

# Genelec 8260A

A Revolutionary 3-way Loudspeaker Design

MDC™

DCW™

MDE™

AutoCal™



GLM



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## 1 Background

In principle a three-way loudspeaker offers clear sonic benefits compared to a two-way system, especially at higher sound levels, due to separate midrange channel. To benefit from such advantages the loudspeaker designer has to choose between a small enclosure which does not allow proper control of the directivity and leads to strong listening environment influence, or a larger enclosure where proper directivity control can be included. The technical dilemma lies in the physical dimensions available for proper midrange and high frequency directivity control.

Since the introduction of the 1022A in 1985, Genelec has approached this issue with proprietary directivity control waveguides (DCW™) having spaced midrange and tweeter drivers. The DCW™ has proven to be a successful concept in the market, and it has been adopted by other companies as well.

With the aim to develop a smaller three-way product with limited physical dimensions, the traditional waveguide simply had insufficient space. So, Genelec started to develop a new coaxial driver solution which would combine MF/HF waveguide for proper directivity control. The early research work and basic solutions were developed in the late 90's to prototype levels.

As an overview, the new 8260A DSP three-way loudspeaker enclosure design is based on the successful 8000 Series MDE™ die-cast aluminum technology. With an extremely compact and unconventional enclosure featuring a 10" bass driver, the LF cut-off extends down to 26 Hz (-3 dB). The revolutionary Minimum Diffraction Coaxial Driver (MDC™) combined with a Directivity Control Waveguide (DCW™) provides exceptional clarity and sound stage imaging. The 8260A is also a true three-way DSP system featuring Genelec loudspeaker Manager (GLM™) network with powerful software controls and excellent flexibility which includes Genelec's proven automatic calibration technology (AutoCal™).

This technical paper describes the essentials of the 8260A system covering the main technologies utilized and key features.

## 2 Timeline of Coaxial Drivers Development

Coincident-source loudspeakers provide advantages over spaced drivers, especially at the crossover region. Improvements in imaging, response and directivity can be achieved. The basic principle of a coaxial driver is to place the high frequency driver at the apex of the low frequency diaphragm. Doing so, the apparent source location does not depend on frequency and the directivity of both drivers may be controlled in the crossover region. Furthermore, coaxial technology utilizes less front panel space than comparable design with spaced drivers.

A very well known early coaxial design is Altec Lansing 604 Duplex from 1941, which had two magnet circuits. The tweeter horn is protruding through the woofer magnet in front of the woofer cone. This product design has had a very long life span. Another very successful design was introduced in 1946, the Tannoy Dual Concentric. It has no visible separate tweeter horn, instead the curved woofer cone forms an essential part of the tweeter horn originating inside the woofer magnet pole piece. Originally this design also eliminated the tweeter magnet as the magnet circuit had two gaps, a larger one for the woofer cone and a smaller one in the rear for the tweeter. This design is still in production although modified in several details. After neodymium iron boron magnets became available, KEF, in 1988, was the first to place a really small dome tweeter at the top of the woofer magnet pole piece, starting a new era of cost effective coaxial drivers.

BMS has designed interesting 2- and 3-way coaxial compression drivers while Cabasse manufactured several designs, from 2-way to 4-way direct radiators. Pioneer has refined the diaphragm materials, just to name a few companies who have been active in this specific driver technology area.

Although conventional coaxial designs provide several key advantages, they also present drawbacks. The woofer cone movement causes inter-modulation and Doppler distortion to the tweeter radiation. The larger the cone displacement the more inter-modulation will be produced. The directivity, although improved at crossover, may not be uniform at higher frequencies. Also, most current common tweeter-midrange driver constructions have inherent acoustic discontinuities, which show as uneven on-axis HF response. Whether these are judged to be important depends totally on applications and the degree of accuracy desired. As the history shows the benefits have exceeded the drawbacks.

The common challenge in all coaxial designs is how to avoid the said acoustical discontinuities and their effects on the response. Diaphragms have to move and there has to be some mounting gaps, but at the same time sound is easily diffracted from such discontinuities. The following picture shows the typical situation, with somewhat uneven response.

