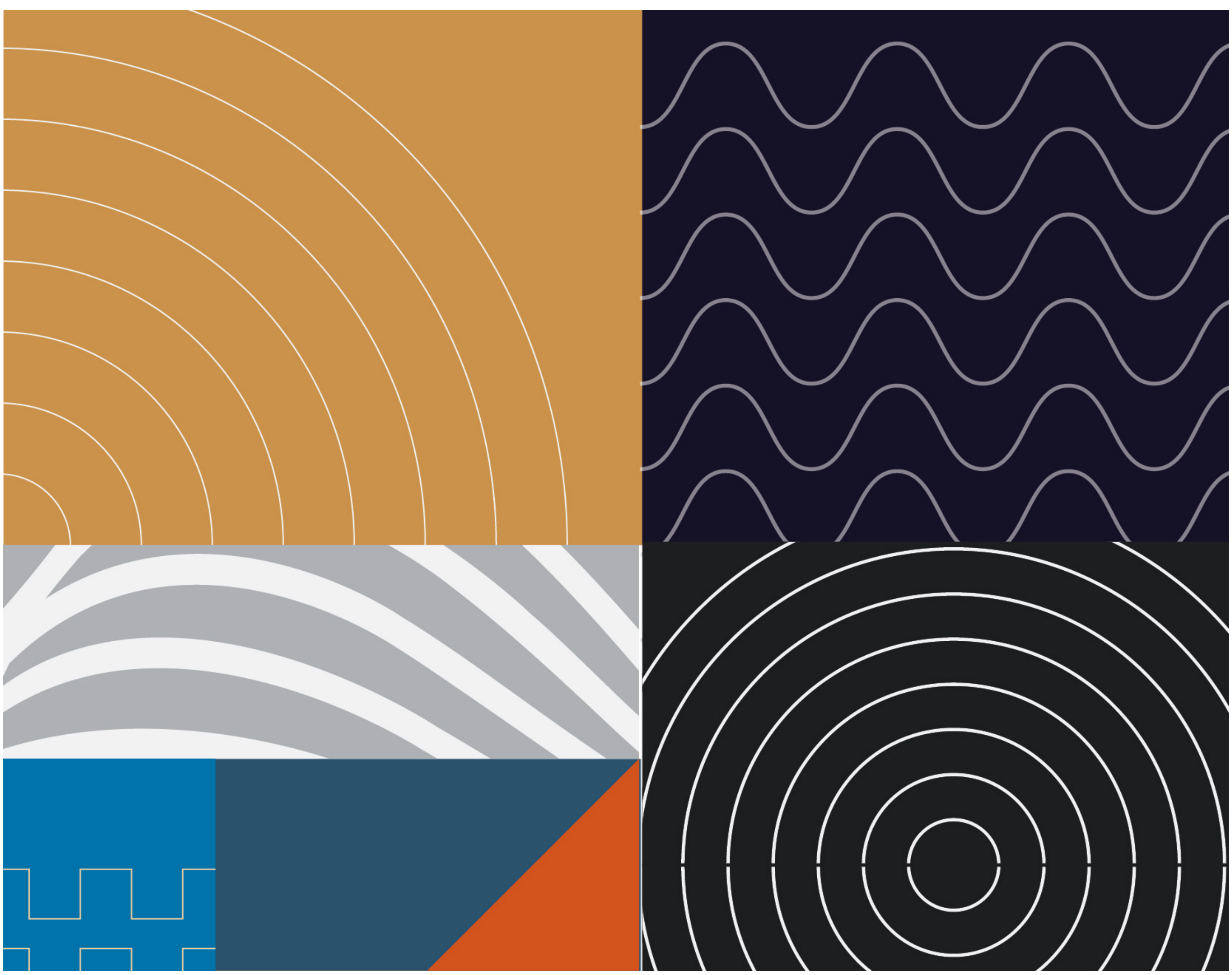
NEW PRODUCT HIGHLIGHT

SPEAKERS



PUIAUDIO.COM

Table of Contents

New Speaker Part Numbers

PUIaudio

AS04016MR-4-LW34

Key Features:
- SPL: 90dB 680Hz~10kHz (0.1W sinewave, 0.1m)
- Rated Input Power: 2W
- Maximum Input Power: 2.5W
- Impedance: 16Ohm
- Φ40mm, Height: 6.5mm
- Operating Temperatures: -40～+85 ℃
- Suggested sealed back-volume: 91.12cc
- Wire Leads for easy installation
- IP 65 Rated

