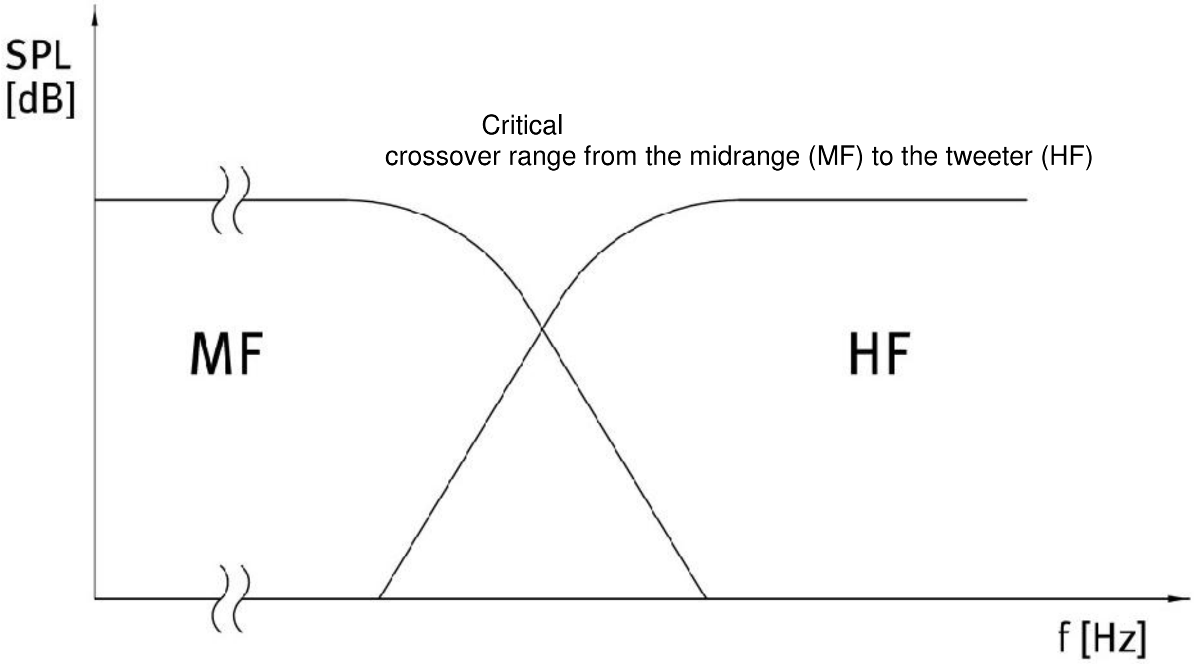
Introduction

The history of loudspeaker technology goes back 100 years.
Since 1926, ELAC has been all about electroacoustics. During recent years, we have focussed on the development and improvement of electroacoustic transducers. In this context, the ELAC compact design was introduced on the market in the 90's. In proportion to the wavelength, the transducers were arranged on the loudspeaker baffle spaced close to one another. It was the goal to develop loudspeakers that approach the ideal point source. This was also the motivation for creating a coaxial driver system which is able to cover a frequency range of 7 octaves.

