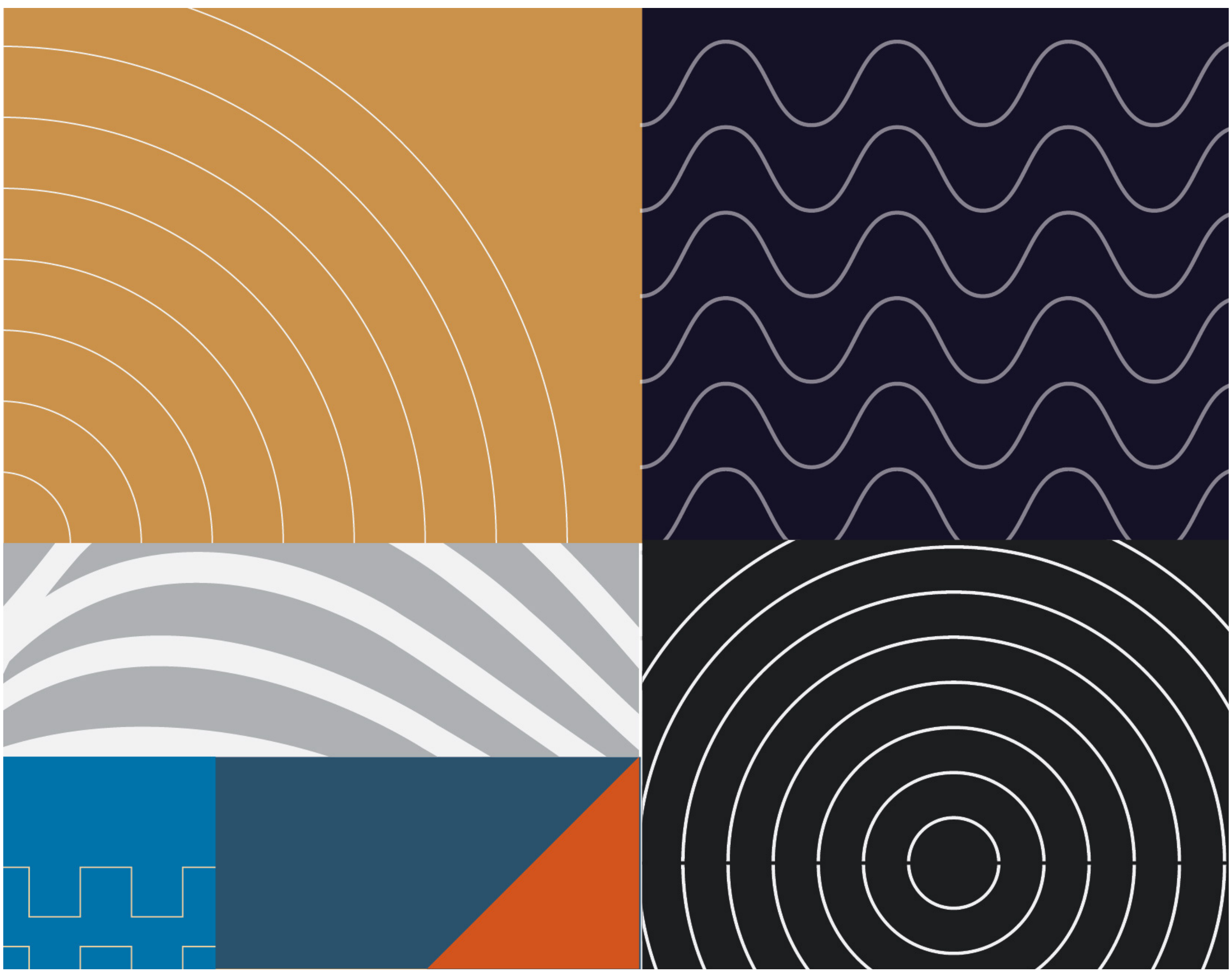
NEW PRODUCT HIGHLIGHT
JUNE 2024

SPEAKERS



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Announcement

PUI Audio is excited to introduce a new lineup of high quality speakers, available in sizes ranging from 20mm to 58mm. These new speakers' features excellent frequency response, slim profile, new footprints, and low total harmonic distortion. Additionally, some models are ingress protected and can withstand high temperatures up to 85 ℃, which makes them ideal for harsh and hazardous environments. To simplify installation, several models feature flange mount.

