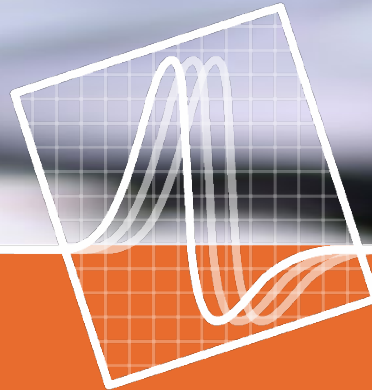




Mobile voice enhancement

for communication and speech recognition



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Technologies and solutions

Mobile Communication Challenges



Noise

- Mobile phones are often used in extremely noisy environments
- User is not heard by the other party
- User does not hear the other party
- VCP advanced dual microphone beamforming and noise cancellation clean the outgoing user voice thus allowing the user to be heard in virtually any practical conditions
- VCP incoming noise reduction and automatic, ambient noise dependent speaker volume and equalization ensures good other party intelligibility in noisy conditions

Speech clarity

- Narrow band speech (NBS) with 3.6KHz bandwidth used in traditional telephony has limited voice intelligibility even in the best usage conditions
- Wide band speech (WBS) with 7KHz bandwidth significantly improves voice communication
- WBS (called “HD voice”) is now being widely introduced by mobile operators
- Straightforward WBS processing (HD voice) requires much more computational resources compared to traditional NBS processing
- VCP WBS processing is fully compliant with HD voice requirements requiring only 30-50% more resources compared to NBS speech processing



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Technologies and solutions

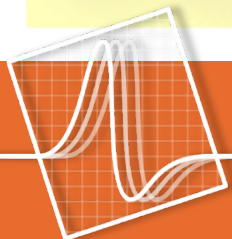
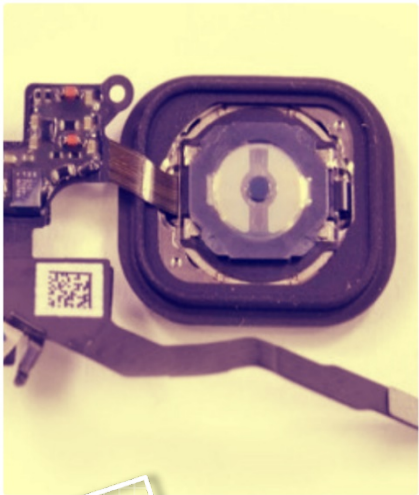


Acoustic echo

- Mobile phones are increasingly used as a means for business conferencing
- Echo of a strong loudspeaker signal is picked up by the microphone together with user's voice
- The same problem happens in handset mode although with much weaker echo
- Alango VCP advanced echo cancellation ensures echo free, maximal duplexity communication in all operational modes
- When echo is suppressed, comfort noise closely matching ambient noise is inserted

Acoustic distortions

- Mobile phone acoustic components (speaker and microphone) are getting smaller and cheaper
- Manufacturers are trying to increase the phones loudness overloading the acoustics and causing highly irregular frequency response
- VCP ultra-high resolution (30Hz) frequency response equalizer allows precise correction of speaker and microphone frequency responses increasing speech intelligibility and facilitating compliance to mobile operator standards
- VCP ultra-high resolution speaker equalization improves acoustic echo cancellation by removing narrow band speaker and device resonances



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Even More Challenges



Large voice strength and distance variations

- Speech level in the microphone may be very different:
 - Some people speak loud, some people do not
 - When it is quiet, people speak quietly; when it is noisy, people speak loud
 - People may speak close or far from a mobile phone microphone
- If not processed correctly, the other party will not hear soft or distant voices
- Alango VCP advanced microphone gain control performs enhancement of soft voices without sacrificing good signal to noise ratio of strong voices in noisy environments

Pure intelligibility

- Understanding fast or foreign speech over a mobile phone is difficult
- Memorizing phone numbers, street addresses or other information is challenging
- Listening for instructions in a voice mail while driving is dangerous
- Alango EasyListen™ technology integrated into VCP dynamically slows down the incoming speech in real time, improving speech intelligibility and helping to memorize important information



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Technologies and solutions

Mobile Voice Communication Package



Integrated package of all pre/post voice processing technologies for mobile communication

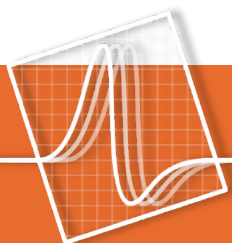
- Dual and more microphone array (close talk and far field operation)
- Advanced stationary and transient noise suppression with ultra-high frequency resolution and shortest adaptation time
- Automatic microphone gain and speaker volume control
- Frequency equalizers with ultra-high resolution
- EasyListen™ speech enhancement technology

✓ End user benefits

- Clear, intelligible voice
- Automatic, ambient noise dependent loudspeaker equalization
- Automatic voice level compensation for different users
- Business class speakerphone availability

✓ OEM benefits

- Support for HD voice
- Support for CS, VoIP, VoLTE
- Availability for different DSP cores and HW platforms
- Simple acoustic tuning for various designs and acoustic components



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Technologies and solutions

Cellular communication

- Leadcore (former Datang): www.leadcoretech.com (TD-SCDMA reference design, 30% market share)
- Mediatek: www.mediatek.com (chipsets based on Blackfin DSP from Analog Devices)
- Sasken Communications: www.sasken.com (multimedia subsystem for Symbian phones, Moto Z8,Z10)
- Augusta Technologies: www.augustatek.com (application processors)
- Emblaze Mobile: www.emblazemobile.com (handset maker, FirstELSE phone)