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PUIaudio

AS05004MR-4-LWC45

Key Features:
- SPL: 103dB 530Hz~20kHz (2W sinewave, 0.1m)
- Rated Input Power: 2W
- Maximum Input Power: 3W
- Impedance: 4Ohm
- Φ50mm, Height: 11.8mm
- Operating Temperatures: -20～+60 ℃
- Suggested sealed back-volume: 166.4cc
- Wire Leads for easy installation
- IP 67 Rated

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PUIaudio

AS05404PS

Key Features
- SPL: 82dB 115Hz~20kHz 1W sinewave, 1m
- Rated Input Power: 10W
- Maximum Input Power: 12W
- Impedance: 4Ohm
- Φ54mm, Height: 36.7mm
- Operating Temperatures: -40～+85 ℃
- Suggested sealed back-volume: 234.7cc

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PUIaudio
WHEN IT NEEDS TO BE HEARD

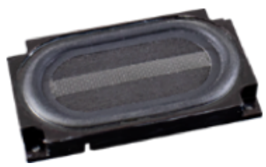
New Speaker Part Numbers

PUIaudio

AS05508MO

Key Features

- SPL: 85dB 300Hz~20kHz 1W sinewave, 1m
- Rated Input Power: 3W
- Maximum Input Power: 4W
- Impedance: 8Ohm
- 55mm x 30.5mm, Height: 13mm
- Operating Temperatures: -40～85 ℃
- Suggested sealed back-volume: 114.4cc
- IP65 Rated



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ASE05008MS-LWC60

Key Features

- SPL: 97dB 680Hz~20kHz 2W sinewave, 0.1m
- Rated Input Power: 2W
- Maximum Input Power: 2.5W
- Impedance: 8Ohm
- Compact Enclosure: 50mm x 35mm x 27.8mm (includes 1mm silicon pad)
- Operating Temperatures: -40～+85 ℃
- Wire Leads for easy installation
- IP 67 Rated

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PUIaudio

AS05008MR-15

Key Features:

- SPL: 93dB 650Hz~10kHz 1.0W Sine wave .1m
- Rated Input Power: 2.5W
- Maximum Input Power: 3W
- Impedance: 8Ohm
- Φ50mm, Height: 17mm
- Operating Temperatures: -40～+80 ℃
- IP 65 Rated

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PUIaudio
WHEN IT NEEDS TO BE HEARD

Overview

PUI Audio is excited to offer new micro speakers in the 40-55mm size range. These micro speakers meet the needs of applications that increasingly demand better performance in smaller footprints. Key models use strong magnets along with a mylar diaphragm to help deliver reliable sound reproduction that improves user experience. Most of these new products are ingress protected and can withstand high temperatures up to 85 °C, which makes them ideal for harsh and hazardous environments. To ease installation, some of the featured speakers include wire leads and flange mount. Key applications include diagnosis & monitoring medical devices as well as various Industrial & consumer devices.

Application/Drive Circuit

This application note illustrates the techniques and hardware required to interface the devices to Class AB and Class D power amplifiers.
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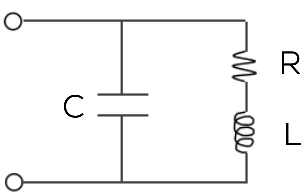
Functional Description

The basic speaker model is a cone, voice coil driven permanent magnet speaker assembly. The enclosure is designed to optimize the speaker assembly frequency response and match the acoustic impedance of the speaker to the surrounding media to obtain maximum efficiency and sound pressure level output. The enclosure main goal is to prevent the speaker's back-wave from interfering with its front wave and creating partial acoustic cancellation. Additionally and equally important, It does allow higher possible drive voltages: the air contained within the enclosure acts as a restorative force that works to return the diaphragm to its quiescent position. As the drive voltage increases, producing increased excursion, the air's spring-force increases, applying ever greater restorative force.
The equivalent electric circuit for a speaker is shown in Figure 1. (Note the similar equivalent circuit for the electromechanical devices).

