CEVA

Silentium
Silence in a Chip

12th YEAR

CEVA TECHNOLOGY
SYMPOSIUM SERIES

Active Noise Control software solution for the next generation earbuds

Igor Kofman
Director Product Management & Business Development, Silentium

www.ceva-dsp.com

Silentium – Noise control across industries

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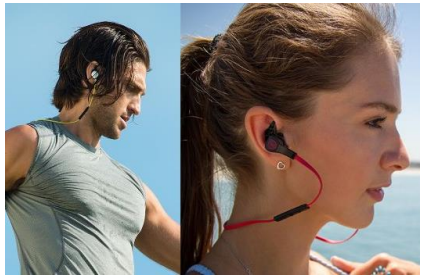
Wearables



Appliances

Automotive

HVAC

Transportation

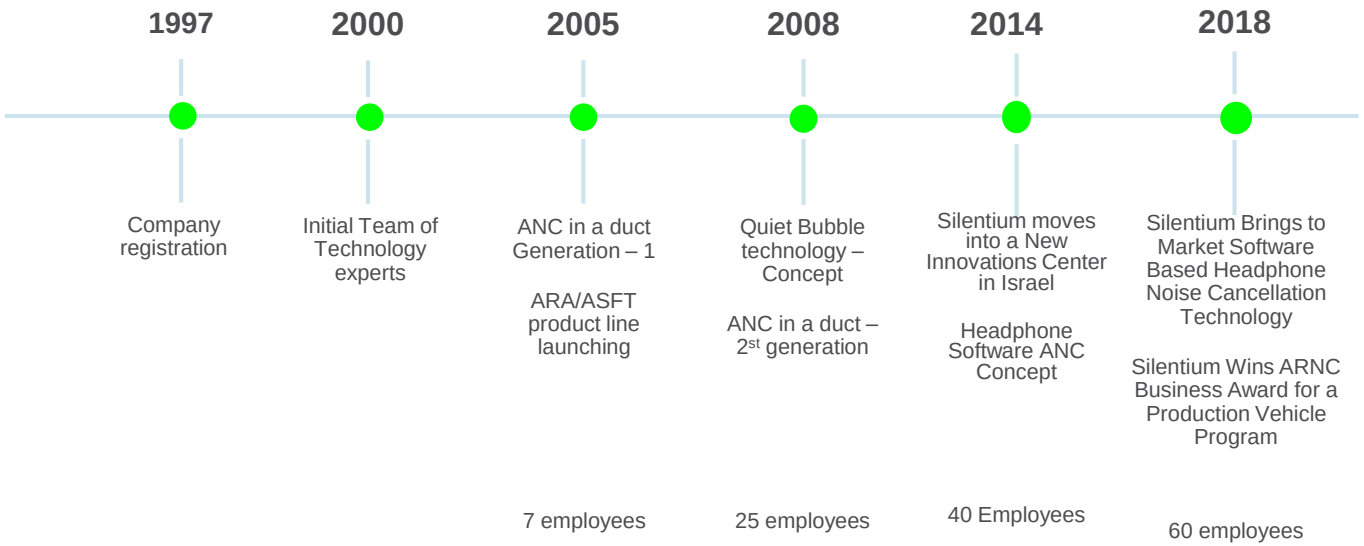
Military

Heavy Industry

IT

Silentium's Heritage

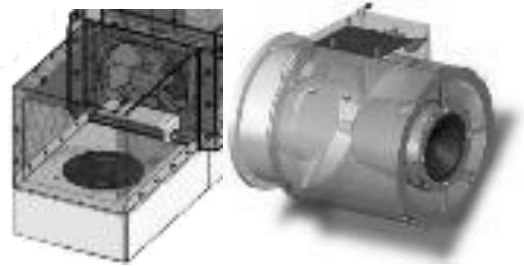
"Born to develop the world's leading ANC technologies"



Foundation of Knowledge

Ducted ANC

- First Soft ANC for CE Product
- Cancels noise directly at the source
- Embedded directly into the noise generating product
- Simple product integration



The “Quiet Bubble™”

- Individual quiet zones
- Allows for privacy and increased effective communication
- Solution embedded into seats, infotainment/audio systems etc.
- Most Advanced Attainable Performance

The Quiet-Phone™ (QP™)

Following strong demand for Silentium patented ANC optimized for headphone products, Silentium established a collaboration program with leading chip makers to license its available ANC S/W for headset applications.