Whether you're developing hand-held devices, portable gadgets, or any application that demands a compact and powerful speaker solution, these new offerings from PUI Audio are the perfect fit.

20mm **25mm** **35mm** **45mm** **58mm**

New Speaker Part Number	Size (mm)	Power (Watts)	Impedance (Ohms)	Resonant Freq (Hz)	SPL (dB) at 10cm
AS02008MR-7	20	0.3	8	580	95
AS02008MR-HT-WP	20	1.2	8	1000	83
AS02208MO	22	1.0	8	1050	90
AS02204CR	22	3.0	8	850	83
AS02204MR-2	22	3.0	8	300	80
AS02308MR-T	22	1.0	8	660	90
AS02404PO	24	2.0	4	450	92
AS02504MO-SP9	25	2.0	4	700	89
AS02504AR	25	3.0	4	320	95
AS03104SR	31	12.0	4	1580	102
AS03208AS-HT	31	3.0	8	230	99
AS03204AS-HT-WP	31	3.0	4	200	97
AS03404MO-SP34	34	2.0	4	600	94
AS03504AR-T	35	4.0	4	220	97
AS03604AR	36	3.0	4	180	104
AS03804MO-SP13	38	2.0	4	600	94
AS04004MO-SP40	40	2.0	4	400	89
AS04004MR-3F	40	5.0	4	1500	102
AS04008PR-6	40	3.0	8	170	100
AS04204PR-2	42	10.0	4	160	98
AS04204PR	42	8.0	4	220	98
AS04504AS	42	6.0	4	140	97
AS04604PR	46	10.0	4	220	99
AS04804PS	48	10.0	4	150	99
AS05208PS	52	4.5	8	130	97
AS05304PS	53	10.0	8	150	99
AS05808PO-WP	58	6.0	8	450	102

- SPL noted above is at the rated input power and at a distance of 10 cm.
- For smaller speakers, resonant frequency noted is in within an enclosure, please reference actual specification.

Understanding T/S Parameters

When designing a loudspeaker enclosure, consideration of the electrical and mechanical elements that shape a speaker's performance is essential. These factors, commonly referred to as Thiele Small parameters or T/S parameters, are instrumental in shaping the sound emitted by a speaker system. The effectiveness of a speaker system is fundamentally linked to the careful design of its enclosure. By isolating the front and rear waves of the speaker, the enclosure plays a critical role in optimizing the performance.
The front wave represents the desired sound, whereas the rear wave, often out of phase, has the potential to disrupt the front wave, leading to distortion. Through strategic design, the enclosure acts as a barrier, mitigating interference and heightening overall audio clarity. In essence, the quality of the speaker system hinges on the thoughtful construction of its enclosure.

T/S parameters, pivotal components in enclosure design, can be dissected into key elements, including Resonant Frequency (Fs), Electrical Q (Qes), Mechanical Q (Qms), Total Q Factor (Qts), Equivalent Volume of Air (VAS), DC Resistance (Re), Effective Piston Area (Sd), Maximum Linear Excursion (Xmax), Power Handling (Pe), and Force Factor (BL). Each parameter plays a distinct role in shaping the speaker's behavior and response.