LG Etna 2



LG Brio



First ELSE



LG Wine 2



LG Adagio



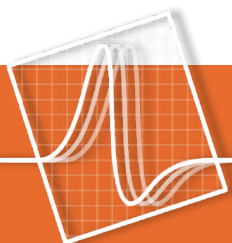
Motorola Z10



TD-SCDMA phones in China
>10M shipped by June 2012



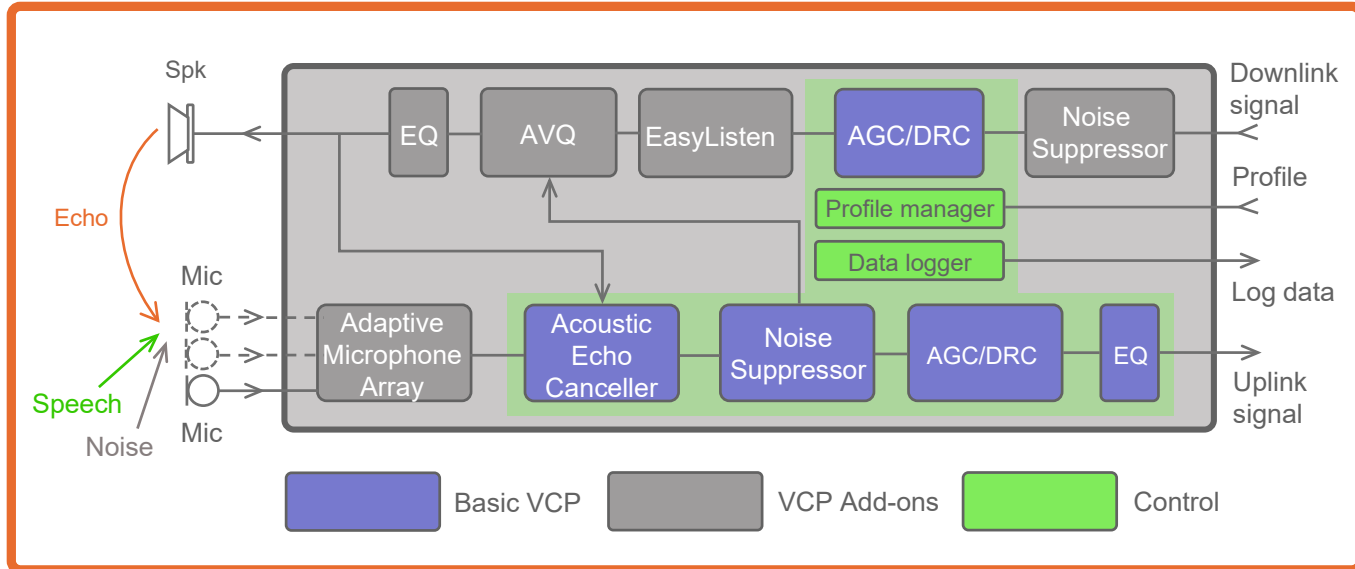
Motorola Z8



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Technologies and solutions

Mobile VCP structure



Control blocks:

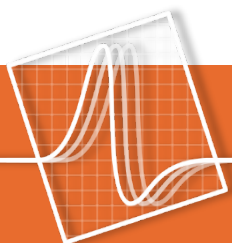
- Profile manager enabling different processing for different operational modes
- Data logger for debugging and acoustic tuning

Tx (microphone) channel processing:

- Adaptive (2-4) microphone array technology
- Sub-band acoustic echo canceller with residual echo suppressor and comfort noise generator
- Noise suppressor for stationary and transient noises reduction
- Automatic microphone gain control with dynamic range compressor
- High resolution microphone frequency response equalizer

Rx (speaker) channel processing:

- Noise suppressor
- Automatic gain control with dynamic range compressor
- Automatic, noise dependent volume & frequency response equalization
- EasyListen™ for improved intelligibility
- Ultra-high resolution loudspeaker frequency response equalizer



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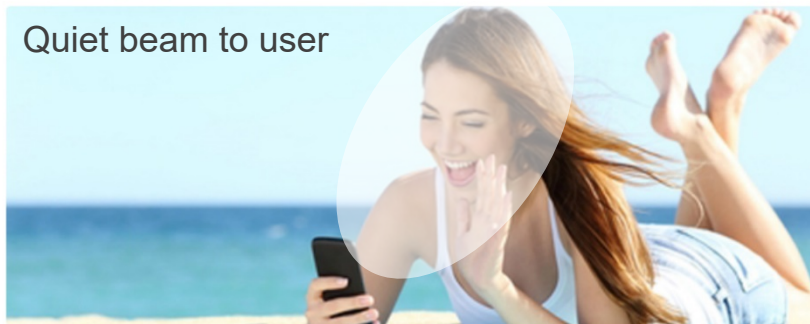
Technologies and solutions

VCP Ambient Noise and Echo Cancellation



Noise & echo cancellation in **handset mode**:

Close-talk adaptive microphone array technology creates “quiet zone” around the device. Acoustic echo, all ambient noises, other people’s voices and distant sounds are filtered out ensuring full duplex, noise and echo free communication.



Noise & echo cancellation in **video call (handheld) mode**:

Far-talk adaptive microphone array technology creates “acoustic beam” of high voice sensitivity towards user’s mouth. Acoustic echo is canceled while ambient noises, other people’s voices and distant sounds are significantly attenuated.



Noise & echo cancellation in **speakerphone mode**:

Long acoustic echoes are completely blocked enabling communication with maximal possible duplicity. Stationary and transient ambient noises are suppressed allowing people around the speakerphone to talk with a comfortable voice strength.

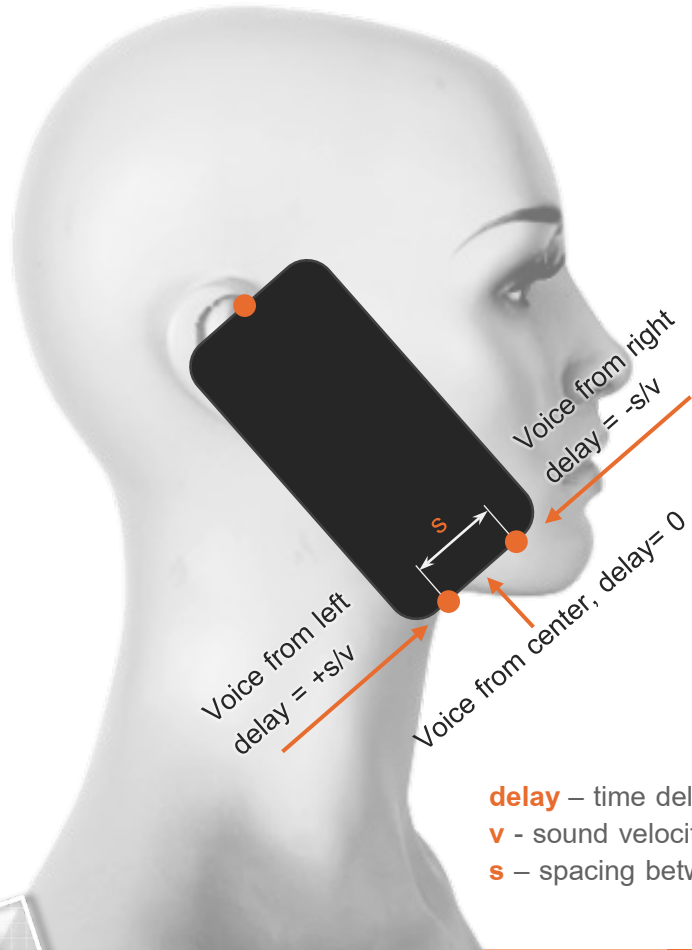


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Technologies and solutions

3-mic array for smartphones

3-mic: 2 primary + 1 reference



delay – time delay between the primary microphones

v - sound velocity

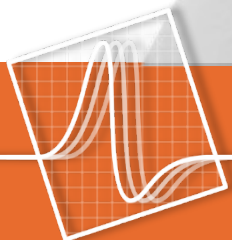
s – spacing between the primary microphones

3-mic system can discriminate efficiently between voice and noise even when the primary microphones are not close to the user's mouth.