- The overall headphone market is projected to reach 1.2 Billion units a year

Earphones and Headphones Market, By Technology

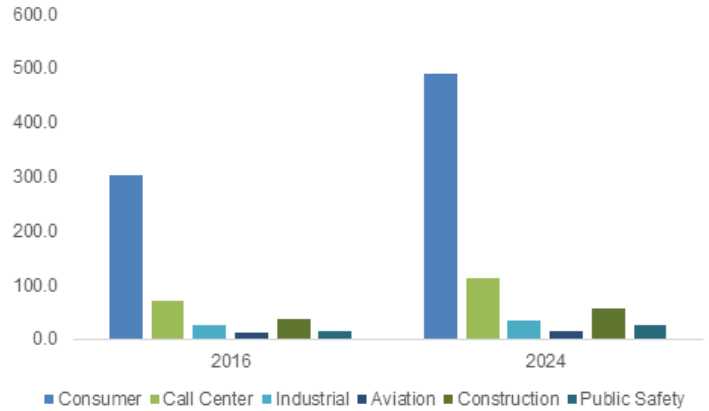
……

Rising demand for wireless technology integrated with the features such as **noise cancellation** and Bluetooth connectivity is expected to contribute to the overall revenue.

The wireless earphones and headphones market is projected to witness over 5% CAGR from 2017 to 2024 due to the ease of convenience and comfort offered by the technology.

Source: Global Market Insights

China earphones market size, by application, 2016 & 2024 (USD Million)



ANC Signal Processing Controller

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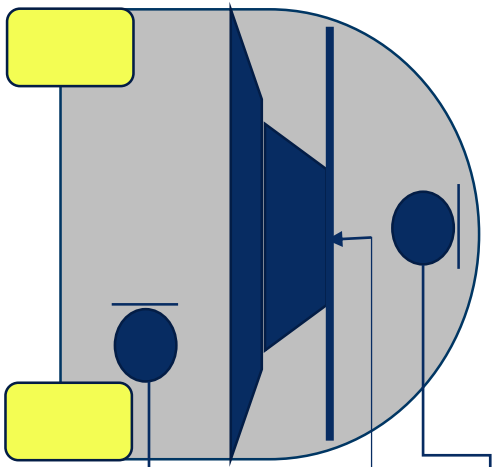
ASIC

- Resource constrained performance
- Limited flexibility during the design process
- Scalability via BOM cost
- Limited system integration with Voice features



DSP IP CORE

- Scalable Performance
- Optimal integration with Audio
- Optimal system level BOM cost
- Few design decisions upfront
- Silentium proprietary simulation Tools

