LIVE BOX

# When Music Comes to LIVE

## WHITE PAPER

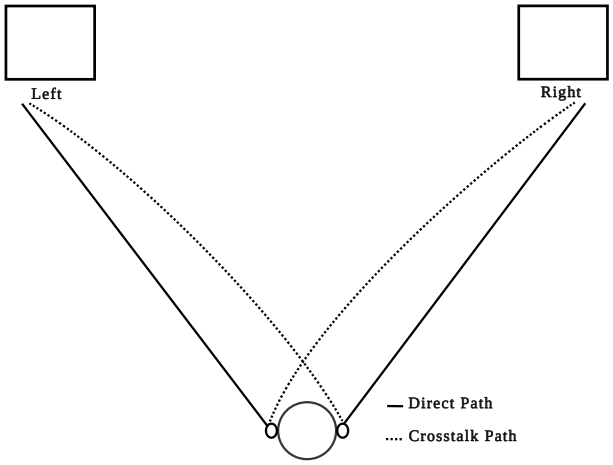
LIVEBOX.audio

# TABLE OF CONTENTS

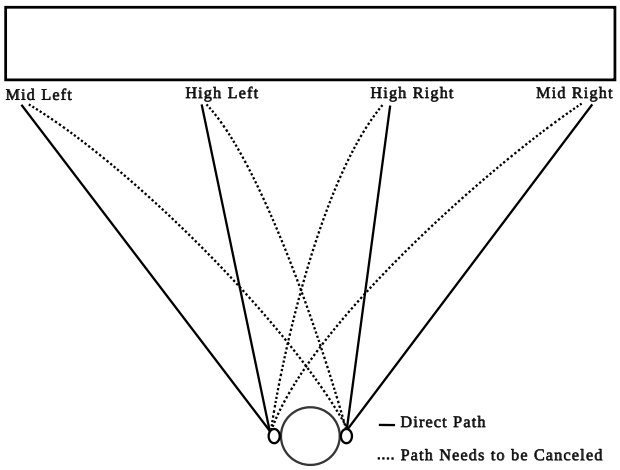
# THE CHALLENGE OF STEREO

Conventional stereo speaker setups are fundamentally flawed.
Stereo is defined as the difference of events happening on the left and right side of the playback system. The clearer the separation between the two channels, the better the stereo reproduction.

In conventional stereo setups, however, the sound emitted from the left speaker will also travel to the listener's right ear, just as the sound from the right speaker will reach the left ear. This interference is called crosstalk, and it diminishes the clarity and purity of the stereo image.




The LIVEBOX implements innovative technology to suppress this crosstalk without creating artifacts in the process, and it combines this crosstalk elimination with a sound reproduction system of exquisite quality to deliver the ultimate stereo experience.



# INTRODUCTION

The LIVEBOX is a fully integrated one-box audio system designed to reproduce sound at the **highest level of fidelity** while achieving a level of **spatial realism** that extends **far beyond its physical form.**

At its core, the LIVEBOX combines **advanced digital signal processing** with a **precisely engineered loudspeaker layout** to control how sound reaches the listener. By addressing the fundamental limitations of conventional stereo playback, most notably the interaction between the left and right channels at the listener's ears, the system is able to reconstruct a **stable and highly accurate soundstage**.

The result is a listening experience that **frees sound** from the confines of the loudspeaker's physical dimensions. It unfolds with **remarkable width and depth**, allowing individual elements within the recording to be located with precision and clarity in space.
The LIVEBOX extends the sound stage well **beyond the boundaries of the enclosure**, both laterally and in depth.

This paper elaborates on the technologies combined in LIVEBOX to achieve a listening experience like no other. For that purpose, it first looks at the outside of the device, only to then delve into its depths and walk you through its signal chain.

The best magic happens when the magician explains the trick, and it still works.

