

IoT Chip Comparison between TI/ Intel/ Qualcomm/ ARM

Course: SoC Introduction

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Introduction

In this modern age, there are a lot of new applications, such as interactive panel, intelligent camera, and EV motor. Those new technology are all based on IoT. It's needed to apply chips on devices to realize the IoT. Namely, the definition of IoT can be described like that, a module can be embedded in objects, machine or things through chips. The chips are called IoT chips. It's in charge of connecting to wireless network for sending and receiving data. As for the characteristic of IoT chips, there are two, longevity and durability. The reason of longevity is that the IoT application will be utilized for a long time to collect data so that it has to be eternal. For the second reason, durability, IoT chips will be applied in a variety of occasions where the climate can be extremely harsh. Therefore, another feature of IoT chip has to be durable.

Case Study

A. Texas Instrument, CC3200 SimpleLink WiFi

i. Architecture

When it comes to IoT chip in TI, TI has issued an IoT chip called CC3200 SimpleLink WiFi. It's the first chip which is equipped with Wi-Fi Internet-on-chip. It means that it is a chip that can connect to the internet on its own. CC3200 SimpleLink WiFi is made up of three parts respectively, Application Controller, Wi-Fi Network Processor, and Power-Management Subsystem. In this chapter, I will mainly focus on the two parts, Application Controller and Wi-Fi Network Processor. Here is the architecture of Application Controller as listed below:

- ARM® Cortex™-M4 MCU
- RAM: 256KB
- Peripheral Drivers in ROM
- 32-Channel Direct Memory Access(μ DMA)
- Hardware Crypto Engine: AES, DES & 3DES

It adopts ARM Cortex series, M4 as its central process unit.

For the memory, here ram is supported and the maximum capacity of the memory can up to 256KB. Besides, because of its functionality, use to connect WiFi, thus, it is equipped with hardware crypto engine. Algorithms included in the crypto engine are AES, Des and 3DES. The block diagram of Application Controller is displayed as figure.1.

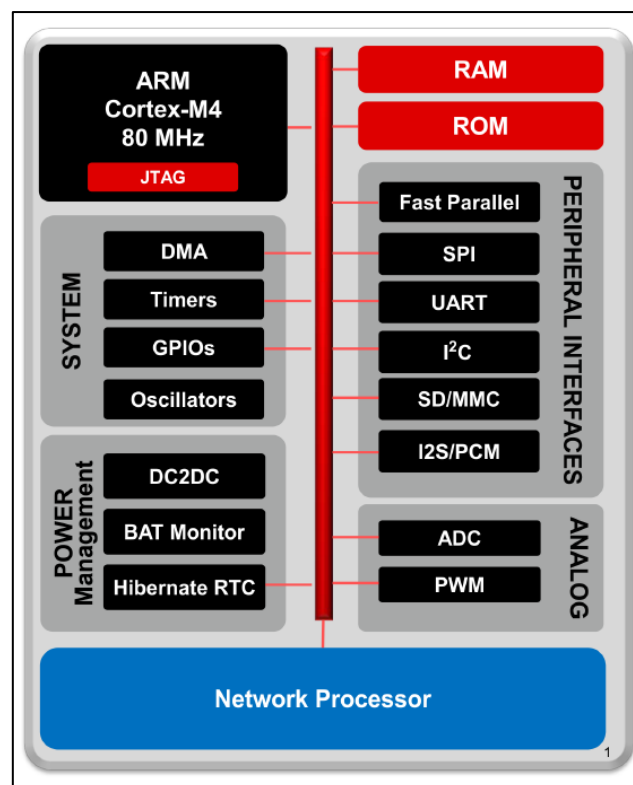


Figure. 1

As for the Wi-Fi Network Processor, figure.2 is the block diagram of it. Basically, it is Wi-Fi internet-on-a-chip. Spontaneously, it covers internet protocols which are stored in

ROM such as 802.11 b/g/n Radio. In addition, TCP/ IP stacks are also equipped.