Multi-way loudspeakers

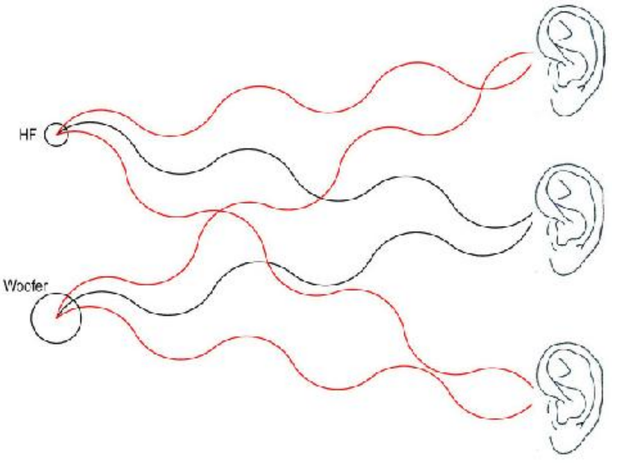
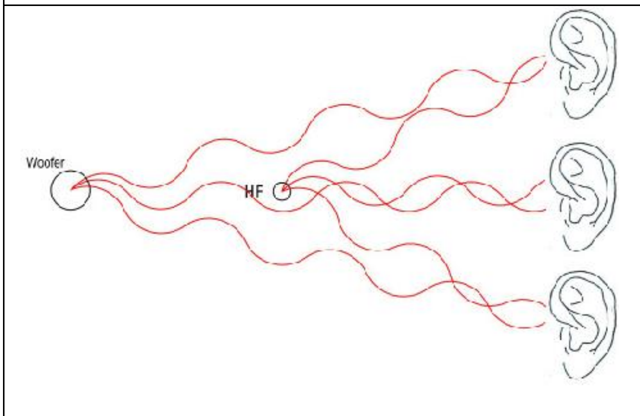
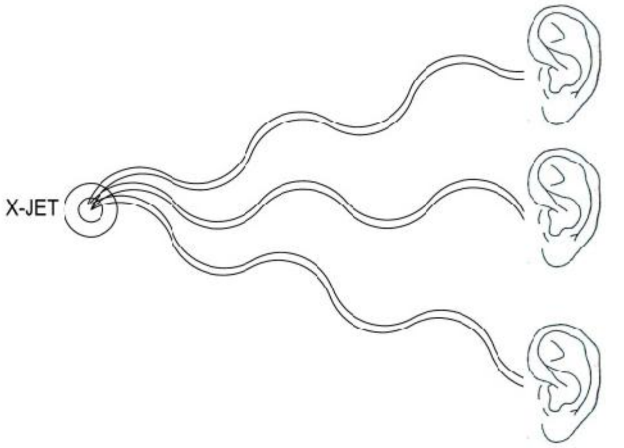
Producing sound pressure in a room requires a diaphragm that moves the air to the rhythm of the music. The air volume that is required for constant sound pressure decreases as a square of the frequency. Taking limited deviation as a starting point (the relation of the peak deviation to the diameter shall be 1:4 max), drivers with diaphragms that provide larger diameters are required for deeper frequencies. In order to ensure that the frequency range used for the reproduction of music can be covered, the spectrum is apportioned to separate transducers which are optimized for each individual frequency range.



picture: amplitude response versus frequency

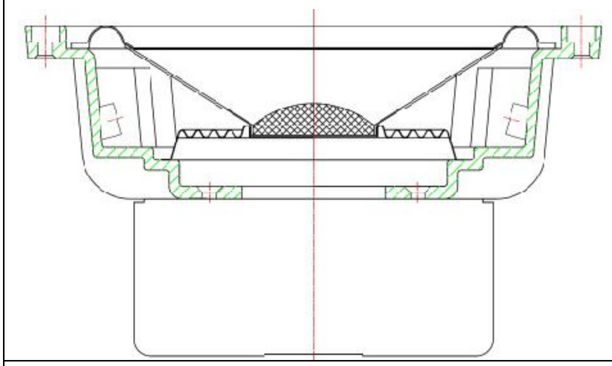
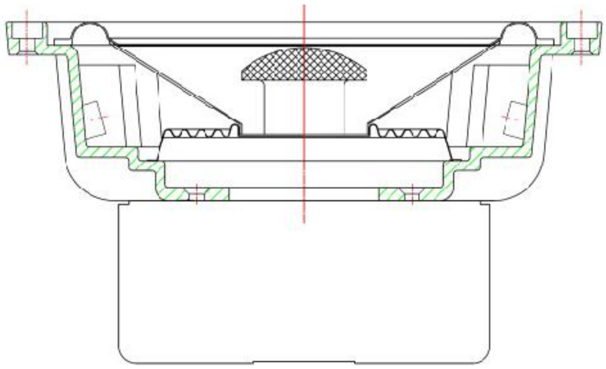
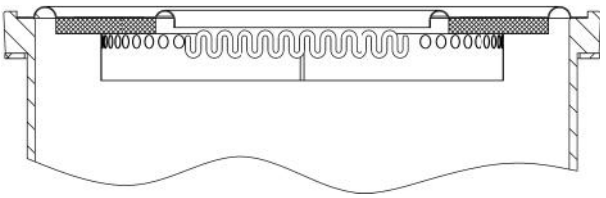
Interference by multiple drivers

Conventional loudspeakers provide sound sources that are arranged above one another on the loudspeaker baffle. Their acoustic centres are arranged vertically at least 15-20cm from each other. The offset of the sound sources can be compensated for by engineering the frequency cross-over network. Therefore, the vertical offset of the drivers is not regarded as problem. However, off axis, the offset leads to phase anomalies due to differences in the frequencies travel time.
For example, if there is a combination of drivers, whose acoustic centres are arranged 20cm from each other and are positioned at a distance of 1m 30° above or below the 0° axis, the path difference to the sound sources will be 8.9cm. At an assumed cross-over frequency of 2 kHz (equal to a wave length of 17.2 cm), this path difference would result in a phase difference of approx. 180degrees between the sound sources. This would result in sound waves cancelling each other out.

