



CEVA TECHNOLOGY
SYMPOSIUM SERIES

Active Noise Control software solution for the next generation earbuds

Igor Kofman

Director Product Management & Business
Development, Silentium

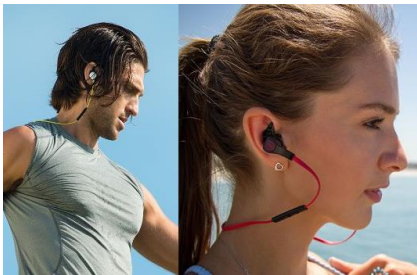
www.ceva-dsp.com



Silentium – Noise control across industries



Wearables



Appliances



Automotive



HVAC



Transportation



Military



Heavy Industry



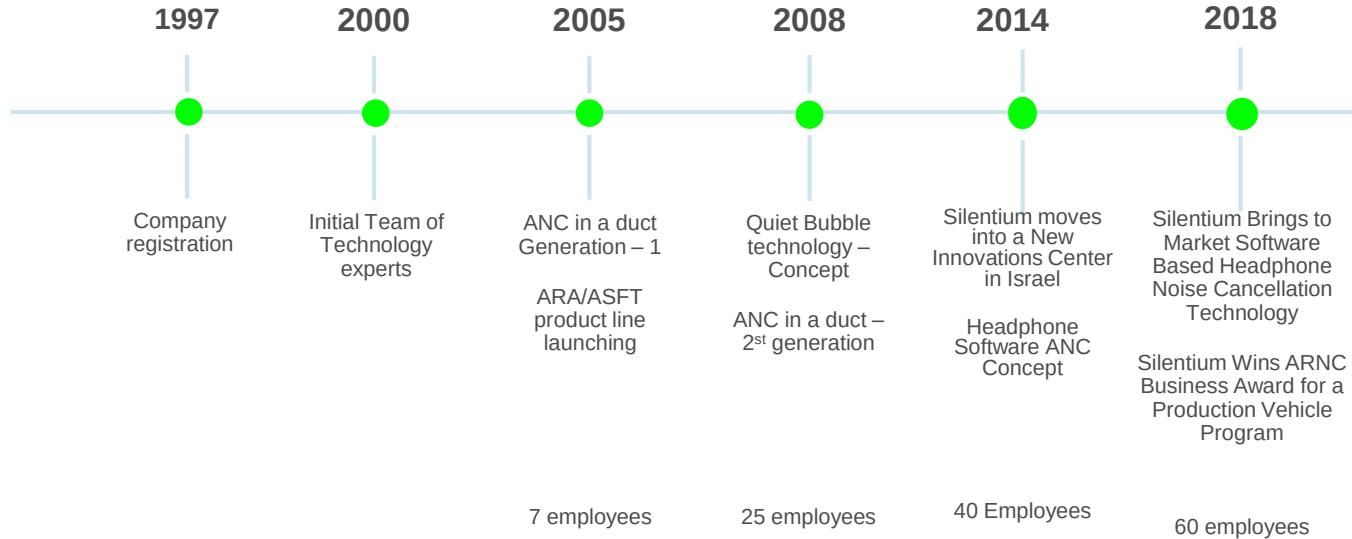
IT



Silentium's Heritage



“Born to develop the world’s leading ANC technologies”

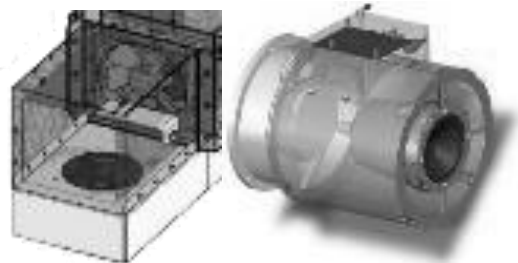


Foundation of Knowledge



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

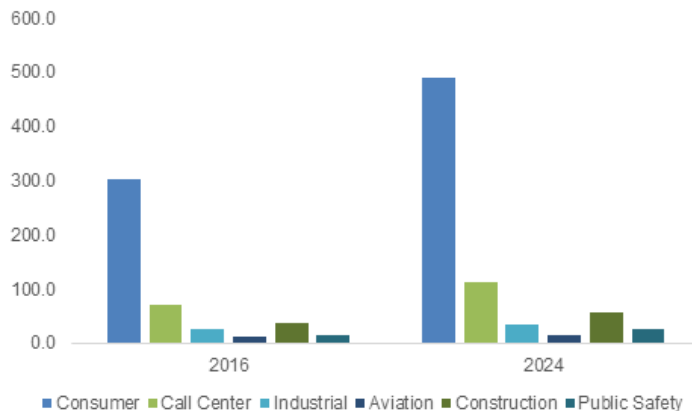
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Rising demand for wireless technology integrated with the features such as **noise cancellation** and Bluetooth connectivity is expected to contribute to the overall revenue.

