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Knowles Electronics
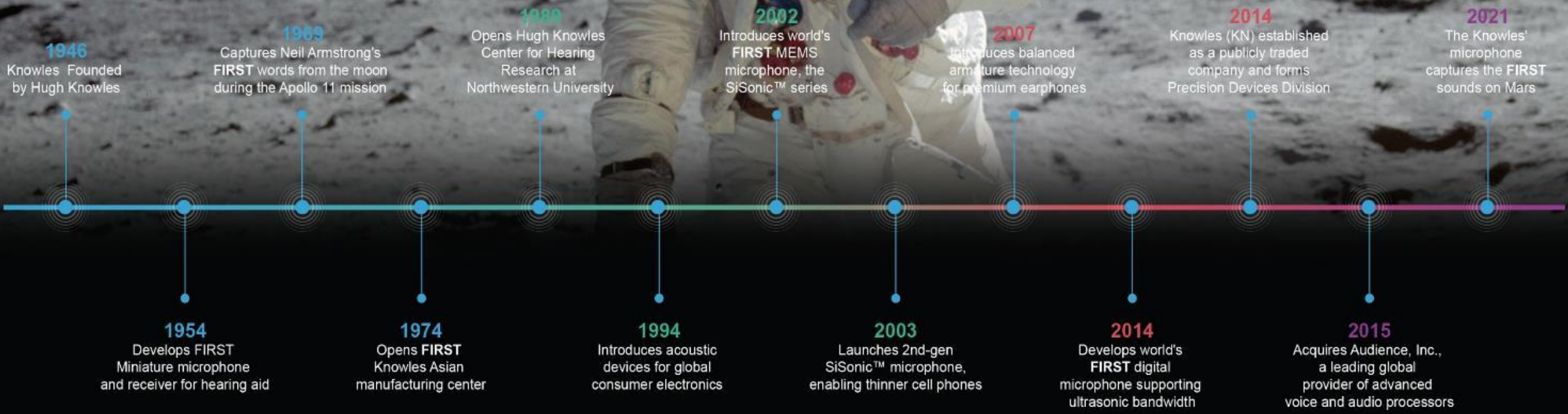
Robin Liao 2023/8/23

