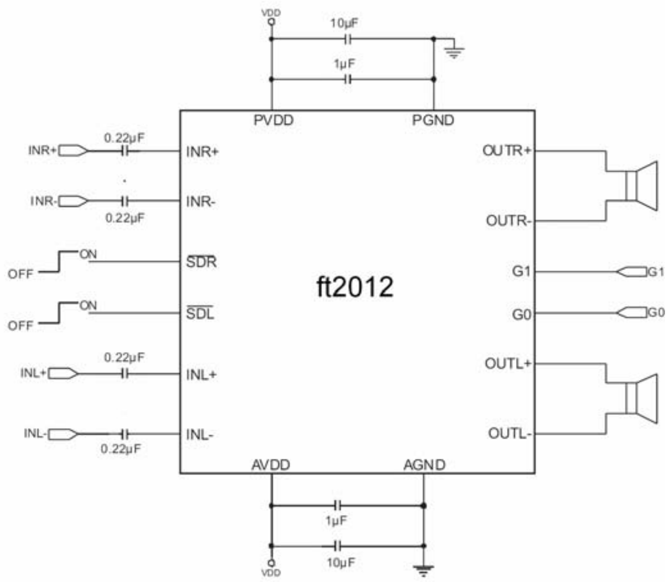
CSP16 Package
2mmX2mm
-40℃~85℃

QFN20 Package
4mmX4mm
-40℃~85℃

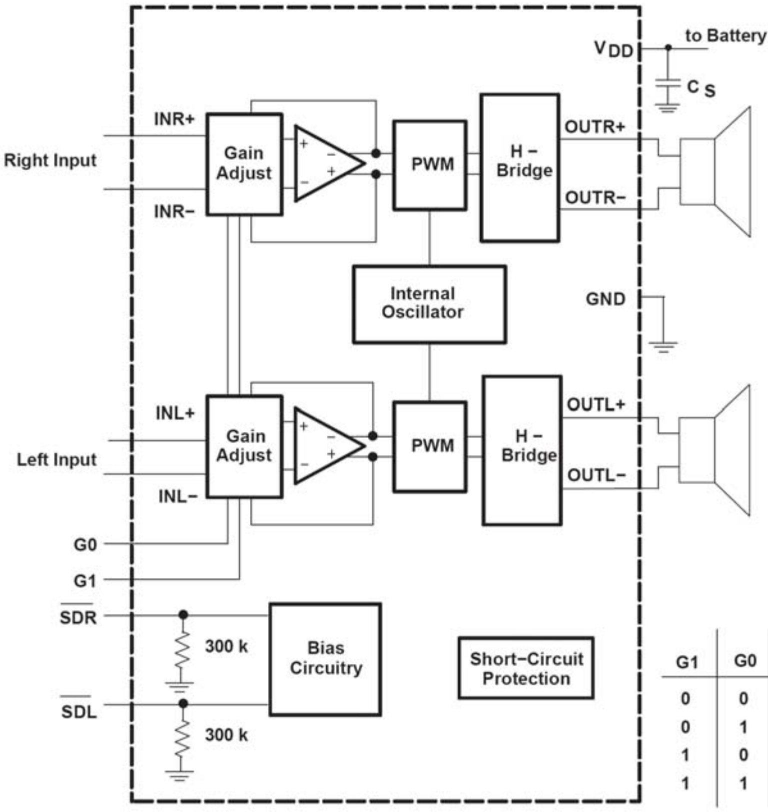
Applications

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

Typical Application Circuit

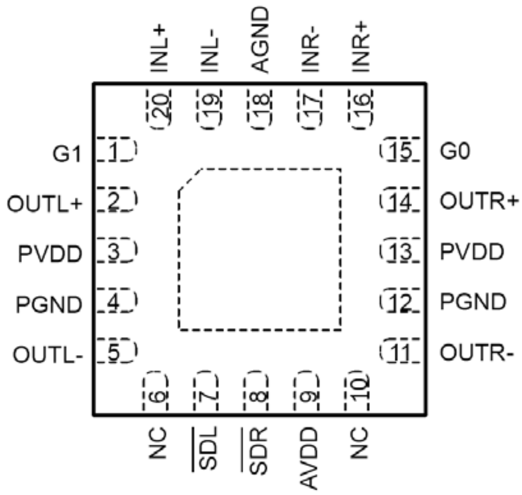


Block Diagram

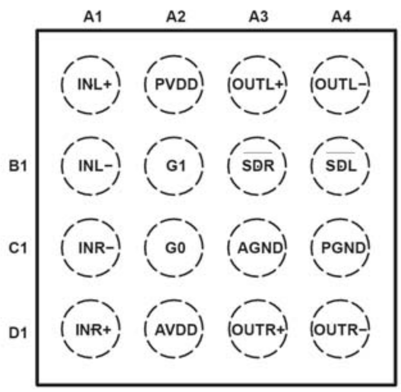


G1	G0	Gain V/V	Gain dB
0	0	2	6
0	1	4	12
1	0	8	18
1	1	16	24

Pin Configuration



QFN 20 Top View



WCSP 16 Top View

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

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})	1.6V 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
$\lvert V_{OO} \rvert$	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
$\lvert I_{IH} \rvert$	High-level input current	V_{DD}=5.5V, V_I= V_{DD}			50	μA
$\lvert I_{IL} \rvert$	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		mA
		V_{DD}=3.6V, no load or output		5.5		

		filter				
I_{SD}	Shutdown current			0.1		μA
$r_{DS(ON)}$	Static Drain-source On-state Resistance	V_{DD}=5.5V		420		mΩ
		V_{DD}=3.6V		520		
	Output impedance in SHUTDOWN	$V_{(\overline{SHOUTDOWN})}$=0.35V		2		kΩ
$f_{(SW)}$	Switching frequency	V_{DD}=2.7V to 5.5V		300		kHZ
	Closed-loop voltage gain	G0, G1=0.35V		6		dB
		G0= V_{DD}, G1=0.35V		12		
		G0=0.35V, G1= V_{DD}		18		
		G0, G1= V_{DD}		24		

