◆General Description

The OCA7237 is a high efficiency filter-less Class-D audio power amplifier with Automatic Gain Control (AGC) technology and an integrated high efficiency charge pump boost power supply. The device constantly monitors output power and dynamically adjust internal gain to prevent long time overstress across the speaker.

The integrated charge pump structure generates 5.9V supply for output stage of amplifier. It can deliver 1W (THD+N=1%) of continuous average power to an 8Ω load by a lithium/Ion battery. The OCA7237 features high efficiency up to 81%, which helps extend battery life when playing audio.

The AGC with multi-level constant output power technology helps designer to select suitable output power which match the speaker.

The OCA7237 has a 47μVrms low output noise at gain=8V/V to improve the signal to noise ratio (SNR).

The OCA7237 is available in small 1.57mmX1.61mm 14-ball WLCSP package with 400μm pitch.

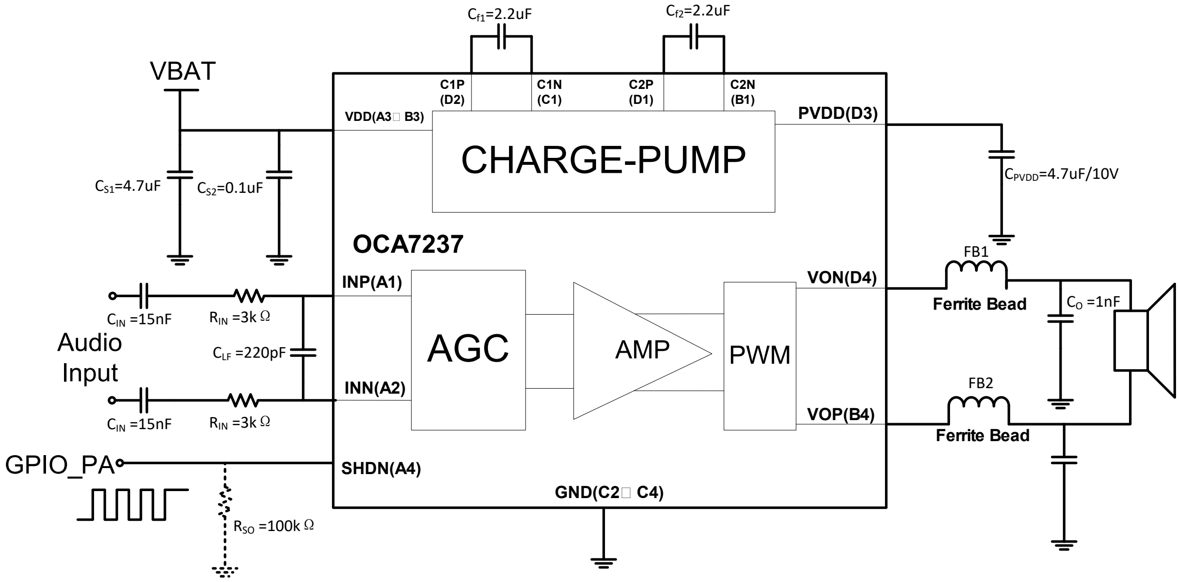
◆Features

- ◆ Built-In AGC With 4 Constant Output Power Control:1.2W,1W,0.8W,0.6W@8Ω
- ◆ Built-in Charge Pump Power Supply
- ◆ Low Output Noise : 47μVrms @ gain=8V/V
- ◆ Vdd=3.8V(A-Weighted)
- ◆ High Efficiency : 81%
- ◆ 2.2W Output into 8Ω Load at 4.2V With THD+N=10%
- ◆ THD+N:0.015%@1kHz,500mW,8Ω Load,3.8V Supply
- ◆ Thermal and Short-Circuit Protection with Auto Recovery
- ◆ Built-in Pop-and-click noise suppression
- ◆ Low RF Susceptibility
- ◆ single wire Pulse Control
- ◆ Available in 1.57mmX1.61mm 14-ball WLCSP Packager

◆Applications

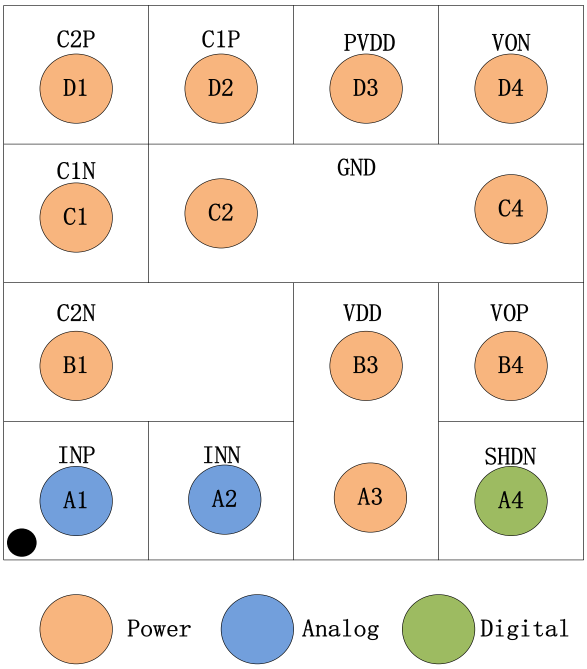
◆Mobile Phones and Tablets
◆Portable Media Players

◆Simplified Application Diagram



◆Pin Configuration and Functions

OCA7237 TOP VIEW



OCA7237 MARKING DIAGRAM

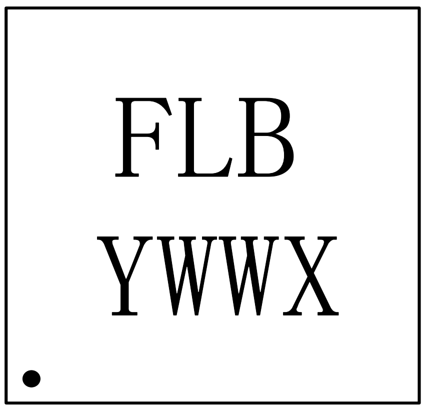


Table 1 Pin Functions

PIN No.	PIN Name	Description
A1	INP	Positive audio input of the Class D Audio Amplifier
A2	INN	Negative audio input of the Class D Audio Amplifier
A3、B3	VDD	Supply voltage
A4	SHDN	Single wire Pulse Control Terminal
B1	C2N	Charge-Pump Flying Capacitor Terminal
B4	VOP	Positive PWM audio Output of the Class D Audio Amplifier
C1	C1N	Charge-Pump Flying Capacitor Terminal
C2,C4	GND	Ground
D1	C2P	Charge-Pump Flying Capacitor Terminal
D2	C1P	Charge-Pump Flying Capacitor Terminal
D3	PVDD	Audio power stage supply voltage
D4	VON	Negative PWM audio Output of the Class D Audio Amplifier

