Faster is better—no doubt about it. But accelerating a PC to AT speeds is no solution if it creates more problems than it solves.

ACCELERATOR Boards

POWER FOR A PRICE

The PC AT is a real spoiler. If you use an AT at work and a PC or XT at home, you know how tough it is going back to your old machine. You've probably grown accustomed to the difference in the keyboards, but you'll never get used to the difference in speed. Starting with the boot-up and for every minute of use, your PC or XT reminds you how hopelessly outclassed it has become. You almost expect cobwebs to grow across your screen as you wait for the machine to do things that take no time at all on an AT.

Speed is not everything—it's the *only* thing. It is the most important characteristic of a computer's hardware and the only reason to use a personal computer in the first place. Recent trends in hardware and software point up the processing deficiencies of the PC and XT more than ever. As expanded memory boards let spreadsheets break the 640K-byte limit, recalculations seem to take forever. The Enhanced Graphics Adapter has more pixels and more colors and thus requires appropriately faster processing. A sophisticated multi-tasking system, such as *Microsoft Windows*, running on a stan-

Photograph: Les Mercullo

dard PC-XT with an EGA is almost intolerable.

It's not pleasant to realize that a machine you spent good money on has become obsolete. The body's in good shape, but the thing really needs a brain transplant—which is to say, it needs an accelerator, or "turbo," board. Such a board replaces the slow microprocessor and associated circuitry in your machine with something faster.

There is a wide variety of turbo boards to choose from—everything from inexpensive little "no-slot" gizmos to mammoth expansion boards that seem to incorporate another entire computer inside the one you already use. There are even a couple of products for the PC AT (see sidebar "Speed Up Your AT"), but this story is really for the rest of us—those who may eventually get an AT, but who, in the meantime, want to make their existing machines as fast and efficient as they can possibly be.

INTEL'S FAMILY Inside your PC or XT, toward the back of the system board midway between the power supply and the rightmost expansion slot, sits an Intel 8088 microprocessor. The 8088 does the bulk of the processing workload in your machine. Eight years ago, the 8088 was a real hotshot. Now, compared with Intel's entire line of 16- and 32-bit microprocessors (also including the 8086, 80188, 80186, 80286, and 80386), the 8088 is the family slowpoke. The 8088 is still rolling out of bed in the morning while everyone else has already eaten breakfast and gone out the door.

Although this 8088 microprocessor is in a socket on your PC or XT system board, you can't just yank it out and put a faster sibling in its place. None of these other Intel microprocessors is "pin-compatible" with the 8088. The pins that go into the socket do different things. The 80186, 80188, and 80286 processors, in fact, are not even the same size and shape.

The only available microprocessor that is pin-compatible with the 8088 is the V20 from Nippon Electric Corp. The NEC V20 is probably the cheapest way to accelerate the processing speed of PCs and XTs (see "Turbocharging Your PC with the V-Series," *PC Magazine*, Volume 4 Number 26). The trouble is, replacing your 8088 with a NEC V20 improves overall processor speed only by about 5 to 10 percent, which in actual use is hardly noticeable.

The main job of a microprocessor, like the 8088, is to read machine code instructions from memory and execute them. Some of these instructions may also access memory to read and write data. The execution of each instruction requires a certain period of time that is often denoted by a number of clock cycles. I'll soon explain exactly what a clock cycle is, but right now all you have to know is that the fewer clock cycles required to execute the machine code instructions, the faster the machine.

Figure 1 shows a table of a few sample machine-code instructions and the number of clock cycles required to execute them for the various Intel and NEC microprocessors. The 80286 is the microprocessor used in the PC AT. The 80386 clock cycles are somewhat deceptive because of an advanced pipelining technique that that chip uses. Actual execution in the 80386 will be faster than the clock cycles indicate.

■ The 8088 is still rolling out of bed in the morning while everyone else has already eaten breakfast and gone out the door.

The table begins with some simple instructions that have not been improved very much in the later models. The do-nothing NOP (no operation), for instance, continues to take three clock cycles regardless of the microprocessor. The more complex instructions like integer multiply (IMUL) and integer divide (IDIV) show impressive improvement with the more recent microprocessors. The earlier processors executed these instructions using a "microcode" technique, where the individual instruction is executed like a small program. The NEC and later Intel processors incorporate dedicated hardware for these complex instructions. (In actual programs, these instructions are relatively rare, however.)

The clock cycle times represent just the internal execution time of the instruction. If the instruction also has to read or write data in memory, more clock cycles are required. All the Intel and NEC microprocessors shown in Figure 1 (except for the 80286 and 80386) require four clock cycles to read or write a byte in memory. The 80286 and 80386 can do it in two. The microprocessor must also read the instruction from memory before it executes it. This is called an instruction fetch. The overhead involved in fetching instructions is minimized in Intel's 16-bit microprocessors by using an instruction queue that reads in instructions while the processor is doing something else.

Although I said earlier that you can't simply take your 8088 out and put another Intel microprocessor in, many accelerator boards contain the hardware necessary to translate the signals of a faster microprocessor into the signals that your system board expects from the 8088. In effect, the turbo board says, "Step aside, slowpoke! One of your faster siblings is taking over this machine."

CLOCKING THE CPU When I speak of a clock cycle, the "clock" in question is the crystal oscillator that paces the work of the microprocessor. The crystal oscillator generates a square wave of a certain frequency. This frequency is the number of clock cycles per second. The time required for one clock cycle is 1 divided by the clock frequency. The speed of a microprocessor is directly proportional to the clock frequency.

For instance, the clock attached to the 8088 in the PC and PC-XT runs at 4,770,000 cycles per second, or 4.77 MHz. The time required for one clock cycle is 1 divided by the clock speed, or .000000210 seconds, more conveniently referred to as 210 nanoseconds. The NOP instruction shown in Figure 1 requires three clock cycles, or 630 nanoseconds.

The PC AT comes with an 80286 microprocessor and is available with either a 6-MHz or an 8-MHz clock. The corre-

Number of Clock Cycles for Sample Machine-Code Instructions

Machine-code instruction	Description	Microprocessor				
		8086 and 8088	V20 and V30	80186 and 80188	80286	80386
NOP	No operation (do nothing)	3	3	3	3	3
ADD AX,100	Add 100 to register AX	4	4	4	3	2
LEA SI,[BX+DI+1]	Load effective address	14	4	6	3	2
JMP label	Jump to near address	15	13	14	7	7
ROL AX,CL	Rotate AX (CL = 12)	56	19	17	17	7
IMUL BX	16-bit integer multiply	128 to 154	41 to 47	34 to 37	21	9 to 22
IDIV BX	16-bit integer divide	165 to 184	38 to 43	53 to 61	25	27

Figure 1: *The 8088 microprocessor used in the IBM PC and XT has the slowest execution times of all the Intel and NEC 16-bit microprocessors. The differences are particularly large in the more complex instructions such as integer multiply and divide.*

sponding clock cycle times are 167 nanoseconds or 125 nanoseconds, respectively, so the NOP executes in 501 or 375 nanoseconds. That's not much of an improvement, but look at the IDIV instruction: A 4.77-MHz 8088 takes at least 34,650 nanoseconds, while an 8-MHz 80286 does it in 3,125 nanoseconds—more than ten times faster.

As many AT owners have discovered, the crystal oscillator that clocks the 80286 in a PC AT is socketed on the AT system board and can easily be replaced with something faster. This simple speed upgrade is not possible on the PC and XT, however. The PC and XT system board has only one crystal oscillator clocking at 14.32 MHz. This clock speed is divided by 3 to get the 8088's 4.77-MHz clock speed. This 4.77-MHz signal is further divided by 4 to get a 1.19-MHz signal for the real-time clock. The 14.32-MHz signal appears on the expansion bus and is picked up by the color/graphics adapter for the dot clock. In short, the clock speed is just too closely tied in with the rest of the operation of the PC to make it easily replaceable. On the PC AT, however, separate crystals are used for system purposes and to clock the 80286.

But an accelerator board can effectively separate the microprocessor clock from the system clock much like the PC AT does. Many of the smaller accelerator boards do little more than just this (see "The No-Slot Alternative to Acceleration (And Why It Makes Sense)" in this issue). So, even if an accelerator board uses an 8088 like the one you already have in your machine, it can speed up your PC by clocking it faster.

BUT NOT TOO FAST Of course, there are limits. Microprocessors are rated to operate reliably only up to a particular clock frequency. Those processors rated to run at faster clock frequencies are more expensive. Most accelerator boards come with microprocessors that can run faster than 4.77 MHz.

You can determine the speed rating of an Intel microprocessor by a suffix that follows the model number, usually printed right on the chip. As you can see in Figure 2, however, these suffixes are sometimes inconsistent and confusing.

The speed rating of a microprocessor determines only the *maximum* speed at which it can be clocked. When clocked at 4.77 MHz, the regular 8088 (rated at 5 MHz) and the 8088-2 (rated for 8 MHz) will perform identically.

WAIT A FEW NANOSECONDS Aside from the speed limitations of the microprocessor, all the hardware components that the processor must communicate with (including expansion boards, input and output boards, and memory) have their own speed limitations. Even if an accelerator board uses a fast clock and a microprocessor rated to run at that clock speed, it would still come up against obstacles.

Memory is the most serious. Memory chips are rated by access speed in nanoseconds. In various PCs, XTs, and ATs, you'll find memory chips rated for a 250-, 200-, 150-, 120-, or 100-nanosecond access time. An accelerator board must be prepared to deal with slow memory and to do something about it.

The PC AT already does something about it. I mentioned earlier that an 80286 normally requires two clock cycles to read or write a byte in memory. On the PC AT, however, memory accesses actually take three clock cycles. Since the memory on the PC AT system board is not quite fast enough to respond to a two-cycle access time, the hardware of the AT system board inserts a wait state into memory accesses.

Wait states are additional clock cycles that external hardware requests from the microprocessor to effectively slow down

Suffixes Indicating Microprocessor Clock Speeds

5 MHz	6 MHz	6 MHz	10 MHz	12.5 MHz	16 MHz
8088		8088-2			
8086		8086-2	8086-1		
		80188	80188-10		
		80186	80186-10	80186-12	
	80286-6	80286-8	80286-10		
				80386-12	80386-16

Figure 2: *Intel indicates the maximum clock speeds of its microprocessors by a suffix, but the numbering scheme isn't very consistent. These are taken from Intel's 1986* Microsystem Component Handbook.

SPEED UP YOUR AT

Here's how to have the fastest AT on the block.

Like most AT owners, I firmly believe that fast is good and faster is better. But the classic approach to speeding up an AT is to throw in a faster clock crystal, and I've hesitated to do that because of the occasional program that might get confused by the faster clock speed. Besides, I thought the AT was already fast enough.

I was wrong, of course, as proven by the AT TurboSwitch II from Megahertz Corp. and the 287Turbo from MicroWay. Since the issue here was speed, project manager Charles Petzold thought it would be fun to try both products on the same AT at the same time. I agreed; it wasn't my AT we were messing with.

AT TurboSwitch II

The AT TurboSwitch II is a strange-looking contraption with far too many wires leading to various parts of the AT. The TurboSwitch itself fits in a rectangular cutout in the back of the AT system unit. (Does anybody know why IBM put the cutout there?) Once installed, it gives you three new controls to fumble with while reaching into the back of your system unit.

The first control is a toggle switch for shifting between turbo mode and standard AT speed. Because some programs may whiz by too quickly at higher speeds, this switch gives you a significant advantage over changing the clock crystal in the system.

The second control is a reset button. This option is unrelated to the turbo feature, but it is welcome nonetheless—especially for those of us who fondly remember the hardware reset in the days before IBM provided us with the Ctrl-Alt-Del alternative.

The third control is the most interesting. It's a rotary switch that lets you choose your clock speed. All the way up to 12.5 MHz. Like a car speedometer that goes to 250 mph or an odometer with seven digits to the left of the decimal point, the TurboSwitch promises more than it can possibly deliver. The problem isn't with the TurboSwitch but with the AT itself.

As the TurboSwitch manual points out, a chain is only as strong as its weakest link, and a computer system can only go as fast as its slowest component. A 12.5-MHz clock speed far exceeds the rated specifications for the AT, and the odds are high indeed (approaching certainty) that something will cry uncle (or parity error) before you get anywhere near that speed.

TRICKY INSTALLATION Unfortunately, before you can use the AT TurboSwitch II you have to install it, and, if you have large hands like mine, that may be a problem.

As I've already mentioned, the TurboSwitch has far too many wires leading out of it. A so-called easy-hook connector (more on that shortly) clips to the clock crystal. Three more wires run to a connector that fits in the 80287 socket. (An 80287 can plug into the connector, piggyback-style.)

Two more wires run from the reset button. One ends in a grounding lug and goes on the screw that holds the TurboSwitch in place. The other ends in a second easy-hook connector that clips to a pin on the chip in the U108 socket.

