



Intel's SL Enhanced Intel486(TM) Microprocessor Family

Intel's SL Enhanced Intel486™ Microprocessor Family Technical Backgrounder

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With the announcement of the SL Enhanced Intel486™ microprocessor family, Intel Corporation brings energy efficiency to its entire line of Intel486™ microprocessors. SL Technology, originally developed for mobile PCs, now provides superior power-management features for desktop computer systems. Such energy-efficient systems will be designed to meet or exceed the Energy Star guidelines set by the Environmental Protection Agency. The EPA's Energy Star program is aimed at reducing power consumption of desktop computer systems, thereby reducing their impact on the environment. In addition, SL Enhanced Intel486™ microprocessors will enable a new class of notebook systems -- high-performance Intel486™ DX2 CPU-based notebooks with color displays that do not sacrifice battery life.

The SL Enhanced Intel486™ microprocessor family is available in a complete range of price/performance, package and voltage options. This flexibility allows PC makers to develop products that meet the mobile and desktop needs of all their customers in the mobile and desktop markets, from low-cost, entry-level Intel486™ SX microprocessor-based systems to high-performance, high-end Intel486™ DX2 microprocessor-based systems. Since the SL Technology in SL Enhanced Intel486™ microprocessors is the same as in Intel SL CPUs, computer manufacturers with prior experience developing systems based on existing SL BIOS will be able to incorporate System Management Mode's (SMM) power-management features into new systems. SL Technology is being added to the SL Enhanced Intel486™ CPUs at no price premium over the existing Intel486™ microprocessors, encouraging system designers to utilize the SL Technology features.

Power Management Comes to the Desktop

Intel's **SL Technology** consists of a number of microprocessor features that deliver superior power-management capabilities. These features operate at two levels: at the system level, controlling the way power is used by the entire system (including peripherals); and at the microprocessor level. Power management at these levels involves putting the CPU into low-power state during non-CPU intensive tasks (such as word processing), or into a very low-power state when the computer is not in use ("sleep" mode.)

SL Technology allows computer manufacturers to design intelligent power-management features in hardware, making the feature independent of software. Power management becomes an integral part of the system, regardless of what operating system or application is being used. Power management works better because SL Technology protects the power-management features from conflicting with software.

System-Level Power Management

At the system level, Intel's SL technology centers on Intel's **System Management Mode (SMM)**, an operating mode first introduced in Intel's SL family of microprocessors (the Intel386™ SL and Intel486™ SL CPUs), which has become a standard in the notebook market. SMM provides intelligent system management that allows the microprocessor to slow down, suspend, or completely shut down various system components so as to maximize energy savings.

The CPU enters SMM upon reception of a **System Management Interrupt (SMI)**, the highest priority non-maskable interrupt the CPU can receive. When an event generates an SMI (the standby button on a notebook is pressed, or a timer indicates an energy-efficient desktop is idle), the CPU responds by saving the current state of the processor (i.e., the software currently running) to a dedicated area called **SMRAM**, to which operating systems and applications do not have access. The CPU then switches into SMM and executes the SMM power-management code, which is also stored in the SMRAM. Once the task for which normal operation was interrupted is complete, the SMI handler executes a RESUME instruction, which restores the former state of the processor by copying its "context" from SMRAM.

In this way, SMM operates transparently to operating system and application software. This means the user does not have to worry whether new or existing software will conflict with the power-management operation. The system hardware can provide the same power-management capabilities whether DOS*, UNIX or Windows* is used. The user is also freed from acquiring different power-management software drivers whenever upgrading to a new revision of an operating system or installing a new application. SMM enables computer manufacturers to provide users with worry-free power management.

Power management works better with SL Technology because SMM protects the power-management features from other software. Early notebooks that did not have SL Technology often experienced problems with power management. These notebooks would often crash when returning from sleep modes if Windows was being used. These problems were eliminated on Intel486™ SL microprocessor-based notebooks because SMM prevents conflicts between power management and software.

Although the initial use of SMM in desktop systems will be in the area of power management, the intelligent system management it provides will also prove useful in other areas. For example, system designers can use SMM to build password protection into the system hardware at the firmware level that is independent of any operating system.

