Cyrix, IBM Push 6x86 to 133 MHz

Versions Offered to Beat All Pentium Speed Grades

by Michael Slater

Close on the heels of Intel's debut of Pentium processors at 150 and 166 MHz *(see* **1001MSB.PDF***)*, Cyrix and IBM have announced 6x86 microprocessors that exceed the performance of Intel's chips at each clock speed. For the first time, competitors to Intel are offering pin-compatible chips that outperform even the fastest members of Intel's mainstream microprocessor line. The announcement also marks IBM's formal debut as a 6x86 supplier.

In tests run by MDR Labs (see sidebar), the 133-MHz 6x86 outperformed the Pentium-166 by 5% on Ziff-Davis's Winstone 96 benchmark, making it the fastest Pentium-pinout device yet announced. The 120-MHz 6x86 similarly edged out Intel's Pentium-150. Table 1 shows the complete benchmark results.

Cyrix, IBM, and SGS-Thomson will mark and promote the parts using "Pxxx+" suffixes. This is similar to the strategy NexGen has followed, but the "+" is intended to show that the 6x86 is not just in the ballpark with the corresponding Pentiums, but delivers higher performance at each speed grade on Windows applications (as measured by Winstone 96, a benchmark suite composed of 13 actual Windows applications driven by scripts).

A Match for the Fastest Pentiums

The new ratings reflect a more conservative stance than Cyrix's initial positioning, which compared the 6x86-100 to the Pentium-133. Using a "reference system" with a fast 1M cache, Cyrix produced benchmark results that showed its 100-MHz chip to be faster than Intel's 133-MHz device. Cyrix and IBM have now introduced a new clock speed, 110 MHz, to deliver performance superior to a Pentium-133 without resorting to unrealistic system configurations.

On the CPUmark16 and CPUmark32 tests, which are synthetic benchmarks designed to isolate processor/memory subsystem performance from disk and graphics I/O, the 6x86 is 3–6% slower than the corresponding Pentium processors. Cyrix and IBM believe that this is because these tests deviate in some ways from the instruction mix and code structure of typical Windows applications. Since Winstone 96 is based on actual applications, it is unquestionably a realistic measure—for those applications in the suite, as driven by the Winstone 96 scripts.

On the SYSmark for Windows NT benchmark, which reflects a different set of applications in a pure 32-bit environment, Cyrix benchmark data shows that the 6x86-P150+ and 6x86-P166+ are faster than their Intel equivalents, while the 6x86-P133+ and 6x86-P120+ fall short by less than 3%.

None of these tests provides a separate floating-point result, so it is impossible to evaluate the integer and FP performance separately from this data. Because there are few FP-intensive application in widespread use, PC benchmarks to measure FP are lagging.

Cyrix's initial 1,000-piece pricing, as Table 2 shows, tends to be slightly higher than Intel's prices for comparable Pentiums, while IBM's is a bit lower. Regardless of the official pricing, market realities are such that Cyrix and IBM's volume prices are likely to be below Intel's at any point in time. Note that the 6x86 prices for a given clock rate are higher than those for Pentium; the pricing is based on performance, not clock speed. This is a key reason for focusing on P+ ratings, rather than clock speed; the price (and even more so, profit) difference between speed grades is significant.

Bus Speed Parity at Higher Clock Speeds

The 6x86 CPU core runs at twice the bus speed; the Cyrix design does not offer the 1.5× multiplier option provided by

	P120			P133			P150			P166		
	Pentium 120 MHz	6x86 100 MHz	Relative Perf.	Pentium 133 MHz	6x86 110 MHz	Relative Perf.	Pentium 150 MHz	6x86 120 MHz	Relative Perf.	Pentium 166 MHz	6x86 133 MHz	Relative Perf.
Winstone 96	70.9	71.7	1.01	76	n/a	n/a	77.6	81.9	1.06	82.7	86.7	1.05
WinBench 96												
CPUmark16	263	247	0.94	294			307	298	0.97	340	329	0.97
CPUmark32	271	254	0.94	298			310	304	0.98	340	333	0.98
Graphics	1120	1110	0.99	1140			1160	1180	1.02	1190	1220	1.03
Disk	22.9	24.9	1.09	24.4			25.4	29.3	1.15	28.1	32.3	1.15

Table 1. Tests performed at MDR Labs show that the 6x86 performs well relative to the corresponding Pentium processors. The "Relative Performance" column shows the ratio of 6x86 to Pentium performance. All test results are from an identical system using a Tyan Computer motherboard with an Intel Triton chip set, 512K pipelined burst cache with 3-1-1-1 performance, 32M 60-ns EDO DRAM, Matrox Millennium graphics card with 1024 × 768 × 256 color display, and Quantum Fireball 1G IDE disk drive. Test results for the 6x86-110 were not available. (Source: MDR Labs)

