ANALOG DEVICES

AHEAD OF WHAT'S POSSIBLE™

ADI AUDIO DSP

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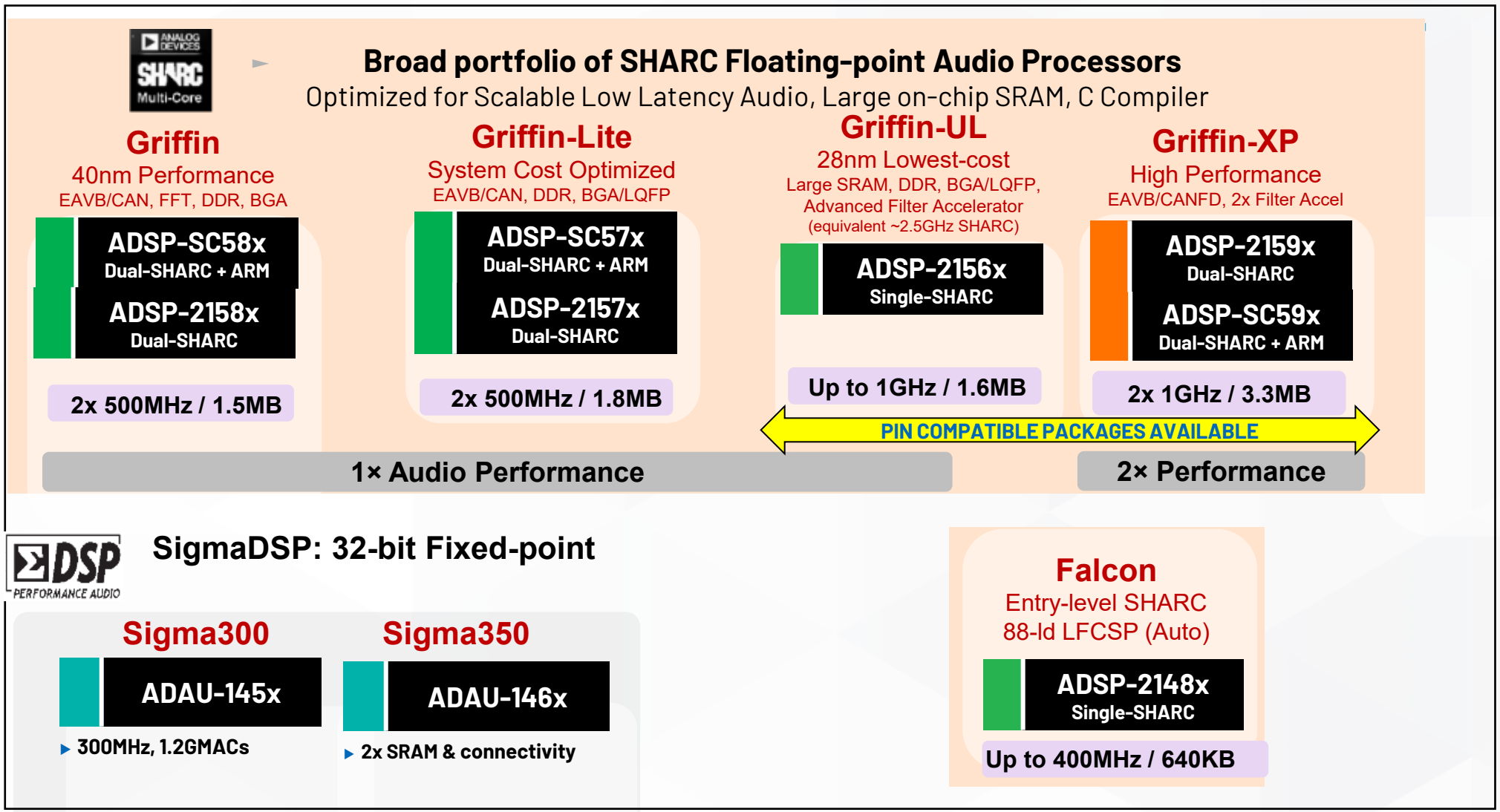
2023 November

Agenda

1. ADI AUDIO DSP的产品组合
2. DSP加速器的使用方法
3. 开发环境
4. ADI AUDIO DSP的Audio Decoder的SDK
5. Audio Solution
6. 成功案例
7. 经常问到的问题

1. ADI AUDIO DSP的产品组合



SHARC DSP Road Map

DSP の相対性能比較

50×

20×

5×

1x

ADSP-2106x

ADSP-21160

ADSP-21161

ADSP-2126x

ADSP-2136x

ADSP-2137x

ADSP-2146x

ADSP-2148x

ADSP-2147x

ADSP-SC58x
ADSP-2158x

ADSP-SC57x
ADSP-2157x

ADSP-2156x

ADSP-SC59x
ADSP-2159x

第2世代

第3世代

第4世代

第5世代

1994 1998 2000 2003 2004 2008 2010 2015 2017 2020 2021

SHARC核在升级

- 主频最高到1GHZ
- 浮点数的位数是64位的，精度提高了
- 增加了ARM核
- 周边的接口丰富起来了(USE/Ethernet/SDIO/PCIE...)

ADI SHARC DSP重要参数的最好值

最好的参数	参数值	芯片型号
主频	1G	ADSP-21569
最大L2内存	1MB	ADSP-21569，ADSP-21565
最多的GPIO口	102	ADSP-21569，ADSP-21567，ADSP-21566,ADSP-SC587W
最大的系统时钟	500M	ADSP-21569
带ARM Cortex-A5	500M	ADSP-SCxx

SHARC DSP周围接口总结表

周围接口	芯片型号
DAI	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
SPORT	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
S/PDIF RX/TX	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
精密时钟发生器	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
I2C（TWI）	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
四数据位SPI	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
双数据位SPI	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
CAN2.0	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
UART	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
链路端口	ADSP-SC58x/2158x，ADSP-SC57x/2157x,ADSP-2156x
增强型PPI	ADSP-SC58x/2158x
通用定时器	仅529-BGA封装提供8个定时器。349-BGA封装无定时器6和7
通用计数器	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
增强型PWM	仅529-BGA封装提供3个ePWM。349-BGA封装无PWM
看门狗定时器	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
ADC控制模块	ADSP-SC58x/2158x
静态存储控制器	ADSP-SC58x/2158x，ADSP-SC57x/2157x,ADSP-2156x
高性能FFT/IFFT	ADSP-SC58x/2158x，ADSP-2148x
FIR/IIR	ADSP-SC58x/2158x，ADSP-SC57x/2157x，ADSP-2148x,ADSP-2156x
谐波分析引擎	ADSP-SC58x/2158x
SINC滤波器	ADSP-SC58x/2158x
安全加密引擎	ADSP-SC58x/2158x，ADSP-SC57x/2157x,ADSP-2156x
多通道12位ADC	ADSP-SC58x/2158x

DSP加速器的使用方法1: Direct Replacement

- **Code: Direct Replacement**
  - #define USE_CORE – all 12 channels are processed by the core
  - #define USE_ACC – all 12 channels are processed by the FIR/IIR accelerator, core waits till accelerator processing is done

- MIPS
  - Core Only
    - Core MIPS Usage: 202.18
    - ACC MIPS Usage: 0.0
  - Direct Replacement with ACC
    - Core MIPS Usage: 160.69
    - ACC MIPS Usage: 157.96
  - Core MIPS Savings: **41.70**

Core Only					
Snapshot No.	**Description**	**Core State**	**Accelerator State**	**Cycles**	**MIPS**
1	Function Entry			73	0.01
2	Misc			43	0.01
3	FIR Processing			838935	157.30
4	IIR Processing			222397	41.70
5	Multiply gain and add IIR Output			16786	3.15
6	Function Exit			59	0.01
7	Free core MIPS			4255250	797.86
				Total	**1000.00**
		Accelerator MIPS Usage	**0.00**	**Core MIPS Spent in FIR/IIR Processing**	**202.18**
		Free Accelerator MIPS	**1000.00**	**Free Core MIPS**	**797.82**

Direct Replacement - ACC					
Snapshot No.	**Description**	**Core State**	**Accelerator State**	**Cycles**	**MIPS**
1	Function Entry			73	0.01
2	Misc			34	0.01
3	FIR Task Queue			709	0.13
4	FIR Processing			442418	82.95
5	IIR Task Queue			2705	0.51
6	IIR Processing			400054	75.01
7	Multiply gain and add IIR Output			10937	2.05
8	Function Exit			59	0.01
9	Free core MIPS			4476031	839.26
				Total MIPS	**1000.00**
		Accelerator MIPS Usage	**157.96**	**Core MIPS Usage**	**160.69**
		Free Accelerator MIPS	**842.04**	**Free Core MIPS**	**839.31**