Speaker Equivalent Circuit

Figure 1



R = Resistance of voice coil and lead wires
L = Inductance of voice coil and lead wires
C = Distributed capacitance

The speaker resistance dominates the electrical characteristics in the normal operating range of 500 Hz to 4 kHz and the speaker appears to be a resistive load to the driving circuit and an inductive load with rising impedance as the drive signal's frequency increases to 20kHz.

Defining Operating Power Level

These new speakers have a maximum power rating of up to 12W. This simply means that the product of the applied RMS voltage and RMS current PLUS any steady state DC voltage and current must not exceed 12W per the following equation:

Equation 1

Power Rating Calculation

$$\text{Total Power } (P_t) \leqslant 12\text{ W} = (E_{RMS})(I_{RMS}) + (E_{DC})(I_{DC})$$

Exceeding this operational limit will cause power dissipation in the voice coil that could result in the coil to mechanically distorting. This distortion could result in mechanical interference between other parts of the speaker components: the magnet structure or the frame. Further, the speaker diaphragm's peak-to-peak excursion limits could be violated, resulting in mechanical deformation of the speaker diaphragm's suspension, which can be unrecoverable. Perceived audio distortion may be noted and continued operation outside the speaker electrical and mechanical limits will typically cause voice coil destruction.

The maximum continuous RMS current that may be applied to the 4Ω or 8Ω speaker assemblies may be calculated.

EXAMPLE 1

$$\text{Power} = (I_{RMS}^2)(R_{SPEAKER})$$

$$I_{RMS} = \left(\frac{P}{R}\right)^{1/2}$$

Speaker Model	Impedance (Ω)	Nominal Power (W)	I_{RMS} (A)
AS04016MR-4-LW34	16	2	0.35
AS05404P	4	10	1.58
AS05004MR-4-LWC45	4	2	0.71
AS05008MR-15	8	2.5	0.56
AS05508MO	8	3	0.61
ASE05008MS-LWC60	8	2	0.50

The minimum RMS voltage required to drive the speakers to maximum power output may be calculated as shown in EXAMPLE 2.

EXAMPLE 2

$$PRMS = (I_{RMS})(V_{RMS})$$

$$VRMS = \frac{P_{RMS}}{I_{RMS}}$$

Speaker Model	Nominal Power (W)	I_{RMS} (A)	V_{RMS} (V)
AS04016MR-4-LW34	2	0.35	5.65
AS05404PS	10	1.58	6.33
AS05004MR-4-LWC45	2	0.71	2.82
AS05008MR-15	2.5	0.56	4.46
AS05508MO	3	0.61	4.92
ASE05008MS-LWC60	2	0.50	4.00

The RMS voltage and current driving the speaker must be calculated from knowledge of the driving waveform.

General Driving Considerations

The speaker assemblies may be directly driven from many circuits with DC coupling. However, any DC offset voltage or current must be continuously dissipated in the speaker. Even more important, any DC voltage present at the speaker connection terminals will produce a constant diaphragm offset. This constant offset will impact the speaker's sound pressure level (SPL) (reducing it) negatively and introducing nonlinearities in the speaker's acoustic output (increasing THD).

It is usually more desirable to AC couple the output to the speaker using a capacitor in series with the speaker as shown in Figure 2.

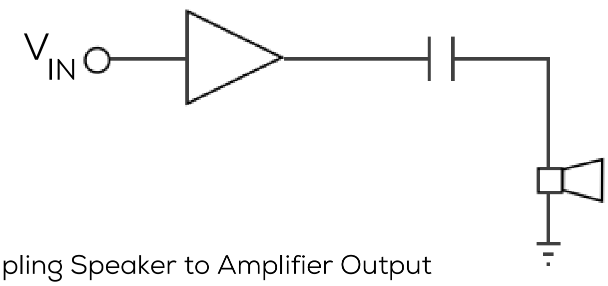


Figure 2 AC-Coupling Speaker to Amplifier Output

The capacitor will block any DC component in the amplifier's output signal and couple the remaining AC output component to the speaker. The capacitor working against the speaker's nominal impedance forms a highpass filter. The filter's cutoff frequency is found using the equation 2

f = 1/2piRC

$C = 1/2\pi Rf$ Equation 2

As an example, an 8Ohm speaker with a nominal low frequency response of 500Hz could use a coupling capacitor with the following value.