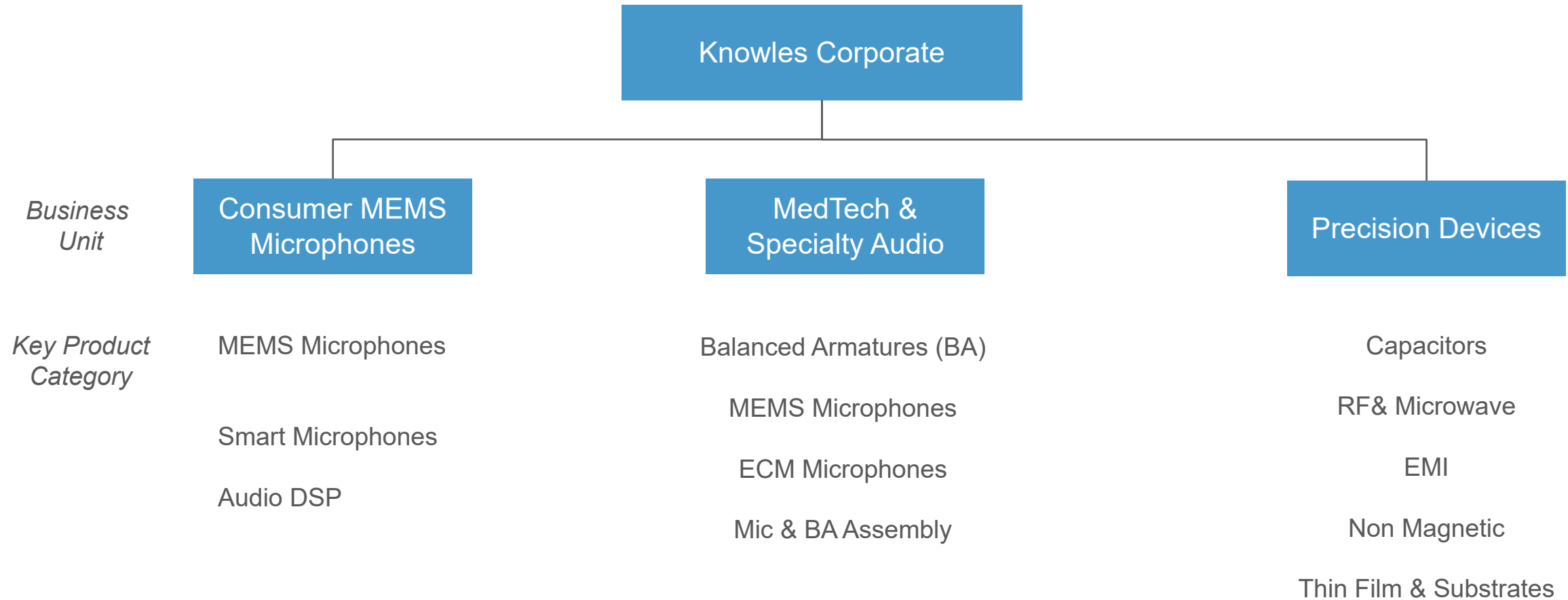## MEMS Microphones & Audio DSP

To Address every Use Case

Celebrating 75 Years of Innovation

1946
Knowles Founded
by Hugh Knowles

1969
Captures Neil Armstrong's
FIRST words from the moon
during the Apollo 11 mission

1989
Opens Hugh Knowles
Center for Hearing
Research at
Northwestern University

2002
Introduces world's
FIRST MEMS
microphone, the
SiSonic™ series

2007
Introduces balanced
armature technology
for premium earphones

2014
Knowles (KN) established
as a publicly traded
company and forms
Precision Devices Division

2021
The Knowles'
microphone
captures the FIRST
sounds on Mars

1954
Develops FIRST
Miniature microphone
and receiver for hearing aid

1974
Opens FIRST
Knowles Asian
manufacturing center

1994
Introduces acoustic
devices for global
consumer electronics

2003
Launches 2nd-gen
SiSonic™ microphone,
enabling thinner cell phones

2014
Develops world's
FIRST digital
microphone supporting
ultrasonic bandwidth

2015
Acquires Audience, Inc.,
a leading global
provider of advanced
voice and audio processors

Knowles Organization

Knowles Corporate

Business Unit	Consumer MEMS Microphones	MedTech & Specialty Audio	Precision Devices
Key Product Category	MEMS Microphones Smart Microphones Audio DSP	Balanced Armatures (BA) MEMS Microphones ECM Microphones Mic & BA Assembly	Capacitors RF& Microwave EMI Non Magnetic Thin Film & Substrates

Knowles develops microphones, speakers, audio solutions, capacitors & RF filters for world's leading tech providers

Key Consumer Use Cases
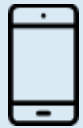
Vlogging

Social Media Content Creation

Cinematic Film Making

WFH – Audio / Video Conferencing

Virtual Learning

Voice User Interface (VoiceUI)

Ambient/Transparency Mode

Active Noise Cancellation

Talk Voice Quality

Bluetooth Voice Call

Cabin Comfort – Road Noise Cancellation

Emerging consumer audio use cases across markets

What Knowles Offers MEMS Mic Customers

Scale
+20Bu MEMS Mics

Dual Factory, Multi-Sourced

Technology
Design Own MEMS, ASIC, Package

Turnkey Product

Support
Best in Class Application Know-how

Global Eng. Support

Quality
Raising Bar on Product Robustness

Field Teams for Fast Response

TWO MEMS MICS FACTORIES

Suzhou, China

Penang, Malaysia

Market Leading Supplier of MEMS Microphones on Scale, Technology, Support & Quality Offering

Our Product Portfolio

Higher Performance, Better Clarity & More Efficiency

Increasing Performance ↑

Digital Mics

Hyperion `NEW`
S:70.5dB, A:129dB SPL
Low power, Latency
Pkg: 4.00 x 3.00 x 1.20
Under Development

Titan `NEW`
S:68.5 dB, A:129dB SPL
Low power, Latency
Pkg: 3.50 x 2.65 x 0.98

Cornell2
S:66dB, A:132.5dB SPL
1% THD 130.5
Pkg: 3.50 x 2.65 x 0.98

Luiso
S:64dB, A:120dB SPL
Entry Tier
Pkg: 3.50 x 2.65 x 0.98

Analog Mics

Raptor `NEW`
S:72dB, A:130dB SPL
LFRO 17Hz, Single Ended
Pkg: 4.00 x 3.00 x 1.20

Falcon / Falcon FB `NEW`
S:68.5dB, A:134dB SPL
LFRO 32/18Hz, Differential
Pkg: 3.50 x 2.65 x 1.00