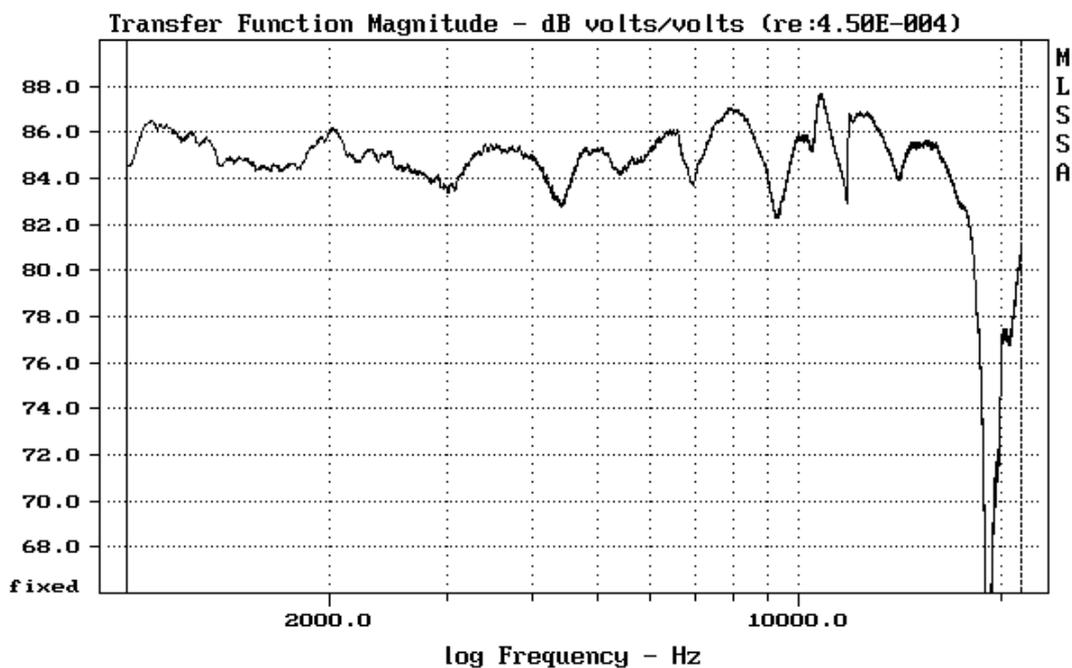


Figure 1: Frequency response of typical coaxial driver. Frequency response from 1 kHz to 20 kHz.

The milestones in the development of coaxial drivers can be summarized as follows:

- Altec Lansing presented their famous 604 Duplex coaxial driver in 1941. The tweeter is horn-loaded and the horn protrudes from the woofer cone apex. The frequency response is irregular due to horn reflecting sound emitted by the cone and due to the small dimensions of the horn itself.
- Introduced in 1946, the Tannoy Dual Concentric design overcomes some of the problems. The tweeter horn is formed inside an hollow pole piece and the woofer cone is an extension of the tweeter horn. Hence there are no reflections from the horn itself.

However, the tweeter response depends on the woofer cone position and the joint between the woofer voice coil and the cone causes diffraction.

- In 1981 Pioneer Electric Corporation introduced a 4-way coaxial flat diaphragm loudspeaker. The diaphragms were made from honeycomb sandwich material. This driver never had any success.
- Mark Dodd, working at that time for Tannoy, published a paper called "*Optimum diaphragm and waveguide geometry for coincident source drive units*", which also led to a patent. The so-called Tannoy "Tulip" waveguide forms the internal passages for the phase plug and creates a spherical wavefront which matches the apex of the cone. Improved bandwidth and response are the claimed benefits.
- In 1988 KEF introduced the "Compound loudspeaker drive unit", a patented design called Uni-Q. A dome tweeter is placed on the woofer magnet pole piece at the center of the woofer cone. This design became possible having efficient magnet materials which helped to reduce the overall dimensions of the tweeter magnetic circuit. This design also relies on the woofer cone as a directionality control device for the tweeter radiation. In wideband use the modulation distortion is present and the diffraction problems are pronounced as the dome directivity is small. Typically, diffraction ripples are located between 10...14 kHz depending on the woofer voice coil diameter.
- BMS, a German company, has developed 2- and 3-way coaxial compression drivers.
- The French company Cabasse has manufactured several different 2-, 3- and 4-way coaxial designs.
- Recently Pioneer/TAD has developed a coaxial MF/HF driver using Beryllium diaphragms.

### 3 The Revolutionary Genelec MDC Solution

Coaxial drivers have existed for many years and are common in two way systems but not so much in three way systems reproducing only mid and high frequencies. Typical to all current coaxial design is somewhat ragged frequency response due to inherent diffraction problems. Though, crossover issues due to non-coincident location of sources are solved with a coaxial configuration. Here lay the seeds of Genelec's Minimum Diffraction Coaxial (MDC™) solution: while it benefits from typical coaxial design advantages, it now overcomes several shortages as well.