◆Absolute Maximum Ratings

Over operating free–air temperature range, TA= 25° C (unless otherwise noted)(1)

Parameter		Min	Max	Unit
Supply Voltage	VDD	-0.3	5.5	V
Input Voltage	INP,INN,SHDN	-0.3	VDD+0.3	V
Operating free-air temperature range T_A		-40	85	° C
Operating junction temperature range T_J		-40	150	° C
Storage temperature range T_{STG}		-65	150	° C
Minimum load impedance		4		Ω
ESD(2)				
Human Body Model (HBM) ESD		2000		V
Machine Model (MM) ESD		200		V
Thermal Metric				
θ_{JA} 14-ball WLCSP 1.57x1.61mm		170		° C/W

(1)Stresses beyond those listed under absolute maximum ratings may cause permanent damage to the device. These are stress ratings only, and functional operation of the device at these or any other conditions beyond those indicated under recommended operating conditions is not implied. Exposure to absolute–maximum–rated conditions for extended periods may affect device reliability.

(2)This device series contains ESD protection and passes the following tests:

Human Body Model (HBM) standard: MIL-STD-883J/Method 3015.8 for all pins.

Machine Model (MM) standard: JESD22−A115C for all pins.

Charged devices and circuit boards can discharge without detection. Although this product features patented or proprietary protection circuitry, damage may occur on devices subjected to high energy ESD. Therefore, proper ESD precautions should be taken to avoid performance degradation or loss of functionality.

◆Electrical Characteristics

VDD=3.6V, T_A = 25° C, R_L = 8Ω+33μH, Rin = 3kΩ, Cin = 1μF (unless otherwise noted)

Parameter	Symbol	Conditions	Min	Typ	Max	Unit
Supply Voltage Range	VDD		3		5	V
Shutdown Current	ISD			0.1	1	μA
Turn Off Time	TOFF		100		500	μs
Over Temp Protection	TOVP			155		° C
Single wire pulse (SHDN PIN)						
High-level Input Voltage	VSDIH		1.3		VDD	V
Low-level Input Voltage	VSDIL		0		0.35	V
High-level Duration	TSDIH		1		10	μs
Low-level Duration	TSDIL		1		10	μs
Charge-Pump(CP) Boost Converter						
Over Voltage Production	VOVP		5.6	5.9	6.2	V
Output Regulation Voltage	PVDDS	No Load, VDD*1.5 < VOVP		1.5*VDD		V
		No Load, VDD*1.5 > VOVP		VOVP		V
Switching Frequency	FCP			1.06		MHz
Power Amplifier (PA)						
Operating Quiescent Current	IQ	Input AC Ground		10	15	mA
Turn-on Time	TON			41.25		ms
Switching Frequency	FPA			800		kHz
Voltage Gain	AV		14.5	16.3	17.5	V/V
Input Impedance	RIN	Speaker Mode		16.6k		Ω
Output Noise Voltage	VN	Rin = 3kΩ, Cin = 15nF, Gain =16, A-weighted		63		μV
		Rin = 10kΩ, Cin = 15nF, Gain=12, A-weighted		54		
		Rin = 24kΩ, Cin = 15nF, Gain=8, A-weighted		47		
Output Impedance in SD	ZO	SHDN = 0		10k		Ω

Total Harmonic Distortion Plus Noise	THD+N	VDD = 3.8V, PO = 0.2W, RL=8Ω+33μH, Mode5			0.01		%
		VDD = 3.8V, PO = 0.5W, RL=8Ω+33μH, Mode5			0.015		
		VDD = 3.8V, PO = 1 W, RL=8Ω+33μH, Mode5			0.02		
Class D + CP Efficiency	η	VDD = 4.2V, PO = 1 W, RL=8Ω+33μH			81.3		%
		VDD = 3.8V, PO = 0.8 W, RL=8Ω+33μH			81.1		
		VDD = 3.3V, PO = 0.6 W, RL=8Ω+33μH			78.2		
Power Supply Ripple Rejection	PSRR	Input AC Ground, Vripple = 200mVpp, VDD = 4.2V	217Hz		-71	-61	dB
			1kHz		-71	-61	
Output Power	PO	VDD = 4.2V, THD+N = 1%, RL=8Ω+33μH			1.78		W
		VDD = 3.8V, THD+N = 1%, RL=8Ω+33μH			1.45		
		VDD = 3.3V, THD+N = 1%, RL=8Ω+33μH			1.07		
		VDD = 4.2V, THD+N = 10%, RL=8Ω+33μH			2.2		
		VDD = 3.8V, THD+N = 10%, RL=8Ω+33μH			1.78		
		VDD = 3.3V, THD+N = 10%, RL=8Ω+33μH			1.3		
		VDD = 4.2V, THD+N = 1%, RL=6Ω+33μH			2.08		
		VDD = 3.8V, THD+N = 1%, RL=6Ω+33μH			1.69		
		VDD = 3.3V, THD+N = 1%, RL=6Ω+33μH			1.23		
		VDD = 4.2V, THD+N = 10%, RL=6Ω+33μH			2.54		
		VDD = 3.8V, THD+N = 10%, RL=6Ω+33μH			2.06		
		VDD = 3.3V, THD+N = 10%, RL=6Ω+33μH			1.51		
		VDD = 4.2V, THD+N = 1%, RL=4Ω+33μH			2.46		
		VDD = 3.8V, THD+N = 1%, RL=4Ω+33μH			1.99		
		VDD = 3.3V, THD+N = 1%, RL=4Ω+33μH			1.43		
		VDD = 4.2V, THD+N = 10%, RL=4Ω+33μH			2.94		
		VDD = 3.8V, THD+N = 10%, RL=4Ω+33μH			2.37		
		VDD = 3.3V, THD+N = 10%, RL=4Ω+33μH			1.73		
			RL=8Ω+33μH	1.05	1.167	1.284	W