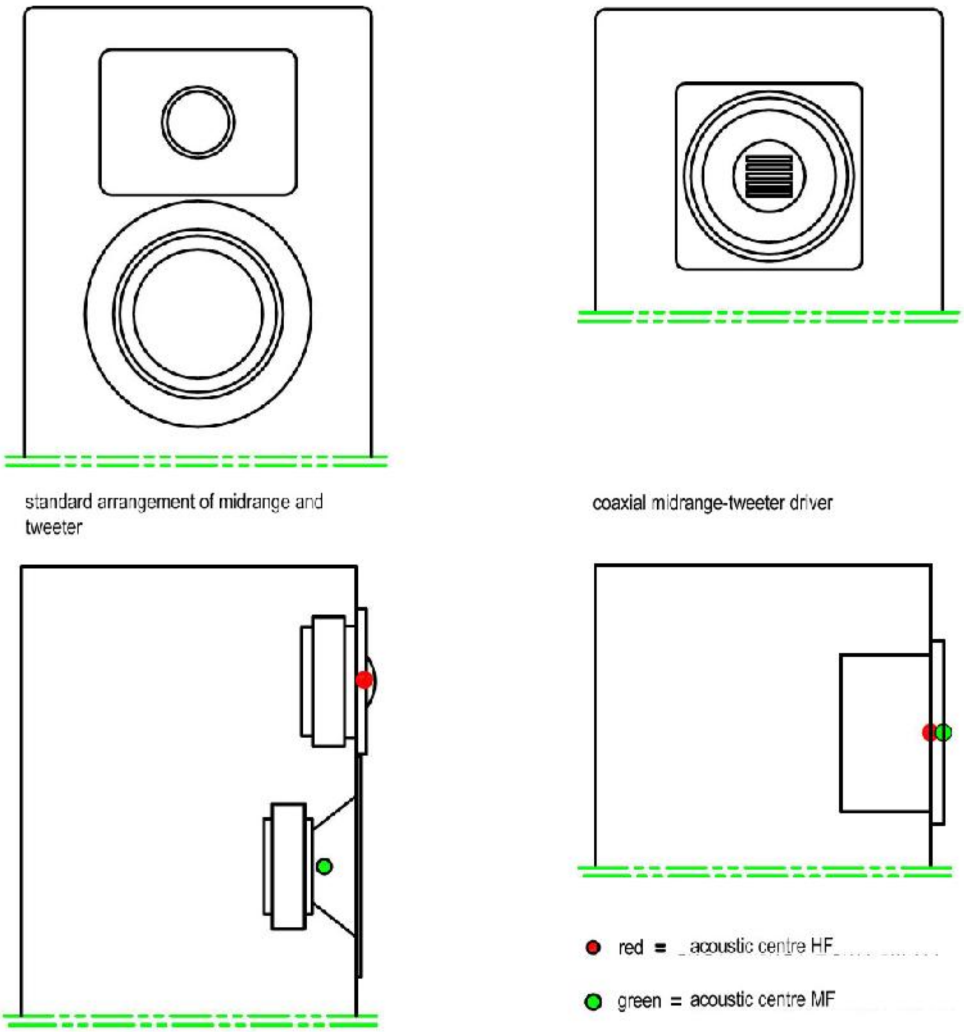
	out of phase in phase out of phase	This figure illustrates the problem of separated sound sources, mentioned above.
	out of phase out of phase out of phase	A similar problem occurs, if there are two offset, coaxial sound sources.
	in phase in phase in phase	Ideal results can be received with two coaxial sound sources, arranged on a coplanar level.