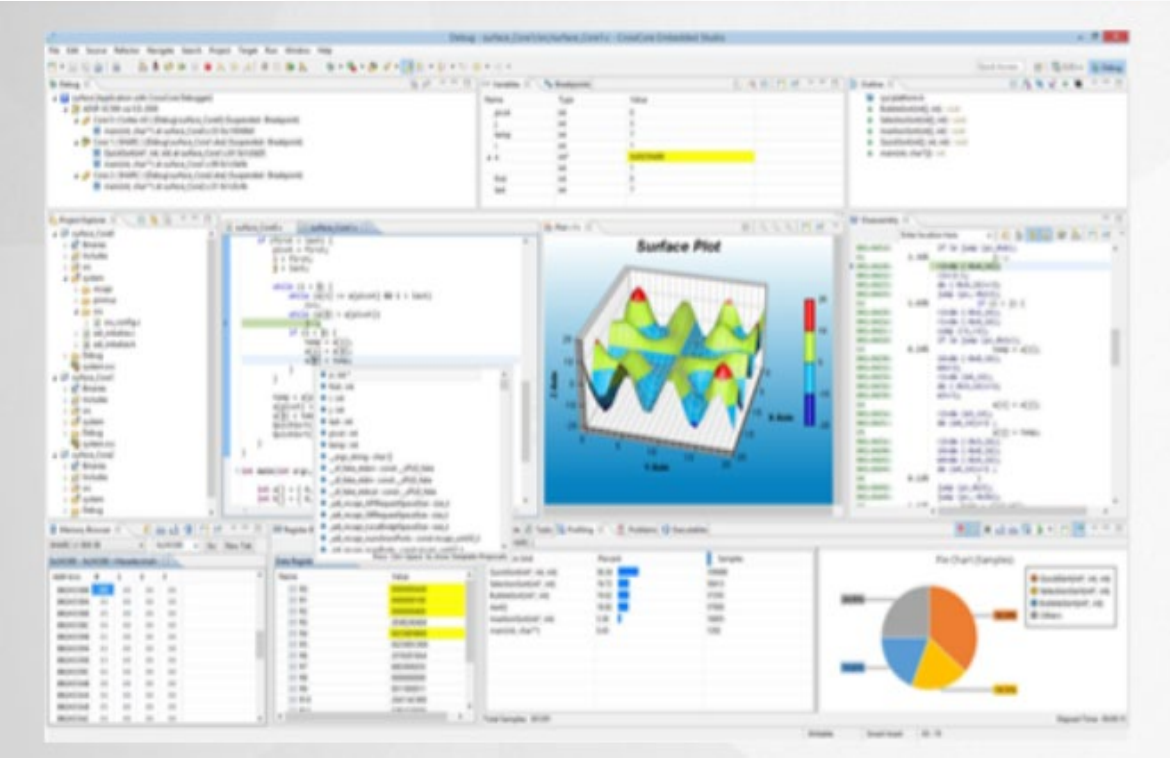
DSP加速器的使用方法2: Split Task

- **Code: Split Task**
  - 7 Channels are processed by FIR/IIR Accelerator
  - 5 Channels are processed by Core in parallel
- MIPS
  - Core Only
    - Core MIPS Usage: 202.18
    - ACC MIPS Usage: 0.0
  - Split Task
    - Core MIPS Usage: 93.76
    - ACC MIPS Usage: 88.03
  - Core MIPS Savings: **108.42**

Split Task					
Snapshot No.	**Description**	**Core State**	**Accelerator State**	**Cycles**	**MIPS**
1	Function Entry			78	0.01
2	FIR Task Queue			733	0.14
3	FIRA Processing of 7 channels, Core FIR Processing 5 channels			255033	47.82
4	FIRA Done Callback - IIR queue task			1664	0.31
5	IIRA Processing of 7 channels, Core FIR Processing of 5 channels			108767	20.39
6	IIRA Processing of 7 channels, Core IIR Processing of 5 channels			105683	19.82
7	Multiply gain and add IIR Output			28053	5.26
8	Function Exit			59	0.01
9	Free core MIPS			4833140	906.21
				Total MIPS	**1000.00**
		Accelerator MIPS Usage	**88.03**	**Core MIPS Usage**	**93.76**
		Free Accelerator MIPS	**911.97**	**Free Core MIPS**	**906.24**

CrossCore® Embedded Studio (CCES)

CrossCore Embedded Studio是针对Blackfin和SHARC处理器系列的集成开发环境(IDE)



Download CrossCore® Embedded Studio

CrossCore® Embedded Studio | Analog Devices

https://www.analog.com/en/design-center/evaluation-hardware-and-software/software/adswt-cces.html#software-overview

- **Save Binary File**
- **Launch Executable**
- **Launch CCES**
- **One-Click License**

ADI DSP Decoder SDK

Our advantages

- Best decode latency – Lowest in the Industry （低延时）
  - Based on system architecture and large internal memory

  （解码的延时业内最小）
- High dynamic range - Full floating-point core

（支持所有浮点的代码）
- High SNR ASRCs – Best for HiFi audio

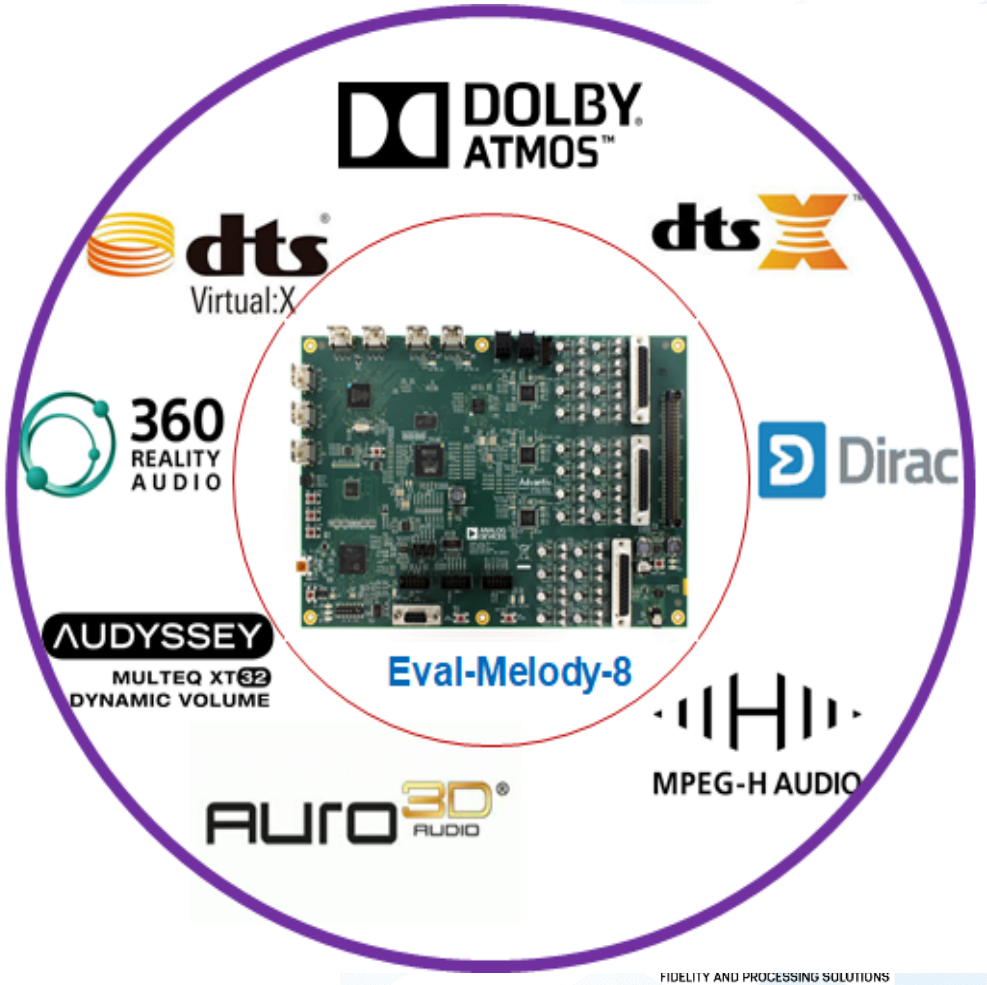
(最好的高保真audio)

Full suite of certified decoders for Home Audio Products

(有家庭影院的全套认证的解码库)
- Well integrated SDKs – No clicks / pops

（很好的软件架构，没有click和pop）
- Best decoder switching time

（不同解码的无缝切换）



SDKs Available now

ADI SHARC DSP Application (AEC)

- Noise Reduction and Automatic Echo Cancelling
- 50us Bus Latecy
- 32 Channel up/down stream for multiple MICs and Speakers
- 40 meters total bus distance, 15 meters between nodes
- FreeRTOS based Operation system supporting Display, SD card, A2B, Algo, UAC, Ethernet etc.

