CubicMOS   Headphone Amplifier with Shutdown Mode   **CM2881**

General Description

The CM2881 is a dual audio power amplifier capable of delivering 105mW per channel of continuous average power into a 16Ω load with 0.1%(THD+N) from a 5V power-supply. Boomer audio power amplifier were designed specifically to provide high quality output power with a minimal amount of external components.
Since CM2881 does not require bootstrap capacitors or snubber networks, it is optimally suited for low power portable systems.
The CM2881 features an externally controlled, low power consumption shutdown mode which is virtually clickless and popless,   as well as an internal thermal shutdown protection mechanism..
The unity-gain stable CM2881 can be configured by external gain-setting resistors..
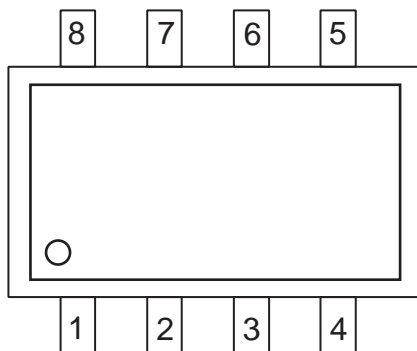
Feature

"Click and Pop" suppression circuitry
No bootstrap capacitors required
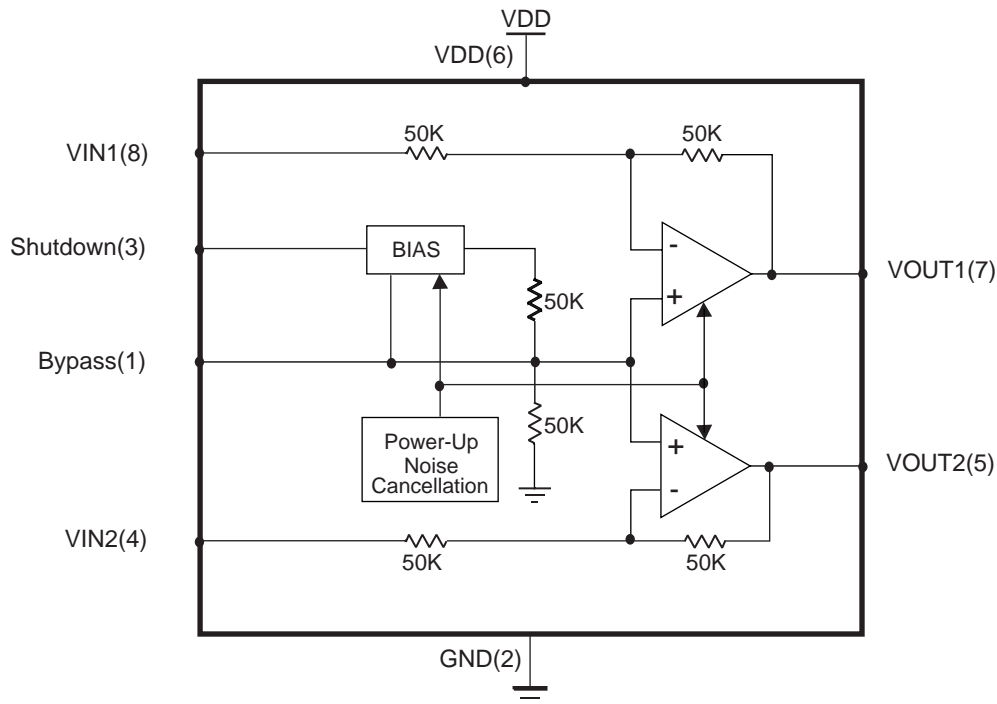Low shutdown current

Applications

Electronic Information Organizers
Palmtops
Cellular and portable phones
Portable Audio Systems
DVD,MP3

Pin Assignment

Pin No.	Pin Name
1	Bypass
2	GND
3	Shutdown
4	V_{IN2}
5	V_{OUT2}
6	V_{DD}
7	V_{OUT1}
8	V_{IN1}