The main structure of the MDC™ tweeter-midrange coaxial design consists of an integrated MF diaphragm-suspension / tweeter construction. The visible part of the coaxial driver is formed by the curved flexible foam surface with the coaxial dome tweeter assembly in its center. There is no conventional spider and the suspension is made of foam over the entire metal cone. The foam damps some of the aluminum cone resonances as well. The inner and outer suspensions are dimensioned in such a way that their possible nonlinearities cancel each other, thus forming a very linear suspension system.

The inner section joins the cone to the tweeter structure without any acoustical discontinuity, and the outer one does the same between the cone and the driver chassis. As there are no acoustically observable discontinuities between the tweeter and the cone, just a smooth surface, there is no diffraction either. The cone profile is very carefully optimized to form an integrated directivity control waveguide for the tweeter radiation. The driver outer edge is terminated to an advanced Genelec DCW™ waveguide in order to control the dispersion of midrange radiation as well.

This breakthrough in coaxial design provides improved imaging and overall sound quality on- and off-axis, extremely smooth frequency response leading to outstanding clarity and

definition of the inner details of the music. Besides providing considerably more sound pressure than Genelec's largest 2-way, the 8260A combines for the first time a coaxial driver (MDC™) within a modern waveguide (DCW™), ensuring drivers to couple coherently over their full operating bandwidth as well as being single MF/HF coincident point source.

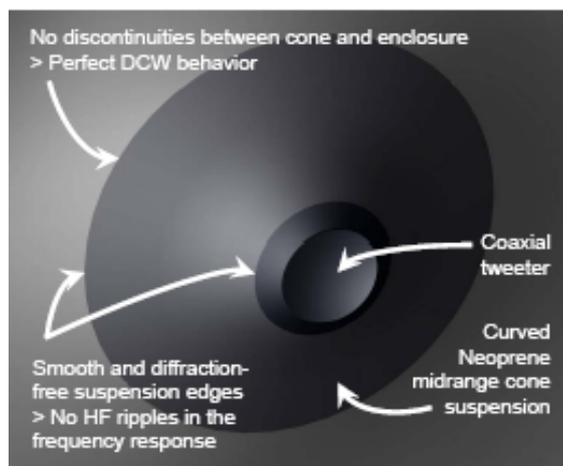


Figure X: The outer layer of the MDC cone structure

Figure X shows a cross-section view of the entire coaxial driver element, including its decoupled mounting. The MDC module consists of the aluminum MF driver chassis with its motor structure, the dome tweeter at the center, and the MF cone with its foam coating, which also forms the necessary surround. The floating mount consists of o-rings in the front and side of the driver as well as on the back plate. As a whole the driver forms an integrated directivity control waveguide extending smoothly from the dome to the outer periphery of the 8260A enclosure.

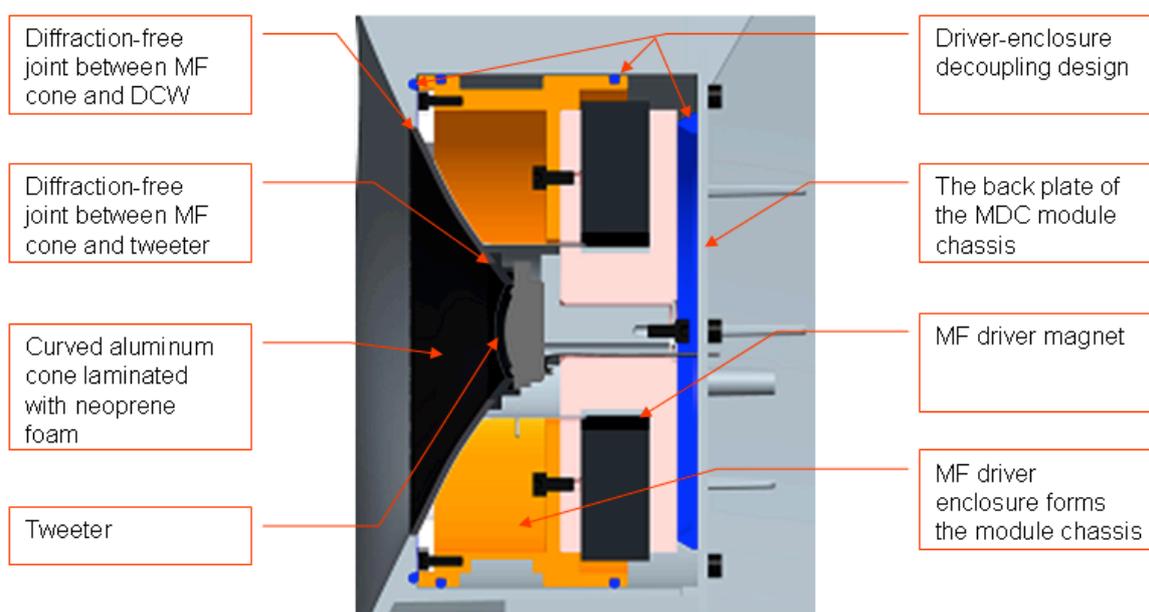


Figure X: The basic structure of coaxial module integrated with its decoupled mounting

