



AD1565 Brief

(AD1565Lite)

AD1565™ ELQFP128

Automotive Audio Solution

High Performance Low Power Low Latency Solution

CPU + DSP dual-core Single-chip

Version: V3.1

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Revision History

Date	Revision	Description
2024-7-28	V1.0	Initial version
2024-8-23	V1.2	Modified I2C description
2024-10-25	V1.4	Modified ordering information
2024-11-5	V1.5	Modified several miscellaneous descriptions
2025-2-12	V2.2	Modified ordering information Modified package dimension
2025-2-19	V2.3	Modified ordering information
2025-2-27	V2.4	Modified system descriptions Reserved SPI5 Added electrical characteristics
2025-3-5	V2.5	Modified power management descriptions Added thermal resistance parameter
2025-3-20	V2.6	Modified package dimension
2025-4-3	V2.7	Modified audio ADC parameter Modified audio DAC parameter
2025-6-6	V2.8	Modified thermal resistance parameter for 4L PCB
2025-8-2	V2.9	Modified audio ADC pass band ripple parameter Modified audio DAC pass band ripple parameter
2025-10-29	V3.1	Added AEC-Q100 qualification

1 Introduction

1.1 Overview

The AD1565 is a highly integrated DSP (Digital Signal Processor) for audio system. The AD1565 integrates a Xtensa-HIFI5 audio DSP with FPU, including up to 8 channels D-MIC interface with decimation filters, and 4 channels A-MIC with high performance ADC, stereo high performance DAC. It integrates five I2S/TDM compatible audio interfaces, which can support 80 channels input and 80 channels output. It also integrates a high-performance ASRC with 8 channels, and THD+N is less than -140dB. The AD1565 also integrates a 32bit ARM Star CPU as the application processor to maintain system control and peripheral interfaces. Large capacity RAM is embedded to meet different automotive audio applications.

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1.2 Key Features

System

- 504MHz Cadence Tensilica HiFi5 DSP core with FPU and Neural Network Extension
- 264MHz ARM STAR-MC1 Processor with FPU and MPU
- Internal 3168KB RAM for data and program
- Internal 32KB CPU ICache for SPI norFlash
- Internal 32KB Cache for SPI PSRAM
- Up to 512M bits extensional SPI serial Flash for custom defined software
- Up to 512M bits extensional SPI pSRAM to support rich and flexible software feature
- Supports 24MHz OSC with on-chip PLL
- Supports for sound effect, such as EQ, Multi-band DRC, Bass boost, Virtual 3D surround, Spatial audio
- Supports audio and voice algorithm such as reverb, anti-howling, echo, pitch shifter, magic voice, vocal remover, DRC, EQ etc.
- Supports hardware AES-128/192/256
- Supports hardware SHA-1 / SHA-224/ SHA-256
- Supports hardware CRC-16/CRC-32
- Supports hardware TRNG
- Built-in 8Kbits OTP with physical unclonable function (PUF)
- Supports RSA 2048 bits digital signature
- Supports firmware encryption
- Supports on the fly decryption (OTFD) with AES-128/256
- Supports 64bits UUID

Audio

- I2S TX*5 and RX*5, supports master/ slave mode, Standard/ Lj/ Rj/ TDM/ PCM format, with 16 to 32bits audio data, sampling rate up to 384KHz, supports multi data lines(limited by available IO pins)
- SPDIF TX*1 and RX*1, sampling rate up to 192KHz
- Built-in stereo 24 bits input sigma-delta DAC
- DAC supports sample rate 8k/12k/16k/ 22.05k/24k/32k/44.1k/48k/88.2k/96kHz
- Built-in stereo 30mW PA for differential mode (headphone). PA output also supports traditional mode

- Built-in dual stereo 24 bits output sigma-delta ADC
- ADC supports sample rate 8k/12k/16k/ 22.05k/24k/32k/44.1k/48k/88.2k/96kHz
- Supports 4 channel single-ended or fully differential analog input
- Supports 8 channel digital or 4 channel analog MEMS microphones(analog input is multiplexing with digital filter, so max input channels of MIC are up to 8)
- Supports full formats audio decoding and local playback
- Supports various performance enhancement methods, includes multi-channel enhancement(MCE), max dynamic range(MDR) with IEEE754 float32 encoding