Controller Architecture

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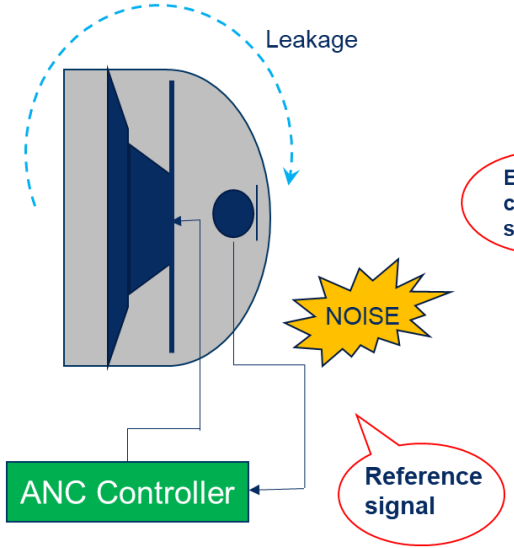
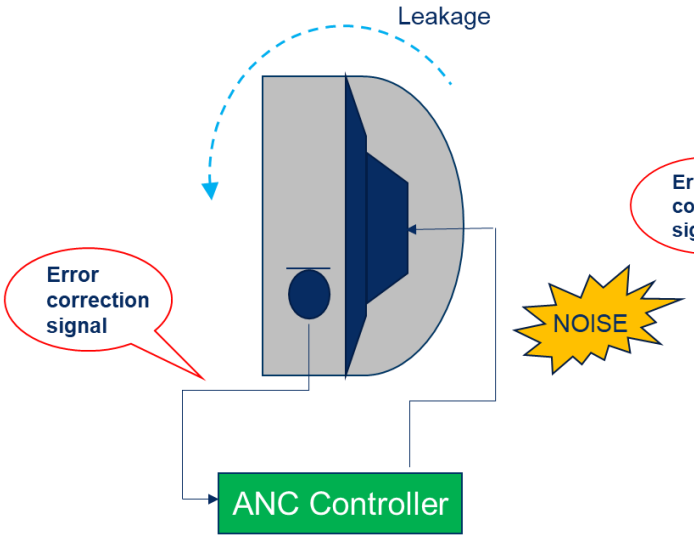
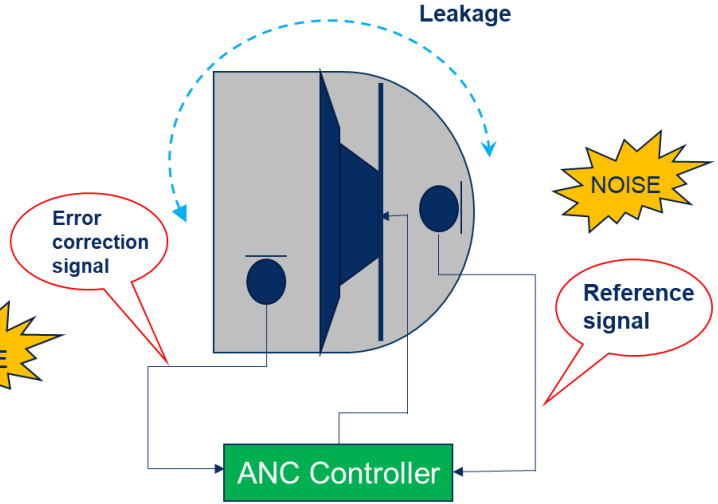
Feed Forward
1 Microphone