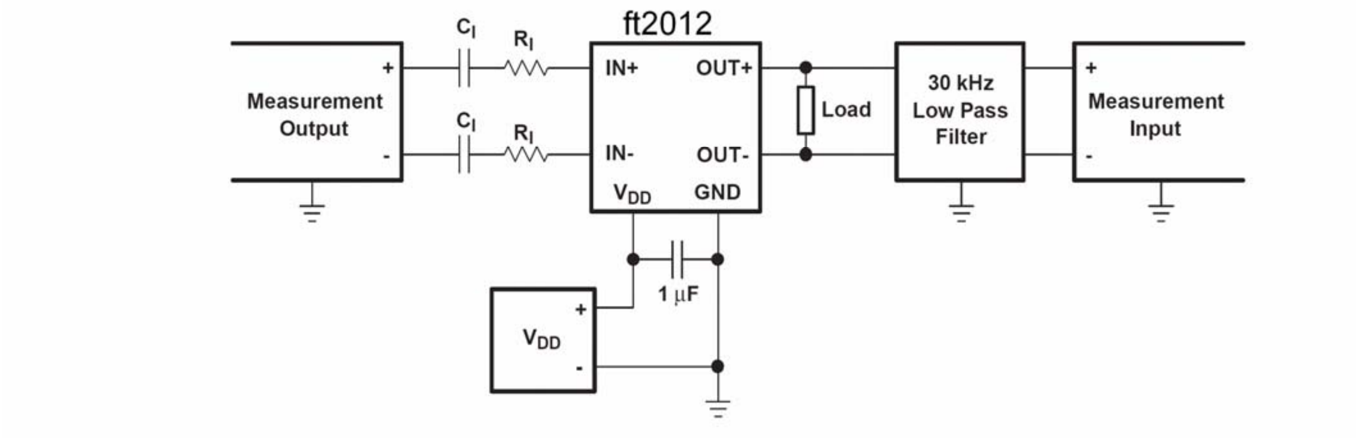
Operating Characteristics

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		2.7		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, R_C=8Ω			0.14%		
		V_{DD}=5V, P_O=0.5W, A_V=6dB, f=1kHz, R_C=8Ω			0.10%		
	Channel crosstalk	V_{DD}=3.6V, 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

Note*: The ft2012 is thermally limited in WCSP and may not achieve 2.7W/ch for 4Ω.

Test Setup for Performance Testing (per channel)



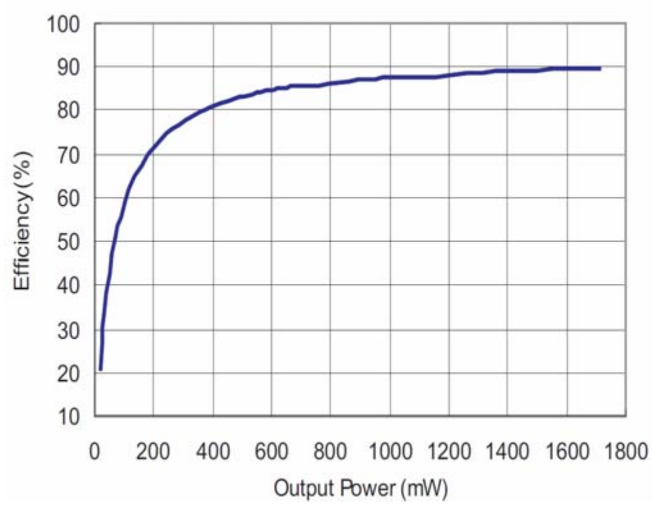
Notes:(1) CI was Shorted for any Common-Mode input voltage measurement;(2) A 33-uH inductor was placed in series with the load resistor to emulate a small speaker for efficiency measurements;(3) The 30-kHz low-pass filter is required even if the analyzer has an internal low-pass filter. An RC low pass filter (100 W, 47 nF) isused on each output for the data sheet graphs.

Typical Operating Characteristics

T =25°C, VDD =5V, f=1kHz, Gain=6dB,QFN Package, unless otherwise noted.