- Resonant Frequency (Fs): The frequency at which a speaker naturally resonates, which is measured in Hertz.
- Electrical Q (Qes): The efficiency of the internal electrical circuit, which influences the overall performance and responsiveness of the speaker.
- Mechanical Q (Qms): The efficiency of the mechanical suspension of the speaker, which affects the ability of the speaker to control its diaphragm movement.
- Total Q Factor (Qts): The combination of the electrical Q (Qes) and the mechanical Q (Qms) and represents the overall damping and efficiency. It is an indicator of a speaker’s low frequency performance, it is Qts. When searching for a speaker to satisfy a desire for good low-frequency performance, settle on speakers with Qts values lower than 0.7. These speakers will operate with minimal or no peaking at system resonance when used with a sealed enclosure volume that takes advantage of a low Qts characteristic.

Understanding T/S Parameters

- Equivalent Volume of Air (VAS): The volume of air that has the same compliance as the speaker’s and is mainly used for sealed boxes (without a vent).
- DC Resistance (Re): The resistance of the voice coil, which influences the electrical properties and power handling capabilities of the speaker.
- Effective Piston Area (Sd): The region of the diaphragm that actively participates in sound generation influences the speaker's efficiency.
- Maximum Linear Excursion(Xmax): The maximum distance the diaphragm can move in one direction and determines the speaker’s ability to reproduce low-frequency content.
- Power Handling (Pe): The maximum power the speaker can handle. (Pe is actually thermal power, determined by the maximum continuous power rating)
- Force Factor (BL): The motor strength of the speaker, as a product of the magnetic field strength (B) and the length of wire in the magnetic field (L).

T/S parameters are vital considerations in selecting speakers, yet the emphasis should not solely be on high or low values. Overall, the speaker's suitability should align with the intended application. Take, for instance, scenarios requiring the reproduction of human voices in music. In such cases, a speaker capable of covering the entire spectrum of human vocal range—with a low resonant frequency —is paramount for faithful reproduction. However, in other cases necessitating smaller, more efficient speakers where high fidelity is less critical, designing around a lower resonant frequency may not be as imperative.

Understanding T/S Parameters

Integrating these parameters, alongside speaker measurements, into modeling software like [BassBox] allows the determination of an enclosure's optimal back volume . Simulations can then predict the speaker's response across various frequencies. Taking PUI's new AS04804PS as an example, BassBox 6 Pro accurately models the low frequency performance using the speaker's T/S parameters (Figure 1) and the speaker's dimensions (figure 2).

