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INTEL DEVELOPER FORUM

Designing to Meet New Expectations for Audio Experiences and Standards Critical for Competitiveness

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intel
experience what's inside™

Agenda

- Introduction
- Far Field Voice and Speech
- Output and Speakers
- Innovation, SoundWire and New Audio Hardware
- Wrap Up

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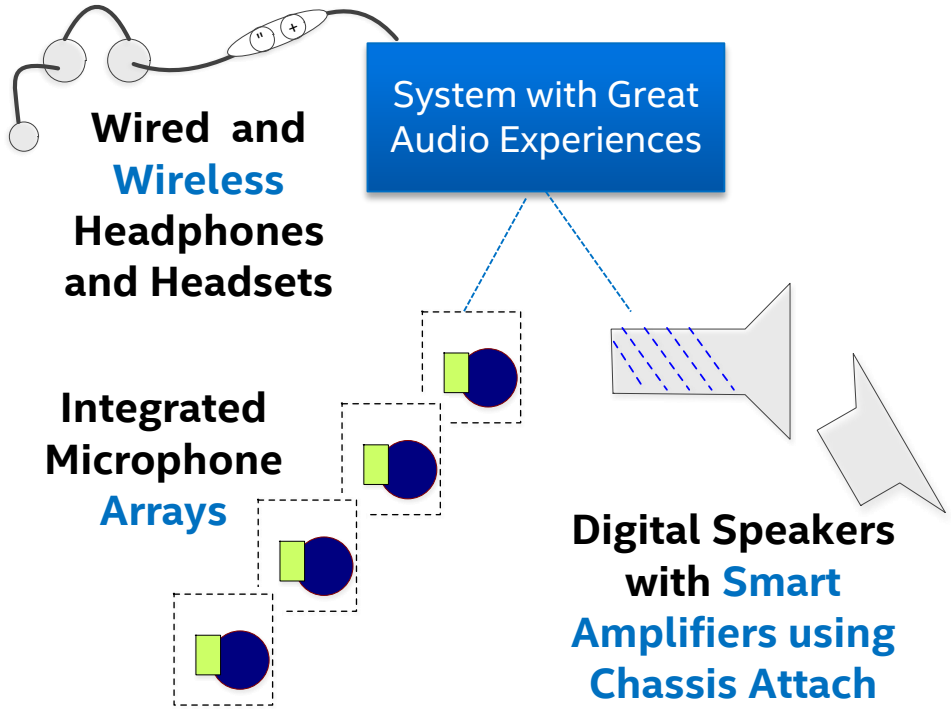
Audio Drives Key Experiences

- Interacting with **AI based bots and intelligent assistants** on your system or in the cloud
- **Communicating** with co-workers, friends and family from anywhere in the room **hands and eyes free**
- Enjoying **music** and **movies**



Computing Renaissance

- We are entering a **computing renaissance**
  - Renaissance is being driven by speech (sometimes called voice) as new interface and new programming paradigm with AI based (chat) BOTs impact
  - AI and speech-based **assistants** and **bots** will have a dramatic impact on the man-machine interface
- Users will want to **use speech NOT text** with hands and **eyes free**
  - Speech outside of mobile becomes key capability
- The next generation of Intel CPUs and GPUs, wireless technologies, mobile screens and optics are going to make the man-machine interface richer and more immersive
- **Great microphones and speakers** critical for every computing device and system

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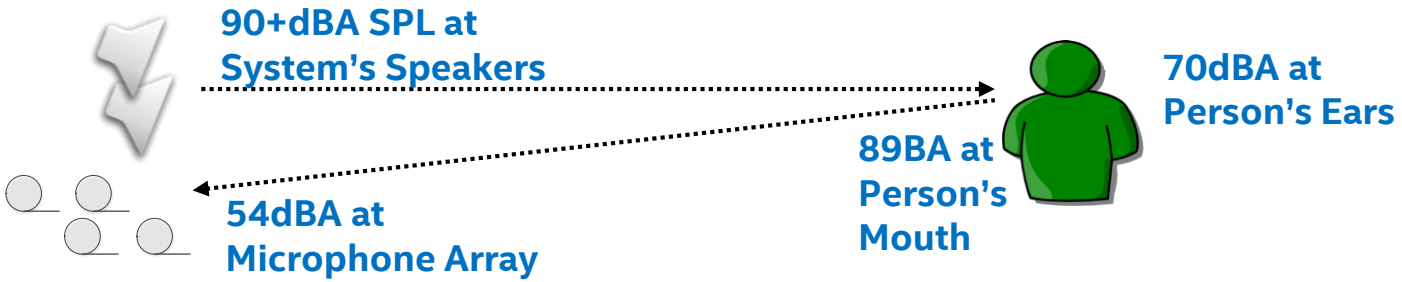
What is “Far-Field Audio”

- “Far Field” is the ability to interact with system up to 4 meters away
  - Can be just in front of a system or full 360 degrees all around the device
  - Includes both clear voice calls and excellent speech recognition
- Transmission of human voice
  - Speech from 4 meters is only ~54dBA at microphones in reverberant rooms
  - Speaker output 85dBA is only 65dBA 4 meters away



- **Input and output** both must be good
  - Must be able to clearly hear device speech interaction responses far-end voice
  - Speech recognition challenge is to properly pick correct speech signal
- Requires improved algorithms, especially AEC and better speakers

Wake on Voice for Far Field

- Far Field Speech is both **hands free** and **eyes free**
- Must be able to gain "**attention**" of the system without any physical contact
- Wake functionality provided by **key phrase** detection in low power states

20"(50cm) > **100"(2 meters)** > **150" (4 meters)**

Wake on Voice in Connected or Modern Standby

Wake on Voice in all low power states

Expected for Future Speech Assistants

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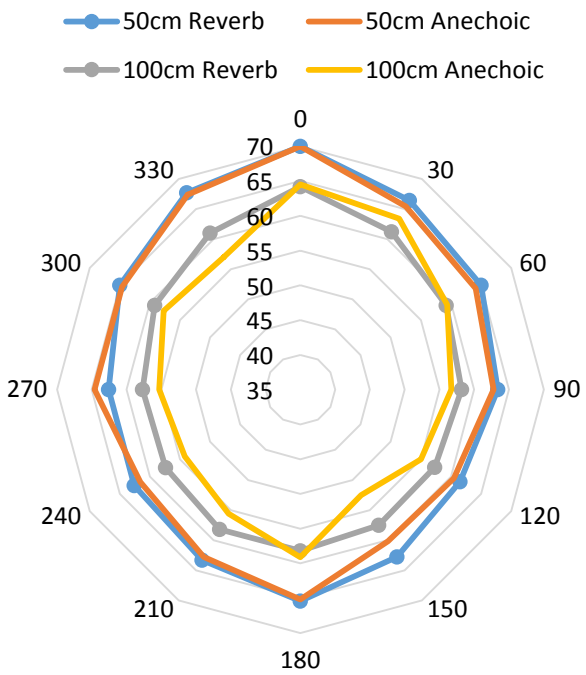
Speaker Output and Reverberation

- Impact of reverb and speaker output

SPL (dBA) around the notebook, with pink noise (reverb vs. anechoic room)



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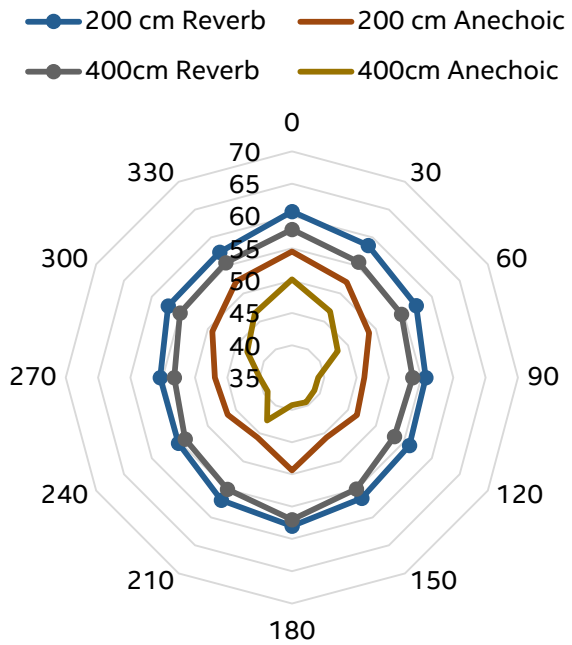

DUT Output level calibrated to 70dBA at 50cm away from the DUT

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Speaker Expectations for Far Field Usages

Real world is what would be recreated for best experience

For whole room (4 meters) real world best case desired

- Human & Machine Speech is 70-85dBa Average with at least 30dB of Dynamic Range attenuated for distance to listener although in noisy environments this might go as high as 90dB peaks; the Frequency for Speech is 100Hz to 16kHz

  100Hz-16kHz
  99dBa Peaks, 12-15dB crest

- Music listened to with at least 40dB of dynamic range and average levels about 70dB at your ears and thus must increase as you move away from the speakers with the frequency desire to go as low as 80Hz and at least up to 16-18kHz

  80Hz-20kHz
  88dBa Peaks, 18dB crest

- Movie sound track likely to have much higher crest factors with perhaps 80dB of dynamic range but with average listening levels again determined by the speech levels but adjusted in loudness as you go further from the speakers

  80Hz-20kHz
  105dBa Peaks, 20+dB crest

Speaker Quality Metrics for Whole Room (Far Field) User Experiences

Basic Notebook or Convertible	Premium Notebook or Convertible	AIO, Portable AIO or "Amazon Echo* like System"
85dB	87dB	100dB
180Hz	165Hz	80Hz
MOS 3.7	MOS 4.1	MOS 4.5

SPL is measured at 50cm distance and the Frequency at the "judged" -3dB Roll-off point

Great Speech when Using 4 Microphones

High-Noise, High-Reverb Conditions

- ASR Engine: Cortana* (CAR)
- Room Condition: RT60 ~450-500ms
- SNR: ~5dB
- Two **Non-Stationary** Noise Sources (TV Broadcast, Other Talker)
- User at 1m, 2m and 3m
- 120 Utterances; Combination of Male and Female Talkers

Conditions:	Unprocessed			4-MIC Processed		
	1m	2m	3m	1m	2m	3m
Speech Only	78.1	81.16	70.21	94.85	92.92	90.66
Speech + Noise	39.29	42.51	25.44	91.47	83.74	78.1
Speech + Noise + Echo	12.56	10.79	3.38	87.76	81.16	74.4

In Low SNR Conditions, 4-MIC Technology Can Improve Performance up to 50% Compared to No Processing

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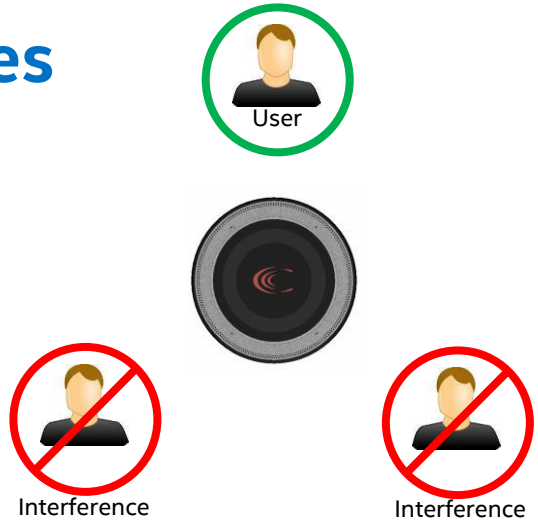
Great Speech when Using 4 Microphones



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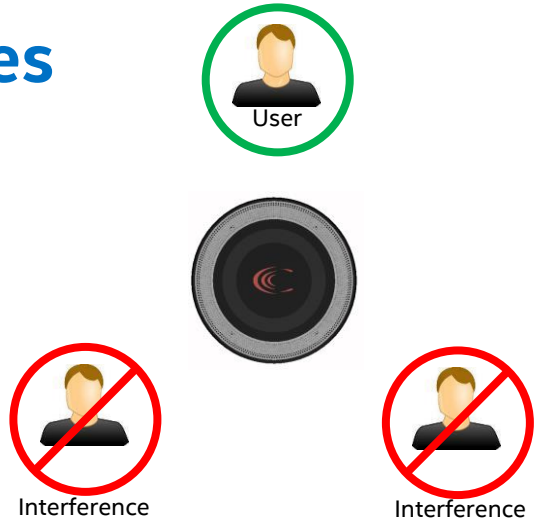

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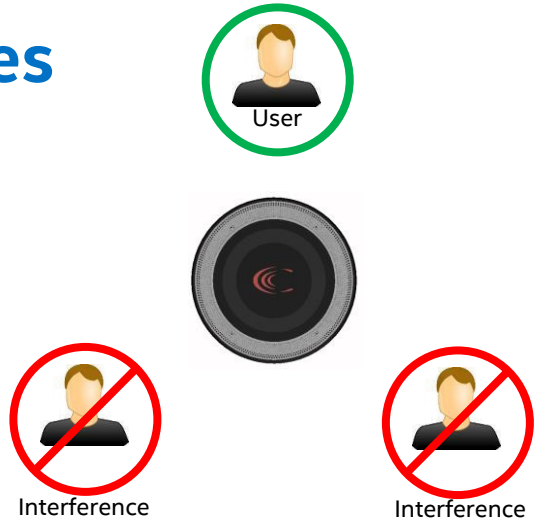

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Designing for Speech Experience

Design platforms that perform extremely well with seamless speech interaction and that works anywhere in the room, “Far Field”