CM2881

CubicMOS   Headphone Amplifier with Shutdown Mode   **CM2881**

Block Diagram

Electrical Characteristics (VDD = 5V)

Symbol	Parameter	Conditions	Typical	Limit	Units
V_{DD}	Supply Voltage			2.0	V (min)
				5.5	V (max)
I_{DD}	Supply Current	V_{IN} = 0V, I_O = 0A	1.3	3.0	mA
I_{SD}	Shutdown Current	V_{IN} = 0V	0.3	5	uA
V_{OS}	Output Offset Voltage	V_{IN} = 0V	1.0	50	mV
P_O	Output Power	0.1% THD+N: f = 1kHz			
		R_L = 16Ω	105	95	mW
		R_L = 32Ω	70	65	mW
THD+N	Total Harmonic Distortion	P_O = 50mW, R_L = 32Ω f = 20Hz to 20kHz	0.1	0.5	%
Crosstalk	Channel Separation	R_L = 32Ω; f = 1kHz; P_O = 70mW	100		dB
PSRR	Power Supply Rejection Ratio	C_B = 1.0 F, V_{RIPPLE} = 100mV_{pp} f =217Hz	72		dB
V_{IH}	(SHUTDOWN) Input Voltage High		1.0	1.5	V (min)
V_{IL}	(SHUTDOWN) Input Voltage Low		0.7	0.4	V (max)

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Headphone Amplifier with Shutdown Mode   **CM2881**

Electrical   Characteristics   (VDD = 3.3V)

Symbol	Parameter	Conditions	Typical	Limit	Units
I_{DD}	Supply Current	V_{IN} = 0V, I_O = 0A	1.1	2.5	mA
I_{SD}	Shutdown Current	V_{IN} = 0V	0.3	5	uA
V_{OS}	Output Offset Voltage	V_{IN} = 0V	1.0	50	mV
P_O	Output Power	0.1% THD+N: f = 1kHz			
		R_L = 16Ω	40	35	mW
		R_L = 32Ω	28	24	mW
THD+N	Total Harmonic Distortion	P_O = 50mW, R_L = 32Ω f = 20Hz to 20kHz	0.5	1	%
PSRR	Power Supply Rejection Ratio	C_B = 1.0uF, V_{RIPPLE} = 100mV$_{pp}$ f =217Hz	72		dB
V_{IH}	(SHUTDOWN) Input Voltage High		1.0	1.5	V (min)
V_{IL}	(SHUTDOWN) Input Voltage Low		0.7	0.4	V (max)

Electrical   Characteristics   (VDD = 2.6V)

Symbol	Parameter	Conditions	Typical	Limit	Units
I_{DD}	Supply Current	V_{IN} = 0V, I_O = 0A	1.0	2.0	mA
I_{SD}	Shutdown Current	V_{IN} = 0V	0.3	5	uA
V_{OS}	Output Offset Voltage	V_{IN} = 0V	1.0	50	mV
P_O	Output Power	0.1% THD+N: f = 1kHz			
		R_L = 16Ω	20	15	mW
		R_L = 32Ω	16	12	mW
THD+N	Total Harmonic Distortion	P_O = 50mW, R_L = 32Ω f = 20Hz to 20kHz	0.3	1	%
PSRR	Power Supply Rejection Ratio	C_B = 1.0uF, V_{RIPPLE} = 100mV$_{pp}$ f =217Hz	72		dB
V_{IH}	(SHUTDOWN) Input Voltage High		1.0	1.5	V (min)
V_{IL}	(SHUTDOWN) Input Voltage Low		0.7	0.4	V (max)

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CubicMOS   **Headphone Amplifier with Shutdown Mode**   **CM2881**

Application Notes

POWER DISSIPATION
Power dissipation is a major concern when using any power amplifier and must be thoroughly understood to ensure a successful design. Equation 1 states the maximum power dissipation point for a single-ended amplifier operating at a given supply voltage and driving a specified output load.