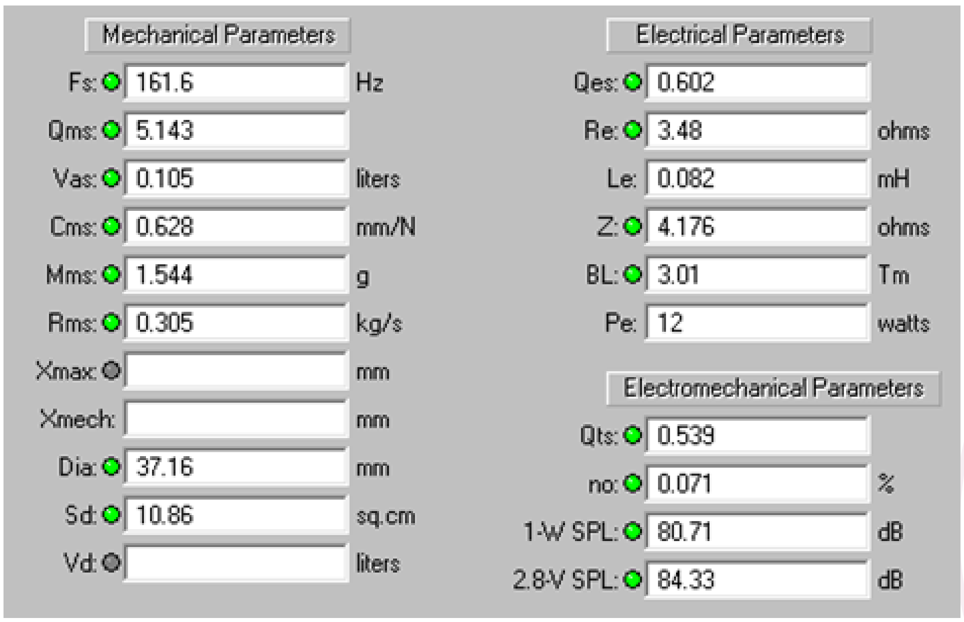


Figure 1: TS Parameters of AS04804PS

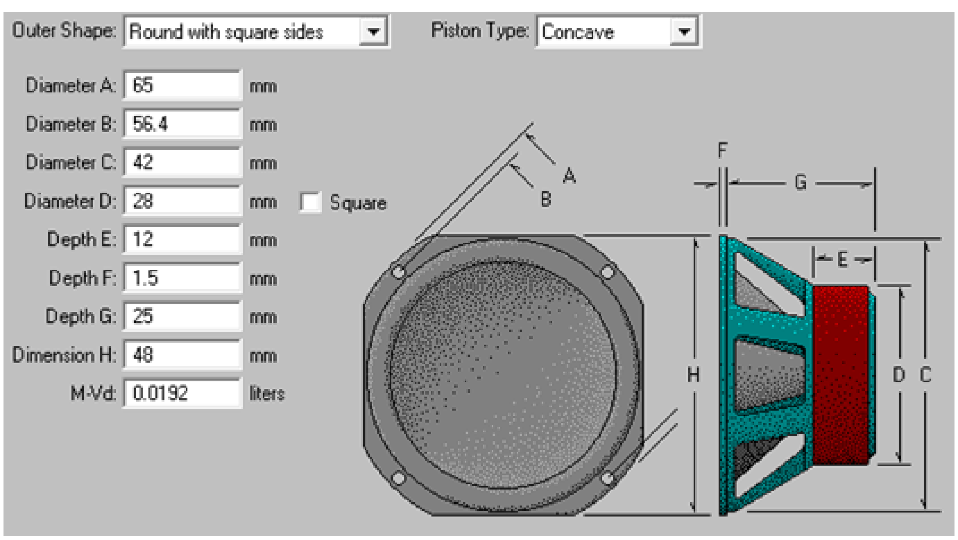


Figure 2: Dimensions of AS04804PS

Understanding T/S Parameters

After entering the T/S parameters and dimensions, the choice of enclosure type becomes pivotal. Opting for a sealed box (Figure 3) is advantageous for some speakers, while others might benefit from a vented box.

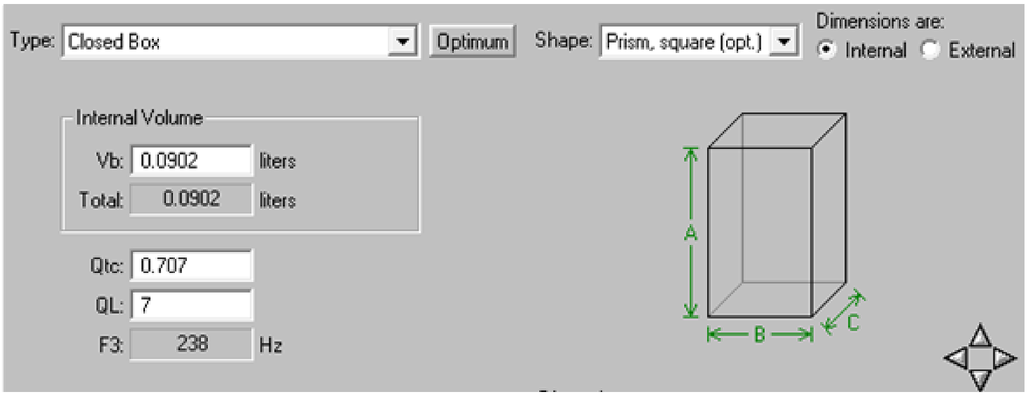


Figure 3: Sealed Box Volume for AS04804PS

Internal damping, influenced by enclosure material or additional damping material, is a critical consideration affecting the required volume for optimal speaker response. The software then calculates the enclosure and outputs a simulated response graph (Figure 4).

