AMD Deploys K6-2 With 3DNow

New K6 Processor Now Shipping at Speeds As High As 333 MHz

by Linley Gwennap

Things are finally looking up for AMD. With its 0.25-micron process now reliably churning out parts, the company has announced a new version of its K6 processor. The new chip extends the original design with improved MMX performance, a 100-MHz Socket 7 bus, CPU speeds of up to 333 MHz, and 3D instruction extensions known as 3DNow (see MPR 6/1/98, p. 18). Echoing Intel's Pentium II and Cyrix's renamed M II, AMD has dubbed its new processor the K6-2.

The K6-2 was originally disclosed as the K6-3D at last fall's Microprocessor Forum (see MPR 10/27/97, p. 19). AMD has delivered the product on schedule and with the same feature set discussed then.

The best news about the K6-2 is the speed yield: the 333-MHz parts are only two speed grades behind Intel's top of the line. By reducing its clock-speed gap, AMD can assign a premium price to its fastest part, charging $369 in quantities of 1,000. This price, nearly twice the company's best price of a few months ago, should help boost AMD's average selling price and aid the company in its quest for profitability.

The K6-2 is the first x86 processor to ship with new instructions specifically designed to enhance 3D performance. The 3DNow instructions will also be implemented by IDT (see MPR 6/1/98, p. 1) and Cyrix later this year. Intel is planning a similar set of extensions for its Katmai processor, due in 1H99. While the new instructions give the K6-2 four times the peak floating-point performance of a Pentium II of the same clock speed, the improvement on typical 3D applications is less impressive: about 15–20%.

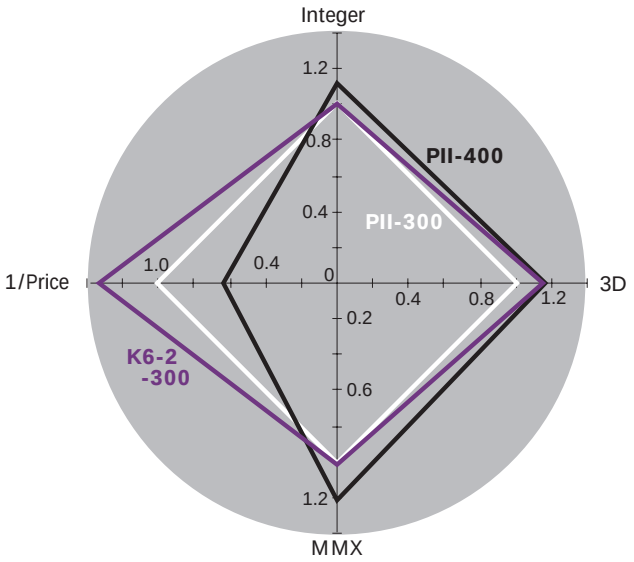

Figure 1. AMD's K6-2/300 offers performance similar to that of the Pentium II-300 on most applications but excels on programs that use the 3DNow instructions. The K6-2 also offers a price advantage over Pentium II. (Data source: AMD except Intel prices)

Three Vectors of Performance

Figure 1 summarizes the relative performance of the K6-2 versus Pentium II using the "three vectors of performance" method favored by Intel. According to AMD, the K6 achieves essentially the same performance as Pentium II on typical PC application benchmarks such as Winstone 98. These benchmarks test only the integer portion of the CPU, as they do not use floating-point or MMX instructions. The K6-233 and K6-266 lag Pentium II slightly on these tests, but the K6-2's move to a 100-MHz bus closes this gap.

AMD has redesigned the MMX unit on the K6-2 to closely match the performance of Pentium II. The original K6 MMX unit issues only one instruction per cycle, half the rate of Pentium II's. As a result, the K6 fell as much as 33% behind Pentium II on some MMX benchmarks (see MPR 9/15/97, p. 18). AMD's new MMX unit can issue two instructions per cycle, with latencies similar to Intel's. As a result, the performance of K6-3D and Pentium II is very similar on tests such as Norton MMX, according to AMD.

The 3DNow instructions can improve performance on applications that make heavy use of single-precision floating-point arithmetic and can be modified to use the new parallel FP operations. The target application, as the name suggests, is 3D geometry, although the new instructions also help with audio and video processing. On the 3D Winbench 98 benchmark, which uses the 3DNow extensions via DirectX calls, the K6-2 achieves an advantage of 15% over a Pentium II at the same clock speed. That allows a 333-MHz K6-2 to outperform a 400-MHz Pentium II on this benchmark, based on AMD's tests.

Benefits of 3DNow Small, May Grow

The K6-2's performance advantage is relatively small for a variety of reasons. Geometry is only one part of the 3D pipeline, which also includes application-level physics, setup, and rendering. Even within the geometry algorithms, only a small fraction of the instructions are sped up by the parallel FP operations. Data is still loaded and stored at the usual rate, and address calculations, branches, and subroutine calls are unaffected. In particular, the K6-2 still lags well behind Pentium II in L2-cache bandwidth. As a result, the potential 4:1 improvement is heavily diluted.

