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GENERAL DESCRIPTION

The CM8662 is a bridge-connected audio power amplifier capable of delivering typically 1.7W of continuous average power to an 4Ω load from a 5V power supply. Boomer audio power amplifiers were designed specifically to provide high quality output power with a minimal amount of external components. Since the CM8662 does not require output coupling capacitors, bootstrap capacitors, or snuuber networks, it is optimally suited for low-power portable systems.

The CM8662 features an externally controlled, low-power consumption shutdown mode, as well as an internal thermal shutdown protection mechanism.

The unity-gain stable CM8662 can be configured by external gain-setting resistors.

APPLICATIONS

◆ Walkie-talkie
◆ LCD-TV / monitor
◆ Toys and Games
◆ USB speaker
◆ Digital recorder

FEATURES

◆ No output coupling capacitors, bootstrap capacitors or snubber circuits are necessary.
◆ SOP, SOP with Power Pad or DIP package.
◆ Unity-gain stable
◆ External gain configuration capability
◆ CMOS technology , save power , Hi-Fi performance
◆ higher efficiency than traditional bipolar amplifier

KEY SPECIFICATION

◆ THD at 0.5W continuous average output power at 1kHz into 8Ω 0.5% (max)
◆ Output power at 10% THD+N at 1kHz into 8Ω 1W (typ)
◆ Shutdown Current $0.7\mu A$ (typ)

PIN CONFIGURATION

DIP/SOP
(Top View)

1	SHUTDOWN	Vo2	8
2	BYPASS	GND	7
3	+IN	VDD	6
4	-IN	Vo1	5
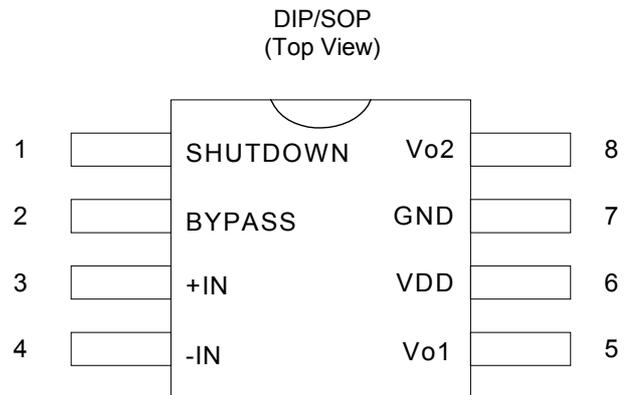
Test CIRCUIT
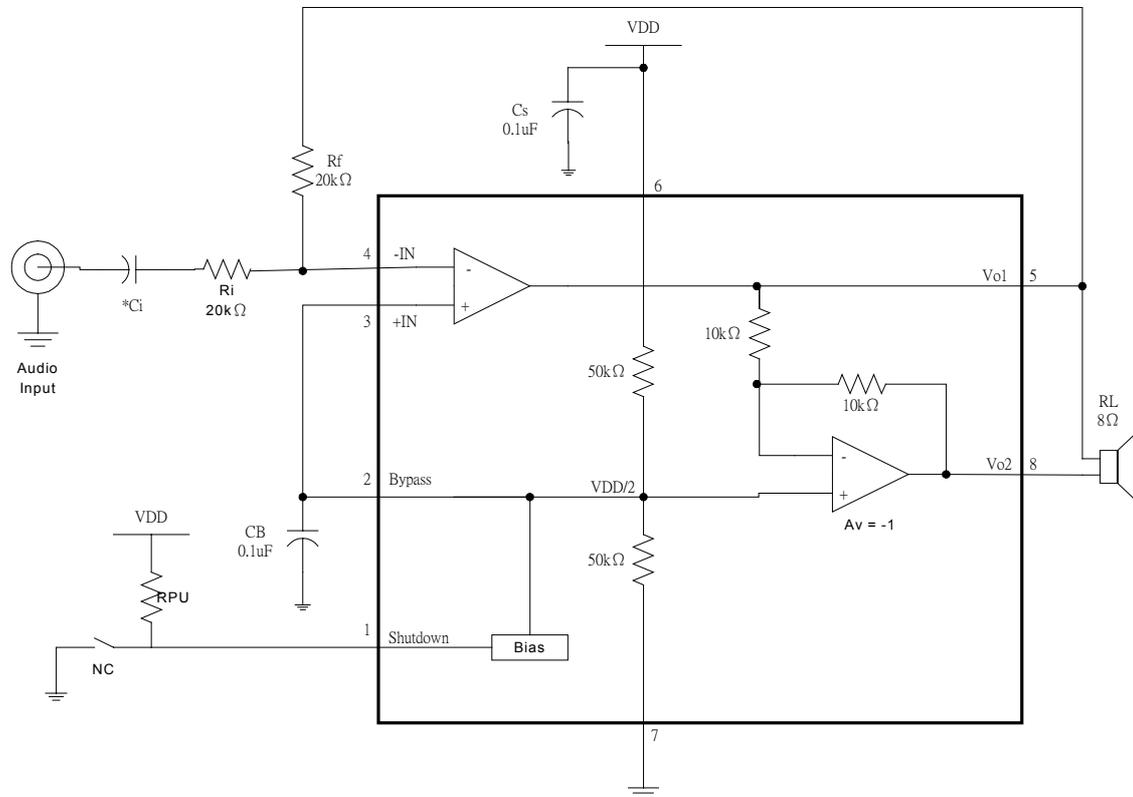
ORDERING INFORMATION