Beamforming technology detects the main signal direction based on the time delay between the two primary microphone signals.

The main signal (user's voice) is enhanced based on the direction of its arrival (left, right or center) thus making the discrimination between voice and noise more reliable.

The signal/noise discrimination is done in narrow frequency sub-bands based on amplitude and phase differences between the enhanced primary and the reference microphone signals.

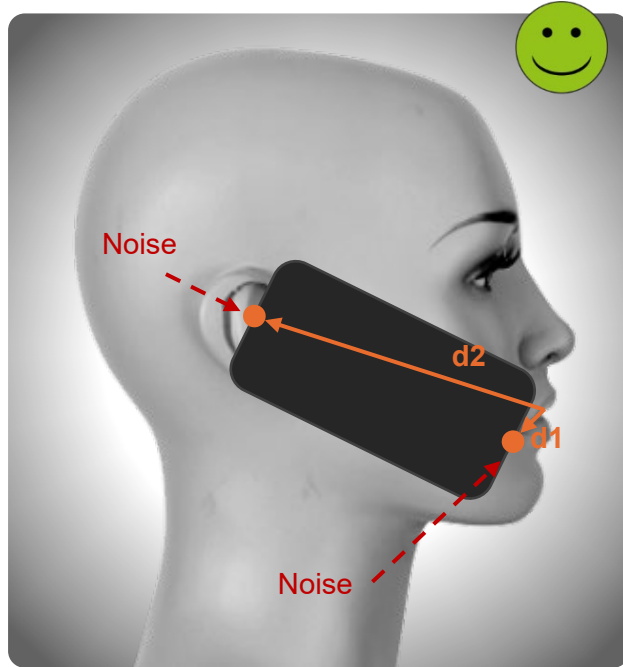


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The difficulties with 2-mic smartphones

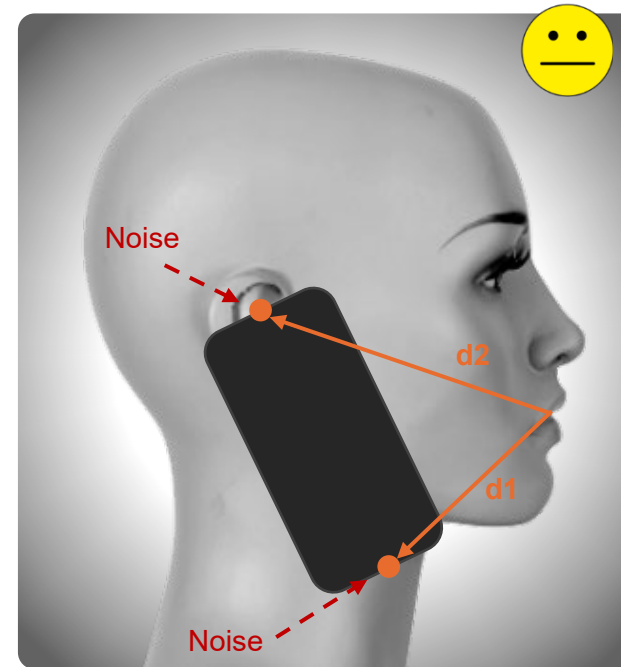
2-mic noise suppression capability depends strongly on the headset orientation



Large $\frac{d2}{d1}$

Good noise suppression

Large $d2/d1$ ratio means large difference between voice level on the two microphones. Both microphones sense similar noise, but the first microphone contains much more voice allowing good discrimination between noise and voice.



$\frac{d2}{d1}$ is close to 1

Pure noise suppression

Almost unity (~ 1) $d2/d1$ ratio means small difference between voice level on the two microphones. The two microphones receive similar signals resulting in bad discrimination between noise and voice.

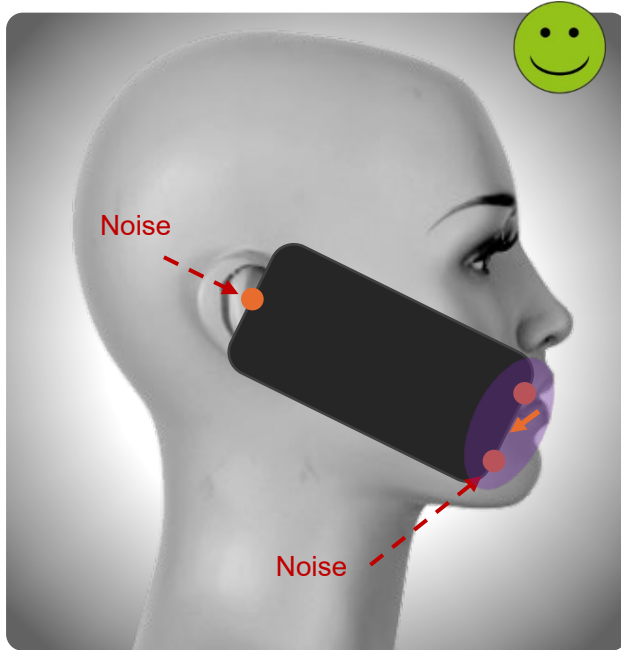
As $d1$ gets larger, the ability to discriminate between speech and noise is degraded.



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Technologies and solutions

3-mic is effective at discriminating between voice and noise

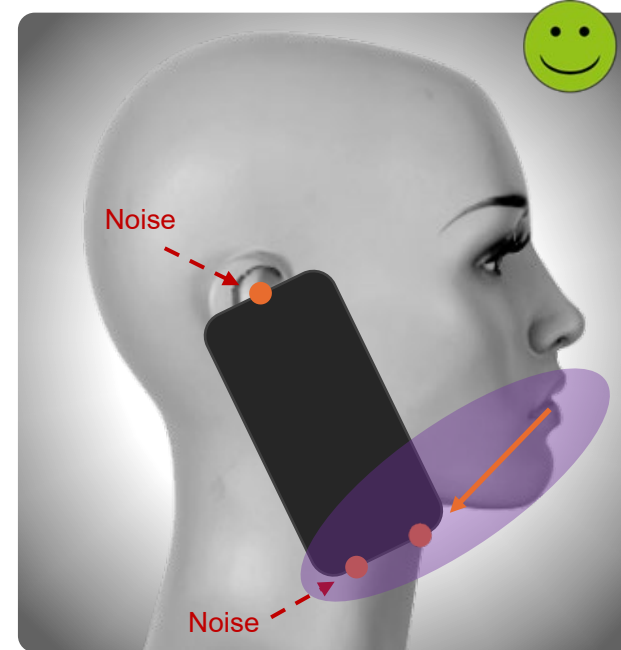


2-mic beamforming
center direction

Broadside Adaptation

The two primary microphones receive the voice signal at the same time. This “zero delay” situation indicates the nominal phone orientation.