$C = 1/2\pi(8)(500)$

$C = 39.8\mu F$

In this example, to ensure that the high-pass cutoff frequency is at least 500Hz, a 47μF standard value is a good choice.

A polarized capacitor may be used if the AC coupled output is always referenced to ground. This is the case with any driving circuit operating from a single supply (V+ and GND). If a split supply (V+ and V-) powers the driving circuit, a non-polarized capacitor can be used to ensure that any input offset voltage that is amplified by the circuit is blocked at the output. This type of capacitor is required because the voltage across it will reverse when the AC output waveform crosses the zero axis and the most polarized electrolytic capacitors can only withstand a 1 to 3 volt reverse polarity.

The AC RMS current should be computed or measured and compared to the capacitor manufacturer's permissible RMS ripple current specification. Selecting a capacitor with a ripple that matches or exceeds the measured or computed value contributes to a long operating life for the capacitor. The ripple current will act with the capacitor's Equivalent Series Resistance (ESR) value to generate heat.

Aluminum electrolytic capacitor will meet most requirements while providing a range of ripple current specifications necessary to drive the 8Ω speaker at full power.

The optimum capacitor value should always be chosen to maximize circuit operation. If the application only requires the generation of a single tone or limited bandwidth audio signal, then the capacitor should be sized at the operating frequency per equation 2.

Analog Amplifier Applications

Analog amplifier circuits are those that amplify a continuous analog waveform and drive a speaker, producing acoustic output. The acoustic output is proportional to the instantaneous amplitude of an signal applied to the amplifier's input.

The most cost-effective means of driving a speaker is to utilize one of the many inexpensive monolithic power audio amplifiers that are currently available from several domestic and foreign sources. Typical complete circuits, powered by 10V to 22V, are shown in figure 3.

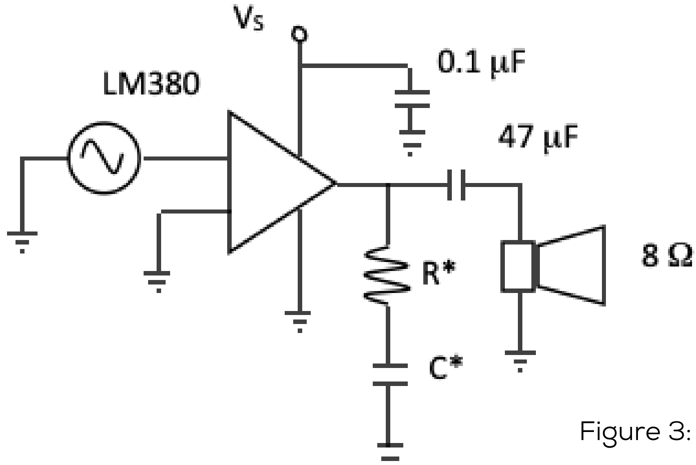


Figure 3: Low Power Audio Amplifier Circuits

Internally set, non-inverting gain: VOUT/VIN = 50

*R = 2.7 Ω and *C = 0.1 μF may be needed to suppress zero crossing, transient oscillations.

Bridge-Tied-Load (BTL) Drive Circuits

Ease of design, single 5V supply, an output voltage swing that is twice that achieved by a single amplifier, and elimination of a coupling capacitor between the amplifier output and the speaker makes a BTL amplifier one of the best choices to drive speakers. Internally, this amplifier topology consists of two inverting amplifiers in operating in series, with the speaker connected between the two outputs.