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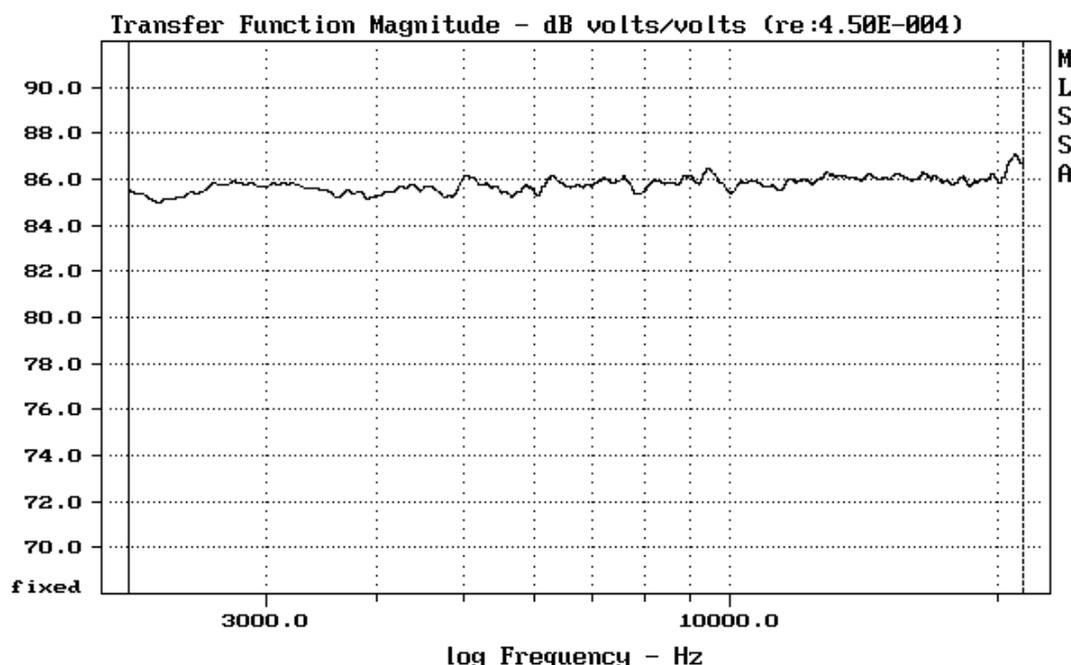


Figure X: On axis frequency response of the Genelec MDC driver.  
The frequency response shown is from 2 kHz to 20 kHz.

## 4 The MDC Driver/Enclosure Decoupling

Together with the drivers, the enclosure tends to participate in the total loudspeaker sound radiation. The sources of enclosure excitations are either acoustical, from the internal and external sound field, or mechanical, from the reaction force on the driver magnet system.

Earlier studies have shown that the dominant excitation mode depends on frequency. The internal pressure is dominant at low frequencies and mechanical excitation is strong at mid and high frequencies.