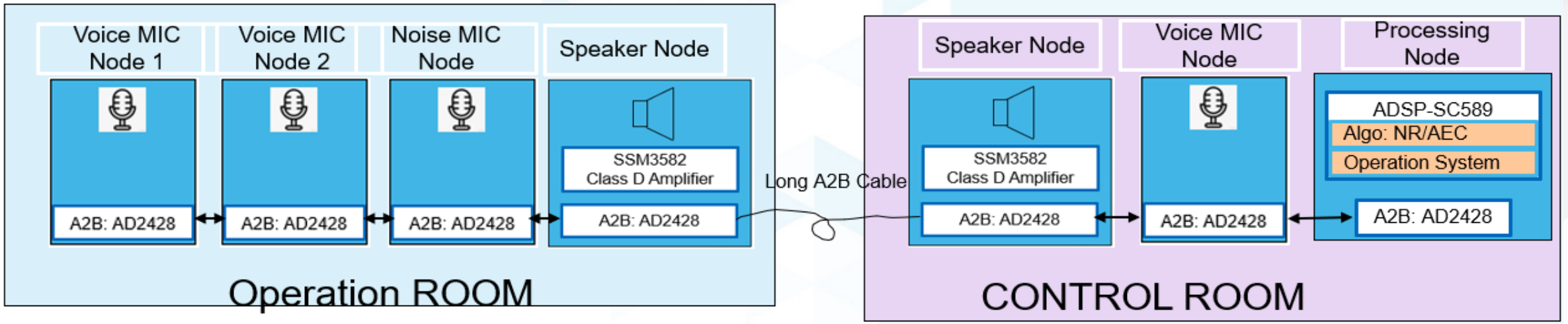
AEC/BF/NR Algorithm

ADI A2B

ANALOG DEVICES DUAL CORE SHARC ARM

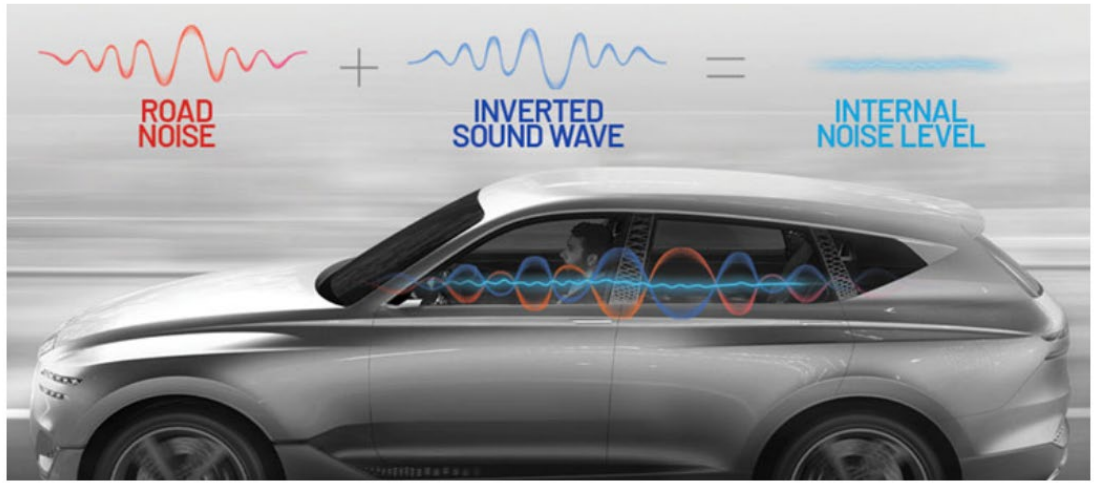
CrossCore Embedded Studio

FreeRtos Based Operation System



ADI SHARC DSP Application (ANC/RNC)

Active noise cancellation (ANC) is rapidly evolving as a technology area that enables car manufacturers to differentiate their vehicles while enhancing the overall passenger experience. Multiple types of ANC are currently being developed, from simple engine order cancellation (EOC) to more advanced road noise cancellation (RNC). Regardless of the implementation or architecture, Analog Devices delivers efficient and cost-optimized signal chain solutions that leverage our core technology competencies, including DSP, automotive audio bus (A²B®), MEMs XL, and associated software.



ANC技术实现了降噪手段的智能化，具有系统体积小、安装方便的优点，可以有效的控制（低频）噪声。当前，ANC技术主要有控制发动机噪声的发动机阶次控制（Engine Order Control, EOC）技术和控制路噪的路噪消除（RoadNoise Cancellation, RNC）技术，通过这些主动降噪技术可以实现声场分区、语音降噪、声场校正等功能，大幅度提升车内的声场环境。

ADXL317 — 3-Axis, ±16 g, I²S Digital Accelerometer

ADI LISTN™ Voice Processing Algorithms

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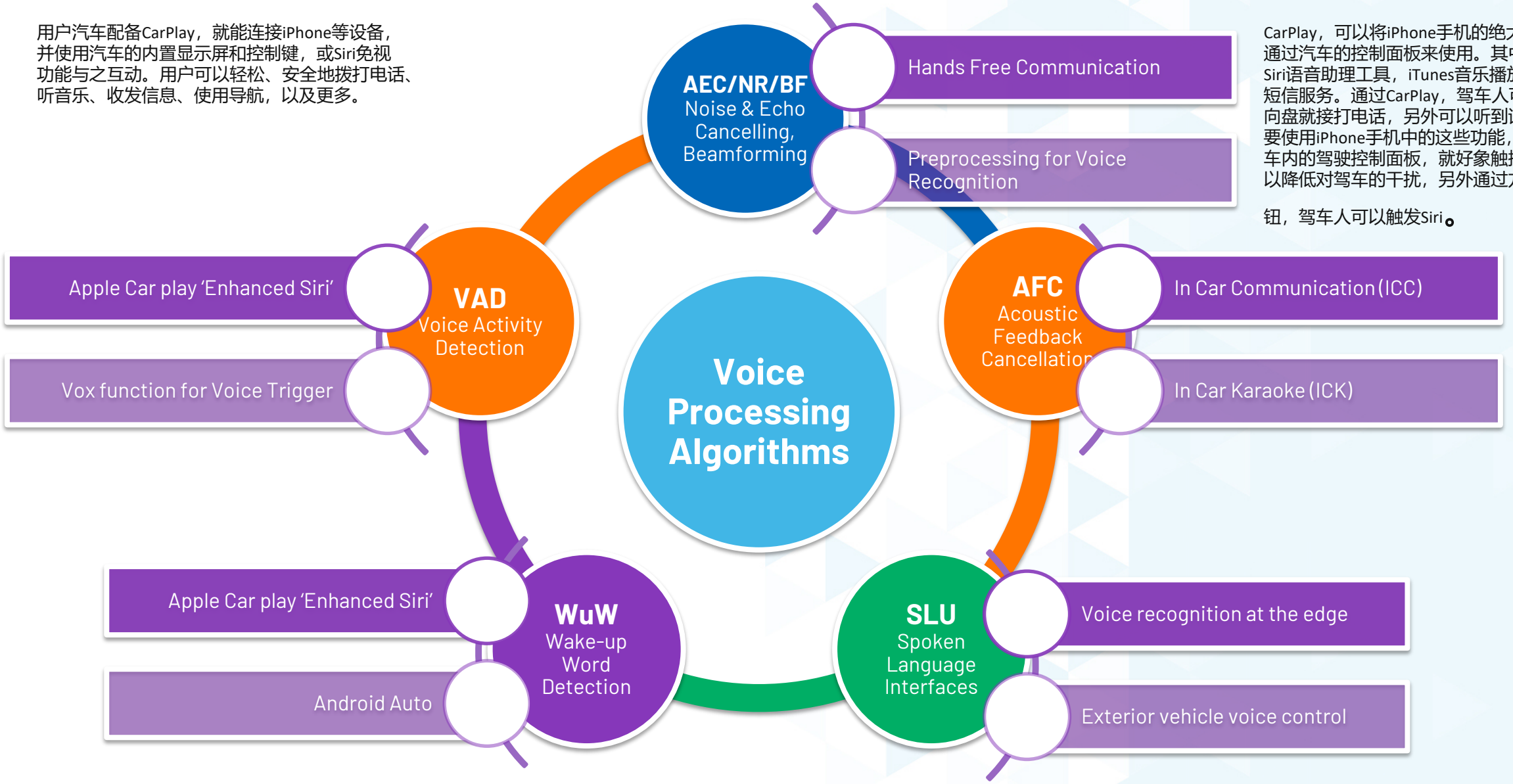
用户汽车配备CarPlay，就能连接iPhone等设备，并使用汽车的内置显示屏和控制键，或Siri免视功能与之互动。用户可以轻松、安全地拨打电话、听音乐、收发信息、使用导航，以及更多。