	Cyrix	IBM		Intel
5x86-100	$68	$68	Pentium-75	$106
5x86-120	$102	—	Pentium-90	$198
			Pentium-100	$198
6x86-P120+	$251	$185	Pentium-120	$252
6x86-P133+	$326	$300	Pentium-133	$321
6x86-P150+	$451	$400	Pentium-150	$428
6x86-P166+	$621	$590	Pentium-166	$632

Table 2. Cyrix and IBM offer the 5x86 to compete with low-end Pentiums, while the 6x86 covers the same performance points as the faster Pentiums. All prices in 1,000s. (Source: vendors)

Pentium. As a result, the 100-MHz 6x86 must use a relatively slow 50-MHz bus. Even so, the 6x86-100 delivers higher performance than the Pentium-120 on Winstone 96. With applications that place exceptionally high demands on bus bandwidth, the 6x86-100's performance will drop off faster than the Pentium-120's.

At higher clock rates, Cyrix's bus-speed disadvantage goes away; the 6x86-120 uses a 60-MHz bus, just like the Pentium-150, while the 6x86-133 uses a 66-MHz bus, as does the Pentium-166. Benchmark tests have not yet been run on the 110-MHz 6x86 because it requires a 55-MHz bus, which is not supported by current production motherboards.

There is still some headroom left. The benchmark results are based on a motherboard using Intel's Triton chip set, which does not support the 6x86's linear burst mode *(see* **081601.PDF***)*. As a result, the chip must operate in its Pentium-compatible burst mode, which introduces an extra bus cycle in about half of all burst transfers to avoid infringing Intel's patented burst order. Even with this handicap, the resulting performance is competitive with Pentium's.

Chip sets that support Cyrix's linear burst order should extract more performance from the chip. All else being equal, linear burst provides a benefit for the 6x86, but all else is not equal. So far, the chip sets that provide linear burst support fall short of Triton's performance because of their slower memory controllers or PCI bridges. Cyrix expects faster linear-burst chip sets to be available soon.

Challenge Now Is to Deliver in Volume

Cyrix and IBM have demonstrated that they can produce high-performance x86 microprocessors; now they must deliver them in volume. Despite an announcement that the 6x86 was shipping last October, very few 6x86-based PCs have yet been delivered. Cyrix and IBM say the delays are over, and additional customers will be announced soon. Cyrix's initial customers for the new 6x86 speeds include MicroExpress, SysTechnology, Computrend, and Cybermax.

Cyrix shipped small production quantities of 6x86 chips from the original three-layer-metal design, a stout 394-mm^2 die. Because only limited quantities could be produced from this design, most system OEMs chose to wait for the revised version, code-named M1R. Its more modest 204-mm^2 die size cuts the estimated production cost to

MDR Labs Certifies Performance

The benchmark results for the 6x86 are the first to emerge from MDR Labs, a new operation run by MicroDesign Resources, publisher of *Microprocessor Report.* MDR Labs, headed by MDR founder Michael Slater, was created to provide microprocessor manufacturers and users with a credible, unbiased source of microprocessor performance measurements.

MDR Labs worked with AMD, Cyrix, IBM, and SGS-Thomson to develop an objective method for comparing the Windows application performance of Pentium-compatible processors with Intel's Pentium. The chip companies have published a document, *Processor Performance Rating (P-rating) Specification,* that describes a standard testing procedure for running the benchmarks, documenting the results, and determining the appropriate P ratings. MDR Labs offers performance certification services to document compliance with the specification. The specification can be obtained from the Cyrix, IBM, or AMD Web sites.

The 6x86 performance analysis project was performed under contract to IBM and Cyrix. MDR Labs retained full control of the test system, software, and test procedure. The test system will be retained at MDR Labs for one year and is available to the industry for inspection to confirm the configuration or the benchmark results.

To eliminate all variables other than the microprocessor, all testing is performed in identical system configurations. To ensure that the results are representative of those that typical users will experience, a system configuration was chosen that is representative of today's high-end systems. (See Table 1 caption for system configuration details.) All testing was performed under Windows 95, with all Windows 95 configuration settings left in their default state.

The complete *MDR Labs Performance Analysis of the 6x86* report is available from the MicroDesign Resources Web site, *www.chipanalyst.com.* The report includes full details of the system configuration and test procedure. Future versions of the report will add benchmark results for the 110-MHz 6x86, for Windows NT benchmarks, and for additional system configurations.

MDR Labs has a range of other benchmarking projects under way, including application-based benchmarking of RISC-based systems. Future plans include benchmarking services for embedded microprocessors. For information, send e-mail to *MDRLabs@mdr.zd.com.*

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about $105 and will enable IBM and SGS-Thomson to produce millions of chips this year.