$$P_{DMAX} = (V_{DD})^2 \ / \ (2\pi^2 R_L) \quad \text{......................(1)}$$

CM2811 has two operational amplifiers in one package, the maximum internal power dissipation point is twice that of the number which results from Equation 1. Even with the large internal power dissipation, the CM2811 does not require heat sinking over a large range of ambient temperature.
From Equation 1, assuming a 5V power supply and a 32Ω load, the maximum power dissipation point is 40mW per amplifier. Thus the maximum package dissipation point is 80mW. The maximum power dissipation point obtained must not be greater than the power dissipation predicted by Equation 2:

$$P_{DMAX} = (T_{JMAX} - T_A) \ / \ \theta_{JA} \quad \text{......................(2)}$$

For the MSOP package, θ_{JA} = 194°C/W, and for the LD package, θ_{JA} = 63°C/W. T_{JMAX} = 150°C for the CM2811. For a given ambient temperature, T_A, of the system surroundings, Equation 2 can be used to find the maximum internal power dissipation supported by the IC packaging. If the result of Equation 1 is greater than that of Equation 2, then either the supply voltage must be decreased, the load impedance increased, or T_A reduced. For the MSOP package in a typical application of a 5V power supply and a 32Ω load, the maximum ambient temperature possible without violating

the maximum junction temperature is approximately 134.5°C. This assumes the device operates at maximum power dissipation and uses surface mount packaging. Internal power dissipation is a function of output power. If typical operation is not around the maximum power dissipation point, operation at higher ambient temperatures is possible. Refer to the Typical Performance Characteristics curves for power dissipation information for lower output power levels.

POWER SUPPLY BYPASSING
As with any power amplifier, proper supply bypassing is critical for low noise performance and high power supply rejection. The capacitor location on both the bypass and power supply pins should be as close to the device as possible. The value of the bypass capacitor directly affects the CM2811 its half-supply voltage stability and PSRR. The stability and supply rejection increase as the bypass capacitors value increases. Typical applications employ a 5V regulator with 10uF and a 0.1uF bypass capacitors which aid in supply stability, but do not eliminate the need for bypassing the supply nodes of the CM2811.
The selection of bypass capacitors, especially C_B, is thus dependent upon desired low frequency PSRR, click and pop performance, (explained in the section, Proper Selection of External Components), system cost, and size constraints.

SHUTDOWN FUNCTION
In order to reduce power consumption while not is use, the CM2811 features amplifier bias circuitry shutdown. This shutdown function is activated by applying a logic high to the SHUTDOWN pin. The trigger point is 1.4V minimum for a logic high level, and 0.4V maximum for a logic low level. It is best to switch between ground and VDD to ensure optimal shutdown operation. By switching the SHUTDOWN pin to VDD, the CM2811 supply current draw will be minimized in idle mode. Whereas the device will be disabled with shutdown voltages less than VDD, the idle current may be greater than the typical value of 0.3uA. In either case, the SHUTDOWN pin should be tied to a fixed voltage to avoid unwanted state changes.
In many applications, a microcontroller or microprocessor output is used to control the shutdown circuitry.
This provides a quick, smooth shutdown transition. Another solution is to use a single-pole, single-throw switch in conjunction with an external pull-up resistor. When the switch is closed, the SHUTDOWN pin is connected to ground and enables the amplifier.
If the switch is open, the external pull-up resistor, R_{PU}, will disable the CM2811. This scheme guarantees that the SHUTDOWN pin will not float, thus preventing unwanted state changes.

PROPER SELECTION OF EXTERNAL COMPONENTS
Selection of external components when using integrated power amplifiers is critical for optimum device and system performance. While the CM2811 is tolerant of external component combinations, consideration must be given to the external component values that maximize overall system quality.
The CM2811 its unity-gain stability allows a designer to maximize system performance. Low gain settings maximize signal-to-noise performance and minimizes THD+N. Low gain configurations require large input signals to obtain a given output power. Input signals equal to or greater than 1 Vrms are available from sources such as audio codecs. Please refer to the section, Audio Power Amplifier Design, for a more complete explanation of proper gain selection.

