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Whitepaper

High-end embedded computing from 12W up

AMD Embedded R-Series SoC processors on congatec COM Express modules

High-end embedded computing from 12W up

With the launch of the first SoC variant of the AMD Embedded R-Series processors this high-end class of desktop processors has also become available for embedded applications. For the first time and thanks to their scalable TDP from 12W upwards, they can now even be used in fully enclosed, fanless systems. Congatec supports the new processor platform on COM Express computer modules.

AMD Embedded R-Series SoC processors' predecessors combined only the CPU and GPU on a single die to an APU (Accelerated Processing Unit). The new System-on-Chips (SoCs) now also integrate the platform controller hub (formerly Southbridge) which makes board designs significantly more compact and energy efficient. The new CPU cores provide around 5% more performance while requiring approximately 40% less energy. At the same time, the scalability of the TDP is extremely wide, ranging from 12W to 35W. When configured for 12W to 15W, they can now for the first time be used in fully fanless designs.

Besides high-performance embedded computing, this opens new applications for the AMD Embedded R-Series in areas that demand extreme robustness or a high degree of system safety. For instance, fully enclosed systems are a must in clinical applications that require the highest standards of hygiene. In the industrial environment, protection from dust and dirt is important. Low maintenance is another important aspect that speaks for fanless systems. So there is a multitude of applications where AMD Embedded R-Series processors have become a viable option for the first time.

Figure 1:
High-end performance compacted down into 125 x 95 mm: conga-TR3 computer module with active heatpipe solution mounted on a carrier board.without loss of performance.

In many cases, the arguments for the AMD Embedded R-Series are the same as in the higher performance range where fans are always required. It is primarily the high-end embedded applications that benefit from the embedded high performance AMD Radeon graphics, or applications that use AMD's support of OpenCL and the Heterogeneous System Architecture (HAS) to their competitive advantage.

The new AMD Embedded R-Series processors are therefore used in applications that require a particularly powerful, highly integrated graphics and/or parallel processing power. Examples can be found among high-end gaming, e.g. digital pinball and arcade machines, in demanding digital signage installations with large 4k displays, as well as image and video analysis in industrial vision systems and medical imaging technology. Other applications that benefit from the high GPGPU performance of the new AMD Embedded R-Series processors include security applications such as video surveillance with face recognition, network firewalls with deep packet inspection, or IoT systems with integrated big data analytics. Let's look at the specific improvements that have been achieved over the previous APU.

The new AMD Embedded R-Series SoC

While the competition continues to implement its processors as multi-chip modules, the AMD Embedded R-Series is the first SoC design in the x86 high-performance segment to integrate GPU, CPU and I/O controllers on a single die. AMD has used this higher level of integration to optimize energy efficiency and reduce power draw. The CPU is based on the new Excavator architecture where two x86 cores share one L2 cache, just like R-Series APU designs. In addition, some functional units have been optimized to save space. For example, the floating-point scheduler, the fused multiply accumulate (FMAC) units as well as the instruction cache have all been compacted to lower energy consumption .

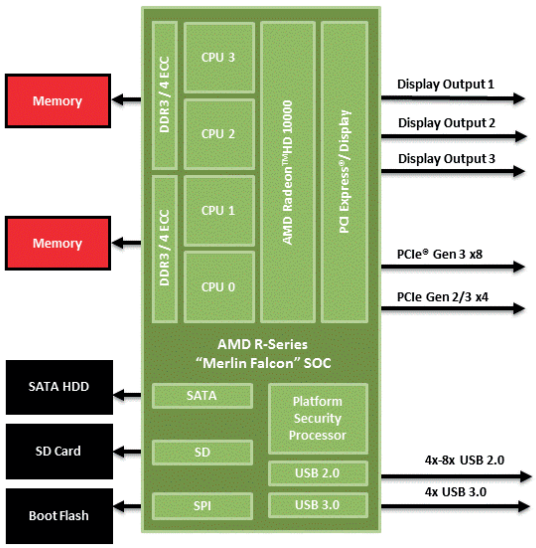

Figure 2:
Everything on a single die: The AMD Embedded R-Series SoCs integrate CPU, GPU and I/O controller. Thanks to architecture optimizations CPU power draw has been reduced to around 57% without loss of performance.