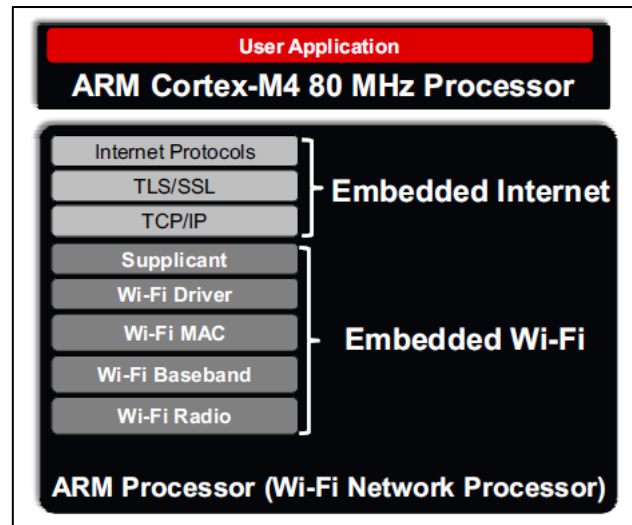


Figure. 2

ii. Performance

Here, I am going to discuss about its performance. For the transmission power, in the communication scheme DSSS and OFDM, it is 18.0 dBm and 14.5 dBm respectively. The receiving signal power is -95.7 dBm for DSSS and -74.0 dBm for OFDM. In terms of the application throughput, it is up to 16 Mbps in UDP and 13 Mbps in TCP.

iii. Application

In this section, I am to introduce its application in real setting. Thanks to its functionality, on chip Wi-Fi, it leads to a cooperation with Amazon AWS. This chip allows IoT developers easily and conveniently connect to Amazon AWS database through the embedded chip. Besides, it also supports many applications like home automation, home appliances and industrial control.

B. Intel, 12th Intel® Core™

i. Architecture

In this chapter, I am going to introduce 12th Intel® Core™.

This is a chip with an extremely strong architecture and designed for IoT application. In this 12th core, its spec is shown as below:

- Processor Core (P+ E): 16 cores
- Intel UHD Graphics 770
- Intel DL Boost
- DDR5-4800 & DDR4-3200
- PCIe5.0 & PCIe4.0

In the past versions of intel chips, the chips are formed with big core and small core. However, in this generation of 12th, the architecture of big and small core is not adopted anymore. Here it becomes P core and C core instead and the architecture is named Alder Lake. Actually, P core and E core are totally same-leveled chip. The difference between P core and E core is that P core is responsible for performance and E core is designed for

handling efficiency. The more detail will be discussed in next paragraph. As for the graphic process, Intel its own product, UHD Graphics 770, is merged into the 12th core. Due to its application, IoT, Intel DL Boost which is an accelerated hardware for enhancing AI operation, is embedded into the chip. Besides, in order to pursue a higher data transmission, PCIe 5.0/4.0 are equipped.

In this part, I will discuss the difference of P core and E core. The block diagram of P core is pasted as figure.3. The former name of P core is Golden Cove. In this generation, it owns a wider, deeper and more intelligent architecture. For the wide function, it now has six decoders, 8 micro-instruction caches. The deeper capability is thanks to more registers for storing data and 512 lines of buffer. As being more intelligent, it is improved the accuracy of catching correct instructions, effectively reduces the latency of L1 cache and optimizes the speed of read and write in L2 cache. As for E core, the block diagram is shown in figure.4, in the past, it is named

Gracemont. It is designed for the throughput. More, it sustains the performance of multitasks when the number of cores increases and the area of chips reduces. For its architecture, it is given a larger instruction cache, 64KB. In the instruction cache, the more useful instructions are placed in places, where close to central process unit. Also, the decoder for variable length instruction is introduced at the first time.



Figure. 3

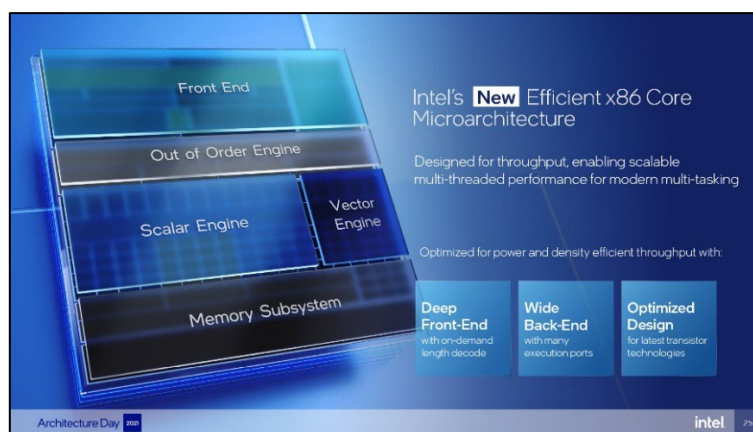


Figure. 4

ii. Performance

As far as the performance of Intel 12th core is concerned, here C core is compared with Skylake CPU. In the situation of single thread, C core can promote 40% of performance, or, in the same performance, the power can be reduced 40%. If the thread is upgraded to 4, multi thread, comparing to the Skylake of 2 cores or 4 threads, C core can increase 80% performance under the same circumstance of power, or it can lower down the consumption of 80% energy. The statistical data is displayed in figure. 5 and figure. 6.