Broadside primary microphone array output is used in conjunction with the reference microphone to create a virtual bubble of silence” enhancing the voice and rejecting ambient noises.

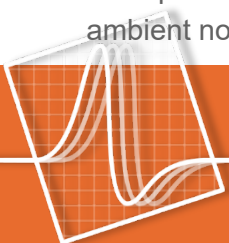


2-mic beamforming
right direction

End-fire Adaptation

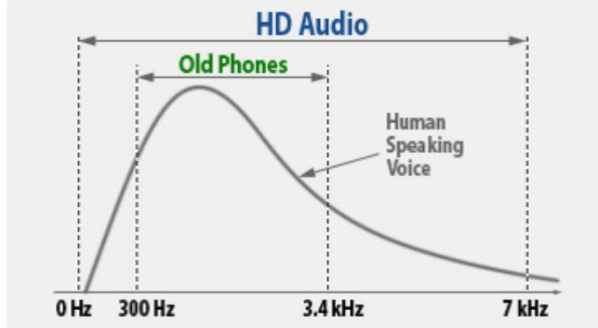
The right microphone receives user’s voice earlier indicating the shifted mouth position relative to the primary microphones.

User’s voice enhanced by the end-fire primary microphone array technology is further cleaned from noise utilizing the reference microphone signal.



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Technologies and solutions



High Definition (HD) voice support:

VCP is fully compliant to support HD voice communication providing much more voice clarity in all conditions. VCP HD voice technology requires only moderate increase in DSP resources compared to brute force approach.

Far end noise suppression:

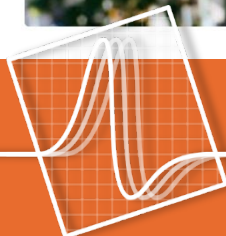
Improves phone user experience by reducing noises and unwanted sounds from the far end.

Automatic speaker volume & equalization:

Automatically adjust speaker volume and frequency according to the ambient noises ensuring the best intelligibility and privacy in varying noise conditions.

EasyListen™:

EasyListen technology additionally boosts intelligibility by slowing down far-end speech in real time. User can easier understand fast talkers or foreign language, have more time to memorize or record numbers.

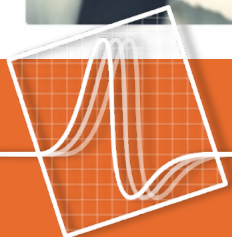
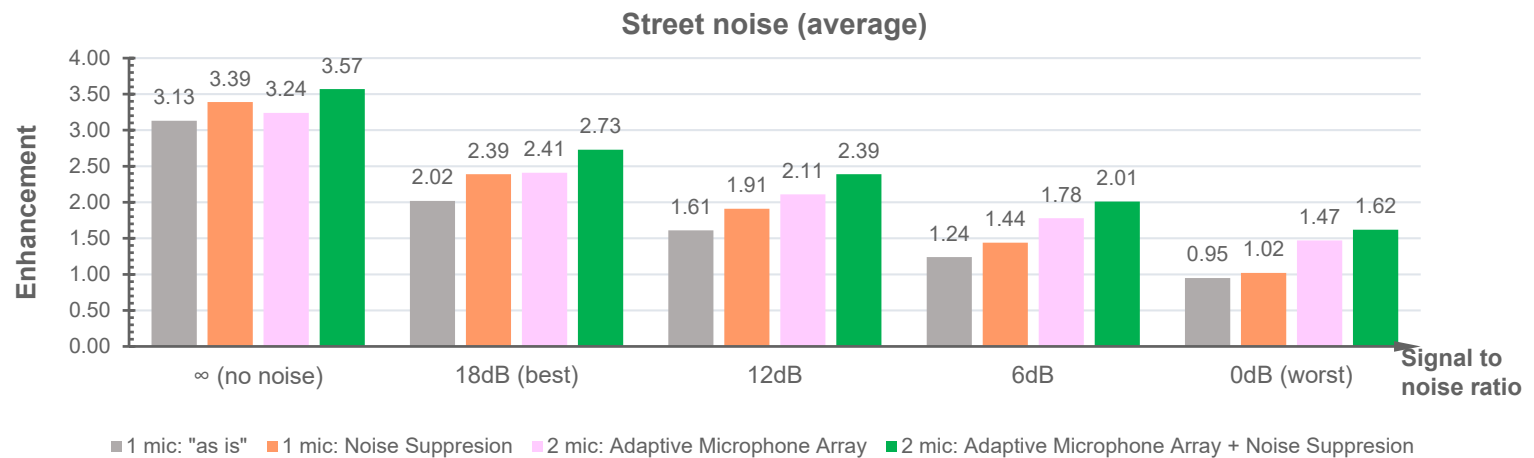
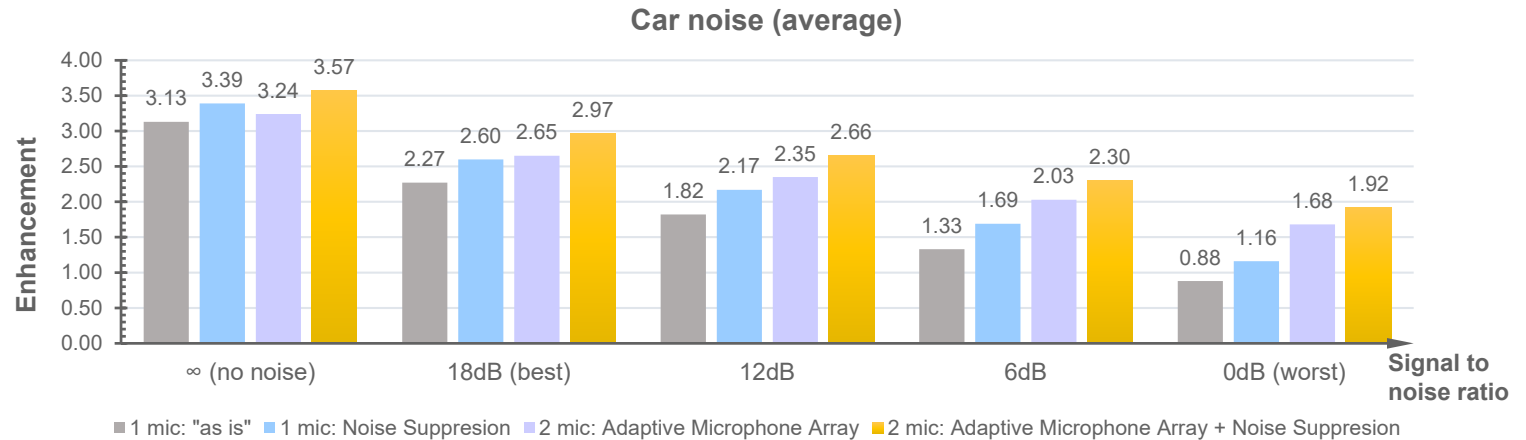