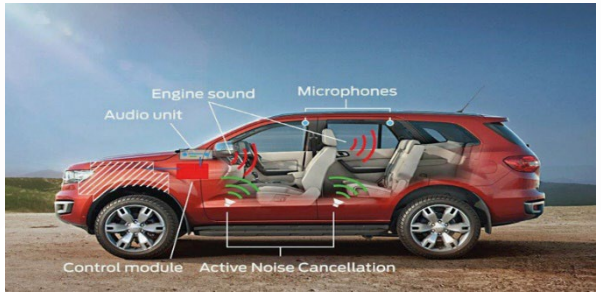
CarPlay，可以将iPhone手机的绝大部分基础功能，通过汽车的控制面板来使用。其中的部分功能包括Siri语音助理工具，iTunes音乐播放，苹果地图以及短信服务。通过CarPlay，驾车人可以双手不离开方向盘就接打电话，另外可以听到语音邮件的内容。要使用iPhone手机中的这些功能，驾车人可以触摸车内的驾驶控制面板，就好象触摸手机一样，这可以降低对驾车的干扰，另外通过方向盘上的一个按钮，驾车人可以触发Siri。

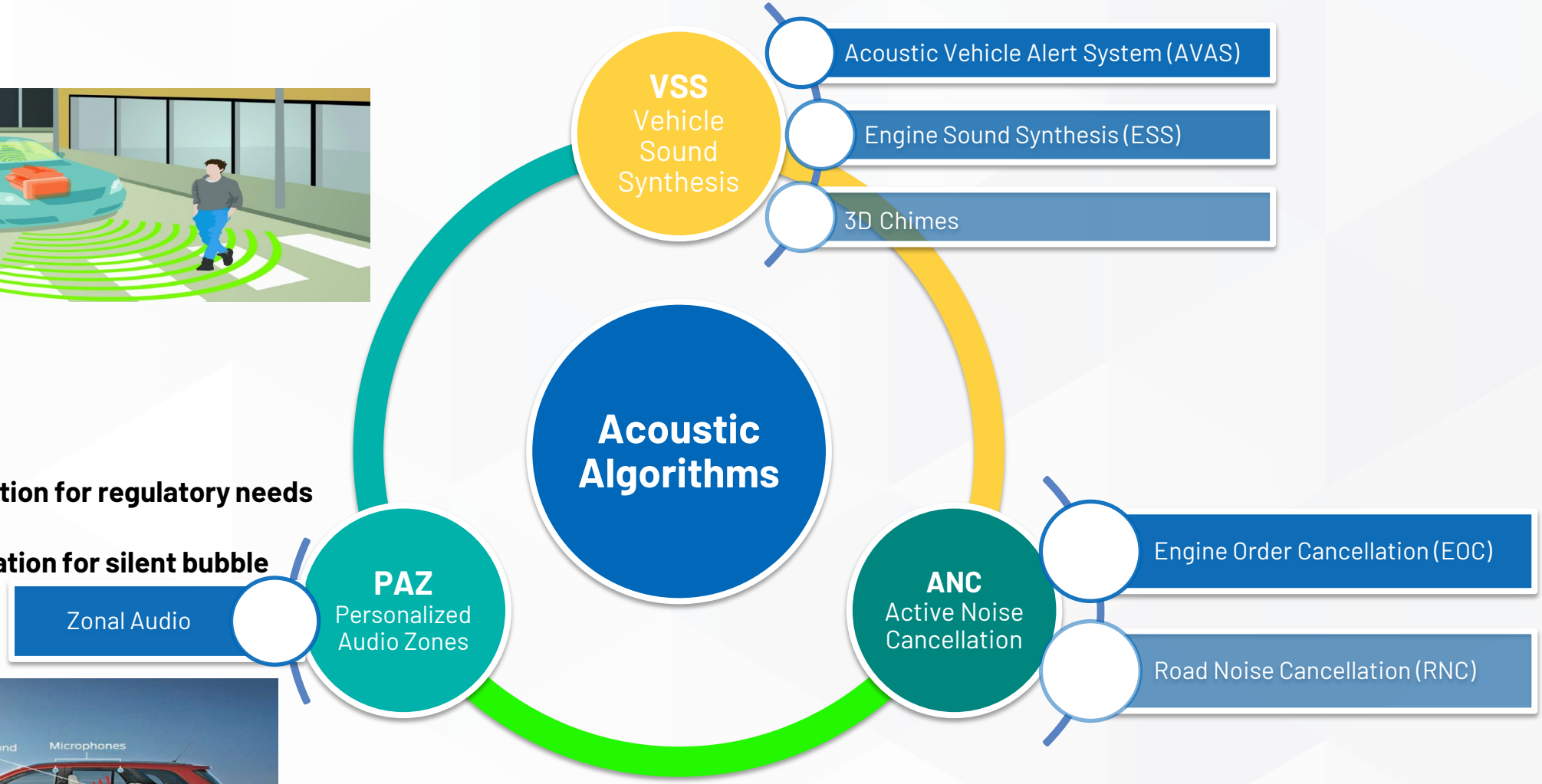


ADI LISTN™ Acoustic Algorithms

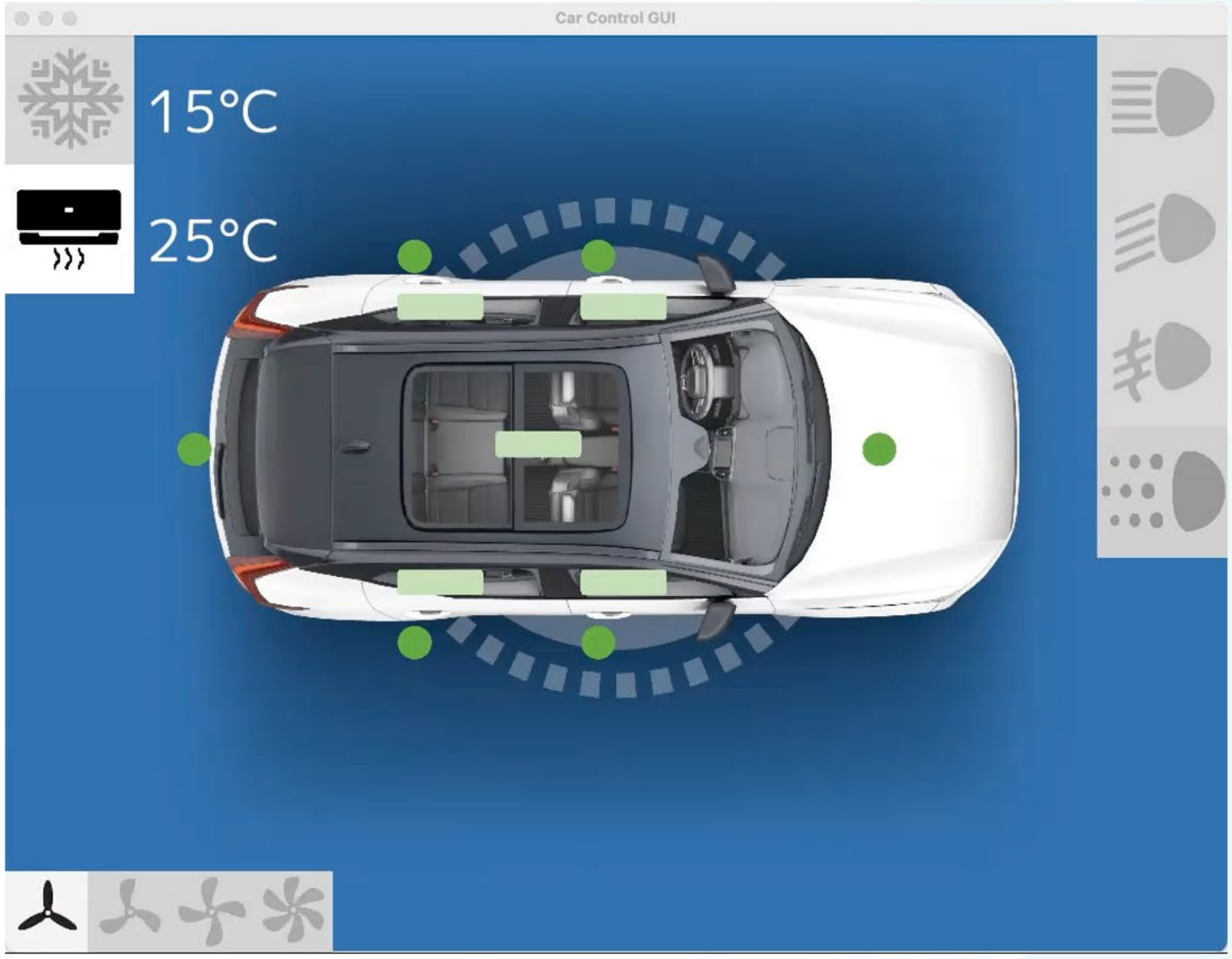
Sound Generation for regulatory needs

Noise Cancellation for silent bubble





Spoken Language Understanding (SLU) for Cabin Control

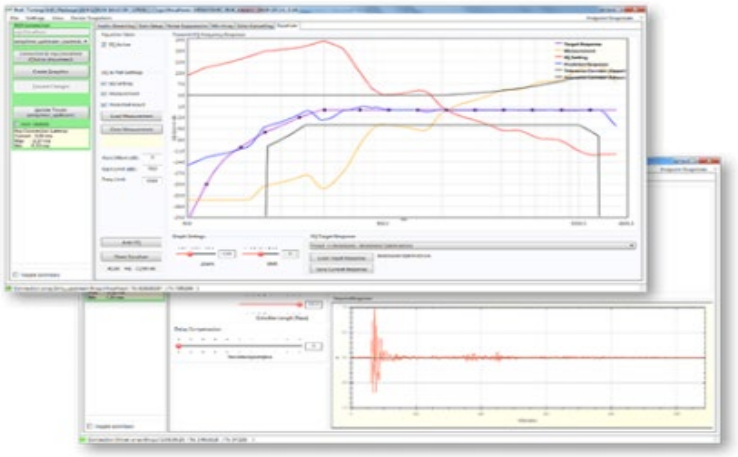


Beamforming Technology

Beamforming starts with two or more microphones arranged as an array. Spatial information of the sound in the vehicle is considered and it is thus possible to distinguish different directions of sound impact.
With beamforming, you can focus on a certain seat position and reduce other voices in the car. This helps with voice recognition because other interfering voices can substantially degrade voice recognition performance. For human communication, beamforming is useful as an add-on to noise reduction because it can reduce non-stationary noise components if they come from off-beam directions.

Audio Signal Processing Software Tools

- ADI *LISTN* Tuning Tool
- The ADI *LISTN* tuning tool is a graphical user interface (GUI) that connects to the target via Ethernet, UART, or SPI. With the ADI *LISTN* automotive audio signal processing suite and its tuning capabilities, it is easy to create a system that passes the relevant automotive specifications such as ITU-T p.1100/1110/1120/1140 and Apple CarPlay.
- Download the ADI *LISTN* Tuning Tool



- ADI *LISTN* EZ-AUDIO System Tuning Tool
- The ADI LISTN EZ-Audio System (EV-21562-AUTO) enables rapid tuning and deployment of a pre-configured 4-channel in/12-channel out audio flow from DSP Concepts running on the ADSP-21562 SHARC audio processor. This custom tuning tool (AWE Tune) allows customers to quickly tailor the audio output for any automotive cabin. Reduce your time to audio using this turnkey hardware/software automotive audio solution jointly developed by Analog Devices and DSP Concepts.