Feed Back
1 Microphone



Hybrid FF/FB
2 Microphones

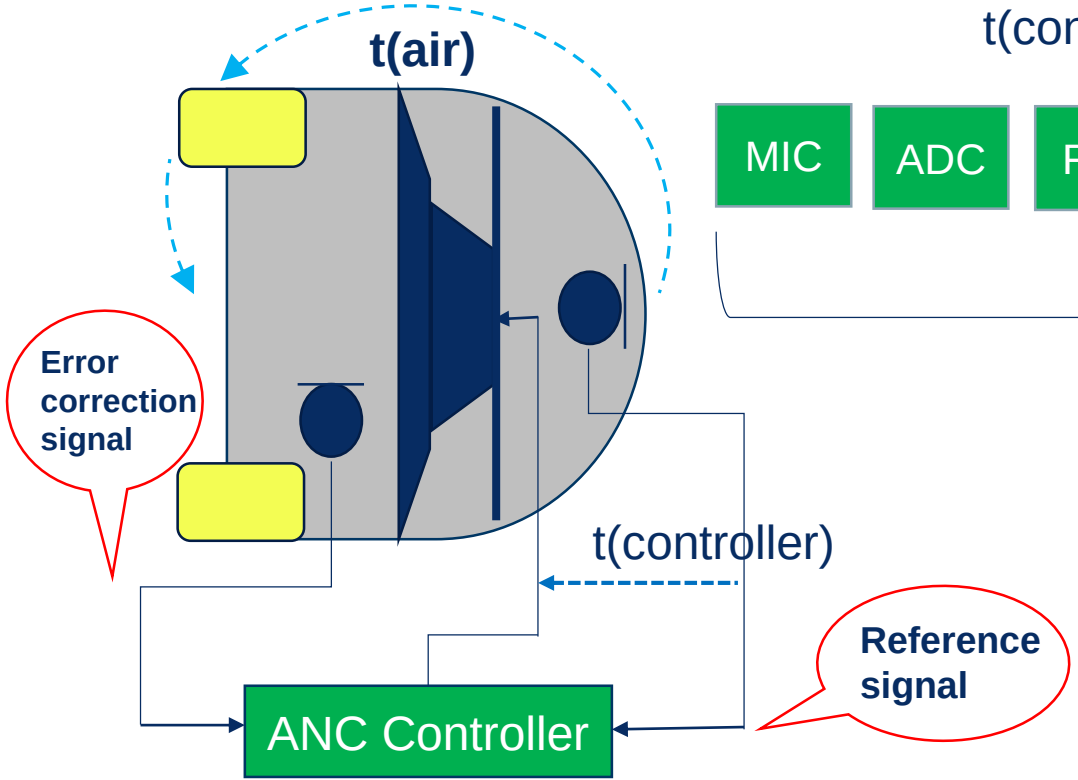


ANC Behavior and Performance

- **Dynamic adaptability**
  - Acoustic leakage from tips/foam
    - – t(air) vs t(mechanical)
  - Dynamic noise sources, noise location, Noise PSD
- **Static adaptability**
  - Acoustic human physiology variations
  - Audio source/type variability, music, voice
- **Environmental adaptability**
  - Airplane, Train, etc.
  - Office

- **Control Interfaces**
- Device user Interface Inputs
- Phone App
- Sensors
- Voice
- IoT

Necessary Conditions for ANC

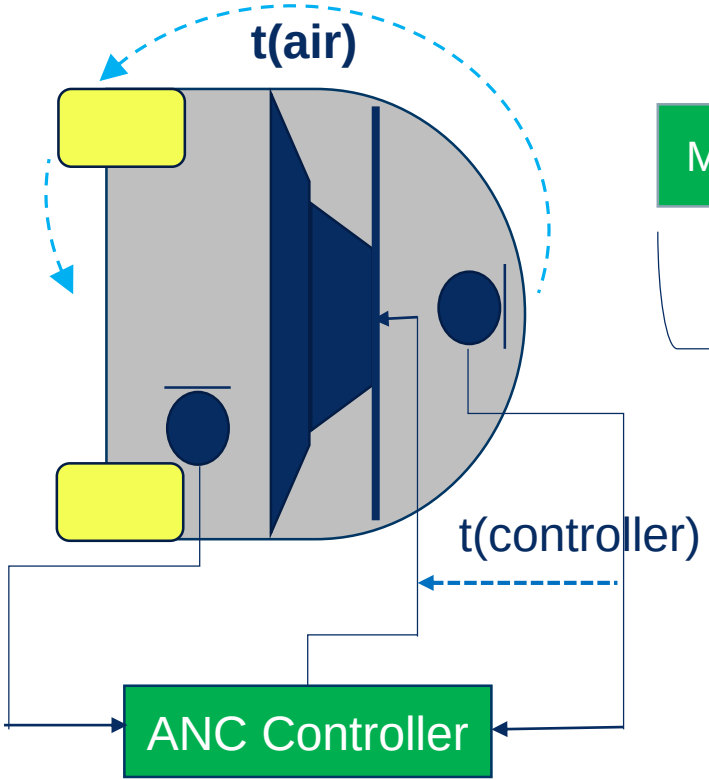


t(controller) < t(air)+t(mechanical)

MIC | ADC | Filters/Algo | DAC | Power Amplifier | Driver

t(controller) = Group Delay
Acoustic path time ~ .050m/340m/s
= 147uS + Mechanical TF

Necessary Conditions for ANC



t(controller) < t(air)