AMD has also refined the power management featured in earlier CPUs and GPUs. Each Excavator core uses 10 so-called adaptive voltage scaling frequency (AVFS) modules. They optimize the voltage and clock rate of the individual functional units, so that each core can utilize the existing power and thermal budget to the maximum. Yet the top TDP of the SoCs remains the same as that of previous APUs - despite the integration of the Southbridge that consumes a significant 7.8W (i.e. 22% of the maximum TDP of 3W) in the shape of the fusion controller hub A75.

At the same time, AMD has increased the performance of the Excavator architecture. Overall, it provides 5% more instructions per clock cycle at 40% less power and 23% smaller die area compared to its predecessor Steamroller and therefore offers significantly more performance per watt. When calculating the performance increase per given watt, a theoretical increase of up to 175% (100% * 100 watts / 60%) * 1.05 = 175%) is possible – that's an enormous performance boost per given watt. Under these circumstances, it would be possible to change designs using first generation APUs into fanless 15W implementations without loss of performance.

The new Radeon GPU and HSA

The improvements don't stop at the CPU; the GPU is also new. The integrated AMD Radeon HD 10000 graphics is now based on the third generation of the Graphics Core Next (GCN 1.3) architecture. The Radeon HD 10000 provides up to 8 compute units with 64 execution units each. This adds up to 512 execution units, offering application developers yet more graphics

performance with the latest DirectX 12 and OpenGL 4.4 3D features. This makes the new SoCs ideal for applications that require game console level graphics performance on up to three screens.

At the same time, developers can use the AMD Radeon HD 10000 graphics for GPGPU tasks. Thanks to full support of the recently adopted HSA specification 1.0, this is now even easier. HSA unifies how programmers address the relevant computing units by dismantling the programming barriers between CPU and GPU and minimizing latencies in the communication between CPU and GPU with a single memory interface. HSA allows programmers to develop applications that make optimal use of the respective CPU and GPU advantages. With HSA, the individual workloads of the AMD R-Series SoCs are automatically processed by the most suitable computing unit, leading to the best possible performance and lowest power draw. The single memory for CPU and GPU speeds up the communication between the two computing units.

The memory therefore has a big impact on overall performance. By supporting high-bandwidth DDR4 RAM with ECC, the new AMD Embedded R-Series meets even the requirements of data-critical server and big data applications. DDR4 RAM is also around 20% more energy efficient than the previous DDR3 RAM, which has an additional positive effect on the performance and power consumption of the overall system.

Other functional units

For the effective handling of multimedia data, the AMD Embedded R-Series SoCs feature a new integrated Universal Video Decoding Unit 6 that supports the current 4K HEVC/H.265 video codec and can decode 18 1080p video streams compressed in H.264. The video compression engine (VCE) has also been improved and in version 3.1 it can compress up to 9 full-HD video streams in H.264 for video-rich applications.

In addition, AMD has integrated a platform security processor (PSP) which incorporates a hardware-based RSA, HSA, and AES encryption along with a true random number generator. Thanks to this additional security engine and a TPM developers are able to implement the highest levels of data and communication security in their applications. This is particularly crucial to protect safety critical IoT and communications applications from data exfiltration and manipulation. On the I/O side, the new AMD Embedded R-Series SoCs are also state-of-the-art, providing PCI Express Gen 3.0 and USB 3.0. This feature set makes them ideal for COM Express implementations that realize the SoCs' full potential with the Type 6 pinout.