The easy-hook connector is an interesting device—think of a spring-loaded hypodermic needle whose "needle" end is bent into a hook. Push the plunger in so that the hooked end comes out, hook the end over a wire, release the plunger—and the connector hangs on to the wire. The only problem is that when you're working in a tight space, such as the inside of an AT, your hand gets in the way, so you can't see whether you're hooking the wire.

SETTING THE SPEED Once it's installed, you simply crank up the TurboSwitch to the highest speed your AT can handle without crashing. In the PC Magazine Labs tests, we managed flaky operation at 9.4 MHz and rock-solid operation at 8.9 MHz. With either setting, the extra speed was immediately obvious just from watching things happen on the screen. During the PC Labs tests, the speeded-up machine consistently clocked in at about 50 percent faster than the standard 6-MHz AT.

(The 8.9-MHz and 9.4-MHz clock speeds were reported by a test program and were slightly different from the markings on the dial-selector switch. The board uses a binary-rate division technique rather than discrete crystals.)

At the 9.4-MHz setting, it appeared that the 80286 was not correctly executing some code, so we decided to replace the 80286 with a 10-MHz version of the chip. This is another fun job and requires

PC MAGAZINE FACT FILE

AT TurboSwitch II
Megahertz Corp.
2681 Parleys Way, Bldg. 2-102
Salt Lake City, UT 84109
(801) 485-8857
List Price: $124.95; utility software, $19.95
Requires: PC AT.
In Short: A switch-selectable clock for your AT's 80286 lets you experiment to see just what speed your AT can tolerate.
CIRCLE **655** ON READER SERVICE CARD

287Turbo
MicroWay Inc.
P.O. Box 79
Kingston, MA 02364
(617) 746-7341
List Price: 8-MHz version, $369; 10-MHz version, $450
Requires: PC AT.
In Short: It won't improve the speed of your 80286, but the 287Turbo corrects a wiring shortcut on your AT system board and runs 80287 math coprocessor operations faster.
CIRCLE **654** ON READER SERVICE CARD

unbolting the hard disk support to get at the socket. The chip was in there so securely that we knew there must be a person on the AT assembly line whose sole job was to install the 80286 in its socket using a 50-pound sledgehammer. With a 10-MHz 80286, the 9.4-MHz speed worked better but still had problems.

287Turbo

While nursing my wounds from installing the TurboSwitch, I bravely moved on to MicroWay's 287Turbo. As the name implies, this gadget is concerned strictly with the 80287 math coprocessor.

What's wrong with the provision for an 80287 already on the PC AT system board? Plenty. IBM chose to wire the 80286 and 80287 together in the simplest manner possible. This method uses the same clock oscillator (12 MHz in a 6-MHz AT) to drive both the 80286 and 80287. The 80286 divides it by 2 (to get the 6-MHz operating speed), and the 80287 divides it by 3, which means that the math coprocessor is working at a pathetic 4 MHz. Since 8-MHz and 10-MHz 80287s are now available, this is a real waste. The 287Turbo simply provides an alternative wiring of the 80287 to clock it independently of the 80286. It is available with either a 24-MHz or 30-MHz crystal to drive the coprocessor at 8 MHz or 10 MHz. We tested the 8-MHz version of the board.

The 287Turbo is a small L-shaped board that plugs into the 80287 socket. To install the 287Turbo, you have to unplug one of the AT's power cables and plug it into the board, then plug a cable from the board into the standard power cable connector. A reset button attaches at the rear hole cover.

In the PC Labs tests, the 287Turbo speeded up floating-point calculation using the 80287 by about 50 percent when used by itself, and speeded it up by roughly 90 percent when used along with the TurboSwitch. The extra speed gained with the TurboSwitch indicates that the test is not 100 percent bound to the 80287, but it may better reflect real-world applications. (The test program was written in C and compiled with the Microsoft C Compiler, Version 3.0.)

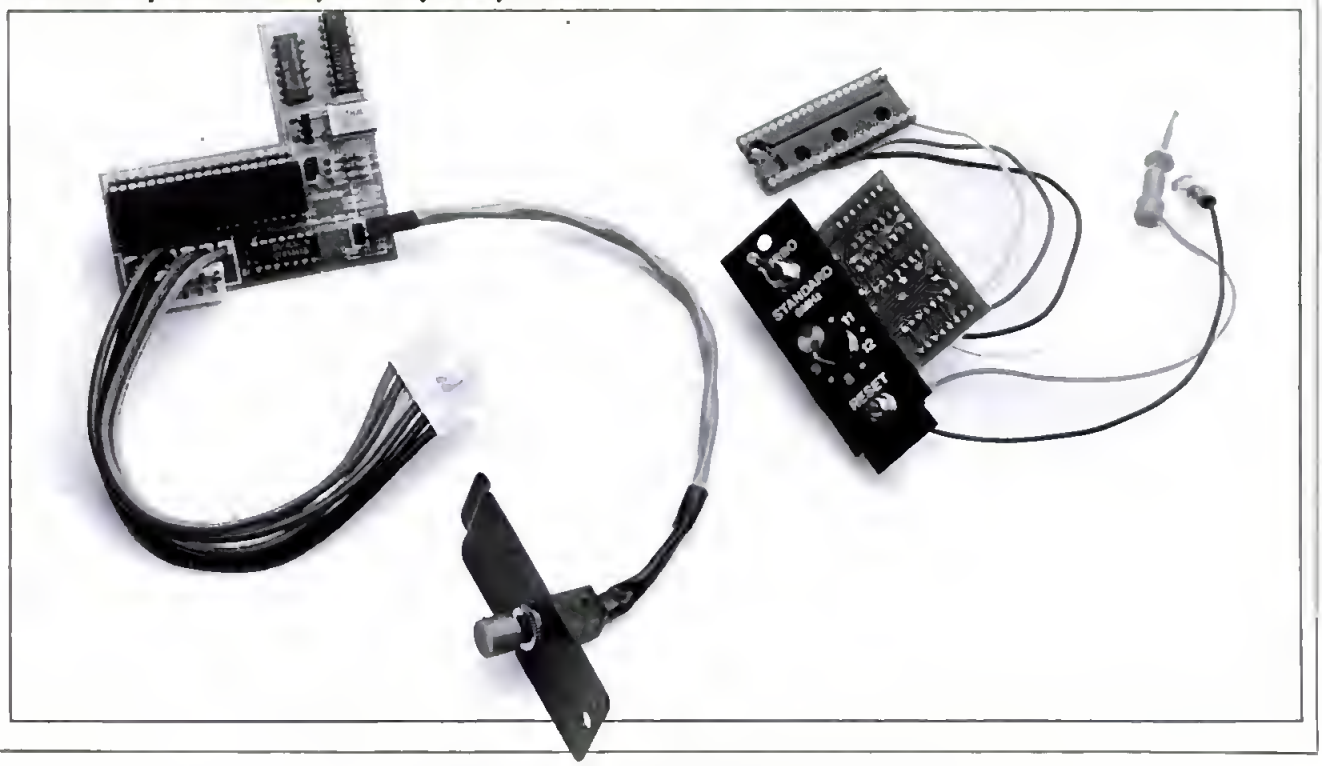
The only problem I ran into with these products was that the additional speed was far too attractive. For the first time, my AT seemed slow, and I'm going to have to do something about that.

These products have also reminded me how nice it is to have a reset button, which brings up an interesting point. According to MicroWay's Stephen Fried, this feature has been responsible for "our largest order to date—from IBM in Boca. They are developing code and need the reset."

Now, if you'll excuse me, I have to go and install something on my AT.

—M. David Stone

If you think your AT is already fast enough, think again. These two little devices, the AT TurboSwitch II (from Megahertz Corp.) and the 287Turbo (from MicroWay), don't exactly use classic approaches to speeding up your AT, but they are good for a fair amount of fun. Only trouble is, once you take them out, your AT may actually seem slow.



Photograph: Thom O'Connor

memory or I/O access. At first impression, a wait state may sound like a crude fix for the problem of incompatible processor and memory speeds, but wait states are a very common part of hardware design. One of the input signals to the microprocessor is dedicated to force the processor to insert wait states into memory accesses.

Accelerator boards are so fast that sometimes they have to insert four or five clock cycles into memory accesses. It may seem as if an 8088 clocked at 9.54 MHz (twice the normal rate of 4.77 MHz) with memory accesses requiring eight clock cycles (four normal and four wait states) would run the same as a 4.77-MHz 8088 with memory accesses in four clock cycles. However, the faster clock guarantees that internal instruction executions will occur more quickly even if memory access does not.

THE DATA I/O FACTOR I've been talking about the pair of microprocessors called the 8086 and 8088 (and the 80186 and 80188) as if they were the same. They are very nearly the same, but only internally. All Intel 16-bit microprocessors can internally manipulate data 16 bits long (often called a "word"). It's how they move this data in and out of the microprocessor that makes the difference.

The 8088 and 80188 speak to the rest of the world (the other components inside your machine, including memory) in 8-bit bytes. When they access data in memory, they do it a byte at a time. The 8086, 80186, and 80286, however, speak in words. They can store or read data 16 bits at a time. The 80386 can access 32 bits at once.

Sometimes word accesses cause a big improvement in speed, but sometimes they do not. The best-case speed advantage of an 8086 over an 8088 clocked at the same speed is precisely double. The worst case is that they will run at the same speed.

For instance, when a word processing program works with text stored in memory, each character takes up 1 byte of storage, so the program will often use byte accesses. For these accesses an 8086 will not show much improvement over an 8088. The opposite extreme is numeric calculations where numbers are often stored in units of words or longer. Instruction fetches also generally occur twice as fast with an 8086 or 80186.

Another way an accelerator board may try to beef up speed is by using an 8086 instead of an 8088. However, this presents another problem, because the rest of your PC or XT is based on byte accesses, and there's not much you can do about it.

The bus through which the processor communicates with expansion boards (including memory) has 62 signal lines: 8 are used for power and grounding, 20 are for the 20-bit address, 2 are clock signals, 6 are interrupts, 7 are involved with Direct Memory Access (DMA), 10 are for timing and miscellaneous uses, and 1 is reserved.

■ Small-size boards don't require a slot and offer little more than a faster clock speed.

That leaves 8 for data. That's a physical restriction.

If an accelerator board uses an 8086, 80186, or 80286, the board itself has to generate 2-byte accesses from every word access coming out of the microprocessor. This process cuts the potential doubling of speed right in half, so you're right back where you started.

Accelerator boards can get around this problem by including their own memory right on the board. They can ignore the memory on your 256K-byte system board and your 384K multifunction board and use 640K of their own memory instead. The 256K memory chips common today let this 640K take up only about a quarter of a full-length accelerator board. Since the microprocessor doesn't have to go through the expansion bus, it can access this memory in 16-bit gulps instead of 8-bit bites.

An accelerator board that uses its own memory has other advantages as well. While an accelerator board may normally have to insert wait states to use memory from your system board or an expansion board, it can avoid these wait states if it uses high-speed memory installed right next to the microprocessor. This configuration allows engineers to cut design corners more closely and get as much speed as possible out of the board. Instead of sending out a signal to the system bus and having it bounce around and shoot up into a lot of old boards, the memory could be just a few inches away. It helps.

However, accelerator boards must then find some way to deal with DMA logic on the system board. The DMA circuitry takes over when a disk access occurs to transport data between memory and the disk controller more quickly. The DMA expects to find the memory on the system board instead of on an accelerator board.

Your PC or XT system board also contains a BIOS (basic input output system) stored in ROM. The ROM is generally slower than random access memory, but it is used extensively for simple screen output and interpreter BASIC. To get around the speed limitation involved in accessing this ROM from the board, some turbo cards have a provision to transfer the contents of this ROM into the memory on the accelerator board.

THE QUICK-CACHE COMPROMISE Of course, once we start talking about an accelerator board with its own 640K bytes of memory, we're starting to talk about big bucks—possibly the type of bucks that tells you it would be best in the long run to buy a PC AT.

There's a compromise approach, however, that often shows up in less expensive half-length boards. These boards include only a very small amount of high-speed memory, generally 4K to 8K. They use this memory for caching.

Here's how they work: When the microprocessor on the accelerator board reads data from system memory in byte accesses with four or five wait states inserted, the board hardware also writes the data into the memory reserved for caching. The next time it reads that data, it need not read from system memory, but it can read directly from the cache with word accesses and no wait states.

At any one time, this cache can hold only 4K or 8K bytes of the total 640K of system memory. It may at first seem as if the cache is just not big enough to signifi-

cantly improve speed. Not true. Memory caching works because most software spends much of its time in small loops, executing the same set of instructions many times over before moving to something else. If any software loop is longer than the size of the memory cache, caching will not work for that loop. But memory caching usually works very well.

However, when improperly implemented, memory caching may cause other problems. For instance, bank-switched memory used in boards supporting the Lotus/Intel/Microsoft expanded memory specification (EMS) cannot work if the EMS section of memory is cached. The accelerator board has no way of knowing that another bank of memory has been selected in the same memory space. Another board with which caching can wreak havoc is the Enhanced Graphics Adapter. Like bank-switched memory, the EGA's 256K bytes are organized into color planes accessible through a single 64K window. The color planes are specified by values written to output ports that the accelerator board cannot interpret.