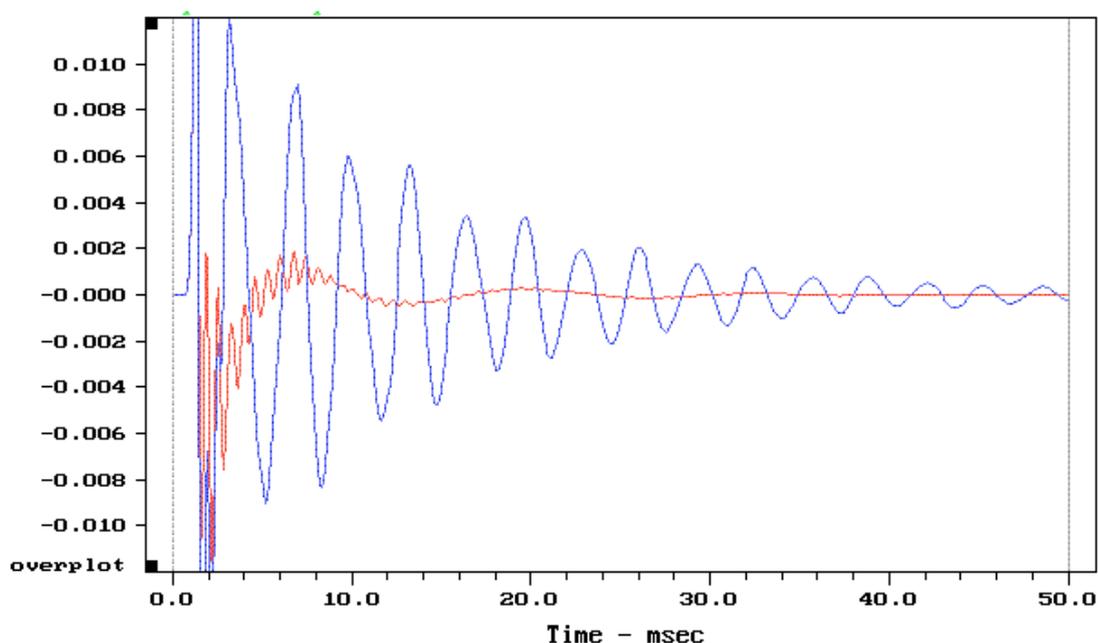
The vibration characteristics of the enclosure panels play a significant role in the overall performance of the loudspeaker. At some frequencies the magnitude of radiation from the enclosure walls can approach that of the drive unit diaphragm itself. It is clear that this should be avoided. To minimize vibration due to the internal pressure excitation we need stiff enclosures. To fulfill such criteria curved surfaces are used as they are inherently much stiffer than flat panels.

The vibration coupling between the enclosure and the driver is fairly simple. The same force that is moving the cone moves also the magnet. Because the mass of the magnet and chassis is huge compared to cone mass, the actual movement - or vibration - of the magnet and chassis is extremely small. However, as there is force, there is vibration, and this tiny vibration is moving around the entire mechanical structures (just like footstep sounds propagate in a condominium between floors and apartments). In the case of a loudspeaker the mechanical structure is the loudspeaker enclosure, and the vibration is traveling around the walls and gradually absorbed in the losses of the enclosure.

The solution to minimize this vibration transmission is to cut the path of the structural wave propagation. The complete coaxial driver is isolated from the enclosure by mounting it floating in its own cavity. It means also that all possible vibrations originating from the woofer are isolated from the MF/HF coaxial unit.

Experimental results of such decoupling solution show the following advantages:

- The magnet motion (the “ground reference” for the cone motion) is better behaved (more inert).
- Cabinet vibrations are substantially reduced.
- The actual diaphragm motion is minimally affected by the decoupling. Only the artifacts are reduced.



**Figure X: Magnet acceleration impulse responses: blue curve – rigid mounting, red curve – decoupled solution. The improvement is clear.**

To summarize, the main novelties of Genelec combined DCW™ and MDC™ designs are:

- Diffraction-free joint between tweeter and midrange diaphragm.
- Diffraction-free joint between midrange diaphragm and DCW waveguide.
- A proprietary midrange diaphragm technology – sandwich structure combining a rigid cone and elastic, lossy materials including the suspension itself.
- A midrange diaphragm-suspension pair which cancels all possible nonlinearities.
- A coaxial driver fully decoupled from the loudspeaker enclosure.

These technology advantages:

- ✓ Lead to smoother frequency response.
- ✓ Ensure the drivers to couple coherently over their full operating bandwidth.
- ✓ Significantly improve the directivity control in the critical frequency range.

- ✓ Provide balanced suspension dynamics to minimize acoustic distortion.
- ✓ Optimize the use of the front baffle area while maintaining the 8000 series appearance and benefits.

## 5 Enclosure Design

Following the current Genelec enclosure design the 8260A uses a die-cast aluminum enclosure, which is beneficial in many aspects. First, for given external dimensions the internal effective volume can be increased, which improves low frequency efficiency and provides extended LF cut-off. In case of the 8260A the cutoff is 26 Hz (-3 dB). The curved surfaces are inherently rigid and their structure resonances are at higher frequencies and thus easily damped. Any heat generated in the power amplifiers and the drivers is effectively conducted away, which improves the system reliability. It becomes also possible to integrate carefully acoustically optimized forms and shapes in the enclosure design, and this can significantly improve overall audio quality compared to conventional designs.

Resilient to handling and wear, die-cast aluminum allows easy integration of supports and mounting options in the enclosure. Finally, aluminum is fully recyclable and thus an environmentally friendly material.

The Genelec Iso-Pod™ vibration isolation stand is a part of the 8260A as well. The Iso-Pod™ stops the propagation of whole enclosure vibration to the surrounding structures. It also allows vertical tilting of the system so that it can be easily aimed at the listening position.