MIC → PDM → Filters/Algo → DAC → Power Amplifier → Driver

Replace ADC with a Digital Microphone

- t(controller) = Group delay
- ANC performance only possible above 250Hz due to microphone latency

Challenges of Intra-Aural ANC

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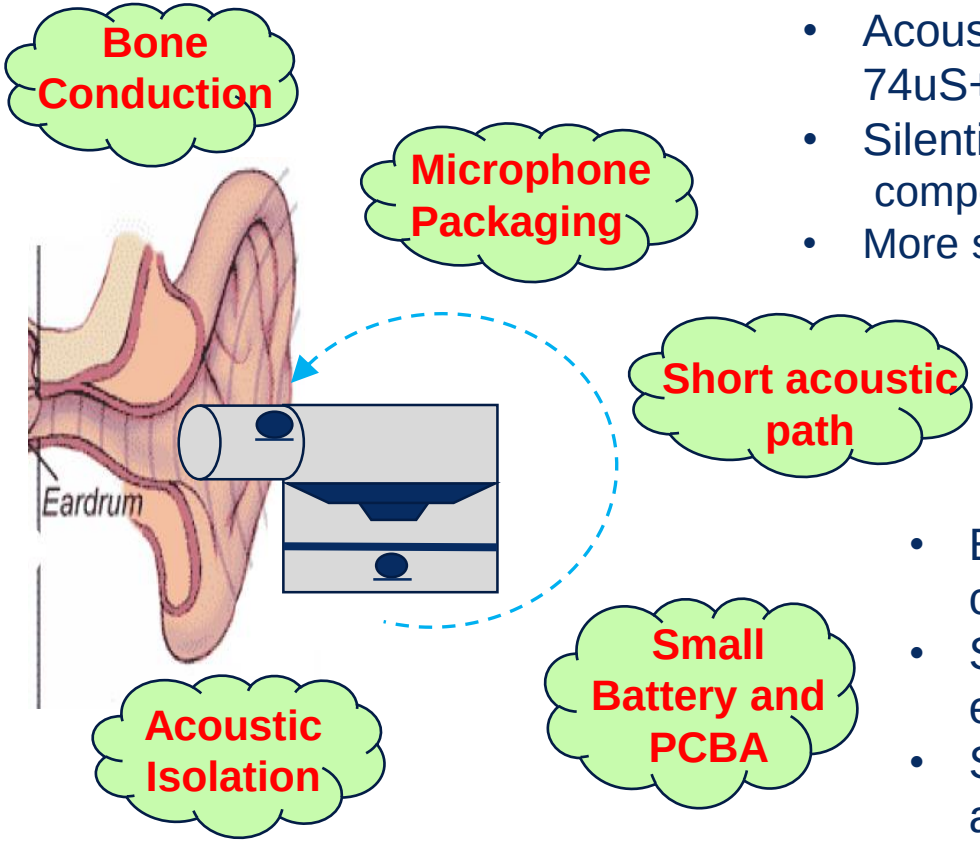

- Acoustic path time ~ .025m/340m/s = 74uS+Mechanical TF
- Silentium predictive algorithms are required to compensate for short Acoustic Path time
- More stringent ADC/DAC requirements
  - Silentium offers maximum broadband performance with Feed Forward only designs, in case two microphones cannot be packaged
- Balanced armature drivers have sealed cavity, but lack in Freq response
- Silentium assists SOC designers with In-ear specific requirements
- Silentium can provide full acoustic design and component selection services

Milestones for an ANC ready SOC

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SOC Product feature definition

Microphone type- analog/digital
Mechanical form
True Wireless
Audio sources
ADC/DAC
Voice/VPA Support
Boot modes
IP Protection

SOC Target Critical Performance Parameters

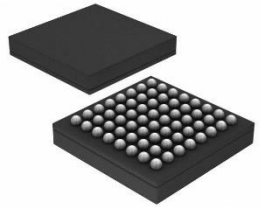
ADC Latency/SNR
I2S Port Speed
Clock domains
Memory
DAC/PA SNR, THD
Hardware accel.
End Of Line programming

FPGA or initial test samples

Initial Library verification
Loopback testing
Early performance demonstrators
Speed & Group delay testing
Audio Integration
Initial MIPS & power modes

SOC Production Release

Production intent ANC Lib – V&V
SOC Final Customer specifications and parameters



End Product – Development Milestones

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Product features and EU definitions

Audio sources for ANC.
Power requirements.
Voice features.
Use cases/UI.
Audio Targets.
ANC Targets.
Wireless Features.

