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SGS Puts 486 PC on a Chip

Aimed at NCs and Other Embedded Applications

by Jim Turley

The most powerful PC-on-a-chip to date, the STPC Consumer merges a 486 CPU with enough peripheral logic to make an entire PC with little more than added memory. The new SGS-Thomson chip goes further than other integrated x86 parts, such as AMD's Elan, in reducing chip count to the absolute minimum while providing full PC compatibility. The device is underpowered for desktop computers, however, or even notebook PCs. Instead, SGS-Thomson is eyeing network computers, Internet-enabled TVs, and point-of-sale terminals—all line-powered systems with large monitors and an interest in PC compatibility.

The first device is sampling now at 66 MHz. SGS-Thomson (ST) plans to ramp the clock speed to 133 MHz by 1Q98, with production coming later in 1998. The first product based on the STPC, a home entertainment system for the Chinese market, is due to ship before the end of this year.

The closest competitor to the STPC Consumer is Elan. Both provide similar performance, but the STPC offers more integration for about the same price. In particular, ST's chip features video input and direct television output. While Elan provides the basics for a flexible embedded system, the STPC includes virtually a complete PC, with no design decisions left for the user.

Design Based on Cyrix 486 Core

The heart of the STPC is a 486DX CPU core. This core is not an original ST design but is Cyrix's 486DX2, called the M7 before its release four years ago (see MPR 8/23/93, p. 1). Like most Cyrix parts, it's a bit different than its Intel or AMD counterparts. Specifically, the Cx486DX2 has no dedicated internal address adder. As a result, the chip is one clock slower than Intel or AMD chips on instructions that calculate addresses, such as jumps, calls, and memory-based operations. Apart from that, the CPU is similar to any other 486DX, complete with an FPU and an 8K unified cache.

SGS-Thomson altered the CPU core for its 0.35-micron HCMOS-6 process, reducing the core size to 51 mm^2. In the redesign, the French/Italian company widened the core's memory bus to 64 bits, doubling the bandwidth for cache misses and memory accesses. ST owns the new design and has full and unrestricted rights to the new core.

External Buses Include PCI, ISA, and IDE

Wrapped around this core is an 8K write-back cache, an eight-entry write buffer, and several bus interfaces. As Figure 1 shows, the chip's external interfaces include PCI, ISA, and EIDE buses, a 64-bit DRAM interface, video input and output ports, and miscellaneous interrupt and DMA signals.

The 32-bit PCI interface includes arbitration logic for three external devices and runs at a fraction of the chip's core frequency, up to 33 MHz. The PCI bus is also bridged internally to a 16-bit ISA controller, providing an interface to common 8- and 16-bit peripherals. The chip's own peripheral controller resides on the PCI bus and in-cludes an EIDE interface for hard disks and CD-ROMs, seven 8237-compatible DMA channels, three 8254-compatible timers, and

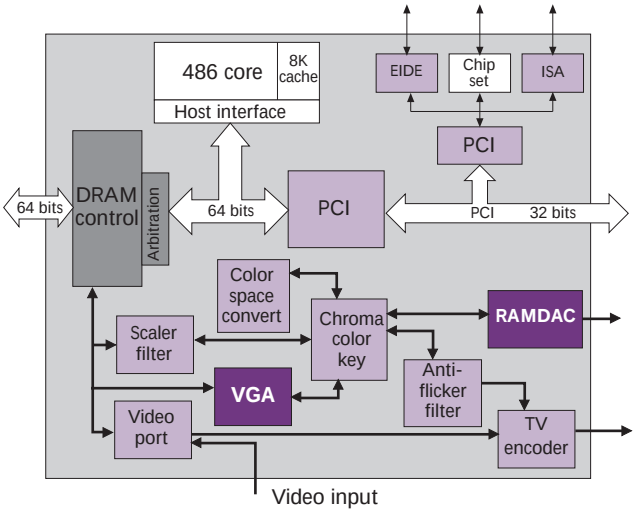

Figure 1. SGS-Thomson's STPC Consumer chip integrates virtually an entire 486-based PC onto a single chip.

8259-compatible interrupt control—in short, everything a PC motherboard needs.

Everything, that is, except the keyboard, mouse, and floppy-disk controller. Even with all the STPC's integrated logic, a full system needs a "super I/O" chip such as National's 87336, as Figure 2 shows. SGS-Thomson didn't integrate these obvious functions because of their high pin count. In future variants of the chip, the mouse, keyboard, floppy, serial, and parallel I/O interfaces will likely be incorporated.

Chip Goes Beyond Graphics to Video Input

While the CPU core was licensed from Cyrix, the graphics and system logic came from Weitek. Weitek's W464 was the first core-logic chip set for 486-based PCs to support a unified memory architecture (UMA). The original two-chip set (see MPR 6/19/95, p. 6) included a system-logic chip and a graphics controller that communicated over a 64-bit bus.