AGC Output Power	POAGC	VDD = 3.8V, Mode1	RL=6Ω+33μH	1.357	1.508	1.658	
			RL=4Ω+33μH	1.85	2.056	2.262	
		VDD = 3.8V, Mode2	RL=8Ω+33μH	0.889	0.988	1.087	
			RL=6Ω+33μH	1.151	1.279	1.407	
			RL=4Ω+33μH	1.667	1.852	2.037	
		VDD = 3.8V, Mode3	RL=8Ω+33μH	0.716	0.795	0.875	
			RL=6Ω+33μH	0.93	1.033	1.137	
			RL=4Ω+33μH	1.35	1.5	1.649	
		VDD = 3.8V, Mode4	RL=8Ω+33μH	0.537	0.597	0.657	
			RL=6Ω+33μH	0.695	0.772	0.849	
			RL=4Ω+33μH	1.011	1.123	1.235	
AGC Attack Time	TATK	VDD = 3.8V, Mode3, Vin = 1.5Vp			36		ms
AGC Release Time	TREL				1		s
AGC Gain Step Size		Voltage Step			0.5		dB
Max Attenuation Gain					-13.5		dB
Signal Noise Ratio	SNR	VDD=4.2V, Po=1.75W, THD+N=1%,8Ω+33μH, Av=8V/V			97		dB

◆Operating Control Description

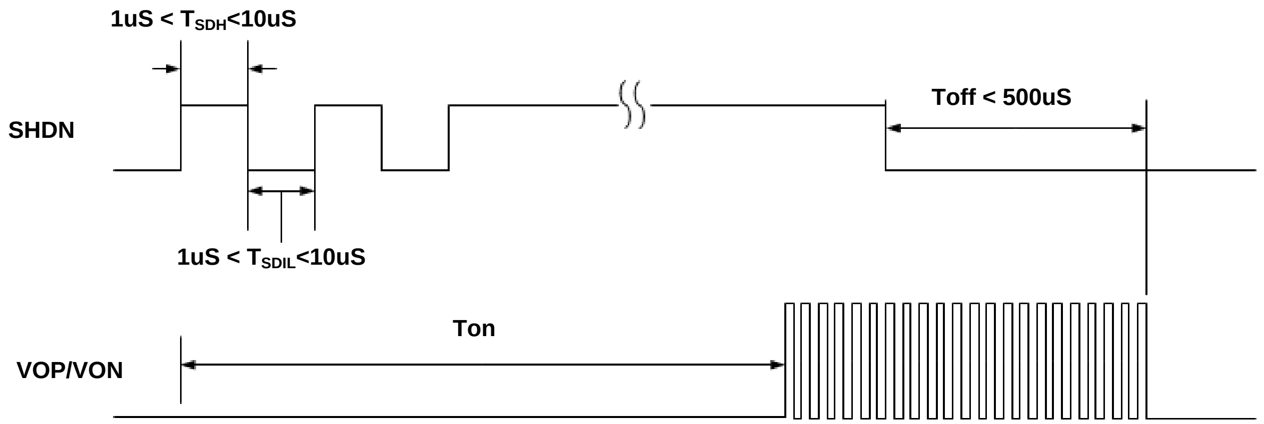
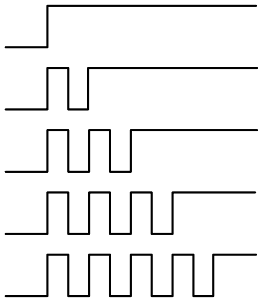


Figure 1. Single Wire Pulse Control timing sequence

Table 2 Operation Mode Description

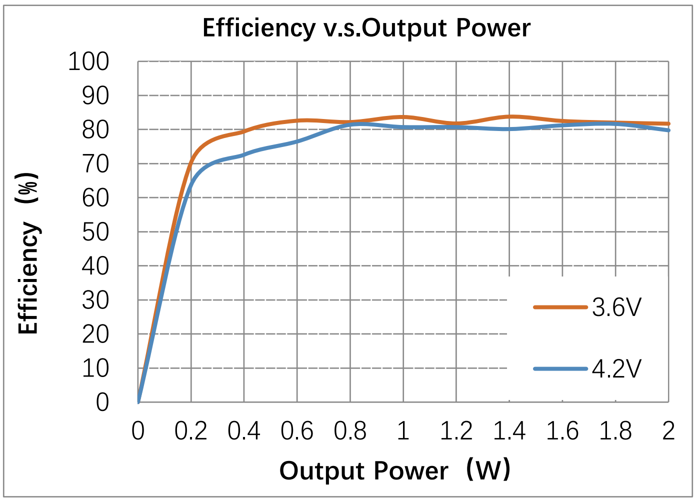


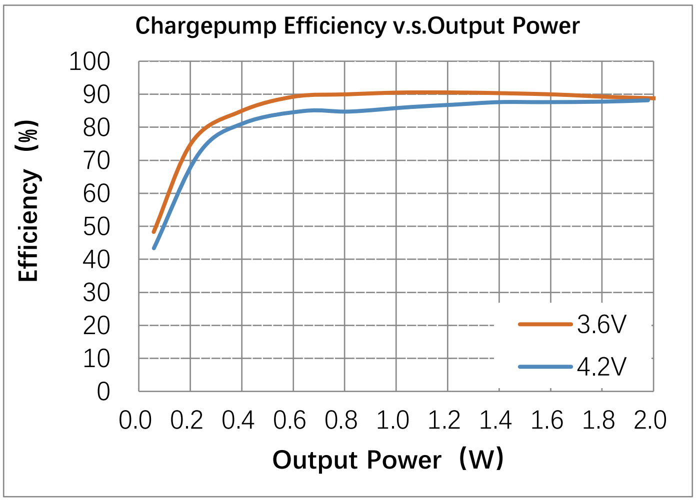
Control signal of SHDN PIN	Mode	Description
Mode1	Mode 1	AGC ON ,1.2W Output Power Control(1)
Mode2	Mode 2	AGC ON ,1.0W Output Power Control(1)
Mode3	Mode 3	AGC ON ,0.8W Output Power Control(1)
Mode4	Mode 4	AGC ON ,0.6W Output Power Control(1)
Mode5	Mode 5	AGC OFF

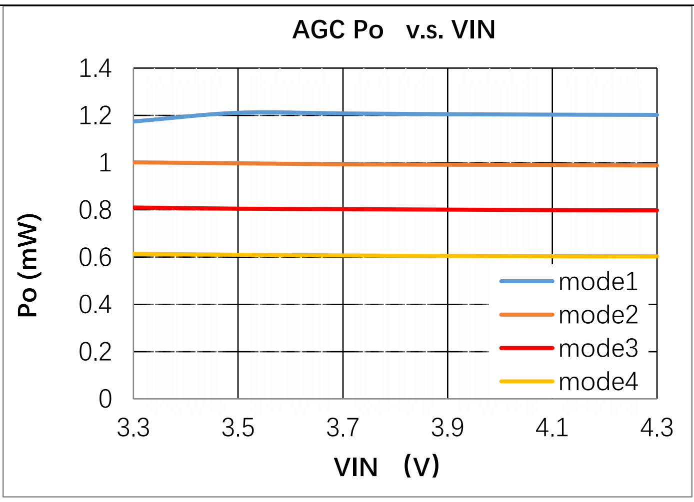
(1) The 1.2W,1.0W,0.8W,0.6W is approximate value, you can get the exact value in "Electrical Characteristics".

