Low-Voltage Chip Sets Emerge for PC Laptops

Memory and Peripherals Still a Bottleneck

By Mark Thorson

All of the necessary parts-CPU, DRAM, system logic, and peripherals-for building PC-compatible systems running at 3V or 3.3V are nearing reality. The reduced power consumption of low-voltage systems makes them attractive for battery-operated laptop and smaller computers. Vendors have announced parts for each function, and many are sampling. Premium DRAM pricing and lack of a key component, the floppy disk controller, appear to be limiting factors on widespread adoption of low-voltage technology, but this is likely to change by early next year.

First to arrive will be hybrid systems, in which the CPU, DRAM, and system logic run at 3V or 3.3V but the expansion bus and possibly some peripheral chips run at 5V. This is necessary for any systems that have AT-compatible slots, so hybrid systems will continue to exist long after the introduction of pure low-voltage systems.

Pure low-voltage systems won't have an AT bus and might not have slots at all. Systems with slots are likely to use the PCMCIA interface which was developed for memory cards, but is now being expanded for use as a peripheral bus. Originally specified for 5V, a 3.3V version of the PCMCIA interface is in development.

To a large extent, the PCMCIA interface can satisfy the need for an expansion bus. It can be used for memory expansion and-with the use of flash memory cards-it can provide nonvolatile file storage, albeit at a high price. I/O devices such as modems, LAN interfaces, and even hard disk drives can be added using the PCMCIA interface.

Other devices typically connected to an expansion bus, such as display and peripheral controllers, can be integrated into the motherboard. Laptops come with built-in displays and mass storage peripherals, so these functions don't require expansion slots. The greatest demand for expandability among low-voltage laptops will be for communication options, such as fax modems, and 3.3V modem chip sets are now emerging.

Low-Voltage CPUs

Table 1 compares the 386- and 486-compatible CPUs available at low voltage. All parts are specified for operation at 3.3V, except Cyrix's Cx486SLC-V25 which has a true 3V power specification-it can operate down to 2.7V (i.e., 10% below nominal voltage). Cyrix's foundry-Texas Instruments-has recently begun second-sourcing the Cyrix ships at significantly lower quoted prices, although negotiated pricing is likely to be comparable. Intel's 386SL is an integrated CPU/system logic chip designed specifically to work with a proprietary companion chip, while the other CPUs are "discrete" processors used with system logic chip sets. Chips and Technologies doesn't offer a 386- or 486-family CPU for low-voltage operation, although its PC/CHIP, an integrated CPU/system logic chip based on an 8086-like core CPU, is available in a 3V version.

Note that the clock speeds listed are the maximum speeds available at low voltage; these speeds are lower than the maximum speeds at 5V because these are 5V designs which have been recharacterized for low-voltage operation. The exception is Cyrix's Cx486SLC which was originally designed for operation from 3V to 5V.

Table 2 shows the price premium charged for representative parts meeting the low-voltage specification. The price premium for Intel's 3.3V parts has dropped dramatically in the past few months; there is now no price premium for the low-end, 16-MHz 386SL.

Table 3 compares the power reduction going from 5V to

Vendor	Part Number	Clock Frequencies (MHz)	Max. Active Power (mW)	Price (1K qty.)	Availability
Intel	386SL	16/20	940/1072	$45/$70 (no cache) $86 (cache, 20 MHz)	Samples—Now Prod.—4Q92
Intel	486SX	16/20/25	858/957/1122	$113/$113/$132	Prod.—Now
AMD	Am386SXLV	25	486	$43	Prod.—Now
AMD	Am386DXLV	25	486	$61	Prod.—Now
Cyrix	Cx486SLC-V25	25	840	$119	Prod.—Now
TI	TI486SLC-V20	20	690	$79	Prod.—Now
TI	TI486SLC-V25	25	840	$89	Prod.—Now

Table 1. Price and availability for 386- and 486-family low-voltage CPUs.

3V or 3.3V. The power savings are quite dramatic, because power is roughly proportional to the square of the voltage.

PicoPower, a recent start-up chip-set vendor, claims its chip sets have a power-reduction mechanism that can slash the active power of standard CPUs without resorting to low voltage technology. Unlike standard power-reduction mechanisms-which are only enabled when system is idle-the PicoPower technique can optimize power consumption on a cycle-by-cycle basis while application software is executing.

PicoPower claims that the 4W typical active power consumption of a 486DX operating at 33 MHz and 5V can be cut to about 1.5-2W for real-world applications, without any loss in performance. The actual power consumption using PicoPower's technique is claimed to be 0.5-3.5W, depending on what the CPU is doing. PicoPower declined to provide technical details while their four patent applications are pending.