- Using enough microphones with sufficient fidelity to provide 4 meter support
- Recommending **4 microphones** for most systems
- Use better quality microphones with **SNR of 63-65dB** or more
- No **singing CAPS**, HDD noise, **no fans or vents** near microphones, etc.
- Well **matched sensitivities** and phase across all microphones in an array
- Properly **sealing the mounting for the microphones** with good isolation for all internal system noises
- Best available signal processing algorithms **specifically designed for speech at 4 meters distances (Far Field)**
  - User and room noise position tracking with adaptive beam forming
  - Blind-Source Separation
  - Great Acoustic Echo Cancelation (AEC)
- Don’t forget the **speaker output SPL** enough to be heard at 4 meters

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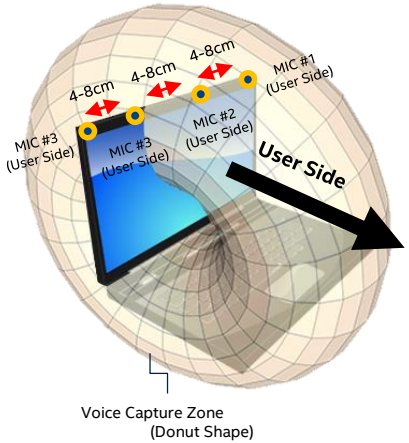
Far-Field Microphone Geometries

4-MIC Linear Placement

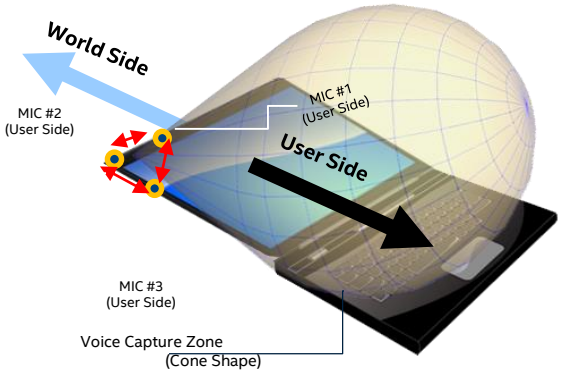


MIC Placement
- Linear (user side), the four MIC can be placed anywhere on the same dimension

Tracking Dimension
- 1-dimension

Performance
- Better directive beam for far-field vs. 3-MIC
- World side noise will not be suppressed. Beam is formed in donut shape
- Donut size can expand to have 360° full range coverage

3-MIC L-Shape Placement

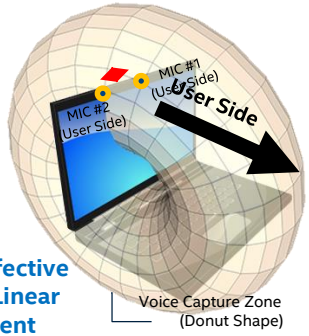


MIC Placement
- L-Shape (user side)

Tracking Dimension
- 2-dimension

Performance
- Better directive beam for far-field vs. 3-MIC
- World side noise will be suppressed when display is sitting "**FLAT**"

Less affective 2-MIC Linear Placement



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forté media

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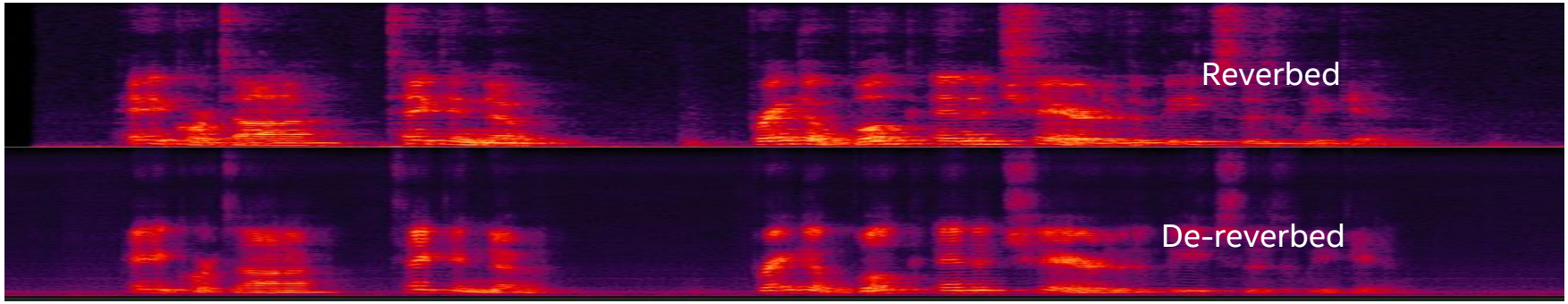
Fortemedia* Far-Field Speech Improvement

Success Rate (%)	3 meters					50 cm
	iS700* ('15)	iS800V1* (2-Mic, 2Q16)	iS800V1* (4-Mic, 2Q16)	iS800V2* (2-Mic,3Q16)	iS800V2* (4-Mic,3Q16)	
Clean	68.26	73.21	75.12	84.83	90.85	98.01
Pub	54.71	67.81	69.18	76.17	82.88	95.12
Cafe	56.45	64.28	65.82	75.03	83.75	95.06
Music	36.35	55.26	62.22	67.61	73.15	96.32



Test setup referenced from Microsoft* Cortana* test conditions

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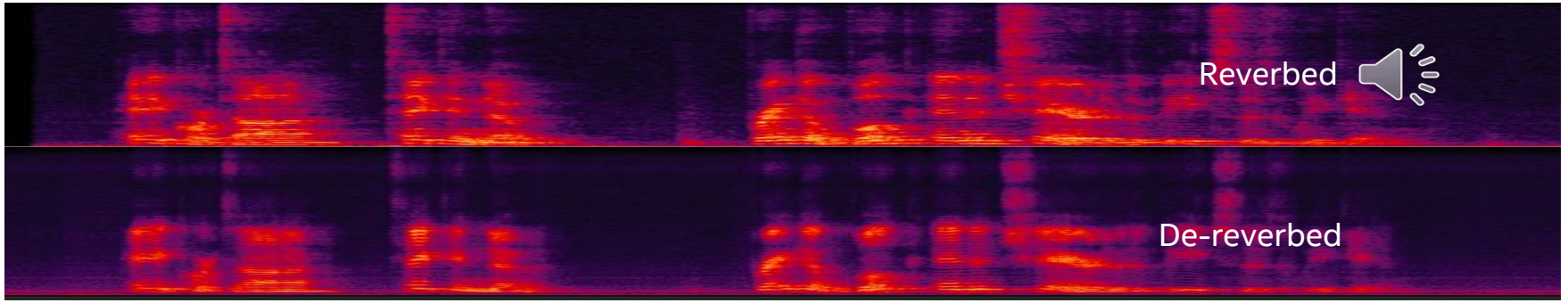

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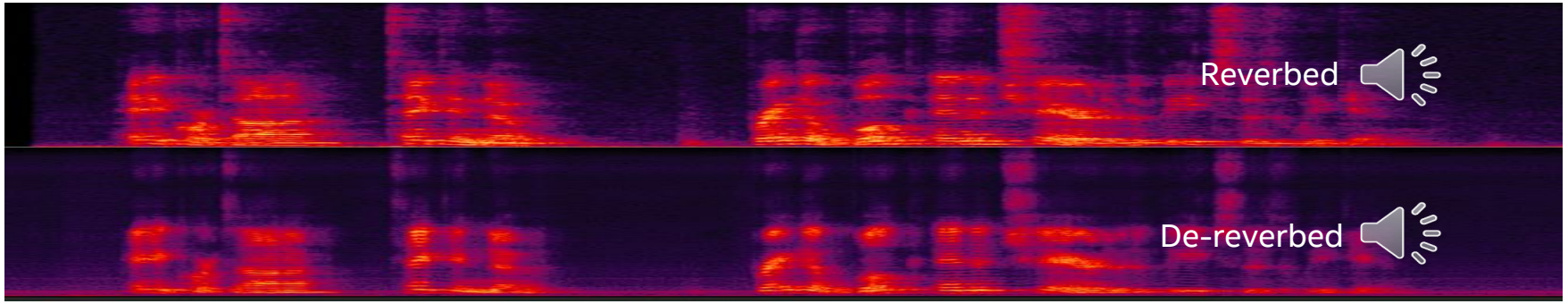

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Speech Platform Evaluation Tool (SPET)

- Modular framework supporting multiple speech environments that validates platform speech subsystem and end to end user experience using form factor specific use cases
  - Not measuring specific ASR quality and performance
- Passing ensures good implementation of electromechanical microphone array design and algorithmic processing ensuring consistent speech recognition on Intel based platforms when using chosen speech environment such as Cortana*, or RockHopper*
- Validates the signal processing built in to the platform under various conditions including environment noise and platform orientation
- Provides advanced tools for supporting preprocessing tuning, batching data generation and performance analysis

SPET Updates for 2017

- Adding additional tests specifically for key phrase recognition performance
  - Includes both false accept & false reject rate testing using multiple corpus
- Adding far-field microphone performance measurement support
- Includes room response measurements – reverb time (RT20/30/60), background NC/NR level, room impulse response
- Microphone frequency response, sensitivity
- Adds speaker frequency response, and loudness
- Improved equalization of background noise speakers at test unit

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Speech Assistant Requirement Expectations

	Today	Expected Next Generation Speech Assistant		
	Microsoft* Cortana* Standard	Standard	Premium	
Test Distance	0.5m	Near 0.5m	Near 0.8m	Far 4m
Noise Pattern	Quiet	Quiet		
	Babble_Pub	Babble_Pub		
	Babble_Cafe	Babble_Cafe		
	Echo	Echo		
		Babble_Pub + Echo		
		Babble_Cafe + Echo		
Speech Pattern	Male + Female	Male + Female + Children (5-12)		
Test Angle	0 deg	0 deg		
		50 deg		
Keyword Spotter	Only applicable for specific Windows* version	Yes		

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Achieving Speaker Quality

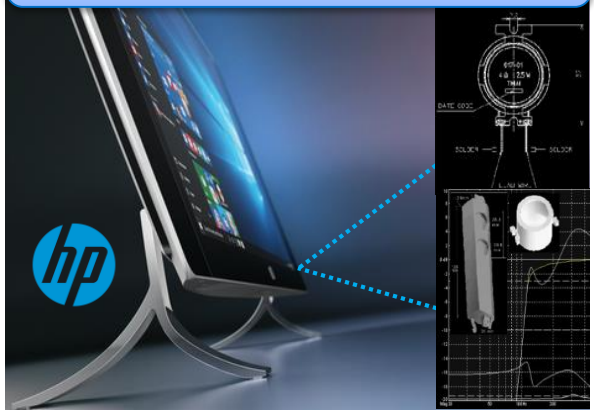
Users feel that PC speaker quality not meeting expectations, matching competitive solutions and not ready for whole room and far field experiences

- A number of options to solve the challenges are available for you to use today…
  - Removing the speaker enclosure (the Box) and utilizing the chassis to provide the sealed volume called **Chassis Attached Transducer (CAT)**
    - Adds substantially to speaker volume (space)
    - Providing opportunity for reducing the audio BOM cost
  - **Smart amplifiers** driving enhanced peak power and providing **speaker protection**
  - **Larger speaker drivers** and use of either **dual magnetics** or dual drivers per side
  - **Digital and multi-coil speakers** with new amplifier enhancing loudness while lowering power consumption
  - **Front firing** of the speakers enhancing loudness and high frequency
  - Passive radiators helping to enhance bass

Cost reduction scenarios described are intended as examples of how a given Intel-based product, in the specified circumstances and configurations, may affect future costs and provide cost savings. Circumstances will vary. Intel does not guarantee any costs or cost reduction.

Introduction to Sound Research

Innovative Designs



- Patent-pending technology
- Optimize for bass, loudness
- System BOM cost reduction

NEW **Gasket Seal Technology**
to complement CAT speakers

Software

- Automated speaker tuning
- Best in class enhancement

NEW **Soft Amp**

NEW **CloudCal*** room tuner

Service

- Product mastering services
- Speaker design consulting
- OEM training and support

SOUND RESEARCH

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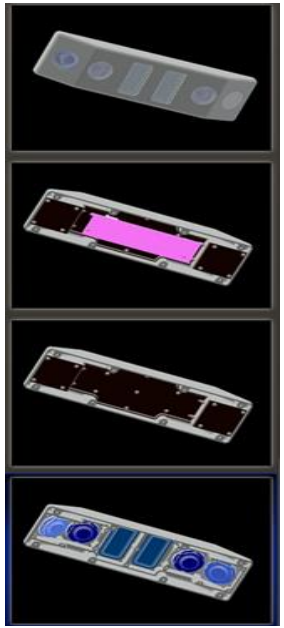
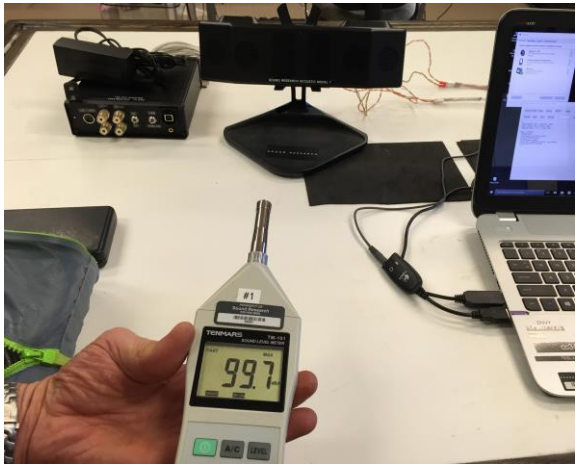
The Smartest, Loudest Speaker is CAT



Hawking's voice was tuned by Stephen himself, using Sound Edge Tuning Tools



Hawking's Voice with CAT Speakers and Smart Amp
99.7dB "A"

SOUNDEDGE

SOUND RESEARCH

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Chassis Attached Transducers (CAT) Speakers and Gasket Seal Technology (GST)