Robin
S:66dB, A:132dB SPL
1% THD 130, Single Ended
Pkg: 2.75 x 1.85 x 0.90

Ford2
S:62.5dB, A:124dB SPL
Entry Tier, Single Ended
Pkg: 2.75 x 1.85 x 0.90

Innovation

Enabling clear voice calls in noisy conditions

V2S
S:64.5dB
BW:4kHz, Low Power Dig
Pkg: 3.30 x 2.30 x 0.93
Under Development

High Performance in Top Ports

Scarlet
S:66dB, A:132dB SPL
Single Ended Analog
Pkg: 2.75 x 1.85 x 0.90
Under Development

Gaudi
S:68dB, A:121dB SPL
Digital
Pkg: 4.00 x 2.00 x 1.10
Under Development

Automotive Grade Mics (AEC-Q100/103)

SPH6855 `NEW`
S:68dB, A:130dB SPL
Digital, -35dBFS
Pkg: 3.50 x 2.65 x 0.98

SPH6655 `NEW`
S:68dB, A:121dB SPL
Digital, -26 dBFS
Pkg: 3.50 x 2.65 x 0.98

SPH8855 `NEW`
S:66dB, A:120dB SPL
Digital, -26dBFS
Pkg: 3.50 x 2.65 x 0.98

SPH9855
S:66dB, A:132.5dB SPL
Digital
Pkg: 3.50 x 2.65 x 0.98

SPH1878/2878
S:67dB, A:134dB SPL
Analog, 85C/105C
Pkg: 3.50 x 2.65 x 1.26

Voice Vibration Sensor (V2S) – A solution to a common challenge

The Need

The Solution

Loud Bar

Traffic

Busy Office

1

2

3

Background noise overwhelms microphones during calls

Multi-mic beamforming and algos help but not sufficient

A targeted solution needed to selectively pick-up speaker's voice

1 Throat/vocal cord – Vibration created on speech

2 Vibration travel from throat to ear. Body is low pass filter and attenuator. V2S in TWS senses vibrations

3 Clear voice signal sent on the Voice Call

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SiSonic™ Product Portfolio
The **broadest microphone portfolio**

Rich feature sets

Multiple Performance Modes
Low Power
+/-1dB Matching
Ultrasonic Bandwidth
High SNR
Low THD
Flat Frequency Response

Digital
PDM
Analog
Single-Ended
Differential

SPM	SPK	SPG	SPC	SPU	SPQ	SPH	SPA	SPW	SPV
4.72 3.76 1.25 mm	4.00 3.00 1.00 mm	4.00 2.00 1.10 mm	3.50 2.00 1.00 mm	3.76 2.95 1.10 mm	3.76 2.24 1.10 mm	3.50 2.65 0.98 mm	3.35 2.50 0.98 mm	3.10 2.50 1.00 mm	2.75 1.85 0.90 mm
Analog	*Digital*	*Digital*	*Digital*			*Digital & Analog*		*Digital*	

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AISonic™

AI and Audio Edge Processors

Advanced DSP algorithms built using Knowles instruction set
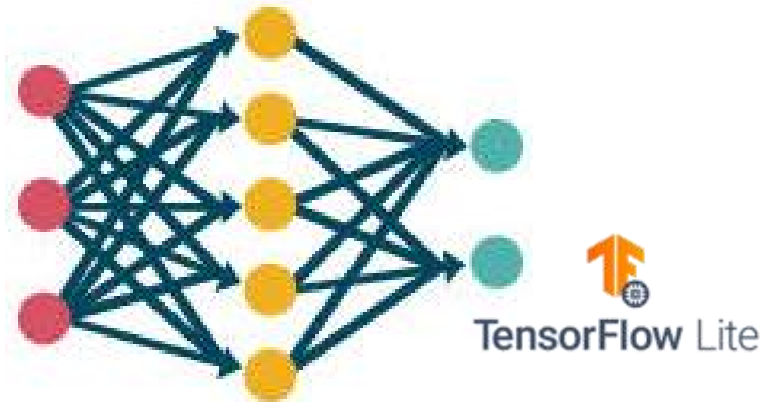
Native hardware accelerated ML instructions for Neural Networks