TYPES OF BOARDS There are, to my mind, three categories of turbo boards for PCs and XTs: small, medium, and large. You can also think of them as fast, faster, and fastest—or cheap, reasonable, and expensive.

In "The No-Slot Alternative to Acceleration (And Why It Makes Sense)," Stephen Davis discusses the small-size boards in more detail. In general, these boards do not require a slot and offer little more than a faster clock speed and perhaps a NEC V20 instead of an 8088. They usually include jumpers to specify different clock speeds or to insert wait states into memory accesses. We reviewed the Maynard Surprise!, Dynatec SuperCharger, MicroSpeed Fast88, Overthruster, and the American Turbo.

The medium-size boards generally require you to put the board into an expansion slot, remove the 8088 microprocessor, and run a cable from the board to the now-empty socket on the system board. Medium-size boards can use anything from a fast 8088 to an 80286 and often include memory caching to supplement the faster processor and clock speed. Those reviewed here include Quadram Quadsprint and SuperSprint, Orchid TinyTurbo 286 and TurboEGA, Microway 286 TurboCache, Victor SpeedPac 286, and PC Technologies 286 Express Card. Also in this category is the oddball Microway 87/88 Turbo Board, which is more like a small card though it takes up a slot.

The large-size boards generally use their own memory and may not even require removing the 8088 from its socket. We tested Earth Computers Turbo Accel-286, Microway Number Smasher/ECM, Classic Technology 286 Speed Pak, Orchid PC Turbo-286e, and the Applied Reasoning PC-elevATor. These boards disable your system board 8088 through a DMA channel and take over your whole system. Sometimes they seem like a whole separate computer in your machine. In fact, some of them may contain the hardware rudiments for multi-tasking and parallel processing. Software support is a whole other matter.

ACCELERATION PROBLEMS IBM's series of personal computers was not designed to allow for easy substitution of the microprocessor or crystal. The installation of a turbo card causes a radical change in the function of a machine. Typically, you can't just put an accelerator board into your PC or XT and then sit back to enjoy the new speed. Chances are, you'll discover problems unlike any you've encountered before. In general, the more complex the board, the more problems you'll find.

Some of these problems arise with applications software that expects to operate at a particular speed. Games are the most obvious example; some of them will present new challenges (and perhaps new fun). Many of the more "advanced" forms of copy protection are also speed-dependent, which may prevent you from using a program at the higher speed. Printer and modem time-outs may be common. Software often uses loops to determine how long to wait for a printer or modem that cannot yet accept more data. If the loop goes too fast, it will terminate prematurely. With some turbo boards, you won't even be able to format a disk.

For very large, complex boards, the problems become more esoteric and unusual. Some of these boards may reveal software bugs that no one has ever found before. For instance, the 80286, in particular, generates several types of internal interrupts that are helpful for an operating system that implements protected mode, but which nobody cares about right now. An 80286 on an accelerator board could easily stumble onto these internal interrupts.

Fortunately, many of the boards can be switched out of turbo mode if trouble arises. The non–turbo mode either operates at the same speed as your PC without

What? No SysInfo?

One test we did not run on the accelerator boards is SysInfo, which is part of *The Norton Utilities*, Versions 3.0 and 3.1. Among other things, SysInfo reports a "Performance Index" of processor speed. A normal PC or XT ranks at 1.0 and a 6-MHz PC AT gets awarded a 5.9, meaning that it's almost six times faster than a PC. A NEC V20 in a standard PC or XT gets a 1.8 from SysInfo, meaning that it's 80 percent faster than an 8088.

These numbers from SysInfo are excessively high. They are higher than anything you'll get from using a PC AT or a V20 and higher than most other measures of processor speed will indicate.

Here's why: The loop that SysInfo times for the Performance Index contains just a few instructions, but among them are an IMUL (integer multiply) and IDIV (integer divide). In actual program machine code, the IDIV and IMUL are fairly rare. They occur in arithmetic calculations, of course, and in array indexing, but you can write entire programs without any IDIV or IMUL instructions at all. Since these two instructions run very slowly on an 8088 and faster on the other Intel and NEC microprocessors, SysInfo greatly exaggerates processor-speed improvement over an 8088.

We told several manufacturers that we would not be running SysInfo for the accelerator boards, and they all applauded our decision. It remains to be seen, however, whether they will continue to use SysInfo results in their advertising.

—Charles Petzold

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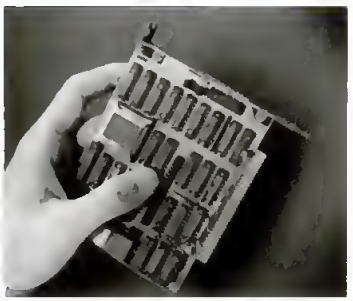

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CIRCLE 352 ON READER SERVICE CARD

PCT
PC Technologies Inc.

The 286 Express Offers AT Speed

By Garry Ray

If you're on the verge of tossing your PC in favor of something faster, hold on a minute: There's an add-on coprocessor that will give you much the same performance of an AT. The 286 Express, from PC Technologies, is probably the most useful "speed-up" board that we've seen to date.

The 286 Express gives complete PC compatibility without the mess and bother of start-up device drivers, memory allocation switches or strange performance limitations that often make other boards too oppressive for the general user. In short, this is the board to consider if you want increased speed and utility for your PC.

At the heart of the unit is an 8MHz Intel 80286 microprocessor, supported by a mere handful of ICs and a 40-pin connector (with cable) that plugs into the slot normally occupied by the PC's 8088. In fact, once you've installed the 286 Express, it will act in exactly the same manner as the 8088, albeit faster. With the assistance of onboard Programmable Array Logic (PAL) chips, the processor obtains a clock speed of 7.2MHz from the 14.3MHz color-burst signal on the PC's expansion bus.

Beyond the speed of the 80286, many of the performance improvements of the 286 Express are due to an on-board 8K-byte memory cache that accumulates instructions from whatever program is running. Since the cache is located on the Express board itself, close to the 80286 microprocessor, PC Technologies was able to force continual program execution with no wait states. IBM's AT, which must seek instructions from relatively distant system memory through the 16-bit system bus, runs with one wait state.

The Express continually monitors program flow and swaps segments of code into and out of the memory cache. For example, if the program has a large 'loop' that can execute within the 8K-byte cache, performance for that section of code will be fairly high—in fact, at the physical limit of processing speed for the 80286 running at 7.2MHz.

If, on the other hand, the program has large, non-contiguous code sections that exceed the 8K-byte cache, then performance will be constrained by the requirement to get that code from the PC memory bus into the cache. In any case, performance will always be markedly better than the PC running with an 8088.

Some programs may run into problems with the cache. Since the cache appears to be system memory, there could be conflicts between what memory the program tries to use (system memory) and what memory the program actually uses (cache memory). Other programs, primarily copy-protection schemes that depend upon the contents of pre-defined memory addresses, will become confused by the cache. To surmount these two problems, the user can disable the cache by removing a single onboard jumper pin, which can be replaced after the task has been completed.

Brief Instructions

After opening the 286 Express packaging, you might be inclined to ask, "Where's the rest?" That's because the entire outfit consists of a half-slot PC board, a chip puller and an incredibly brief 12-page installation and instruction manual.

Typically, this sort of product might include a floppy disk with one or more device drivers, a full-slot board loaded with processors, chips and other electronic circuitry and a tome chock-full of rather technical installation and operational instructions. Not so with the 286 Express—it's a simple plug-and-go performer that dispenses with the normal raft of technical considerations.

To get the board running, you simply remove the 8088 with the primitive but functional chip-puller and insert the 286 Express connector. Caution is the key word here, because the chip-puller is more a scaled-down crowbar than anything else. It is not at all difficult to bend the pins of the 8088 using the device. The same is true when installing the circuit replacement; it's relatively easy to bend the pins of the plug.

However, once the board has been installed, it functions as the PC's main—strike that, only—processor at speeds of two to four times greater than the unadorned PC. In fact, with most applications, the 286 Express turns in processing times even greater than IBM's standard 6MHz AT.

In our tests, we measured the performance of the Express against a number of other coprocessor and "speed-up" boards, in addition to the PC, AT and an AT-compatible running at both 6 and 10MHz. (The standard IBM AT runs at 6MHz.)

The results clearly showed that the Express was not only faster than all the PC add-on boards tested by PC Week, but faster than the IBM AT. In fact, most tests showed the Express running at speeds somewhere between those of the AT at 6 and 10MHz. The conclusion of our tests is that the 286 Express turns in speeds roughly equivalent to those of an AT or compatible running at 8MHz.

On the other hand, disk operations are not greatly affected by the Express. This is not a limitation of the board, but rather a physical limitation imposed by the storage devices themselves. If your hard disk runs at 90 milliseconds average access, then that's all you're going to get—no speed-up board can improve disk performance.

However, since the Express will process disk-bound commands (those that control disk access) faster than normal, there will be some measure of improvement in overall performance of disk-intensive programs. Our Disktest, for example, improved by about 15 to 20 percent solely because of the presence of the Express board.

Compatibility with a variety of peripheral boards was well proven in the four weeks we used the Express. In not a single instance did we experience any problems with add-on boards of any type, including some of the new expanded memory boards, modems and local area network adapters. The Express proved ruggedly reliable, causing absolutely no problems with all the software and hardware we tested.

The 286 Express is an elegant solution to a pressing problem—how to get more bang for the buck from a PC. For many users, it could be the alternative to purchasing an AT, bridging the gap between the PC and the next generation of 80386 machines due in 1987.

But whether you intend to upgrade in the future or not, the 286 Express should prove a handsome solution to any concerns about PC performance. ■

PC WEEK DATABOX

Produet: 286 Express

Category: PC accelerator board

Who should buy: Those desiring increased performance from an IBM PC or XT

Deseription: 286 Express adds increased performance to an IBM PC or XT

Distribution: Retail and direct

Company:
PC Technologies Inc.
704 Airport Blvd.
P.O. Box 2090
Ann Arbor, Mich. 48106
(313) 996-9690
(800) 821-3086

286 Express Benchmark

	Sieve	Video Scroll	Squarea	Lotus 1-2-3 Multiplication	Payments	Squarea
286 Express	13	9	23	4	13	26
PC 4.77MHz	54	11	1:12	10	34	1:25
AT 6MHz	16	7	28	3.5	12	26
AT10 MHz	10	3	17	2	7	17
Orchid PC Turbo	22	5	39	5	16	40

PC Technologies' 286 Express: Turns in speeds comparable to an AT running at 8MHz.

AS SEEN IN PC WEEK

the accelerator board or emulates that operation. Switching between the modes will require a reboot if the turbo board must switch between two different microprocessors. Some boards that can be switched on the fly may include programs or a keyboard combination that handles this switch.

THE COPROCESSOR PROBLEM Right next to the 8088 socket on the system board of a PC or XT is another socket for an optional Intel 8087 Numeric Processor Extension, also called the floating-point math coprocessor. The PC AT has a socket for a similar 80287 chip.

Software can take advantage of an 8087 or 80287 to speed up floating-point calculations. (For instance, *1-2-3*, Release 2, supports an 8087, but Release 1A did not.) Ironically, accelerator boards run into the most problems in offering full support of a math coprocessor. If this is important to you, then you should read very carefully what the reviewers have to say about the boards in this regard.

Part of the problem comes from 8087 and 80287 error handling. An error in the math coprocessor is generated by operations like a division by 0, overflow or underflow, and taking the logarithm of a nonpositive number.

Programs can handle 8087 errors in several ways. They can continually check what numbers they load into the math coprocessor so that errors never occur. They can ignore errors, because the 8087 will give a "reasonable" result for every calculation. Software can also check the status registers following every 8087 calculation to see if an error has occurred. This latter approach is probably the most common method of dealing with the 8087, but it results in a greater software overhead and slows things down.

The most sophisticated and fastest way for software to handle 8087 errors is to program the coprocessor to generate an "exception interrupt" whenever an error occurs. A separate interrupt routine then deals with it. On the IBM PC, the 8087 is wired to generate a non-maskable interrupt (NMI) for this exception interrupt. Switch 2 on the system board DIP switch lets this signal pass to the 8088.

An accelerator board that uses an 80286 cannot use the 8087 on the system board but instead must include an 80287 to provide the same floating-point hardware support. Often, however, the exception interrupt of the 80287 is not implemented the same way. Programs that use the interrupt method for handling errors will not work right.

Microsoft's C, FORTRAN, and Pascal compilers all use the exception interrupt approach to error handling. (Of course, if you buy an applications program that uses an 8087, you probably won't know what it was programmed in.) Suppose the accelerator board does not properly enable the exception interrupt line and you use a program written in C, FORTRAN, or Pascal compiled with the Microsoft compilers: if this program at some time attempts to take the logarithm of 0 (or something else that generates an 8087 error), the program will hang and you'll have to reboot. It's as simple as that.