- **Speakers require volume** (space) to achieve the best loudness and bass (low frequency)
- Thinner form-factors mean less internal volume to be utilized for speakers and mounting speaker boxes in a chassis means you're putting **a box inside of a box**
  - Plastic surrounding traditionally used, significantly reduces the usable volume
  - Speaker enclosure & mounting is complex & custom for every design adding to design & BOM cost
- CAT solution **removes the speaker enclosure (Box)** & **utilizes the chassis to provide the volume** while reducing the overall BOM cost
- Challenges with CAT:
  - High mechanical Q sealing
  - **Avoid glue** in platform assembly
  - ODM **HVM friendly**

- CAT without GST mounts directly to chassis using glue which easily cracks & flexes
  - Leads to distortion & poor bass response
  - Difficult & expensive to replace damaged or defective glue-attached transducers
- CAT with GST Speakers attach such that they are easily replaceable while eliminating separate fasteners/grommets where possible, reducing parts count and complexity
- GST supports speakers of all shapes & sizes

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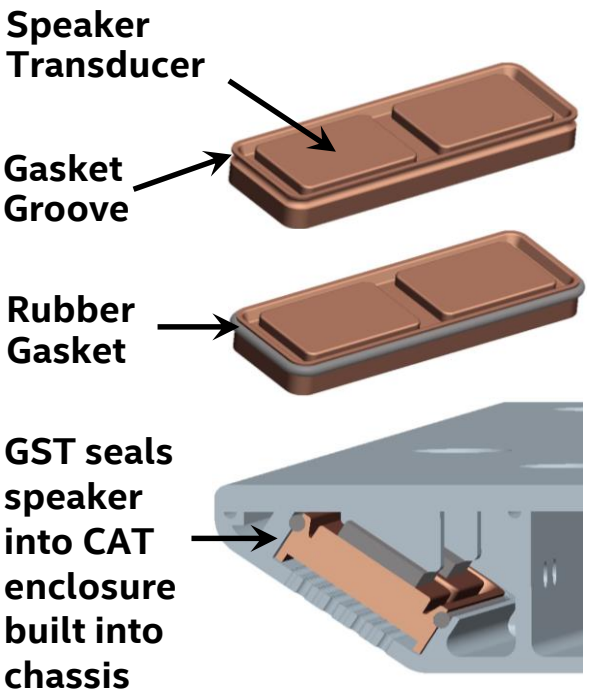
Gasket Seal Technology



CAT/GST Advantages

- **Bigger Speaker Drivers**
  from more efficient use of space
- **Superior Bass**
  from additional back volume and better sealing (high "Q")
- **Maximum Loudness**
  from larger speakers and more stable attachment to chassis
- **Lower Support Cost**
  More reliable, easily replaceable
- **Potentially reduced BoM**
  Reduced parts count, less glue

GST Partnership Speaker Vendors

LUXSHARE ICT

VECO VANSONIC ENTERPRISE CO., LTD.

FOSTER

FG Forgrand

SAMPLES AVAILABLE NOW

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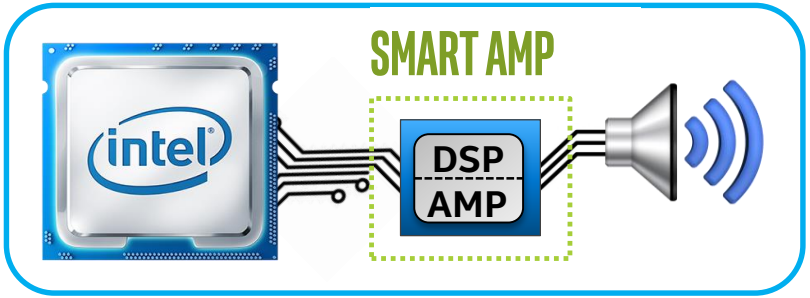
Smart Amplifiers

Another Approach for Loudness and Improved Bass

- Typically speakers are driven conservatively because of little or no direct knowledge of the overall system interactions (amplifier, speaker, enclosure, and chassis)

- Smart amplifiers can improve performance without compromising coil temperature, mechanical excursion, material fatigue, etc.

Smart…



- Smart amplifiers utilize a separate DSP for processing to optimize the amplifier for the speaker you're driving
- Uses feedback mechanisms and known speaker characteristics from manufacturer to provide the best performance
- This means you are able to optimize the amplifier for the speaker in your system

SOUND RESEARCH

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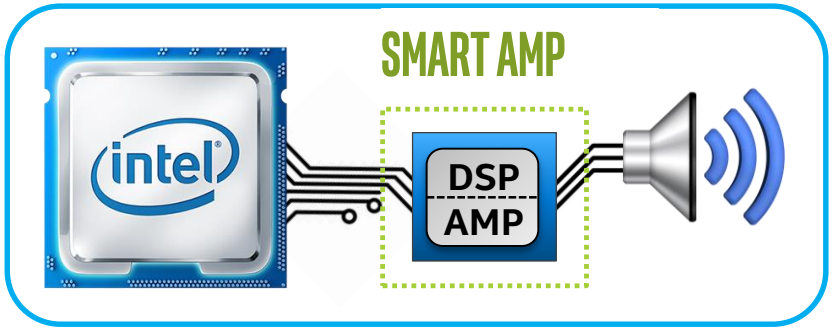
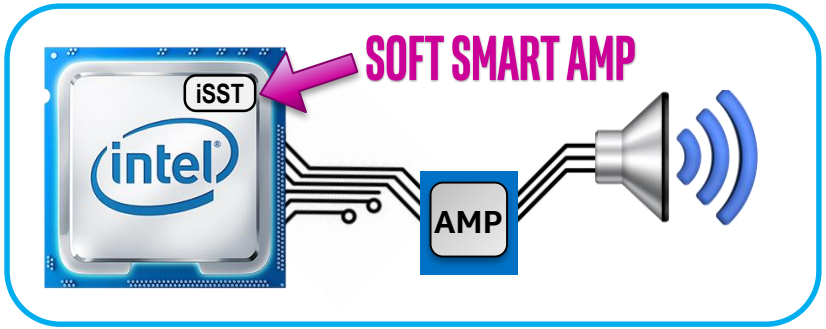
Another Approach for Loudness

Smart…



Smarter…



SOUNDEDGE*

SOFT SMART AMP BENEFITS

CHEAP

Potentially lower BoM with equivalent speaker driver protection

LOUD

Maximum SPL with minimal distortion and enhanced audio fidelity

GOOD

Better sounding solution when tuned with SpeakerCal*

SOUND RESEARCH

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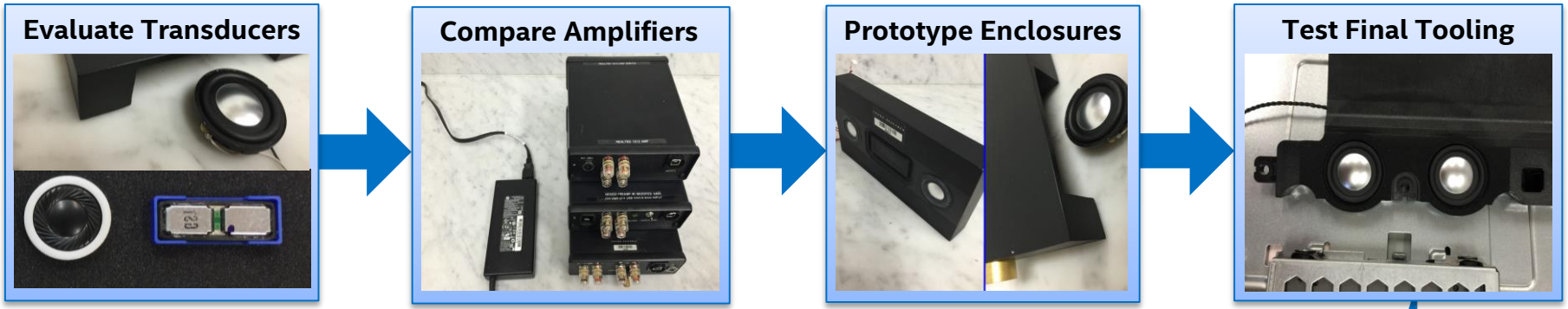
Cost reduction scenarios described are intended as examples of how a given Intel-based product, in the specified circumstances and configurations, may affect future costs and provide cost savings. Circumstances will vary. Intel does not guarantee any costs or cost reduction.

Example with 2016 HP Envy* All-In-Ones



Design Goals

- Maximize **SPL**
- Optimize **Bass**
- Reduce **BoM Cost**

SOUND RESEARCH

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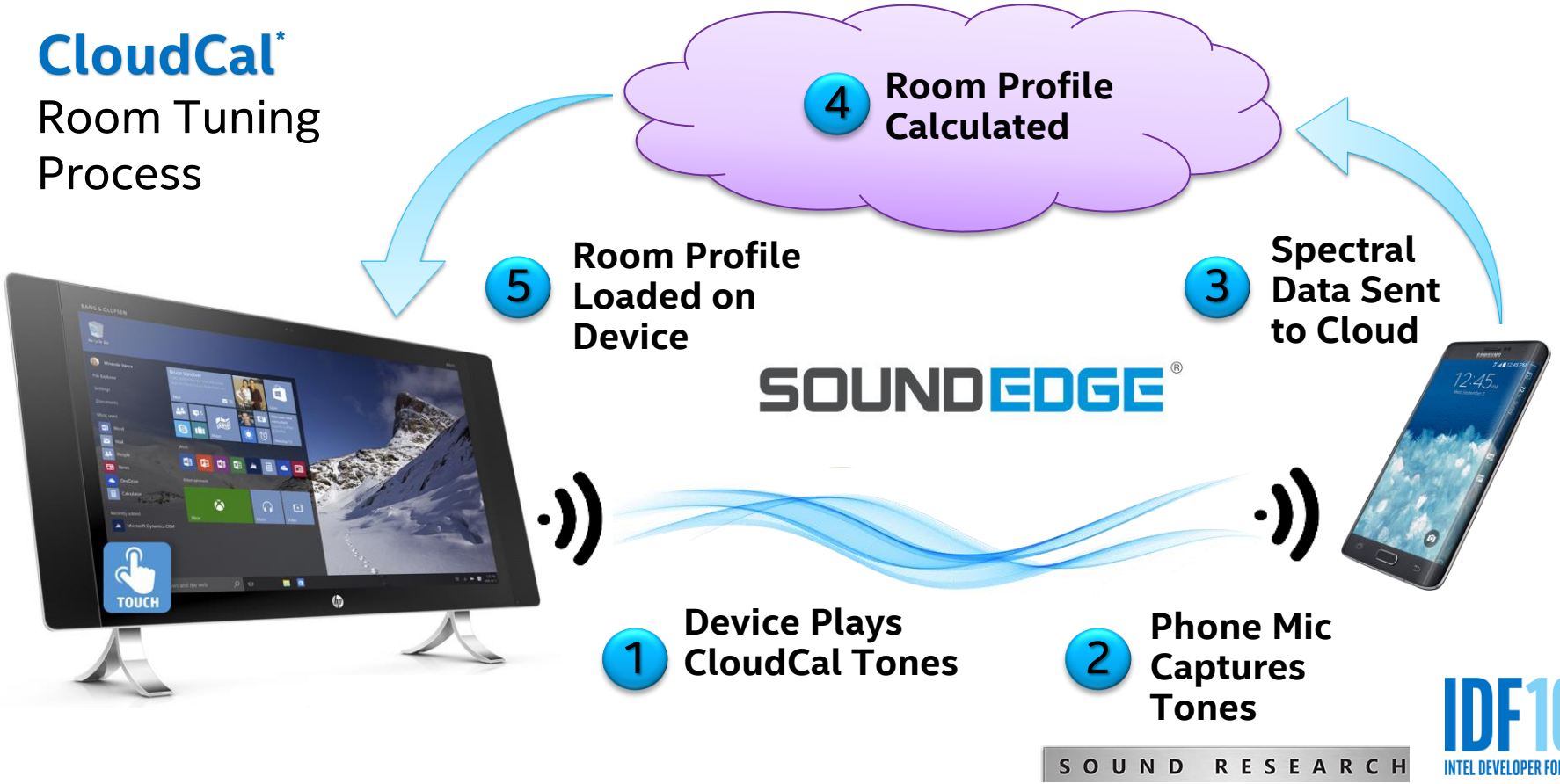
Software Example: CloudCal* Room Tuner

CloudCal*
Room Tuning Process



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Agenda

- Introduction
- Far Field Voice and Speech
- Output and Speakers
- **Innovation, SoundWire and New Audio Hardware**
- Wrap Up

Innovation with Audio

Key User Experiences

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Innovation with Audio

Key User Experiences	Ready Today
Speech based interactions with AI based assistants and bots	Great microphones, algorithms and new improved speech engines such as Cortana* and Amazon* Alexa*
Conferencing and speech recognition from **anywhere in the room**	Improved MEMS microphones and noise reduction algorithms including source separation
Great sounding speakers so don't have to use headphones	New amplifiers and speaker driver technologies such as multi-coil, speaker modules and enclosure-less

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Innovation with Audio

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New User Experiences	Opportunities
VR with fantastic gaming, conferencing spatial audio with head tracking	Digital headphones with 6-axis reporting and new low latency and power algorithms
Audio in **multiple rooms** simultaneously	Synchronization primitives, network streaming
User's **identification and biometrics** using voice and speech	Integrated DSP with low power new biometrics algorithms
Continuously **sensing** and adapting to environment	Multi-modality, open DSP, low power microphone, algorithms and apps
World and user side audio for conferencing and content creation	Microphone arrays with world facing microphone, new algorithms with input from 3/6 axis sensors providing spatial audio

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Intel® Smart Sound Technology Evolution

Today

Low-Power Audio, Voice & Speech

Low-power, end-to-end audio, voice and speech processing

Longer Battery Life

Integrated Audio DSP enables new user experiences and saves power

High-Quality Audio Fidelity

Optimized speakers and headphones performance takes PC audio to next level

Intel® Wake on Voice

Wake up your PC and use voice for control and assistance (including in standby)

Open DSP FDK

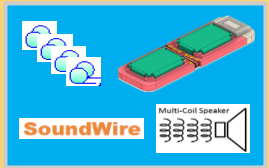
Developer access to Audio DSP to create new experiences

Next Generation

Enhanced Audio DSP

2x performance and 50% more memory to enable more advanced features

Audio Platform Innovations



Simplified interface, improved audio/ speech fidelity, and reduced power

Improved Speech Recognition

Hardware acceleration for faster and more accurate speech recognition

All information provided here is subject to change without notice. Contact your Intel representative to obtain the latest Intel roadmaps.

