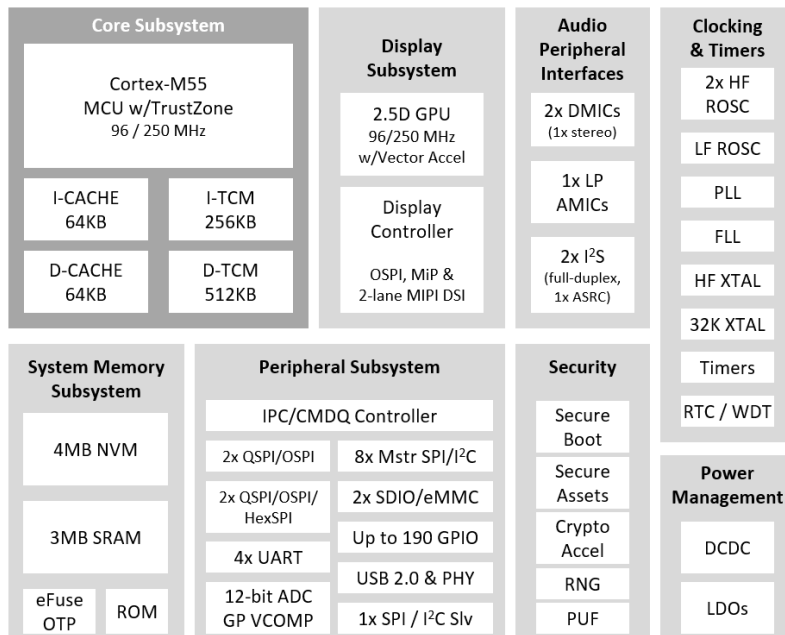# Apollo510 Low Power System-on-Chip

Product Brief

Ambiq®, a leader in ultra-low power semiconductor solutions for IoT, introduces the the new Apollo510, the first member of the Apollo5 SoC family, which is uniquely positioned to kickstart the age of truly ubiquitous, practical, and meaningful AI.

The Apollo510 SoC is a complete overhaul of hardware and software that fully leverages Arm's AI-focused Cortex®-M55® CPU with Helium technology and reaches processing speeds up to 250MHz. The Apollo510 achieves 16x better latency while reducing power by over 2x compared to Ambiq's previous power efficiency leader, the Apollo4. This desirable combination of performance and efficiency allows our customers to deploy sophisticated speech, vision, health, and industrial AI models on battery-powered devices everywhere, making it the most efficient semiconductor on the market to operate with the M55. The Apollo510 is available in BGA and CSP package options.

With 1 to 4 MB of embedded NVM and 1.15 to 3.75 MB of SRAM, the Apollo5 Family has more than enough compute power and storage to handle complex algorithms and neural networks while displaying vibrant, crystal-clear, and smooth graphics. If additional memory is required, external memory is supported through Ambiq's high-bandwidth Octal/Hex-SPI and eMMC interfaces.

Apollo510 SoC

Feature Highlights:

- Up to 250 MHz clock frequency with turboSPOT®

- Up to 250 MHz 2D/2.5D graphics accelerator with enhanced anti-aliasing, dithering and hardware vector graphics acceleration

- MIPI DSI 1.2 with up to two lanes at 1.5 Gbps delivering a feature-rich user interface

- Enhanced memory performance with 64kB I and 64kB D caches, including caching for external, and 250 MT/s DDR external memory interface

- Ultra-low power analog microphone ADC for truly always-on voice processing

- Excels as an application processor with a fully integrated audio subsystem and interface to other communication devices

- Flexible I^{2}C/SPI serial interfaces for analog and digital sensor processing, with both master and slave capability

Block Diagram

Core Subsystem

Cortex-M55 MCU w/TrustZone 96 / 250 MHz

I-CACHE 64KB	I-TCM 256KB
D-CACHE 64KB	D-TCM 512KB

Display Subsystem

2.5D GPU 96/250 MHz w/Vector Accel

Display Controller OSPI, MiP & 2-lane MIPI DSI

Audio Peripheral Interfaces

2x DMICs (1x stereo)

1x LP AMICs

2x I^{2}S (full-duplex, 1x ASRC)