# OVERVIEW

LIVEBOX offers a unique listening experience with an immersive stereo image. Its key propositions are:

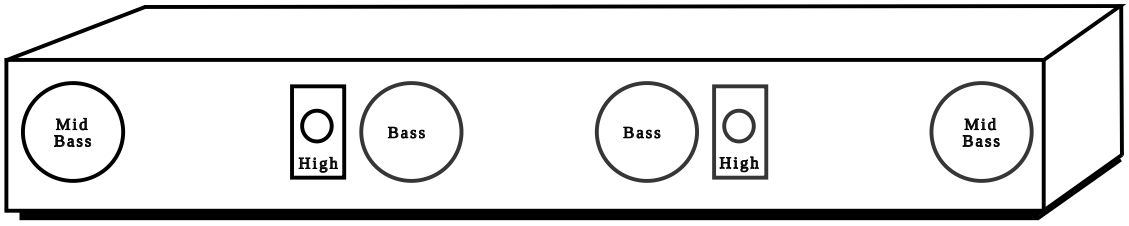
| | |
|---|---|
| **Live at home.** | The captivating emotion of a live performance, recreated by extending the sound stage beyond the boundaries of the enclosure. |
| **Designed to fit.** | Custom finishes and dedicated furniture options for seamless integration. |
| **Tuned for you.** | Custom EQ and advanced DSP tools offer flexibility in sound tailoring. |
| **Fully integrated.** | High-performance audio in a fully integrated one-box solution. |
| **Joint Venture** | Weiss Engineering, PSI Audio & Illusonic |

# The shape of the LIVEBOX

To optimize the effect of the complex technology, the LIVEBOX cabinets must **adhere to strict requirements** in terms of dimensions, material, and crafting precision. The cabinets are therefore entirely hand-made in Switzerland by PSI Audio to ensure manufacturing excellence, tight quality control, and to keep lead-time to a minimum. Custom finishes and selectable colors ensure seamless integration. Only selected materials, suitable for the requirements of the LIVEBOX, are used:

**HDF** ensures effective vibration absorption while remaining machinable and stable over time. **HDF** is the optimal choice of material for loudspeakers in general and is chosen by most high-end loudspeakers manufactures who often combine it with veneer to enhance perceived value.

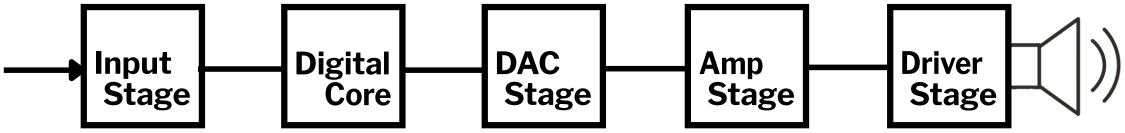
The shape of the LIVEBOX is defined by its distinctive driver layout within the horizontal enclosure, which forms the basis of the LIVEBOX's proprietary spatial rendering engine. The midrange drivers and tweeters are positioned to **maximize crosstalk cancellation,** as described in the section "What's That Sound" (page 7)**,** with minimal tonal coloration.
The midrange drivers are positioned at the outer ends of the enclosure.
The tweeters are close to the bass driver, close to the center.




**The port** spans the entire bottom surface of the enclosure, with openings to both the front and rear. This design ensures smooth, well-controlled airflow while maintaining a flat frequency response and minimizing phase distortion.

# Take A Look Inside The LIVEBOX

In the following sections, you'll gain insight into what's inside the LIVEBOX and what makes it truly unique.
We begin with an overview of the audio signal flow - tracing the path the music takes from the input all the way to your ears.
This is illustrated in the block diagram below, presenting a simplified abstraction of the individual stages the signal passes through.




The Input Stage is the initial point of entry for the music into the LIVEBOX with various input options supporting nearly all use cases:

| Digital | Network | Analog |
|---|---|---|
| • XLR (AES/EBU)<br>• RCA (S/PDIF)<br>• TOS (S/PDIF) | • USB<br>• UPnP<br>• Roon Ready<br>• Qobuz Connect | • XLR<br>• RCA |

From the input stage, the signal enters the **Digital Core Engine** — the technological heart of the LIVEBOX. Here, advanced processing algorithms shape the soundstage, perform precise crosstalk cancellation, and enable individually tailored listening experiences. The underlying technologies and acoustic concepts are explored in the following sections: "And Who is Doing the Magic Math" (Page 6), "What's that Sound?" (Page 7-8), and "Ready to Tune In?" (Page 9).