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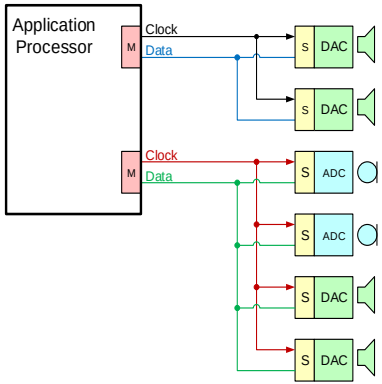
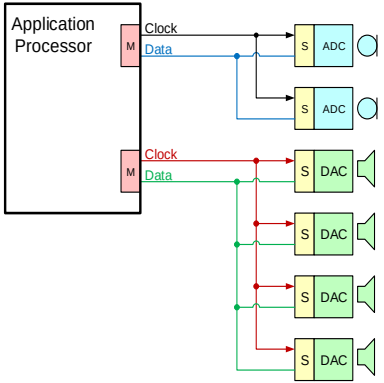
SoundWire*

- Robust, scalable, two-pin multi-drop bus
- Low power, low latency, well-bounded PHY and transport with master and slaves
- Embedded control, commands, status
- In-band interrupts, wakes with clock stop
- Multiple dynamically reconfigurable streams
- PCM, PDM, isochronous and asynchronous transfer modes
- Fast device configuration up to 20 Mbits/s
- Multiple clock frequencies up to 12MHz
- Double data rate signaling, lower power

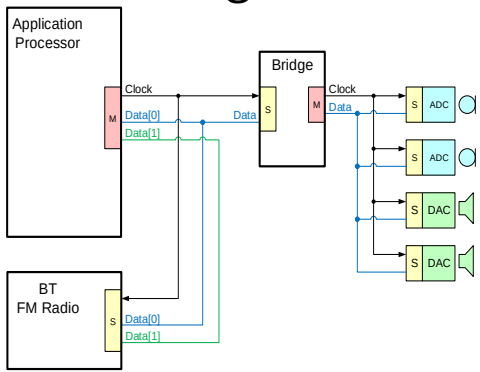
Functional Partitioning



Routing/Use Case Partitioning

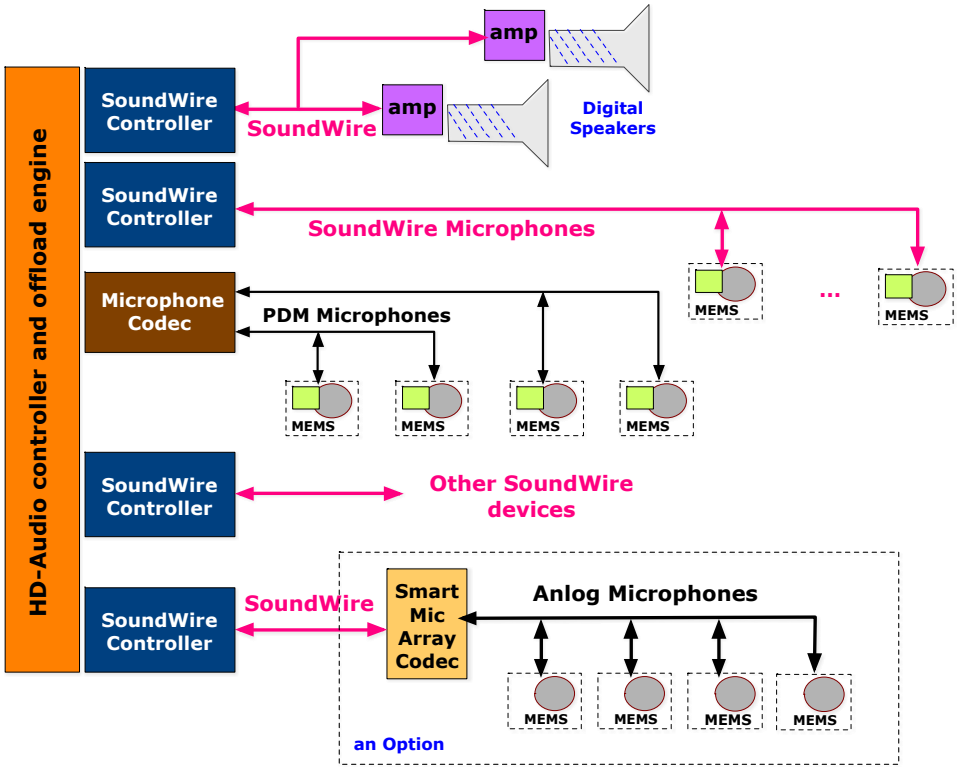


Bridged

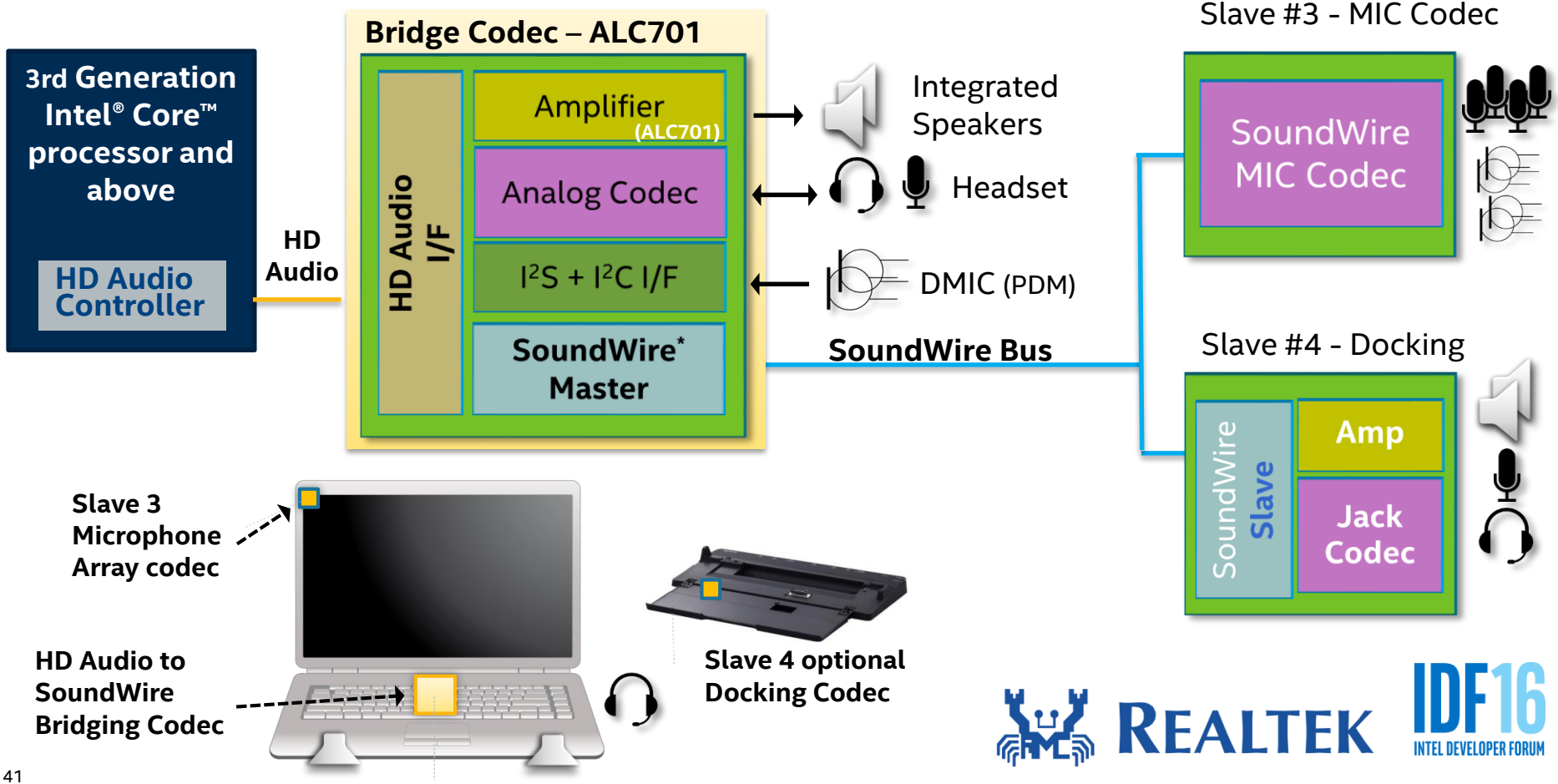


SoundWire* Integration

- Four controllers each with their own physical link (segment)
  - Two physical interfaces are shared with DMICs
  - 3rd and 4th take back some pins from I2S & HD-audio
- SoundWire* interfaces are part of HD-audio controller
- SoundWire support will require the use of the audio offload engine (a hardware DSP) & the bus and offload drivers as part of Intel® Smart Sound Technology



Bridging Architecture Available Now



REALTEK

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SoundWire* with Integrated Controllers

3rd Generation Intel® Core™ processor and above

- SoundWire* Master #1
- SoundWire Master #2
- SoundWire Master #3
- SoundWire Master #4

SoundWire Bus #1

SoundWire Bus #2

SoundWire Bus #3

Slave #1 - CAT (Left)

SoundWire Amplifier

Integrated Speaker

Slave #1 - CAT (Right)

SoundWire Amplifier

Integrated Speaker

Slave #2 - Jack Codec

SoundWire Jack Codec

Slave #3 - MIC Codec

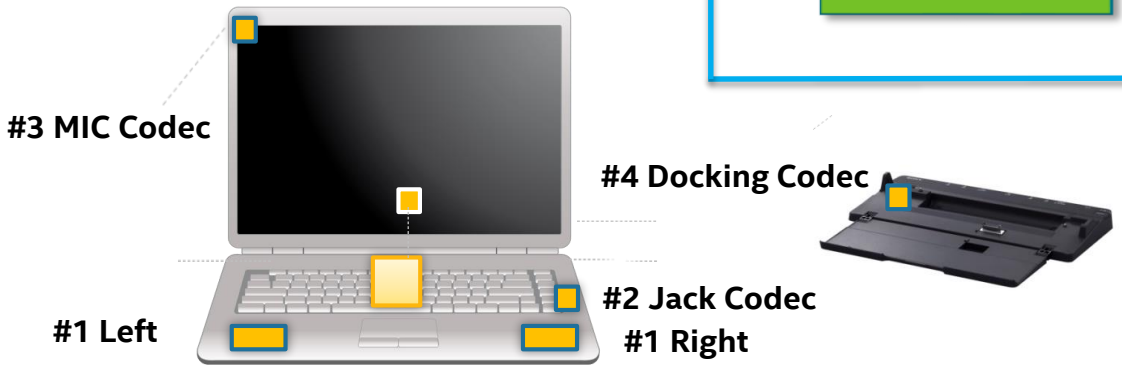
SoundWire MIC Codec

Slave #4 – Docking Codec

Slave

Amp

Jack Codec



REALTEK

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SoundWire* Digital Speaker Module (DSM)

3rd Generation Intel® Core™ processor and above

HD-Audio Controller

Bridge Codec – ALC700

HD-Audio

Analog Codec

PDM Input

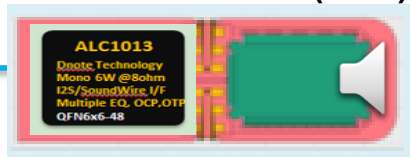
SoundWire Master

Headset

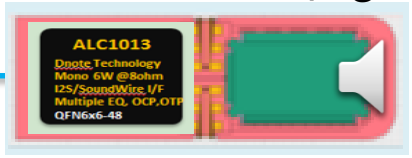
DMIC (PDM)

SoundWire Bus

Slave #1 - CAT (Left)



Slave #1 - CAT (Right)