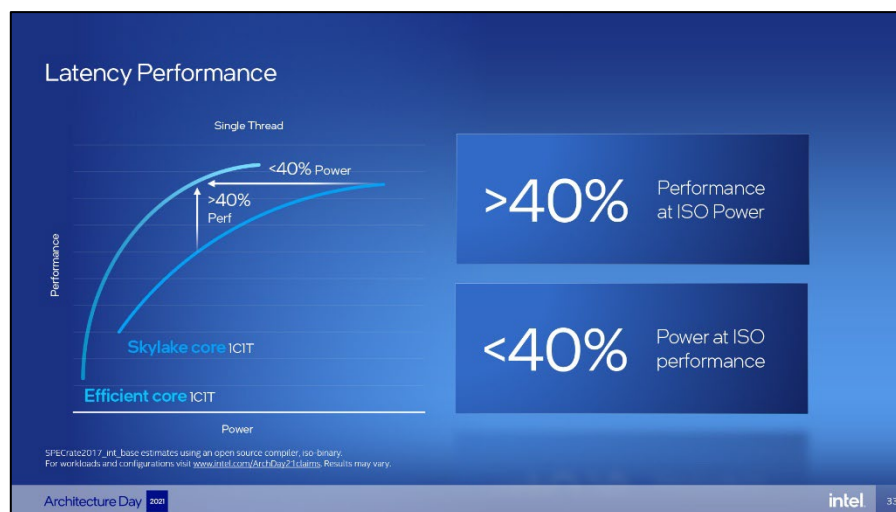


Figure. 5

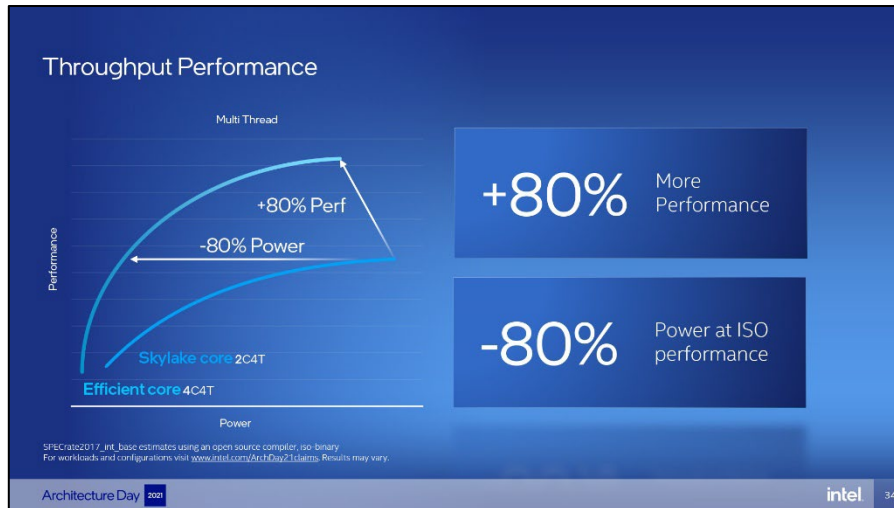


Figure. 6

When it comes to the entire performance of 12th core, it is better than 11th core, Cypress Cove micro architecture. It provides 19% of IPC, and also offers a wider deeper architecture. Intel claims that 12th core is the best CPU up to now.