■ The marriage of a PC or XT with an accelerator board is an unnatural and often hostile union. It's surprising that such marriages work at all.

WHAT THE BOARDS WON'T DO If you're looking only for improved processing speed, an accelerator board will give it to you. If you're looking for anything else, you're going to be disappointed. In short, accelerator boards will *not* turn your PC or XT into an AT.

Accelerator cards will not significantly improve disk access speed. They will improve the software overhead required for file I/O, but once the red light goes on, your disk will not work faster. We ran file I/O tests on all the accelerator boards reviewed here and found no real improvement.

If you have been thinking about getting an accelerator board with an 80286 to take advantage of the forthcoming "Future DOS" (Microsoft's term) that will run in 80286 protected mode and access 16 megabytes of memory, you can forget it. The boards that do not have their own memory cannot access 16 megabytes of memory because they can address memory only through the 20-bit address lines on the system board bus.

Some of the larger boards can currently switch to protected mode using their own memory on the board, but even here it's quite improbable that this memory will be accessible in a protected-mode DOS. Future DOS will probably have to take over the whole machine in protected mode and will not be able to recognize the accelerator board. Even if it did, you would be limited to the memory you could actually install on the board.

WHAT THEY'RE REALLY LIKE Although I've been discussing turbo boards mostly in the abstract, by now you should see that the marriage of a PC or XT with an accelerator board is an unnatural and often hostile union. It's surprising that such marriages work at all.

Accelerator boards, in general, rate fairly high on the "fritter factor" scale. PCs and XTs were not designed to accommodate easy replacement of the microprocessor. The reviewers working in the PC Magazine Labs had to struggle with recalcitrant cables, bent (and sometimes broken) pins, and large hands trying to fit into small spaces. In general, everyone was thankful that we were experimenting on PC Labs' machines instead of our own.

Twice during this testing, two XTs installed with different accelerator boards developed damaged hard disk file allocation tables. This is a serious problem if you value your files. In one case the hard disk had to be reformatted. We couldn't directly trace the cause back to the accelerator boards, but they sure looked guilty.

"To accelerate or not to accelerate" is not really the question. The question is "How?" As for me, I've discovered that there's really only one way to get an AT on my desk, and that is to buy one.

Charles Petzold is a contributing editor of PC Magazine.

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CHEETAH

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ACS

CIRCLE 106 ON READER SERVICE CARD

87/88 Turbo Board

If you like to tinker with your PC, you'll love MicroWay's 87/88 Turbo Board. This motherboard accelerator offers a combination of tricks to speed up your PC and leaves it to you to find the optimum speed.

The 87/88 Turbo Board package includes an 8-MHz NEC V20, three clock crystals, and an optional 8088Turbo Board for the motherboard. The board itself is a half-card that plugs into an expansion slot and includes a short cable that replaces the 8284 in the clock chip socket.

MicroWay says it considers the board a hacker's device. One reason for the label is that before installing this board, you may have to modify your motherboard. The 8284 clock chip is soldered on some IBM PCs and socketed on others. If it's soldered, you'll first have to unsolder the chip and solder a socket on the board.

Whether or not you feel comfortable with this idea, you should probably check out your 8284 clock chip before you buy the board. On the PC, the 8284 chip is alongside the power supply—between the power supply and the expansion slots. On the XT, the 8284 is in the same general area, but it is further away from the power supply.

Even if you start with a socketed 8284, installing this board takes more tinkering than do most expansion boards. First you have to remove your 8088 from the system board and replace it with the NEC V20.

PC MAGAZINE FACT FILE

87/88 Turbo Board
MicroWay Inc.
P.O. Box 79
Kingston, MA 02364
(617) 746-7341
List Price: Without 8087, $149; with 8087-2, $295; $149 for 8087-2 itself
Requires: PC or PC-XT.
In Short: Described by MicroWay as "a hacker's board," the 87/88 Turbo Board has three jumper-selectable fast-mode speeds and allows "on-the-fly" switching between fast mode and slow mode from the keyboard with Ctrl-Alt-P and Ctrl-Alt-L.

CIRCLE 695 ON READER SERVICE CARD

■ Motherboard accelerators are highly machine-dependent. The only way to find out how fast your machine can go is to try it.

Then you may have to shuffle the boards in your system to free up the slot closest to the 8284 socket. The 87/88 Turbo Board goes into the expansion slot, the 8284 clock chip gets pulled, and the cable from the board plugs into the 8284 socket.

And at this point, you are finally ready to start fooling around with clock crystals. The three crystals that come with this board run at 20 MHz, 22 MHz, and 24 MHz, yielding system speeds of 6.7 MHz, 7.2 MHz, and 8 MHz. The 20-MHz crystal is soldered onto the board. Either of the other two crystals can plug into a socket. A jumper on the board lets you choose between the soldered crystal and the socket.

FINDING THE RIGHT SPEED Motherboard accelerators are highly machine-dependent, and the only way to find out how fast your machine can go is to try it. The idea is to start with the 24-MHz crystal and work your way down until you reach a speed that works. If your computer crashes, it's not working.

MicroWay says that most IBM PCs will run at 6.7 MHz, a "goodly percentage" will run at 7.2 MHz, and most will not run at 8 MHz. On the other hand, many clones will run at 8 MHz, as will many of the newer IBM motherboards. (The machine I used managed 7.2 MHz.) The 87/88 Turbo Board does not put any wait states into memory accesses. The main limitation will probably result from the speed of memory chips on your system board or expansion board.

A MicroWay representative also pointed out that high-quality motherboards are available for "next to nothing" (about $150), and that it might be worth the additional investment to replace the current motherboard in your PC. But of course it would be silly to replace the current board until you find out for sure that it won't run at 8 MHz.

BEING BRIEF In keeping with its view of this board as a hacker's device, MicroWay's documentation—I hesitate to call it a manual—consists of two pages of text. Miraculously, this single piece of paper contains all the information you need to set up the board. Still, I am sure that it would benefit tremendously from an illustration showing where to find the 8284 clock chip.

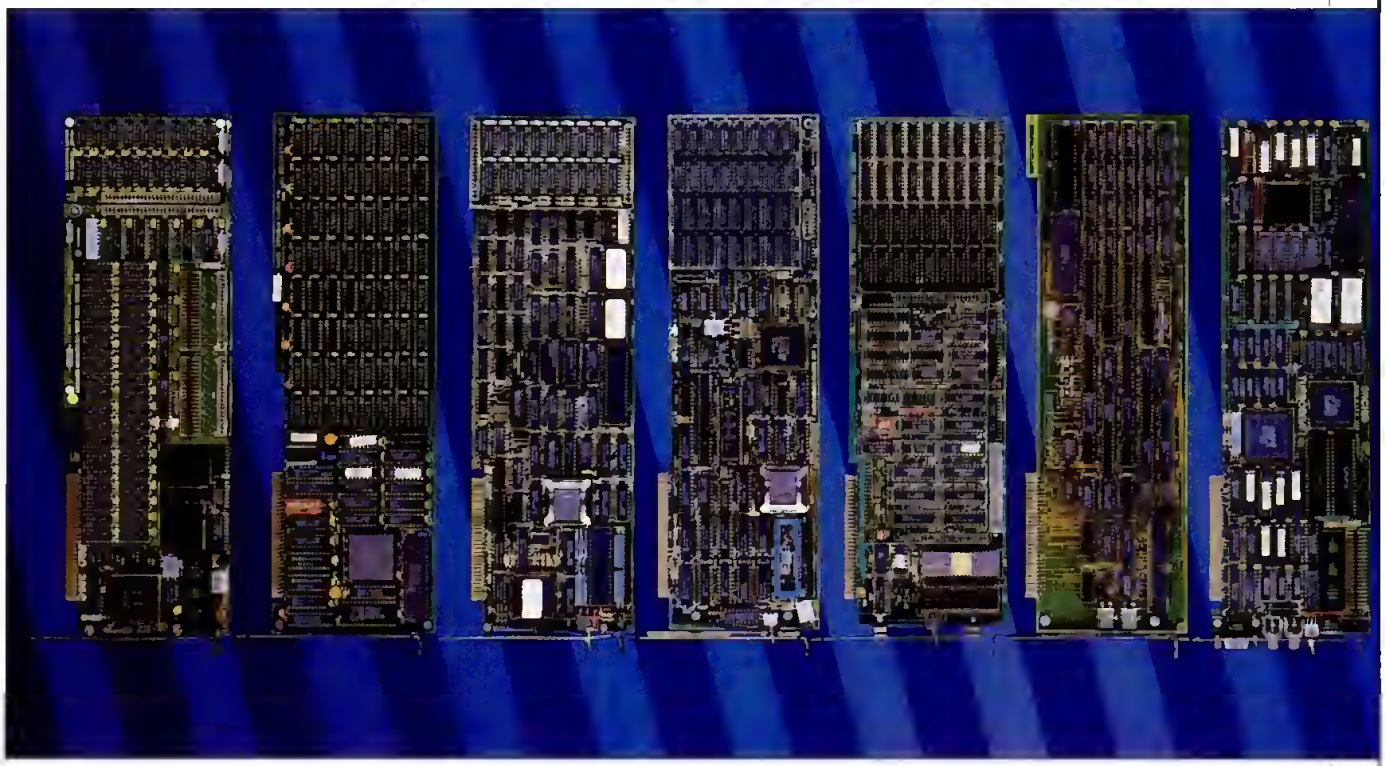
Once installed, the 87/88 Turbo Board is simple to use. When you boot up, the machine runs at the standard 4.77 MHz. There is a toggle switch on the back of the board that lets you switch to the faster speed—down for fast and up for standard PC speed.

More convenient is a memory-resident program that comes with the board and lets you switch speeds with Ctrl-Alt-P and Ctrl-Alt-L. The idea is to load the memory-resident program into your AUTOEXEC.BAT file and use it as needed. This ability to switch speeds midstream can be useful—particularly if you have programs with copy-protection schemes that refuse to let you start a program when running at the faster speed.

If the memory-resident program conflicts with anything else on your system, there is also a pair of non-memory-resident programs for speeding up and slowing down the system.

Two other noteworthy features on this board should be pointed out: a clock/calendar and a reset button. The reset button is extremely welcome for all those times when the Ctrl-Alt-Del combination refuses to reboot the system, and you don't want to power down.

And of course there is the issue of speed. On the PC Magazine Labs tests, the 87/88 Turbo Board consistently managed a speed improvement of 1½ to 2 times that of a standard PC. You won't outrace an AT with this board, but given the moderate price—$149 without an 8087, or $295 with it—the 87/88 Turbo Board is worth considering.—**M. David Stone**



Quadsprint

If you want to soup up your PC but don't believe in going too far beyond the speed limit, try Quadram Corp.'s Quadsprint. It is simple in design, consisting only of a 10-MHz 8086 and 4K bytes of cache, but in operation it supplies some of the benefits normally found in more-expensive units. At its optimum setting—that is, when the cache is enabled—operations show an increase of as much as 200 percent in throughput, though not always. However, the new low price ($345) is a small investment for the increase in productivity.

You can almost install the Quadsprint blindfolded—it's that easy. The difficult part is extracting the PC's native 8088 and plugging the connecting cable into the empty socket. Fortunately, the cable is long enough to let you install the card in almost any slot; you can then drape the cable over the intervening cards. On an XT, this technique is mandatory because the first two full-length slots are usually taken up by the hard disk and floppy disk controller cards. The only other hardware installation procedure involves setting a jumper.

The Quadsprint comes with three jumpers, but only one concerns you—the other two are for factory diagnostics and I/O addresses, and the thin manual does not document either one. Presumably, if you have special installation needs, tech support at Quadram will walk you through the proper jumper settings. The jumper you need to set enables or disables the 4K-byte cache memory, and if you forget to set it during installation, don't worry.