#1 Left

#1 Right

Bridged SoundWire Master

SoundWire* DSM with Dnote* Technology

SESUB

Dnote Digital Speaker Driver IC

Forgrand

REALTEK

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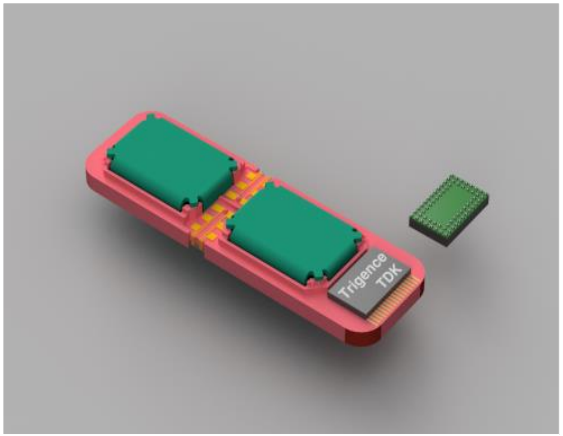
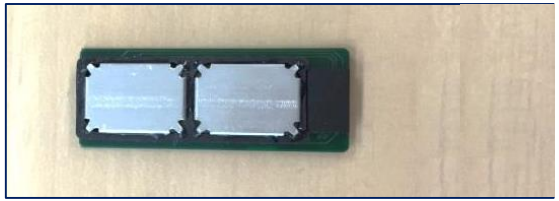
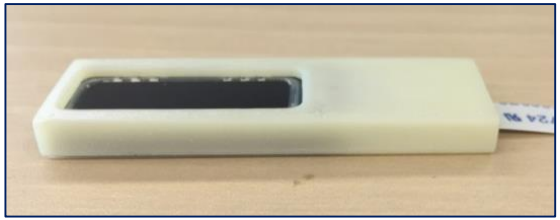
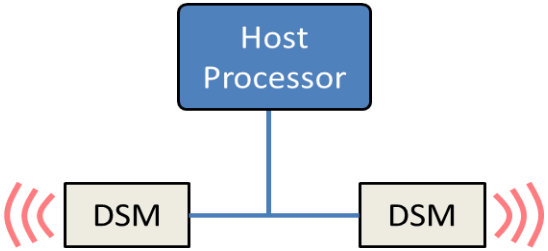
Digital Speakers and Modules (DSMs) Using Trigence* Dnote* Technology

- Self-contained digital components
- Complete digital speaker sub-systems
- Individually addressable at the host level
- Incorporate a bi-directional digital audio interface, audio DSP, Dnote* processor, and digital speaker within a single speaker from









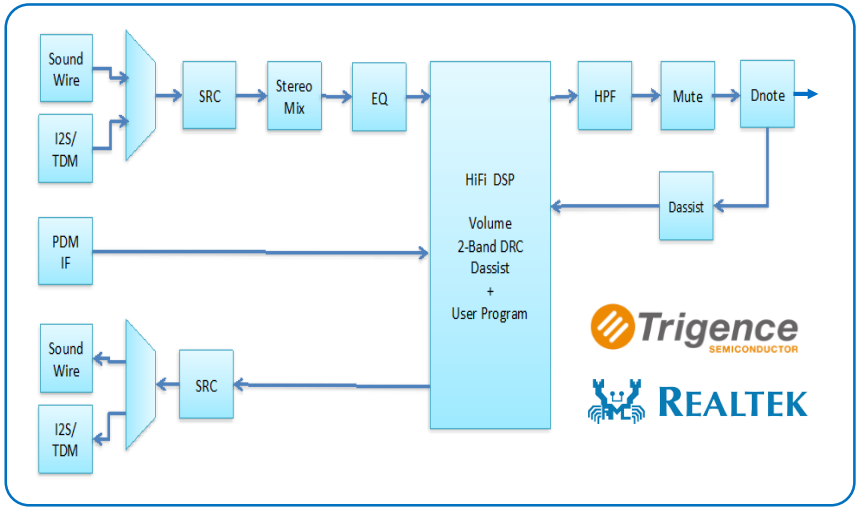
Advantages

- Lower Power and Supplies
- Improve Audio Quality
- Simplify System Architecture
- Offer Advanced Functionality
- Lower Overall Cost
- Faster design and qualification

Trigence SEMICONDUCTOR

IDF16 INTEL DEVELOPER FORUM

Digital Speaker Driver IC (ALC1013)



- **SoundWire***, I²S and TDM audio interfaces
- 200 MHz Tensilica* HiFi2 DSP (~100MHz available for customer IP / functionality)
- **D-Assist** speaker compensation algorithms - derived from active measurement of speaker characteristics

- **Dnote* Digital Amplifier System**
- True 24-bit audio output with < -120dB in-band noise floor
- Greater output power than a conventional Class-D amplifier from the same power supply voltage

Power Supply	Dnote (8Ω x 6)	Class-D (8Ω)
1.8V	0.75W	0.15W
3.3V	2.55W	0.45W
5.0V	6.75W	1.0W

- Improved Power Efficiency (1W into speaker)
  - Dnote consumes 1.1W from system
  - Typical D-Class consumes 2.1W
- All digital / generic bulk CMOS solution

Trigence SEMICONDUCTOR

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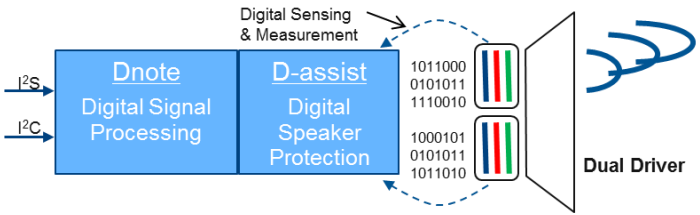
Speaker Compensation with D-Assist*

- D-Assist* is a suite of speaker compensation algorithms designed to maximize the performance of digital micro-speakers through the precise sensing and compensation of physical electro-mechanical properties
- D-Assist makes use of techniques that are only possible through the close coupling of the driving and sensing electronics with the speaker mechanics



DSA - Digital Smart-Amp

- Entirely digital smart-amp implementation
- Offers speaker protection and greater perceived SPL
- Does not rely on current sensing resistors or probe-tones
- No loss in efficiency over non smart-amp implementation

DDR - Digital Distortion Reduction

- Dynamically compensates THD (Total Harmonic Distortion) degradation in the speaker
- Typical overall speaker THD reduction to less than 20% of uncorrected value

DTSC - Digital Thiele-Small Correction

- Uses active measurement of speaker characteristics to provides control over and compensation of a speaker's Thiele-Small Parameters through use of on-chip DSP

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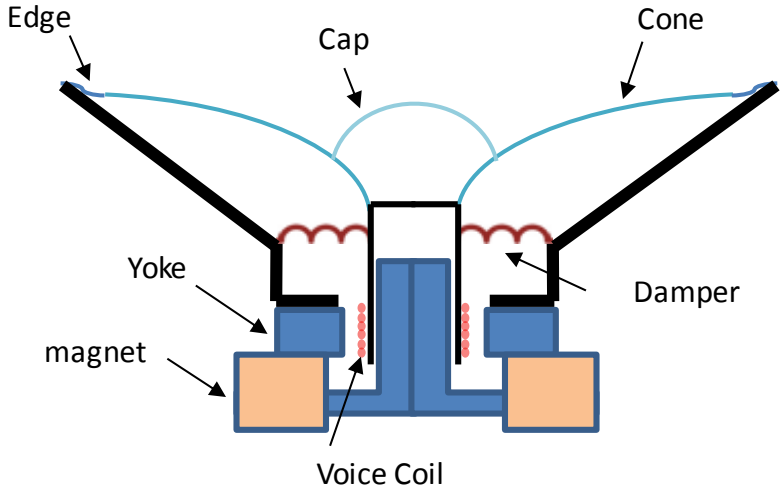
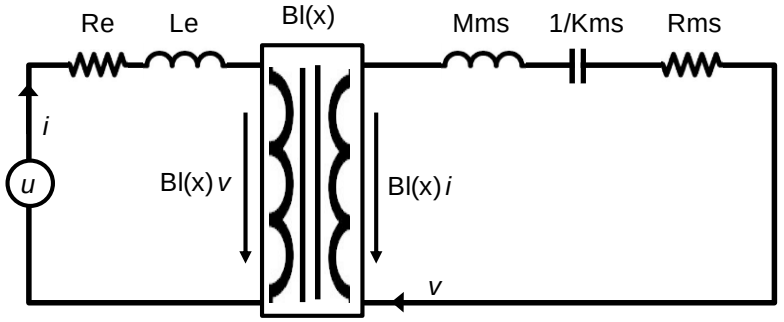
Thiele-Small Parameters





Re : Coil Resistance
Le : Coil Inductance
Bl : Force Factor
Kms : Mechanical Stiffness
Rms : Mechanical Resistance
Mms : Driver Mass

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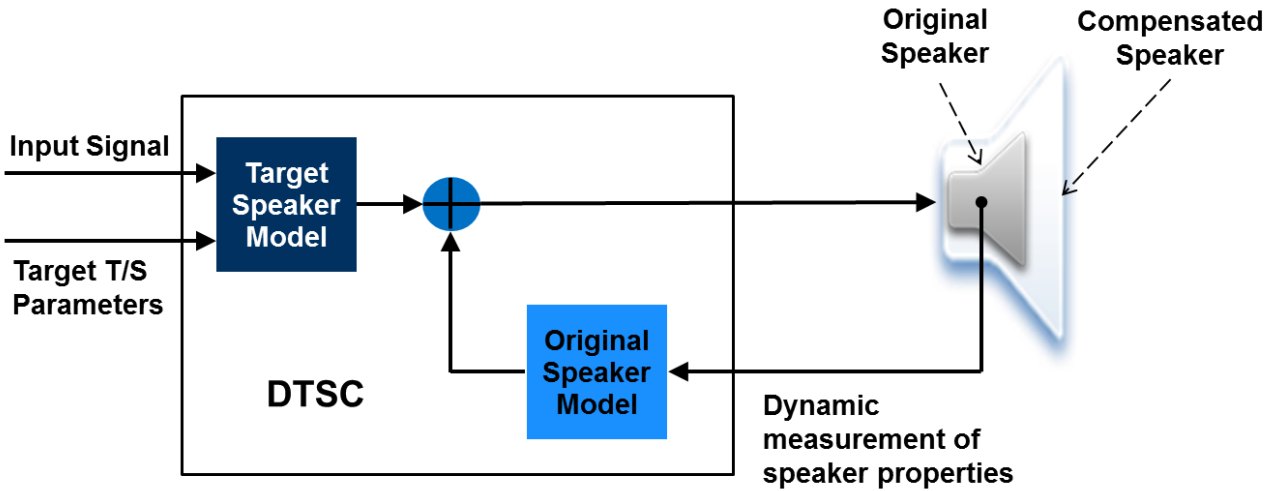
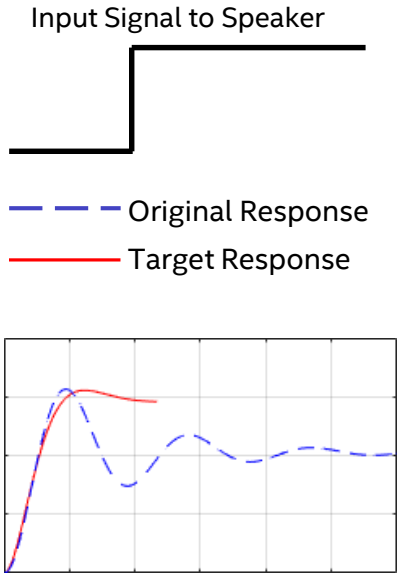
Basic DTSC Architecture





- Uses physical model of transducer and modern feed-forward control theory to permit the **time-domain equalization** of the speaker's transient response
- Original Speaker approximates the same sound as Target Speaker model if measurement of Original Speaker parameters is accurate

- Strong bass
- Boost-down treble
- Intermediate rise time
- Short reverb time
- Improved clarity

Trigence SEMICONDUCTOR

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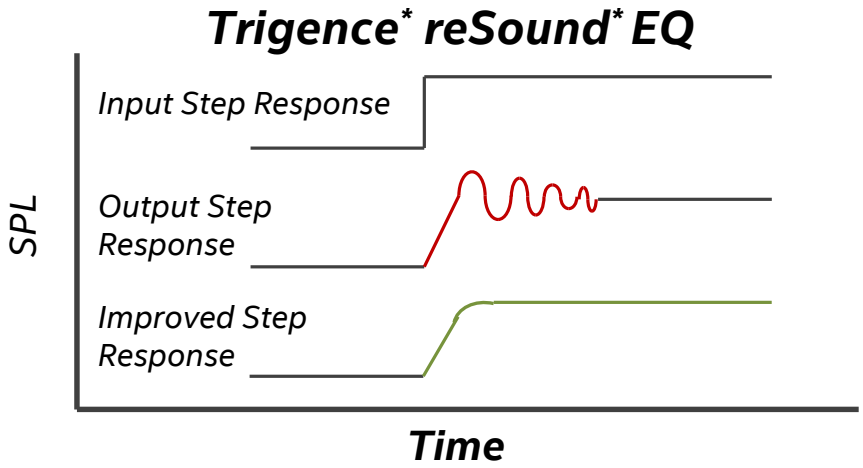
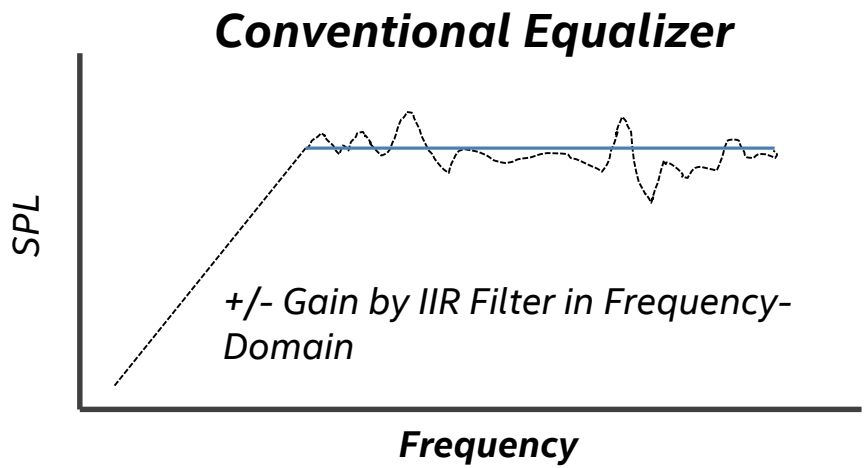
Comparison with Frequency Domain EQ





- Can control signal response
- No group delay or phase shifts
- Minimal THD or noise degradation
- No need for “golden ear” to perfect sound
- **Easy** to perceive improvement