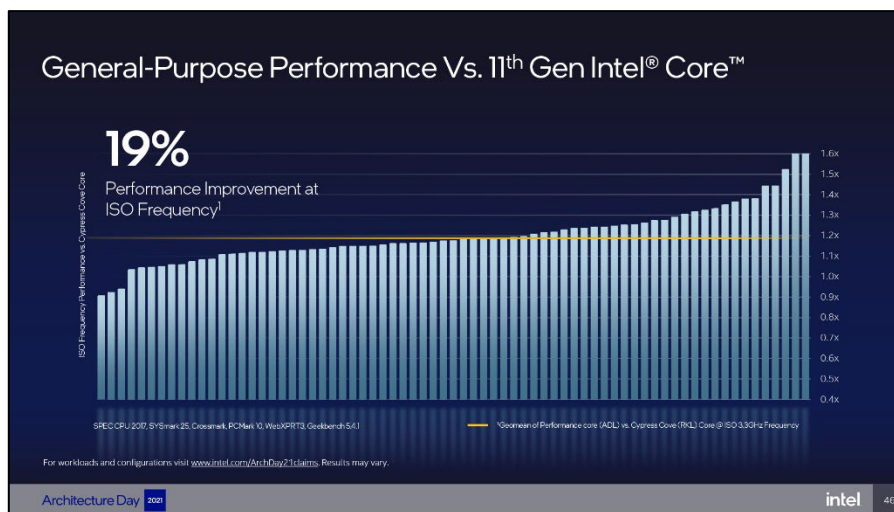


Figure. 7

iii. Application

Thanks to its strong architecture, Alder lake, it is quite suitable for interactive flat panel displays, industrial pc. Intel also claims that its GPU, UHD Graphics 770, is powerful. Therefore, it's a proper CPU for applying in ultrasound imaging like figure. 9

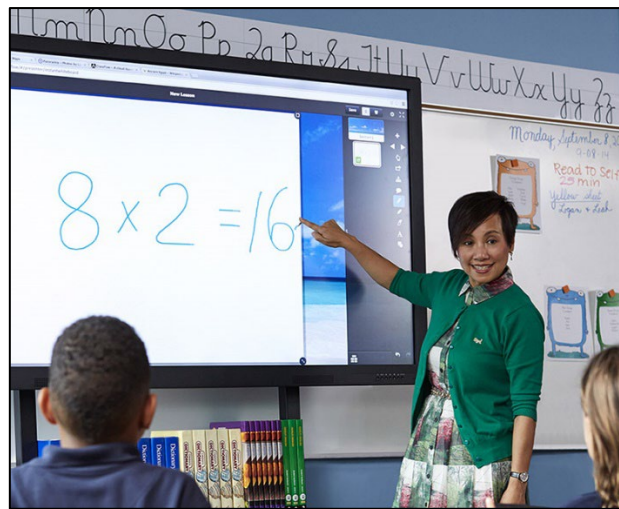


Figure. 8



Figure. 9

C. Qualcomm, QCS8250

i. Architecture

In this section, I will go through a chip from Qualcomm. Qualcomm is a company that mostly is attentive to wireless modem communication technology, and it also develops IoT chip recently. Here, I am going to introduce a chip. The series number of the chip is “QCS8250”. It is designed for IoT application. The block diagram of the architecture is shown in figure. 10.

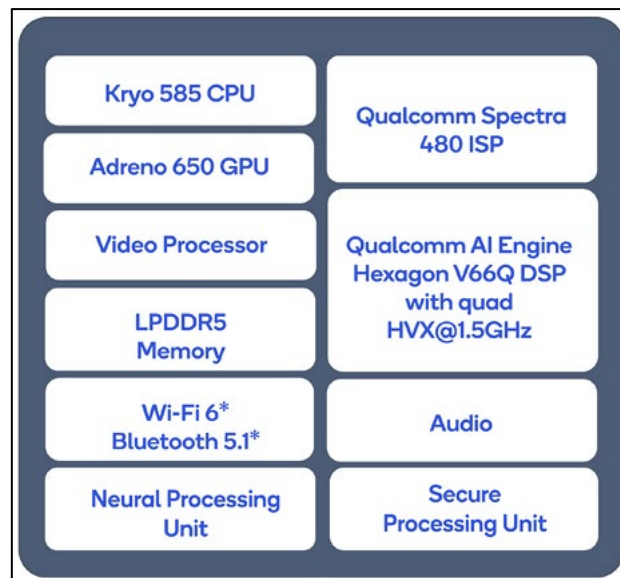


Figure. 10

In this chip, its central process unit is Kry585. In this cpu, it contains 8 cores, including one big core, Cortex-A77 which can

work at 2.84GHz, and three cores, A77 which can operate at 2.42GHz. As for small cores, there are 4 small cores, which are A55 functioning at 1.8GHz. In this chip, it is also equipped with GPU, Adreno 650 GPU. It is manufactured by the 7-nanometer process providing by TSMC. Comparing to past generation, Adreno 640, it promotes 25% of the ability of displaying image, and also lower down the 35% of energy consumption. For the memory, LPDDR5 here is installed. Due to the application of the high efficient machine learning, here is a neural processing unit. Besides, there is an image signal processor called Spectra 480 image signal processor. It supports 10 billion of pixels, and provides 20 billion of image processing speed.