TensorFlow Lite
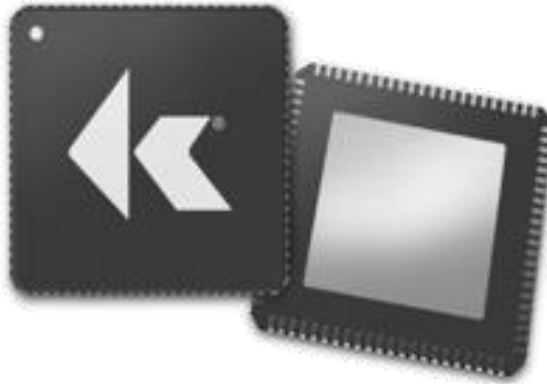
Knowles AISonic™ Edge Processor

Leading Compute Efficiency for long battery life

$$\frac{MOPS}{mW}$$

Reference System Solutions for Time to Market and Quality

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AISonic™ Success Stories

▶ Since the launch of the IA8201 it has been designed into multiple product categories establishing leadership in
- Performance and Power for voice applications for battery powered devices
- Scalability and ease of integration across a myriad of embedded platforms

Bluetooth Speakers Consumer and Enterprise

3-6mics

Smart TVs, Screens, Monitors And Remotes

2 mics

IoT and Farfield Devices

1-4 mics

White Goods and Smart Homes

4-5 mics

Solution capable of multiple ASRs via Amazon Voice Interoperability Initiative, 2MB memory

OTE

6 mics

TBA

TWS

6 mics

Gaming Headsets, Enterprise OTE, and TWS with low power voice enhancement and output processing

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Polycom Sync Series (Sync20/40/60)

BnO A Series

B&O Enterprise Series

Jabra Evolve2 85 Series

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AISonic™
Edge Processors

Acoustic Challenges for VUI

Conference Speakers

Double Talk

Range and AEC

Algorithm Partners

RETUNE DSP
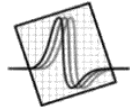
ALANGO

Broad coverage of Voice Call Standards

zoom

amazon alexa

Beamformer and Mic Array Tuning

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14

Televisions

Voice Commands in –ve SER with Loud TV Volumes

Range and Large Seating areas

Voice Commands in –ve SNR with Babble or Loud Distractors
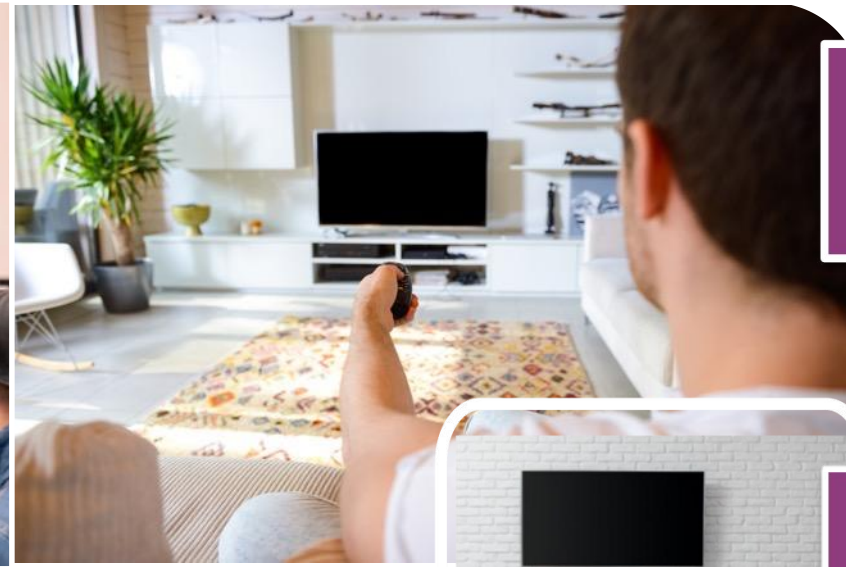
Rear Wall Reverberation

Algorithm Partners

RETUNE DSP.