## 6 Digital Signal Processing in 8260A

The DSP processor in the 8260A contains all basic loudspeaker functions, such as the crossover filters, driver equalization, driver position alignment, as well as all the room alignment related filters, such as the room response equalizers and propagation delay correction.

Digital signal processing allows for steep crossover filters with high stop band attenuation. The benefits of the MDC coaxial midrange-tweeter driver, the directivity control waveguide DCW structure and the softly curved MDE enclosure design are perfected by steep crossover filters, minimizing co-radiation from any two drivers within their crossover frequency ranges. Such steep crossovers significantly reduce the sound quality changes when moving away from the loudspeaker acoustical axis in the vertical direction.

The 8260A features six fully configurable notch filters, two high- and two low frequency shelving filters for room alignment and calibration. The adjustment ranges of the notch filters are very wide and flexible. This allows both for broad response alignments as well as careful correction of room mode problems. The parametric notches and shelving filters can be set automatically using AutoCal automatic room alignment process built in the GLM™ software.

The 8260A is a masterpiece in electro-acoustic system thinking, as mechanical, acoustical, and signal processing designs are intimately linked together. The excellent mechano-acoustical design produces constant directivity characteristics. Combined with digital signal processing the result is a loudspeaker capable of outstanding performance in very different and challenging acoustic environments.

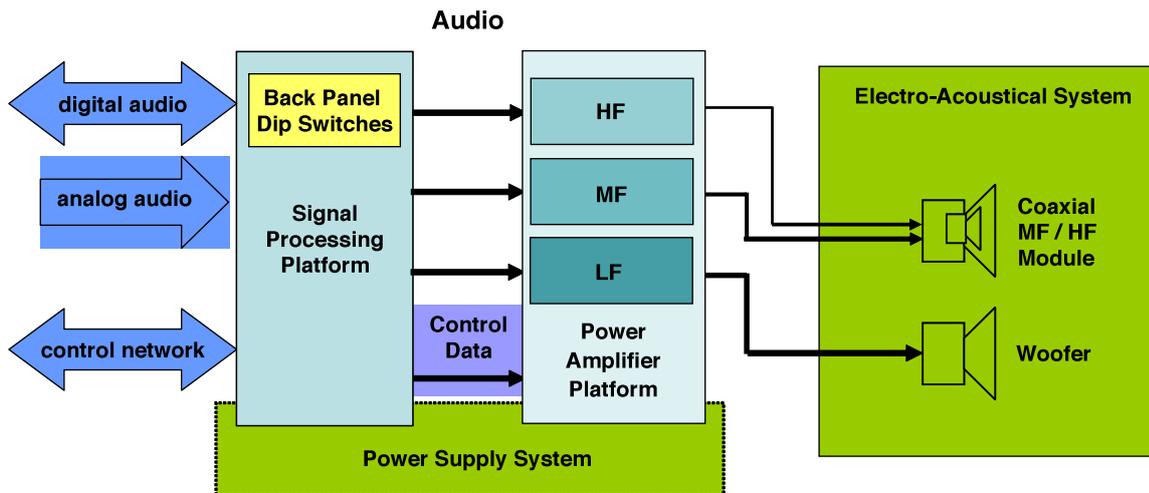


Figure X: Main building blocks of Genelec 8260A loudspeaker

## 7.1 Signal processing

The DSP hardware is a true three-way, which implies that the driver feed signals for the tweeter, midrange and woofer are all fed into their own three DA converters, then to three power amplifiers, and then finally onto each drive unit.

The monitoring volume is adjusted by scaling the digital audio signal before the DA conversion. Proper dithering is applied to the digital audio signal at the level adjustment stage to ensure that the signal path remains linear and free of any distortions when the signal is scaled (dithering refers to a signal processing operation that maintains linearity of the digital audio signal when its magnitude or level is changed).

The 8260A accepts any professional digital audio format on its AES/EBU input. The input sample rate can be any frequency between 32 kHz to 192 kHz, with an internal sampling rate of 96 kHz. S/P-DIF digital audio signals can be read if short cabling - preferably less than 3 meters – and impedance converters are used.

The power amplifiers are physically integrated into the aluminum MDE enclosure walls to enable very efficient heat transfer when the loudspeaker is heavily loaded. This provides high system reliability in stressful operating conditions.

The loudspeaker drivers are protected by overload protection circuitry. This automatic resetting function is designed to be activated as conservatively as possible to maintain loudspeaker driver reliability and life time.