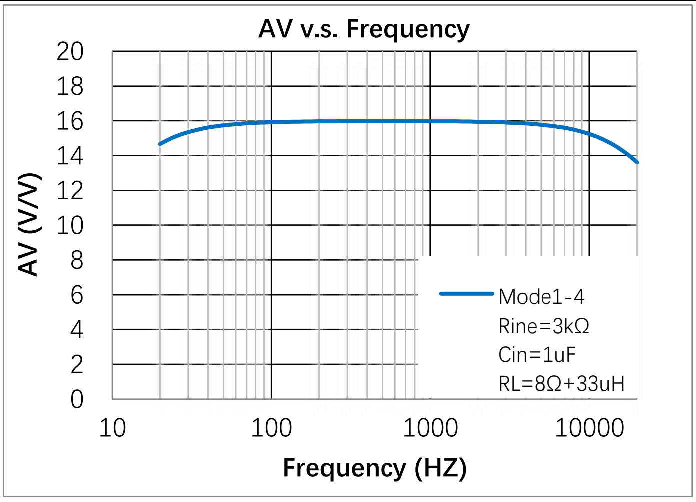
◆Typical Characteristics

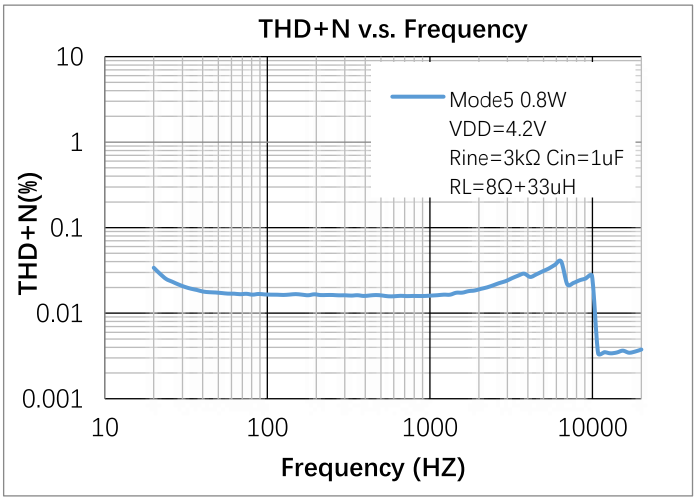
(Unless otherwise noted,VDD=4.2V, C_{IN}=15nF, Rine=3KΩ, RL=8Ω+33uH)