Part Number	Temperature Range	Package
CM8662IP	-40℃ ～ +85℃	8-PIN DIP8
CM8662IS	-40℃ ～ +85℃	8-PIN SOP8

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ABSOLUTE MAXIMUM RATINGS (Note 2)

Supply Voltage (V_{IN}) ………………………….………… +6.0V
Storage Temperature (T_S) ……………………… -65℃ to +150℃
Input Voltage (V_{IN}) …………………………. -0.3V to VDD + 0.3V
Power Dissipation (**Note 3**) …………………… Internally Limited
ESD Susceptibility (**Note 4**) ……………………………….. 3500V
ESD Susceptibility (**Note 5**) ………………………………... 250V
Junction Temperature ……………………………………… 150℃
Soldering Information
  Small Outline Package
  Vapor Phase (60 sec) …………………………………... 215℃
  Infrared (15 sec) …………………………………………. 220℃

Thermal Resistance
Θ_{Jc} (typ) – SOP-08…...………………………………….. 35℃/W
Θ_{Jc} (typ) –DIP-08………………………………….. 37℃/W

OPERATING RATINGS (Note 2)

Temperature Range
$T_{MIN} \leqq T_A \leqq T_{MAX}$ …………………………. -40℃ $\leqq T_A \leqq$ +85℃
Supply Voltage (V_{IN}) ………….…………2.7V $\leqq V_{DD} \leqq$ 5.5V

ELECTRICAL CHARACTERISTICS (Note 1) (Note 2)

The following specifications apply for V_{DD} = 5V unless otherwise specified. Limits apply for T_A = 25℃.

Symbol	Parameter	Test Conditions	CM8662			Unit
			Min.	Typ.	Max.	
V_{DD}	Supply Voltage		2.7		5.5	V
I_{DD}	Quiescent Power Supply	V_{IN} = 0V, I_O = 0A (Note 8)		3.6	6.5	mA
I_{SD}	Shutdown Current	V_{PIN1} = V_{DD}		0.7	5	μA
V_{OS}	Output offset Voltage	V_{IN} = 0V		5	50	mV
P_O	Output Power	THD = 1% (max); f = 1kHz; R_L = 8Ω THD+N = 10% ; f = 1kHz; R_L = 8Ω	500	875 1000		mW
THD + N	Total Harmonic Distortion + Noise	P_O = 500mWrms; R_L = 8Ω A_{VD} = 2; 20Hz $\leqq$ f $\leqq$ 20kHz		0.55		%
PSRR	Power Supply Rejection Ratio	V_{DD} = 4.9V to 5.1V		50		dB

Note 1. All voltage are measured with respect to the ground pin, unless otherwise specified.