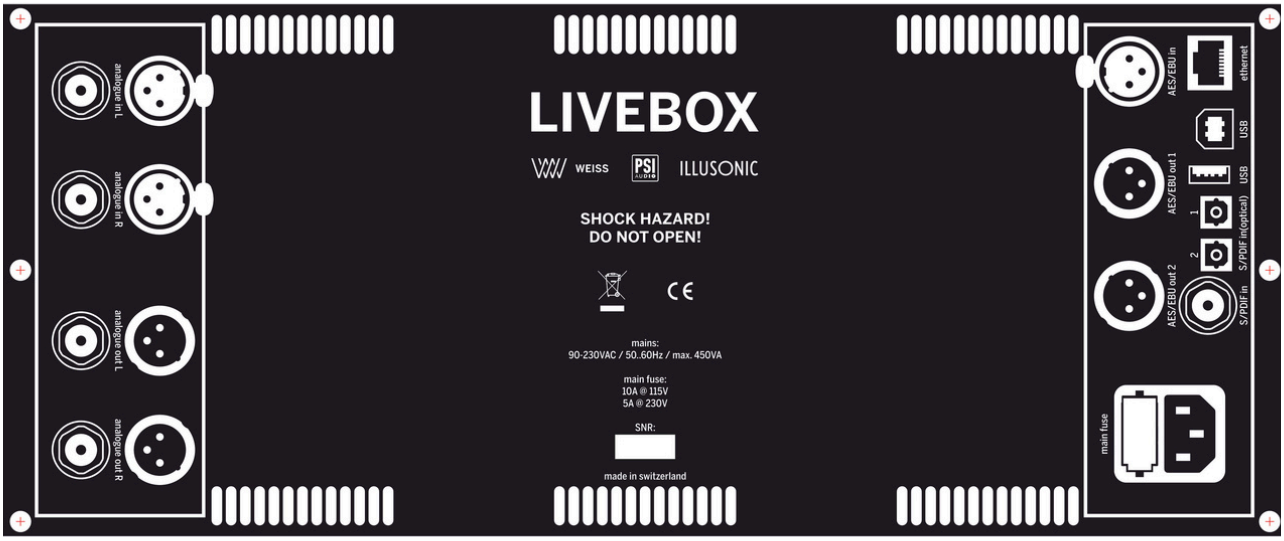
Next, you see the **DAC Output Stage**, which handles the crucial conversion from digital to analog. As a result, all signals passing through the LIVEBOX are handled in the digital domain and need to be converted to become audible for human ears, a topic explored in more detail in the section "It's the Conversion that Matters" on Page 10.

After the conversion to analog, the signals are amplified in the **Amp Stage**, which will be discussed in the section "The Driving Force of the LIVEBOX" (Page 11).

The signal path is completed by the **Driver Stage**, where the processed audio is ultimately translated into the characteristic LIVEBOX listening experience. More details can be found in the section "Welcome the Handmade PSI Drivers" (Page 12).

# Input Stage — The Entry Point of All Audio Signals

The Input Stage is the entry point of all audio signals into the LIVEBOX. It is designed to accommodate a wide range of use cases, from traditional analog sources to modern digital and network-based playback systems, while ensuring high signal integrity throughout the audio path.




*Rear panel of the LIVEBOX with USB, AES/EBU and S/PDIF inputs, analog connections, and a network port.*

**Analog inputs** are provided via XLR and RCA connectors. These signals are converted to the digital domain at the input stage, ensuring that all subsequent processing is performed with full precision and consistency.

The LIVEBOX supports both digital and analog inputs. **Digital sources** can be connected via XLR (AES/EBU), RCA (S/PDIF), optical (TOSLINK), and USB.

**Network-based playback** is fully supported and forms an integral part of the system. The LIVEBOX can operate within modern streaming environments, including UPnP-based applications, Roon-based systems, and services such as Qobuz. This enables direct access to high-resolution audio content.

Regardless of the input format, all signals entering the LIVEBOX are handled with the same objective: to preserve the integrity of the source while preparing the signal for the subsequent processing stages. From this point onward, the signal enters the Digital Core, where the main processing and system-specific functions are applied.

