

Piezo Audio Speakers & Amplifiers are the perfect answer for audio sound, voice messages and complex audio information into portable devices.

When there is no place"a piezo speaker feels comfortable". "Perfect fit" and "slim line" are the words you can add to your design.

A few years ago piezoelectric speakers were only known as piezo tweeters. Loudspeakers that are able to produce only high audio frequencies, typically from around 2 kHz to 20 kHz.

" Polymer/ metal membrane"

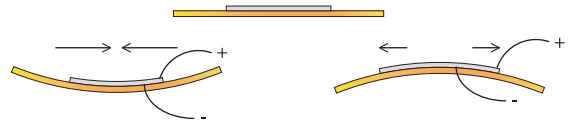
The Basic Four of Piezoelectric Audio Speakers

Piezoelectric speakers have a total different working principle than an electro dynamic speaker. There is no coil, no magnetic field and no large current consumption.

"No electro-magnetic field (EMC/EMI)"

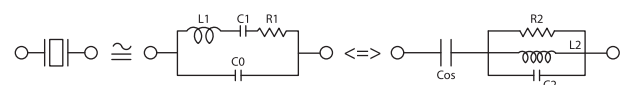
The heart of each piezoelectric speaker is a ceramic disc that interacts when it feels a certain voltage difference.

An increase of the signal amplitude V_{pp} (Voltage peak to peak), will result in a larger piezo deformation and result in a larger sound output.



"Interacting with voltage variations"
"More V_{pp} creates more sound output"

Piezoelectric speakers have a complex electronic equivalent circuit but mainly they can be seen as a capacitive load with values between 10nF and 1 μ F.



The capacitive value of the speaker is an important characteristic for the amplifier circuit of the speaker.

"Piezoelectric means capacitive load"

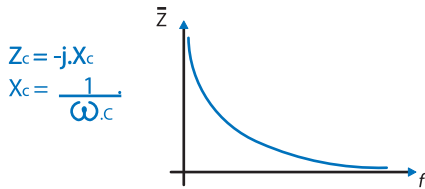
Most amplifier IC's are developed for electrodynamic speakers. They can deliver high current variations and are limited to a voltage level of +/- 10 V_{pp} .

Piezoceramic speakers demand voltage variations. The current consumption is extreme small and the voltage peak to peak level goes up to 60 V_{pp} .

"Piezo Audio Amplifier is needed"

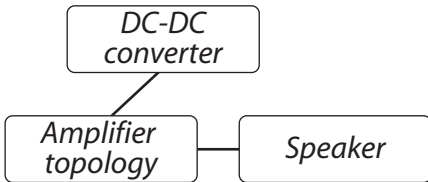
Capacitive load

Because piezoelectric speakers mainly act as a capacitive load, the complex impedance will decrease with an increase of the frequency. The capacitive reactance is an asymptotic function.

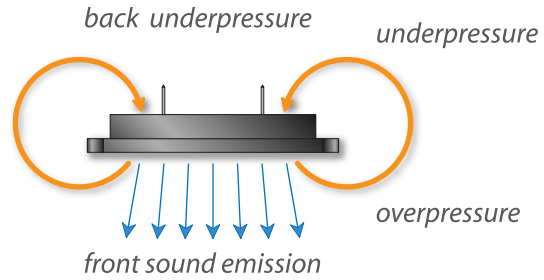
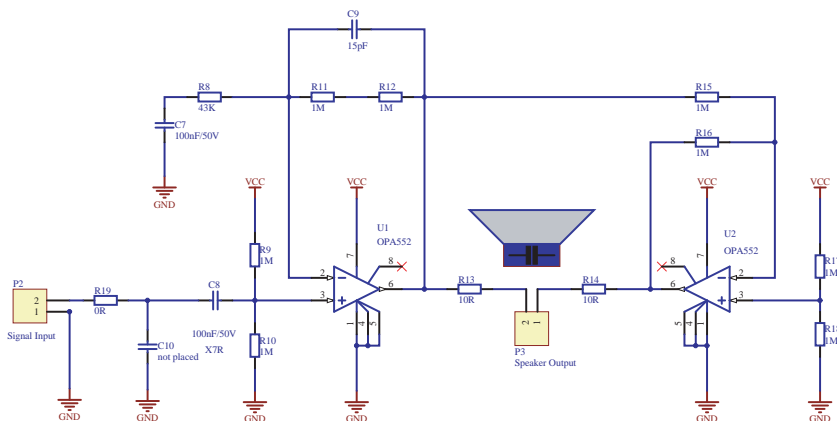


