Samsung Exynos 5410 Processor -
Experience the Ultimate Performance and Versatility

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Abstract

Mobile devices have been innovating to boost their performance and overcome power challenges since 2010. Therefore, high-speed and multi-core CPU is mandatory for mobile devices. Energy efficiency is equally important for a longer battery life in mobile devices.

Moreover, users’ expectancy on mobile devices has increased rapidly with wishes like multimedia activities, which includes web browsing, watching FHD video, playing 3D games, and multitasking for an extended period.

Exynos 5 Octa has been designed to satisfy ever-growing demands of users for ultimate performance and versatility with an extended battery life.

The key features of Exynos 5410 are:

- System-on-a-chip (SoC) based on the 32-bit RISC processor for smart phone and tablet PCs. Designed with 28 nm low power HKMG process, Exynos 5410 provides performance features like Octa core CPU, big.LITTLE™ processing, 3D graphics hardware, highest memory bandwidth, high-speed mobile storage interface, 1080p 60 fps video hardware, 13 MP image signal processor, and WQXGA display.

- Cortex™-A15 quad core (each core runs at 1.6 GHz speed), whose performance is twice higher than Cortex-A9 core (runs at 1.2 GHz speed).[^1]

- Cortex-A7 quad core (each core runs at 1.2 GHz speed), whose comparable performance is 11 percent lower than Cortex-A9 core (at 1.2 GHz speed), but whose power is 56 percent lower than Cortex-A9 core.[^1]

- big.LITTLE processing provides over 50 percent energy saving with same performance by using high-performance CPUs (big) as well as efficiency tuned CPUs (LITTLE).

- The 28 nm HKMG process that improves performance by 10 percent when compared with 32 nm HKMG process.

- The outstanding 3D graphics performance with a variety of APIs like DirectX® 9.3, OpenGL® ES 1.1/2.0 and OpenVG™ 1.1 that you can use for GPUs with OpenCL™ 1.1 embedded profile.

- The 12.8 GB/s memory bandwidth with 2-port 800 MHz LPDDR3 for heavy traffic operations like 1080p video en/decoding, 3D graphics display, and high-resolution image signal processing with WQXGA display.

- The 400 MB/s host bandwidth with 200 MHz DDR 8-bit eMMC5.0 for faster data transaction like booting, app swap, contents download, and web browsing.

- The 1080p 60 fps video performance, which is critical for 3D stereoscopic playback/record and wireless display.

- Image signal processor (ISP) of 13 MP 30 fps or 8 MP (5 MP and 3 MP) 30 fps for stereo 3D graphic recording with add-on post processing units, like dynamic range compression (DRC), 3-dimensional noise reduction (3DNR), video digital image stabilization (VDIS), optical distortion compensation (ODC), and face detection (FD) integrated. Its ISP pipeline supports zero-shutter lag.
Exynos 5410 Technical Values

Key features that help you experience ultimate performance and versatility are:

- Fast and efficient core performance
- Powerful 3D hardware engine performance
- Wide memory bandwidth
- Higher mobile storage interface
- Optimal video performance
- Strong image signal processor
- Low power consumption

Figure 1: Block diagram of Exynos 5410

World’s First Octa core

Exynos 5410 is designed for high-end smartphone and tablets that require fast operation and response as well as longer battery life. It is the first chip in the market to integrate Cortex-A15 quad and Cortex-A7 quad core.

Cortex-A15 quad core has an exceptional performance that can be compared to the CPU in a computer. Performance/MHz of Cortex-A15 is 40 percent higher than that of Cortex-A9.

Energy efficiency of Cortex-A7 quad core is much better than Cortex-A15. Energy consumption of Cortex-A7 is around 70 percent lower than that of Cortex-A15.\(^1\)

Cortex-A15 and Cortex-A7 are compatible to each other. Both incorporate all features, including enhanced VFP and Neon coprocessor. In interconnection, they also support 128-bit AMBA4 master and slave ports with upcoming cache coherent interconnect.

Ultimate Energy Efficiency with big.LITTLE architecture

The basic concept of big.LITTLE architecture (or big.LITTLE processing) is to put different CPU cores (big and LITTLE core), as shown in the Figure 2. It shares a role when executing software programs or applications. While big core ensures high performance, LITTLE core is designed for the energy efficiency.