CubicMOS   **Headphone Amplifier with Shutdown Mode**   **CM2881**

Application Notes

Selection of Input and Output Capacitor Size
Besides gain, one of the major considerations is the closed loop bandwidth of the amplifier. To a large extent, the bandwidth is dicated by the choice of external components shown in Figure 1. Both the input coupling capacitor, Ci, and the output coupling capacitor, Co, form first order high pass filters which limit low frequency response. These values should be based on the desired frequency response weighed against the following:
Large value input and output capacitors are both expensive and space consuming for portable designs. Clearly a certain sized capacitor is needed to couple in low frequencies without severe attenuation. But in many cases the speakers used in portable systems, whether internal or external, have little ability to reproduce signals below 150Hz. Thus large input and output capacitors may not increase system performance. In addition to system cost and size, click and pop performance is affected by the size of the input coupling capacitor, Ci. A larger input coupling capacitor requires more charge to reach its quiescent DC voltage (nominally 1/2 VDD). This charge comes from the output via the feedback and is apt to create pops upon device enable. Turn on pops can be minimized by reducing Ci value based on necessary low frequency response. Besides minimizing the input and output capacitor values, careful consideration should be paid to the bypass capacitor value. Bypass capacitor C_B is the most critical component to minimize turn on pops since it determines how fast the CM2811 turns on. The slower the CM2811 its outputs ramp to their quiescent DC voltage (nominally 1/2 VDD), the smaller the turn on pop. While the device will function properly, (no oscillations or motorboating), with C_B equal to 1uF, the device will be much more susceptible to turn on clicks and pops. Thus, a value of C_B equal to 1uF or larger is recommended in all but the most cost sensitive designs.
Also, careful consideration must be taken in selecting a certain type of capacitor to be used in the system. Different types of capacitors (tantalum, electrolytic, ceramic) have unique performance characteristics and may affect overall system performance.

AUDIO POWER AMPLIFIER DESIGN
Design a Dual 70mW/32Ω Audio Amplifier
Given:
Power Output 70mW
Load Impedance 32Ω
Input Level 1Vrms (max)
Input Impedance 60kΩ (min)
Bandwidth 100 Hz - 20 kHz $\pm$ 0.50dB
A designer must first determine the minimum supply rail to obtain the specified output power. By extrapolating from the Output Power vs Supply Voltage graphs in the Typical Performance Characteristics section, the supply rail can be easily found.
A second way to determine the minimum supply rail is to calculate the required V_OPEAK using Equation (3) and add the dropout voltage. For a single-ended application, the minimum supply voltage can be approximated by (2V_OPEAK + (V_ODTOP + V_ODBOT)), where V_ODBOT and V_ODTOP are extrapolated from the Dropout Voltage vs Supply Voltage curve in the Typical Performance Characteristics section.

$$V_{opeak} = \sqrt{(2R_L P_0)} \quad ....(3)$$

Using the Output Power vs Supply Voltage graph for a 32Ω load, the minimum supply rail is 4.8V. Since 5V is a standard supply voltage in most applications, it is chosen for the supply rail. Extra supply voltage creates headroom that allows the CM2881 to reproduce peaks in excess of 70mW without clipping the signal. At this time, the designer must make sure that the power supply choice along with the output impedance does not violate the conditions explained in the Power Dissipation section.
Remember that the maximum power dissipation point from Equation 1 must be multiplied by two since there are two independent amplifiers inside the package.
The final design step is to address the bandwidth requirements which must be stated as a pair of -3dB frequency points. Five times away from a -3dB point is 0.17dB down from passband response assuming a single pole roll-off. As stated in the External Components section, Ci and Co create first order highpass filters. Thus to obtain the desired frequency low response of 100Hz within $\pm$0.5dB, both poles must be taken into consideration. The combination of two single order filters at the same frequency forms a second order response. This results in a signal which is down 0.34dB at five times away from the single order filter -3dB point. Thus, a frequency of 20Hz is used in the following equations to ensure that the response is better than 0.5dB down at 100Hz.