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)



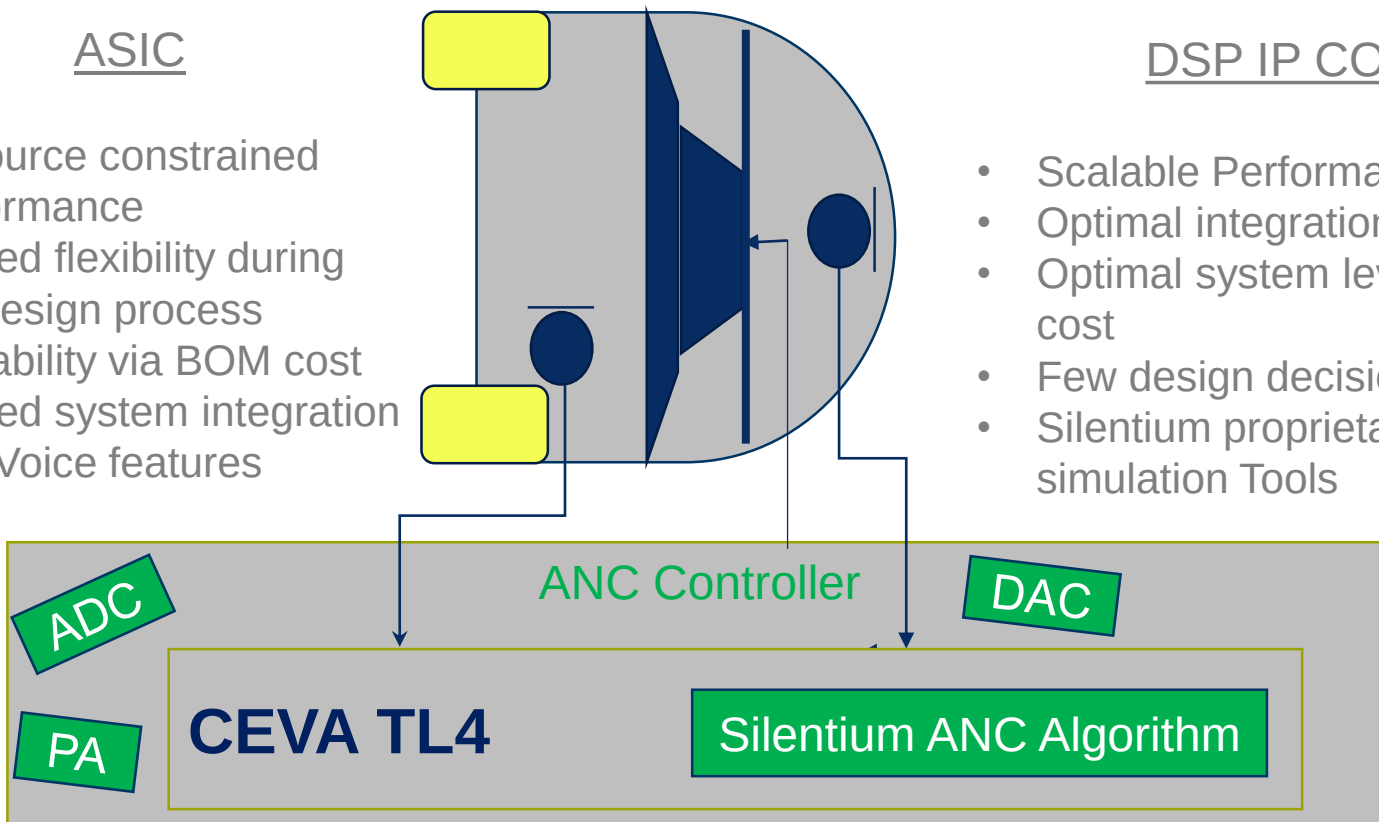
ANC Signal Processing Controller

ASIC

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

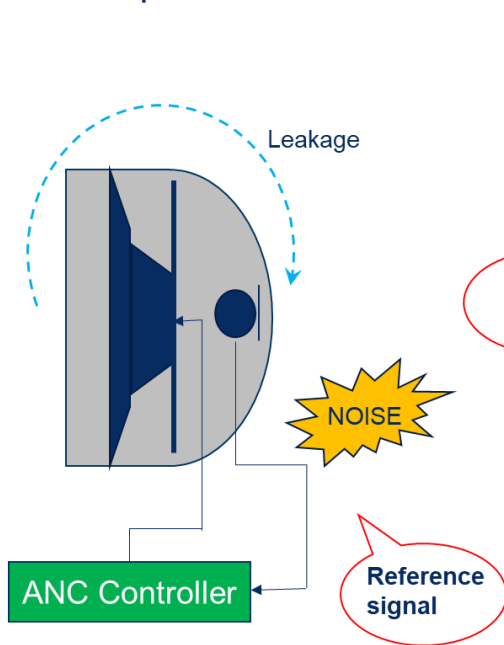
DSP IP CORE

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