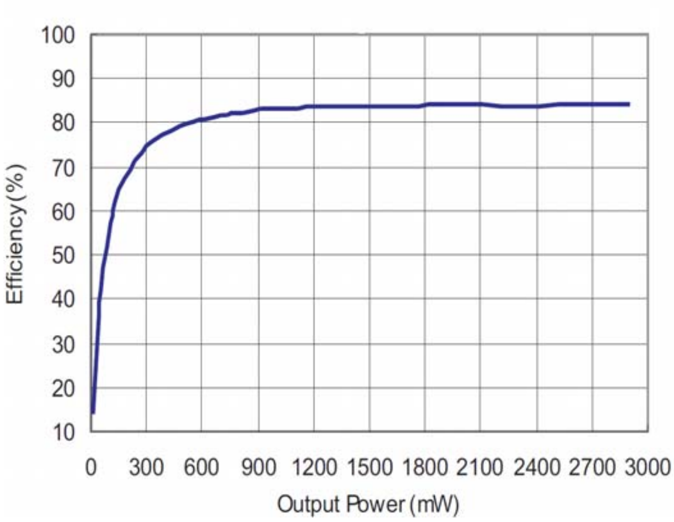
1. Efficiency VS Output Power

RL =8Ω,L =33 H

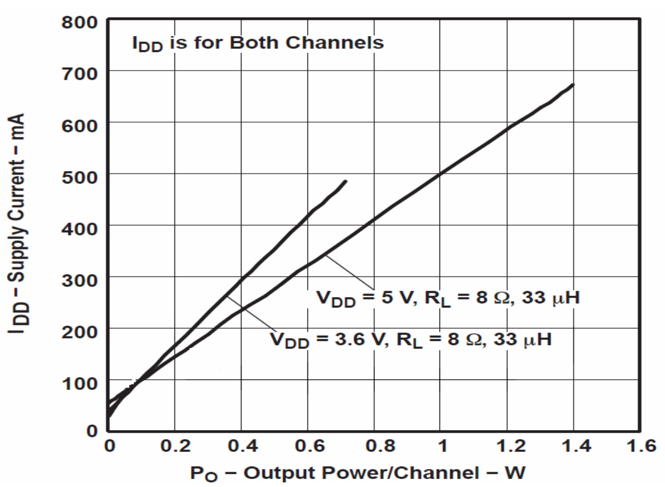


2. Efficiency VS Output Power

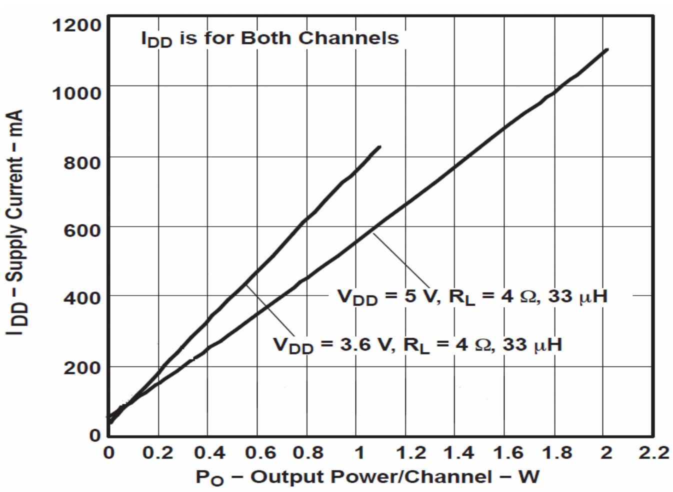
RL =4Ω, L =33 H



3. Supply Current VS Output Power



4. Supply Current VS Output Power

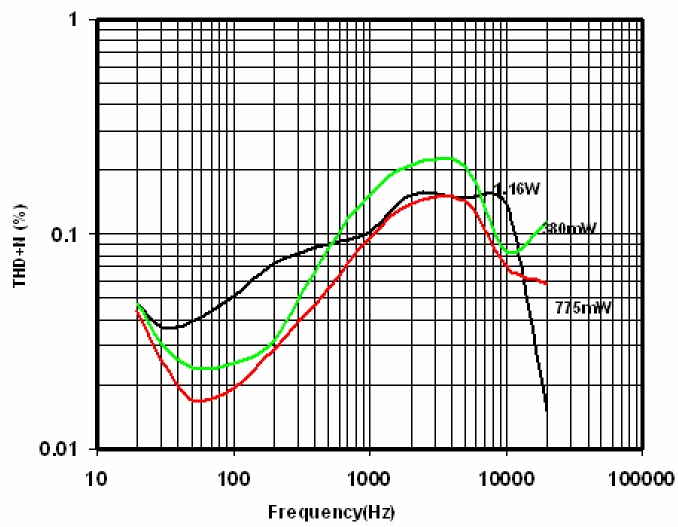


Typical Operating Characteristics

T =25°C, VDD =5V, f=1kHz, Gain=6dB,QFN Package, unless otherwise noted.