Power Management

- Supports DC5V VCC and VDD power supply, and VC18 power supply optional
- Supports ONOFF pin for chip reset function

Peripheral Interfaces

- Supports SD2.0/MMC/eMMC4.3 card interface up to 54MHz
- Supports SDIO2.0 interface up to 54MHz
- USB 2.0 DRD, supports full-speed and high-speed, compatible with USB-IF BC1.2
- Serial Interface: SPI*5(master 96MHz, slave 48MHz), UART*4(up to 3MHz), I2C*6(up to 3.4MHz)
- Supports Remote Control with internal IRC
- 10 PWM drivers independent of CPU
- Supports 12-bit LRADC

Package

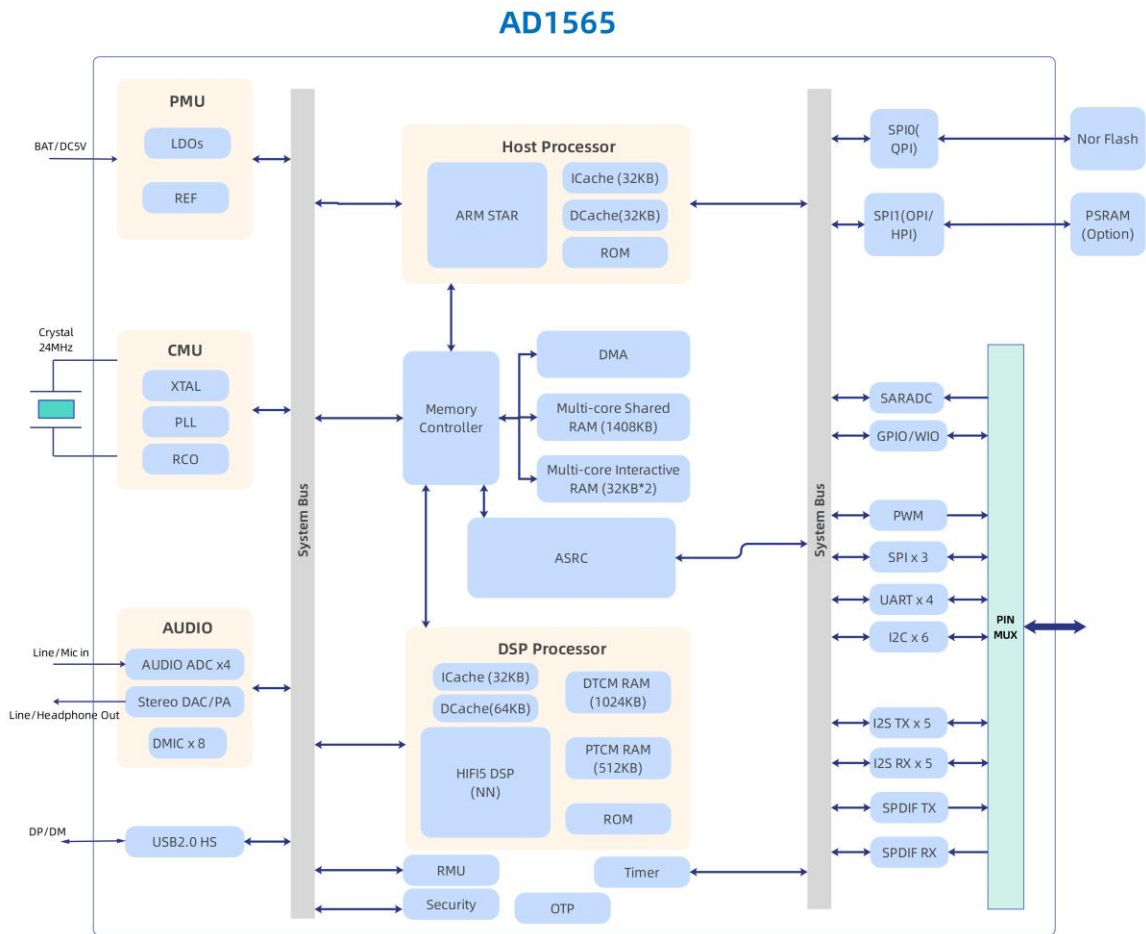
- ELQFP128(14mm*14mm, Pitch 0.4mm)