A typical BTL circuit is shown in Figure 4. This amplifier is able to force a1W with no more than 1% THD into an 8Ω speaker load while operating on a single 5V supply voltage

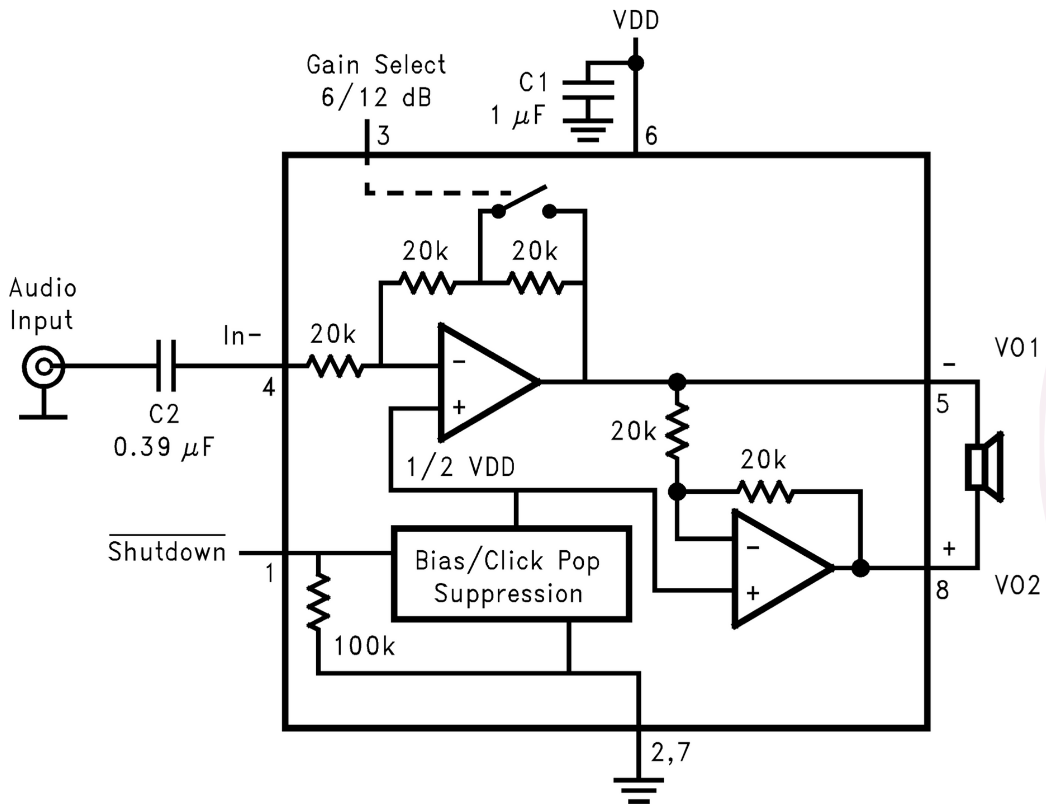


Figure 4. LM4906 Bridge-Tied Load (BTL) Amplifier

Higher Power Analog Amplifier

For those applications that require more than 1W of drive power, the circuit shown in Figure 5 will meet that need. This amplifier can deliver up to 20W while operating on a 45V supply voltage. The output power scales with supply voltage: if 10W is desired, the supply voltage is a nominal 32V.