Amplifier configurations

The construction of a Piezo Audio Amplifier (PAA) consists of two basic electronic concepts.



A DC-DC converter brings a lower voltage to a higher level and creates the maximum voltage level for the end amplifier.



The end amplifier can be made out of different amplifier topologies. Class AB, class D, Class G,...

The combination and efficiency of the used DC-DC converter and amplifier topology will determine the main power consumption.

To avoid high voltage levels the Bridge-Tied Load configuration is commonly used.

An audio signal of 60 volt peak-to-peak (Vpp) can be created with a DC voltage of 30V.

Creating a voltage level of 30Vdc instead of 60Vdc is easier done with a DC-DC converter.

The piezoelectric speaker is between two amplifiers. The left side will see a 30Vpp signal while on the right the same signal of 30Vpp will appear reversed (180° phase shifted). With this technique the piezo speaker will see a total audio signal of 60Vpp.

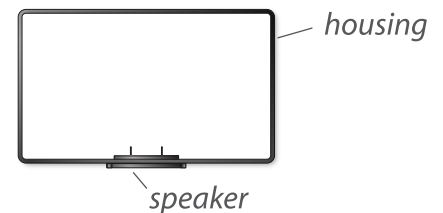
e.g. [PAA-StepUpBTL-01](#)

Fundamental acoustic mountings

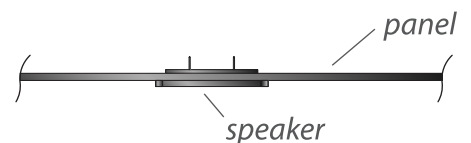
Piezoceramic speakers produce sound by the forward and backward movement of a flat membrane.

During this movement the membrane creates an air pressure wave in front and at the backside of the membrane.

A forward movement will create a slight overpressure at the frontside and a slight underpressure at the backside and vice versa. It is therefore important that the front and backside are acoustically isolated from each other to avoid air pressure cancellation and consequently a serious reduction of the sound output.



When a speaker is mounted in a panel or in the wall of a housing, the front side is acoustically isolated from the backside.



Piezoelectric Speaker Terminology

Piezo, derived from the Greek piezein, which means to squeeze or press

Piezoelectricity, is the charge which accumulates in certain solid materials (notably crystals, certain ceramics) in response to applied mechanical stress. The word piezoelectricity means electricity resulting from pressure.

Piezoceramic, is a ceramic disc with piezo characteristics. The disc will expand when a certain voltage level is applied.

Piezoelectric audio speaker, is a broadband loudspeaker made out of piezo material. Start frequency from 200Hz up to 20kHz.

SPL, Sound Pressure Level refers to a certain dB level at a certain distance.

dB, Decibel is a logarithmic unit that indicates the ratio of a physical quantity (usually power or intensity) relative to a specified or implied reference level.

A change in power ratio by a factor of 10 is a 10 dB change. A change in power ratio by a factor two is approximately a 3dB change.

Vpp, Voltage peak to peak is the voltage difference between the maximum and minimum voltage level of a signal.

PAA: Piezo Audio Amplifier is a single integrated circuit, or a PCB developed to amplify small audio signals, that drives piezoelectric audio loudspeaker elements.