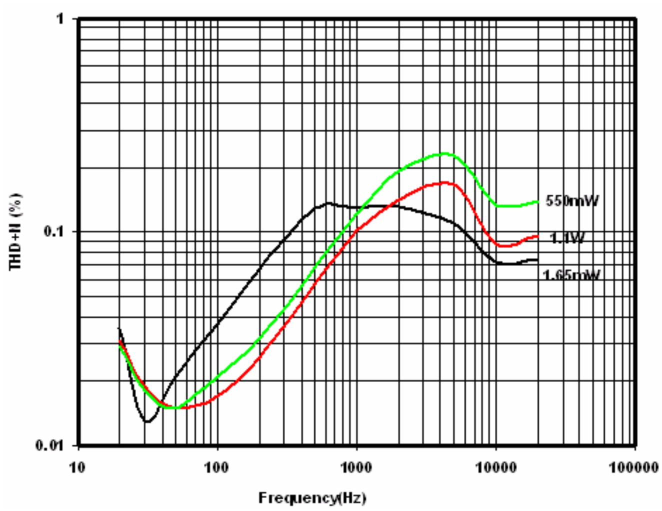
5. THD+N VS Frequency

VDD=5V,RL=8Ω, Ci=1uF,Av=6dB



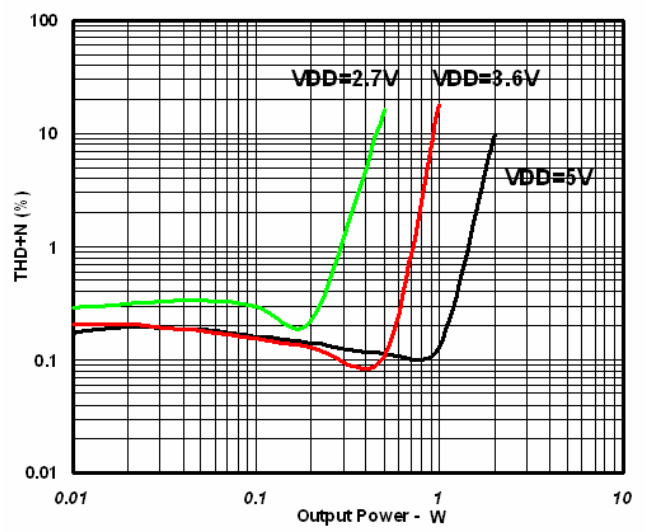
6. THD+N VS Frequency

VDD=5V,RL=4Ω, Ci=1uF,Av=6dB



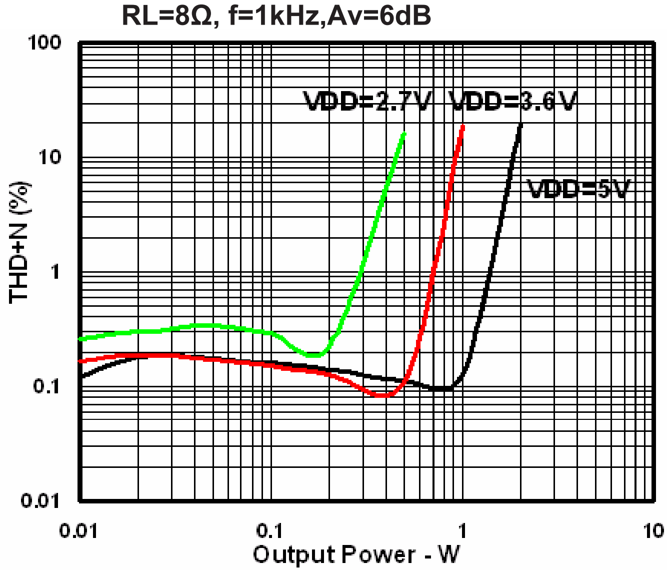
7 .THD+N VS Output Power

RL=8Ω, f=1kHz,Av=24dB



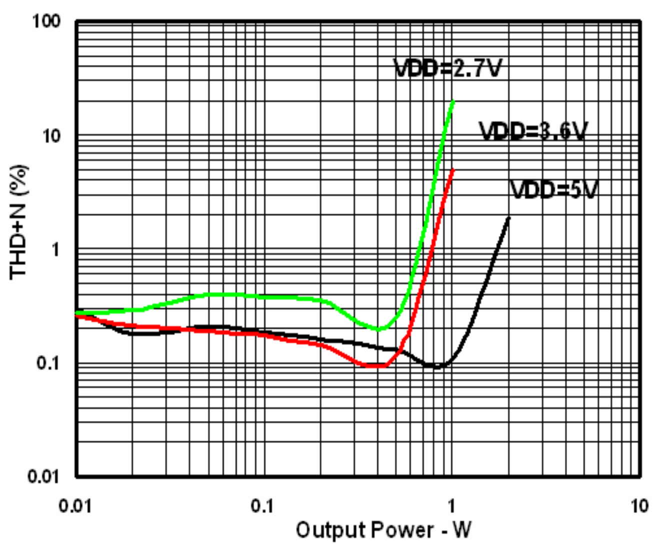
8. THD+N VS Output Power