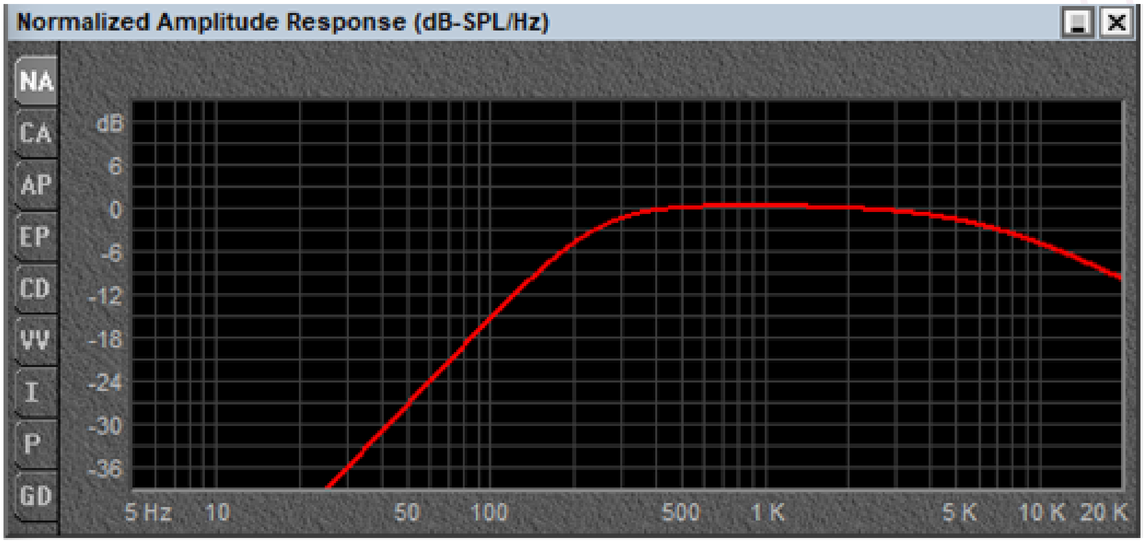


Figure 4: Simulated Response of AS04804PS

Understanding T/S Parameters

In acoustic engineering, Thiele/Small parameters are foundational to speaker design, intricately defining dynamic characteristics. The integration of these parameters into modeling software like BassBox facilitates precise optimization of loudspeaker enclosures. Practical application involves selecting enclosure types, such as sealed or vented, based on specific speaker characteristics.
The key principle lies in recognizing the direct impact of enclosure design on speaker system quality. Armed with this technical understanding, designers can navigate T/S parameters and modeling tools to achieve optimal audio experiences.

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

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

$$I_{RMS} = \left(\frac{P}{R}\right)^{½}$$

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

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

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

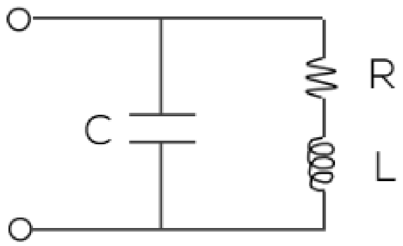
The RMS voltage and current driving the speaker must be calculated from knowledge of the driving waveform.

Speaker Driver

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).

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.

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.