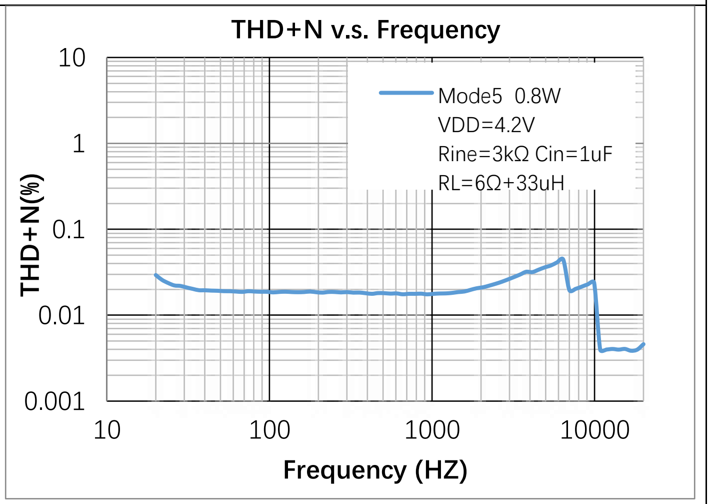


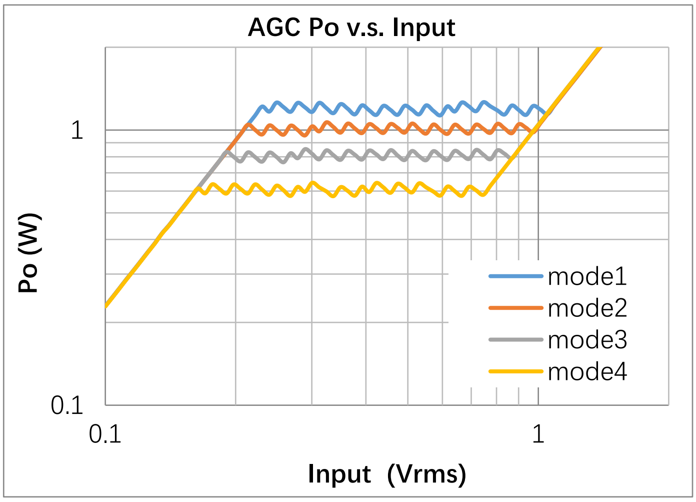


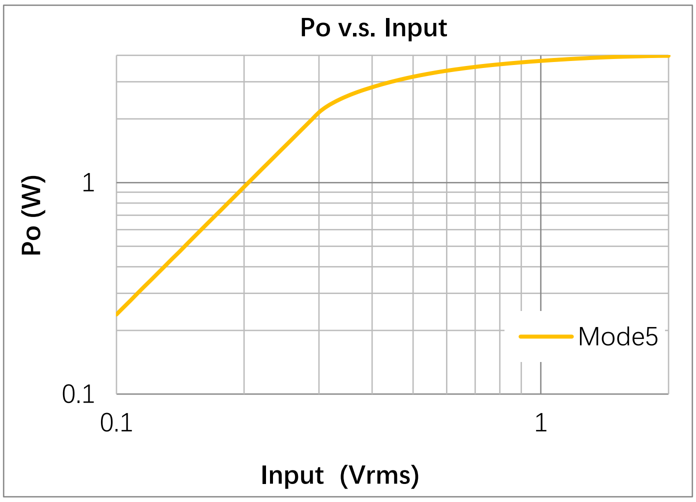


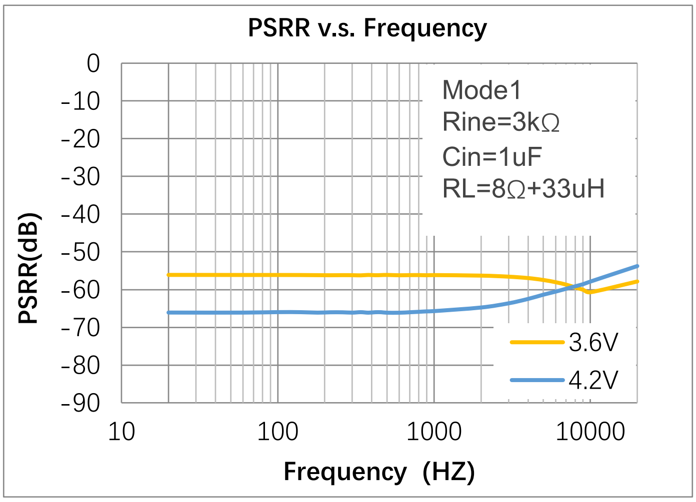


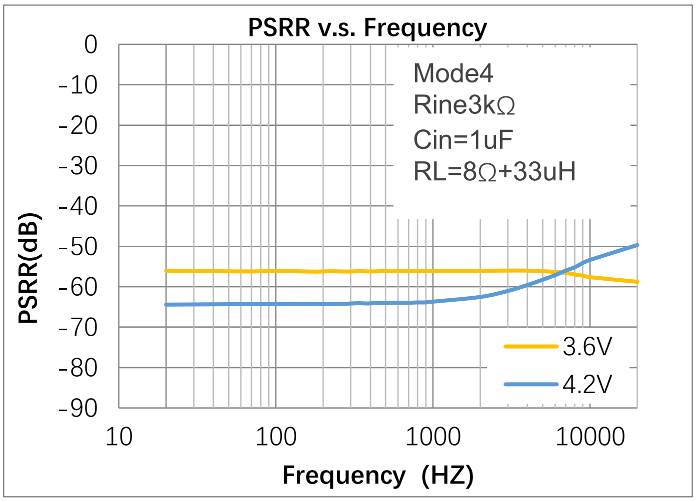


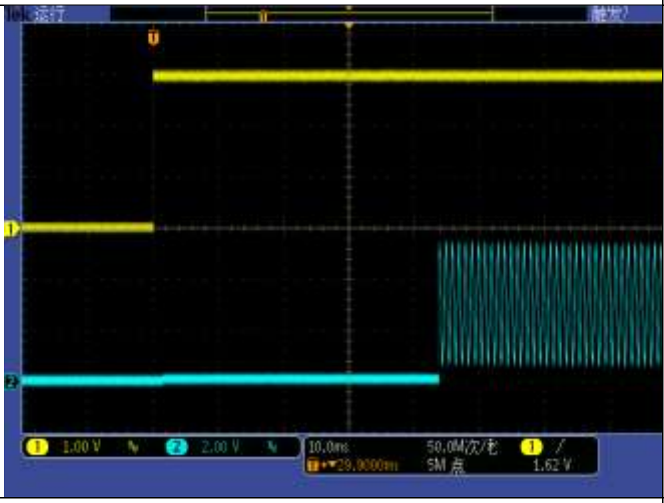
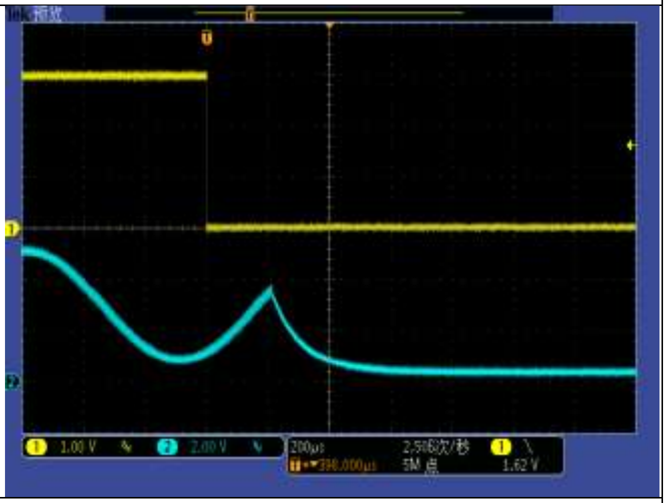
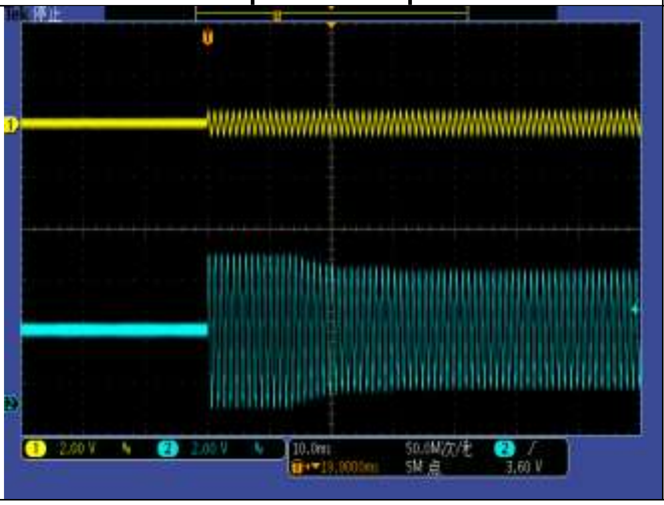
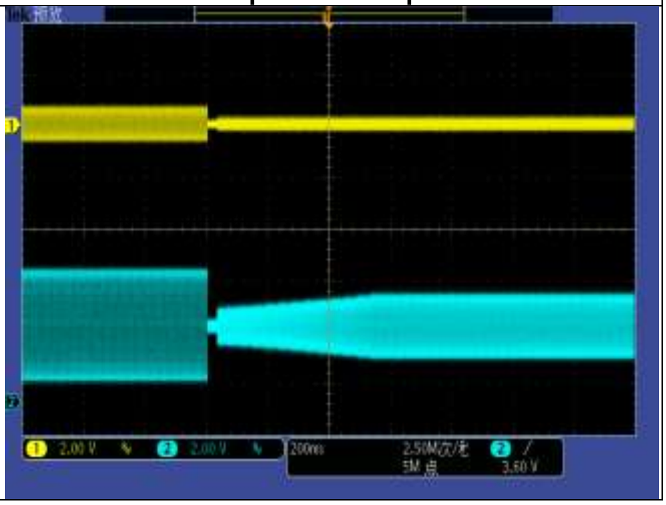



