The Advantages of Integrated RAM

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The AMD® Am186™ER microcontroller and its sister chip, the Am188™ER microcontroller, represent system integration and performance that were previously unattainable. The system level benefits of this integration make the Am186ER microcontroller a compelling product.

Memory integration forms

The memory integration has taken several forms: caches, scratchpads, and system level memory. Each form of the memory integration has its advantages and disadvantages.

A cache generally improves performance in a system if the external memory is not able to respond with no wait states. The cache keeps a subset of the large memory information, usually by storing the most recently used. Because of locality of reference, the most recently used is also the most likely to be used next. The typical example is a system using DRAM (which will generally have multiple wait states to respond to accesses) and a cache. Some systems (e.g., Am486®) would even have multiple levels of caches with one level on-chip and the second level external between the processor and the main system memory. The cache is good for enhancing system performance, but it does not replace system components. On the Am186ER microcontroller, AMD chose not to integrate the RAM in the form of a cache because we were already able to use 70-ns commodity memory for no wait state operation at 40 MHz. No performance enhancement would be achieved and, as importantly, no system cost reduction would be made. A cache augments external RAM, it does not replace it.

Several microcontrollers have integrated a small piece of memory as a scratchpad. Like a cache, a scratchpad generally doesn't replace other system components. The one exception to this is non-volatile RAM. Many systems, but not all, use some small section of non-volatile memory to store parameters. The rise of the use of Flash in systems has integrated this feature with the instruction store. A portion of the Flash is used as the scratchpad non-volatile RAM. A use of scratchpad RAM is similar to a cache. Instead of the no-wait-state memory being a variation of most recently used (and thus most likely to be used again next), the scratchpad contains data or program code that is known to be speed critical. While this provides a performance increase, it again does not replace system components.

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The integration of system components is one of the driving forces behind embedded systems. By reducing the number of components, the system cost, power, and size are generally reduced. Because of the non-uniformity of embedded systems, the amount of memory required to replace external components varies with the application. Integrating more memory than required generally defeats the advantages of system cost and power reduction by integration. Similarly, integrating insufficient amounts of memory defeats the purpose as external components are still required.

8-bit microcontrollers have successfully integrated system-level memory for some time. The secret behind their success is the smaller core size of the CPU (leaving more room for the memory integration) and the limited addressing range. The limited addressing range of the 8-bit architectures mean less memory can be used by the architecture for any purpose (code, data or peripherals). Since the total memory useable is so much smaller, less memory needs to be integrated to be all required for the system. This limited address range is also a key reason why many embedded designers move to 16-bit architectures to overcome this limitation. The Am186ER and Am188ER microcontrollers overcome these limitations by integrating the standard 186 core with additional system logic and the RAM. The use of .35 micron process technology enables all of this to be integrated cost effectively.

SRAM market drivers

The main SRAM market drivers are second-level PC caches and price-per-bit cost reductions through integration of larger memory arrays. The L2 caches for PCs require relatively fast access times and cache sizes proportioned to the main memory and integrated cache of the CPU. Because of the volume of the L2 cache for PCs, the SRAM configuration used for them become the “commodity” SRAM. While other SRAM configurations will exist, these are generally not as cost effective in a system because of the lack of the volume PC market as the driving force to enable and reward cost reductions. In recent years, the 32Kx8 SRAM was the SRAM of choice for second-level caches. With the desktop shift from 486 to 5- and 6-series processors, the SRAM used for L2 caches have also shifted. The trend for PC L2 caches is now higher density and bursting, synchronous SRAM. The result for the embedded market should be confusion, temporarily low prices and increasing difficulty of assuring the SRAM supply as vendors exit that density of the market. Examples of this can be seen with previous SRAM generations such as 4Kx4 and 8Kx8. The effect of this can be shown in the projected low density SRAM availability decline as forecast by Dataquest (May 1996).

As you can see from the chart on the following page, the availability of low density SRAM is projected to decline over the next five years. The mix of SRAM will shift to higher and higher density with time.

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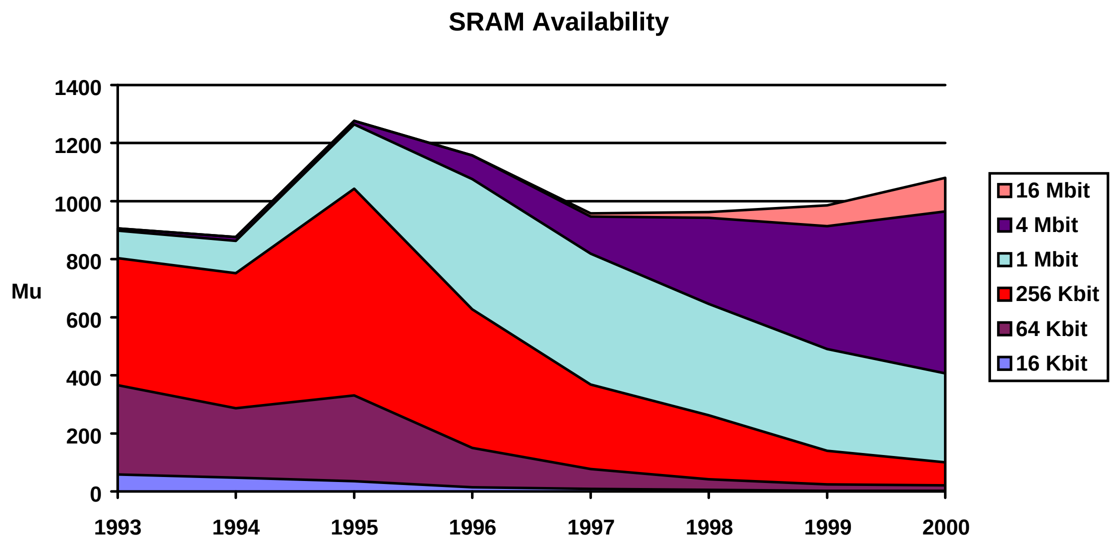