Acoustic components selection and modeling

Driver & microphone Characterization.
Design of tips/foam.
Acoustic cavity modeling.
Target ID design.
Initial performance simulation.

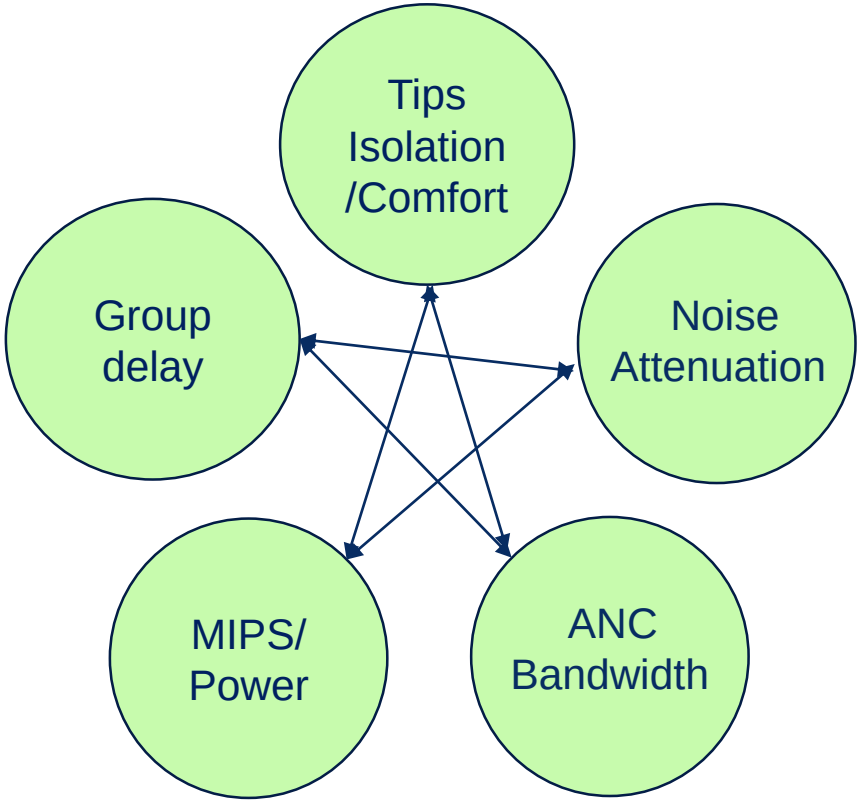
Digital Audio Architecture

Clocking, digital audio design.
Target PCBA, electrical architecture.
Prepare ANC library for production.
ANC performance in target ID.