RL=8Ω, f=1kHz,Av=6dB



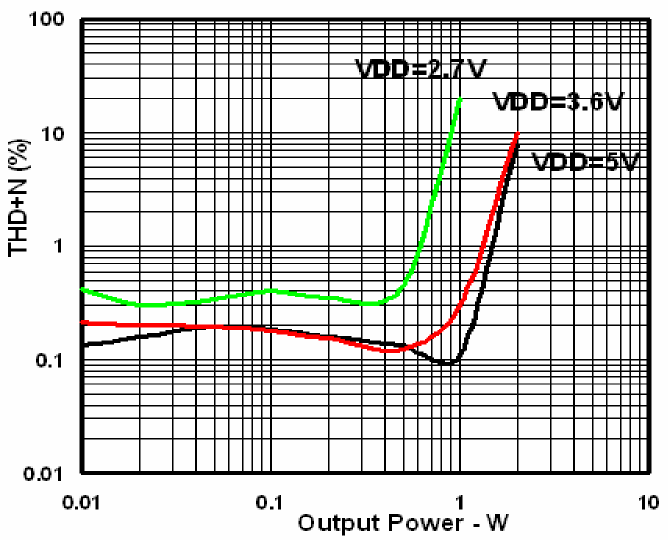
9. THD+N VS Output Power

RL=4Ω, f=1kHz,Av=24dB



10. THD+N VS Output Power

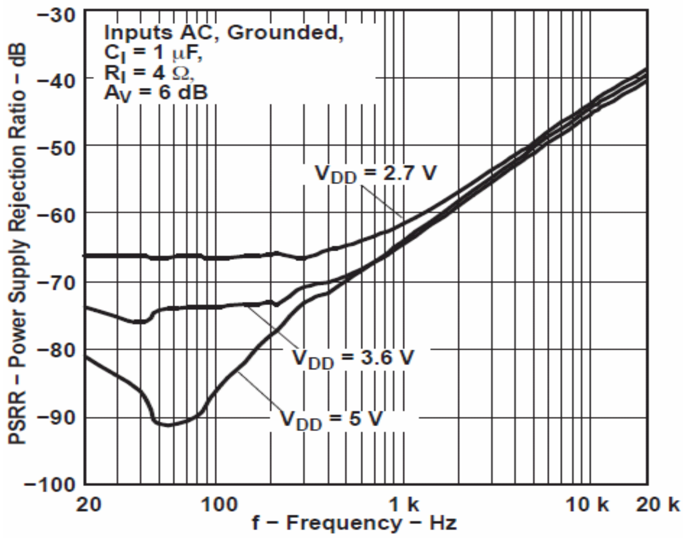
RL=4Ω, f=1kHz,Av=6dB



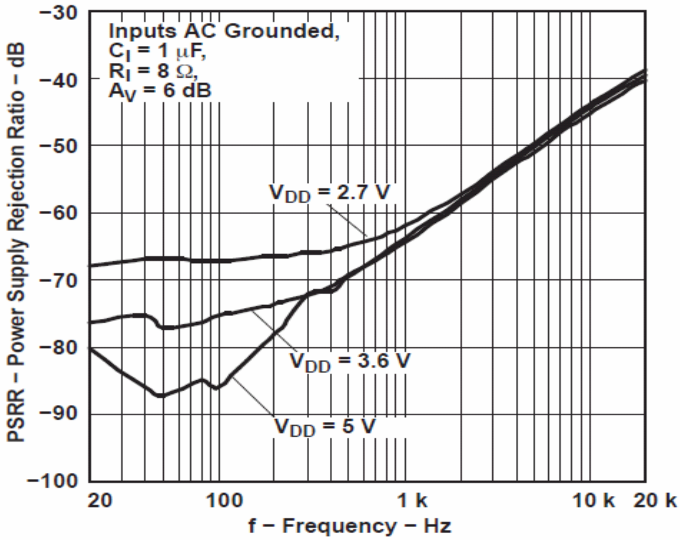
Typical Operating Characteristics

T =25°C, VDD =5V, f=1kHz, Gain=6dB,QFN Package, unless otherwise noted.