Applications

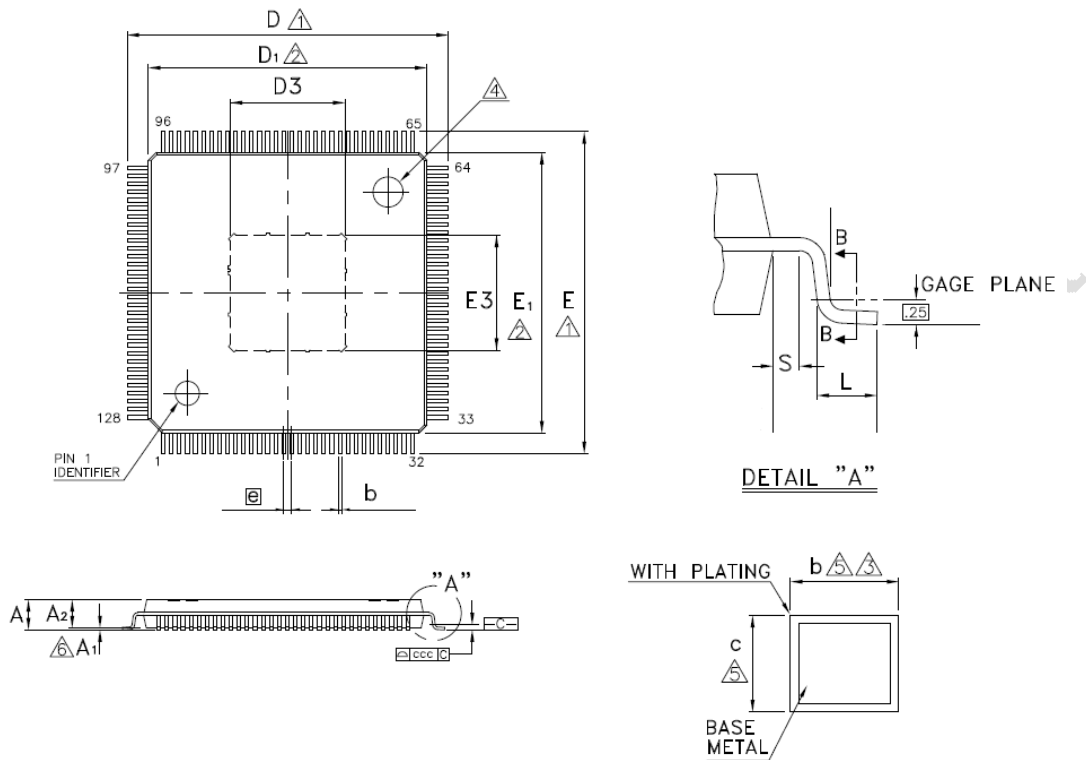
- Automotive Audio DSP
- AEC-Q100 qualified

Note: Refer to chapter2 Ordering Information for AD1565Lite series detail

1.3 Block Diagram



1.4.2 Package Dimensions



Symbol	Dimension in mm			Dimension in inch		
	Min	Nom	Max	Min	Nom	Max
A	—	—	1.60	—	—	0.063
A ₁	0.025	—	0.127	0.001	—	0.005
A ₂	1.35	1.40	1.45	0.053	0.055	0.057
b	0.13	0.18	0.23	0.005	0.007	0.009
c	0.09	0.14	0.20	0.004	0.006	0.008
D	15.85	16.00	16.15	0.624	0.630	0.636
D ₁	13.90	14.00	14.10	0.547	0.551	0.555
E	15.85	16.00	16.15	0.624	0.630	0.636
E ₁	13.90	14.00	14.10	0.547	0.551	0.555
ⓐ	0.40 BSC			0.016 BSC		
L	0.45	0.60	0.75	0.018	0.024	0.030
S	0.20	—	—	0.008	—	—
ccc	0.08			0.003		

Exposed Pad Size		
L/F	Dimension in mm	Dimension in inch
①	D3/E3 5.72 REF	0.225 REF

NOTE: DIMENSIONS D1 AND E1 DO NOT INCLUDE MOLD PROTRUSION.

