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INTEL SHIPS FASTEST MOBILE CPUS

Top-Speed Pentium 4-M Reaches 2.2GHz

By Tom R. Halfhill {9/30/02-01}

Intel has introduced 11 new speed grades of its mobile processors, including a 2.2GHz Pentium 4-M that's 10% faster than the previous top-of-the-line 2.0GHz Pentium 4-M. The faster CPUs are already shipping to customers. Soon after Intel's September 16 announcement, seven PC vendors unveiled notebooks that use the new 2.2GHz speed champ.

AMD quickly followed a week later by announcing two faster speed grades of the mobile Athlon XP: the 2000+ and 1900+, which run at 1.67GHz and 1.6GHz, respectively. They are priced at $345 and $239 in 1,000-unit quantities and are shipping in notebook computers from Compaq and Fujitsu.

At $562 in 1,000-unit quantities, the 2.2GHz Pentium 4-M is the most expensive mobile PC processor. Still, it's a bargain compared with the original price of the 2.0GHz Pentium 4-M, which was $637 at introduction last June. The Pentium 4-M commanded a hefty premium because it was the first mobile processor to reach 2.0GHz. But the high price didn't last long; it now sells for $348, a reduction of 45% in only one quarter.

The other 10 new speed grades are Pentium III-M processors and mobile Celerons based on the Pentium III-M or Pentium 4-M microarchitectures. Mobile Celerons that run at 1.4GHz or faster use the newer Pentium 4-M core; slower Celerons use the older Pentium III-M core. Intel brands some Pentium III-M and Celeron processors as low-voltage (LV) or ultralow-voltage (ULV) chips. The lowest operating voltage for branding a chip LV is about 1.05V, and the lowest operating voltage for ULV is about 0.95V—when the computer runs on batteries. On AC power, the computer uses Intel's SpeedStep technology to boost the core voltage and clock frequency to slightly higher levels.

	Core Frequency (AC/DC)	Core Design	FSB Frequency	On-Chip L2 Cache	Core Voltage (AD/DC)	Average Power† (DC)	TDP†	Price (1K)
Pentium 4-M	2.2/1.2GHz*	Pentium 4	400MHz	512KB	1/3V/1.2V	<2.0W	<35W	$562
Pentium III-M	1.33GHz/ 800MHz*	Pentium III	133MHz	512KB	1.4V/1.15V	<1.5W	<22W	$508
Pentium III-M	1.26GHz/ 800MHz*	Pentium III	133MHz	512KB	1.4V/1.15V	<1.5W	<22W	$401
LV Pentium III-M	1GHz/ 533MHz*	Pentium III	133MHz	512KB	1.15V	<1.0W	<12W	$316
ULV Pentium III-M	866/400MHz*	Pentium III	133MHz	512KB	1.1V/0.95V	<0.5W	<7W	$209
ULV Pentium III-M	850/400MHz*	Pentium III	100MHz	512KB	1.1V/0.95V	<0.5W	<7W	$209
Celeron	1.8GHz	Pentium 4	400MHz	256KB	1.3V	<2.0W	<35W	$149
Celeron	1.7GHz	Pentium 4	400MHz	256KB	1.3V	<2.0W	<35W	$134
Celeron	1.6GHz	Pentium 4	400MHz	256KB	1.3V	<2.0W	<35W	$112
ULV Celeron	733MHz	Pentium III	133MHz	256KB	1.1V	<0.5W	<7W	$144
ULV Celeron	700MHz	Pentium III	133MHz	256KB	1.1V	<0.5W	<7W	$144

Table 1. These are Intel's specifications for the 11 new speed grades of mobile PC processors. Note the disparity in front-side bus speeds among the processors based on Pentium III-M and Pentium 4-M cores. (*SpeedStep AC/DC variable clock frequencies; †Intel's estimates)