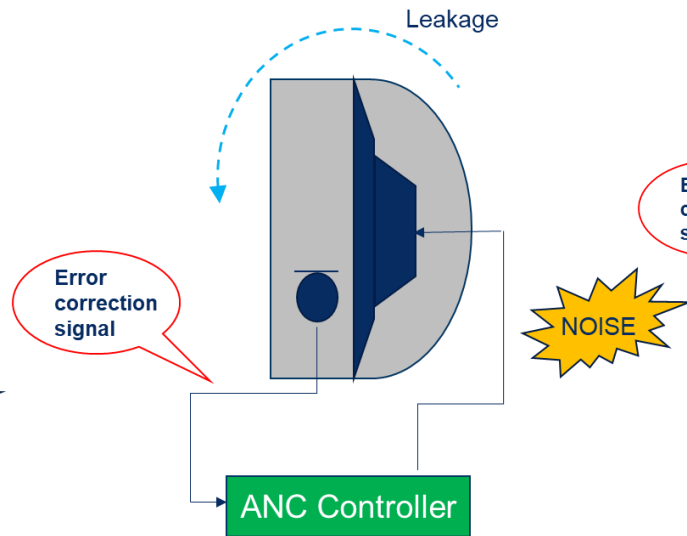


Controller Architecture

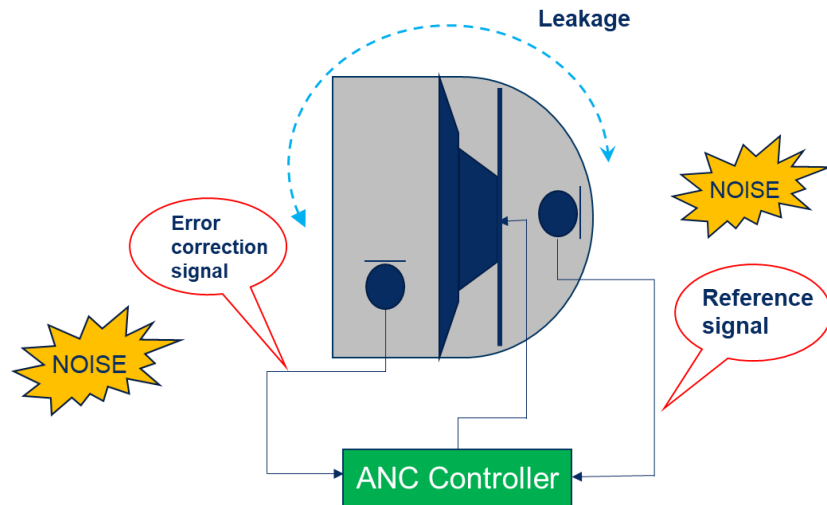
Feed Forward 1 Microphone



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

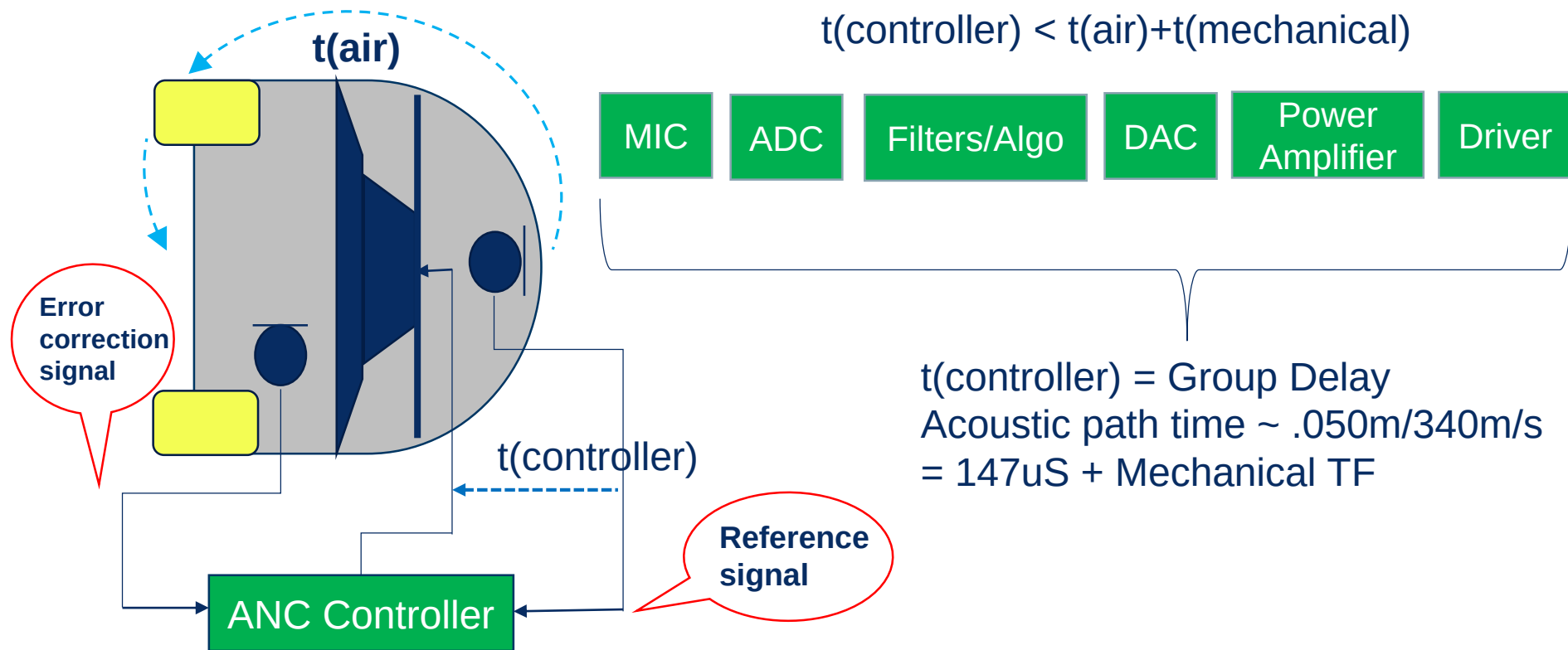
- **Environmental adaptability**

- Airplane, Train, etc.
- Office