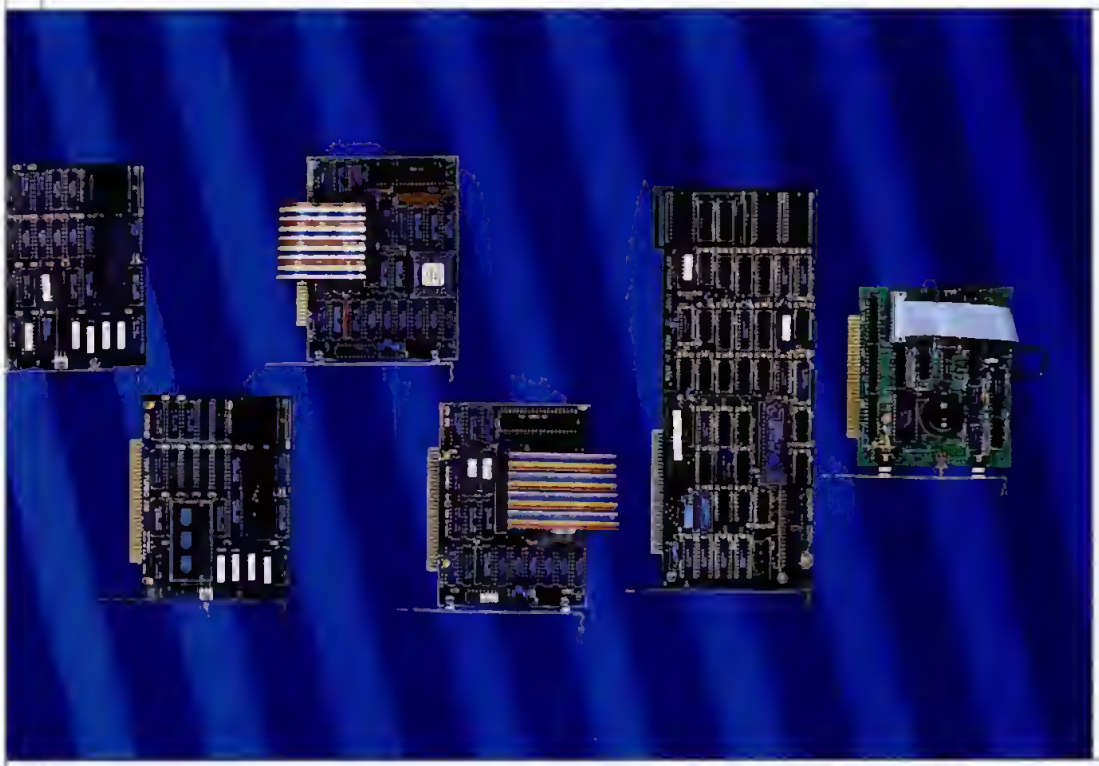
Unlike what many other accelerator boards that use caching require, you do not need to disassemble your PC and pull out the card every time you need to disable or enable the cache. Quadram has supplied a software solution in the form of two one-line BASIC statements. This implementation is one that other manufacturers of accelerator boards should take careful note of—users are never too thrilled about opening their system and fiddling with its innards. The cache's implementation does present one inconvenience, though. If your XT has less than 640K bytes of RAM and the cache is enabled, you cannot warm boot. The manual recommends disabling the cache with the OUT statement and then warm booting.

SNOW WARNING Running the Quadsprint with an EGA card presented none of the problems found with other accelerators. When it was connected to a color/graphics adapter, however, it did occasionally produce an inordinate amount of snow on the CGA. The interference appears on the left side of the screen whether you are in DOS or in an application such as *WordStar*. At its worst, though, the snow is simply annoying; it does not affect the readability of the screen. According to a Quadram spokesperson, snow is one price

PC MAGAZINE FACT FILE

Quadsprint
Quadram Corp.
4355 International Blvd.
Norcross, GA 30093
(404) 923-6666
List Price: $345; optional daughterboard, $95
Requires: IBM PC or XT, a full slot.
In Short: Quadram's Quadsprint is a low-cost full-length board that doesn't quite make it in speed but is easy to install and use.

CIRCLE **661** ON READER SERVICE CARD



From left to right: Orchid Technology's PC Turbo-286e, Applied Reasoning's PC-elevATor, Classic Technology's 286 Speed Pak, Earth Computers' Turbo Accel-286, MicroWay's Number Smasher/ECM, Quadrum's SuperSprint, Orchid Technology's TurboEGA, MicroWay's 286 TurboCache, Orchid's TinyTurbo 286, Victor Technologies' SpeedPac 286, PC Technologies' 286 Express Card, Quadram's Quadsprint, MicroWay's 87/88 Turbo Board.

Photograph: Roberto Brosan

you pay with any accelerator card. However, while almost every card I tested displayed some snow, the Quadsprint produced more than I had expected. It results from the Quadsprint's very conservatively timed bus operations, which actually access the screen more slowly than those of a standard PC or XT.

These conservative bus operations also showed up when I ran the Quadsprint with caching disabled. Without the benefit of the cache, many of the performance tests ran slower than those of a standard PC or XT. The 4K-byte cache is half the size of caches on some other cards, so programs with very large loops (or lots of nested calls) will not show much of an improvement in speed.

OPTIONAL DAUGHTERBOARD If you use any software that requires an 8087 math coprocessor, you need to purchase the optional daughterboard. Although we asked Quadram to submit one for testing and a spokesperson promised to send us one immediately, it did not arrive by the time this review was submitted.

The Quadsprint manual is brief and easy to follow—almost what you would want for a user-friendly add-on. However, its appendix includes a glossary of terms that are also applicable to other Quadram products. Consequently, it contains a number of terms that have little or no bearing on the Quadsprint. The documentation also omits an index and any mention of the optional 8087 daughterboard.

The Quadsprint may not be on the cutting edge of accelerator technology, but it is dependable, easy to use, and, at $345, quite reasonable.—**Vincent Puglia**

286 Express Card

Since—for all intents and purposes—Victor Technologies' SpeedPac 286 (reviewed in this issue) and PC Technologies' 286 Express Card are one and the same card, you would expect that both companies would send exactly the same boards for review. You may expect it, but you shouldn't count on it. While Victor Technologies sent an EGA-compatible card when asked, PC Technologies did not. (It is, however, safe to assume that if Victor Technologies has an EGA-compatible card, its supplier, PC Technologies, also has one.) For this reason, the compatibility problems displayed when testing the cards in EGA graphics modes are presented in this review rather than in both.

A HALF-SLOT CARD PC Technologies' 286 Express Card is a half-length card that fits comfortably into the XT's half-slots. The accelerator consists of an 80286 running at 7.2 MHz and 8K bytes of RAM for caching. An optional 80287 math coprocessor can be plugged into the board. Installation requires removing your system's native 8088, sliding the card into

PC MAGAZINE FACT FILE

286 Express Card
PC Technologies Inc.
704 Airport Blvd.
Ann Arbor, MI 48106
(313) 996-9690
List Price: $595
Requires: IBM PC or XT, a half-length slot.
In Short: The 286 Express Card replaces your 8088 with an 80286 and 8K bytes of cache.

CIRCLE **659** ON READER SERVICE CARD

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an empty slot (preferably J7), and connecting the card's cable to the empty 8088 socket. Jumpers are available for telling the card how much memory is installed in the system and for enabling the cache. The jumpers could be set to something lower than system memory if part of your 640K contains bank-switched memory, which must not be cached. The entire process is adequately described and illustrated in the documentation.

The testing conducted at PC Magazine Labs demonstrates that the 286 Express Card and Victor Technologies' SpeedPac 286 are identical cards. The efficiency of the caching is responsible for most of the speed improvement. For instance, the PC Labs *1-2-3* test showed virtually no improvement with caching disabled. With caching enabled, however, it took about one-third the PC's normal time to complete.

AN EGA MODE PROBLEM The 286 Express Card tested had a problem with the enhanced graphics modes of the EGA. For example, when scrolling text in an EGA graphics mode, every other scrolled character was displayed twice. If a directory listing showed a file named TEST .DAT, it would turn into EETTDDTT when the screen was scrolled. All the characters on odd-byte addresses were being written back to the screen at both even and odd addresses. The reason for this strange behavior is related to EGA internal registers that latch existing screen data when a byte location is read in graphics mode. For its caching logic, the 286 Express Card was apparently reading both the byte on the even address and the next byte on the odd address whenever the 80286 wanted to read a byte on only the even address. This caused the data in the EGA internal registers to be invalid. (This was a problem only in EGA graphics modes. Text modes and CGA-compatible graphics modes worked fine.)

According to a spokesman, if you already own a PC Technologies' 286 Express Card and wish to upgrade to an EGA-compatible card, it is going to cost you $100. On the surface, this policy may seem reasonable; however, if you consider that Victor Technologies is providing its customers an even-swap upgrade, you have to begin to wonder a little.

As far as your system is concerned, any one of PC Technologies' 286 cards—whether with its own label or someone else's—provides the same performance. As far as your wallet is concerned, the Victor Technologies' SpeedPac 286 is much more palatable if you are upgrading.

—Vincent Puglia

SpeedPac 286

Victor Technologies' SpeedPac 286 (the original equipment manufacturer is PC Technologies) is a half-length accelerator card that includes an on-board 80286 chip, which runs at 7.2 MHz, 8K bytes of RAM caching, and a socket for an optional 80287 math coprocessor. The SpeedPac 286 also offers easy installation and relatively transparent use.

If your system reflects the default jumper settings (256K bytes of RAM with cache enabled), installation consists of pulling your system's native 4.77-MHz 8088 chip, inserting the card into one of the slots near the power supply, and plugging the connecting cable into the empty 8088 socket. If you are installing the half-length card in an XT, the card slides easily into the second slot just behind drive A:. If your system requires a different setting—for example, if it has 640K bytes of RAM or you need to disable the caching—you reset the jumpers according to the clearly labeled illustrations in the 19-page documentation.

(Note: Earlier versions of the manual suggested inserting the SpeedPac into slot J8, the slot closest to the microprocessor sockets. The newest manual states—correctly—that such an installation may present problems. If you currently own a SpeedPac 286 and it is generating an "1801" system board error message during the boot process, simply move the card from the J8 slot to the J7 slot. Your problems should evaporate.)

USER-TRANSPARENT CACHING The SpeedPac 286 does not come with its own RAM except for the 8K bytes it uses for caching. To get around the need to access information off the system's standard 8-bit bus, the SpeedPac 286 uses a user-transparent caching system. Upon executing a program, the card copies blocks of code and data from the PC's main memory into an area on its 16-bit bus. This enables the card to access words rather than bytes. It doesn't speed up screen operations much and shows very little improvement for a test with a loop greater than the 8K cache, but otherwise it improves speeds about two to three times those of a standard PC or PC-XT.

Another advantage of the caching approach versus the on-board 16-bit RAM approach is that you get to keep the memory already installed in your system. Some of the boards that come with 16-bit RAM require you to disable all 8-bit memory above 256K bytes, and even after that they either access the remaining 8-bit memory as bytes or resort to caching.

SOFTWARE INCOMPATIBILITY While caching increases the speed of many operations, it can have the reverse effect with programs that tend to jump around to areas that are not cached. A cached system also raises the possibility of some software incompatibility. Victor circumvents these problems by suggesting that you disable the caching when running such programs. This causes the performance of the card to crawl along at the PC's normal snail's pace.

Disabling caching is not as easy as it sounds. You must first shut down the system, then remove the cover, and finally either pull the card out or reach gingerly into the unit so as to reach the jumpers. PC Technologies really should have permitted a software switch for caching.

The newest version of the SpeedPac

PC MAGAZINE FACT FILE

SpeedPac 286
Victor Technologies Inc.
380 El Pueblo Rd.
Scotts Valley, CA 95066-0001
(408) 438-6680
List Price: $595
Requires: IBM PC or XT, a half-length slot.
In Short: The SpeedPac 286 provides increased throughput with the aid of caching. Installation is a snap, and usage is virtually transparent.

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We wanted to offer a speedup card that would be the compliment to our disk speedup software, (incidentally included at no extra charge.) We wanted it to be literally the most advanced, fastest, most feature rich board available today. We could only be satisfied with a board that was the finest example of the engineering art.

There is no question we have met our every objective by developing and manufacturing the *BREAKTHRU 286* card. This is the best designed and most functional speed up card available today. We guarantee it.

HERE IS WHAT MAKES IT SO SPECIAL.

First, it installs so easily. It is a half slot card, only five inches in length. You don't even have to give up a full slot. What's more, unlike competing products it works in the Compaq and most clones. The instructions are so simple we considered showing a picture of a child putting it in. Easy diagrams show how you just place the card in an open slot, remove the original processor and connect a single cable. There is no software required. From that moment you are running faster than an AT.

Second, it is advanced. The *BREAKTHRU 286* replaces the CPU of the PC or XT with an 80286 microprocessor that is faster than the one found in the AT. A 16K cache memor provides zero-wait-access to the most recently used code and data. In benchmark tests the card accelerated softwar programs—both custom and off-the-shelf anywhere from 200% to as much as 700%. Wow!

Third, you have full compatibility. All existing sys RAM, hardware, and peripheral cards can be used withou software modification. It operates with LAN and mainfra communication products and conforms to the Lotus/Intel Microsoft Expanded Memory Specification (EMS). Softwa compatibility is virtually universal.

Fourth, it is the best there is. There are several othe boards on the market. Some are priced about the same as *BREAKTHRU 286* and some are cheaper. We at PCSG h compared them all, but there simply was no comparison. What we discovered is that many cards being sold offer o a marginal speed up in spite of their claims. We found sor to be merely versions of the obsolete 8088 or 8086, and oth to be just poorly engineered. The 8MHz *BREAKTHRU 2* unequivocally the best executed and most completely reli speedup board manufactured today.