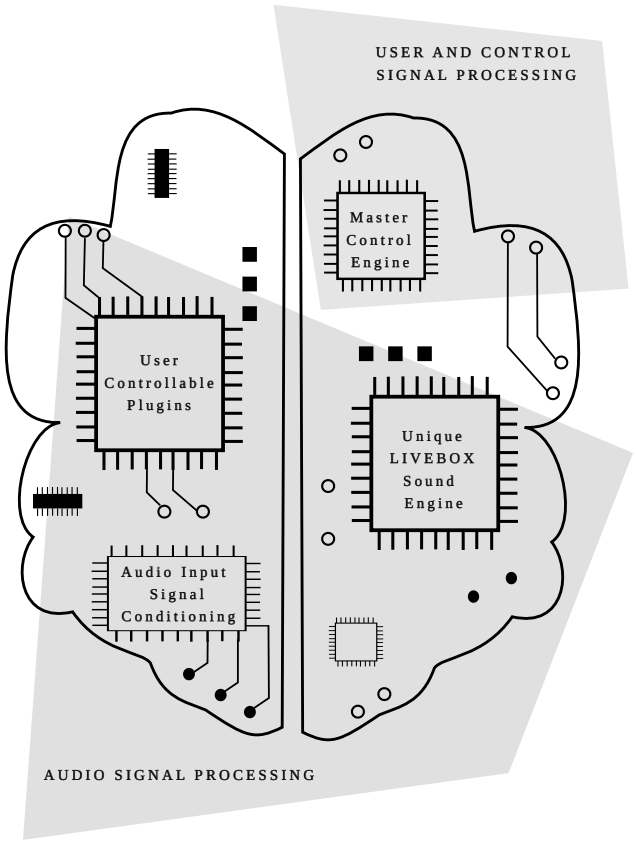
Digital Core

# And Who is Doing the Magic Math?

The brain of the LIVEBOX is digital, an ensemble of two DSPs, Atmel chips, and an ARM processor.

The sketch of this digital brain on the right shows the main processing blocks, which can be subdivided into two categories: the audio signal processing domain and the user and control signal processing domain.
All audio signal processing is handled by two ADSP-21488 SHARC DSPs. As a first step, all **input signals** are prepared for further processing. In addition, the first DSP manages a range of user-controllable **source-enhancement plugins and output-optimization plugins**. For detailed information on these plugins, we refer to the manual and the WEISS DAC50x Whitepapers (DAC-501-4ch, DAC-502-4ch - Weiss Engineering).

The second DSP implements the unique LIVEBOX Sound Engine.




This includes the LIVEBOX's **Crosstalk Canceling Sound Engine** along with the LIVEBOX's Sound Optimization Engine and the LIVEBOX's Tuning Engine (see chapters: "What's that Sound?", Pages 7-8, and "Ready to Tune In?", Page 9).

However, the digital brain processes not only audio signals but also essential control and user-interaction data. The system, therefore, requires continuous supervision and orchestration provided by the **Master Control Engine**.
This Master Control Engine primarily runs on an AM335x ARM processor, but interacts with several supporting Atmel microcontrollers. It primarily operates within the user and control signal-processing domain, but also serves as a critical interface to the audio signal-processing domain, playing a central role in the overall architecture.

In addition, the engine provides audio streaming and rendering capabilities, supporting **Roon Ready, Qobuz Connect, UPnP, and USB Audio.**

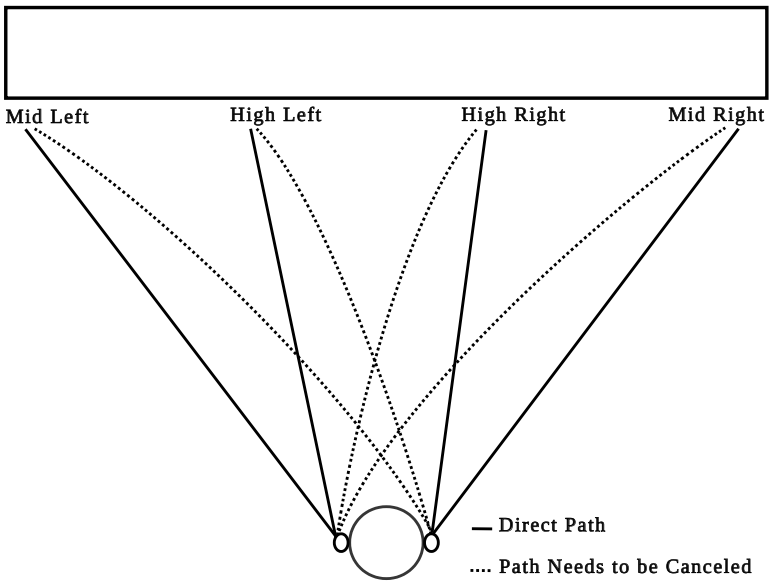
XTC ENGINE

# What's that Sound?

The unique sound of the LIVEBOX is based on a special Crosstalk Canceling (XTC) algorithm developed in collaboration with **ILLUSONIC**.