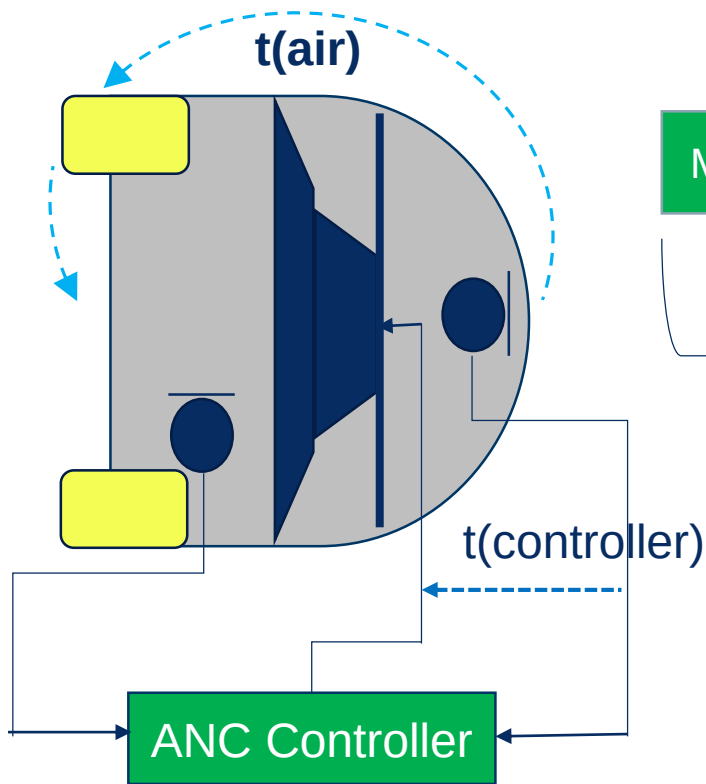
- **Control Interfaces**

- Device user Interface Inputs
- Phone App
- Sensors
- Voice
- IoT

Necessary Conditions for ANC



Necessary Conditions for ANC



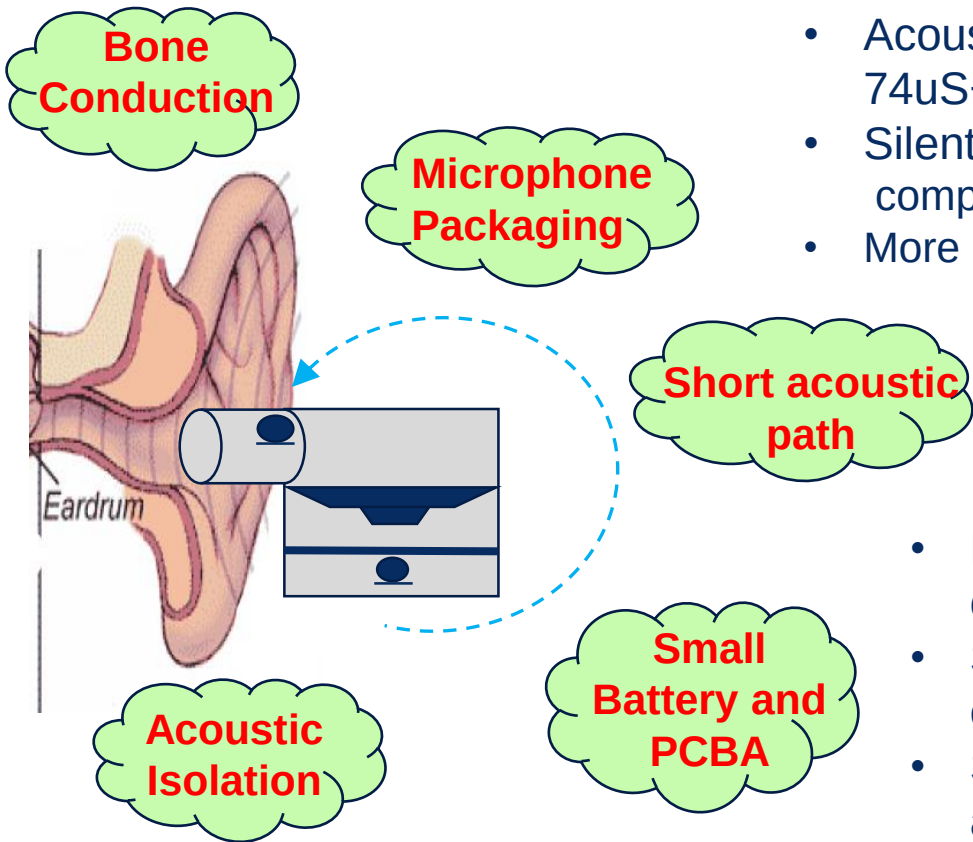
$$t(\text{controller}) < t(\text{air})$$



Replace ADC
with a Digital
Microphone

- $t(\text{controller})$ = Group delay
- ANC performance only possible above 250Hz due to microphone latency

Challenges of Intra-Aural ANC



- Acoustic path time $\sim .025\text{m}/340\text{m/s} = 74\mu\text{s} + \text{Mechanical TF}$
- 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