Vendor	Part Number	Clock Frequency	Price (1K qty., 5V)	Price (1K qty., 3V or 3.3V)	Price Premium (%)
Intel	386SL (no cache)	16	$45.00	$45.00	0%
Intel	386SL (no cache)	20	$45.00	$70.00	56%
Intel	386SL (cache)	20	$63.00	$86.00	37%
Intel	486SX	16	$94.00	$113.00	20%
Intel	486SX	20	$94.00	$113.00	20%
Intel	486SX	25	$109.00	$132.00	21%
AMD	Am386SXLV	25	$37.00	$43.00	16%
AMD	Am386DXLV	25	$53.00	$61.00	15%
Cyrix	Cx486SLC-V25	25	$99.00	$119.00	20%
TI	TI486SLC-V20	20	$59.00	$79.00	34%
TI	TI486SLC-V25	25	$69.00	$89.00	29%

Table 2. Price premium for 386- and 486-family low-voltage CPUs.

Low-Voltage System-Logic Chip Sets

Table 4 compares low-voltage system-logic chip sets. As with the CPUs, the clock frequencies are shown for low-voltage operation, which may be slower than the maximum speeds available at 5V. For most vendors, there is no pricing premium for chip sets specified for low-voltage operation. Notable exceptions are Western Digital and HK Technology, which both charge about a 22% premium for 3.3V versions.

The entry for Headland (now the Headland division of LSI Logic) is a two-chip set consisting of the HT25 system controller and the HT35 power management/peripheral controller; the latter incorporates a number of functions not always provided in a basic chip set, including the keyboard controller, mouse port, serial port, parallel port, IDE interface, real-time clock, and power management functions (see sidebar). Internally, the HT35 uses an 8051-based core processor. Unlike the other chip sets, the HT25 and HT35 were specifically designed for operation at 3V or 3.3V. They are not specified for 5V operation.

HK Technology offers a two-chip solution. Unlike their earlier chip sets, the HK4100 includes the peripheral functions formerly provided in an 82C206.

The power consumption and pricing shown for Oak's OakNote chip set is for the basic two-chip set (OTI-041 and OTI-042). Its power management features are designed to work with a third chip, the OTI-043 LCD display controller.

PicoPower has two single-chip system logic solutions, Evergreen and Evergreen Plus. The former is designed to run at either 3.3V or 5V, while the latter will be a pin-compatible version to support hybrid 3.3V/5V systems. Evergreen supports 25 MHz operation at 3.3V, or 33 MHz at 5V; Evergreen Plus will support 33 MHz at 3.3V.

VLSI Technology's SCAMP II SX chip set for 386SX systems consists of the VL82C315A system controller and the VL82C322A power management chip. A third chip, the VL82C3216 cache controller/write buffer, is added for handling the 386DX and 486SX. This chip interfaces the 32-bit local bus for the CPU and cache (the latter requires external SRAMs) to a 386SX-like 16-bit bus for the system controller.

Western Digital's WD7900LV consists of a three-chip set that includes two serial ports, a parallel port, a

Vendor	Part Number	Clock Frequency	Max. Active Power (mW, 5V)	Max. Active Power (mW, 3V or 3.3V)	Power Reduction (%)
Intel	386SL	20	2625	1072	60%
Intel	486SX	25	2800	1122	60%
AMD	Am386SXLV/Am386DXLV	25	1375	486	65%
Cyrix	Cx486SLC-V25	25	2750	840	70%
TI	TI486SLC-V20	20	2500	690	72%
TI	TI486SCL-V25	25	2750	840	70%

Table 3. Power reduction provided by 386- and 486-family low-voltage CPUs.

Vendor	Part Number	CPU Type	Clock Frequencies (MHz)	Max. Active Power (mW)	Price (1K qty.)	Availability
ACC Micro	2036LV	386SX	20	tbd	$19.50	Samples—Now; Prod.—4Q92
ACC Micro	2046LV	486SX	25	tbd	$45.00	Samples—Now; Prod.—4Q92
Headland	HT25/HT35	386SX	25	tbd	$58.65	Prod.—Now
HK Technology	HK4100	386DX/486SX	25	167	$22.00	Prod.—Now
Oak Technology	OakNote	386SX	25	208	$40.00	Samples—4Q92; Prod.—1Q93
PicoPower	Evergreen	386DX/486SX	25	150	$55.00	Prod.—Now
PicoPower	Evergreen Plus	386DX/486SX	33	150	$65.00	Samples—10/92; Prod.—1Q93
VLSI Technology	SCAMP II SX	386SX	16/20/25	211/264/330	$61.50	Prod.—Now
VLSI Technology	SCAMP II DX	386DX/486SX	16/20/25	317/396/495	$87.65	Prod.—Now
Western Digital	WD7855LV	386SX	16/20/25	1250	$56.00	Samples—Now
Western Digital	WD7900LV	386SX	16/20/25	1350	$66.00	Samples—Now

Table 4. Comparison of system logic chip sets for use with 386- and 486-family low-voltage CPUs.

real-time clock, a floppy disk controller, and a 1K on-chip cache. Their WD7855LV chip set is essentially the same, but lacks the cache. Inclusion of the floppy disk controller may be an important feature for early market entry, because separate low-voltage floppy disk controllers are currently unavailable even as samples.