Figure 2: big.LITTLE Processing\(^2\)

Since big core and LITTLE core are architecturally identical, they can execute the same application that is compiled from the same source code. For fast switching, big.LITTLE processing uses CCI (Cache Coherent Interconnect). As shown in Figure 2, big.LITTLE processing is designed to switch in less than 20,000 cycles or 20 ms when cores run at 1 GHz. This is a short period that end users do not recognize the switching.

Mobile AP providers adopt different approaches. NVIDIA\(^6\) uses vSMP (Variable Symmetric Multi Processing) and Qualcomm employs aSMP (Asynchronous Symmetric Multi Processing).

vSMP architecture consists of four high performance cores implemented in LPG process for high performance and a companion core implemented in LP process for low power mode. It is depicted in the left part of Figure 3, where Core A represents the companion core and Core Bs represent high performance cores. For a comparison, big.LITTLE processing is also depicted in the right part of Figure 3, where B represents big core and L represents LITTLE core.
Figure 3: vSMP vs. big.LITTLE Processing

vSMP is the architecture in Krait, which is a customized CPU of Qualcomm®. The cores and their L2 caches can run at separate voltages and clock rates, a feature that can help lower power between 25 and 40 percent, Qualcomm claims. Additionally, each core in an vSMP system can be operated in a lower power mode due to the independent voltage and frequency control per core. Therefore, it may save more CPU power because of lower DVFS level than synchronous SMP architecture or sSMP.

The mW/Performance metric is commonly used to indicate the power-performance advantage that processors based on big.LITTLE processing stand to gain. Using Cortex-A7 core in this architecture leads to 3.3x reduction in power consumption, compared to Cortex-A15 core. Figure 4 illustrates the comparison of energy efficiency and power-performance mappings for vSMP and big.LITTLE processing.

Figure 4: Comparison of energy efficiency of vSMP and big.LITTLE processing

Advanced 28 nm HKMG Low Power Process

Being the process shrink from 32 nm LP, 28 nm LPP has 20 percent smaller area than 32 nm LP without any additional cost. This is because it can easily reuse existing design infrastructure of 32 nm LP. Also, being a Gate-first process, which is known to be less complex and offer a better scaling when compared to Gate last process. This makes 28 nm LPP a very cost effective process technology.

The 28 nm LPP enables 10 percent additional performance improvement by adopting a more mature HK/MG process from 32 nm LP. The 10 percent performance improvement comes without any major process change or major additional process steps thereby ensuring the design porting from 32 nm LP and avoiding any significant cost increase.

The 28 nm LPP HK/MG is the second generation process. HK/MG technology, built on the two years of development and successful high-volume production of 32 nm LP HK/MG, which is the first generation process. While the process is more mature, the yield improvement trend is much faster when compared to previous technologies.

Outstanding 3D Performance

Recently mobile OS uses 3D graphic engine for not only 3D rendering but also for all basic graphic works on screen. Alternatively, 3D graphic engine operates UI overlay, home screen, 3D games, and so on. It means that 3D performance has become a very important index for measuring overall performance of Mobile AP. Historically, Exynos series has always been in the lead in terms of 3D performance. Yet again, Exynos 5410 will raise the standard of mobile AP 3D performance.

Screen resolution is directly related to 3D performance. WQXGA resolution is more than two times of WXGA. It means that mobile AP must have at least two times better 3D performance than the previous generation. To satisfy WQXGA resolution, mobile AP requires a new 3D engine and architecture.

PowerVR™ SGX544 MP3 GPU of Imagination Technologies is a more advanced mobile 3D engine. With this powerful GPU, Exynos 5410 drives stereoscopic 3D graphics and supports wide range of APIs like OpenGL ES1.1 and 2.0 and OpenVG 1.1. Universal scalable shader engine in GPU supports feature sets in excess of Microsoft® Vertex Shader 3.0 and Pixel Shader3.0 and OpenGL 2.0.

Figure 5: 3D Performance comparison
12.8 GB/s Memory Bandwidth

Displaying a 24 bpp WQXGA screen at 60 frames per second consumes 1 GB/s bandwidth. As it is combined with partial images and UI icons, final display out requires 8 GB/s bandwidth. This effective bandwidth does not include memory utilization. If utilization is 80 percent, required real bandwidth is 10 GB/s.

![Figure 6: Required effective memory bandwidth by display size](image)

Additionally, WQXGA display combined with worst case scenarios (like UI with overlay types of 1080p video playback, camera preview and encoding, and simultaneous HDMI™ out to HDTV) makes memory bandwidth management more difficult.

Exynos 5410 has been designed for WQXGA display with effective bandwidth; therefore, it can support such worst-case scenarios.