- Cannot control signal response
- Inherent phase shift /delay through IIR filters
- Needs “golden ear” to perfect sound flavor
- Degrades THD and increases noise level
- **Difficult** to understand improvement or not

Trigence SEMICONDUCTOR

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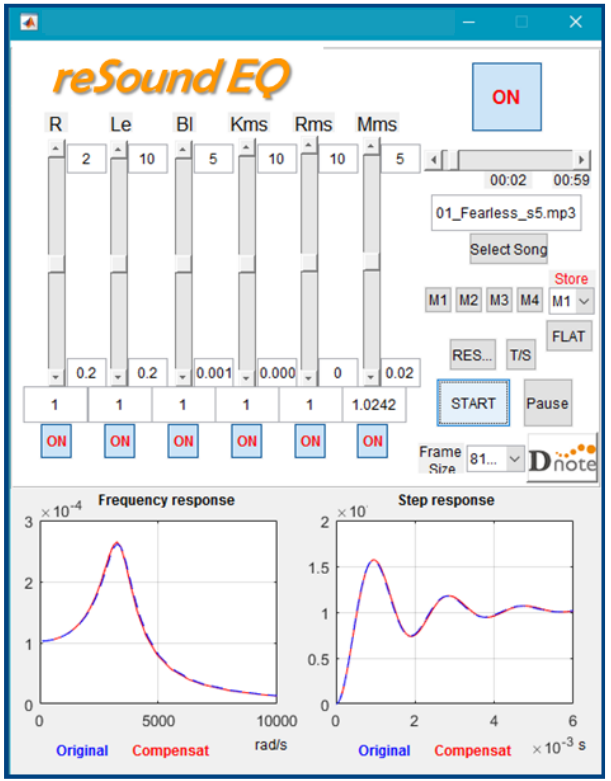
Trigence* reSound* EQ

- Works with all ALC1013-based Digital Speaker Modules (DSMs)
- Enables dynamic tuning of DTSC functionality within the speaker
- Fast, simple speaker alignment / compensation tool
- Designed specifically to improve Digital Speaker transducer quality



reSound EQ demo

Agenda

- Introduction
- Far Field Voice and Speech
- Output and Speakers
- Innovation, SoundWire and New Audio Hardware
- **Wrap Up**

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Summary and Next Steps

- Computing renaissance being driven by audio especially voice and speech with AI and bots, thus becoming critical to competitiveness
- Far field for at least 4 meters voice and speech can be supported today with the new generation of improved processing algorithms from multiple vendors, improved microphone arrays with more microphones
- Speakers with 85dB SPL and 180Hz can be provided today using larger drivers, digital speakers, improved amplifiers and CAT
- SoundWire* and new audio hardware should be adopted where possible

Additional Sources of Information

- A PDF of this presentation is available from our Technical Session Catalog: www.intel.com/idfsessionsSF. This URL is also printed on the top of Session Agenda Pages in the Pocket Guide.

- See Realtek*, Trigence*, Forte Media* and Conexant* in the showcase

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Technical Sessions in PC Innovation Track

Tuesday, August 16, 2016

11:00 AM – 12:00 PM *PCITS02* — Designing to Meet New Expectations for Audio Experiences and Standards Critical for Competitiveness ***Level 2 Room 2009***
11:00 AM – 12:00 PM *VRGTS01* — Bringing Virtual Reality to the Mainstream ***Level 2 Room 2005***
1:15 PM – 2:15 PM *VRGTS02* — Overclocking Innovation: 2016 Enhancements and New Opportunities ***Level 2 Room 2005***
2:30 PM – 3:30 PM *SOFTS03* — ChromeOS* and coreboot* on Intel® Architecture Platforms – A Primer ***Level 2 Room 2006***
2:30 PM – 3:30 PM *VRGTS03* — Developing Virtual Reality Solution with Intel® Architecture ***Level 2 Room 2005***
4:00 PM – 5:00 PM *CONTS02* — Simplified Platform Power Measurement Using USB Type-C* Interface to Drive Software Power Optimization ***Level 2 Room 2008***
4:00 PM – 5:00 PM *SOFTS05* — Intel® Software Guard Extensions Technology Overview and Programming Model ***Level 2 Room 2006***

Wednesday, August 17, 2016

11:00 AM – 12:00 PM *PCITS01* — Touch/Stylus Technologies for 2016 – Intel® and Ecosystem Drives Improved Touch/Stylus User Experience ***Level 2 Room 2000***
1:15 PM – 2:15 PM *CONBZ03* — Thunderbolt™ 3 Technology – The USB Type-C* that Does It All ***Level 2 Room 2007***
1:15 PM – 2:15 PM *PCITS03* — Google Play* on Chrome OS* + Intel® Architecture – A Primer on Developing the Best Apps ***Level 2 Room 2000***
1:15 PM – 2:15 PM *SOFTS06* — Machine Learning: Optimizing Deep Learning Usages on Intel® Client Platform ***Level 2 Room 2006***
2:30 PM – 3:30 PM *CONTS03* — Shape the Personal Home Gateway: Flexible Design for the Connected Home ***Level 2 Room 2007***
2:30 PM – 3:30 PM *PCITS04* — Evolving the 2 in 1 through New Usages, Technologies, and Form Factor Design Optimization ***Level 2 Room 2000***
4:00 PM – 5:00 PM *PCITS05* — Intel® Authenticate – Innovation and Multi-Factor Authentication for Enterprise ***Level 2 Room 2000***

Thursday, August 18, 2016

9:30 AM – 10:30 AM *MASTS06* — Unifying the Storage Interface Across Client and Data Center ***Level 2 Room 2002***
9:30 AM – 10:30 AM *PCITS06* — Enhancing and Extending Intel® Unite™ with Plugins ***Level 2 Room 2004***
10:45 AM – 11:45 AM *PCITS07* — Driving Enterprise Value with Intel® Core™ vPro™ Processor ***Level 2 Room 2004***
2:15 PM – 3:15 PM *PCITS08* — Modern Standby: Why and How ***Level 2 Room 2004***

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- Software and workloads used in performance tests may have been optimized for performance only on Intel microprocessors. Performance tests, such as SYSmark and MobileMark, are measured using specific computer systems, components, software, operations and functions. Any change to any of those factors may cause the results to vary. You should consult other information and performance tests to assist you in fully evaluating your contemplated purchases, including the performance of that product when combined with other products. For more complete information visit http://www.intel.com/performance.
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Backup

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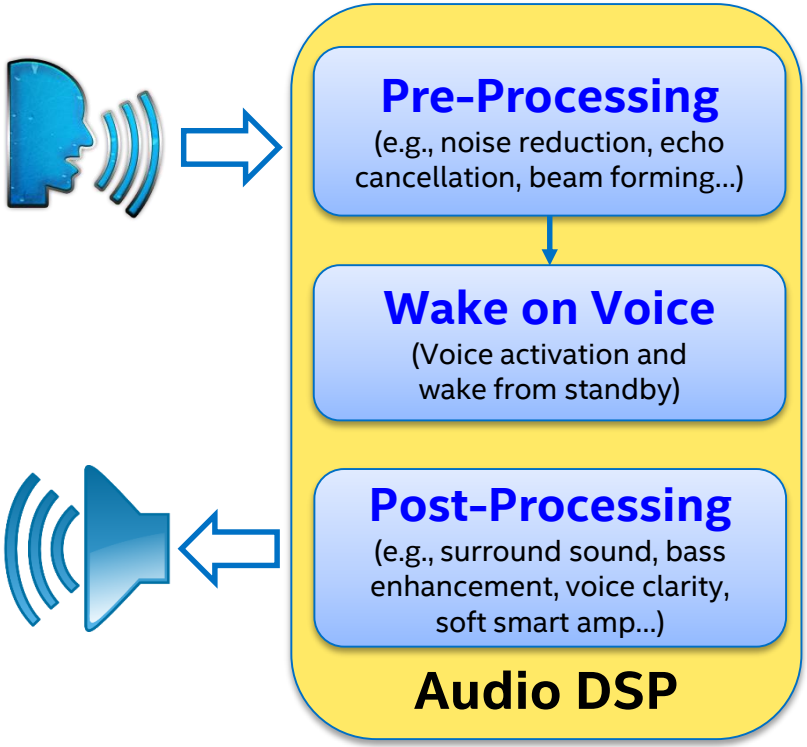
Intel® Smart Sound Technology Audio DSP



forté media intel

- **Enhanced voice, speech and audio quality** from microphone(s)
- **Improved voice communications and speech recognition accuracy**

intel

- Supports **voice activation from S0** and **wake from standby**
- **Improved battery life** running on audio DSP -vs- host CPU

AUDYSSEY DOLBY dts Sound WAVES

- **Enhanced audio playback quality** for headphones and speakers
- Soft smart amp for **cost-reduction, speaker protection and improved audio fidelity**

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SPET Updates for 2017

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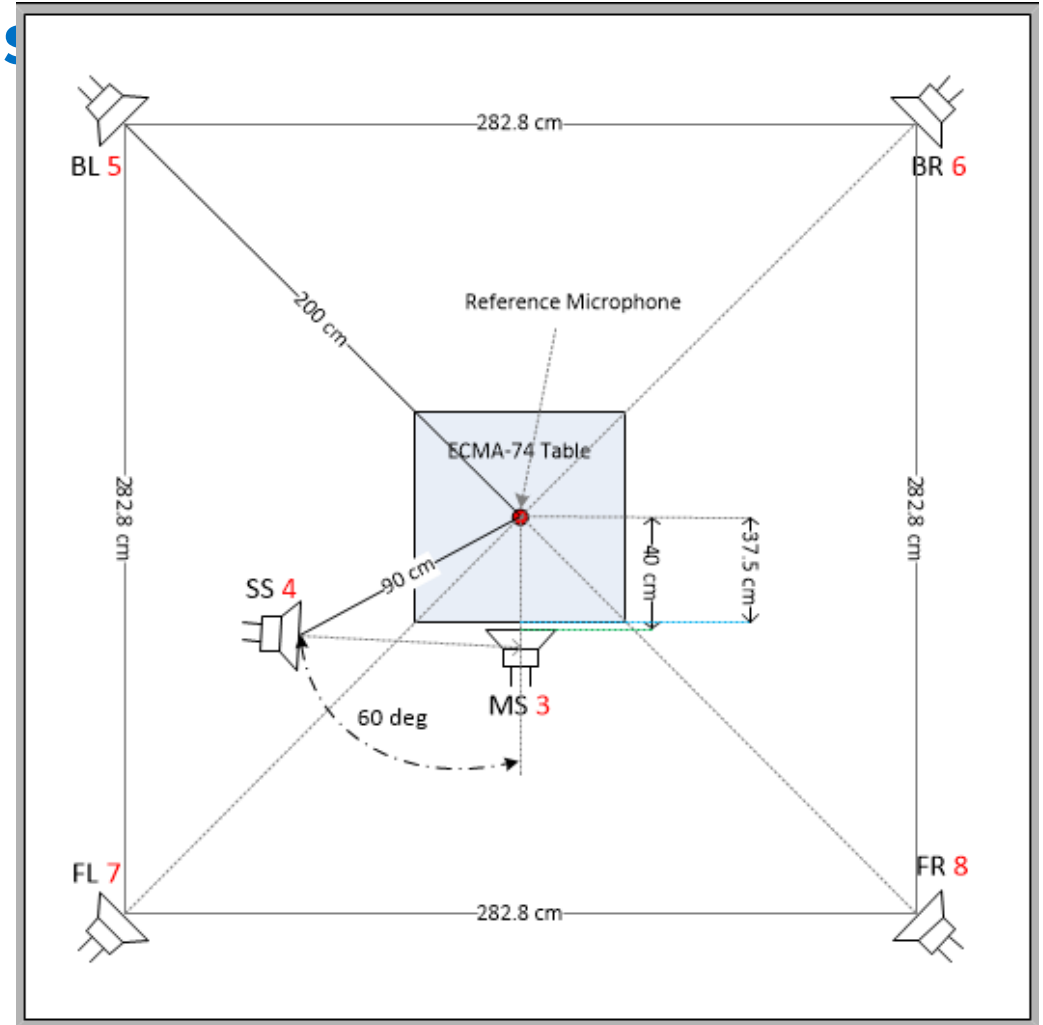
SPET Updates



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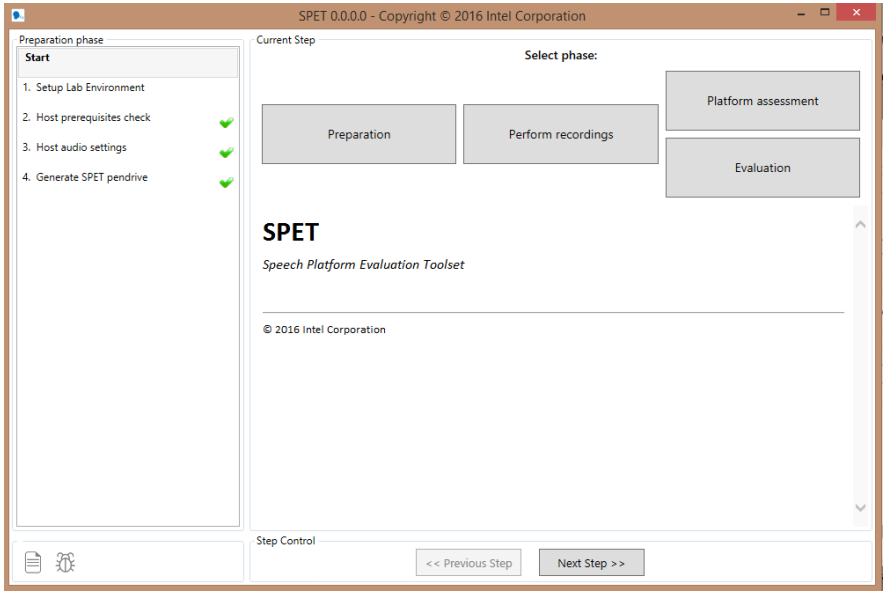
SPET Updates for 2017