Late last year, S-MOS Systems announced its SPC2055 floppy disk controller for operation at 3V or 3.3V, but there has been a considerable delay in the availability of samples. Originally planned to be sampling in December of last year, S-MOS now expects to have samples in late November of this year, with volume availability to follow by early first quarter of 1993. National Semiconductor expects to deliver samples of a low-voltage floppy disk controller in the first quarter, but no specific information is available at this time. Standard Micro plans to sample a low-voltage member of their 37C66x family in the first quarter, and NEC plans to introduce a low-voltage version of its µPD72070 in mid-1993.

Lexicon: Laptop, Notebook, Palmtop

Several overlapping terms are used to describe battery-operated systems. Although no definitions are satisfactory to everyone, here is our attempt to sharpen the meaning of these terms:

Laptop-refers to the previous generation of portable systems, which usually weigh ten pounds or more. They often were based on the 286 processor.

Notebook-refers to the mid-range to high-end of the current generation of portable systems. These usually weigh about 4-6 pounds, use a 386SX processor (or better), and have a full-size keyboard with a 480 × 640 display.

Subnotebook-systems with a full-size or slightly shrunken keyboard and display, sufficient for DOS applications such as text editing. These systems may be based on low-end CPUs such as NEC's V30 or Chips and Technologies' PC/CHIP.

Palmtop-very small systems which can fit in a coat pocket, such as Hewlett-Packard's HP95LX or Sharp's Wizard. Data entry is through either a pen or a calculator-like keypad. Some of these systems lack binary compatibility with x86 processors.

Conclusion

On returning from a recent tour of Far East system manufacturers, William Wong (at that time with chip-set vendor Oak Technology, now with AT&T Microelectronics) told µPR he sees DRAM as being the limiting factor to the production of low-voltage systems. The board vendors tell him they see about a 30-70% price premium for low-voltage DRAMs. He expects this premium to evaporate in the near future as DRAM manufacturers ramp up production. Wong predicts appearance of prototypes for hybrid systems at the fall 1992 Comdex, with volume shipments in 1Q93; he thinks pure low-voltage systems won't appear until fall Comdex in 1993.

Robert H. J. Lee, president and CEO of PicoPower, is skeptical that low-voltage systems will become a significant part of the PC market until 1994. He points out that the main power sinks in a laptop are (in descending order) the LCD backlight, the hard disk drive, and the CPU. Of these, only the CPU benefits from reduced voltage. The power consumption of the disk drive is largely unaffected by lower voltage, while the power consumption of the LCD backlight increases. (Fluorescent backlights require high-voltage AC power. The converter to generate this power from 5V DC typically has a conversion loss of 15-20%, which rises to 20-30% for low-voltage systems.)

Lee also questions the advisability of running a system directly off unregulated battery power. Although this seems to be one of the advantages of low-voltage systems (especially 3V systems, as opposed to 3.3V), Lee argues that variations in battery output make this an unreliable alternative to the more conservative approach of using 7.2V or 12V battery power with a 5V regulator.

Lee's observations make a good case against low-voltage technology in traditional PC systems. The case for pure 3V or 3.3V systems is most compelling for low-end systems in which there is no disk drive or backlit display. However, it seems inevitable that low-voltage technology will become a standard feature among higher-end portable computers-at least for the CPU and memory-even if the system-level power savings are small. ♦

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Embedded Micros Support Low-Power PCs

A few vendors of PC system logic components have recently introduced integrated peripheral chips based on 8-bit microcontrollers. An independent CPU allows power-management strategies in which the host CPU can be completely shut down, while the microcontroller scans the system for events that justify waking up the system. It can also implement simple background tasks such as monitoring battery power and controlling recharge rate. All of these microcontroller-based peripheral chips are available for operation at 3V or 3.3V.

Motorola offers the LapKat, based on programmed versions of standard 68HC05-family parts. Programmed for use as a peripheral, it offers an 8042-compatible keyboard controller, keyboard matrix scanner, 6818-compatible real-time clock, two serial ports, parallel port, IDE interface control, and power management features. The source code for LapKat is provided essentially for free, subject to license restrictions, as a baseline design from which customers can develop their own customized solutions.

The Headland division of LSI Logic offers the HT35, a custom chip based on an 8051-compatible core from LSI's design library. It is designed to work with Headland's HT25 system logic chip for 386SX-based systems. Its features are very similar to Motorola's LapKat. It costs $21.10 in 1K quantity and is available now.

Hitachi has recently introduced the H8/3332 IKAP (Intelligent Keyboard and Power Management), based on an H8-family core processor. It provides an 8042-compatible keyboard controller, keyboard matrix scanner, keyboard and mouse ports, and power management features. It costs $9.50 in 10K quantity and is expected to begin sampling in October.