AGC Po v.s. Input
Po (W)
1
0.1
0.1
1
Input (Vrms)
mode1
mode2
mode3
mode4


Po v.s. Input
Po (W)
1
0.1
0.1
1
Input (Vrms)
Mode5


PSRR v.s. Frequency
PSRR(dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
10
100
1000
10000
Frequency (HZ)
Mode1
Rine=3kΩ
Cin=1uF
RL=8Ω+33uH
3.6V
4.2V


PSRR v.s. Frequency
PSRR(dB)
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
10
100
1000
10000
Frequency (HZ)
Mode4
Rine3kΩ
Cin=1uF
RL=8Ω+33uH
3.6V
4.2V

<table>
<tr><th>Start-up Waveform
CH1:SHDN CH2:Vout</th><th>Shut-down Waveform
CH1:SHDN CH2:Vout</th></tr>
<tr><td></td><td></td></tr>
<tr><td>AGC Start-up Waveform
CH1:Input CH2:Output</td><td>AGC Shut-dowm Waveform
CH1:Input CH2:Output</td></tr>
<tr><td></td><td></td></tr>
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◆Functional Description

The OCA7237 is a high efficiency Class- D audio power amplifier with an integrated Charge-Pump Converter.

Fully Differential Amplifier

The OCA7237 features a filter-less modulation scheme that reduces external component count, conserving board space and reducing system cost. With no signal applied, the outputs switch between PVDD and GND with 50% duty cycle, in phase, causing the two outputs to cancel. This cancellation results in no net voltage across the speaker, thus there is no current to the load in the idle state. With an input signal applied, the duty cycle (pulse width) of the Class D output changes. For increasing output voltage, the duty cycle of VOP increases, while the duty cycle of VON decreases. For decreasing output voltages, the converse occurs. The difference between the two pulse widths yields the differential output voltage.

The OCA7237 uses a fully differential amplifier with differential inputs and outputs. The differential output voltage equals the differential input multiplied by the amplifier gain. The OCA7237 can also be used with a single-ended input. However, using differential input signals when in a noisy environment, like a wireless handset, ensures maximum system noise rejection.

Charge Pump Converter

The OCA7237 consists of an 1.5X charger pump converter. The converter takes the supply voltage (VDD), and increases it to a higher output voltage (PVDD), which power supply of output stage. The Converter incorporates over voltage protection (OVP) that prevents PVDD exceeding its maximum permitted voltage (typ: 5.9V).

Single Wire Pulse Control

The OCA7237 implements a single wire pulse method to control the operation mode. Users can easily select the mode that needed by applying a serial pulse signal to the SHDN pin. The detail operation is showed in the Figure1.

Mode Switch Timing Sequence

In order to avoid entering an error state, OCA7237 should be powered up first, and then input control signal. When the operating mode need to be changed, SHDN should be pulled down more than 1ms, and then input the new control signal(see Figure 2).

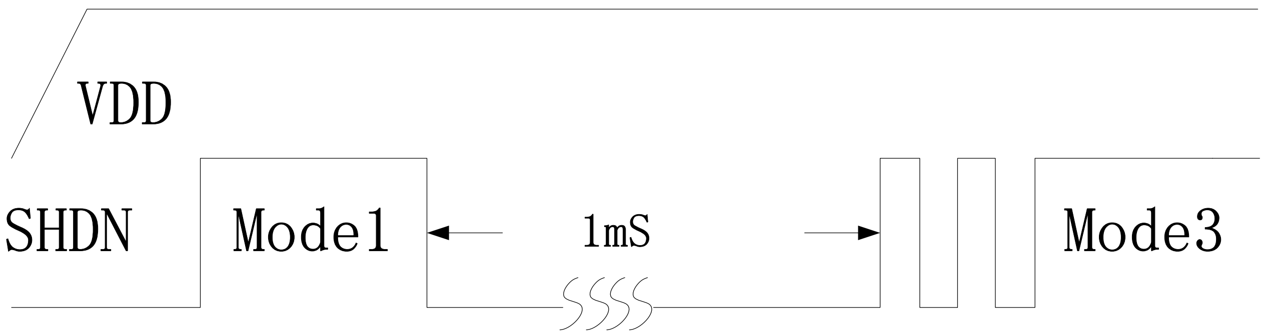


Figure 2. Operating mode switch timing sequence

Auto Gain Control (AGC)

The AGC feature provides continuous automatic gain adjustment to the amplifier through an internal PGA. It continuously monitors the output and adjusts the gain of the loudspeaker amplifier signal path if necessary. This Feature enhances the perceived audio loudness and at the same time prevents speaker damage from overload condition. The gain changes constantly as the audio signal increases or decreases with 0.5dB per voltage step (1dB per power step). If the audio signal has near-constant amplitude, the gain does not change.

The AGC protects the speaker by limiting long-term high output power on the load. Figure 3 shows how the AGC Power is defined.