- Download the ADI *LISTN* EZ-AUDIO System Tuning Tool

SigmaDSP Feature Comparison Table

ANALOG DEVICES
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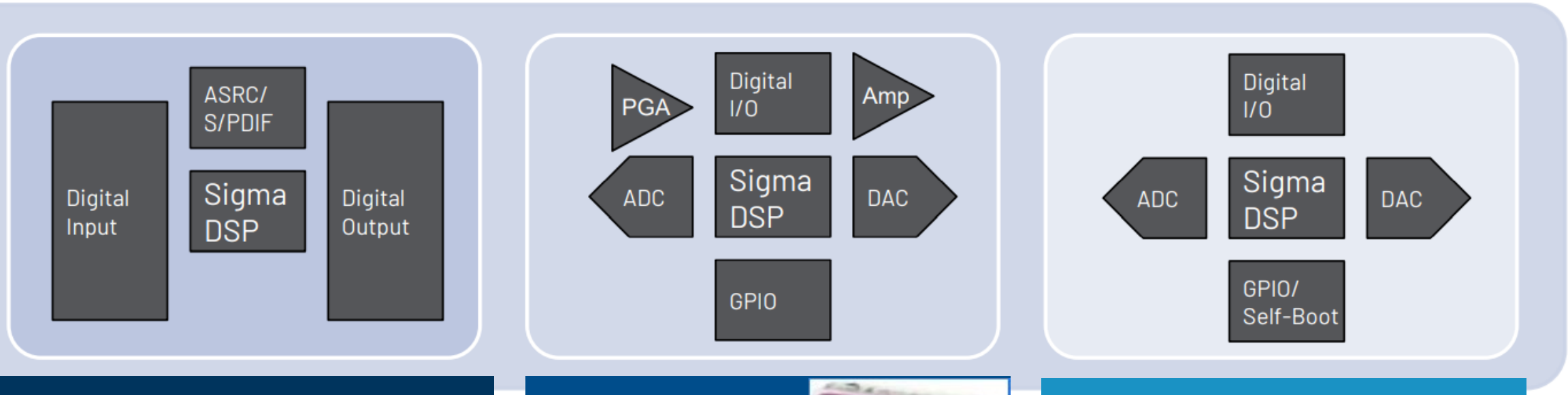
	Sigma 100	Sigma 100	Sigma 100	Sigma 200	Sigma 200	Sigma 300	Sigma 350	Sigma 350	Sigma 350
	AD1940 AD1941	ADAU1701 ADAU1401A	ADAU1702	ADAU1761	ADAU1781	ADAU1442 ADAU1445 ADAU1446	ADAU1450 ADAU1451 ADAU1452	ADAU1462 ADAU1466	ADAU1463 ADAU1467
Core Frequency (MHz)	75	50	25	50	50	172	294 ADAU1450: 147	294	294
Program RAM (kWord)	1.5	1	0.5	1	0.5	3.5	8	24	24
Instructions per sample @ 48 kHz	1536	1024	512	1024	1024	3584	6144 (SIMD)	6144 (SIMD)	6144 (SIMD)
Parameter RAM (kWord)	1	1	1	1	0.5	4	ADAU1450: 8 ADAU1451: 16 ADAU1452: 40	ADAU1462: 48 ADAU1466: 80	ADAU1463: 48 ADAU1467: 80
Data RAM (kWord)	6	2	0.5	4	0.5	8	Shared with parameter RAM	Shared with parameter RAM	Shared with parameter RAM
ADC/DAC Channels	0/0	2/4	2/4	2/2	2/2	0/0	0/0	0/0	0/0
Digital I/O Channels	16/16	8/8	8/8	8/8 2 × digital mics	8/8 2 × PDM mics	24/24	48/48	48/48	48/48
Aux ADC		4 ch, 8-bit	4 ch, 8-bit			4 ch, 10-bit	6 ch, 10-bit	6 ch, 10-bit	8 ch, 10-bit
GPIOs		12	12	4	5	12	14	14	26
Self-boot		I^2C	I^2C			I^2C	I^2C/SPI	I^2C/SPI	I^2C/SPI
Master Port							I^2C/SPI	I^2C/SPI	I^2C/SPI
ASRCs (Channels/ Sample Rates)	No	No	No	No	No	*ADAU1442*: 16/8 *ADAU1445*: 16/2	ADAU1450: No ADAU1451: 16/8 ADAU1452: 16/8	16/8	16/8
S/PDIF							1450: No 1451/52 :I/O 96 kHz	In/Out (192 kHz)	In/Out (192 kHz)
Package	48-lead LQFP 7 mm × 7 mm	48-lead LQFP 7 mm × 7 mm	48-lead LQFP 7 mm × 7 mm	32-lead LFCSP 5 mm × 5 mm	32-lead LFCSP 5 mm × 5 mm	100-lead TQFP and LQFP 14 mm × 14mm	72-lead LFCSP 10 mm × 10 mm	72-lead LFCSP 10 mm × 10 mm	88-lead LFCSP 12 mm × 12 mm
Status	Released	Released	Released	Released	Released	Released	Released	Released	Released

APPLICATION



车载

- AD1940, ADAU144x,
- ADAU1452...