2 Ordering Information

Series	Memory	DSP	Minimum Order Quantity	Packaging Form
AD1565	3168KB	504MHz HiFi5	900 EA	Tray
AD1565Lite	1200KB	300MHz HiFi5	900 EA	Tray

AD1565 Series

Part Number	Ta	Feature Code	Package Type	Package Size
AD1565C1SW5A	0~70°C	Consumer	E-PAD LQFP128L	14mm x 14mm x 1.6mm
AD1565A2SW5A	-40~85°C	Industrial	E-PAD LQFP128L	14mm x 14mm x 1.6mm
AD1565A3SW5A	-40~105°C	Automotive	E-PAD LQFP128L	14mm x 14mm x 1.6mm

AD1565Lite Series

Part Number	Ta	Feature Code	Package Type	Package Size
AD1565A3SW3A	-40~105°C	Automotive	E-PAD LQFP128L	14mm x 14mm x 1.6mm

3 Electrical Characteristics

3.1 Absolute Maximum Ratings

Parameter	Symbol	Min	Typ	Max	Unit
Ambient Temperature	Tamb	-40	-	105	°C
Storage temperature	Tstg	-55		+150	°C
Thermal Resistance(Junction to Case)	θ_{jc} (4 layer JEDEC PCB)	-	10.8	-	°C/W
Thermal Resistance(Junction to Ambient)	θ_{ja} (4 layer JEDEC PCB)	-	21.1	-	°C/W
ESD Stress voltage	Vesd (Human body model)	2000	-	-	V
Supply Voltage	DC5V	-0.3	-	5.5	V
	VCC	-0.3	-	3.6	V
	VDD	-0.3	-	1.0	V
Input Voltage	GPIO	-0.3	-	3.6	V

3.2 Recommended PWR Supply

Supply Voltage	Min	Typ	Max	Unit
DC5V	4.5	5.0	5.5	V
VCC	3.0	3.3	3.6	V
VDD	0.9	0.95	1.0	V
VC18 (optional)	1.75	1.85	2.05	V

Note: VC18 power supply is only required when internal audio PA is enabled.

3.3 DC Characteristics

Parameter	Symbol	Min.	Max.	Unit	Condition
Low-level input voltage	VIL	-	0.8	V	VCC = 3.1V Tamb = 25 °C
High-level input voltage	VIH	2.0	-	V	
Low-level output voltage	VOL	-	0.4	V	
High-level output voltage	VOH	2.4	-	V	

3.4 ASRC Performance

In rate->out rate	THD+N(dB)		RMS Level(dBFS)	F(Cut-off)Hz(-3db pos)
8k->48k	1khz:	-142db	+/-0.005 dBFS	-
	Sweep:	-141 db		3.7khz
11.025k->48k	1khz:	-142 db	+/-0.005 dBFS	-
	Sweep:	-141 db		5.2khz
12k->48k	1khz:	-142 db	+/-0.005 dBFS	-
	Sweep:	-141 db		5.6khz
16k->48k	1khz:	-143 db	+/-0.005 dBFS	-
	Sweep:	-140 db		7.5khz
22.05k->48k	1khz:	-141 db	+/-0.005 dBFS	-
	Sweep:	-140 db		10.3khz
24k->48k	1khz:	-140 db	+/-0.005 dBFS	-
	Sweep:	-140 db		11.2khz
32k->48k	1khz:	-142 db	+/-0.005 dBFS	-
	Sweep:	-140 db		14.9khz
44.1k->48k	1khz:	-141 db	+/-0.005 dBFS	-
	Sweep:	-141 db		20.5khz
48k->48k	1khz:	-144 db	+/-0.005 dBFS	-
	Sweep:	-143 db		22.5khz
96k->48k	1khz:	-144 db	+/-0.005 dBFS	-
	Sweep:	-144 db		21.9khz
48k->44.1k	1khz:	-142 db	+/-0.005 dBFS	-
	Sweep:	-141 db		20.8khz
8k->96k	1khz:	-142 db	+/-0.005 dBFS	-
	Sweep:	-140 db		3.7khz