32 Kbyte of integrated RAM

The Am186ER microcontroller breaks new ground for 16-bit microcontrollers by integrating enough RAM to be sufficient for many systems while also providing 32-bit performance at a 16-bit price. The Am186ER controller integrates 32 Kbyte of RAM. For the Am186ER controller, this is organized as 16Kx16. For the Am188ER controller, this is organized as 32Kx8.

Many embedded applications require 32 Kbyte of RAM or less. Because of the size of external SRAM available, 186 systems requiring 32 Kbyte of RAM would purchase two 32K x 8 SRAM. The dual SRAM are required for the 16-bit wide external data path of the 186. The resulting system would have twice the RAM "required" by the application, consume more power (two SRAM vs. one), take more bus space, but deliver the performance (16-bit wide external data path) and be the most effective in system cost/performance given the limitations of the external SRAM availability. While there were some "boutique" SRAMs available with 16Kx16 configurations, the price and availability of these made them significantly less popular than the "commodity" 32Kx8 configuration.

The 32 Kbyte of integrated RAM can also be used to augment external RAM. For embedded applications which have slightly outgrown their current RAM requirements, the Am186ER microcontroller's internal RAM can be placed adjacent to the external RAM in the address map. This can provide a significant system cost advantage vs. moving to the next larger SRAM size externally. This can be applied to any system that requires X + 32 Kbyte of RAM where X equals the current RAM requirements.

Reducing system power consumption

The Am186ER controller provides significant system power savings over alternatives through two means. The primary power reduction is achieved by switching to 3.3 V

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Vcc. Further system savings are available based on the integration of the RAM. External SRAM generally specify a higher maximum power consumption number based on their 4T cell SRAM cell which relies on poly-based resistors that increase power consumption. Further, using two 32Kx8 to get the data width means the RAM power is doubled. The net result is that the Am186ER controller at 3.3 V with its integrated 32 Kbyte of RAM is roughly half the power of the equivalent power Am186EM controller at 5 V. In addition, whatever power would have been used with the external SRAM can be saved in the Am186ER controller. The external SRAM generally run from 200 to 400 mW maximum per SRAM. Thus, the total system power savings is roughly 1/3 compared to the 5-V Am186EM controller and two external SRAMs.

Inventory management simplified

One advantage of integration is to simplify inventory management. The cost of inventory management is not always recognizable or even traceable in some OEMs. The costs associated with inventory management are associated with qualifying multiple suppliers, keeping additional inventory to assure sufficient parts to stay in production, accounting costs associated with additional booking and billing, etc. The Am186ER microcontroller simplifies this process by consolidating the system RAM and microcontroller into one vendor. AMD has additional advantages in inventory management by providing multiple pieces of the system (e.g., Flash), the quality management associated with the ISO 9002 and our Total Order Management project.

System reliability and size

External SRAM and DRAM are the standard for 16-bit embedded systems. The Am186ER controller improves the system reliability by reducing the number of components in a system by replacing the external system SRAM. Fewer parts, less routing and a less complicated system means fewer things to go wrong. The elimination of two external SRAM reduces the board space requirements, allowing for a smaller and cheaper PWB or more functionality in the same space.

Summary

The advantages and benefits of the Am186ER and Am188ER microcontroller features are summarized in the table on the following page.

Embedding 32 Kbyte of RAM open new possibilities for the 16-bit embedded market. The immediate benefits of lower system cost, less power, smaller board space and improved system reliability are augmented with the future benefits of long-term integrated RAM supply and simplified inventory management. The Am186ER microcontroller continues the AMD commitment to innovation and system cost reduction in the 16-bit x86 architecture. Future innovation will continue to take advantage of AMD’s world class process technology.

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Feature	Advantages	Benefit
Am186EM core	Compatibility, performance, system integration	Quick time to market and 32-bit performance.
Lower power	Lower power than any 16-bit microcontroller with external SRAM. External SRAM tends to be specified with very high worst case power numbers	Lower power reduces the system cost for power supply, and thermal cooling. Alternatively, lower power can enable more end product functionality.
More integrated	Smaller footprint	Enables design flexibility which can lead to lower cost or more end product functionality. Fewer components and less routing make for a more reliable end product.
Lower solution cost	Lower solution cost compared to a typical 16-bit microcontroller and 2 external SRAMs	The 32-bit performance and quick time-to-market are delivered at competitive system cost.
Stable availability of memory	The number of 32Kx8 SRAM vendors will be reduced in coming years due to the changing requirements for the PC cache market which is the market driving SRAM vendors.	The number of vendors required can be reduced, inventory management is made easier, and long term support is linked to the microcontroller.

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