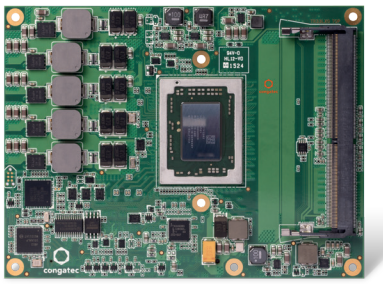

Figure 3:
The conga-TR3 computer module from congatec comes equipped with a 12-35W AMD Embedded R-Series processor. Providing high-performance SoC graphics and HSA 1.0 support, it can theoretically yield up to 75% more performance per watt.

COM Express Basic

The first three congatec COM Express Basic modules with AMD R-Series processors are available with either one of the two 2.1 GHz / 1.8 GHz quad-core AMD Embedded R-Series processors (RX-421BD / RX-418GD) or a 1.6 GHz dual-core processor (RX-216GD). The COM Express Basic form factor is ideal for this generation of processors. Not only does it provide an area of 125 x 95 mm that is adequate for the required heatsink design, it also offers two double-row SMD connectors with 440 pins for numerous high-speed interfaces. In addition, COM Express is optimized for the high-performance interfaces of standard PCs and meets even the most extreme ruggedness requirements thanks to its stable connection to the application-specific carrier board. Therefore, COM Express is often the preferred solution for high-end embedded designs with custom interface sets where the standard feature set of Mini-ITX motherboards is inadequate or application space limited.

Does the processor match your system design?

Individual system designs always present the embedded design engineer with some challenging questions: Is my system design really suitable for the chosen processor? Will I be able to operate the system long-term and without overheating, or will the application bring the system down when it comes to load peaks? It is key to ensure that the design does not overheat the processor, as this would shorten the service life or lead to extremely premature failures. Fortunately, there are now not one but two factors that make it easier for developers to balance hardware design, processor and application requirements.

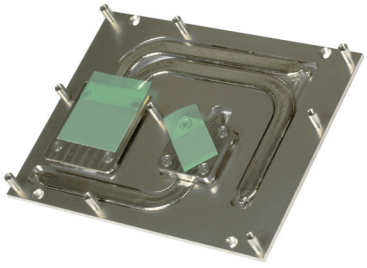

Figure 4:
congatec's heatspreader provides a thermal interface to define the height of a design for cooling solutions with an identical footprint.75% more performance per watt.

The first factor is the configurable TDP of the processor. The second factor is the availability of fanless cooling solutions that are a good fit for the computer module and processor. They make it possible to optimize the design step by step to the requirements of a given hardware design and application. The new AMD Embedded R-Series SoC processors are configurable from 12W to 35W. If the application is prone to overheating the system in certain scenarios, it is possible to minimize the hotspot at certain points by limiting the maximum heat output so that the system always remains within the permitted thermal range. Another option is to play with heatsink variants, provided different cooling concepts are offered for an identical footprint.

Since the PICMG COM Express specifications allow designers to limit the height of the heatspreader it is possible to develop heatsink solutions with an identical footprint that offer different options. These can range from simple embedded heatsinks with fins to heatsinks with a housing connection, high-performance coolers with combined heatpipe and heatspreader technology, or integrated active coolers.

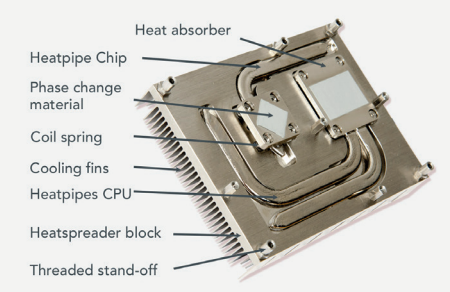

Figure 5:
congatec's patented cooling solutions with particularly flat heatpipes ensure that the conga TX3 module stays cool even when powered with 35W.

The availability of configurable TDP together with starter kits that offer flexible heatsink variants will enable system developers to succeed more quickly than with trial & error attempts at system design and housing. The new AMD R-Series processor generation makes thermal design a lot easier. However, OEM developers will continue to face questions that require direct access to the expertise of module suppliers. It is then a real advantage if the manufacturer has defined a transparent process that guarantees personal support, making it unnecessary to go from pillar to post and explain issues again each time.

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