CAMERA

- ADAU1761,ADAU1781

SPEAKER

- ADAU1701...

SigmaDSP 4代与3代的对比

172 MHz Single MAC Core

24 Channel Digital I/O

100 pins, 16×16 mm TQFP

~960 mW Maximum Operation

294 MHz 4-Mult 2-ALU Core

48 Channel Digital I/O

72 pins, 10×10 mm LFCSP

~450 mW Maximum Operation

Performance (Standard use case) (▲2.8×)

Channel Count (▲2×)

Package Area (▼60%)

Power (▼50%)

Portable ANC Product

Released

ANC Codecs

ADAU 1777
- FDSP/Sigma DSP
- 4-ADCs, 2-DACs

ADAU 1787
- FDSP/Sigma DSP
- 4-ADCs, 2-DACs
- 8 DMIC in
- Ultra low power
- 2.7x2.3mm2, 0.35mm WLCSP

Lark
- FDSP/HiFi-3z (100MHz)
- SRAM 320kB
- 3-ADCs, 1-DACs,
- 4 DMIC in

ADAU 1788
- FDSP/Sigma DSP
- 2-ADCs, 1-DACs
- 4 DMIC in
- Ultra low power
- 2.7x2.3mm2, 0.35mm WLCSP

Lark-Lite
- FDSP
- 3-ADCs, 1-DACs
-

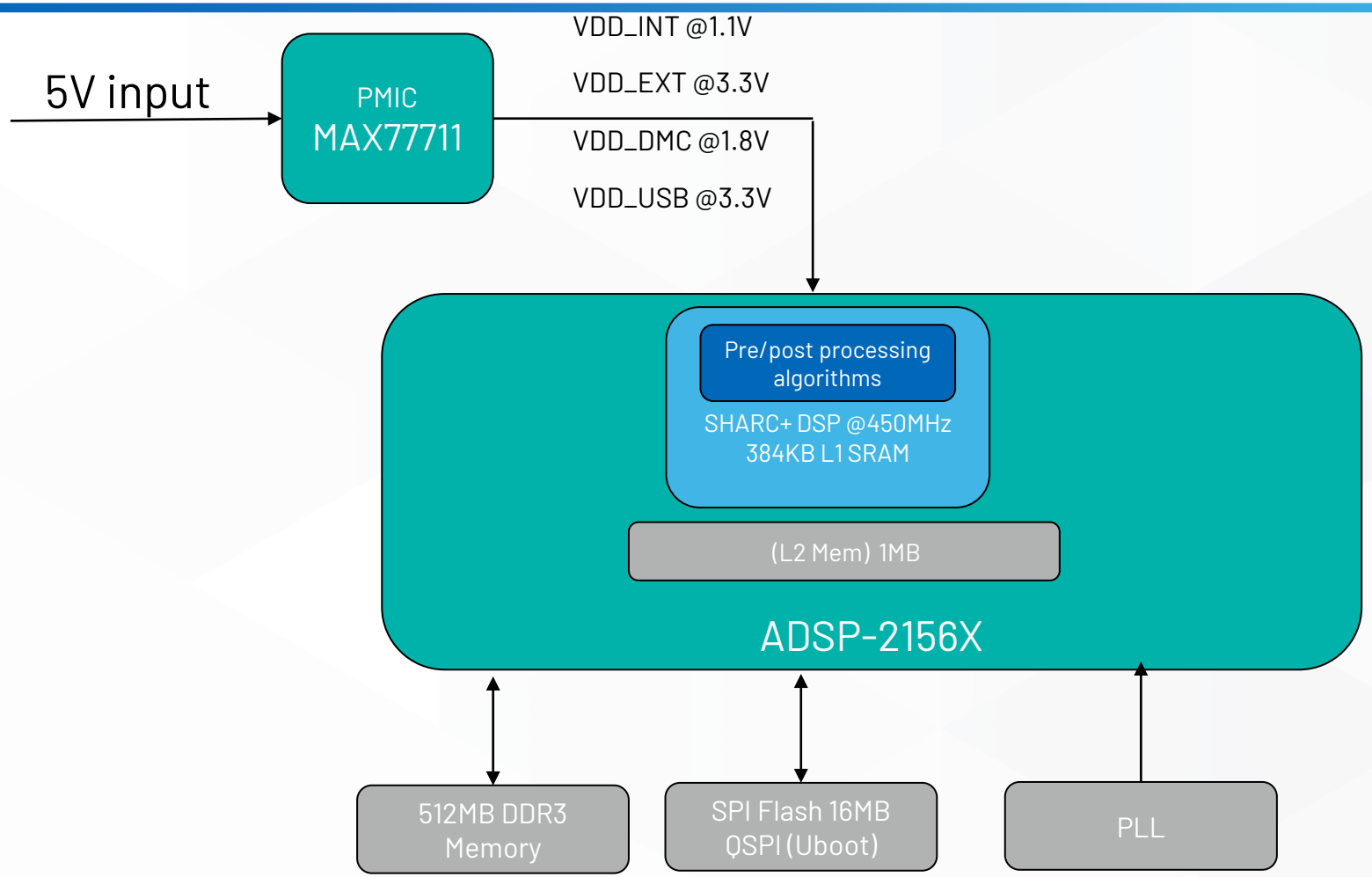
Class-D

SSM 3515
- I2S/TDM Input, Mono
- Low Power
- 31W (4Ω)class D
- 1.8x2.2mm2, 0.4mm WLCSP

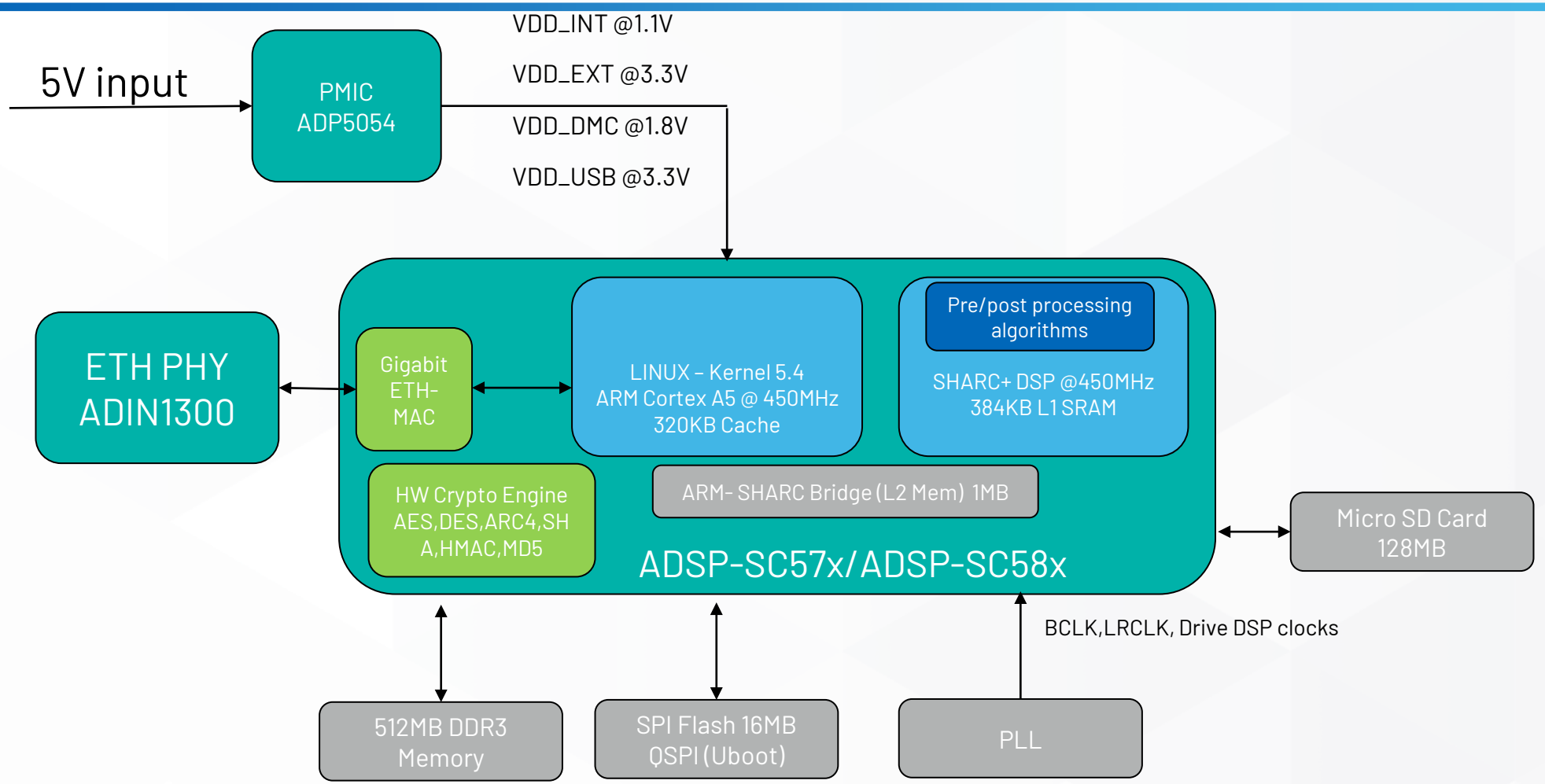
SSM 3582
- I2S/TDM Input
- Stereo 2x 32W (4Ω)
- 6x6mm2 LFCSP