$C_i \geq 1 / (2\pi * 60k\Omega * 20 \text{ Hz}) = 0.133uF;$ use 0.22uF .... (4)

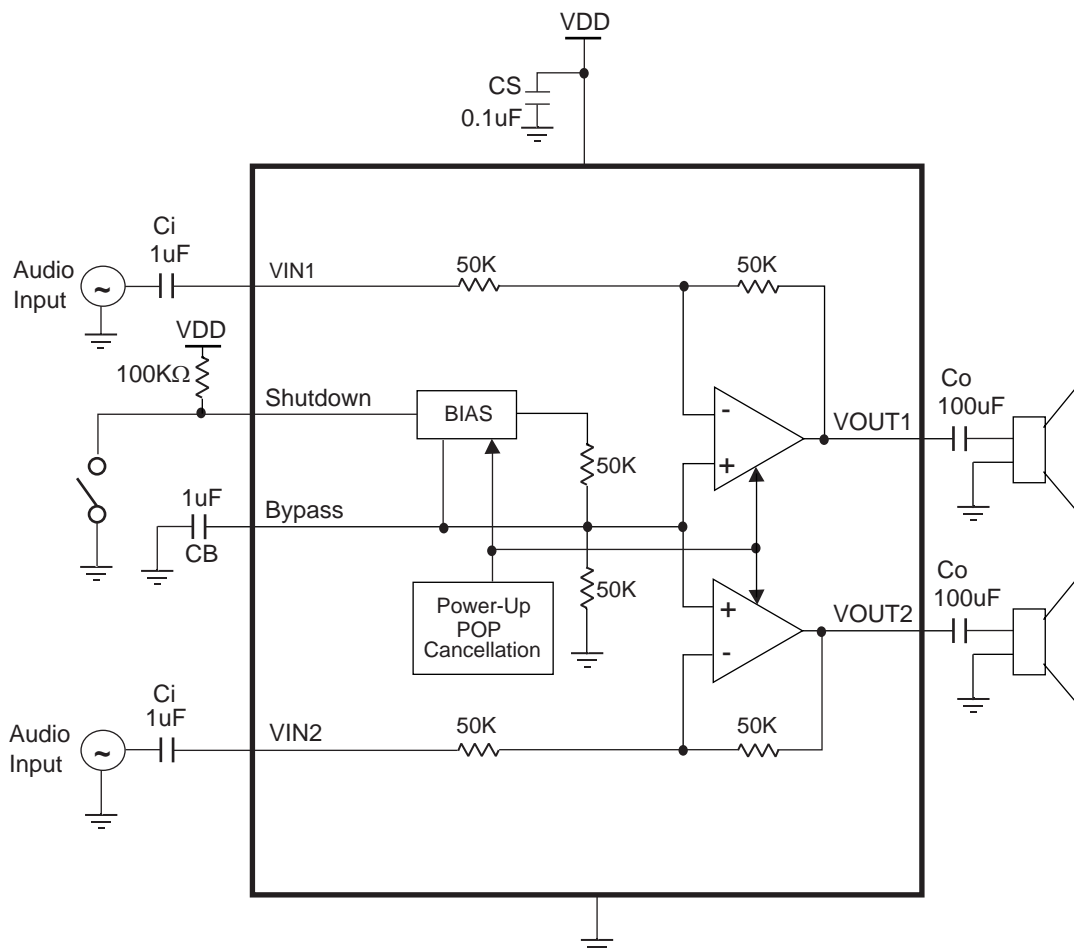$C_o \geq 1 / (2\pi * 32\Omega * 20 \text{ Hz}) = 249uF;$ use 330uF ....(5)