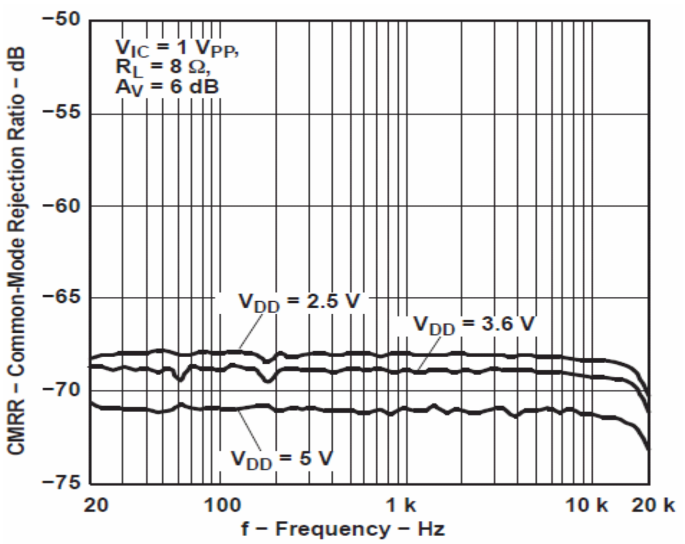
11. PSRR VS Frequency



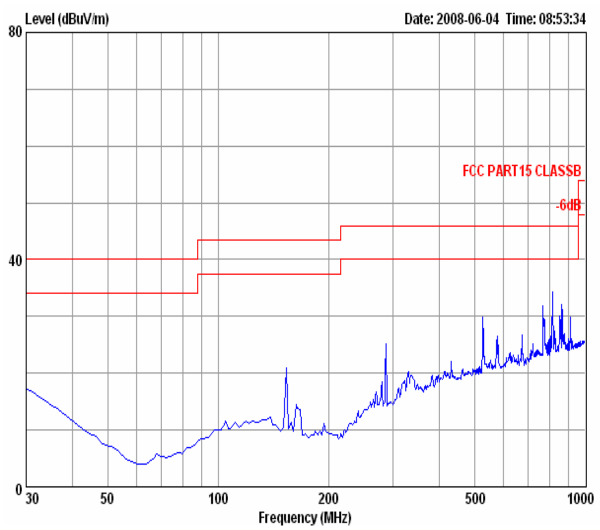
12. PSRR VS Frequency



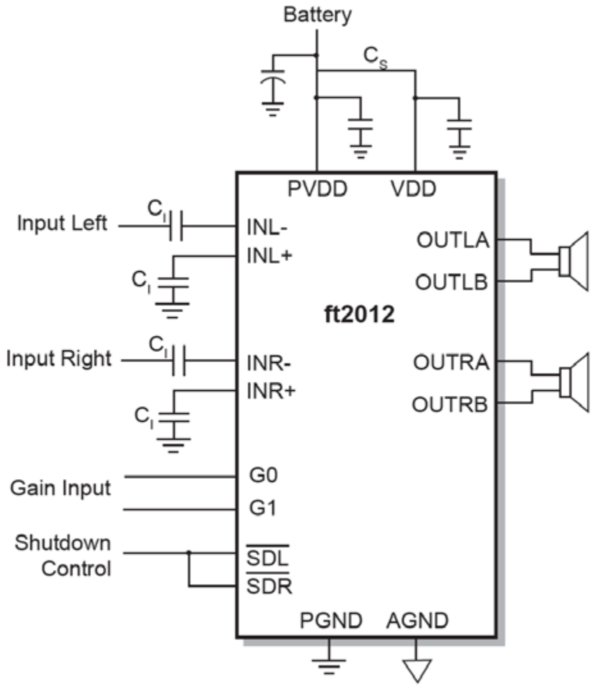
13. CMRR VS Frequency



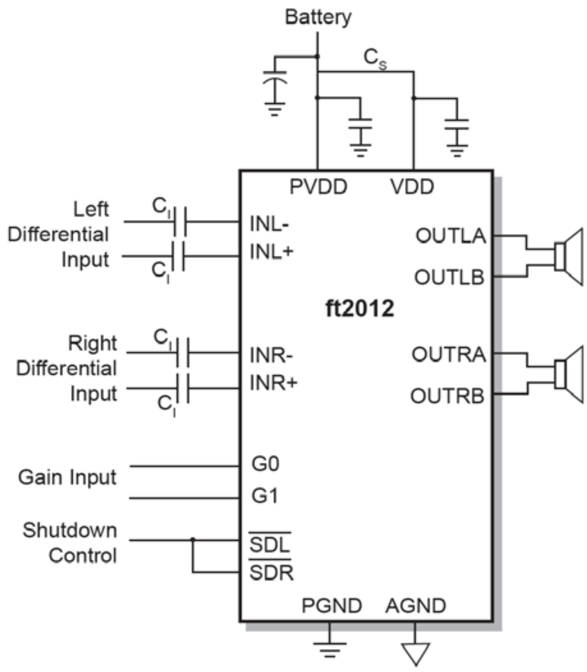
14. FCC Level



Application Information



Single-Ended Input



Differential Input

Decoupling Capacitor (C_S)

The ft2012 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 ft2012 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 ft2012 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.

Gain Setting Table

G1	G0	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

Input Capacitors (C_I)

The input capacitors and input resistors form a high-pass filter with the corner frequency, f_C, 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

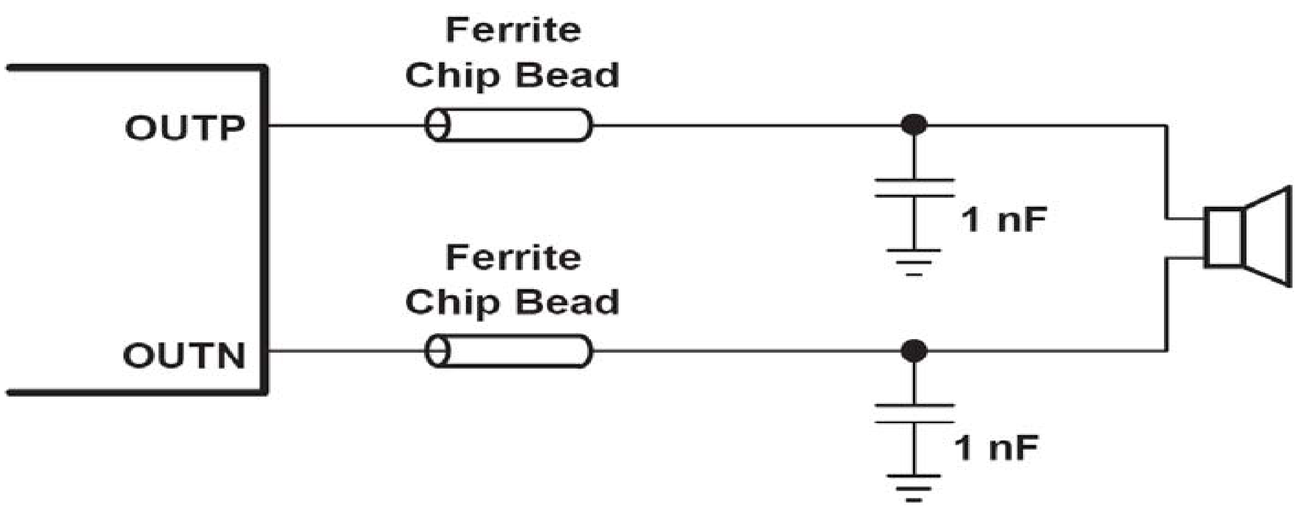
In using Class-D amplifiers with CODECs and DACs, sometimes there is an increase in the output noise floor from the audio amplifier. This occurs when mixing of the output frequencies of the CODEC/DAC mix with the switching frequencies of the audio amplifier input stage. The noise increase can be solved 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.