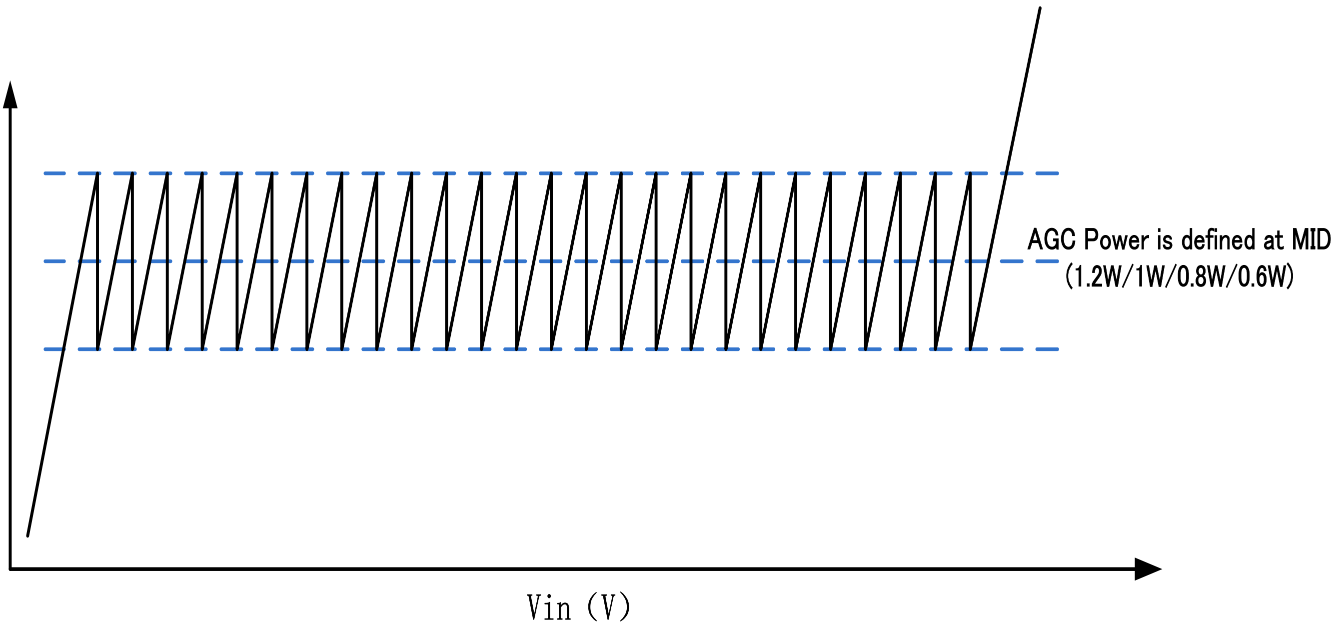


Figure 3. Output Power vs. Input Signal Diagram Showing how AGC Power is Defined

◆Application Information

Components Selection

Use very low ESR ceramic capacitors (X5R/X7R) will help to reduce the output resistance of the charge pump and thus improve the system efficiency. Capacitors constructed using X5R (-55° C to +85° C) or X7R (-55° C to +125° C) dielectric materials are preferred because they are compact, feature low ESR and are sufficiently stale over a wide temperature range. The capacitance value decreases over the DC biasing voltage range (50% to 85% decrease). Consequently, the selected capacitor should have a nominal value that is three to four times higher than the required minimum effective capacitance.

Decoupling Capacitor (CS)

The OCA7237 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) 4.7μF ceramic capacitor placed as close as possible to the device VDD pin works best. Placing this decoupling capacitor close to the OCA7237 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 higher-frequency noise signals, a 0.1μF capacitor placed near the audio power amplifier would also help.

Charge Pump Flying Capacitor (Cf1,Cf2)

The flying capacitor affects the load regulation and output impedance of the charge pump. The value of flying capacitor is too small results in a loss of current drive, leading to a loss of amplifier headroom. A higher valued flying capacitor improves load regulation and lowers charge pump output impedance to an extent. Selecting a 2.2μF/6.3V will help regarding the load regulation and the device’s ability to provide sufficient current drive.

Charge Pump Hold Capacitor (CPVDD)

The value and ESR of the hold capacitor(CPVDD) directly affects the ripple on CPVDD. Increasing the value of CPVDD reduces output ripple.

Decreasing the ESR of CPVDD reduces both output ripple and charge pump output impedance. A 4.7uF/10V capacitor is recommended.

Beam 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 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. When use filter, it should be placed as close as possible to the device VOP/VON pin.

Input Resistors (RIN)

The OCA7237 has internal input resistors of 16.6kΩ. The input resistors set the gain of the amplifier according to equation below.

$$\mathrm{Gain} = \frac{320\mathrm{k}\Omega}{R_{IN} + 16.6\mathrm{k}\Omega}$$

Place the input resistors very close to INN/INP pin to limit noise injection on the high-impedance nodes.

Input Capacitors (CIN)

The input capacitors and input resistors form a high-pass filter with the corner frequency, f_C, determined in equation below.

$$f_c = \frac{1}{2\pi * C_{IN} * (R_{IN} + 16.6k\Omega)}$$

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. 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, it may cause turn-on pop noise.

Input Low-Pass Filter Capacitors (CLP)

The input low pass filter capacitors and input resistors form a low-pass filter with the corner frequency f_L, determined in equation below.

$$f_L = \frac{1}{2\pi * 2 * C_{LP} * (R_{IN}//R_{INS})}$$

Large ripple voltages can be present at the output of ΔΣ DACs and CODECs, just above the audio frequency. This out-of-band noise is due to the noise shaping of the delta-sigma modulator in the DAC. Some Class-D amplifiers have higher output noise when used in combination with these DACs and CODECs. This is because out-of-band noise from the CODEC/DAC mixes with the Class-D switching frequencies in the audio amplifier input stage.

The low-pass filter reduces the out-of-band noise and RF noise, filtering out-of-band frequencies that could degrade in-band noise performance. This low-pass filter also prevents AGC errors due to out-of-band noise.

When the music sounds sharp, the low-pass filter can attenuate part of the high-frequency input signal, make music signal soft and comfortable. The R_{INS} is internal input resistor and its value is 16.6KΩ .The recommended value of C_{LP} is 220pF,R_{IN} is 3KΩ .The -3dB point of the low-pass filter is found using equation below:

$$f_L = \frac{1}{2\pi * 2 * 220pF * (3K\Omega//16.6K\Omega)} = 142.5KHz$$

TVS Tubes

To improve system ESD performance, bidirectional TVS tube is needed. The symmetrical TVS tube without Snapback characteristics is supposed to be selected to ensure good sound effects (see Figure4).The TVS tube should be placed near the speaker.