Headphone Amplifier with Shutdown Mode   **CM2881**
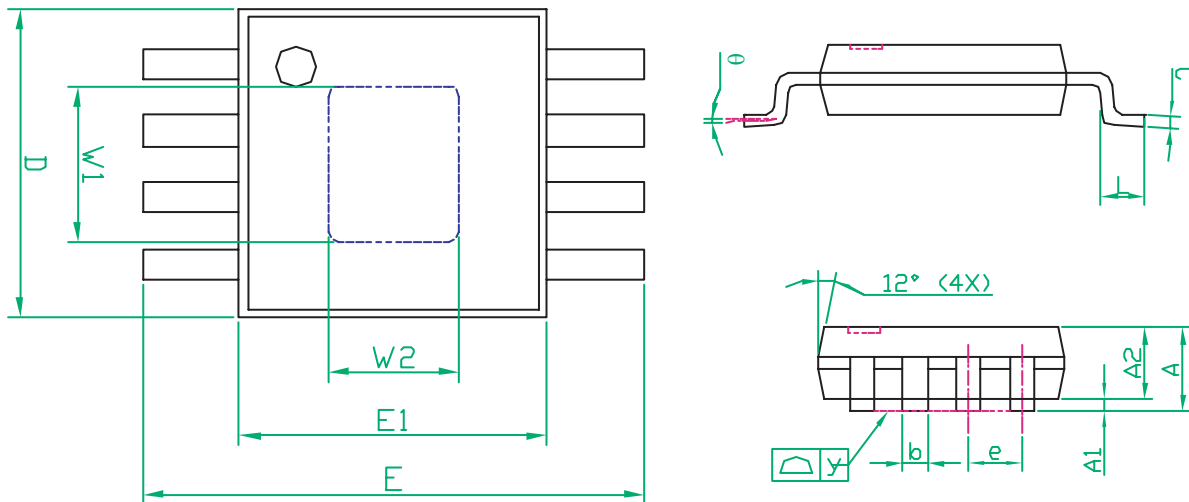
Example Circuit

External Components Description

Components	Functional Description
1. Ci	This is the input coupling capacitor. It blocks the DC voltage at, and couples the input signal to, the amplifier's input terminals. Ci also creates a highpass filter with the internal input resistor, Ri, at $fc = 1/(2\pi R_i C_i)$. The minimum value of Ri is 60kΩ. Refer to the section, Proper Selection of External Components, for an explanation of how to determine the value of Ci.
2. Cs	This is the supply bypass capacitor. It provides power supply filtering. Refer to the Application Information section for proper placement and selection of the supply bypass capacitor.
3. CB	This is the BYPASS pin capacitor. It provides half-supply filtering. Refer to the section, Proper Selection of External Components, for information concerning proper placement and selection of CB.
4. Co	This is the output coupling capacitor. It blocks the DC voltage at the amplifier's output and it forms a high pass filter with R_L at $F_O = 1/(2\pi R_L C_O)$

CubicMOS   **Headphone Amplifier with Shutdown Mode**   **CM2881**

Package Dimensions

SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHES		
	MIN	NOM	MAX	MIN	NOM	MAX
A	0.81	0.92	1.07	0.032	0.036	0.042
A1	0.00	———	0.10	0.000	———	0.004
A2	0.76	0.86	0.97	0.030	0.034	0.038
b	0.28	0.30	0.38	0.011	0.012	0.015
C	0.13	0.15	0.23	0.005	0.006	0.009
D	2.90	3.00	3.10	0.114	0.118	0.122
E	4.70	4.90	5.10	0.185	0.193	0.201
E1	2.90	3.00	3.10	0.114	0.118	0.122
e	———	0.65	———	———	0.026	———
L	0.40	0.53	0.66	0.016	0.021	0.026
y	———	———	0.10	———	———	0.004
θ	0°	———	6°	0°	———	6°
W1	1.27	———	1.52	0.050	———	0.060
W2	1.02	———	1.27	0.040	———	0.050