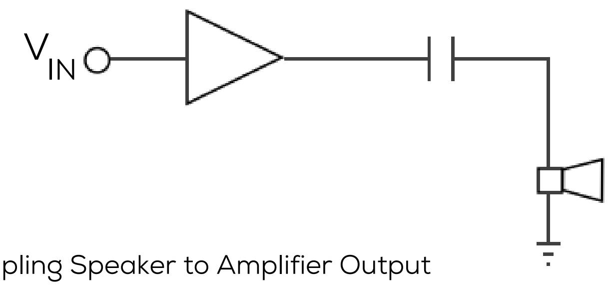


Figure 2 AC-Coupling Speaker to Amplifier Output

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.

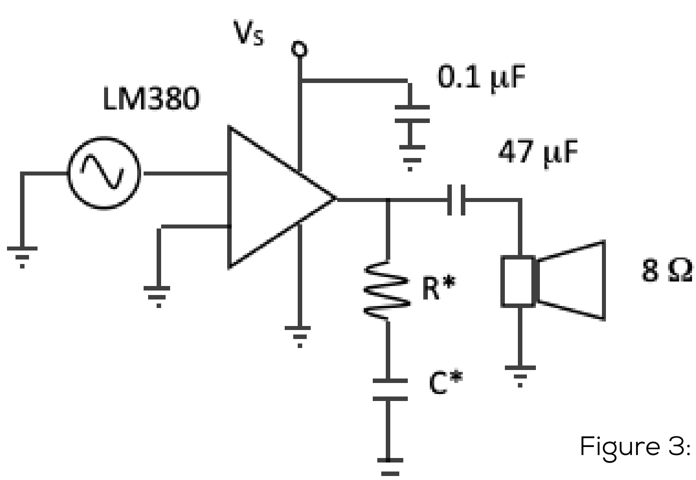


Figure 3: Low Power Audio Amplifier Circuits

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 a 1W with no more than 1% THD into an 8Ω speaker load while operating on a single 5V supply voltage