ii. Performance

The performance of QCS8250 is quite excellent. For its cpu, Kryo585, it upgrades the 25% of arithmetical capability, and, meanwhile, it saves 25% of the energy consumption. The GPU, Adreno 650, promotes the ability, 25%, of faster graphic

rendering, and lets the power more efficient, 35%. However, there is a competitor of QCS8250. The chip is called RK3588, which is provided by Rockchip, a company locates in Shanghai. The performance between these two chips is firmly same. Nevertheless, when it comes to the ability of GPU, Qualcomm's GPU capability is mush better than RK3588. Therefore, if someday you are handling a more complicated application of image processing, QCS8250 is still more appropriate to be chosen as your chip.



Figure. 11

iii. Application

Thanks to the strong graphical ability of QCS8250, it is extremely suitable for connected cameras, unattended retail,

such as Amazon go. In the Amazon go shop, there are hundreds of connected cameras set up on the ceiling. They are all connected in order to distinguish which product has been taken from the shelf. Thus, this is one of the applications for QCS8250. What's more, it suits video collaboration and healthcare. That's about the functionality of QCS8250.



Figure. 12



Figure. 13

D. ARM, Cortex- M85

i. Architecture

For the last section of the case study, I will talk about a chip from ARM. It's called Cortex-M85. ARM has developed a variety of different type of chip. For the M series, its function is mostly used in embedded system. Here is its block diagram as shown in figure. 14.

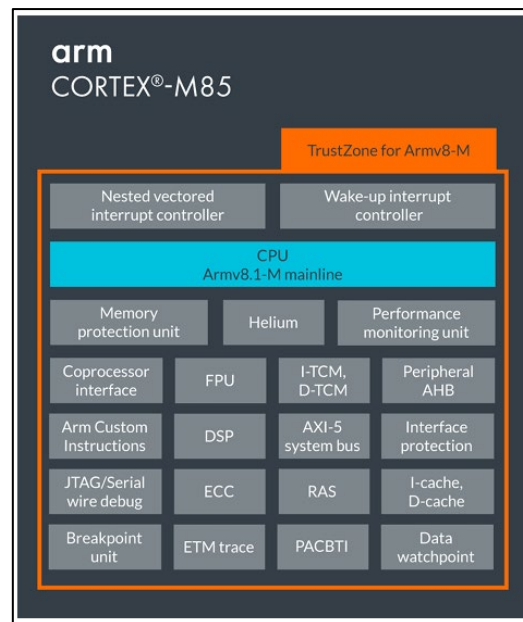


Figure. 14

In Cortex-M85, it uses the architecture of Armv8.1-M. It is enclosed several functions such as the high efficient capability of handling vectors. It allows DSP and Machine Learning to be accelerated. It also can help

to deal with the expansion of the vectors and floating-point calculation. For the cache, I-cache and D-cache are expanded to 64KB. In order to react the high-speeded calculation, there is an inspecting unit for correcting the DSP signal and the confidentiality.

In ARM, there are a bunch of products. For each product, it has its instruction set. In Cortex-M85, it operates with the instruction, ARM Helium. ARM Helium is m-profile vector expansion, and it greatly upgrades the performance of DSP and Machin Learning. As for the memory, with an eye to increase the on-chip memory, it is divided into two parts, I-TCM and D-TCM. All in all, this is the brief introduction of Cortex-M85.

ii. Performance

As far as the performance is concerned, the graph is pasted as the figure.15. Comparing to traditional performance, Cortex-M85 is better than Cortex-M7 more 30%. Take machine learning performance into comparison, Cortex-M85 perform much better than Cortex-M55 for 20%. When it comes to

general performance, Cortex-M85 has the best ability in Cortex-M series. Therefore, if there is a strong needed, Cortex-M85 will be the best choice.