The following figure shows typical ferrite bead and LC output filters.



Typical Ferrite Chip Bead Filter

Shutdown operation(SD)

In order to reduce power consumption while not in use, the ft2012 contains shutdown circuitry to turn off the amplifier's bias circuitry. It features independent shutdown controls for each channel.

This shutdown turns the amplifier off when logic low is placed on the SDL/SDR pin. By switching the shutdown pin to GND, the ft2012 supply current draw will be minimized in idle mode.

Under Voltage Lock-out (UVLO)

The ft2012 incorporates circuitry designed to detect low supply voltage. When the supply voltage drops to 2.3V or below, the ft2012 goes into a state of shutdown, and the device comes out of its shutdown state and restore to normal function only when reset the power supply or SD pin.

Over Temperature Protection

Thermal protection on the ft2012 prevents the device from damage when the internal die temperature exceeds 135°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 3 0 °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 ft2012 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.

PCB Layout

As output power increases, interconnect resistance (PCB traces and wires) between the amplifier, load and power supply create a voltage drop. The voltage loss on the traces between the ft2012 and the load results is lower output power and decreased efficiency. Higher trace resistance between the supply and the ft2012 has the same effect as a poorly regulated supply, increase ripple on the supply line also reducing the peak output power. The effects of residual trace resistance increases as output current increases due to higher output power, decreased load impedance or both. To maintain the highest output voltage swing and corresponding peak output power, the PCB traces that connect the output pins to the load and the supply pins to the power supply should be as wide as possible to minimize trace resistance.

The use of power and ground planes will give the best THD+N performance. While reducing trace resistance, the use of power planes also creates parasite capacitors that help to filter the power supply line.

The inductive nature of the transducer load can also result in overshoot on one or both edges, clamped by the parasitic diodes to GND and V_{DD} in each case. From an EMI stand- point, this is an aggressive waveform that can radiate or conduct to other components in the system and cause interference. It is essential to keep the power and output traces short and well shielded if possible. Use of ground planes, beads, and micro-strip layout techniques are all useful in preventing unwanted interference.

As the distance from the ft2012 and the speaker increase, the amount of EMI radiation will increase since the output wires or traces acting as antenna become more efficient with length. What is acceptable EMI is highly application specific.

Ferrite chip inductors placed close to the ft2012 may be needed to reduce EMI radiation. The value of the ferrite chip is very application specific.

Ordering Information

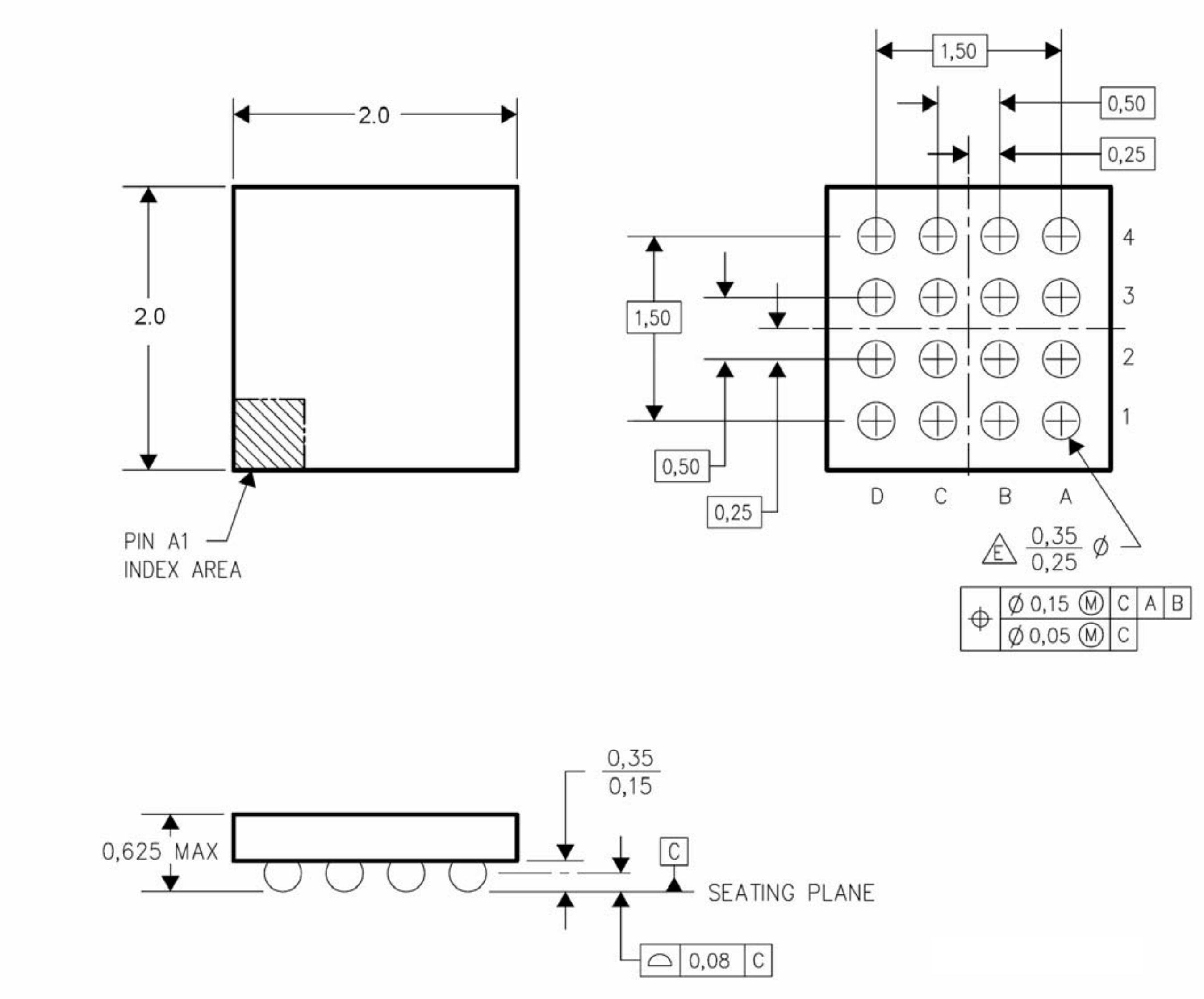
Part Number	Package Type	Package Qty	Operating Temperature range
ft2012W	WCSP-16	3,000 Units/ Reel	-40 °C to 85°C
ft2012Q	QFN-20	5,000 Units/ Reel	-40 °C to 85°C