Note 2. Absolute Maximum Ratings indicate limits beyond which damage to the device may occur. Operating Ratings indicate conditions for which the device is functional, but do not guarantee specific performance limits. Electrical Characteristics state DC and AC electrical specifications under particular test conditions which guarantee specific performance limits. This assumes that the device is within Operating Ratings. Specifications are not guaranteed for parameters where no limit is given, however, the typical value is a good indication of device performance.

Note 3. The maximum power dissipation must be derated at elevated temperature and is dictated by T_{JMAX}, Θ_{JA} and the ambient temperature TA. The maximum allowable power dissipation is PDMAX = (T_{MAX} - T_A)/ Θ_{JA} . The typical junction-to-ambient thermal resistance, when board mounted, is 170℃/W for package SOP-08, and PSOP-08, and is 107℃/W for package number PDIP-08

Note 4. Human body model, 100pF discharged through a 1.5kΩ resistor.

Note 5. Machine model, 200 pF - 240 pF discharged through all pins.

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AUTOMATIC SWITCHING CIRCUIT
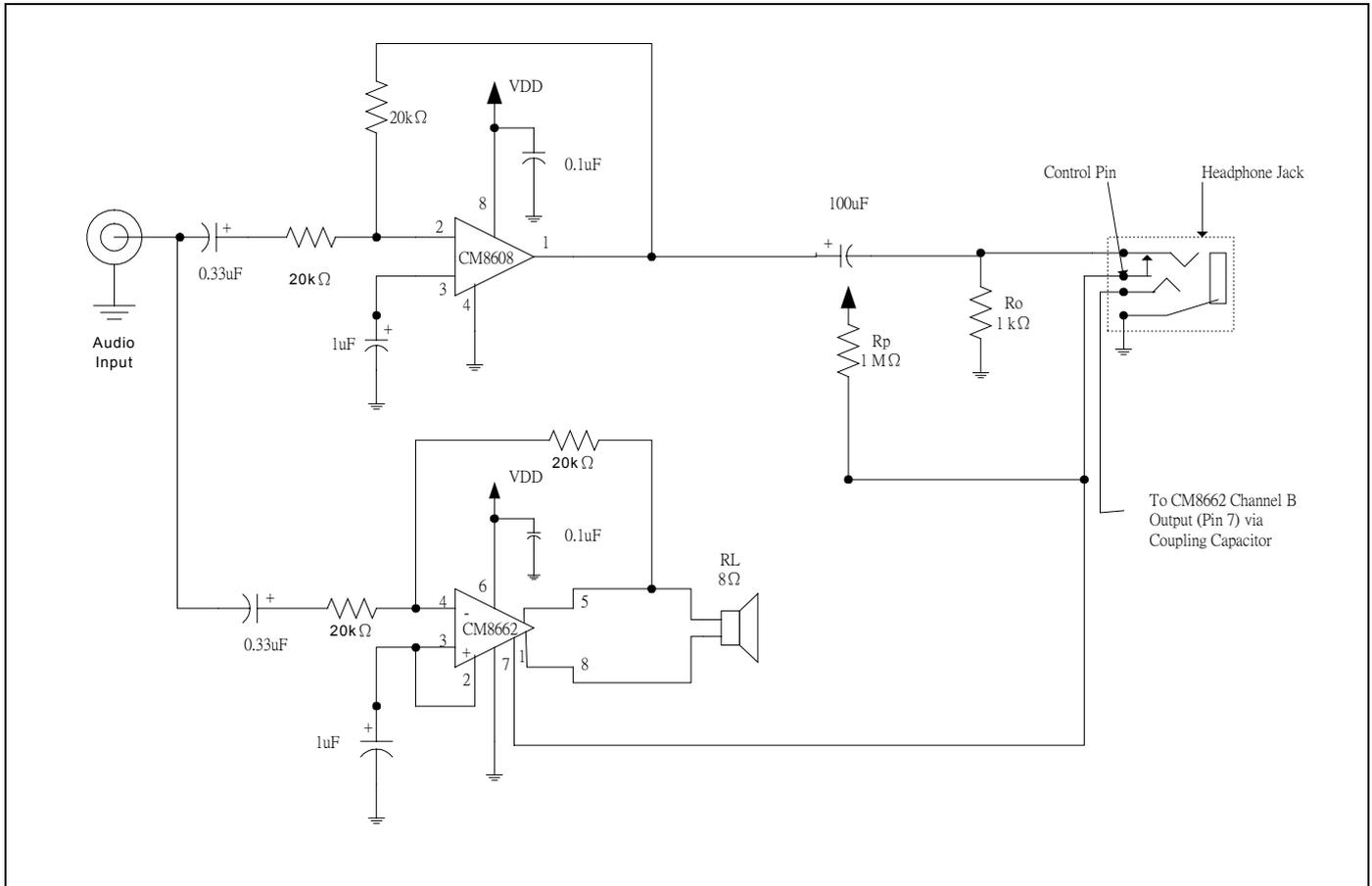
EXTERNAL COMPONENTS DESCRIPTION (Figure 1)