Voice Commands with Multi-channel Audio

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Acoustic Challenges due to interference

Mic is covered

**Find My Remote
Or
Push 2 Talk as
backup**

**Low
Power**

Omnidirectional listening

IA8201 can compensate with multi-mic Algorithm

**Algorithm
Partners**

RETUNE DSP

sensory

# of Mics	Performance	Power Consumption mWHr/day
1	SNR>+5db Range: 1-2m	IA611; ~11mWhr/day
2	SNR>0db Range: 2-4m	IA700; ~7.5mWHr/day
3	SNR>-7db Range: >4m	IA8201; ~14mWhr/day

White Goods

Voice Commands in –ve SNR with Babble or Loud Distractors

Noise suppression of fans, motors and vibrations

Range and Large Seating areas

Algorithm Partners

RETUNE DSP

ALANGO

sensory

Tune for Mic Array locations

Multi-mic beamforming for Boomless and Open Office

Output processing For Spatial Audio

Algorithm Partners

Chatable

ALANGO

fluent.ai

Accelerometer for Voice Enhancement
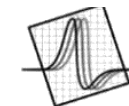
Low power for long Battery Life

Machine learning for scene detection and Hearing Augmentation
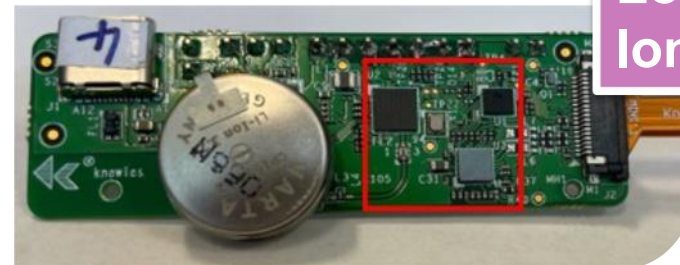
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AISonic™
Edge Processor
Roadmap

Knowles Intelligent Audio Solutions

IA611
Single-Core Top Port

Shipping

- Low power always-on voice wake
- DSP + Mic = smallest footprint
- Lowest system cost solution

IA700
NEW

Single-Core Low Power Edge Processor

- 100MHz HMD-Lite 32-bit core
- Pair with 2x Cornell2 Microphone for Beam Forming

IA8201
Dual-Core Audio Processor

Shipping

- 175MHz AU/ML cores with up to 128b data-path (4x 32-bit MACs/cycle)
- 1MB/4x PDM mic or 8x with TDM

IA8202
NEW

Extended Memory Quad-Core Audio Processor (Sampling Aug'22)

Discrete 2x 8201 Shipping

- Multi-channel AEC, Concurrent Voice UI ASR and Calling
- Ambient contextual detection
- Local ASR
- Low power VAD
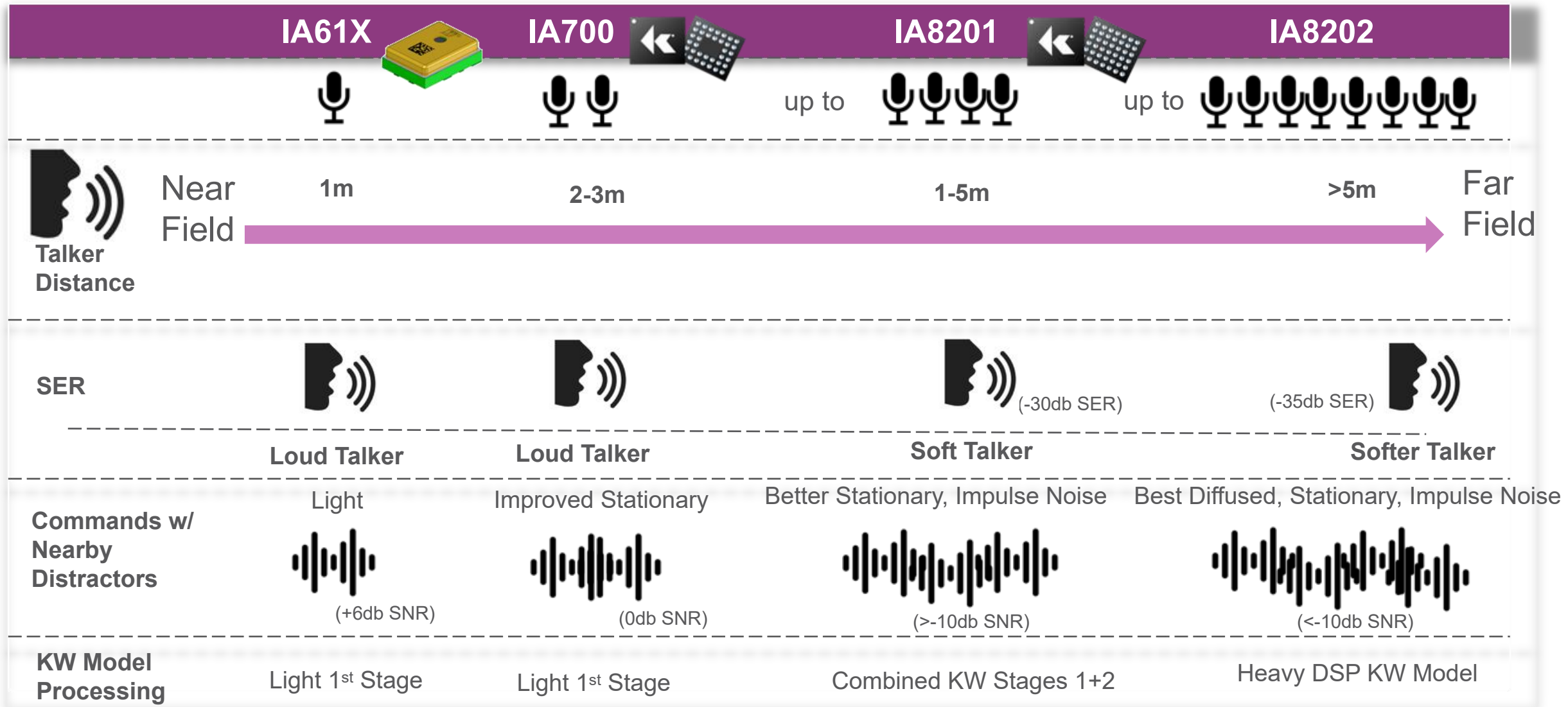- 2MB usable memory
- 8 mic inputs