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Technologies and solutions

Objective Voice Quality Improvement with VCP

Objective phone call speech quality before and after VCP processing measured according to ITU PESQ-MOS (more is better)

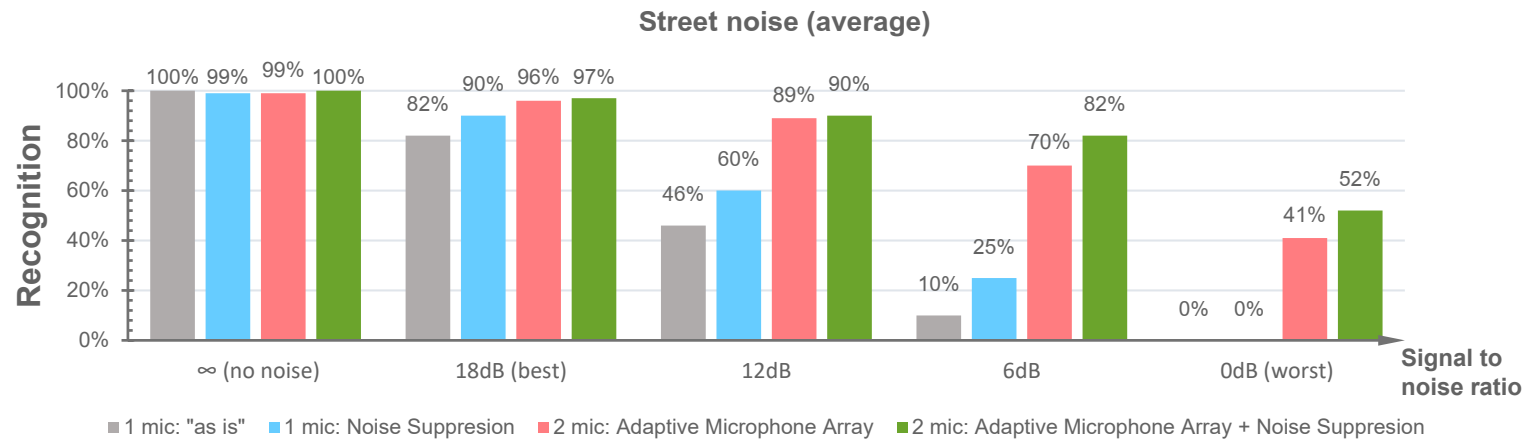
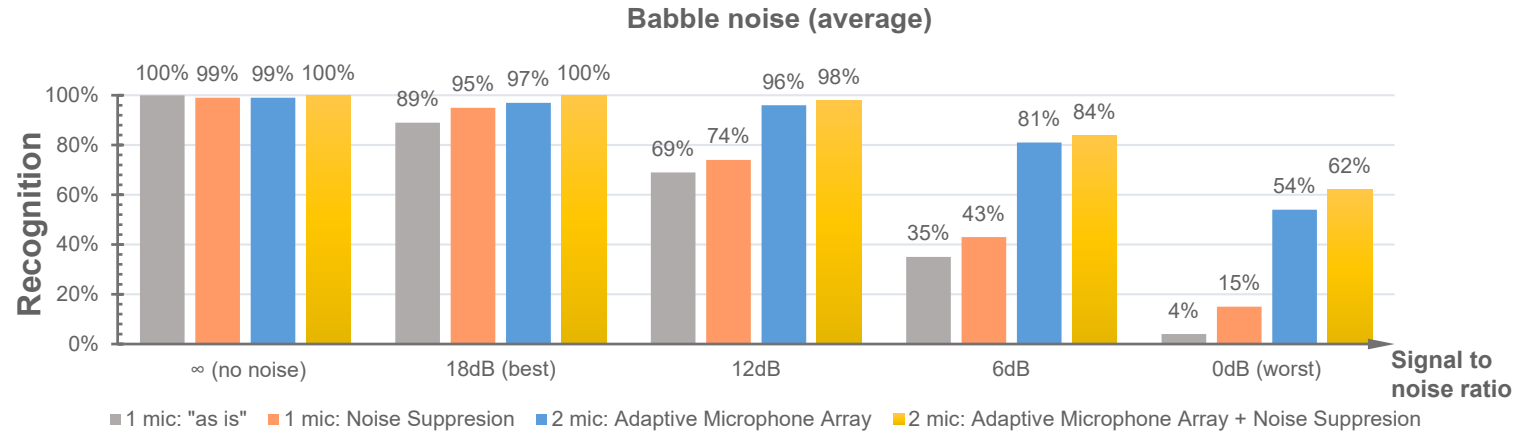


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Technologies and solutions

Speech recognition improvement with VCP

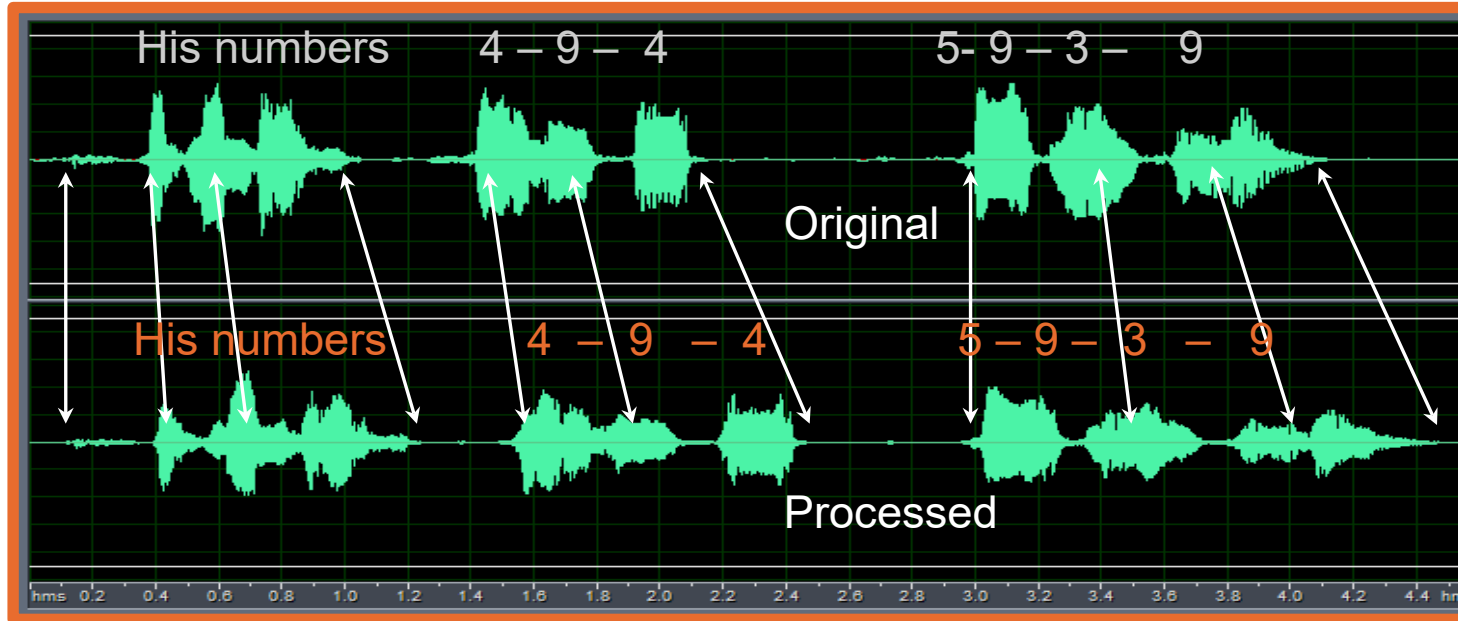
Percentage of correctly recognized phrases 2 microphone smartphone array (iPhone 5 configuration)