Components		Functional Description
1	R_i	Inverting input resistance which sets the closed-loop gain in conjunction with R_f. This resistor also forms a high pass filter with C_i and $f_c = 1/(2\pi R_i C_i)$
2	C_i	Input coupling capacitor which blocks the DC voltage at the amplifier's input terminals. Also creates a highpass filter with R_i at $f_c = 1/(2\pi R_i C_i)$. Refer to the section, **Proper Selection of External Components**, for an explanation of how to determine the value of C_i.
3	R_F	Feedback resistance which sets the closed-loop gain in conjunction with R_i.
4	C_S	Supply bypass capacitor which provides power supply filtering. Refer to the **Power Supply Bypassing** section for proper placement and selection of the supply bypass capacitor.
5	C_B	Bypass pin capacitor which provides half-supply filtering. Refer to the **Proper Selection of External Components** section for proper placement and selection of the half-supply bypass capacitor.

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APPLICATION INFORMATION

Bridge Configuration Explanation
As shown in Figure 1, the CM8662 has two operational amplifiers internally, allowing for a few different amplifier configuration. The first amplifier's gain is externally configurable, while the second amplifier is internally fixed in a unity-gain, inverting configuration. The closed-loop gain of the first amplifier is set by selecting the ratio of R_f to R_i while the second amplifier's gain is fixed by the two internal $10k\Omega$ resistors. Figure 1 shows that the output of amplifier one serves as the input to amplifier two which results in both amplifiers producing signals identical in magnitude, but out of phase $180°$. Consequently, the differential gain for the IC is

$$A_{VD} = 2*(R_f/R_i)$$

By dividing the load differentially through output V_{o1} and V_{o2}, and amplifier configuration commonly referred to as "bridged mode" is established. Bridged mode operation is different from the classical single-ended amplifier configuration where one side of the load is connected to ground.
A bridge amplifier design has a few distinct advantages over the single-ended configuration, as it provides differential drive to the load, thus doubling output swing for a specified supply voltage. Consequently, four times the output power is possible as compared to a single-ended amplifier under the same conditions. This increase in attainable output power assumes that the amplifier is not current limited or clipped. In order to choose an amplifier's closed-loop gain without causing excessive clipping which will damage high frequency transducers used in loudspeaker systems, please refer to the **Audio Power Amplifier Design** section.

A bridge configuration, such as the one used in CM8662, also creates a second advantage over single-ended amplifier. Since the differential outputs, V_{o1} and V_{o2}, are biased at half-supply, no net DC voltage exists across the load. This eliminates the need for an output coupling capacitor which is required in a single supply, single-ended amplifier configuration. Without an output coupling capacitor, the half-supply bias across the load would result in both increased internal IC power dissipation and also permanent loudspeaker damage.