Coaxial loudspeakers

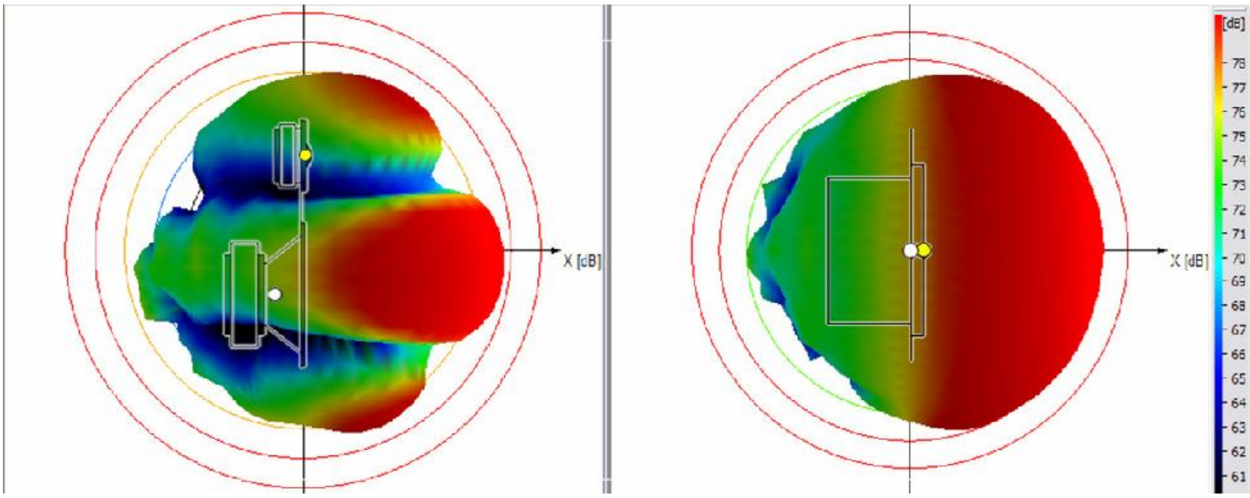
A coaxial loudspeaker is a combination of at least two drivers, that work in different frequency ranges and that are arranged concentrically (coaxial) on an axis. The following figures show some coaxial designs.

	Most of the coaxial units are provided with a tweeter diaphragm in the centre of the woofers' diaphragm. This is positioned on the pole body of the woofers magnet. The sound waves that are radiated by the diaphragm of the tweeter hit the funnel-shaped diaphragm of the woofer (cone). From here, they will be reflected. If the diaphragm also transfers deep frequencies, the reflections will be modulated by the movements.
	Similar problems occur if the tweeter diaphragm is mounted on an extension of the pole body. Here, the diaphragm of the tweeter is usually positioned on a small, circular space which leads to a ripple frequency response due to the missing loudspeaker baffle which functions as a plane of reflection.
	This figure shows the design of the ELAC X-JET which uses a flat diaphragm as a ring-shaped radiating element. The advantage is that the diaphragms are arranged on the same plane without using a funnel-shaped element. Thus, both drivers can radiate sound and approach an ideal point source over a broad frequency range.

Directional pattern of coaxial loudspeakers



Compared to a conventional 2-way combination, (e. g. midrange woofer + tweeter) the advantage with coaxial technology is that propagating sound waves can be heterodyned in an optimized way. Usually, separated sound sources with optimized networks only display unified dispersion on the axis of radiation. The following figure shows the ideal omnidirectional radiated sound of a coaxial loudspeaker (right) compared to the limited directional pattern of separated drivers.



pic: three-dimensional direction pattern of a conventional loudspeaker, frequency: 2370 (Hz)

pic: three-dimensional direction pattern of a loudspeaker with coaxial ELAC X JET, frequency: 2370 (Hz)

Acoustic effects of coaxial loudspeakers (definition of acoustic terms)

The objective of developing a loudspeaker is to reproduce all sounds that can be heard by the human ear at the same volume. In most cases, this leads to a linear amplitude response at a distance of 1m.This linear response should not only be measured on the main axis of radiation, but also 10°- 20° out-of-range. This is extremely important because the sound waves of the loudspeaker run directly and also via reflections in the room (e. g. floor and ceiling reflections) to the listener. Here, we talk of primary sound fields and diffuse sound fields. Both are important for the tonal accuracy of a loudspeaker.

The key factor for the localization of acoustic events is the first wave front that reaches the listener. Usually, it is the first 1 to max 2 ms. After that, the primary sound field superimposes the diffuse sound field but this depends on the distance between the loudspeaker and the listener and also on the room design.