SSM 6515
- Ultra-low power
- 0.984 x 1.444mm2;0.35mm WLCSP
- 113dB AW SNR, <3uV AW Noise

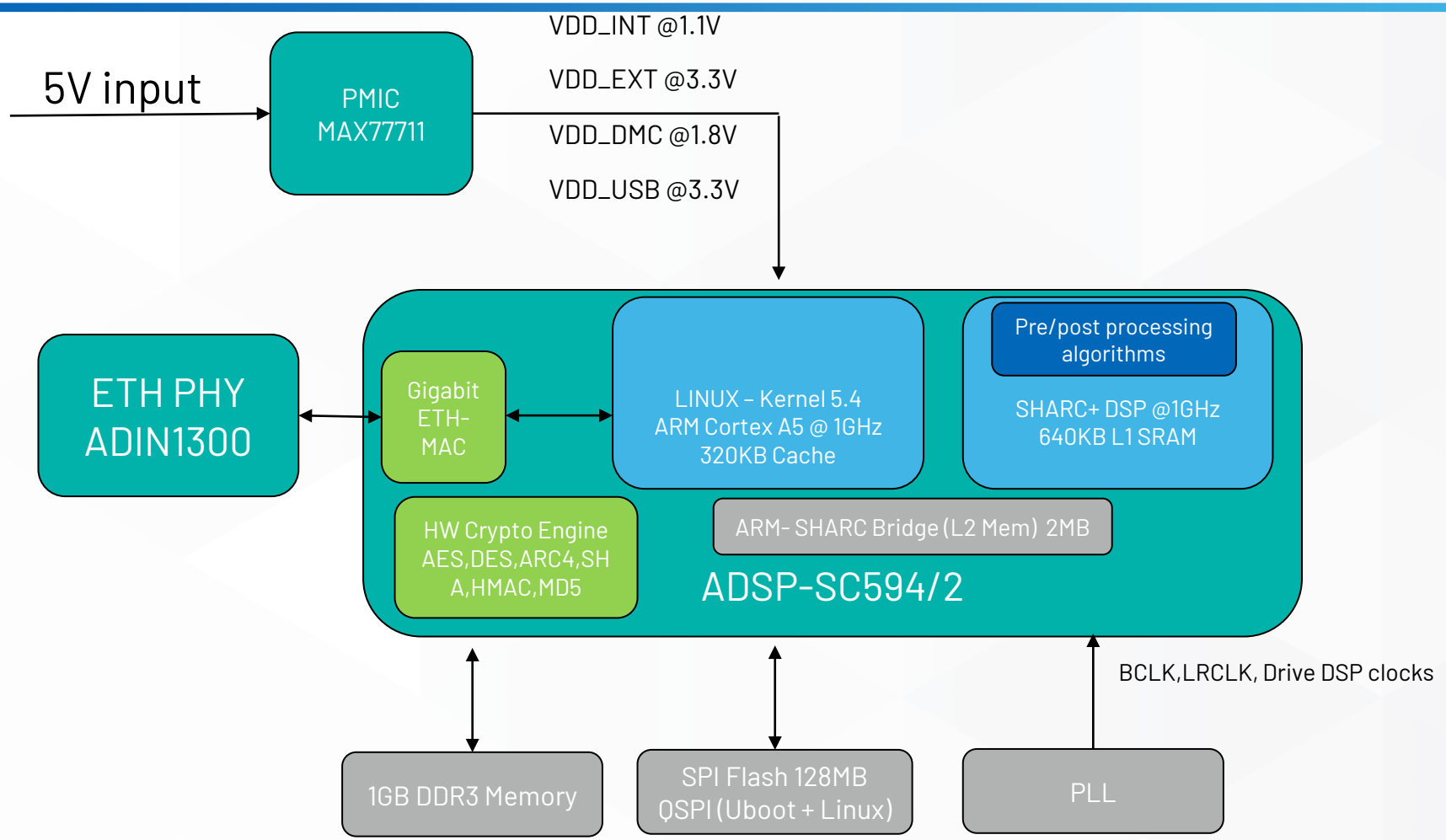
System block diagram - ADSP-2156X (400 BGA)



System block diagram - ADSP-SC57x/ADSP-SC58x



System block diagram - ADSP-SC594/



Class-D 产品组合

- Low Power (1W - 3W)
  - SSM2375/2377 : Analog Input, Mono
  - SSM2519/2537 : Digital Input, Mono
  - SSM2518 : Digital Input, Stereo
  - SSM4567 : Digital Input, Mono, Boosted 5V, Current and Voltage Sensing
  - SSM4329 : Digital or Analog Input, Mono, Boosted 5V, Current and Voltage Sensing, SigmaDSP
- Medium Power (5W – 50W)
  - SSM3302 : Analog Input, Stereo
  - SSM3515 : Digital Input, Mono
  - SSM3582 : Digital Input, Stereo
  - SSM3525 : Digital Input, Mono, Current and Voltage Sensing

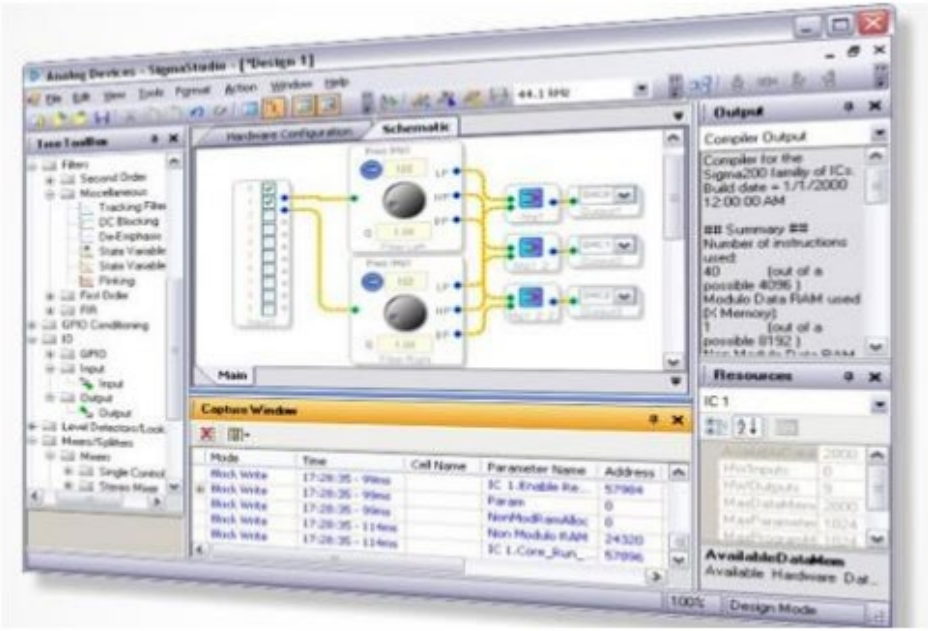
美信的audio 功放

Low Power Amplifer	Description	Mid to High Power Amplifier	Description
MAX98361	2.5W Plug & Play PCM Class D Amplifier	MAX98365	14V Plug and Play Class D Amp
MAX98363	3.2W Soundwire 1.2 Class D Amplifier	MAX98395	14V Digital Input Class DG Amp with IV sense
MAX98388/9	7W Class D Amplifer with IV Sense	MAX98396	20V Digital Input Class DG with IV sense
MAX98380	Boosted Class D Amplifer with 3x charge pump	MAX98397	28V Digital Input Class DG with IV sense
MAX98390	10V Boosted Class DH w/int DSM	SM3515	Mono Digital input Class D Amp
MAX98304	Mono 3.2W Analog Input Class D Amplifier	SM3582	Stereo Digital input Class D Amp
MAX98306	Stereo 3.7W Analog Input Class D Amplifer		

在线技术支持的网站

▸ WIKI

- 有关**Sigma Studio**的各种各样的文档
- 有**70**多个教程
- 有**30**多个**project**例子



▸ EngineerZone

https://ez.analog.com/

- 工程师技术论坛，在这里可以找到所有**ADI**芯片的经常问到的问题

在线技术支持网站--WIKI

https://wiki.analog.com/resources/tools-software/sigmastudio

SigmaStudio and SigmaDSP Documentation

Table of Contents

Welcome to the Analog Devices SigmaStudio Graphical Development Tool!