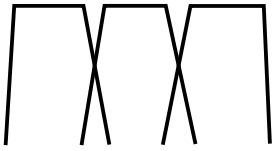
At its core, a Crosstalk Canceling algorithm tries to make each ear hear only what it's **supposed to hear.**

In other words, as shown in the schematic on the right, the sound from the mid-left speaker should be heard only by the left ear and not by the right ear. The intended signal paths are visualized with straight lines - the signal path that the algorithm should cancel is the dotted line and is called the left-right crosstalk.

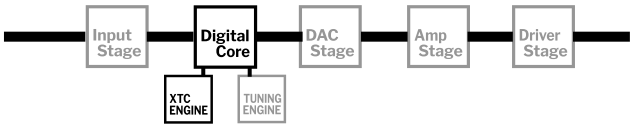



**Conventional XTC** algorithms work only in a narrow frequency band and suffer from coloration due to the comb-filter of the uncancelled portion of the signal. Such comb-filters cause certain frequencies to be boosted while others are canceled, creating an uneven sound, an issue the **LIVEBOX's XTC** effectively eliminates.
Furthermore, the **LIVEBOX's XTC** algorithm allows independent control of the direct sound at both listener's ears by canceling the left-right crosstalk.

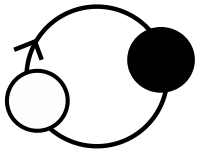
## Multiband



The LIVEBOX effectively overcomes the usual limitations by virtue of its innovative **multiband XTC** algorithm.
By positioning midrange drivers and tweeters at varying distances from the listener, the effective operating frequency range of the **XTC** can be expanded, creating the unique **Broadband Cancellation** performance of the LIVEBOX.

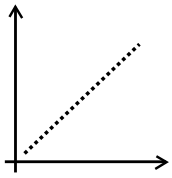



## Hybrid



As opposed to equalizing out the remaining comb-filters, as **conventional XTC** algorithms do, the algorithm in the LIVEBOX adds the original stereo signal in such a way that the overall **frequency response** becomes **flat**.
As a result, a **natural timbre** emerges for the combination of **XTC** and the stereo input signal.

## Linear Phase

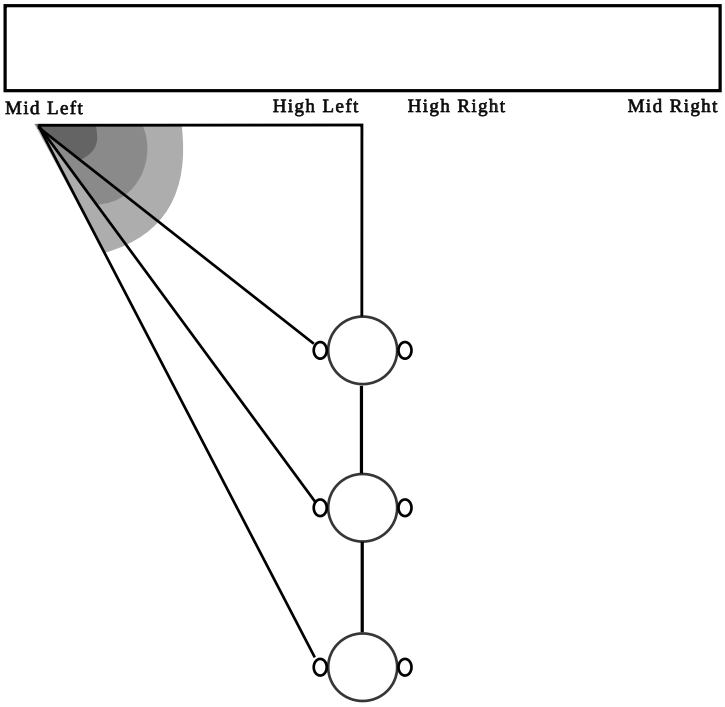


In order to allow the seamless mixing of **XTC** and stereo signals, all filters of the algorithm are **linear phase**.
This ensures the LIVEBOX's absolute accuracy in the time domain.