## 7.2 Hardware user interface

The 8260A hardware interface located on the loudspeaker rear panel include dual-mode interface compatibility with digital AES/EBU input and output as well as analog Input. The Genelec proprietary CAT5 physical layer-based control network uses RJ45 connections. The loudspeaker system can be used with Genelec GLM network or without it. In the latter case (Stand-alone Mode) a complete set of DIP-switch controls are accessible on the rear panel. The system volume control can be adjusted by the source or by the network (via the GLM software or via a hardware controller).

Overload and clipping status are indicated using a front panel LED light. Also the probability of a digital audio input clip is indicated, warning from a signal extremely close to the full scale signal. The digital audio signal can actually become clipped in the audio workstation, digital console, or an outboard signal processor unit, and to indicate the clipping probability has proven to be a beneficial function in the monitoring loudspeaker also.

As with other 8200 series loudspeakers, the rear panel DIP LED light is on if the loudspeaker is not on the GLM loudspeaker control network, i.e. the loudspeaker is working in stand-alone mode.

## 7 The GLM User Interface

The GLM™ software handles the 8260A like any other Genelec DSP loudspeaker in a system and hence it is possible to mix the 8260A with 8200 series two-way loudspeakers in the same system together with 7200 series DSP subwoofers. This allows a great freedom in designing system setups. GLM™ features outstanding functionality such as:

- Main screen volume, solos, mutes, bass manager bypass control.
- Settings can be stored in the loudspeaker hardware for Stand Alone use.
- Customized setups are stored and retrieved in System Setup files.
- Unlimited System Setup files to store optimizations for different listening positions in the room.
- Rapid cabling and System Setup performed either manually or by using GLM software wizards.
- Acoustical setup performed either manually or by using AutoCal algorithms.
- Extensive set of notch filters for a three-way system.
- Definition and selection of Speaker Groups.
- Comprehensive acoustic editor window.
- Interactive parameter adjustments (Response Editor).

The GLM software supporting the 8260A is version 1.2.1 for Windows XP and Vista. For Macintosh, GLM is available in OS X versions 10.3.9 onwards. Existing GLM network interface and GLM measurement microphone can be used with the 8260A.

GLM also features AutoLink™ an additional proprietary software allowing the user to automate GLM start-up and set certain functions into computer keyboard keys for easy access and operation, even without having the GLM software user interface visible. One example of the use is to tie system setup files to certain keyboard keys. Pressing the key will automatically open and load the system setup. This can be used for example to optimize monitoring for several individual seats in the room, such as the primary monitoring position and the producer's position, or to move quickly between the main monitoring system and the smaller near field monitoring system.