3.5 Audio ADC Parameters

Channel						
Parameter	Conditions	Min	Typ	Max	Unit	
Full Scale Input Voltage	THD+N < 1% (Differential input)	-	1.2	-	Vrms	
Analog gain	Bypass preamplifier 6db/step	-6	-	+18	dB	
Input resistor	-	-	5/10/20	-	kΩ	
Digital gain	0.375dB/step	-108	-	53.625	dB	
Analog to Digital Converter						
Resolution	-	-	-	24	Bits	
Input Sample Rate	-	8	-	96	kHz	
SNR	Bypass preamplifier fin = 1kHz@Full Scale Input Voltage B/W = 20Hz~20kHz Fs=48kHz 10kR input res analog gain=0dB	Single ended	-	107	-	dBA
		Differential	-	111	-	
		2 channel enhancement	-	113	-	
		Differential 4 channel enhancement	-	116	-	
Dynamic Range	Bypass preamplifier fin = 1kHz@-60dB	Single ended	-	107	-	dBA
		Differential	-	111	-	
		Differential 2 channel enhancement	-	113	-	
		Differential 4 channel enhancement	-	116	-	

	S Input Voltage B/W = 20Hz~20kHz Fs=48kHz 10kR input res analog gain=0dB	Differential 4 channel enhancement	-	116	-	
THD+N	Bypass preamplifier Differential input B/W = 20Hz~20kHz Fs=48kHz 10kR input res	fin = 1kHz@-3dBFS Input Voltage analog gain=0dB	-	-100	-	dBA
		fin = 1kHz@200mVrm s analog gain=0dB	-	-90	-	
		fin = 1kHz@10mVrms analog gain=12dB	-	-72	-	
Noise equivalent-input-noise	Bypass preamplifier 10kR input res Differential input A-weight	analog gain=0dB	-	3.6	-	uVrms
		analog gain=12dB	-	2.6	-	
ADC Decimation Filter						
Parameter	Conditions		Min	Typ	Max	Unit
Pass Band	typical at fs = 48 kHz	$0.453 \times fs$		21.74		kHz
Pass Band Ripple			-0.06		0.06	dB
Transition Band		$0.5 \times fs$		24		kHz
Stop Band		$0.506 \times fs$		24.288		kHz
Stop Band Attenuation			70			dB
Group Delay		$33.5/fs$	698			us

3.6 Audio DAC Parameters

Digital to Analog Converter						
Parameter	Conditions	Min	Typ	Max	Unit	
Resolution	-	-	-	24	Bits	
Output Sample Rate	-	8	-	96	kHz	
SNR	f = 1kHz@0dBFS output B/W = 20Hz~20kHz Fs=48kHz, Load=10KΩ Full Differential Output Analog Gain=0dB	Noise detection mode enable	-	120	-	dB
		-	-	113	-	dB
Dynamic Range	f = 1kHz@-60dBFS output B/W = 20Hz~20kHz Fs=48kHz, Load=10KΩ Full Differential Output Analog Gain=0dB	-	110	-	dB	
THD+N	B/W = 20Hz~20kHz Fs=48kHz, Full Differential Output Analog Gain=0dB	f = 1kHz@0dBFS Load=10KΩ	-	-93	-	dB
		f = 1kHz@1mW Output level & 32R HP	-	-86	-	dB
		f = 1kHz@12.5mVrms Output level & Lineout Load=10 KΩ	-	-68	-	dB
Noise	Differential output , 10kR load , A-Weight	-	2	-	uVrms	
Digital gain	0.375dB/step	-71.2 5	-	24	dB	

Stereo crosstalk	f = 1kHz@0dBFS output Full Differential Output Fs=48kHz, Load=10KΩ Analog Gain=0dB		-	-11 0	-	dB	
PWR Amplifier							
Analog gain	-		-17.5	-	0	dB	
Max Amplitude/PWR	f = 1kHz@0dBFS	Single Ended	-	-	0.48	Vrms	
	Fs=48kHz, Load=16Ω	Full Differential	-	-	0.7	Vrms	
	f = 1kHz@0dBFS	Single Ended	-	-	0.48	Vrms	
	Fs=48kHz, Load=32Ω	Full Differential	-	-	0.95	Vrms	
	f = 1kHz@0dBFS Fs=48kHz, Load=10K Ω	Full Differential Output	-	-	0.95	Vrms	
DAC Interpolation Filter							
Parameter	Conditions		Min	Typ	Max	Unit	
Pass band	Typical at fs=48kfs	$0.419 \times fs$		20.1		Khz	
Pass band ripple			-0.01		+0.0 1	dB	
Transition band(-3db)		$0.44375 \times fs$			21.3		Khz
Stop band		$0.5 \times fs$			24		Khz
Stop band attenuation				99			dB
Group delay			$35/fs$		729		us

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