PCSG has since early 1983 dominated the lap portable market with ROM software such a Lucid spreadsheet and Write ROM that reviewers rated as excellent. We were pr to successfully enter the IBM PC market last year with dis access speedup software. Now we are so pleased with the *BREAKTHRU* speedup card. We use them on our own P to make them faster than AT's. We are really excited about this product.

PCSG makes the unabashed statement that the *BREAKT 286* card represents more advanced technology than boar by Orchid, Quadram, Victor, Mountain, P.C. Technologie Phoenix... we could go on.

But an ad can't let you experience it for yourself. That's we sell the *BREAKTHRU 286* on a 60 day trial. If you are completely satisfied return it within 60 days for a full refu It is priced at $595. Call today with your MasterCard, Visa American Express or COD instructions and we will ship y card the very next day.

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286 ran flawlessly when tested with both CGA and EGA cards. Earlier versions displayed serious compatibility problems with IBM's EGA card because of a conflict with the EGA internal registers when writing dots on even-byte addresses. (See the review of PC Technologies' 286 Express Card for a full description of the problem.) According to a spokesperson from Victor, the upgrade policy is a straight swap. You send in the old card, and the company sends you the upgraded EGA-compatible board.

The SpeedPac 286 can accommodate either a 5-MHz or an 8-MHz 80287 math coprocessor. Installation requires inserting a socket plug into the 8087 socket, setting a jumper to select the proper clock speed, and setting your system board's coprocessor DIP switch to off. Following the manual's directions will present you with a problem if you have an Intel Above Board installed. It seems that the Above Board system manager does not like the DIP switch set to off, and if it is, the Above Board will report an error and refuse to load. Leaving the switch set to on—as the Above Board wants it—presents no problems. Using an 8-MHz 80287 increases floating-point calculations performed with the math coprocessor by the speed of about 20 percent over the 5-MHz version.

If you are looking to increase your processing speed significantly, do not want to make that many changes to the present configuration of your system, and do not think you will ever need to disable your cache, Victor Technologies' SpeedPac 286 is a good investment.

—Vincent Puglia

TinyTurbo 286

The TinyTurbo 286, from Orchid Technology, is one of those rare pieces of equipment that does what it's supposed to with no fuss, no muss, and remarkably little bother. Its purpose, of course, is to speed up your PC or XT, and it does so in a way that isn't likely to interfere with anything else in your system.

The TinyTurbo 286 is built around the 80286. The chip is rated at 8 MHz and runs at a little over 7 MHz, or somewhat faster than the AT. There is also room for an optional 80287 on the board. A jumper next to the 80287 socket lets you set the board for either the 5-MHz version of the coprocessor or the more expensive 8-MHz version. PC Magazine Labs used the 8-MHz version for its tests.

The TinyTurbo board is half-card size and designed to fit in the slot closest to the 8088 on the system board. Installation entails removing the 8088 from its socket and plugging it into a small piggyback board on the TinyTurbo. A 3-inch cable runs from the piggyback board to the 8088 socket. Once you have gotten the board installed, a switch on the back lets you run your system using either the 80286 at high speed or the 8088 at the standard 4.77 MHz.

AN ODD TWIST The only problem I had with this board was during installation. Pulling the 8088 from the system board is not a trivial task, even with the chip-puller that comes with the board. And once you get the 8088 out, straighten the pins, and plug it into the piggyback board, you still have to plug the connector from the 3-inch cable into the 8088 socket on the system board.

The piggyback board on the TinyTurbo is offset from the socket on the motherboard by about half an inch. If you put the board in first and then try to plug in the cable, as suggested in the manual, you'll find that the offset puts a strain on the ribbon cable, making it difficult to line up the pins with the socket. It works better to plug the connector in first, then put the board into the slot. But because of the offset, there is no way to avoid a twist in the cable.

This isn't really a problem, except that the manual states that the cable should not have a twist in it. After staring at the cable for a few minutes, I called Orchid to find out what was wrong. It was the manual.

JUST WHAT YOU NEED TO KNOW Aside from this one inaccuracy, the manual fares well. A scant 12 pages long, it covers everything you'll need to know for installing and using the board. What's more, it's written in clear language and includes a useful illustration and professional design layout. The manual is weak on explanation and technical information, but that comes under the category of things you might like to know, not things you have to know.

The manual claims, "Once TinyTurbo is installed, your system will work just the way it did before, only faster." That's just a shade off the absolute truth.

For most programs, you can set the switch on the board to turbo mode and zip along at high speed. On most of the PC Labs tests, the board clocked in at two to three times the speed of a standard PC. The difference is enough to be obvious in even the most casual use—asking for a directory, for example, or watching *1-2-3* recalculate a spreadsheet.

There are some programs, mostly games, where the extra speed doesn't help. In those cases you simply flick the switch to go back to normal PC-XT speed using the 8088. In this PC mode, your system behaves just as if the TinyTurbo 286 weren't there. You can even use an 8087 on the system board, if you have one. The 3-inch distance between 8088 and 8087 made no difference in the PC Labs tests.

The one drawback to changing speed is that it also reboots the system. This means you can't change speed midstream, but it also gives you a hardware reset feature for those times when Ctrl-Alt-Del doesn't work.

CACHE MEMORY ON BOARD One warning: also on the board is 8K of RAM for cache memory, and much of the speed of the TinyTurbo 286 comes from this cache technique. The board includes a jumper for enabling or disabling the cache. I tested it both ways and found

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TinyTurbo 286
Orchid Technology Inc.
47790 Westinghouse Dr.
Fremont, CA 94539
(415) 490-8586
List Price: Without 80287, $695
Requires: PC or PC-XT.
In Short: The 8K cache and conservative system board interface of the TinyTurbo 286 make it easy to use, reliable, and trouble-free.

CIRCLE 604 ON READER SERVICE CARD

that with the cache disabled, the speeds were significantly slower—in many cases approaching the speed for a standard PC. When the TinyTurbo 286 board accesses either system board or expansion board memory, it inserts five wait states to stretch out the read or write cycle and accommodate slow memory chips. When accessing memory from the cache, however, it uses 16-bit reads with no wait states.

According to the manual, some "less compatible" computers may need the cache feature disabled. In those cases, the TinyTurbo is not worth the price. But with the PC or XT there is no reason to disable the cache, and with the cache this board looks good indeed. I'm not about to trade my AT for a TinyTurbo-equipped PC. But would I put a TinyTurbo in my PC if that were my working machine? You betcha.—**M. David Stone**

286 TurboCache

When we were sorting through accelerator boards as they arrived at the PC Magazine Labs, we couldn't help noticing the similarity between MicroWay's 286 TurboCache and Orchid Technology's TinyTurbo 286. The boards were the exact same size and appeared to have the same components in the same place. The only obvious difference between them that we could spot was that one board said Orchid, while the other had a label that said MicroWay 286 TurboCache.

A deftly applied fingernail proved that the MicroWay label was simply pasted over Orchid's board, and calls to MicroWay and Orchid confirmed that the boards themselves were identical. So why does MicroWay's version sell for $100 less than Orchid's version?

A FEW DIFFERENCES The answer seems to be a matter of cutting corners, with the biggest difference being that MicroWay offers a 1-year warranty while Orchid offers 2 years.

Another noteworthy difference shows up in the manuals. It's obvious that one of them is a rewritten version of the other. But, as noted elsewhere, Orchid's manual offers a useful illustration and a well-designed layout. MicroWay's manual skips the illustration, leaving you to find jumpers and sockets on your own. And its layout makes the text more difficult to read. On the plus side, MicroWay's manual contains additional technical information (though some of it is wrong and is being rewritten).

BUNDLED PROGRAMS MicroWay also bundles several utility programs with the board, including a print buffer, a RAMdisk, an 80287 test program, and a hard disk cache (not the same thing as the 8K memory cache). And where Orchid's manual tells you to test the 80287 on your board by running a program that uses it, MicroWay's manual just tells you to run the 80287 test program.

The overall effect is that MicroWay's version of this board is more of a hacker's package than Orchid's version. If you feel comfortable with that, then the $100 savings is probably worth it. If you don't feel comfortable buying a hacker's package, then the better installation instructions and the 2 year's warranty may well be worth the extra $100.—**M. David Stone**

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286 TurboCache
MicroWay Inc.
P.O. Box 79
Kingston, MA 02364
(617) 746-7341
List Price: Without 80287, $595; optional 5-MHz 80287-3, $179; optional 8-MHz 80287-8, $295
Requires: PC or PC-XT
In Short: MicroWay's 286 TurboCache is the same board as Orchid's TinyTurbo 286, but MicroWay includes some additional technical information and utility programs that don't come with Orchid's board.
CIRCLE 662 ON READER SERVICE CARD

TurboEGA

Orchid Technology describes the TurboEGA as "the world's fastest enhanced graphics adapter." When you first learn what this board is all about, the statement seems a little deceptive. On closer look, however, it turns out Orchid is absolutely correct, but not in the way that you might think.

Above all, the TurboEGA is a clever and innovative marketing idea. On one board Orchid combines an enhanced graphics adapter and an accelerator for a PC or XT. The accelerator part of the TurboEGA is basically Orchid's TinyTurbo 286, which lists at $695. Orchid's regular EGA board is $595. Together on one card they offer no more functionality or greater graphics speed than if you installed the two cards separately. (Text speed is another story.) But the TurboEGA costs only $945, fits in one slot, and Orchid throws in a free copy of *Microsoft Windows*.

Like the TinyTurbo 286, the installation and use of the TurboEGA is fairly simple. You remove your 8088 and plug it into the TurboEGA. You run a cable from the board to the 8088 socket. A set of jumpers tells the TurboEGA how much memory to cache. A toggle in the back switches between 8088 mode and turbo mode. Switching between modes causes a reboot.

GRAPHICS DISPLAY The EGA part of the TurboEGA is a standard configuration based on the ubiquitous Chips and Technologies EGA CHIPSet. It has all the trappings and features found on most other EGA boards (see "Achieving the Standard: 12 EGA Boards," *PC Magazine*, Volume 5 Number 14).

With the turbo mode switched *off*, EGA graphics are no faster or slower than on IBM's EGA or on any other EGA built around the Chips and Technologies EGA

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TurboEGA
Orchid Technology Inc.
47790 Westinghouse Dr.
Fremont, CA 94539
(415) 490-8586
List Price: $945; for optional 80287, $375
Requires: IBM PC, XT, or compatible.
In Short: By giving you an accelerator and an enhanced graphics adapter combined on one board, the TurboEGA saves you a slot and some money. This is an ideal board for people who are looking for both features.
CIRCLE 664 ON READER SERVICE CARD

CHIPSet. With the turbo mode switched *on*, the graphics are no faster or slower than on IBM's EGA board with Orchid's TinyTurbo 286 installed, which lets your graphics run about twice as fast.

TEXT DISPLAY For the display of text through the BIOS, however, the Turbo EGA's combination of the accelerator and EGA on one board provides a distinct advantage. In turbo mode, the 80286 accesses the EGA ROM BIOS in 16-bit words rather than 8-bit bytes. That's a speed improvement you cannot get with separate accelerator and EGA boards in a PC or XT. Even on an AT, the 80286 accesses an EGA BIOS in bytes. This enhancement affects only text displays (and works only on programs that do not write directly to the screen) because the BIOS is not normally used for graphics.

The TurboEGA BIOS also proves that you can still get some "turbo" power from tight programming without any hardware speedups. Generally, DOS uses the BIOS Teletype routine for screen output. Since the speed of this Teletype routine determines, for instance, how fast a DIR listing displays to the screen, it's something you'll experience every time you use your PC. It just so happens that the BIOS Teletype routine in the TurboEGA has been highly optimized for speed. For instance, the first thing the Interrupt 10h BIOS routine does is check to see if it's being asked to do a Teletype call.

This software optimization is significant. Even in non-turbo mode, the BIOS Teletype routines are twice as fast as IBM's EGA BIOS and faster than any of the EGA boards reviewed in "Achieving the Standard: 12 EGA Boards." (However, because of this optimization, the Teletype routines will disable screen-recall programs.)

STILL SOME BUGS The EGA BIOS in the board I tested (Version 1.2) still needs some work, but the bugs are not severe and are typical of EGA boards in early stages of marketing. The Write String logic is not consistent with IBM's, and the automatic font loading on a mode reset causes the EGA to crash.

An included disk contains software for CGA or Hercules emulation using the Non-Maskable Interrupt (NMI) technique. I have not been happy with this form of emulation on other boards, and I'm still not happy with it. In fact, it results in one small hitch to the TurboEGA. Because the emulation software and 8087 Exception interrupt both use the NMI, the manual recommends that the "coprocessor installed" switch on the system board be turned on, even if an 8087 is installed. This disables the 8087 Exception interrupt in non-turbo mode.

Without the CGA and Hercules emulation software, I found I could leave the switch off without any problems, and the system board 8087 worked fine in non-turbo mode. So, if you throw away the emulation software, you'll be able to get full functionality out of the system board 8087 while in 8088 mode and out of the 80287 on the TurboEGA board while in turbo mode. Terrific.