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Technologies and solutions

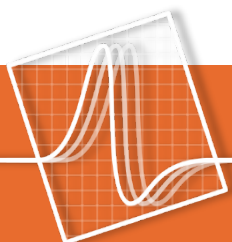
Visual example:



Someone speaks too fast?
Foreign language?
Need to write down a phone number?
Don't ask to speak slower –
activate EasyListen.

EasyListen™ technology performs sophisticated, real-time speech analysis, stretching (slowing) those parts of speech that are important for intelligibility. Accumulated delay is compensated during pauses.

Listening example:



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Technologies and solutions

VCP Technical Information

Supported Sampling Rates:

- 8 KHz, 16 KHz, 24KHz

Adaptive Microphone Array:

- Convergence time: <30ms
- Linear noise attenuation: up to 24dB
- Non-linear noise attenuation: up to 20dB

Acoustic Echo Canceller:

- Filter convergence: < 300ms with no initial echo
- Convergence in double talk and intense noise
- Robustness to speaker signal distortions
- Maximal echo tail: up to 700ms
- Residual echo level (echo suppression level): < -70dB

Noise suppression:

- Maximal: - 40dB
- Noise adaptation time: 100-500ms (depending on the noise type)

AGC maximal gain:

- 24dB

Tx frequency equalizer band width:

- 125Hz

Rx frequency equalizer band width:

- 35Hz

Automatic speaker volume and equalization control:

- up to 30dB in each sub-band

EasyListen™ maximal speech stretch:

- 50% (30% recommended)

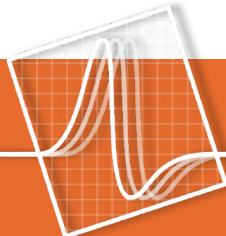
Supported DSP cores & resources requirements:

According to customers' requests VCP has been ported and optimized for a number of DSP and MCU cores: ARM9, ARM11, ARM Cortex A8, A9, A15, M4, CEVA TL-III, Renesas SH2, Tensilica (next release) ARC, Blackfin, Coolflux, Kalimba. It is used with several popular operating systems including Android, Linux, WinCE, µITRON. Support for additional cores and operating systems will be added in a near future.

The resources requirements given below correspond to ARM Cortex A8 with basic VCP package*.

MODE	MIPS (Million Instructions Per Second)	RAM (Data)	ROM (Code)
NBS-Narrow Band Speech (8KHz)	30	20 kBytes	55 kBytes
WBS-Wide Band Speech (16KHz)	45	30 kBytes	55 kBytes
SWBS-Super Wide Band Speech (24 KHz)	65	34 kBytes	55 kBytes

* Numbers are provided for reference only. Real numbers may vary depending on system configuration.



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Technologies and solutions

VCP Integration, Tuning and Support

Market proven solution:

- Alango Voice Communication Package enables echo/noise free voice communication in millions of devices including a variety of mobile phones and their accessories, hands-free car systems and speakerphones
- VCP is compliant with a variety of international telecommunication standards for mobile and stationary devices

Simple integration and use:

- VCP has a simple, well documented, field proven set of APIs that are easy to understand and integrate into a device audio path
- VCP comes with an extensive technology guide with a detailed description of algorithms and controlling parameters.

Advanced auxiliary and tuning tools:

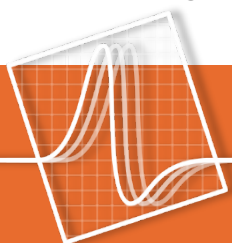
- Alango has developed a set of auxiliary tools facilitating a device real time device tuning
- VCP Configurator is a visual tool under MS Windows™ allowing easy, intuitive modification of VCP parameters creating different processing profiles
- VCP Signal Logger allows (with proper VCP integration) real time visualization of VCP input/output signals and spectrograms, listening for inputs and outputs, recording signal logs for further analysis

Simple integration and use:

- VCP has a simple, well documented, field proven set of APIs that are easy to understand and integrate into a device audio path
- VCP comes with an extensive technology guide with a detailed description of algorithms and controlling parameters.

Great support:

- Integration and acoustic tuning guidance from Alango experts



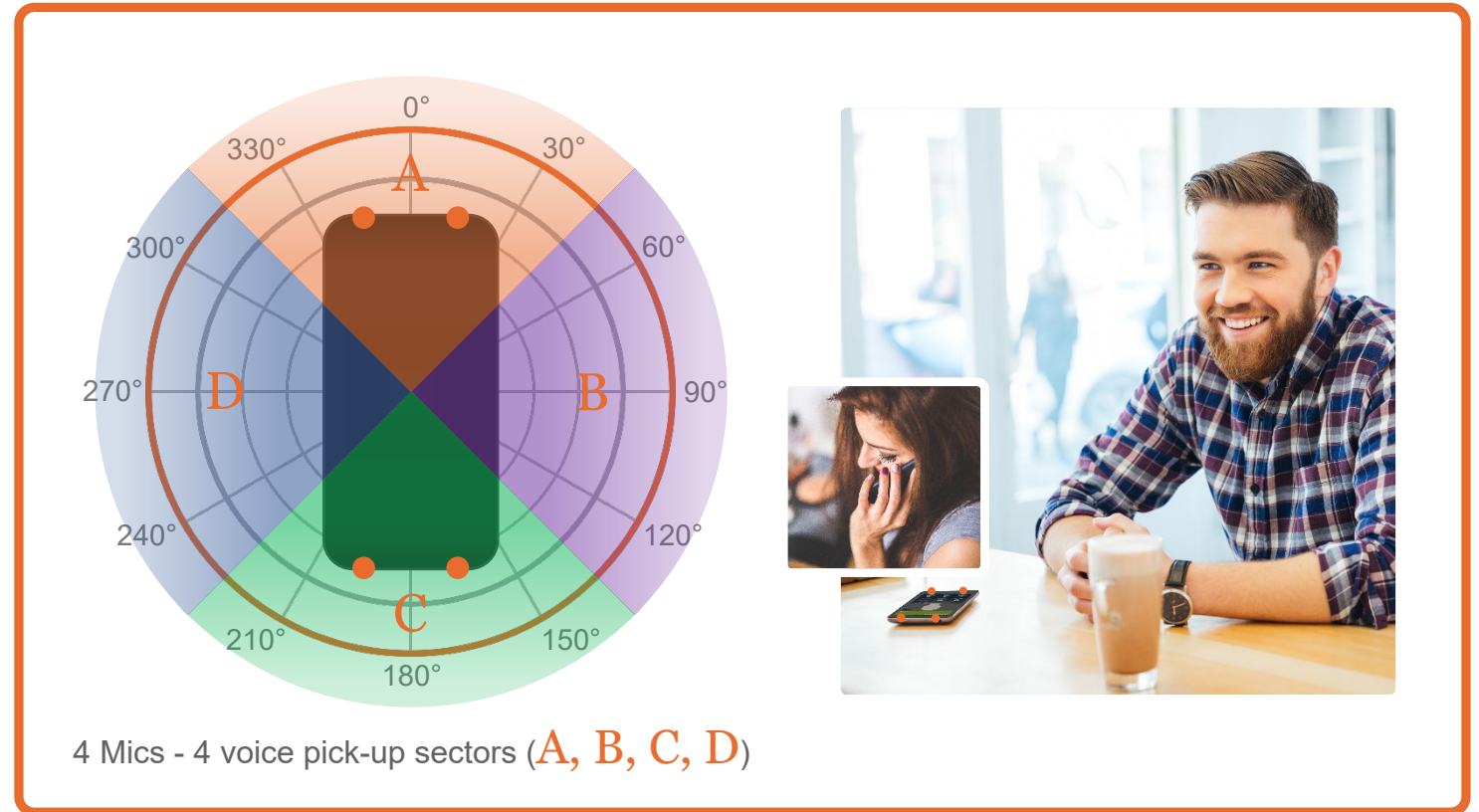
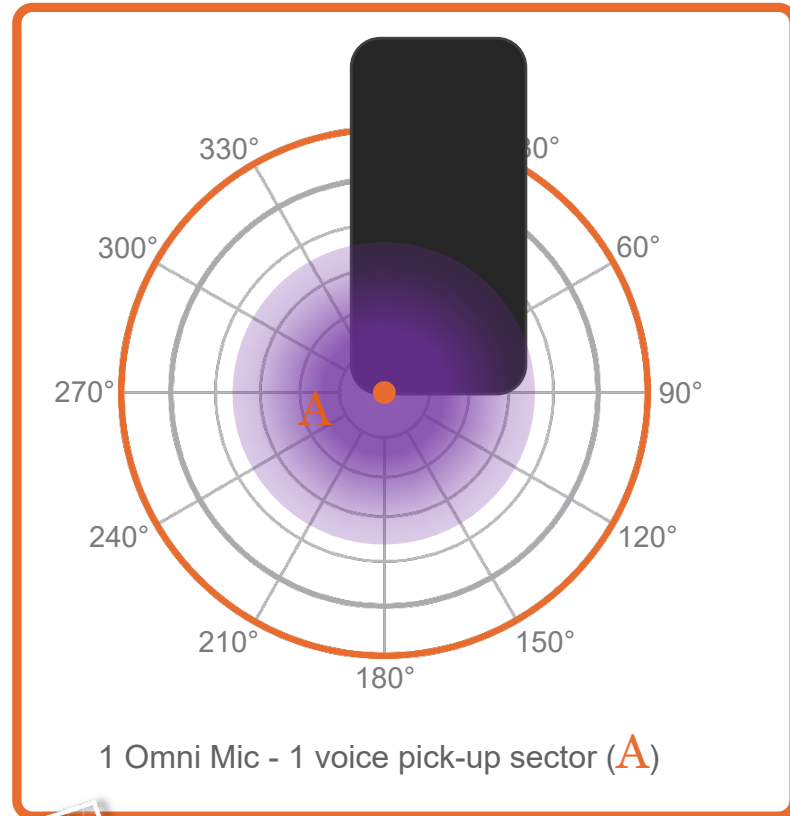
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Technologies and solutions

Far-field voice enhancement technology

The 3-4-mic array technology greatly extends the voice pickup distance compared to 1 microphone.

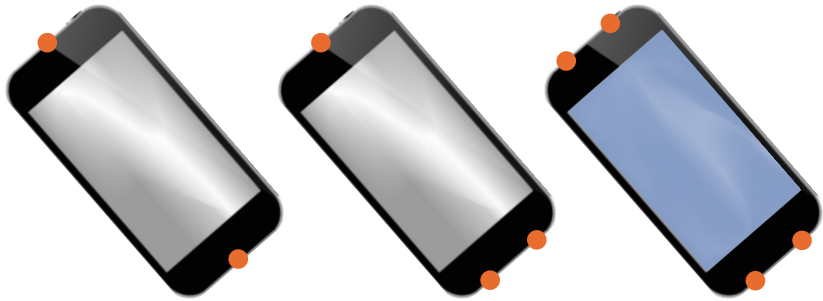
The output is the prime voice signal according to which of the beamforming sectors has the best Signal-to-Noise Ratio (SNR).