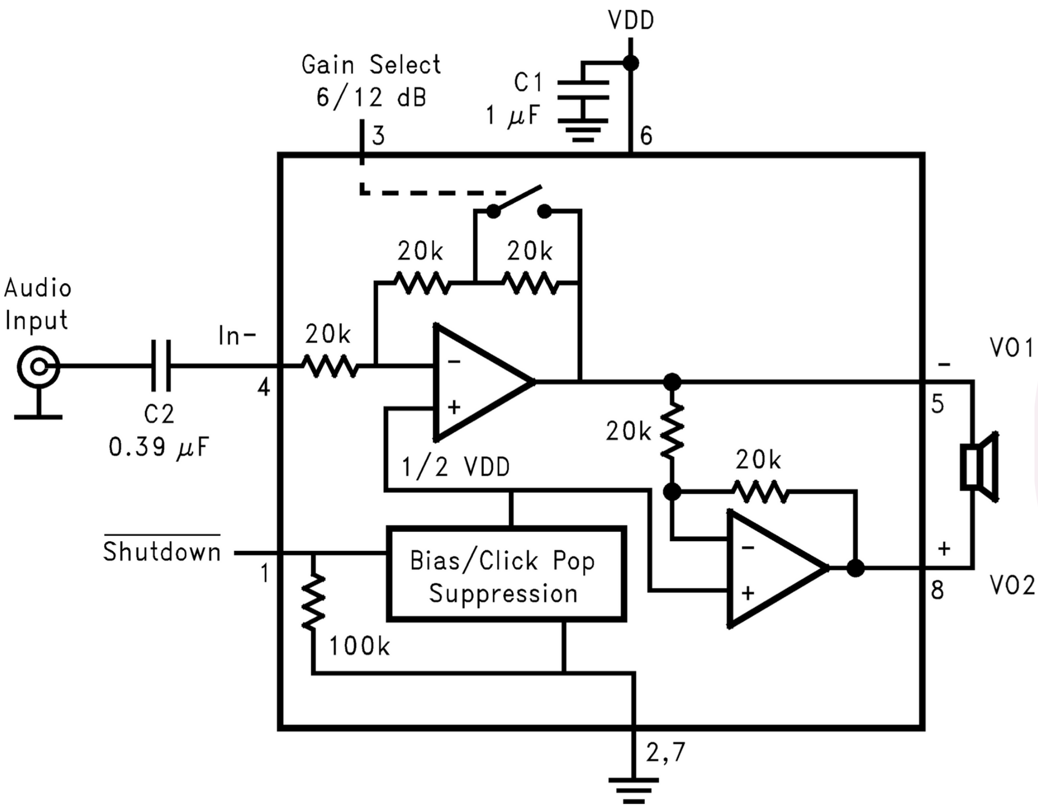


Figure 4. LM4906 Bridge-Tied Load (BTL) Amplifier

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.

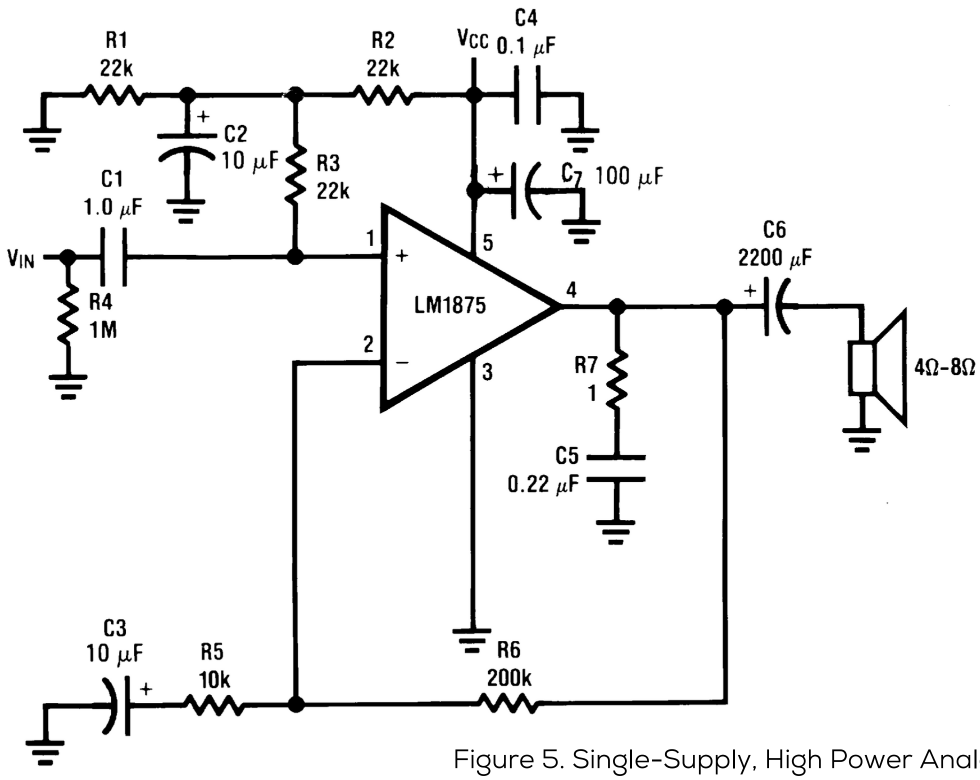


Figure 5. Single-Supply, High Power Analog Amplifier

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.