Power Dissipation
Power dissipation is a major concern when designing a successful amplifier, whether the amplifier is bridged or single-ended. A direct consequence of the increased power delivered to the load by a bridge amplifier is an increase in internal power dissipation. Equation 1 states the maximum power dissipation point for a bridge amplifier operating at a given supply voltage and driving a specified output load.

$$P_{DMAX} = 4*(V_{DD})^2/(2\pi^2 R_L) \qquad (1)$$

Since the CM8662 has two operational amplifiers in one package, the maximum internal power dissipation is 4 times that of a single-ended amplifier. Even with this substantial increase in power dissipation, the CM8662 does not require heatsinking. From Equation 1, assuming a 5V power supply and an 8Ω load, the maximum power dissipation point is 625mW. The maximum power dissipation point obtained from Equation 1 must not be greater than the power dissipation that results from Equation 2:

$$P_{DMAX} = (T_{JMAX} - T_A)/\Theta_{JA} \qquad (2)$$

For package M08A, Θ_{JA}= 170℃/W and for package N08E, Θ_{JA}= 107℃/W. T_{JMAX}=150℃ for the CM8662. Depending on the 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 wither the supply voltage must be decreased, the load impedance increased, or the ambient temperature reduced. For the typical application of a 5V power supply, with an 8Ω load, the maximum ambient temperature possible without violating the maximum junction temperature is approximately 44℃ provided that device operation is around the maximum power dissipation point. Power dissipation is a function of output power and thus, if typical operation is not around the maximum power dissipation point, the ambient temperature can be increased. Refer to the **Typical Performance Characteristics** curves for power dissipation information for lower output powers.

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. As displayed in the **Typical Performance Characteristics** section, the effect of a larger half supply bypass capacitor is improved PSSR due to increased half-supply stability. Typical applications employ a 5V regulator with $10\mu F$ and a $0.1\mu F$ bypass capacitors which aid in supply stability, but do not eliminate the need for bypassing the supply nodes of the CM8662. The selection of bypass capacitors, especially C_B, is thus dependant upon desired PSSR requirements, click and pop performance as explained in the section, Proper Selection of External Components, system cost, and size constraints.

Shutdown Function
In order to reduce power consumption while not in use, the CM8662 contains a shutdown pin to externally turn off the amplifier's bias circuitry. The shutdown feature turns the amplifier off when a logic high is placed on the shutdown pin. The trigger point between a logic low and logic high level is typically half supply. It is best to switch between ground and supply to provide maximum device performance. By switching the shutdown pin to V_{DD}, the CM8662 supply current draw will be minimized in idle mode. While the device will be disabled with shutdown pin voltage less than V_{DD}, the idle current may be greater than the typical value of $0.7\mu A$. In either case, the shutdown pin should be tied to a definite voltage because leaving the pin floating may result in an unwanted shutdown condition.
In many applications, a microcontroller or microprocessor output is used to control the shutdown circuitry which provides a quick, smooth transition into shutdown. Another solution is to use a single-pole, single-throw switch that when closed, is connected to ground and enables the amplifier. If the switch is open, then a soft pull-up resistor of $47k\Omega$ will disable the CM8662. There are no soft pull-up resistors inside the CM8662, so a definite shutdown pin voltage must be applied externally, or the internal logic gate will be left floating which could disable the amplifier unexpectedly.

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APPLICATION INFORMATION (CONTINUED)

Proper Selection of External Components

Proper selection of external components in applications using integrated power amplifiers is critical to optimize device and system performance. While the CM8662 is tolerant of external component combinations, consideration to component values must be used to maximize overall system quality.

The CM8662 is unity-gain stable which gives a designer maximum system flexibility. The CM8662 should be used in low gain configurations to minimize THD+N values, and maximize the signal to noise ratio. Low gain configurations require large input signals to obtain a given output power. Input signals equal to or greater than 1Vrms 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.

Besides gain, one of the major considerations is the closed-loop bandwidth of the amplifier. To a large extent, the band-width is dictated by the choice of external components shown in Figure 1. The input coupling capacitor, C_j, forms a first order high pass filter which limits low frequency response. This value should be chosen based on needed frequency response for a few distinct reasons.

Selection of Input Capacitor Size

Large input capacitors are both expensive and space hungry for portable design. 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 100-150Hz. Thus using a large input capacitors may not increase system performance.

In addition to system cost and size, click and pop performance is effected by the size of the input coupling capacitor, C_j. A larger input coupling capacitor requires more charge to reach its quiescent DC voltage (nominally 1/2 V_{DD}). This charge comes from the output via the feedback and is apt to create pops upon device enable. Thus, by minimizing the capacitor size based on necessary low frequency response, turn-on pops can be minimized.