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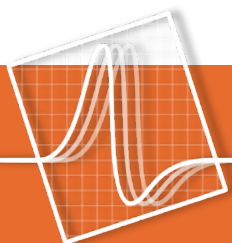
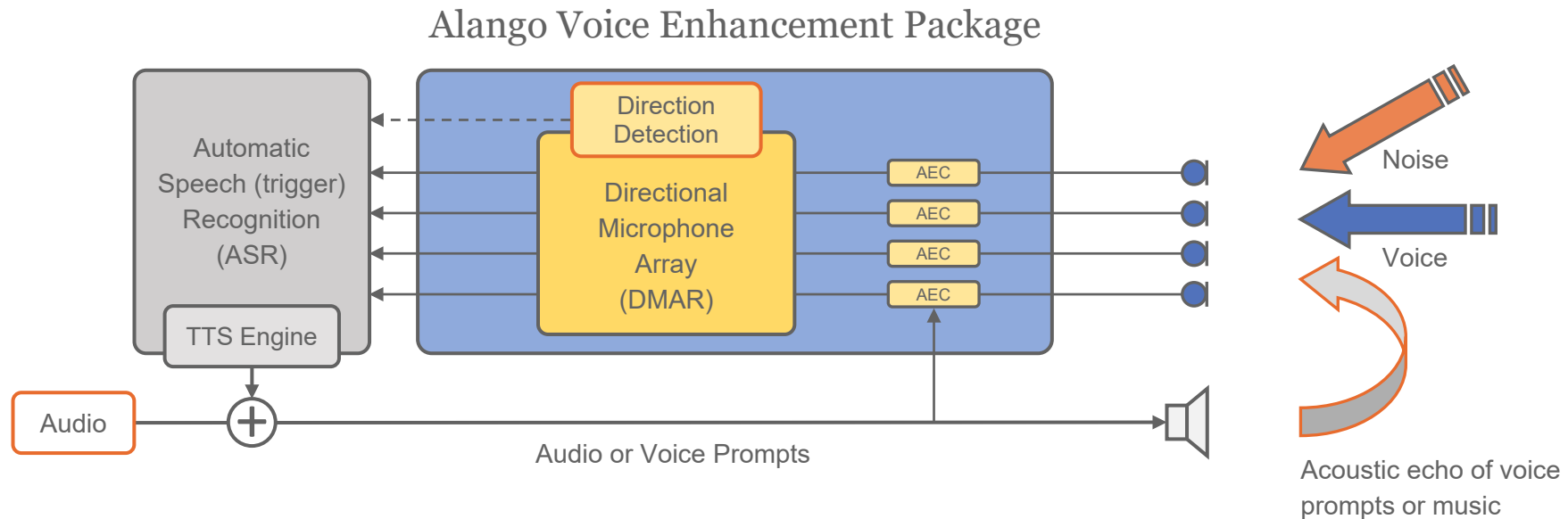
Technologies and solutions

Voice Enhancement Package



Voice Enhancement Package (VEP) is a set of software technologies utilizing a number of microphones to enhance the voice signal before it is provided to the speech recognition engine.

While, in general, the number of microphones is unlimited, in smartphones the number of microphones cannot exceed 4 for cost, design and power consumption reasons.



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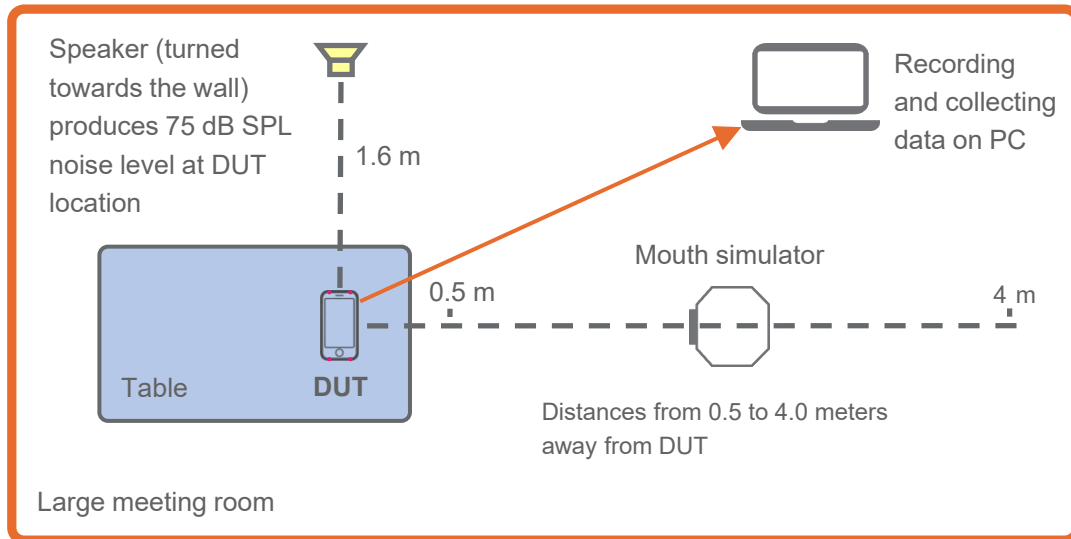
Technologies and solutions

Far-field speech recognition enhancement

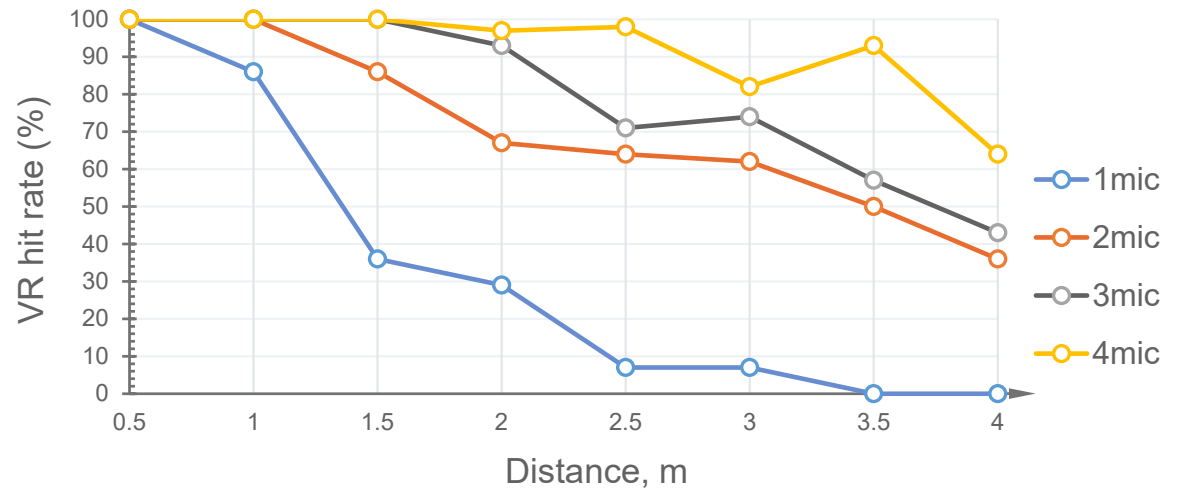
Test Results

Compare voice trigger recognition rate in a controllable and reproducible acoustic environment (office meeting room), using:

- 1 microphone raw audio (without any additional processing)
- 2 microphones processed audio (2mic multidirectional voice enhancement)
- 3 microphones processed audio (3mic multidirectional voice enhancement)
- 4 microphones processed audio (4mic multidirectional voice enhancement)



Voice Trigger Results (82dB SPL)



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Technologies and solutions

VCP Contact Information

Don't hesitate to contact us if you want to be our customer or just have any comments. We are looking forward hearing from you!

Please, send your questions, comments, thoughts, proposals to info@alango.com or specifically

Mr. Robert Schragar (Sales enquiries): sales@alango.com

Mr. Alex Radzishovsky (Technical enquiries): tech@alango.com

Dr. Alexander Goldin (CEO): ceo@alango.com

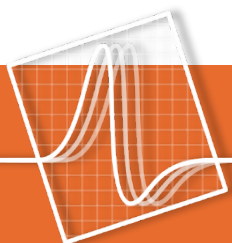
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