All four of the currently announced clock rates are being produced using the second-generation, five-layer-metal design built on IBM's CMOS-5S process. Cyrix calls this a 0.6-micron process. It has a drawn gate dimension of 0.44 microns *(see* **090905.PDF***)*, but its metal pitches are not as tight as Intel's 0.5-micron P852 process (which Intel calls 0.6-micron despite its 0.5-micron gates). This gives it the speed but not the density of Intel's process.

Cyrix originally expected 120 MHz to be the top clock rate from this process but found reasonable yield at 133 MHz. Production volumes of the top clock rate will be limited, however, until Cyrix and IBM complete a 10% shrink, now in process and due to be in production in the second half of the year. These parts should boost the top clock rate to at least 150 MHz.

This still leaves Cyrix a process generation behind Intel, which will be moving to a 0.28-micron CMOS process in the same timeframe; it is the 6x86's more advanced microarchitecture that enables it to compete at the same performance points as Pentium. If, in the future, Cyrix is able to implement its designs using process technology matching Intel's in the same time frame, its performance position could improve significantly.

SGS-Thomson, Cyrix's other licensee, has not yet begun 6x86 shipments but has said that it expects to begin shipping the chip in the second quarter. SGS-Thomson is now qualifying a five-layer-metal process at its Phoenix (Ariz.) fab, which it built explicitly for the x86 market.

Competing with Future Pentiums

At 150 MHz and above, bus speed will become problematic with the current design, which supports either a 2× or a 3× clock. With a 3× clock, the bus speed would be only 50 MHz, leaving the chip starved for memory access. The 2× clock multiplier would yield a 75-MHz bus speed, which would boost performance but would require that chip sets and motherboard designs be pushed to higher speeds than have yet been achieved for production PC designs.

A 150-MHz 6x86 with a 75-MHz bus should be faster than a Pentium-200, which Intel plans to ship later this year *(see* **1002MSB.PDF***)*. By the end of this year, however, the future of Intel's Pentium line will shift to the P55C, which we expect to offer twice as much on-chip cache, pipeline enhancements to improve performance, and the MMX multimedia instruction-set extensions.

Even putting aside the multimedia extensions, the 6x86 will have a hard time competing with the P55C because the P55C's larger cache will give that chip better scalability to faster clock rates. Furthermore, the P55C's pipeline enhancements may narrow or eliminate the intrinsic per-clock advantage of the 6x86.

Cyrix's response to these challenges is the M2, which the company expects to introduce late this year and put into production in early 1997. The M2 will be designed for scalability to higher clock rates (implying a larger on-chip cache) and will include multimedia extensions—though it is not clear whether these extensions will be compatible with Intel's. If Cyrix implements its own multimedia extensions, the software support challenge could be formidable, especially since AMD is now likely to go with the Intel standard. Other than the multimedia extensions and some enhancements to boost 32-bit performance, the M2 will have essentially the same CPU core as the 6x86.

Price & Availability

The 6x86 is available now in volume from Cyrix at all speeds except 133 MHz; this fastest version is in limited production now, with volume planned for the second quarter. IBM is quoting general availability for all speeds beginning March 1. SGS-Thomson plans to begin production in the second quarter. See Table 2 for pricing.

For more information, contact Cyrix at 800.462.9749, 214.968.8388, or *www.cyrix.com;* IBM Microelectronics through its fax-back service at 415.855.4121 or via the Web at *www.chips.ibm.com.*

A Renewed Challenge for Intel

Regardless of these future issues, the 6x86 is the strongest direct competitor Intel has ever faced at the high end of its product line. Because Pentium Pro does not yet compete in the Windows 95 market, it does not give Intel any advantage against the 6x86. AMD's K5 is still in the future, and it appears likely that the 6x86 will retain a substantial performance lead. NexGen's 586 is far behind in performance and its incompatible pinout limits its prospects.

The 6x86 therefore looks like the strongest of the Pentium challengers for 1996. Intel's Pentium-class market share—which has been virtually 100%—can only shrink, but the rapid growth of the Pentium market should allow good growth for Intel and for the Cyrix/IBM/SGS-Thomson trio. With average selling prices for high-speed Pentiums well above $200, Cyrix would have to sell less than two million 6x86 processors—only a few percent of the market—to dramatically increase its revenue. Cyrix's stated goal is 10% combined market share for the 6x86 from all three suppliers, implying a total of 5–6 million processors.

After a difficult 1995, the 6x86 looks like just what Cyrix, IBM, and SGS-Thomson need to make a stronger showing in 1996, moving out of the economy market and into the high end. Even if the 6x86 achieves only a comparable unit market share to what Cyrix and its partners captured with its 486 family, the new chip will yield much higher revenue and profits. Whether the Cyrix coalition can retain this position beyond 1996 will depend on when the M2 goes into production and how it compares with the P55C. M