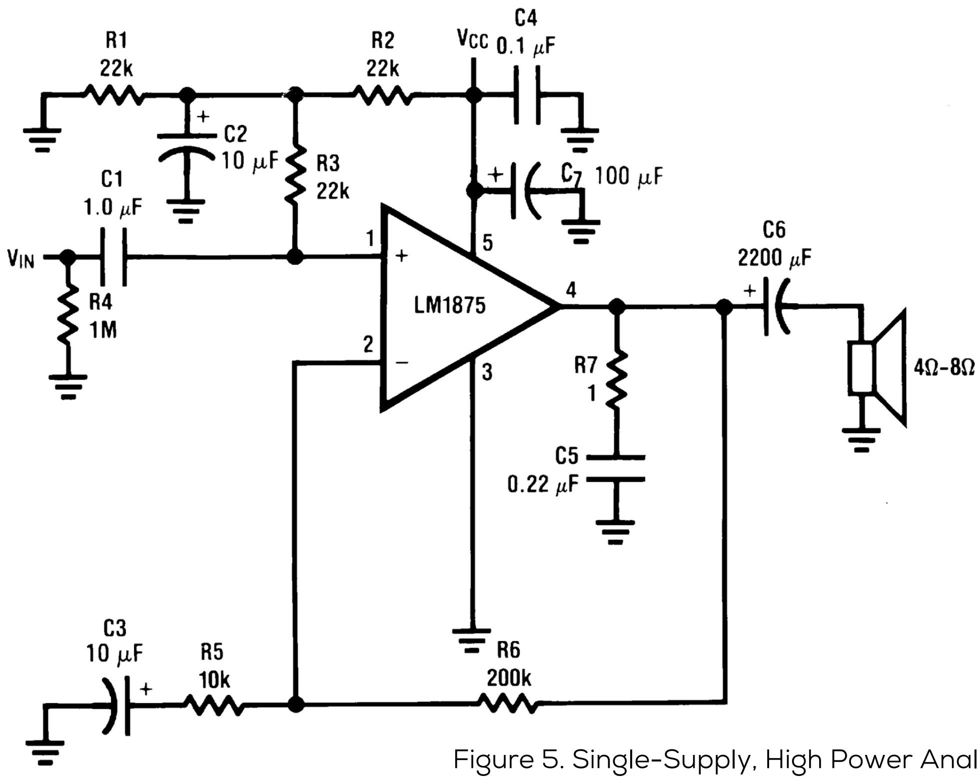


Figure 5. Single-Supply, High Power Analog Amplifier

As Figure 5 shows, the value of C6 working with an 8Ω speaker load results in a high pass filter with a cutoff frequency of approximately 9Hz. The output coupling capacitor value can easily be changed to accommodate a high pass cutoff consistent with a speaker's low frequency response characteristics. Equation 2 (reproduced as Equation 3) can be used to find an alternate value of C6.

$C = 1/2\pi R(\Omega)f(Hz)$ Equation 3

As an example, for a speaker with a low frequency response that begins a roll-off at 300Hz, we can set the cutoff at 200Hz by changing C6 as follows:

$C = 1/2\pi(8\Omega)(200Hz)$

$C = 100\mu F$

If a split power supply is available, the output capacitor can be eliminated, as shown in Figure 6.

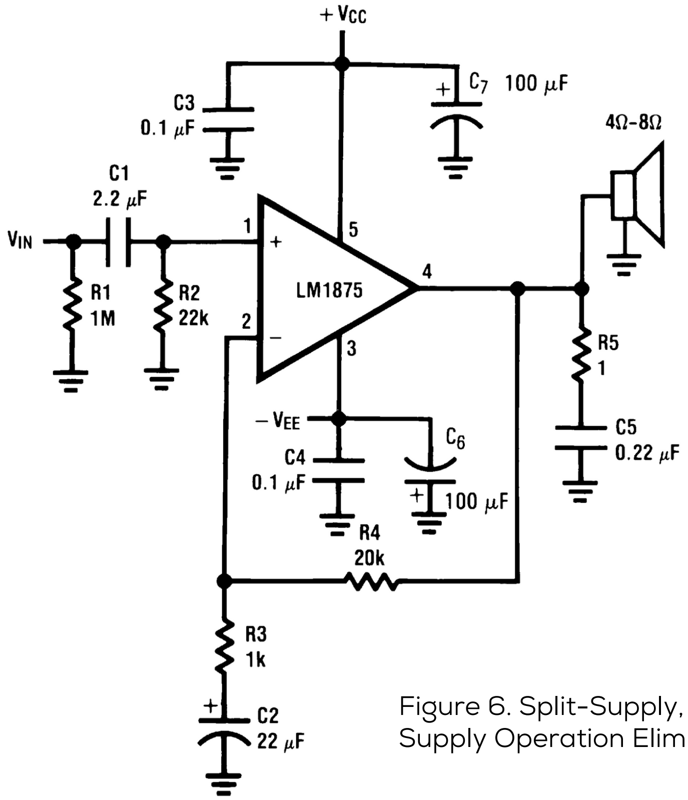


Figure 6. Split-Supply, High Power Analog Amplifier. The Split-Supply Operation Eliminates Figure 5's Output Coupling Capacitor

The power supply voltage for the amplifier shown in Figures 5 and 6 can be selected as a function of the desired output power specified for a speaker driver. Table 1 list the supply (both single-ended and split) for a range of output power.