A HOT COMBINATION So what is the TurboEGA exactly? I've decided that it's a multifunction board. But whereas most multifunction boards combine relatively mundane items such as memory, parallel and serial ports, and a clock, the TurboEGA combines two hot (but still relatively uncommon) PC enhancements. This is a daring and interesting twist on the multifunction concept, and Orchid has carried it off very well.

The TurboEGA may be "the world's fastest EGA," but it's also "the world's prettiest accelerator." I like this board—I like it a lot.—**Charles Petzold**

SuperSprint

Quadram Corp.'s newest accelerator card, the SuperSprint, is somewhat similar to the Quadsprint (reviewed in this issue) in that it offers reliability, ease of use, and a conservative speed increase at a reasonable price. It differs from the Quadsprint in that its design includes a larger cache area and a socket for an optional 8087.

The SuperSprint's 10-MHz 8086 comes on a full-length card that draws 7½ watts of power. While the beta test board I reviewed included jumpers, Quadram has stated that they will be replaced with more-manageable DIP switches (a change already reflected in the documentation). Rather than being limited to the 4K bytes of direct-mapped cache found on the Quadsprint, the SuperSprint has two types of caching: 32K bytes for direct page and 96K bytes for image caching.

Installing the SuperSprint is about as complicated as whistling Dixie: you may never want to do it professionally, but you will be able to do it whenever called upon. Even novices should be able to pull their 8088 chip, slap the SuperSprint into an empty slot, and connect the cable within 5 minutes of taking the cover off their PC or XT. If you are nervous about opening a computer and playing with its seemingly intricate components, know that with the SuperSprint—unlike with many other boards that include a cache—you can disable the cache without removing the card.

When you boot your system, the SuperSprint copies the first 96K bytes of memory into its image cache. This is the area in memory that contains DOS, interrupts, and the beginning code of many applications. Another 32K bytes of on-board 16-bit direct page caching enables the SuperSprint to access some of the other data.

SOFTWARE-SWITCHING THE CACHE Perhaps the nicest feature of this board (and one that other manufacturers would do well to include in their comparable boards) is its ability to enable or disable the cache with a one-line BASIC statement. (If you have never used BASIC, don't worry, because the documentation gives detailed instructions.) You cannot appreciate such a feature until you install a new program or card, only to discover some incompatibility problem. With a software

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SuperSprint
Quadram Corp.
4355 International Blvd.
Norcross, GA 30093
(404) 923-6666
List Price: $595
Requires: IBM PC or XT, a full slot.
In Short: Quadram's SuperSprint provides transparent usage and a reliable, albeit conservative, increase in throughput for a reasonable price.

CIRCLE 660 ON READER SERVICE CARD

switch, you simply disable the cache, determine whether the accelerator card is at fault, and proceed from there. Without the software switch, you need to disassemble your unit, remove the card, change the jumper setting, reconnect your card, and then proceed. I love switches that do not require shutting down the system.

The SuperSprint is completely EGA compatible. Like almost everything else about this board, its use of the enhanced graphics adapter is transparent. Unlike the Quadsprint, the SuperSprint displayed virtually no snow when used with a color/graphics card.

THE ONE EXCEPTION The only PC Labs test that the SuperSprint failed had to do with the 8087. Like some other boards in this roundup, Quadram's board failed to enable the Exception interrupt. As explained in this article's introduction, this may present problems when running programs compiled under Microsoft C, FORTRAN, and Pascal. Aside from that, the floating-point calculation with the 8087 math coprocessor showed an increase of almost 2½ times that of a standard XT.

We also received a version of *MicroCache* with the SuperSprint. This noncopy-protected software includes utilities for disk caching, print spooling, and RAMdisks. It supports EMS, EEMS, and extended memory schemes. The software is easy to use and offers enough flexibility and power to make it quite useful.

COMPETENT DOCUMENTATION The documentation we received with the board may have been a preliminary version, but it was at least up to par with Quadram's other manuals. Besides giving installation and usage instructions and specifications, it included a detailed section on enabling and disabling the cache from DOS and *WordStar*, plus another section that described the actual caching implementation.

Quadram's SuperSprint may not scream down the silicon corridors of your PC's memory, but it does sprint across them at a respectable clip. If you need speed and reliability but do not want to push your machine to the limits, the SuperSprint is probably what you are looking for.—**Vincent Puglia**

Number Smasher/ECM

MicroWay's Number Smasher/ECM contains a 10-MHz 8086 that runs at 9.54 MHz, precisely double the speed of the 8088 in your IBM PC or XT. The board can include up to 1 megabyte of memory, which replaces the memory on your system and expansion boards. Processor speed doubles because of the faster clock and sometimes almost triples owing to the 16-bit accesses of the 8086. MicroWay says it will soon start shipping the Number Smasher with a NEC V30 instead of an 8086. That will help even more.

■ ECM is MicroWay's approach to expanding DOS memory to 1,016K.

To install the Number Smasher, you must remove your 8088 and 8087 and any expansion memory that would conflict with memory on the accelerator board. A cable from the Number Smasher connects to the 8088 socket.

EASY MODE SWITCHING The Number Smasher's 8086 can run in either fast mode (9.54 MHz with 16-bit accesses) or slow mode (4.77 MHz with 8-bit accesses). You can switch between modes without rebooting by a variety of methods: a toggle switch on the back of the board, running the two programs provided on disk (called Slow and Fast), or through the keyboard after you've installed the memory-resident FS.COM. In either slow or fast mode, the processor uses an optional 8087, which may be installed on the Number Smasher board.

Number Smasher software also includes a diagnostics program, 8087 test programs, disk caching, a RAMdisk, and print spooler utilities.

The slow mode emulates (but does not exactly duplicate) an 8088 running at 4.77 MHz. It will actually run somewhat slower (sometimes up to 20 percent slower) than a normal machine. This results from the 8086 16-bit accesses. External hardware on the board translates each word access to 2-byte accesses, so the Number Smasher board must sometimes make one more byte-instruction fetch than is necessary.

The fast mode has no wait states in the 16-bit memory accesses except for memory writes that occur in the 256K bytes of system board memory (or 64K for old PCs). Five wait states are inserted when the board also writes to system board memory, so the DMA controller continues to work.

THE ECM MODULE At the time of this testing, MicroWay had just developed a new "improved" Number Smasher that incorporated an Extended Conventional Memory (ECM) module. The most charitable thing I can say is that the ECM module is in the early stages of development and may be improved in the future. ECM is MicroWay's approach to expanding DOS memory beyond the 640K-byte limit all the way up to 1,016K.

Use of ECM requires a device driver called MEGADOS to be listed in your CONFIG.SYS file and a program called MEMSET. When you execute MEMSET with a parameter indicating the desired memory size of DOS, your machine reboots with that new size. You may also instruct MEMSET to copy the contents of the ROM BIOS and ROM BASIC into the Number Smasher memory. Doing so will significantly speed up BIOS operations

PC MAGAZINE FACT FILE

Number Smasher/ECM
MicroWay Inc.
P.O. Box 79
Kingston, MA 02364
(617) 746-7341
List Price: $699 (512K); $799 (1 Mbyte); $250 for optional 8-MHz 8087; $295 for optional 12-MHz 8087
Requires: IBM PC or XT
In Short: The Number Smasher/ECM is very fast even though it relies on an 8086 rather than an 80286. However, a new Extended Conventional Memory module that comes with the board is not yet bug-free and perhaps will never be.

CIRCLE 657 ON READER SERVICE CARD

Five Tips On Buying A Personal Computer Through The Mail.

Buying by mail is one of the best ways thare is to purchase computer aquipmant. It's fast, convenient and cost efficient. But with those benefits comas e risk . . . many of those inexpansiva PC clones can turn into axpensiva haedachas after arriving in the mail.

Before you ordar PC aquipmant from anyone through an ad, make sure it passes the following test. Taking a minute now could save you e lot of money . . . and e lot of eggrevation.

1. **Does the product come complete?**
   Many mail-ordar outfits leeva out monitors, display cards, disk drive controllers and othar essentiels in an effort to keep the edvertised price low. By the tima you edd in the cost of these components, you may not be getting such a "hargain" after all.
2. **Is the machine fully tested?**
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(such as screen output) and interpreter BASIC programs.

However, since ECM allows for large DOS sizes by switching around the way it addresses banks of memory, it has many of the problems I encountered with All Computers' All Card (for a review, see "More Options for Enlarging the Dimensions of Memory," *PC Magazine*, Volume 5 Number 11), which attempts to do something similar. Once you go beyond 704K bytes, you have to start doing something with programs that write directly to the screen. These programs include virtually all word processors, spreadsheets, pop-ups, and any program that uses graphics. MicroWay's solution (like All Computers') is to patch these programs. The patch requires additional code to flip the display in and out of the memory space. MicroWay makes available some patches to popular programs (such as *1-2-3* and *WordStar*), but I did not see these.

OTHER PROBLEMS First, ECM is not compatible with EGA graphics in the enhanced (350-scan-line) mode. You cannot expand DOS beyond 640K bytes if you use these modes. Second, although I followed the manual's instructions in setting the Intel Above Board/PC to segment E000h and running MEMSET to avoid that segment, upon reboot the Expanded Memory Manager could not find the memory on the Above Board. Third, when I set a big DOS that encompassed segment B000h (where the screen normally resides) and loaded a bunch of dummy resident programs that boosted me up to that segment, I found that a program would load in both the ECM RAM and onto my screen (right before it crashed).

The old Number Smasher without ECM was a nice, clean, relatively straightforward accelerator board that performed very well, The new model with ECM tries to do more than just accelerate and does not yet do it well. Although MicroWay says it will continually make enhancements and improvements to fix up ECM, I fear the company may well be in an engineering quagmire with this board.

Fortunately, you can ignore the ECM module entirely and still have a very fast, very reliable, and reasonably priced accelerator.—**Charles Petzold**

Turbo Accel-286

Earth Computers' Turbo Accel-286 full-length card comes with 640K bytes of 16-bit RAM and a toggle for switching between 8088 and 80286 modes. The card also accommodates an optional 80287 math coprocessor. Jumpers select the clock speed of the 80287 and the amount of memory to be accessed on the motherboard. While the Turbo Accel-286 shows some nice speed increases, its installation, a poor manual, and design problems seriously hamper its functionality.

Installing Earth Computers' Turbo Accel-286 on an XT requires tremendous patience—more than you may be prepared to expend. While the process is similar to that of comparable boards—you remove the 8088 from the motherboard, plug it into the Earth card, set the memory switches, and connect the cable to the empty 8088 socket—Job-like patience is necessary primarily because of logistics. The combination of a full-length card and the placement of the disk controller cards leaves little room for connecting the relatively short and extremely rigid cable.

TROUBLESOME INSTALLATION It took close to 15 minutes to plug the cable into the empty 8088 socket. Then, when I moved the system a few inches on the desktop, the cable slipped out of the socket and had to be reinserted. Installation on an IBM PC should be easier. (Earth Computers claims a longer cable is available, but it didn't send me one when asked. This apparent lack of concern from the company was manifested in other areas as well.)

A toggle in the back of the card allows you to switch between 80286 and 8088 modes. In effect, the toggling avoids compatibility problems by letting you run programs in the slower mode. The documentation notes that you should use the 8088 mode when performing such operations as a DISKCOPY and other timer-dependent programs. Since this involves switching between processors, toggling between modes requires rebooting the system.

If you have less than 256K bytes of RAM on the motherboard, you need to set the memory configuration jumpers before you can squeeze the Earth card into an empty slot. Then you must disable all memory on any multifunction card that fills your system to the 640K DOS limit. In other words, if you want the optimum speed without conflicts in memory addressing and you already have a 640K system, you pull as many chips as you can so that the 80286 is addressing words rather than bytes. Presumably, the people at Earth Computers believe that you can afford to use the old 8-bit RAM chips as pushpins on your bulletin board. A far more elegant solution would have been to allow the 8-bit memory to be used as a cache or RAMdisk. This disabling refers only to memory below 640K; expanded memory (EMS) such as that found on the Intel Above Board is compatible with the Turbo Accel-286.

AN EGA FIX At the end of the review process, Earth Computers sent a disk with a program that copied the ROM BIOS into the 16-bit RAM memory on the board. This utility lets you run BASIC programs in the 286 mode. Two other programs on the disk were an EGA fix and a fix for 80287 operation. Neither fix is what you would expect after having paid $995 for the board.

If you boot the system in turbo mode when using an EGA card, the system asks you to hit F1 to resume. Once you do so and run Earth's EGA fix, the system comes up in 40-column mode and you need to execute a MODE CO80 command. While the entire process—except for hitting F1—can be placed in AUTOEXEC.BAT, the solution is less than elegant and borders on the absurd. Even

PC MAGAZINE FACT FILE

Turbo Accel-286
Earth Computers
10536 Bechler River
Fountain Valley, CA 92728
(714) 964-5784
List Price: $995
Requires: IBM PC or XT, a full slot.
In Short: Although the Turbo Accel-286 offers speedy operation in 80286 mode and a toggle to run the 8088, its functionality is hampered by design problems and inadequate software fixes.