Unfortunately for Weitek, the W464's market timing was bad. By late 1995, the desktop market had moved to Pentium, and the W464 didn't have LCD or low-power support for notebook makers. A planned follow-on version, the W564, evolved into the STPC's graphics controller.

Integrated onto the STPC, Weitek's video controller offers just about everything a designer could want. Display resolution can be up to 1024 × 768 with a 75-Hz refresh rate and up to 32 bits per pixel. The part has no 3D acceleration, but does offer a fair level of 2D Windows acceleration.

The most interesting enhancement ST made to the graphics controller is the addition of a television output with color-space conversion, flicker filter, and PAL/NTSC encoder. The chip is able to drive a monitor, a television, or both. BIOS firmware detects the presence of a monitor via the DDC interface; if no monitor is connected, it automatically enables the TV output controls. Output can be routed to the internal 75-Hz RAMDAC or to the 4:2:2 YCrCb color converter with an antiflicker filter.

The chip also has a video-input port. Video input streams are routed to an off-screen video buffer. During output, the graphics and video content are merged after the video is scaled and color-converted. The video can also be chroma- or color-keyed. The chip comes with Macrovision copy protection to discourage piracy of video material.

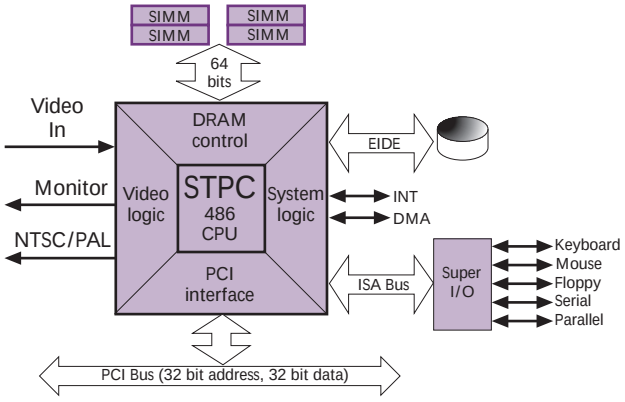

Figure 2. The STPC Consumer requires only a common super I/O chip and memory to build a complete system.

Memory Interface Handles FPM, EDO SIMMs

The STPC's DRAM interface directly manages 2–4 standard SIMM sockets. Sockets may be populated singly or in pairs, with fast-page-mode or extended-data-out (EDO) devices; the chip automatically detects the quantity and type. Parity SIMMs are allowed, but the processor itself does not support parity. Overall memory capacity ranges from a minimum of 2M to a maximum of 128M, given current SIMM availability.

A variation of the STPC that supports synchronous DRAM (SDRAM) in addition to FPM/EDO is planned for 1998.

Power, Size Kept to a Minimum

Power management was one of the design concerns of the ST engineering team. The chip complies with the APM (advanced power management) standard, so the BIOS and OS can shut off portions of the chip as needed. The chip also includes three timers to detect progressively longer periods of inactivity; control logic then places the device into standby, doze, or suspend mode.

ST estimates the power consumption of the 66-MHz STPC at 3.0–3.5 W under typical workloads. While this seems a bit high for a 3.3-V chip running at a mere 66 MHz, the chip does include a large amount of power-hungry system logic. A full system, with DRAM, BIOS, and super I/O controller would dissipate about 4–5 W. This is much less than a normal

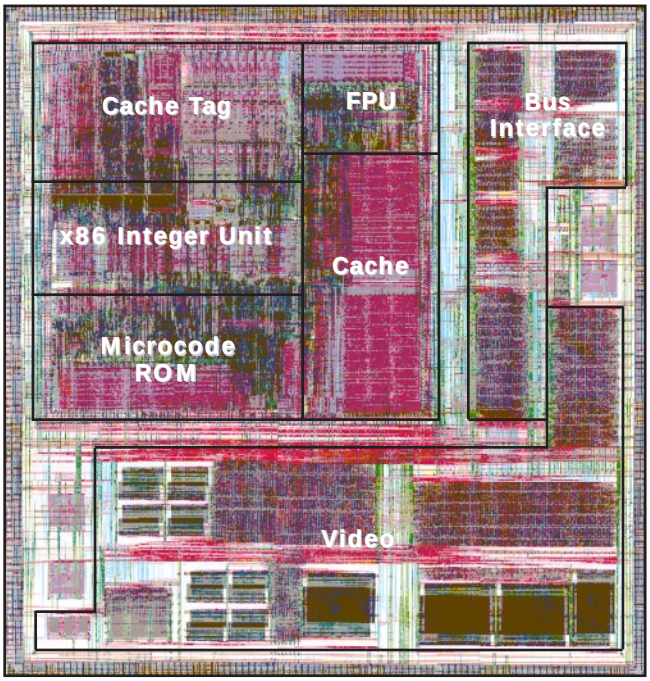

Figure 3. SGS-Thomson's STPC measures 144 mm^2 in ST's 0.35-micron four-layer-metal process.

PC motherboard consumes and well within the acceptable range for most line-powered applications.