8Ω Output Power (W)	Single Supply (V)	Split Supply (±V)
3	16	8
4	20	10
10	32	16

Class D Amplifiers

Class D amplifiers, when compared to the Class AB amplifiers shown above, have the major benefit of higher efficiency when compared to analog amplifiers operating at the same output power level. While historically these amplifiers required output filters to suppress the switching frequency present in the output signal, many current designs are filterless, further increasing the system efficiency through reduced parts count. This amplifier operates on a single supply (applied to pin B1 and B2) with a range of 2.5V to 5.5V. At VDD = 5.0V, the output power into an 8Ω load is a nominal 1.46W and 2.57W into a 4Ω load.

The example circuit shown in Figure 7.

This device has two gain settings, determined by the voltage applied the GAIN pin (A2). A gain of 6dB is selected by connecting GAIN to the supply voltage (VDD) and a gain of 12dB is achieved by applying GND.

The input coupling capacitor (CI in Figure 7) value working with the input resistance of IN- will determine the cutoff frequency of the highpass filter formed at the amplifier's input. The input resistance is a function of the voltage applied to the GAIN pin: with the supply voltage applied, the input resistance is a nominal 150kΩ; with GND applied to the GAIN pin, the input resistance is 75kΩ. Therefore, the capacitor's value can be determined as follows

$CI = 1/2\pi(R_{IN})f_{-3dB}$ Equation 4

If, for example, a cutoff of 100Hz is desired, CI is found to be

10.6nF (GAIN = V_{DD}) (Choose 11nF as the closest standard value.)

Or

21.2nF (GAIN = GND) (Choose 22nF as the closest standard value.)

Lastly, use the same CI value for the capacitor connected between IN+ and GND.

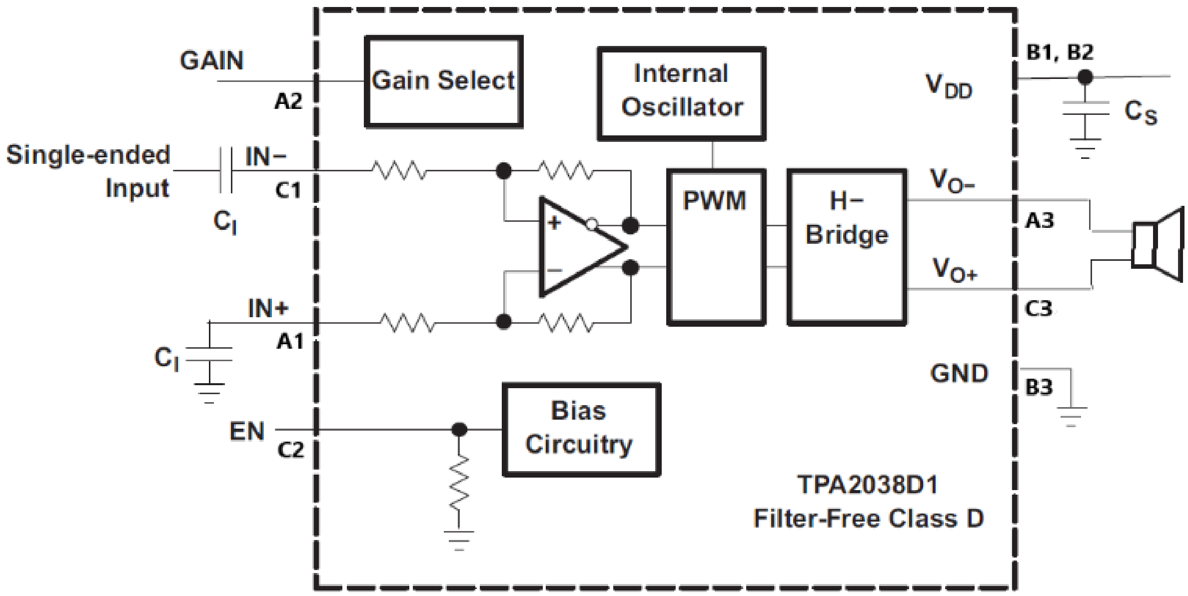


Figure 7. Filterless, Single-Supply Class D Amplifier Drives 8Ω Speaker with 1.4W

Please reference all micro speakers in the 40-55mm size range here.

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