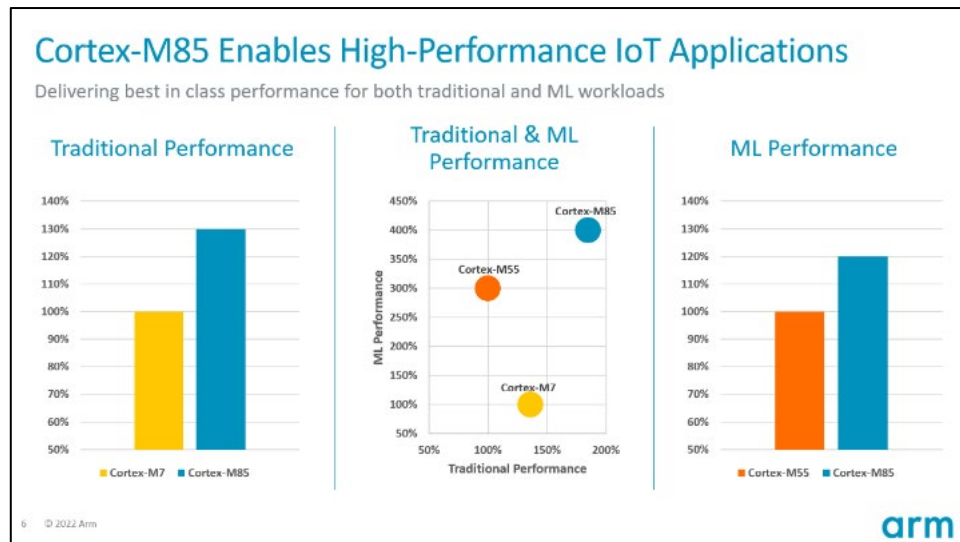


Figure. 15

iii. Application

As its original meaning of M series, Cortex-M85 is eligible for embedded system such as smart speakers, utility robots, and drone control. For the consumer electronic device, AR/VR is a really great application. What's more, nowadays, the demand of automotive increases drastically. Cortex-M85 can offer a good care of this application. That's the part of application of Cortex-M85.

Market Analysis

In this section, I will go through the comparison between each product. The S.W.O.T analysis is shown as the Table. 1.

First, for CC3200 SimpleLink Wi-Fi from Texas Instrument, its strength is low power consumption and equipped with crypto engine. Its competitor is the chip, ESP32. It's the chip from ESPRESSIF, Shanghai. As for Intel Core 12th, it has the architecture of P and E core. It makes the efficiency of CPU upgrade dramatically, but, as for the energy consumption, it will consume energy more than M1, Apple. Also, the speed of LPDDR5 is lower than M1. For QCS8250 from Qualcomm, it functions at the optimization of AI, and connecting capability of Wi-Fi 6 and 5G. However, its expansion is not that excellent compared with Rockchip RK3588. The price of QCS8250 is higher than RK3588 as well. For the last product, Cortex-M85, it is said that it is the best processor in the world up to now since it has the instruction set, Helium. It effectively handles the function of AI. Nevertheless, it is expensive.

	Strength	Weakness	Opportunity	Thread
Texas Instrument CC3200 SimpleLink Wi-Fi	<ul style="list-style-type: none"> • Low Power • Embedded Wi-Fi • Crypto Engine 	<ul style="list-style-type: none"> • Out-dated CPU 	<ul style="list-style-type: none"> • Change CPU • Promote RAM 	<ul style="list-style-type: none"> • ESP32
Intel 12th Intel® Core™	<ul style="list-style-type: none"> • P-core + E-core • Strong GPU 	<ul style="list-style-type: none"> • High Power • LPDDR Speed 	<ul style="list-style-type: none"> • More E-core • Reduce Power 	<ul style="list-style-type: none"> • Apple M1
Qualcomm QCS8250	<ul style="list-style-type: none"> • AI Optimization • Wi-Fi 6/5G Connection 	<ul style="list-style-type: none"> • No output for 8K • High Price 	<ul style="list-style-type: none"> • AI Expansion • Output for 8K display 	<ul style="list-style-type: none"> • Rock-chip RK3588
ARM Cortex-M85	<ul style="list-style-type: none"> • Armv8.1 • Helium 	<ul style="list-style-type: none"> • High Price • Hard to use 	<ul style="list-style-type: none"> • Low Price • Power Management 	No

Table. 1

Reference

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