Edge Smart Mic	Audio Edge Processors

	IA61X	IA700	IA8201	IA8202
Talker Distance	Near Field — 1m	2-3m	up to 1-5m	up to >5m — Far Field
SER			(-30db SER)	(-35db SER)
	Loud Talker	Loud Talker	Soft Talker	Softer Talker
Commands w/ Nearby Distractors	Light (+6db SNR)	Improved Stationary (0db SNR)	Better Stationary, Impulse Noise (>-10db SNR)	Best Diffused, Stationary, Impulse Noise (<-10db SNR)
KW Model Processing	Light 1st Stage	Light 1st Stage	Combined KW Stages 1+2	Heavy DSP KW Model

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Product Comparison

Product	SmartMic	IA700	IA8201	IA8202
Memory	248kB (168kB User Avail)	248kB (168kB User Avail)	1.44MB (1MB User Avail)	2.88MB (2MB User Avail)
Size/Package	SPH (microphone) 3.50mm x 2.65mm x 0.98 9 pin	QFN 3.5mm x 3.5mm	LGA 3mm x 2.6mm QFN 6mm x 6mm	QFN 8mm x 8mm
Digital Audio IO	2x PDM in, 2x PDM out, 1x I2S/TDM	4x PDM in, 2xPDM out, 3x I2S/TDM (4ch in/out)	4x PDM in, 2xPDM out, 3x I2S/TDM (4ch in/out)	8 PDM in, 2x PDM out 8 I2S/TDM (8ch in/out)
# of Mics	1mic (integrated)	1 to 2 mics	1 to 4 mics	1 to 8 mics
Avail Sensor Interfaces	N/A	2x I2C, 2x SPI, GPIOs	2x I2C, 2x SPI, GPIOs	5x I2C, 3x SPI, GPIOs
Ports	1 I2C, 1 UART, 1 SPI GPIO	2x I2C, 2x SPI, 2 x UART, 8 GPIOs w/interrupts	2x I2C, 2x SPI, 2 x UART, 24 GPIOs w/interrupts	5x I2C, 3x SPI, 2x UART Up to 32 GPIOs w/ interrupts, 57 GPIOs total

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Open DSP: 3rd Party Developer Ecosystem