Note*: The ft2012 is thermally limited in WCSP and may not achieve 2.7W/ch for 4Ω.

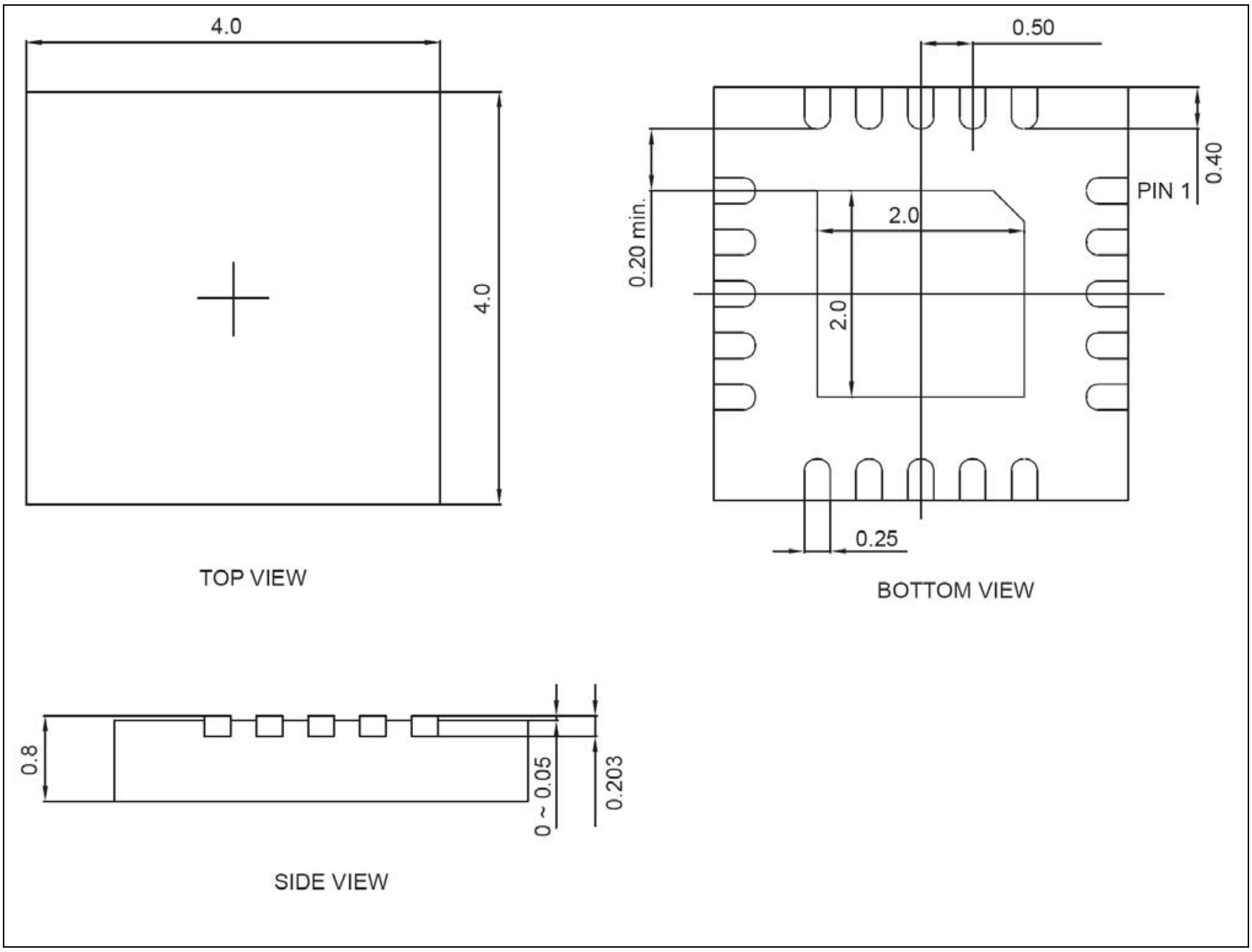
Mechanical Data

Notes*:All Dimensions are in millimeters.

WCSP-16



QFN-20


4.0
4.0
TOP VIEW
0.50
0.40
PIN 1
0.20 min.
2.0
2.0
0.25
BOTTOM VIEW
0.8
0 ~ 0.05
0.203
SIDE VIEW

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