Pink Noise:

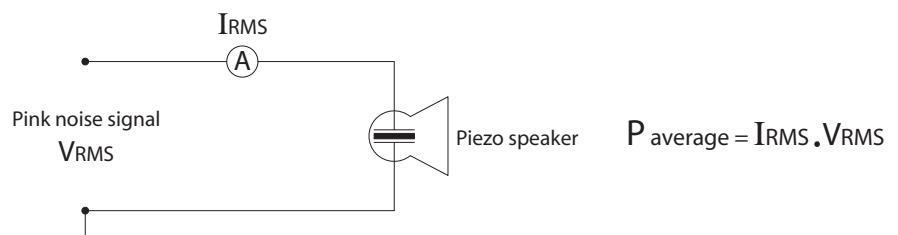
1/f noise is a signal with a frequency spectrum such that the power spectral density is inversely proportional to the frequency. In pink noise, each octave carries an equal amount of noise power. There is equal energy in all octaves (or similar log bundles)

Power consumption

The average power consumption of piezoelectric speakers can be calculated by multiplying the RMS-voltage and RMS-current.

The RMS-voltage (V_{rms}) is defined by the input signal. The used signal is a standard pink noise signal with a value of 10,6 / 21,21 V_{rms} . The signal has the same energy as a sine wave of 30 / 60Vpp

The RMS-current (I_{rms}) is measured with a true rms multimeter (Fluke 87IV) in series with the speaker. A piezoelectric speaker can mainly be seen as a capacitive load and therefore there will be no DC current consumption. The only current consumption will be of the AC-current component



Piezoelectric audio speakers will have more power consumption in the lower frequencies than electromagnetic speakers but have less power consumption in the higher frequencies.

The main power consumption will not come from the piezoelectric speaker but from the amplifier that is driving the speaker. The total concept has to be seen. How more efficient the Piezo audio amplifier is in combination with the piezoelectric speaker, how less the power consumption will be.

Piezo Audio Amplifier IC's

With the benefits of piezoelectric speakers:

- very flat
- small dimensions
- low weight
-

A lot of big electronic component companies have added specific amplifier IC's for piezoceramic speakers to their product range.



=> MAX9788
=> MAX9738



=> TPA2100P1



=> LM4960
=> LM4961
=> LM4962



=> LT3469



=> SN4915



=> AK7846
=> AK7845

Waterproof Speaker

To have the best sound output a grid pattern can be made in the house of your application. A fine grid pattern is recommended.

The piezoelectric speaker has to be fixed with silicone glue above the pattern holes.

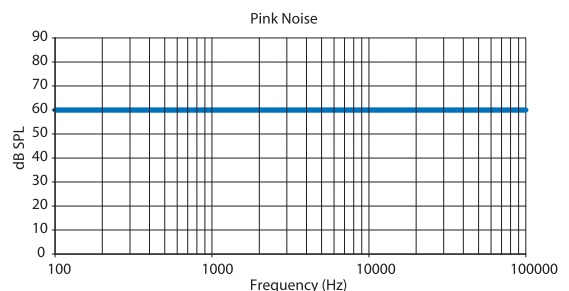
In this way the sound can go into the air through the grid pattern. The acoustic waves created by the front and the back side of the speaker are separate from each other. Which is one of the basic rules.

Frequency Response graph

The amplification graph of a speaker is shown in a logarithmic scale.

A theoretical ideal response graph for a speaker would be a flat line that covers the complete human audio frequency range from 20Hz to 20kHz.

A pink noise, which has equal energy in all octave bands, results in such a flat line on a logarithmic scale. It reflects the working of our human ear.



When a pink noise with a certain V_{rms} is sent to a speaker and the produced sound of the speaker is recorded with a microphone, the amplification response of the speaker can be shown.

The frequency response graph gives you an idea about the quality of the speaker. The total SPL gives you an idea about the complete loudness you can expect with a certain signal on a certain distance.