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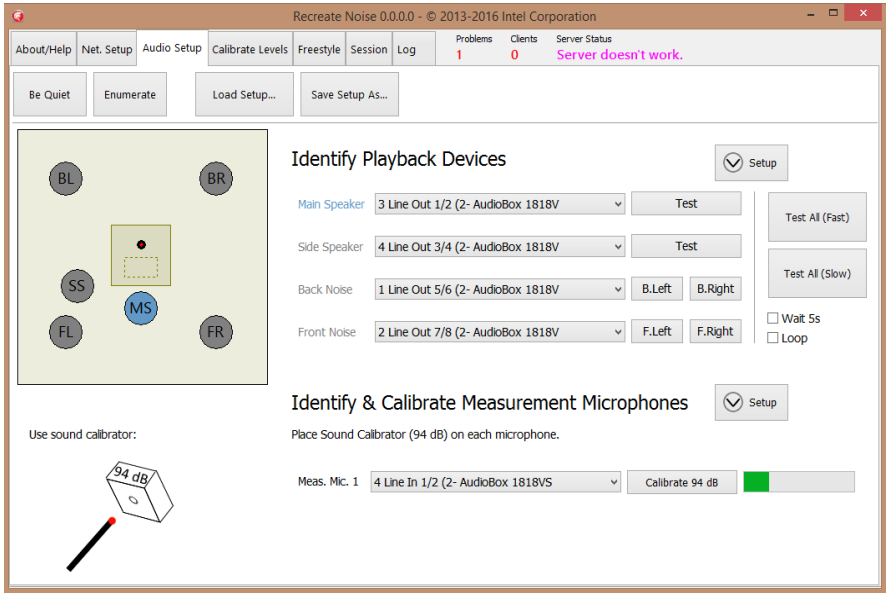

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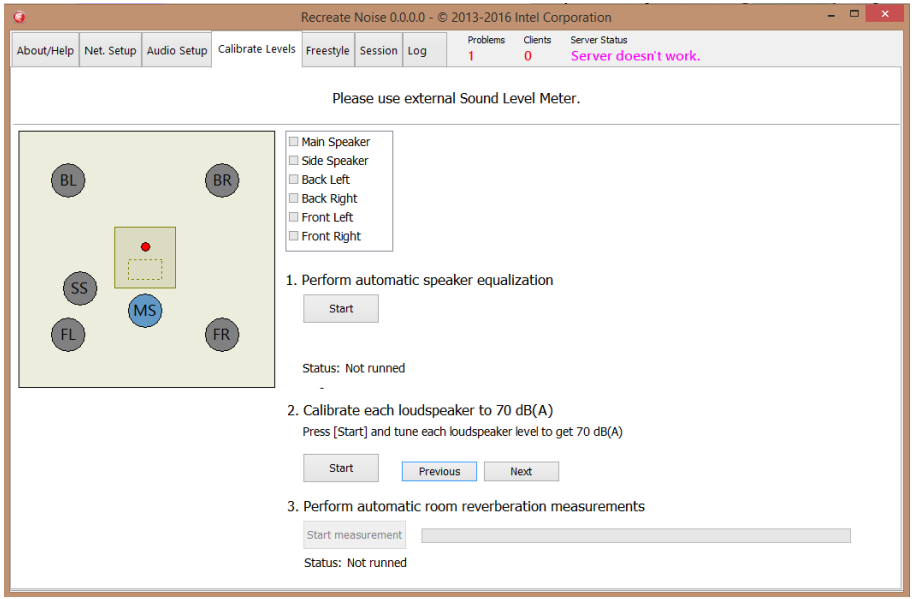

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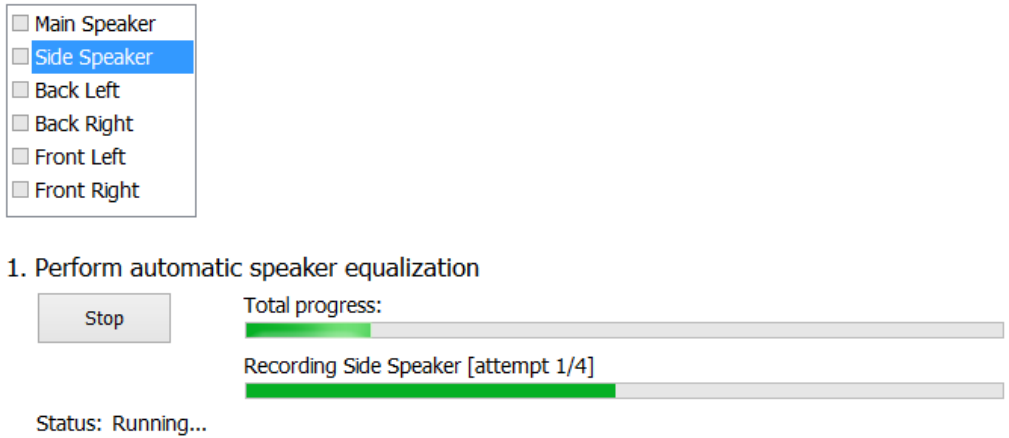

SPET Updates for 2017

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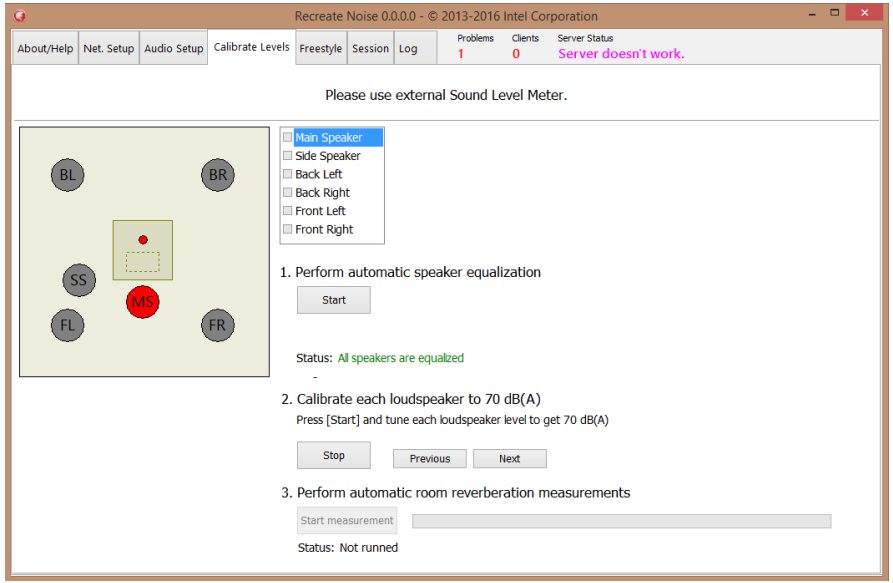

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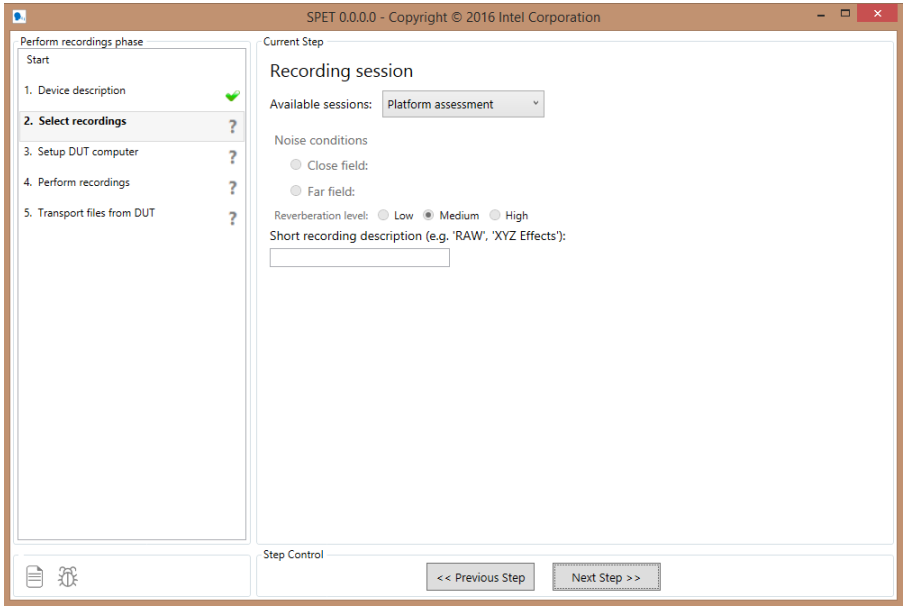

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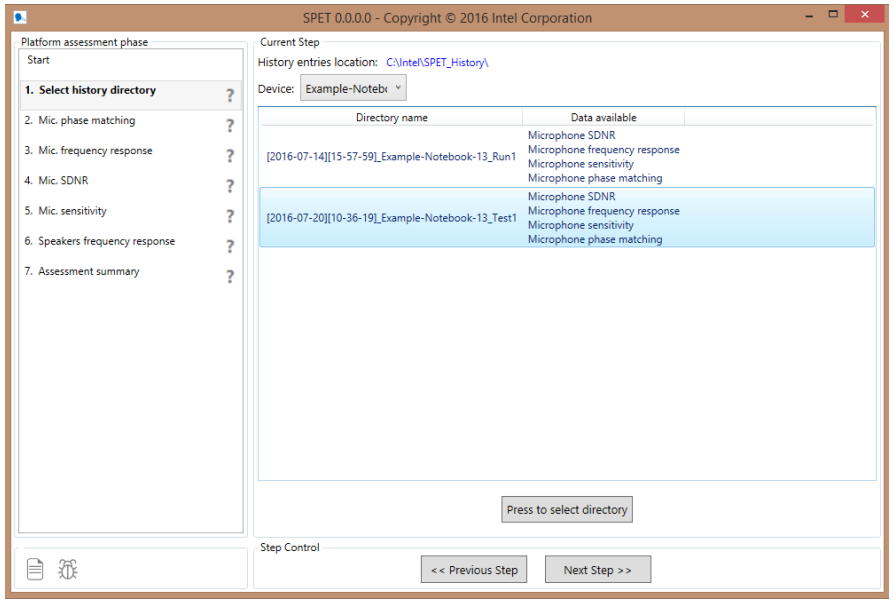

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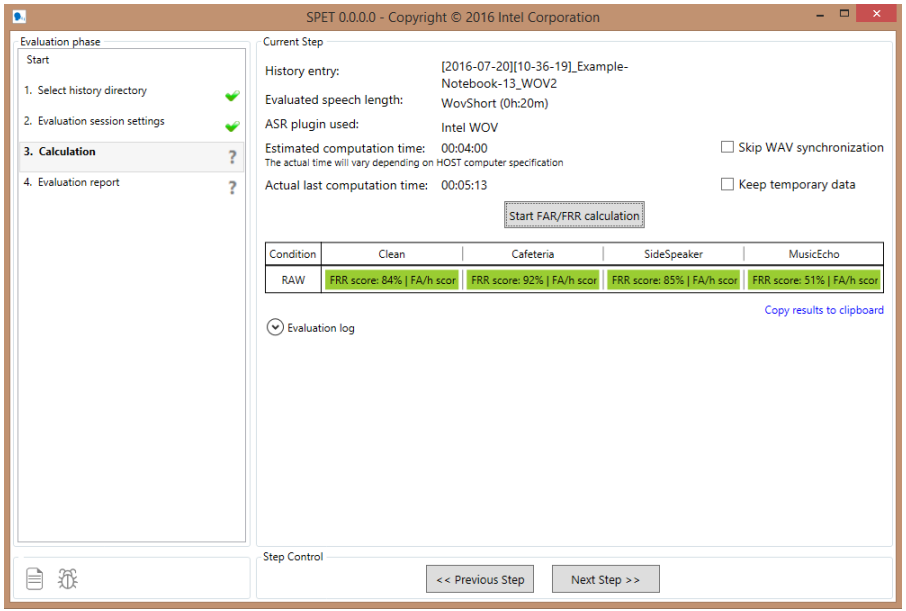

Transducers Technology Roadmap

Before Now

Analog **PDM** **I2S** **SoundWire***

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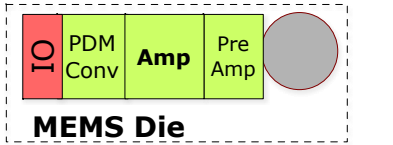
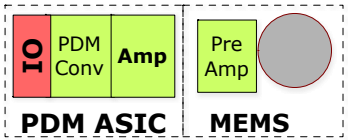
Transducers Technology Roadmap