Exynos 5410 has adopted 2-port 800 MHz LPDDR3 to support 12.8 GB/s, which is more than two times of Exynos 4 Quad as illustrated in Figure 7. With 12.8 GB/s memory bandwidth, Exynos 5410 can make seamless UI motions and rich application operating momentum on a WQXGA resolution.

World’s Best Mobile Storage Performance

Like PC case, performance bottleneck of mobile device is mass storage. After Exynos S Dual, AP of Samsung System LSI Business has storage performance leadership by adopting latest version of mobile storage.

By adopting eMMC5.0 (embedded multimedia card) and USB3.0 interface for the first time in the industry, Exynos 5410 boasts fast data transfer speed. This feature is required to support advanced processing power on mobile devices as users want to experience upgraded mobile computing like faster booting, web browsing, and 3D game loading.

The host bandwidth of eMMC5.0 is 400 MB/s by using 8-bit parallel interface with DDR 200 MHz, which is double when compared to eMMC4.5. The sequential Read and Write speed of eMMC5.0 are 250 MB/s and 60 MB/s respectively.

![Figure 8: Storage Performance comparison](image)

WQXGA Display Solution with Low-Power eDP® and PSR

The conventional MIPI interface has a maximum of four lanes running at 1 Gbps. However, in most cases, when considering EMI and tuning issues, effective speed is less than 900 Mbps. Therefore, using MIPI interface cannot guarantee a more complex resolution higher than Full HD.

Exynos 5410 does not require an external eDP converter to support WQXGA. Additionally, conventional eDP is used for laptops and consumes much more power than the MIPI interface used in mobile devices. Therefore, Samsung System LSI has specially designed eDP for Exynos 5410, which consumes six times less power than a conventional eDP interface.

![Figure 7: Exynos memory bandwidth comparison](image)
The eDP in Exynos 5410 supports PSR (Panel-Self-Refresh) to save set power consumption. When Exynos 5410 detects an unchanged still image display, it sends a PSR command to T-con to operate PSR.

In PSR mode, T-con stores output image of Exynos 5410 in its eDRAM and displays it on the panel. Simultaneously, Exynos 5410 can turn off display-related blocks and frame buffer memory reading. This PSR mode consumes 20 times less power than active mode in AP. This reduction in power consumption is very effective, especially for a tablet application mainly used for reading content like web pages, e-books, and magazines.

WiFi display requires a lot of memory bandwidth because it has to decode and encode 1080p video simultaneously, along with a working basic UI and communication. Therefore, Exynos 5410 is the core of a perfect home entertainment solution. It is the only option to make real WiFi display with more options possible for different scenarios.

**13 MP 30 fps ISP Performance**

In mobile devices, resolution and performance of camera has increased manifold. Camera also should have computation features. Camera quality is mainly affected by ISP (Image Signal Processor). Additionally, faster processing, data transfer speed, and additional features from Digital Still Camera are required within form factor limitations in mobile devices. For all these reasons, mobile AP companies started to integrate ISP.

Exynos 5410 can process 3A (Auto Exposure, Auto White Balancing, and Auto Focus) up to 13 MP 14-bit Bayer RGB format, which is DSC level sensor with 30 fps speed. Maximum resolution is 17 MP with 15 fps. It can process 8 MP (5 MP and 3 MP) with 30 fps for stereo 3D graphic. In camera support, 30 fps update is very important to build a zero shutter lag solution. The zero shutter lag means no delay between shooting (preview) and storing data on the storage. To minimize it, AP should update incoming data of camera on SDRAM directly, while it displays on a preview screen. At least 30 fps update on DRAM can is required to ensure a delay of less than 33 ms, a delay not felt as a lag.

ISP of Exynos 5410 has additional features like face detection and VDIS (Video Digital Image Stabilization), which stabilizes video recording. Additionally, Exynos 5410 supports ODC (Optical Distortion Compensation) which corrects edge distortion of lens and 3DNR (3-Dimensional Noise Reduction), which reduces noise on video recording.
Summary

Exynos 5410 provides ultimate performance and versatility. Its Octa core CPU, big.LITTLE processing, and 3D graphics hardware provide fast and efficient operation in smartphone and tablets. Besides, its 12.8 GB/s memory bandwidth, DDR 200 MHz eMMC5.0, 1080p 60 fps video, and 13 MP 30 fps, ISP provide seamless UI and graphics.

Figure 11: Performance and Power of Exynos 5410

![Performance and Power of Exynos 5410](image-url)
References


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