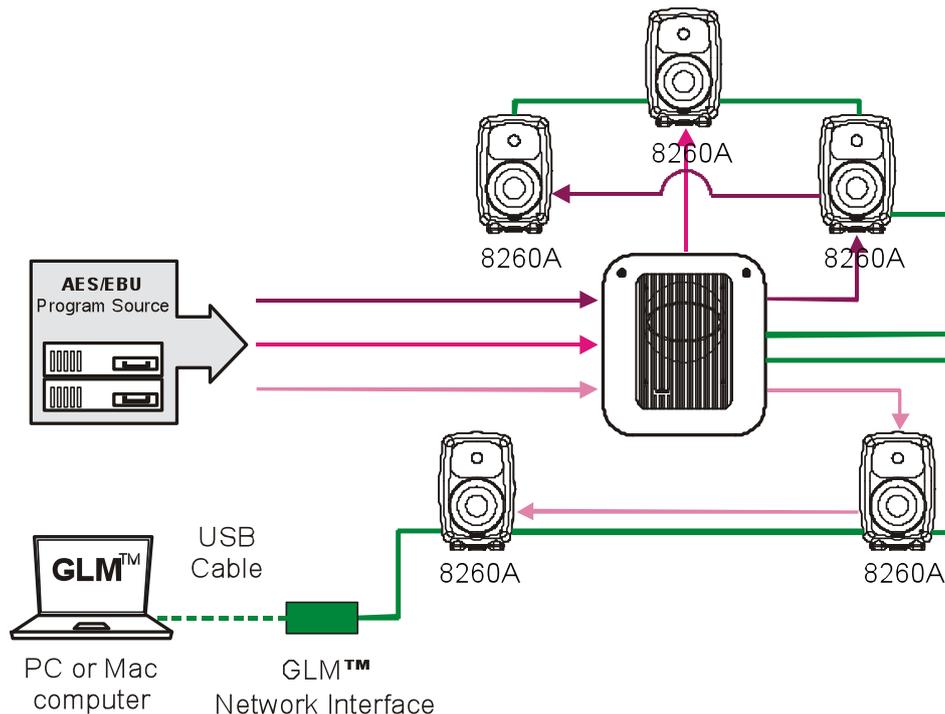


Figure X: Basic multichannel configuration with 8260A three-way systems

## 8 AutoCal - Automatic Room Alignment

Genelec AutoCal™ is a fully automated acoustical calibration tool for a single room multichannel loudspeaker system. The AutoCal™ system uses loudspeaker-generated log-sweep sine signals recorded by a calibrated high quality microphone to determine the correct acoustical alignment for every loudspeaker and subwoofer on the Genelec Loudspeaker Manager (GLM™) control network. It provides consistent and accurate frequency response for a multichannel audio system in widely varying room environments.

The three-way DSP 8260A tends to be placed in larger rooms compared to 8200-series two-way loudspeaker. Assuming the typical application areas, the 8260A has an extended set of room response controls. This means it can be easily adjusted to acoustically more complex spaces.

AutoCal can align a system of loudspeakers consisting 8200 and 7200 series products. The system alignments provided by AutoCal include:

- Frequency response calibration for each loudspeaker, including 8260A.
- Frequency response calibration for each subwoofer.
- The frequency response calibration can be designed based on a single microphone position (SinglePoint™), or an average of up to four microphone positions (MultiPoint™). This feature is especially useful for rooms with multiple operators or with producer listening positions.
- Time-of-flight (i.e. delay) calibration at the primary listening/monitoring position.
- Sound level (i.e. loudspeaker/subwoofer sensitivity) calibration at the listening position.
- Subwoofer-loudspeaker crossover optimization.

Once the frequency response of every monitor and subwoofer is calculated, AutoCal™ determines the correct acoustical settings for flat frequency response at the listening position (or an average over the MultiPoint™ area), aligns for equal delay from all loudspeakers to the primary listening position, and aligns output levels and subwoofer/main loudspeaker crossover phase. There are several internal algorithms to match the applied correction to the perception capabilities of the human ear.

All calibration information is then saved in a single 'System Setup' file that can be recalled in less than a second. The automated calibration procedure aligns distances within 1.5 cm (3/4") and levels to within 1 dB. A typical 5.1 system takes less than five minutes to calibrate.

<place a figure of the GLM Acoustic Response Editor window for 8260A here>

## 9 Conclusion

The 8260A loudspeaker system represents Genelec's cutting-edge innovations in all technology domains. The cornerstone of the MDE enclosure design draws on the advantages of the acclaimed 8000 series.

In addition, the electronic domain (hardware and software) of the system benefits from the 8200 Series design with the advanced AutoCal calibration system, part of GLM software. The technology in Genelec DSP systems offers improved usability and consistency for often complicated and rapidly changing productions, and provides extremely efficient and effective tools for integrating loudspeakers into the acoustics of the listening environment.

The MDC™ coaxial MF/HF driver is an engineering breakthrough and makes the 8260A loudspeaker unique in the market for its outstanding sound quality.

All these breakthroughs are the results of long-term persistent and solution-oriented research and development work.

## 10 8260A Key Features

- ☑ Considerably more sound pressure (SPL) than Genelec largest 2-way systems.
- ☑ Improved sound quality due to the dedicated midrange channel. This improves midrange clarity and keeps the subjective clarity even with slightly overloaded low frequency channel.
- ☑ Outstanding imaging and off-axis definition due to coincident MF and HF (MDC™) drivers.
- ☑ Exceptional clarity and precise imaging thanks to the absence of discontinuities in the design of the Minimum Diffraction Coaxial (MDC™) driver combined with the Advanced Directivity Control Waveguide (DCW™)
- ☑ Better sound clarity and audibility of the inner details of the music due to decoupling of the MDC™ driver from the enclosure.
- ☑ Industrial and robust enclosure design: die-cast aluminum Minimum Diffraction Enclosure – MDE™.
- ☑ Effective and reliable auto-calibration of stereo and surround systems thanks to AutoCal – automatic room alignment – technology.
- ☑ New generation of low distortion drivers.
- ☑ Advanced filtering and power amplification.
- ☑ High performance reflex port design avoiding port turbulence and noise as well as improving LF efficiency and definition.
- ☑ Proprietary GLM control network formation over CAT5 connections.
- ☑ Comprehensive user interface with GLM™ software
- ☑ AES/EBU or analog audio signals compatibility.
- ☑ Better integration of loudspeakers in the digital studio environment.
- ☑ Free-standing design which can also be flush mounted.