The impact of 3DNow will be greater on some 3D applications, particularly in the future. One of the most

FP-intensive parts of the 3D pipeline is lighting, which is very susceptible to improvement using 3DNow. Most current 3D games, however, use very simple lighting models: typically one or two light sources without specular lighting. Adding more sources or moving to specular lighting can double the K6-2's performance advantage. Future games that are designed for 3DNow or for Katmai may use more advanced lighting to take advantage of these new instructions.

Most applications will utilize 3DNow through calls to DirectX 6 geometry routines (see MPR 3/9/98, p. 14), which have been modified to take advantage of the new instructions if they are available. This method gives 3D software a small performance boost with no redesign at all. DirectX 6, however, is not scheduled to ship until next month. A bigger boost can be achieved by rewriting application-level code to also utilize 3DNow. Many 3D games include complex FP-intensive algorithms to move objects through a 3D space. These algorithms can be improved by using 3DNow.

On the other hand, most existing 3D games will not be improved at all by 3DNow. These games use their own geometry engines instead of DirectX. AMD did not improve its performance on standard FP instructions, so these games will run slower on a K6-2 than on a Pentium II. Many new games, however, will use DirectX geometry.

At the K6-2 launch, AMD listed a dozen DirectX-based games that are currently available, including Incoming, Ares Rising, and Team Apache. Conspicuously missing were Quake II, the most popular 3D game, and Trespasser, which the company frequently points to as one of the best games for the K6-2. These games should both be available with 3DNow this summer. In addition to DX6 support, AMD has developed 3DNow-enhanced routines for OpenGL and Glide, the other popular 3D APIs. The company expects hundreds of enhanced titles to be available by Christmas.

Original K6 Remains in Lineup

The K6-2 contains 9.3 million transistors and measures 81 mm^2 in AMD's 0.25-micron five-layer-metal CMOS process. The new features, primarily the 3DNow execution units and the improved MMX unit, add 13 mm^2 (19%) to the original K6 die. Because of this increase, AMD will not immediately remove the old K6 from its lineup. Instead, the company will sell both parts, as Table 1 shows. Because of its various improvements, the K6-2 carries a premium of about $30 at 266 MHz and 300 MHz. The K6 is not available at 333 MHz, however, so customers wanting the ultimate in performance must pay for the K6-2. Conversely, the K6-2 is not sold at 233 MHz.

The company plans to position the older K6 for price-sensitive customers who don't care as much about 3D or MMX performance. These include business users and some overseas markets. AMD expects most U.S. consumers will be willing to pay extra for the new K6-2 features. The company projects it will ship more K6-2 processors than K6 chips in 1998, despite the former's midyear start.

Price & Availability

AMD is now shipping the K6-2 at clock speeds of up to 333 MHz. See table below for pricing. For more information, access *www.amd.com/products/cpg/k623d.*

AMD could have simply dropped the original K6 from its price list in favor of the K6-2. This strategy would simplify its product line while building a base of 3DNow-equipped systems more quickly. Given the K6-2's larger die, however, this strategy would have reduced AMD's yields. If the company's yields were in good shape, it could probably stand such a modest hit, but apparently AMD does not want to jeopardize its ability to deliver chips. The company may phase out the K6 in the future as its fab situation improves.

Roadmap Looking Up

AMD reports that speed yields on the K6-2 are so good that it expects to introduce a 350-MHz version within the next month. While this speed grade will match Intel's in clock speed, AMD's part will offer only a minor performance improvement over its 333-MHz product, since the differences in CPU and bus speeds are both less than 5%. Intel, on the other hand, moves from a 66- to a 100-MHz system bus when it reaches the 350 level.

Later this year, AMD hopes to tweak its 0.25-micron process to improve its speed. The new process should boost the K6-2 to 400 MHz. By the end of the year, the company also expects to deploy the K6-3 (previously called the K6+ 3D), which adds a 256K on-chip level-two cache to the current part. The new cache could give the K6-3 a clock-for-clock performance advantage over Pentium II. With Intel's best part in 2H98 expected to be a Pentium II-450, AMD should be able to price the K6-3 near the top of Intel's line.

These higher-performance parts will improve AMD's financial picture. The key for AMD, however, is to deliver K6 chips of any sort in large quantities, a feat that has eluded the company in recent quarters. The company says it is now on track to deliver more than 12 million K6 processors this year. We expect it to reach this goal, taking market share from Intel's low end in the process. The going will get tougher in 1999, after Intel stops making Socket 7 parts and leaves AMD to carry on alone. But for the rest of this year, AMD should see significant gains if it can execute moderately well. M

Product (CPU/Bus Speed)	List Price	Product (CPU/Bus Speed)	List Price
K6-2 333/95 MHz	$369	n/a	n/a
K6-2 300/100 MHz	$281	K6 300/66 MHz	$246
K6-2 266/88 MHz	$185	K6 266/66 MHz	$156
n/a	n/a	K6 233/66 MHz	$100

Table 1. AMD's K6 and K6-2 lines overlap at two speeds. List prices in 1,000-unit quantities. n/a=not available. (Source: AMD)