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

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

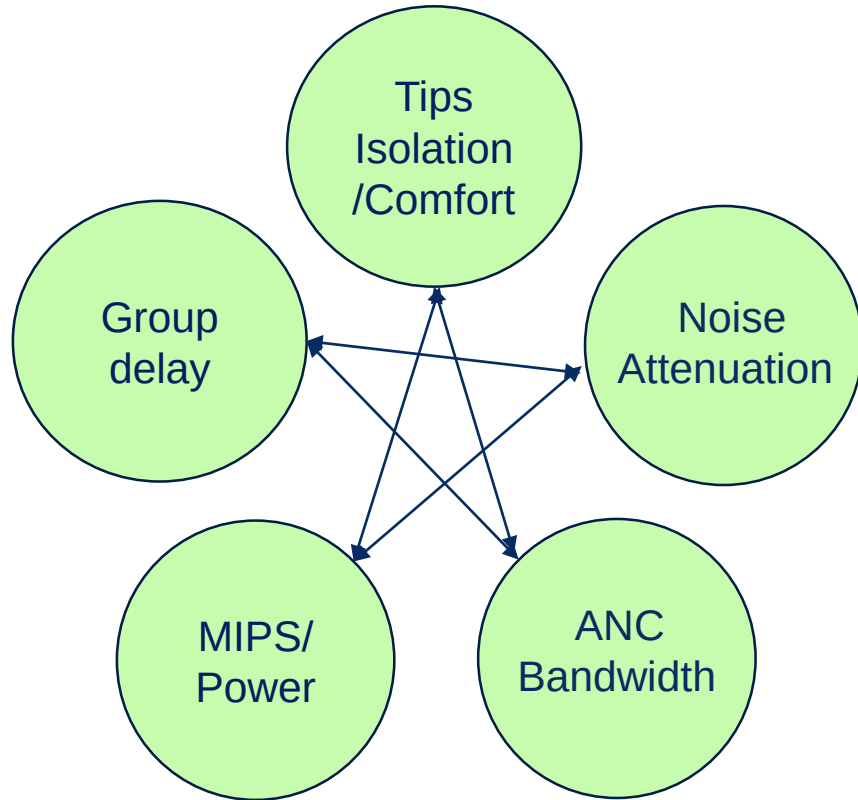
*Clocking, digital audio
design.
Target PCBA,
electrical architecture.
Prepare ANC library
for production.
ANC performance in
target ID.*

Release/
Alpha build

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

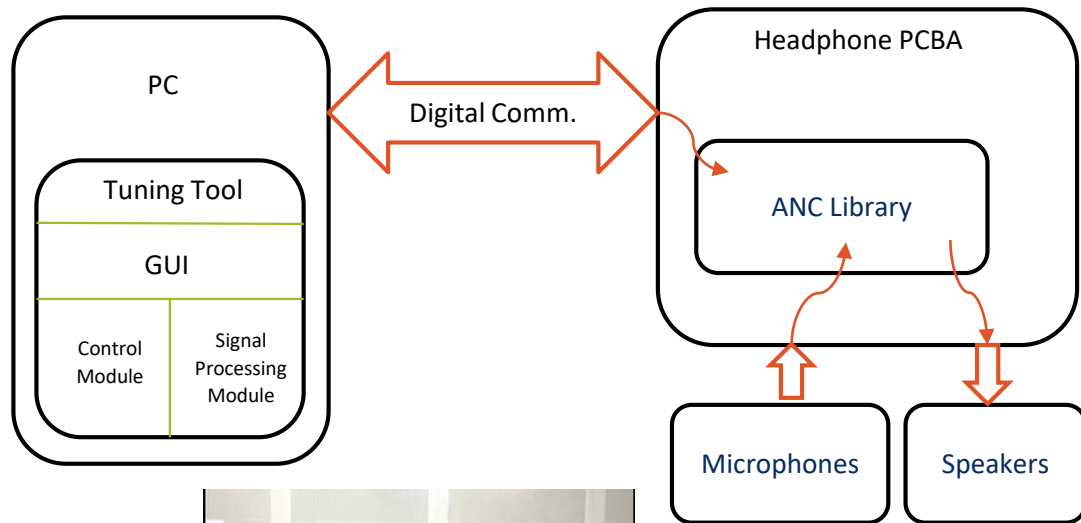


ANC Performance Continuum



- 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



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