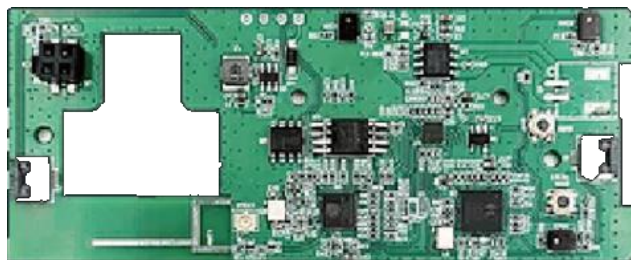Algorithms perform better on Knowles open DSP architecture
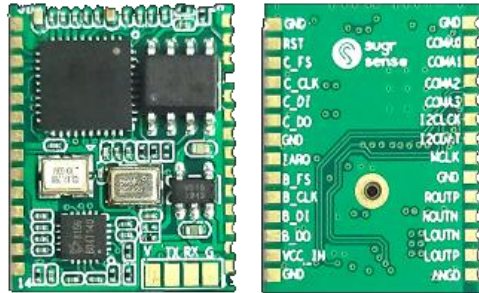
Sugr w BLE

Sugr w USB

Sugr w WiFi

Libre with Wi-Fi
And AWS Integration
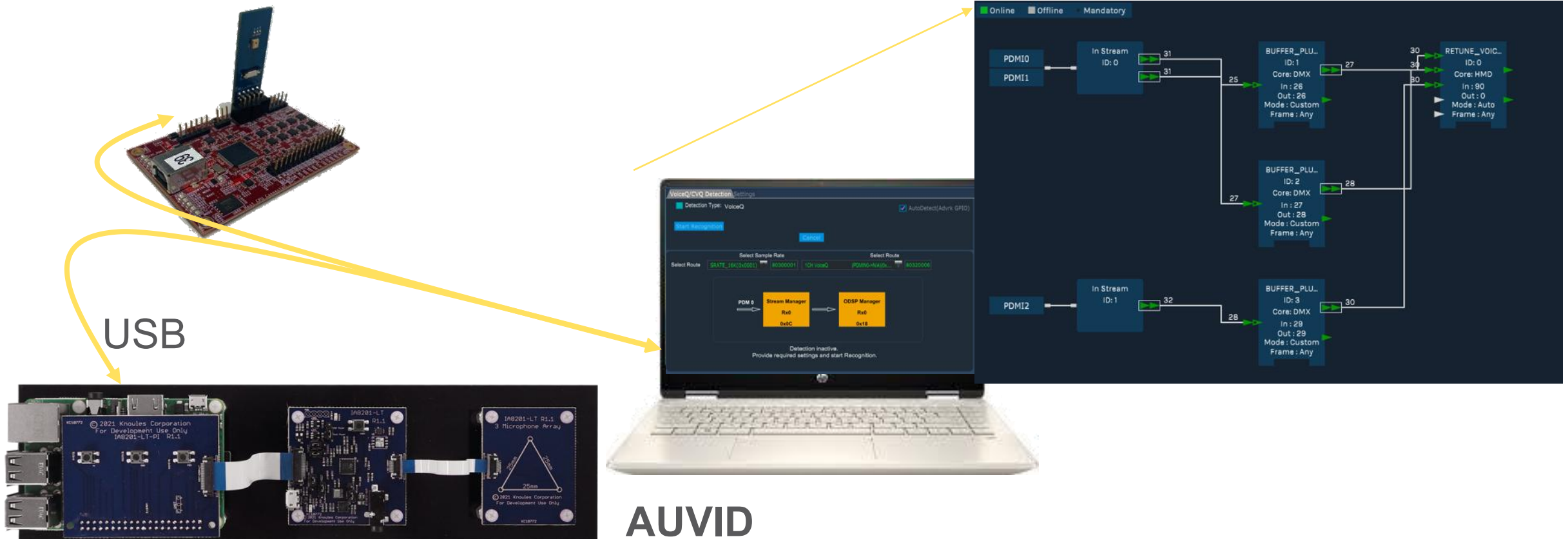
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USB

AUVID
- A Knowles IDE for development, simulations and debugging
- SDK libraries provide access to intrinsics, plug-in framework

The myKnowles Portal

https://solutions.knowles.com

- One-stop-shop for resources, periodic product updates, sales collateral, tools and support

- Sign SLA evaluation license agreement instantly

- View different Solution Kits available from Knowles

- Download Software Releases and Documentation

- Watch "*How-To*" Training Videos

- Post questions and receive answers via Community forums

- Request for Hardware Kits

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Thank You