Sigma DSP入门的示例

http://wiki.analog.com/resources/tools-software/sigmastudio/tutorials

Example Projects And Documents

This section includes project files that are intended to be used with SigmaDSP Evaluation Boards.

AD194x Examples

AD1940 Quickstart Project

ADAU144x Examples

ADAU144x Audio

Evaluation board setup - analog input channels 0 and 1, S/PDIF output channels 0 and 1
Basic audio path with IIR filters
Using basic sound generation techniques to emulate a turn signal sound
ADAU1442/ADAU1445 S/PDIF input routed through ASRC and output to S/PDIF transmitter and serial outpu

ADAU144x GPIO

Select a lowpass filter using a pushbutton
Control a multiplexer using a pushbutton
Select from audio sources using a pushbutton
Control the volume of the audio using two pushbuttons
Control the volume of the audio using a rotary encoder

ADAU170x Examples

ADAU170x Audio

Basic stereo audio input and output
Creating differential DAC outputs by inverting one copy of the signal
Mono peak limiter with adjustable threshold
Example of an automotive audio system in a modular design

ADAU170x GPIO

Use potentiometer connected to auxiliary ADC to select from a few filters
Use a single pushbutton to select from a number of low pass filters

General SigmaDSP Tutorials

These tutorials show signal flows for common use cases. They are not full example projects - please scroll down for those. The table of contents can help you jump to content for specific processors.

- Basic DSP Examples
- Dynamics Processor Examples
- Filter Examples
- GPIO Conditioning Examples
- Level Detectors Examples
- Mixers/Splitters Examples
- Multiplexer/Demultiplexer Examples
- System Examples
- Volume Control Examples
- Probe and Stimulus Blocks

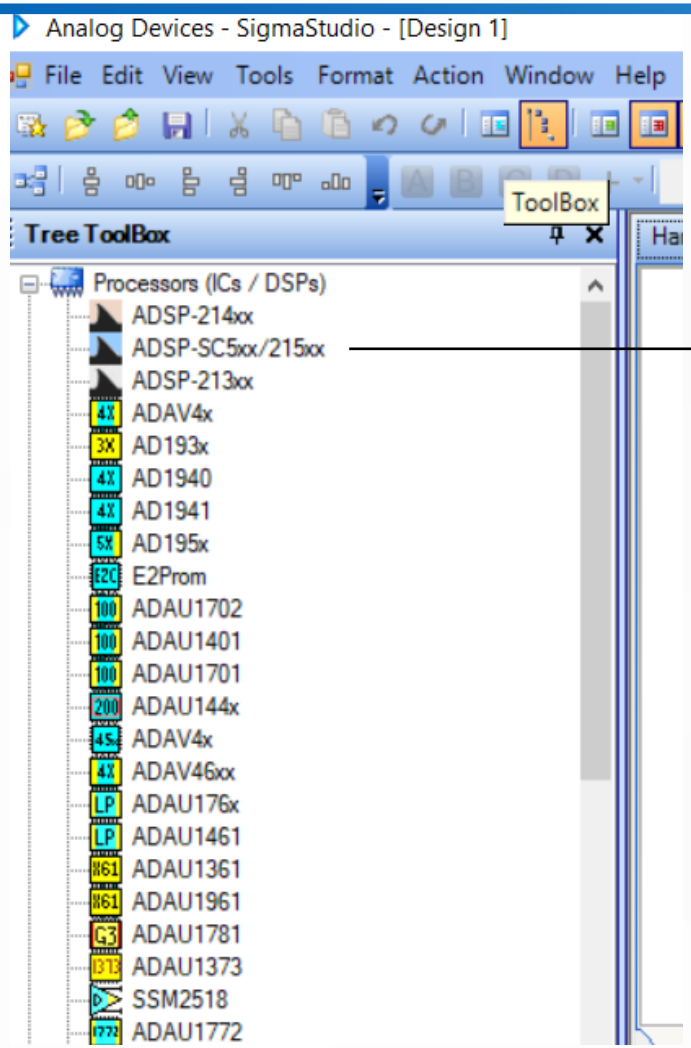
Microcontroller Code Generation and Implementation Tutorials

- **Interfacing SigmaDSP Processors with a Microcontroller** (written for Arduino-compatible processors)
- Booting a SigmaDSP from a microcontroller with no C compiler

Acoustic Echo Cancellation and Noise Reduction

AEC and NR Examples

Sigma Studio 4.7 For SHARC DSP



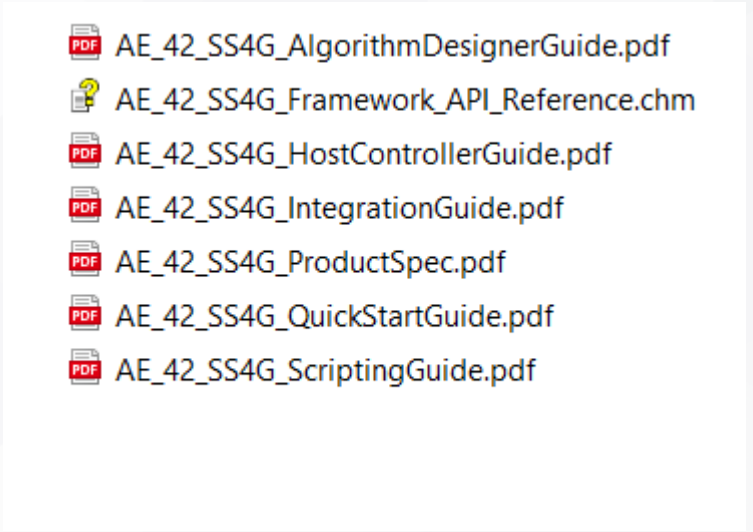
Supporting of ADSP-215xx

Help Document of Sigma Studio 4.7

- Location :

C:\Analog Devices\SoftwareModules\SigmaStudioForSHARC-SH-Rel4.7.0\Docs

- Beginner:
- Framework:
- Customer’s algorithm for Sigam Studio



经常问到的问题

(1)如何获得DSP的例程

ADSP-2156X

https://download.analog.com/tools/EZBoards/2156x/Releases/Release_1.0.1/ADI_ADSP-2156x_EZ-KIT-Rel1.0.1.exe

ADSP-214XX

http://download.analog.com/tools/EZBoards/21479/Releases/Release_1.0.0/ADI_ADSP-21479_EZKIT-Rel1.0.0.exe

(2)ADSP-21489的数据宽度

_都是32位

(3)如何获得DSP的寄存器的文档

https://www.analog.com/media/en/dsp-documentation/processor-manuals/SC58x-2158x-hrm.pdf

https://www.analog.com/media/en/dsp-documentation/processor-manuals/ADSP-214xx_hwr_rev1.1.pdf

(4)ADI的DSP安全boot的文档和例程

https://www.analog.com/media/en/technical-documentation/application-notes/EE366v02.pdf
https://www.analog.com/media/en/technical-documentation/application-notes/EE366v02.zip

(5)软件SigmaStudio for SHARC 4.7.0

需要登陆https://www.analog.com/srf，完成问卷就可以获得

(6）SHARC DSP汇编指令集的文档

http://www.analog.com/media/en/dsp-documentation/processor-manuals/SC58x-2158x-prm.pdf

(7) SHARC DSP Application Notes

http://www.analog.com/en/products/processors-dsp/sharc/ADSP-SC589.html#product-documentation

(8) FFT MIPS and example code

refer the below mentioned Ezone link which talks about SHARC+ FFT.
https://ez.analog.com/dsp/software-and-development-tools/cces/f/q-a/549486/sharc-fft-time

Q & A

ANALOG DEVICES
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THANKS!