Besides minimizing the input capacitor size, 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 CM8662 turns on. The slower the CM8662's, outputs ramp to their quiescent DC voltage (nominally 1/2 V_{DD}), the smaller the turn-on pop. Choosing C_B equal to 1.0 μF along with a small value of C_j (in the range of 0.1 μF to 0.39 μF), should produce virtually clickless and popless shutdown function. While the device will function properly, (no oscillations or motorboating), with C_B equal to 0.1 μF, the device will be much more susceptible to turn-on clicks and pops. Thus, a value of C_B equal to 0.1 μF or larger is recommended in all but the most cost sensitive designs.

Audio Power Amplifier Design
Design a 500mW/8Ω Audio Amplifier
Given:

Power Output	500mWrms
Load Impedance	8Ω
Input Level	1 Vrms
Input Impedance	20kΩ
Bandwidth	100Hz-20kHz$\pm$0.25dB

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. Using this method, the minimum supply voltage would be ($V_{opeak} + (2*V_{OD})$), where V_{OD} is extrapolated from the Dropout Voltage vs Supply Voltage curve in the Typical Performance Characteristics section.

$$V_{opeak} = \sqrt{(2R_LP_0)} \qquad (3)$$

Using the Output Power vs Supply Voltage graph for an 8Ω load, the minimum supply rail is 4.3V. But 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 CM8662 to reproduce peaks in excess of 500mW 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.

Once the power dissipation equations have been addressed, the required differential gain can be determined from Equation 4.

$$A_{VD} \geq \sqrt{(R_LP_0)}/(V_{IN}) = V_{orms}/V_{inrms} \qquad (4)$$
$$R_i/R_f = A_{VD}/2 \qquad (5)$$

For Equation 4, the minimum A_{VD} is 2; use A_{VD}=2. Since the desired input impedance was 20kΩ, and with a AVD of 2, a ratio of 1:1 of R_f to R_i results in an allocation of $R_i=R_f$= 20kΩ. 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 which is better than the required $\pm$0.25dB specified. This fact results in a low and high frequency pole of 20Hz and 100kHz respectively. As stated in the External Components section, R_j in conjunction with C_j create a highpass filter.

$$C_j \geq 1/(2\pi*20\ k\Omega*20Hz)=0.397\ \mu F; \text{ use } 0.39\ \mu F$$

The high frequency pole is determined by the product of the desired high frequency pole, f_H, and the differential gain, A_{VD}. With an A_{VD}=2 and f_H=100kHz, the resulting GBWP of 12.5MHz. This figure displays that if a designer has a need to design an amplifier with a high differential gain, the CM8662 can still be used without running into bandwidth problems.

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Application circuit :

CM8662典型应用电路图
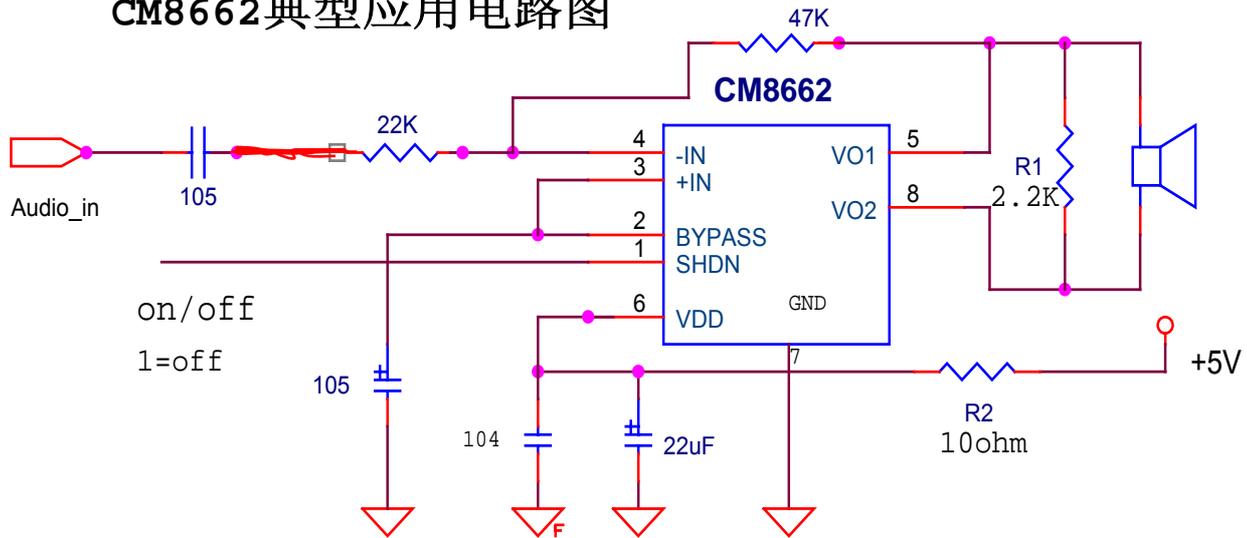
R1,R2有助于抑制纹波和噪音,提高PSRR和信噪比