Clocking & Timers

- 2x HF ROSC
- LF ROSC
- PLL
- FLL
- HF XTAL
- 32K XTAL
- Timers
- RTC / WDT

System Memory Subsystem

- 4MB NVM
- 3MB SRAM
- eFuse OTP
- ROM

Peripheral Subsystem

IPC/CMDQ Controller	
2x QSPI/OSPI	8x Mstr SPI/I^{2}C
2x QSPI/OSPI/ HexSPI	2x SDIO/eMMC
4x UART	Up to 190 GPIO
	USB 2.0 & PHY
12-bit ADC GP VCOMP	1x SPI / I^{2}C Slv

Security

- Secure Boot
- Secure Assets
- Crypto Accel
- RNG
- PUF

Power Management

- DCDC
- LDOs

Block Diagram for the Ultra-Low Power Apollo510

Features and Specifications

High-Performance Arm Cortex-M55 Processor with Helium

- Supports TrustZone security extensions
- Integrated 64 kB Instruction Cache and 64 kB Data Cache
- Integrated 256/512 kB Tightly Coupled Memory (TCM) Instr./Data
- Up to 250 MHz clock frequency
- Helium (MVE) vector integer, half and single-precision floating point
- Scalar half, single, and double precision floating-point
- Memory Protection Unit (MPU)

Security Features

- Arm TrustZone®
- Secure boot
- OTP key storage
- PUF-based identity/sign/verify
- Secure over-the-air (OTA) updates
- Secure wired updates
- Key revocation

Ultra-Low Power Memory

- Up to 4MB of non-volatile memory for code/data
- Up to 3.75MB of TCM and system RAM for code/data

Ultra-Low Power Interface for On- and Off-Chip Sensors

- 12-bit ADC, 11 selectable input channels
- Up to 1.7 MS/s sampling rate
- Temperature sensor with ±3℃ accuracy

Ultra-Low Power Flexible Serial Peripherals

- 2x 1/2/4/8-bit wide SPI master interfaces
- 2x 1/2/4/8/16-bit wide SPI master interface
- 8x I²C/SPI masters for peripheral communication
- I²C/SPI slave for host communications
- 4x UART modules with FIFOs and flow control
- 1x USB 2.0 FS/HS device controller
- SDIO v3.0/eMMC (2x)

Display

- Memory in Pixel (MiP) display interface with fast-forward
- LCD controller
- MIPI DSI 1.2 with 2 data lanes up to 1.5 Gbps (768 Mbps per lane)
- Up to 640x480 resolution at 60 fps
- 4 layers with alpha blending
- Frame buffer decompression

Audio Processing

- 1x LP Always-on Audio ADC
- 2x PDM DMIC interface
- 2x full-duplex multichannel I²S ports, 1 with ASRC

Graphics

- 96 MHz / 250 MHz operating modes
- 2.5D-like graphics accelerator with vector graphics acceleration
- Anti-aliasing hardware acceleration
- Rasterizer / full alpha blending / texture mapping
- Texture / frame buffer compression (TSC4, 6, 6A and 12)
- Dithering and radial/conical fill support

Rich Set of Clock Sources

- PLL for precise clocking applications
- 16-52 MHz and 32.768 kHz Crystal (XTAL) oscillators
- 1 kHz Low Frequency RC (LFRC) oscillator
- 2x High Frequency RC (HFRC) oscillator

Power Management

- Operating range: 1.71-2.2 V
- SIMO buck
- Multiple I/O voltages supported

Applications

- Smart watches/bands
- Wireless sensors and IoT
- Activity and fitness monitors
- Children's watches
- Animal trackers
- Motion and tracking devices
- Alarms and security system
- Far-field voice remotes
- Consumer medical devices
- Predictive maintenance
- Smart home

Package Options

- BGA with 183 GPIO
- CSP with 144 GPIO

Ordering Information

- AP510EVB (EVB)

-20°C to +70°C:
- AP510NFA-CBR (BGA)
- AP510NFA-CCR (CSP)

-40°C to +85°C:
- AP510NFA-IBR (BGA)
- AP510NFA-ICR (CSP)

Product images shown are for illustration purposes only and may not be an exact representation of the products.