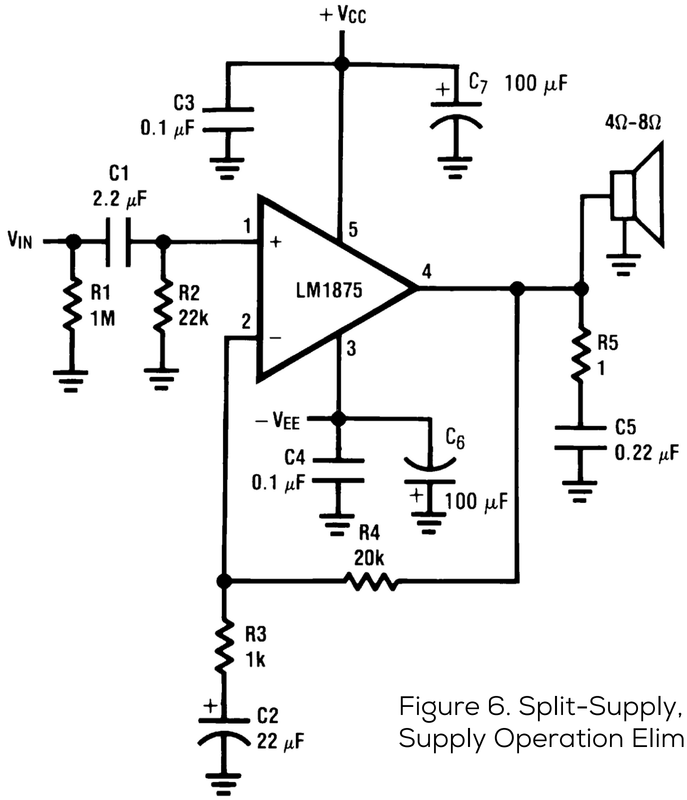


Figure 6. Split-Supply, High Power Analog Amplifier. The Split-Supply Operation Eliminates Figure 5's Output Coupling Capacitor

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

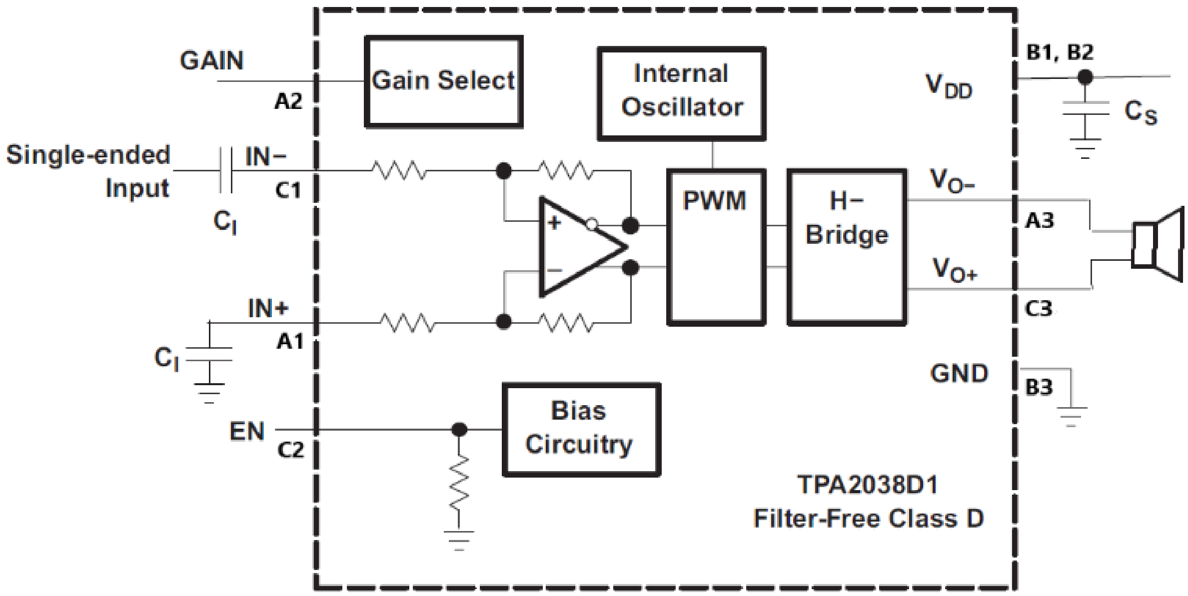


Figure 7. Filterless, Single-Supply Class D Amplifier Drives 8Ω Speaker with 1.4W

Please reference all micro speakers in the 20-58mm size range here.

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