如果环境不恶劣，R1,R2 都可以省略掉

增大 **47K** 的反馈电阻来提高放大倍数和输出功率
减小 **47K** 的反馈电阻来降低放大倍数和输出功率

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PACKAGE DIMENSION

8-PIN DIP8
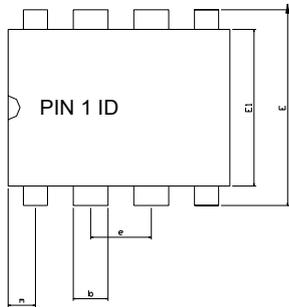
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A	---	---	4.32	---	---	0.170
A1	0.38	---	---	0.015	---	---
b	1.40	---	1.65	0.055	---	0.065
b1	0.40	---	0.56	0.016	---	0.022
C	0.20	---	0.31	0.008	---	0.012
D	9.27	---	9.77	0.365	---	0.385
E	7.49	---	8.26	0.295	---	0.325
E1	6.09	---	6.61	0.240	---	0.260
e	---	2.54	---	---	0.100	---
L	3.18	---	---	0.125	---	---
m	0.50	---	---	0.02	---	---
θ	0°	---	15°	0°	---	15°
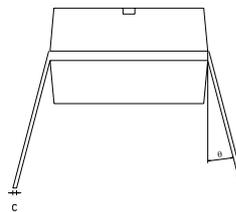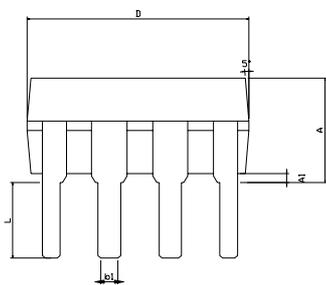
8-PIN SOP8
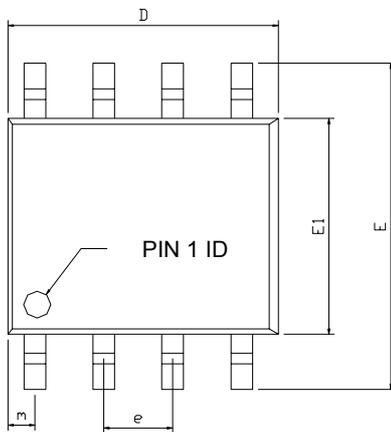
SYMBOLS	DIMENSIONS IN MILLIMETERS			DIMENSIONS IN INCHS		
	MIN	NOM	MAX	MIN	NOM	MAX
A1	0.10	---	0.25	0.004	---	0.010
A2	1.40	---	1.55	0.055	---	0.061
b	0.30	---	0.51	0.012	---	0.020
C	0.15	---	0.26	0.006	---	0.010
D	4.60	---	5.06	0.169	---	0.199
E	5.79	---	6.20	0.228	---	0.244
E1	3.76	---	4.01	0.148	---	0.158
e	---	1.27	---	---	0.050	---
L	0.38	---	0.69	0.015	---	0.035
m	0.43	---	0.69	0.017	---	0.027
θ	0°	---	8°	0°	---	8°