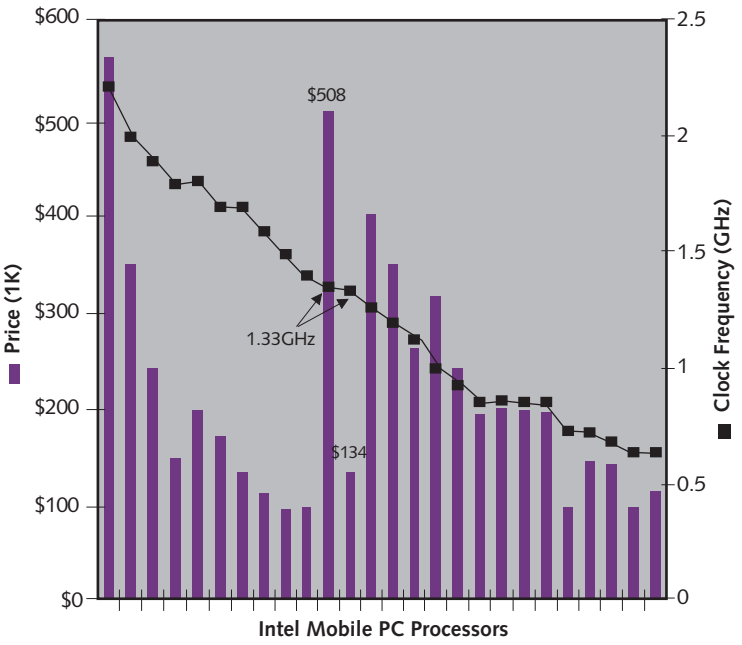

Figure 1. Intel's product line of mobile PC processors is closely tiered by clock frequency and price, but it has some sharp peaks and valleys because of microarchitectural differences and marketing strategies. (Each vertical bar represents an Intel mobile CPU and its price; the matching dot shows the CPU's clock frequency.) Note the anomolies, such as two 1.33GHz processors priced at $134 and $508.

Kenneth, What's the Wattage?

Table 1 summarizes the specifications for the 11 new speed grades. Intel manufactures all these chips in a 0.13-micron CMOS process. The power-consumption numbers are Intel's estimates for a processor running an "average" workload (based on popular industry benchmarks) and the thermal design power (TDP). The average-power rating is more relevant for predicting battery life, whereas the TDP is what system engineers need to know so they can design laptops that won't melt in your lap. Intel's TDP of less than 35W for the speedy 2.2GHz Pentium 4-M seems optimistic, considering that the TDP for the desktop version of the same chip is a balmy 55W.

With these introductions, Intel has filled almost every conceivable gap in its mobile product line. The low end starts at 650MHz and $96 for an LV mobile Celeron and creeps up to 2.2GHz and $562 in increments as tiny as 16MHz, 0.1V, and $0. For instance, the LV Pentium III-M is available at either 850MHz or 866MHz, and both are priced at $198. Smart shoppers can get 1.8% more clock speed for 0% more money. On the other hand, customers mindful of power consumption can buy the ULV version of the same processor at the same clock speeds for $209—a premium of 5% for saving a tenth of a volt.

Figure 1 shows how closely Intel has laddered its mobile CPUs by clock frequency and price. This exercise revealed a few more oddities, such as a 1.33GHz Celeron that inexplicably costs 40% more than a slightly faster 1.4GHz Celeron built in the same 0.13-micron fabrication process with the same amount of L2 cache (256K). There's also a 1.33GHz Pentium III-M that costs a whopping 429% more than a higher-clock-speed 1.5GHz Celeron. Maybe this is Intel's way of nudging customers toward the next-generation architecture. Although the Pentium III-M has twice as much L2 cache (512K vs. 256K), which might erase the Celeron's 12% advantage in clock frequency, the Celeron is based on the newer Pentium 4-M core, so it has a front-side bus that is three times faster (400MHz vs. 133MHz), an L1 trace cache, SSE2 extensions, and other fringe benefits. The L2 caches of the two would ordinarily be the same size, except that Intel customarily disables or removes half of the L2 cache in Celeron processors to differentiate them from their Pentium-branded forebears.