The chip is housed in a 388-contact plastic ball-grid array (BGA) package. At 66 MHz, the part needs no exotic heat-dissipation measures. The 100-, 120-, and 133-MHz parts, however, will be packaged in a slugged version of the plastic BGA; the slug will contact the printed-circuit board, where a heat spreader should be mounted.

In ST's 0.35-micron process, the entire chip measures 12 × 12 mm. As Figure 3 shows, roughly two-thirds of the die is devoted to peripheral logic. The part is built using five metal layers, although the CPU core uses only four. The 3.3-V chip handles 5-V I/O for compatibility with PC peripherals.

For testing, the chip can adopt a 486DX bus interface. The part's I/O pins are multiplexed with its internal 486-compatible bus and, with just a physical adapter, the STPC can be inserted in any 486 socket and run 486 test vectors.

Performance Plans From 66 MHz to 133 MHz

ST plans to offer the STPC in four speed grades: 66 MHz (with a 66-MHz bus), 100/50 MHz, 120/60 MHz, and 133/66 MHz. These "bus" speeds, however, are purely internal, affecting only the bandwidth between the CPU core and the on-chip peripherals. The external buses, such as IDE and ISA, always run at their accustomed frequencies.

The performance of the not-yet-sampling 133-MHz version is equivalent to a 90-MHz Pentium, according to the company's simulations. It is also equal to AMD's 486DX5-133, which has a nearly identical CPU core and cache structure. Interpolating from that point suggests the performance of the current 66-MHz version is something below that of the original 60-MHz Pentium. SGS-Thomson expects to have hard benchmark data in another 2–3 months.

The overall system performance of the chip should be somewhat better than that of a 486DX2-66 PC of yesteryear because of the STPC's wide internal bus. PCI and ISA performance should not change relative to a standard PC, but the 64-bit interface to external memory should more than make up for the bottleneck inherent in UMA designs.

Future Growth Calls for More Speed, Peripherals

In addition to producing faster speed grades in the coming months, ST plans to alter the peripheral mix of the STPC to address particular markets. PCMCIA, USB, 1394 (FireWire), and serial and parallel ports are all on the short list of possible enhancements. The company's business strategy is to produce a small number of standard parts for specific markets and allow high-volume customers to specify derivatives.

To increase performance further, SGS-Thomson will first move the STPC family to a 0.25-micron process, boosting its speed to an estimated 200 MHz. After that, the company will have to break away from its aging 486 core. ST's intention is to have a Pentium-class core in 1999. Two possible paths to this goal would be to license Cyrix's 6x86 core (see MPR 10/25/93, p. 1) or to take advantage of ST's recent acquisition of Metaflow (see MPR 6/23/97, p. 4).

Price & Availability

At 66 and 100 MHz, the STPC Consumer is sampling now; production is scheduled for 4Q97. The 120- and 133-MHz versions will begin sampling in 4Q97, with production in 1Q98. In extremely large quantities (one million units), SGS-Thomson is quoting prices of "under $40" for the 66-MHz device.

For more information, contact SGS-Thomson (Lincoln, Mass.) at 617.259.0300 or SGS-Thomson (Rousset, France) at 33.42.25.88.00, or point your Web browser to *www.st.com/stonline/news/p696nt.htm*.

STPC More Integrated Than Elan

SGS-Thomson is not the first company to try its hand at highly integrated x86 processors. After a string of failures in the early part of this decade, Elan and National's NS486 family have emerged as the only ones with any measure of success.

The two 486-based Elans (see MPR 10/28/96, p. 5) are less highly integrated, swapping the FPU, video interface, PCI, and IDE for serial, parallel, and keyboard I/O. The STPC boasts a 64-bit bus; Elan, like most 486s, has a 32-bit bus. Both firms are shipping at 66 MHz, but only ST has publicly announced a roadmap to higher frequencies. Both sell for $45–$50 in 1,000-piece quantities. The NS486SXF and 'SXL (see MPR 9/11/95, p. 1) are much cheaper but also much slower, and they don't offer full PC compatibility.

ST has announced one customer so far: Sichuan Ding Tian Microelectronics. The Chinese company plans to build low-cost, PC-based "entertainment systems" as part of a government-backed project for the domestic consumer market.

The IBM Personal Computer has become just another design macro. By integrating even more functions than the original Model 5150 motherboard, SGS-Thomson has nudged the idea of the completely embeddable PC forward. The STPC allows anyone to build a network computer, Internet TV, or set-top box with a simple bill of materials. Ironically, software compatibility with the PC probably will not be important in these systems. The STPC is simply the quickest and most convenient way to create an embedded system.

It's not the cheapest way, however, nor will it yield the fastest system. This chip makes the most sense for systems that will see moderate volume but have stringent time-to-market pressures. Any number of other CPUs offer better price/performance, but few can touch the tool support and basic design simplicity of a PC on a chip. The tradeoff here is ease versus cost-effectiveness. For makers of automated kiosks, terminals, and NCs, the STPC offers designers a fast track to working hardware. M