Before Now

Analog **PDM** **I2S** **SoundWire***



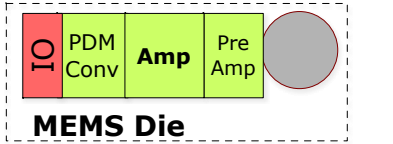


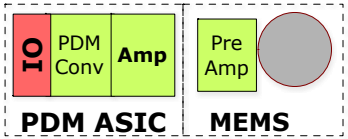
Arrays **Improved Mounting**

Transducers Technology Roadmap

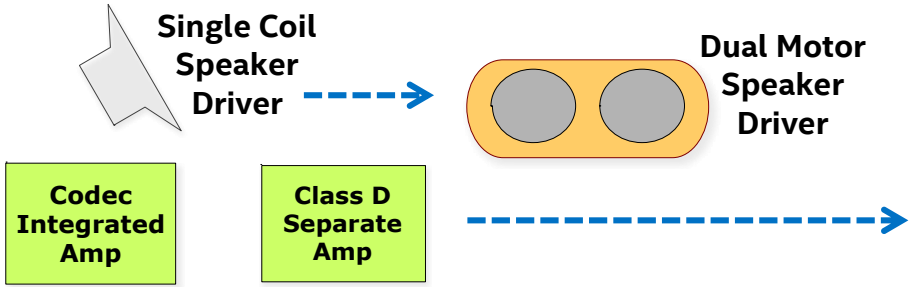
Before Now

Analog PDM I2S SoundWire*





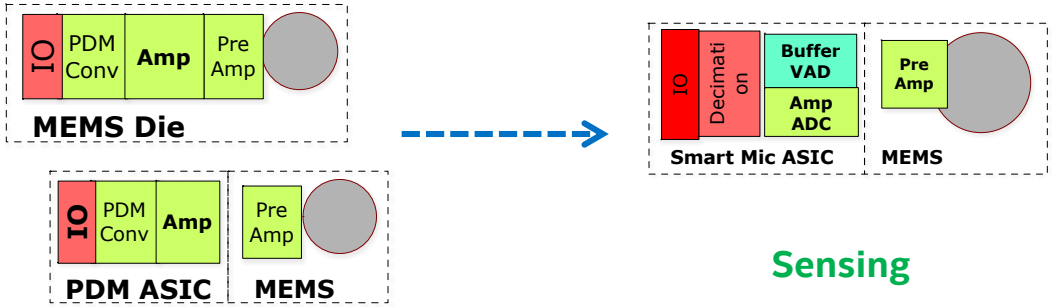
Arrays Improved Mounting



Transducers Technology Roadmap

Before Now

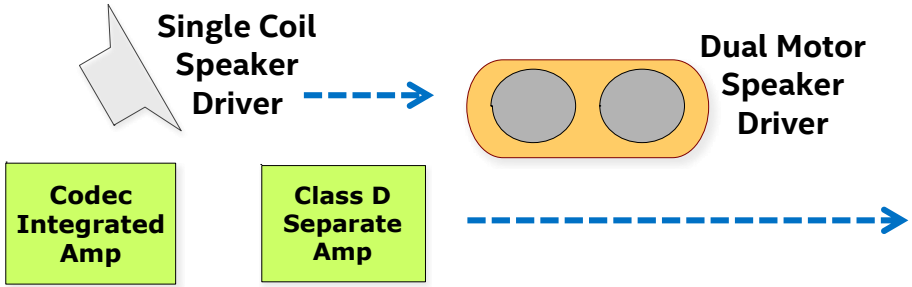
Analog PDM I2S SoundWire*



Sensing

Controllable Gain

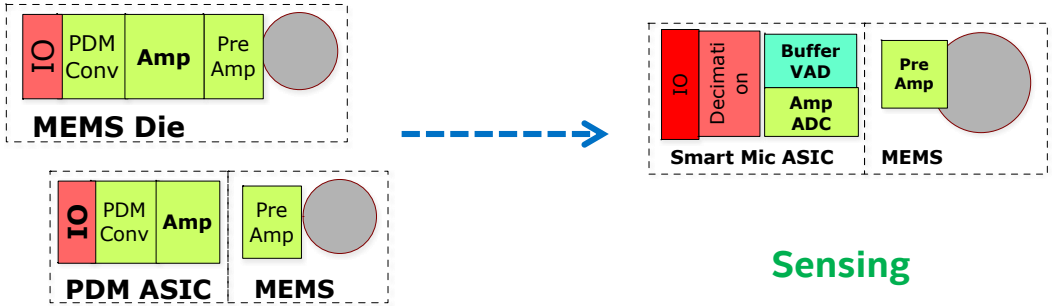
Arrays Improved Mounting Ultrasonics



Transducers Technology Roadmap

Before Now

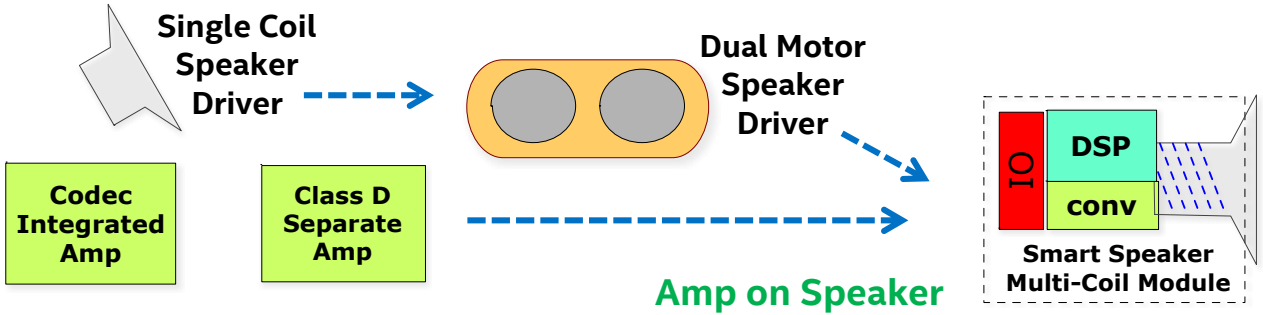
Analog PDM I2S SoundWire*



Sensing

Controllable Gain

Arrays Improved Mounting Ultrasonics



Amp on Speaker

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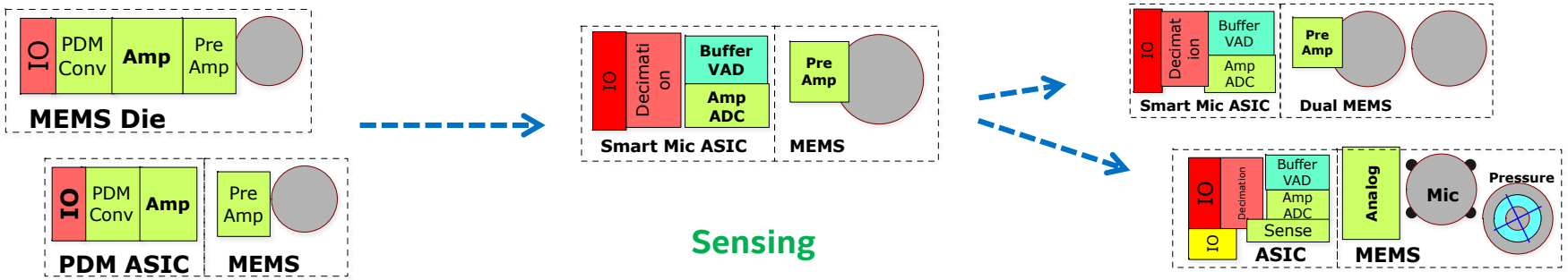
Transducers Technology Roadmap

Before Now

Analog PDM I2S SoundWire*



Sensing

Controllable Gain

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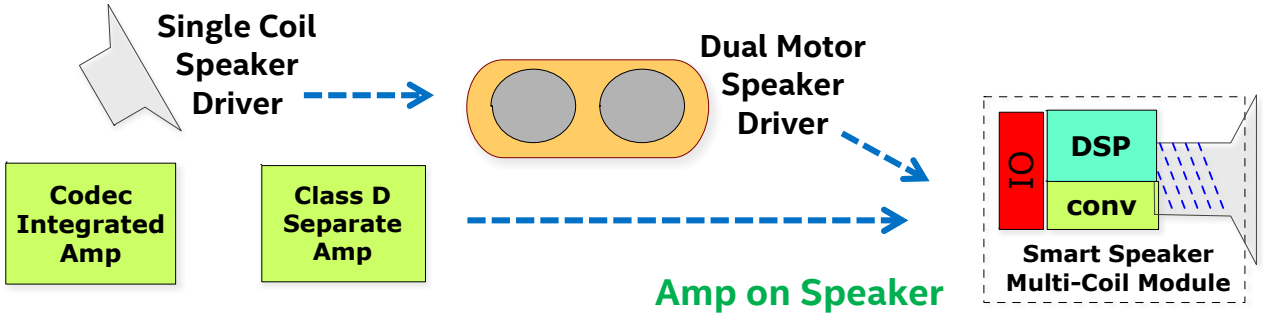

Amp on Speaker

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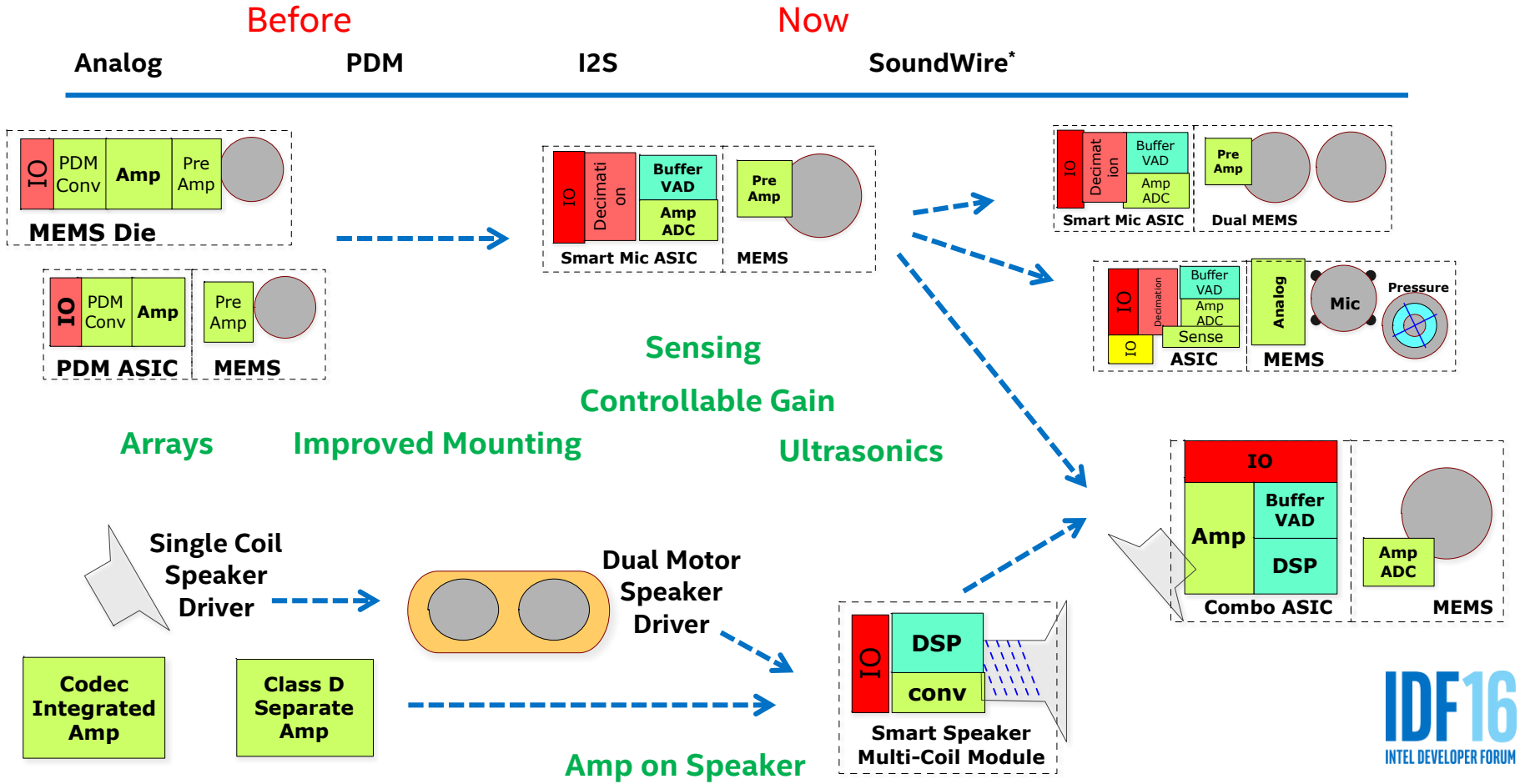
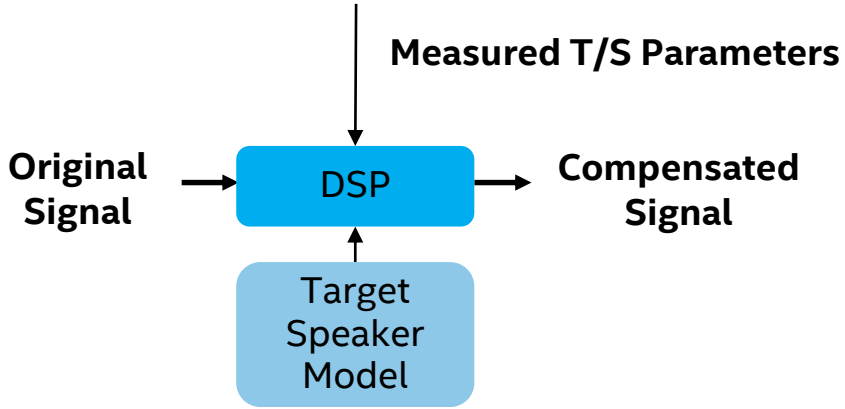
Transducers Technology Roadmap



Digital Thiele-Small Correction

- **DTSC**, Trigence's* Digital Thiele-Small Correction technology offers new type of equalizer tool to improve / compensate the electro-mechanical characteristics of speakers through the precise real-time measurement of the speaker properties, and use of on-chip DSP
- Uses physical model of transducer and modern feed-forward control theory to permit the time-domain equalization of speaker response
- Easy to produce preferred sound flavor
  - Stronger or slower bass
  - Fast or slow transient attack
  - Simple boost up or down of mid-high
  - Short or long reverberation
  - Clarity or warm sound



Trigence SEMICONDUCTOR

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