Release/ Alpha build

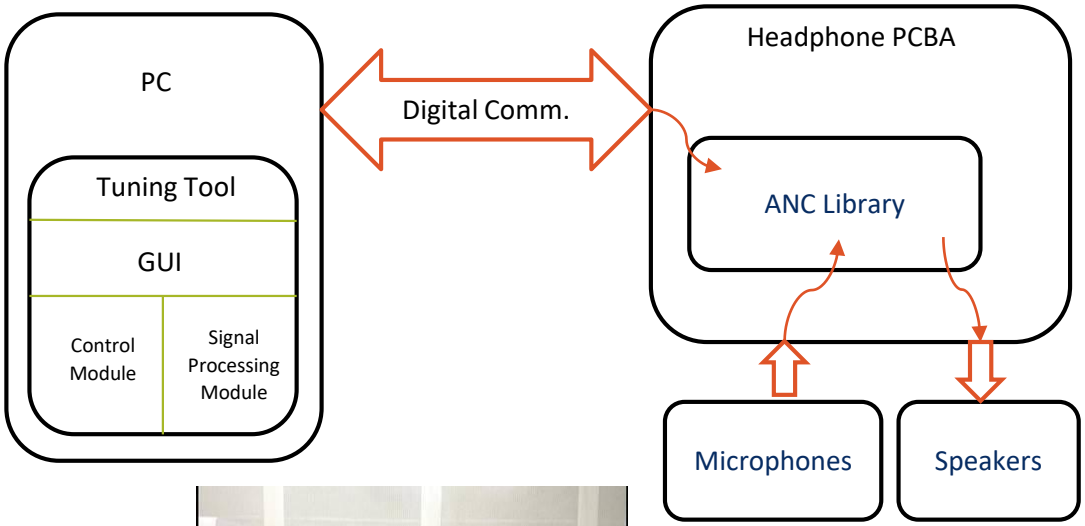
End-Of-Line calibration strategy.
EOL equipment integration.
Final mechanical tolerances.
Critical characteristics measured, verified
Final acoustic calibration.

ANC Performance Continuum



- Predictive Filters - are employed to mitigate longer group delays.
- "Soft" ANC - unmatched capability in design and flexibility
  - MIPS vs. design goals adjustment.
- Flexible architectures - balance SOC and end product goals.
- Tight tips, foam cushions and bands provide isolation, but can reduce comfort. Broadband ANC can balance performance and comfort.

Calibration and Characterization



- Acoustic path modeling.
- Simulation environment for ANC performance prediction.
- Performance Simulation and Coherence Evaluation.
- Proprietary calibration strategy for dynamic noise sources.
- Ability to compensate for leakage in open design (no-tips)
- SOC/PCBA serial connection to tools required.

Steps to a successful customer demonstrator

- Identify demo goals and constraints: ANC, Audio, MIPS, power
- ANC library optimization with an FPGA version of a target SOC
- Identify necessary external components ADC, DAC, PA, etc.
- PCBA level integration
- Drivers, APIs, BSP for the full system with ADC, MICs, FPGA, etc.
- ANC ready acoustics/mechanical headphone prototype. Can also be an existing off the shelf product with quality acoustic components
- ANC acoustic calibration for a target acoustics/mechanics
- Silentium supports you to deliver a complete ANC solution to the end customer

Headset and adjacent areas of competency

- Acoustic cavity modeling
- Acoustic user testing/evaluation
- DSP design, ADC design, Digital and Analog Audio system architecture.
- Acoustic and Electronic echo cancellers, Noise Discrimination and Beamforming
- Audio testing and characterization
- Component specification and electro-mechanical system level integration
- Substrate processes: Flex, Rigid, Rigid/Flex, HDI, LDS
- Headset Power optimization
- Calibration and EOL Unit testing
- Headset sensing and UI Sensing IR, Capacitive, Acoustic

CEVA & Silentium Turnkey ANC Solution

- Based on CEVA ultra-low-power sound DSP
- Fully adaptive broadband ANC technology for power constrained applications like True Wireless.
- Algorithms and Filters delivering performance in all headphone geometries including demanding in-ear applications. The product is ANC Library.
- Soft ANC solution reduces BOM cost, time to market, tightly integrates with audio algorithms.
- Full acoustics design capability, simulation, characterization, calibration and user testing. Full support to End Product designers.
- Chip level consulting for ANC system integration and interoperability with Voice applications.
- Non-competitive partnerships with Chip Design, IP Design and OEM Companies.
- Reduce technology risk and time to market of the full supply chain with Chip and Product Level expertise.
- Full End Of Line solution with partners

Global Team – Local Focus

-Israel,Tel Aviv
Headquarters and R&D

-UK, London

-Korea

-China, Shanghai
Engineering center

-Hong Kong

-USA, Boston

Thank You

Igor Kofman
Director Product Management &
Business Development
igor.k@silentium.com

www.ceva-dsp.com

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