As a concept, LIVEBOX was presented at the 2016 AES Convention in Paris. A paper was published in 2017. The title of the publication is "Linear Phase Crosstalk Cancellation Filters", by Arnaud Reymond, Christof Faller (ILLUSONIC), and Daniel Weiss (WEISS Engineering) (AES Convention 142, Paper 9734, May 2017).

One more decisive aspect of the XTC algorithm is the Speaker-Listener-Distance (SLD), which can be adjusted in the user interface to ensure the optimal sound experience for the user at home.

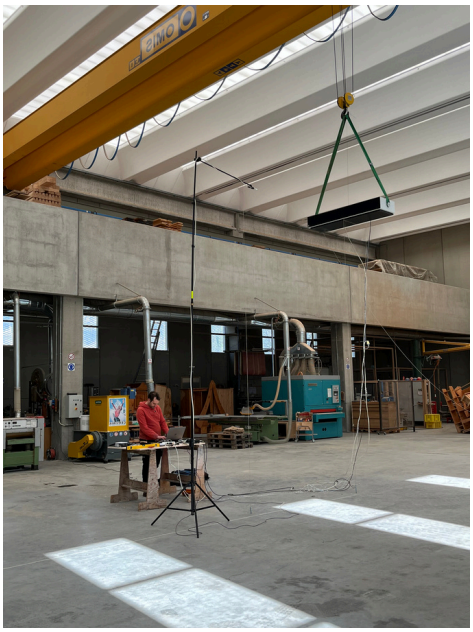
The gray area in the schematic on the right illustrates different angles between the LIVEBOX and the sound path from the mid and high drivers to the listener.
**These angles vary with the distance** between the listener and the LIVEBOX and can have considerable impact on the algorithm's final sound.
The XTC's optimal operating frequency range is defined by these **speaker-to-listener angles**. Inappropriate setting of the SLD can lead to less-than-ideal listening results.



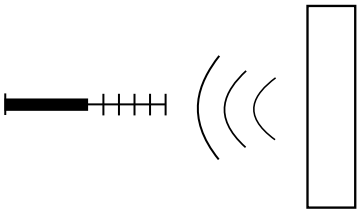
TUNING ENGINE

# System Calibration and Tuning

While the unique XTC algorithm is **mathematically linear in frequency response**, its real-world performance is influenced by the loudspeaker system.
Therefore, **measurements and optimizations** are carried out with the complete system in place to ensure consistent performance in practice.

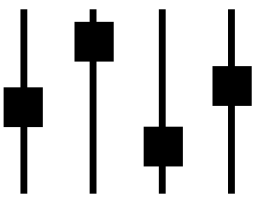


## Speaker–Listener Distance



In the development phase, detailed measurements were undertaken at each Speaker-Listener Distance. The filter architecture was further refined alongside the multiband processing to ensure a **balanced sound-pressure response** across all frequencies.

## Tuning



As part of the production process, each LIVEBOX driver is **individually measured** in an anechoic chamber at PSI Audio. Together with carefully matched components, dedicated filtering is applied to every unit to ensure precise left–right consistency. This accuracy is essential for the stability and performance of the XTC system.

# DAC Stage It's the Conversion that Matters

The LIVEBOX is equipped with a **Digital-to-Analogue-Conversion** Stage manufactured by **WEISS Engineering** which has been a pioneer in this field since the very beginning of Digital-to-Analog conversion for audio.

The D/A conversion stage is a crucial part of the audio signal path, with its quality having a direct impact on the overall performance of the system. The LIVEBOX uses the high-performance ES9038PRO chip for eight channels of D/A conversion. Six channels are dedicated to the individual loudspeaker drivers, while the remaining two channels are used for the additional analog outputs.

The analog stage of the LIVEBOX D/A conversion is designed for **maximum signal integrity and precision.**
It features a fully balanced architecture, ensuring optimal noise rejection and signal symmetry throughout the signal path.

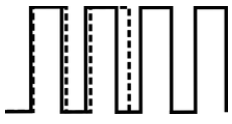
A dedicated, locally regulated power supply in each section is employed to isolate the analog circuitry from digital noise and to ensure stable, low-noise operation.

Output level is adjustable in four discrete analog steps along with the continuous digital Volume Control.