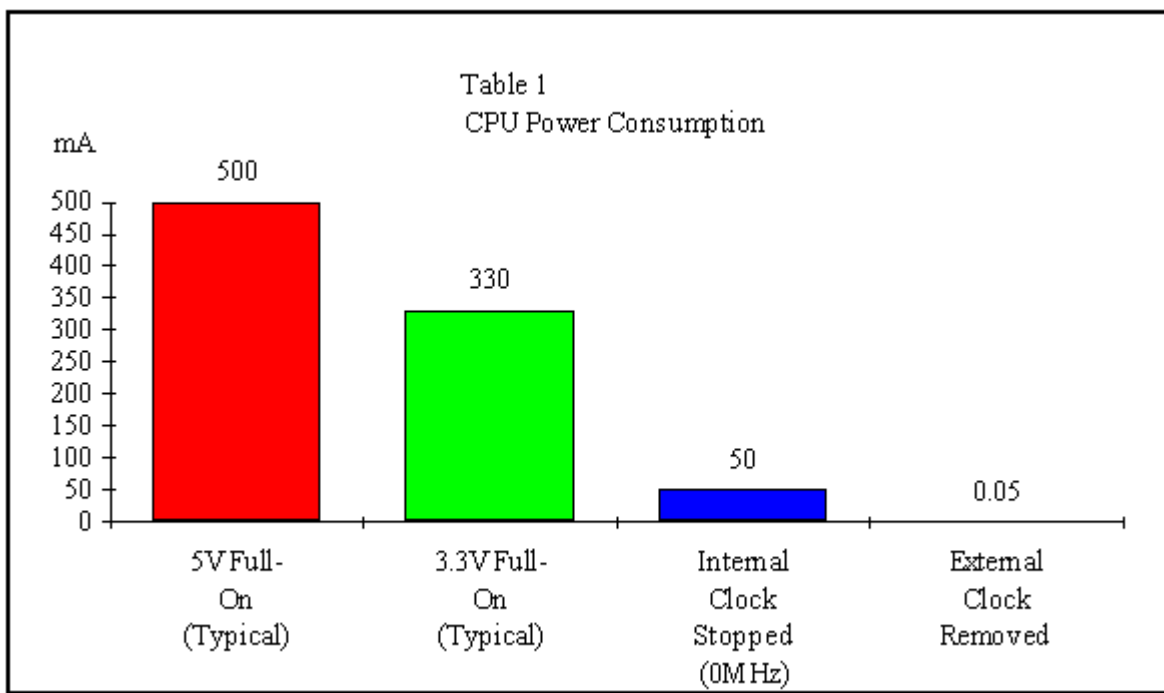
CPU-Level Power Management

The SL Enhanced Intel486™ CPU family incorporates power-saving technology at the CPU level beginning with the manufacturing process; the chips are implemented with fully static CMOS process technology. This **static design** allows the CPU frequency to be reduced to 0 MHz, where the CPU uses very little power. In addition, **3.3 volt** versions of the CPU are available. These 3.3 volt SL Enhanced Intel486™ CPUs use less than half the power of the 5 volt versions, providing significant increases to notebook battery life.

One of the SL Technology features used to manage the power consumption of the CPU is **Stop Clock**. Stop Clock is a microprocessor input that provides fine-tuned control over the CPU's clock frequency, enabling a variety of energy-conservation techniques. When Stop Clock is enabled, the internal frequency of the CPU can be lowered to 0 MHz, causing the CPU to consume only 20-50 milliamps or less than 0.25 watts when the stop clock is asserted; when the clock is taken away, the processor power consumption drops to the micro amp range. This is the CPU's low-power sleep mode, needed when the PC is put in its sleep mode to meet the Energy Star guidelines. Stop Clock also allows the CPU to return to "full-on" state within microseconds--a necessity for desktop systems that are, for example, connected to a network.

With Stop Clock enabled, the external clock frequency can also be removed altogether (for example, when the system is left unattended for a set period of time) lowering power consumption to the micro

amp range, resulting in even greater power savings. This additional level of power saving is especially critical in battery-operated notebook systems, since every extra minute of battery life is precious. The ability of Stop Clock to vary clock input and CPU speed results in dramatic power savings. Table 1 shows the effect of clock control on the energy usage of a 33-MHz SL Enhanced Intel486™ microprocessor. Note the savings in power usage when the clock is slowed or stopped altogether.