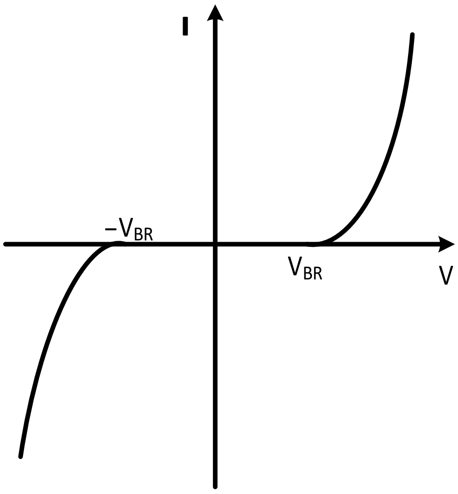


Figure 4. Bidirectional TVS tube without Snapback characteristics I/V

Input Signal wire layout

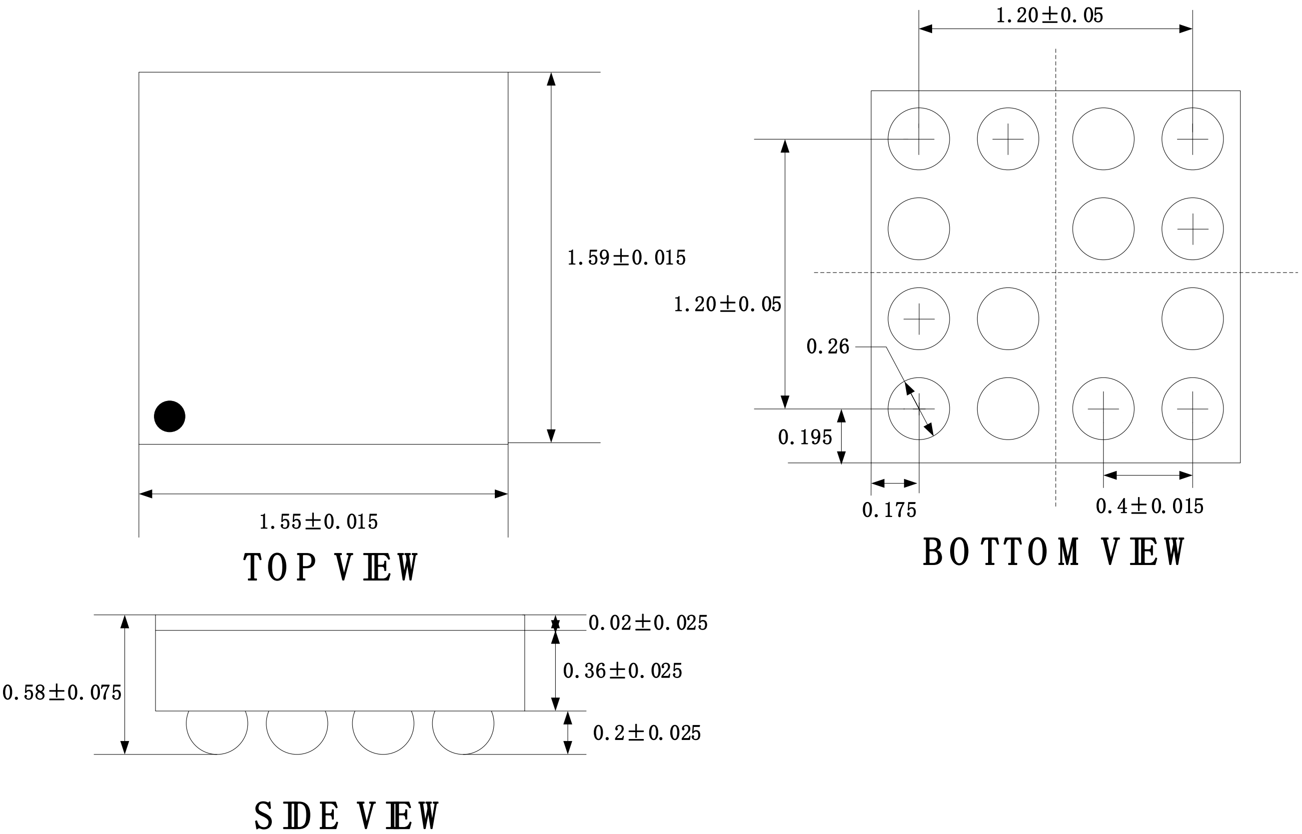
The audio signal wires between baseband and OCA7237 should line in the inner layer, and they also should be shielded with ground on both sides. In single ended input application, ground of the input signal need to try to close base-band, in order to avoid the coupling noise.

◆Ordering Information

Device	Temperature Range	Package	Shipping	MSL
OCA7237WPAD	−40° C to +85° C	14-ball WLCSP 1.57x1.61mm	3000 / tape & Reel	1

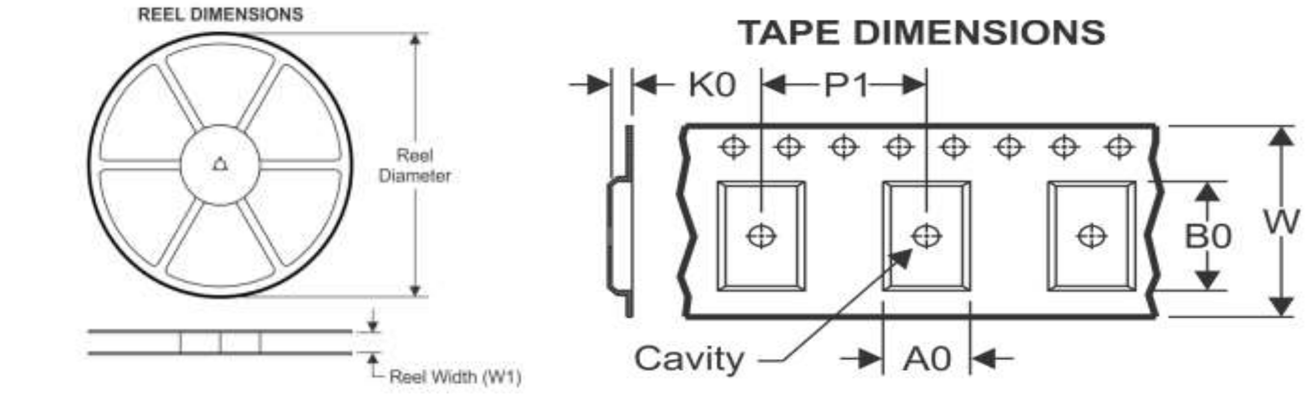
◆Package Information

WLCSP-14B

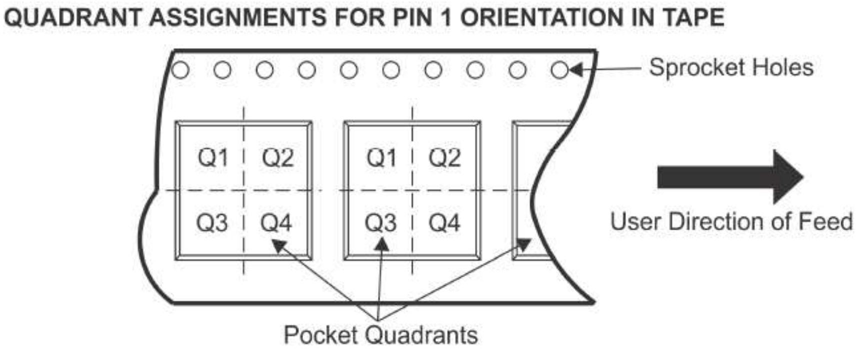


NOTE： ALL dimensions are in millimeters

◆Packing Information



A0	Dimension designed to accommodate the component width
B0	Dimension designed to accommodate the component length
K0	Dimension designed to accommodate the component thickness
W	Overall width of the carrier tape
P1	Pitch between successive cavity centers



Package tape	Package Drawing	MSL	SPQ	Reel Diameter(mm)	Reel Width W1(mm)
WLCSP-14B	FLB	Level-1-260C	3000	180	8.4
A0 (mm)	**B0 (mm)**	**K0 (mm)**	**P1 (mm)**	**W (mm)**	**PIN A1 Quadrant**
2	2.1	1	4	8	Q1

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