## I/V Conversion

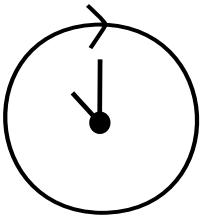

The subsequent current to voltage conversion, level settings and output buffering is built in a **minimalistic** manner for **maximum fidelity**.

## Jitter Reduction



The **ES9038PRO** has an effective **jitter reduction** mechanism, which is essential for a D/A converter.

## Presicion



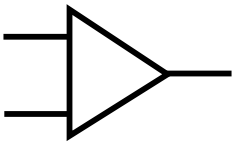
The **master clock** for the D/A conversion process is **local** to the DAC chip. The precision (jitter) of the clocks is ultimately decisive for the quality of the conversion.

Amp Stage

# The Driving Force of the LIVEBOX

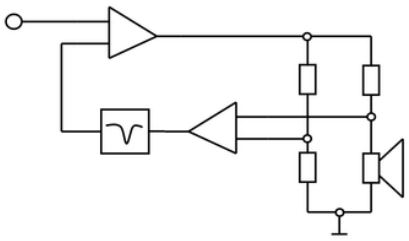
The LIVEBOX integrates PSI Audio amplifiers, which, working in conjunction with the **PSI Adaptive Output Impedance (AOI),** refine and complete the LIVEBOX's output stage.

## Amplifiers



The tweeters are driven by **Class A/B** amplifiers, which operate with lower energy demand than the bass and midrange sections.
The bass and mid range drivers are powered with **Class G/H** amplifiers. These amplifiers can seamlessly switch between 2 pairs of voltage levels when needed.
By mastering this complex design, PSI Audio was able to design **highly energy-efficient amplifiers with low distortion**, reduced thermal stress, and no need for heat sinks.

Another specialty of the Output Stage used in the LIVEBOX is the **Adaptive Output Impedance (AOI)** on all drivers. A schematic diagram is shown on the left.
**AOI is a motion feedback system** which avoids coloration of the sound by compensating the physical characteristics of the drivers.
The aim is to achieve the same damping factors at all frequencies and controlling the impedance from the amplifier to the driver to the waveguide and to the ported cabinet.



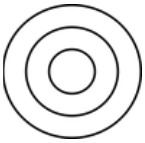
# Driver Stage PSIs Handmade Drivers

The LIVEBOX features **PSI Audio Neodymium Tweeters and PSI Audio Mid and Bass Drivers,** well known for their precision, high Sound Pressure Level (SPL)**,** and extremely low distortion characteristics.

## Hand Made

All drivers are designed and manufactured by PSI Audio in Switzerland, with each unit **handcrafted**.
PSI Audio has been manufacturing its own drivers for over 40 years. Indeed, this is paramount to ensuring high-fidelity sound with minimal distortion, and each driver delivers exactly what is needed.

## Technology



The **Neodymium Tweeters** are equipped with a special dome membrane attached to a light voice coil, which is then assembled to the neodymium magnetic circuit. They are built with so-called waveguides to control the dispersion of sound waves in the room.
For optimal SPL output, the membrane's acceleration needs to be as high as physically possible. This is achieved with a very light mobile mass but also a tight gap in the magnetic circuit. Needless to say, that accuracy in the assembly process is crucial. PSI Audio has acquired and refined this expertise over decades.

## Calibration

Each driver of each LIVEBOX is individually checked, calibrated, and accurately measured in PSI Audio's large anechoic room in Yverdon-les-Bains, Switzerland.
Each LIVEBOX therefore comes with perfect drivers and matched amplification that can be used for accurate cross-talk cancellation. An important part of the sound experience.

# Who is Behind the LIVEBOX

### WEISS Engineering

specialized in digital audio and audio signal conversion with more than 40 years of experience in digital audio

Weiss Engineering Ltd.
Florastrasse 42
8610 Uster
Switzerland

### ILLUSONIC

audio innovation leader, enabling breakthrough products in professional audio, broadcast, consumer, and international ISO/MPEG audio standards.

Illusonic GmbH
Stationsstrasse 20
8606 Greifensee
Switzerland

### PSI AUDIO

a global reference for linear, phase-accurate analog monitoring

Relec SA – PSI Audio
Rue des Petits-Champs 11 a+b
1400 Yverdon-les-Bains
Switzerland

# Website & Showrooms

**Website**

**livebox.audio**

**Showrooms**

**livebox.audio/where-to-experience**