The X-JET coaxial loudspeaker works as a point source over 7 octaves. In comparison to conventional designs, there will be no inteference by the lower midrange with the coaxial design. This applies to the main axis of radiation (0 degrees) and also to a broad area around it. This results in a homogenous frontal directional pattern and consistent off axis sound at all frequencies.

Musical spaciousness arises out of a loudspeaker’s consistent wide-angle sound radiation. The ‘cleaner’ it is, the wider the stereo image. Good localization and the ability to ‚listen into’ the stereo sound is possible when loudspeakers with X-JET are used in good spatial conditions.

Term	Definition
localization	term, that describes the virtual presentation of a spacial event as perceived by the human ear
sound power	sound power is a measure of sonic energy and belongs strict to the sound source
directional pattern	description of the radiation behaviour of a sound source under different solid angles
acoustic power concentration	concentration of acoustic radiation of a sound source (the relation of acoustic power on axis referred to the averaged acoustic power over all radiation angles)
directivity index	10 * log (sound power concentration) [dB]

ELAC 115mm X-JET

With ELACs coaxial technology, the two drivers are not positioned on one ‚axis', but more advantageous, they are arranged on the same acoustics plane. This way, the loudspeaker approaches the ideal point source.

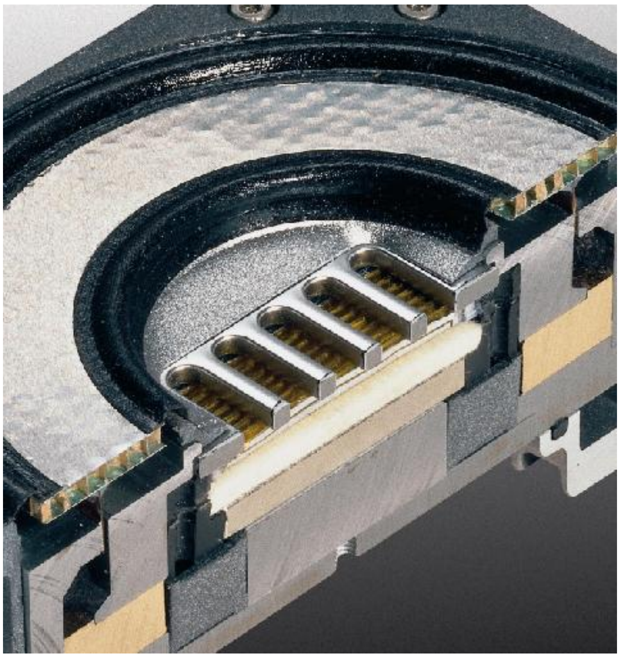
The advantage is optimized sound power and homogenous sound dispersion in the room over the entire listening area. The result: both the amplitude and phase of sound waves, independent of frequency, are linear over an angle of 180 degrees resulting in incredibly detailed imaging over a broad listening area.

The ELAC 115mm X-JET consists of two separate driver systems:
the flat aluminium honeycomb midrange-tweeter driver for the midrange and the JET III tweeter for the high frequencies. This combination offers a number of features and covers a frequency range of **7** octaves (400Hz – 50kHz).

The ultralight 50/105mm Ø flat aluminium honeycomb midrange diaphragm offers a magnet system with a strong neodymium magnet system and a reduced stray sound field. The system is driven by a 78 mm moving coil. The coppered aluminium flat wire, edgewise wound, is arranged on a ventilated capton bobbin. The design of the moving coil ensures optimum magnet gap efficiency. High efficiency is gained by means of the reduced moved mass (e. g. lightweight fabric surrounds with dampening material).
The tweeter consists of a modification of the Jet III (linear out to a frequency of 50 kHz) with a combined coaxial magnet system that is concentrically arranged on a ring-shaped radiating element (midrange tweeter).

The system is arranged in a 115 * 115mm basket made of glass-fibre reinforced polyamide. An eightfold screwed connection with an aluminium die-cast enclosure ensures mechanically solid reinforcement and cooling of the system. At the same time, the system is sealed hermetically from the cabinet.

The strength of this ELAC transducer lies in the frequency range that is important for the reproduction of voices and imaging.
The tweeter yields a precise upper cut-off frequency of 50 kHz. This makes the driver an ideal component fort he reproduction of DVD-A and SACD.



The coaxial midrange-tweeter driver consists of:

a unique combination of a flat aluminium honeycomb midrange diaphragm and a concentrically arranged JET tweeter in a coaxial design featuring compact dimensions and high efficiency.