By far the widest remaining gap in Intel's mobile product line is the difference in memory bandwidth. All Pentium III-M processors and the Celerons based on their cores have 100MHz or 133MHz front-side buses. The Pentium 4-M processors and the Celerons based on their cores have front-side buses that run at a base frequency of 100MHz, but they transfer four bits of data per clock cycle per wire, so their effective bus frequencies are 400MHz. Their huge advantage in memory bandwidth will likely persist until next year, when Intel introduces Banias, a new low-power mobile-processor microarchitecture. We expect Banias to have a 100MHz front-side bus that's quad-pumped to 400MHz, like the Pentium 4-M.

AMD and Transmeta Trail Behind

Intel continues to maintain a commanding lead over AMD and Transmeta in mobile-processor performance—and especially in market share. AMD's fastest mobile CPU is the new Athlon XP 2000+, which runs at 1.67GHz and costs $345. For perhaps 10% less performance than the 2.2GHz Pentium 4-M, it costs 39% less. Transmeta's fastest mobile CPU is the 933MHz Crusoe TM5800; Transmeta won't publicly disclose the price. The TM5800 delivers less performance on most benchmarks than its clock frequency implies, and its TDP is about 7W. Intel's ULV mobile processors run at 400MHz to 733MHz on battery power, and their TDP is comparable.

At the low end, AMD sells a 1.0GHz mobile Duron for $59—a bottom-feeding bargain that's only one-fifth the cost of a 1.0GHz Pentium III-M. Transmeta's low-end TM5800 runs at 800MHz.

In market share, Intel reigns supreme. Gartner/Dataquest recently reported that AMD doubled its share of the worldwide mobile-processor market from 5.3% to 11.3% in 2Q02. Nevertheless, AMD's hard-fought gains don't substantially change the pecking order: Intel has about an order of magnitude more share than AMD, and AMD has about an order of magnitude more share than Transmeta.

It's remarkable that Intel has retained such a large share of the mobile market with microarchitectures

designed primarily for high performance rather than for low power consumption. It appears that the market values raw performance over battery life. Notebook computers with Crusoe processors usually run longer on a battery charge than notebooks with Intel and AMD processors, yet Transmeta has much less market share than Intel or AMD. Indeed, there seems to be a perversely inverse relationship between mobile CPU power consumption and mobile CPU market share.

Of course, there are other factors at play, such as marketing muscle and longstanding business relationships. Otherwise, Transmeta could dramatically gain market share by selling a 10GHz Crusoe that burns a kilowatt.

In any case, Intel will have to alter its mobile strategy before it hits a wall with TDP. Traditionally, Intel has repositioned its desktop processors as mobile processors after making a few tweaks, such as deeper sleep modes and lower voltages. That strategy yields diminishing returns as skyrocketing clock frequencies, large die sizes, gate leakage, and other factors inflate power consumption to unprecedented levels. Intel's competitors are victims of the same technology trends, but their chips are much smaller, so the TDP wall is further away.

Intel hopes Banias will redefine the mobile-processor market in 2003. It's a realistic expectation. As Intel's first x86 microarchitecture designed specifically for mobile PCs and lower power consumption, Banias threatens to radically alter the watts-per-megahertz balance of power that Intel faces against the smaller Athlon and power-stingy Crusoe chips.

Price & Availability

Intel's 11 new speed grades of mobile PC processors are available now at prices ranging from $144 for 700MHz to $562 for 2.2GHz in 1,000-unit quantities. For more information, visit *www.intel.com*. AMD's mobile Athlon XP 2000+ and 1900+ are available now at $345 and $239, respectively, in 1,000-unit quantities. For more information visit *www.amd.com*.