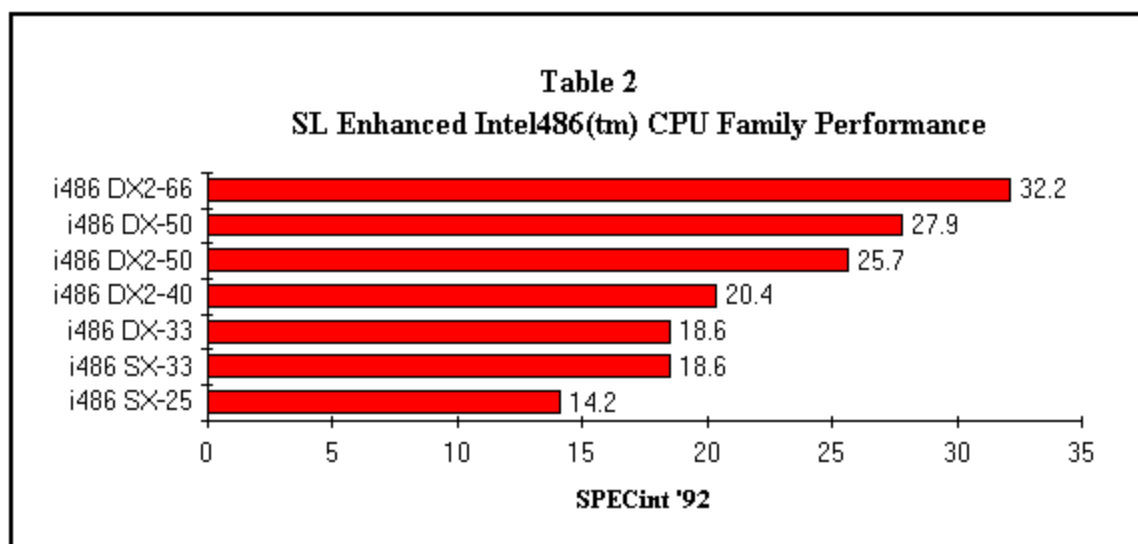
Another approach to CPU power management involves the **Auto Halt** feature, an enhancement of the existing HALT instruction of Intel486™ CPUs. In SL Enhanced Intel486™ CPUs, when a HALT is executed (stopping the CPU from executing further instructions) the CPU automatically enters its low-power (20-50 milliamp) sleep mode. This software approach to invoking sleep mode provides savings of up to four watts over the standard Intel486™ microprocessor HALT instruction.

A new SL Technology feature for the SL Enhanced Intel486™ DX2 microprocessor is **Auto Idle**, which reduces the internal clock frequency of clock-doubled CPUs when the CPU is idle during a memory or I/O read or write. For example, when the CPU is writing information to a disk drive, a clock-doubled 66-MHz CPU is slowed to 33-MHz during idle cycles, resulting in immediate 50 percent power savings, during disk activity, without affecting the system's performance. On average, a SL Enhanced Intel486™ DX2 CPU will use 10 percent less power due to the Auto Idle feature. This savings occurs automatically, without an impact to performance or a need to be controlled by the system or software.

Flexibility in Design

Manufacturers of notebook and desktop computer systems will find a complete range of SL Enhanced Intel486™ CPUs to meet every design goal.

SL Enhanced Intel486™ CPUs will be available in implementations ranging from Intel486™ DX2 CPUs, providing the maximum performance for mobile and desktop systems, to Intel486™ SX CPUs for low-cost, entry-level systems. These CPUs will be available in a range of speeds, from a 25-MHz Intel486™ microprocessor to a 66-MHz Intel486™ DX2 microprocessor. Intel is also now offering a new level of 3.3 volt performance with the new 3.3 volt, 40-MHz Intel486™ DX2 microprocessor. Refer to Table 2 for performance comparison for the entire SL Enhanced Intel486™ microprocessor family.



Note: These measurements were made on a desktop system with second-level cache. SL Enhanced Intel486™ CPUs will be available in versions operating at 5 volts (currently the standard for desktop systems) and at 3.3 volts (rapidly becoming the standard for notebook systems). The 3.3V versions provide up to a 50 percent saving in power over the 5 volt version. 3.3 volt SL Enhanced Intel486™ CPUs enable notebooks to have the longest battery life -- long enough for up to a full day's work. Finally, Intel's SL Enhanced family of CPUs will be available in a variety of packages for a broad range of form factors. They include PGA (Pin Grid Array) to provide upgradability and universal motherboard capability for desktop systems; Plastic Quad Flat Package (PQFP), for compatibility with the existing i486™ CPU family; and SQFP (Shrink Quad Flat Package), a package that is over 40 percent smaller in volume than PQFP, making it ideal for notebook computers. The pinouts of SL Enhanced Intel486™ CPUs are supersets of the existing Intel486™ CPUs, making them plug-in compatible. Table 3 shows the various speed, voltage, and package options available in the SL Enhanced Intel486™ CPU family.

High-Performance Power Management

The Intel SL Enhanced Intel486™ microprocessor family provides superior power management for desktop computer systems, while providing increased design flexibility for notebook systems. It will allow vendors to achieve dramatic energy savings without sacrificing performance, in a fashion that is completely transparent to operating systems and application software.

SL Technology will be built into all future Intel microprocessors, and SMM has already been incorporated in Intel's newest high-performance CPU, the Pentium® processor. SL Technology provides scalable power management for systems ranging in size from hand-held portable units to high-performance servers. Power management and energy efficiency are now, and will be in future implementations, standard features of the Intel architecture.

Product Offerings

SL ENHANCED i486™ CPU	VOLTAGE	CPU FREQUENCY		168 PGA	208 SQFP	196 PQFP
i486 DX2	5V		NEW* 40	50	66	X
	3.3V					X
i486 DX	5V		33			X
	5V			50		X
	3.3V		33			X
i486 SX	5V	25	33			X
	3.3V	25	33			X

DESKTOP FOCUS: 5 Volts, 168 PGA
MOBILE FOCUS: 3.3 Volts, 208 SQFP

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