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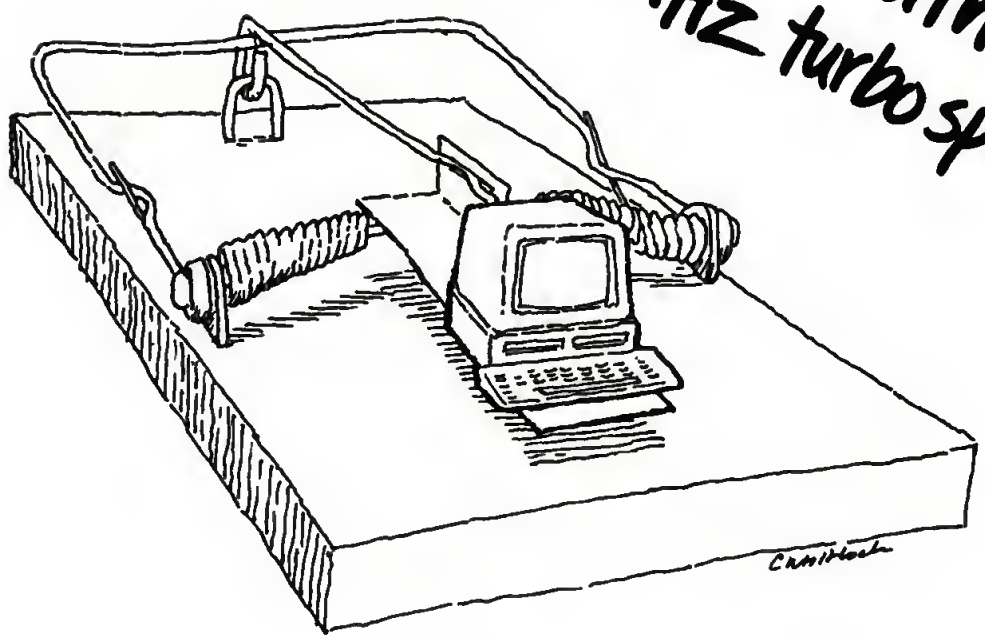

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when running on a CGA, the board is far from trouble-free, displaying approximately 3 inches of snow on the left side of the screen.

While the Turbo Accel-286 can accommodate either a 5- or an 8-MHz 80287 math coprocessor, it does so with great difficulty. To begin with, the pinholes in the socket are so small that the installation of the chip will invariably bend or break a few pins. Once you or your dealer manages to get the 80287 plugged into the socket, you will find that programs will be unable to use it.

Programs that support a math coprocessor will be able to detect that an 80287 is installed (using the standard routine recommended by Intel), but they will hang when they actually try to use the 80287 for calculations. I tried out several different 8-MHz 80287 math coprocessor chips in the Turbo Accel-286, and they all experienced the same problem in both the 5- and 8-MHz selection. This indicates that the 80287 is not properly connected to the 80286. Quite possibly, the essential 80287 Busy signal is not wired up right. Obviously, the situation is worse than if programs couldn't find the 80287 at all.

■ Installing Earth Computers' Turbo Accel-286 on an XT requires tremendous patience—more than you may be prepared to expend.

It was only after I advised Earth Computers of the problem that the company sent the disk with the fixes. However, instead of addressing the problem, the fix simply reset the coprocessor DIP switch on the motherboard. But since most programs do not use this as a presence-test for the math coprocessor, it didn't help at all.

Earlier Turbo Accel-286 boards came with 1 megabyte of RAM. However, because they lacked any software and because of certain design problems, such as conflicts with memory addressing (programs never knew whether they were running in 8-bit or 16-bit memory), Earth Computers came out with the 640K-byte board. This lack of foresight and concern on the company's part, coupled with the implementation of its new board, has since caused me to worry about the quality of any of its boards.—**Vincent Puglia**

286 Speed Pak

Classic Technology's 286 Speed Pak ranks as one of the fastest accelerator boards tested here. It runs an 8-MHz 80286 and includes 1 megabyte of on-board memory. A socket is included for an 8-MHz 80287. In fast mode, the board transfers the contents of your ROM BIOS into memory on the board and accesses both the transferred BIOS and conventional user memory with 16-bit words.

The short (30-page) manual covers installation of the board. This involves transferring your 8088 to the 286 Speed Pak and attaching a cable between the board and an empty socket. You must also remove an 8087 if you have one and remove or disable all memory on expansion boards except expanded memory conforming to the Lotus/Intel/Microsoft expanded memory specification. The manual also recommends removing all but the first 64K bytes of memory from the XT system board. It's not necessary, but it reduces power consumption. You can make your XT think it has only 64K on the system board by setting the DIP switches appropriately.

MIRRORED MEMORY Although the 286 Speed Pak uses 640K bytes of on-board memory, your existing system board memory is not entirely neglected. To prevent running afoul of the DMA controller for disk accesses, it must also write to remaining system board memory. This mirrored system board memory is 256K on a 256K PC, but only 64K on a 64K PC or PC-XT.

A resident program, called Speedup, included with the 286 Speed Pak fills up what's left of this lower 64K bytes of XT memory, and so your applications programs run in memory that is not mirrored. Software with the 286 Speed Pak includes a RAMdisk and print spooler. The RAMdisk software is an old-fashioned resident program that requires setting your system board DIP switches to indicate that another drive is present. (Most modern RAMdisks are CONFIG.SYS driver programs.) Unfortunately, the RAMdisk and print spooler take up part of your 640K of conventional memory, even though the board has leftover RAM that is not used for anything.

A toggle switch on the back of the board selects between the 8-MHz 80286 and the 4.77 MHz 8088. The slow mode puts your 8088 back into the socket, so to speak, and makes your system work almost as it did without the board. Your programs still have access to the 640K bytes of memory on the 286 Speed Pak, but you lose the use of a math coprocessor.

Since the toggle selects between two processors, you can't make the switch on the fly. Doing so usually causes the PC to crash. In the best case your machine will simply reboot.

EGA compatibility is a problem. When you power up your machine in turbo mode, an EGA board will emit one long and three short beeps (a memory-check error), switch to 40-column mode, and come up thinking it has just 64K bytes of memory. (Classic Technology says this is a problem that occurs with about one out of four of IBM's EGAs, but I encountered it with two out of two. Classic also says it has a hardware jumper to fix it.)

PC MAGAZINE FACT FILE

286 Speed Pak
Classic Technology Inc.
2090 Concourse Dr.
San Jose, CA 95131
(408) 434-9333
List Price: $995; $299 for optional 5-MHz 80287-3; $499 for optional 8-MHz 80287-8; $895 for optional 2.5-Mbyte memory module card
Requires: IBM PC, XT, or compatible.
In Short: The 286 Speed Pak is certainly fast enough, but it displayed some instability and had problems with the EGA during bootup. The board probably makes most sense when used with the memory modules and Classic's multitasking software (neither are reviewed here), but then you're getting into big bucks.
CIRCLE 656 ON READER SERVICE CARD

RANDOM CRASHES I didn't encounter any compatibility problems with normal programs, but the board had a habit of randomly crashing—not often enough to make it unusable but just enough to make me leery of it. The board consistently crashed only when running one of the PC Magazine Labs test programs that used channel 2 of the 8254 timer chip for some precise measurements of processor speed and wait states. Although some other accelerator boards caused this program to report strange results, the Classic 286 Speed Pak was the only one that crashed it.

Although I did not have the opportunity to test them, Classic Technology also sells 2.5-megabyte memory modules that plug into the 286 Speed Pak but use up a slot each. These memory modules provide AT-type extended memory with a 24-bit address and 16-bit data path for the 80286 accesses. Classic Technology sells a multitasking system that incorporates use of these boards with software support.

Although Classic Technology believes that the board will be compatible with a future protected-mode DOS, the company is wisely not emphasizing that potential. I'd wait and see. Once you start adding up the cost of the memory modules ($895 and a slot each), it starts to make much more sense to just buy an AT and be sure.

—Charles Petzold

■ PC-elevATor

The PC-elevATor with an 80286 running at 10 MHz is the winner in any speed contest for accelerator boards. The board installed easily and, like a skyscraper lift, whizzed through most of the PC Magazine Labs tests at ear-popping speeds. Unfortunately, however, it did not quite make it through all the tests, giving our staff a rather bumpy ride.

Our trip skyward began uneventfully enough. Installation consisted of merely plugging the full-sized PC-elevATor board into an open slot and running an install program on the supplied utilities disk. The install program requests the name of a directory (which must already exist) into which it will copy the PC-elevATor command and system files; otherwise, installation is automatic, and no operator intervention is required. During installation, PC-elevATor's main system file, UP.SYS, is copied in the root directory and its name is automatically appended to the CONFIG.SYS file. At this point, installation is basically complete, although you may elect to further modify your CONFIG.SYS and UP.SYS files in order to take advantage of PC-elevATor's more-advanced features, such as extended and expanded memory and print spooling.

■ When PC-elevATor is running properly, it screams with performance.

UPSTAIRS/DOWNSTAIRS Once installed, PC-elevATor is invoked by running a program called Up. Up actually performs a warm boot, passing control of the entire system to the PC-elevATor board and its 80286 processor. In theory, most users would want to add Up to their AUTOEXEC.BAT files and then spend all their time "upstairs" in the accelerated mode. However, PC-elevATor also comes with a program called Down, which restores the PC to its original mode of operation. This allows you to run programs that may be dependent on the PC's normal clock speed without having to physically disable the elevATor hardware. The PC-elevATor software also includes a program called Level, which displays the current mode of operation ("upstairs" or "downstairs"). A special feature of Level even makes it possible to add an appropriate status message to the system prompt, such as "UP C>" or "DOWN C>".

When PC-elevATor is running properly in its upstairs mode, it fairly screams with performance. As expected, of course, the disk-intensive tasks in our PC Labs tests showed only marginal improvement. CPU-dependent tasks were what you'd expect from an 80286 running at 10 MHz with no wait states. The times were not quite double the speed of a 6-MHz PC AT, but they were pretty close.

PC-elevATor shows off its greatest speed—and greatest peculiarities—in handling the screen. Normally, programs cannot write to the color/graphics adapter until the display is in a vertical or horizontal retrace. Otherwise, snow will appear on the screen. The PC-elevATor buffers all screen outputs and then blitzes them out to the screen in fast bursts.

The improvement in speed for programs that use screen output is incredible: 3½ times faster than a 6-MHz PC AT in the screen output using the BIOS Teletype call and better than double the speed of a 6-MHz PC AT for our *1-2-3* macro.

But the result insofar as how the screen looks is strange. The PC-elevATor's method of updating the screen in discontinuous spurts gives the screen a jerky feeling and ruins the effect of many graphics displays, including animated screen displays. Another related graphics problem is that PC-elevATor will not support IBM's Enhanced Graphics Adapter, except when it is running in Color/Graphics Adapter mode. The most serious problem, however, was that the PC-elevATor board we tested simply didn't work all the time.

RELIABILITY VERSUS SPEED Our reliability problems with the PC-elevATor began immediately after installation. Everything worked fine in the downstairs mode, but some very strange things began

PC MAGAZINE FACT FILE

PC-elevATor
Applied Reasoning Corp.
765 Concord Ave.
Cambridge, MA 02138
(617) 492-0700
List Prices: 8 MHz with 1 Mbyte of RAM, $1,195; with 2 Mbytes of RAM, $1,595. 10 MHz with 1 Mbyte of RAM, $1,995; with 2 Mbytes of RAM, $2,745; 5-MHz 80287 coprocessor, $325; 8-MHz 80287 coprocessor, $425.
Requires: IBM PC or compatible, one expansion slot.
In Short: This 80286-based entry is a veritable speed demon, but it took us a while to get one that worked right. It supplies Lotus/Intel/Microsoft expanded memory specification and AT's extended memory right on the board, but it doesn't support IBM's Enhanced Graphics Adapter.

CIRCLE 693 ON READER SERVICE CARD

"Medium" Accelerator Boards: Summary of Features

	Price	Card length	Installation	Micro-processor	Clock speed (MHz)	Wait states	Memory caching	Caching efficiency (speed improvement)	Emulates normal speed	80287 option	8087 Exception Interrupt works	EGA compatibility	Intel Above Board compatibility
87/88 Turbo Board	$149	½ length	Cable to 8284 socket	NEC V20	6.67, 7.4, 8.0	0	None	N/A	Software	(Uses 8087 on system board)	Yes	OK	OK
Quadsprint	$345	¾ length	Cable to 8088 socket	8086	9.54	6 to 7	4K	400%	Disables cache with jumper	Optional daughterboard	Not tested	OK	OK
286 Express Card	$595	½ length	Cable to 8088 socket	80286	7.2	5 to 6	8K	525%	Disables cache with jumper	Yes	Yes	Problem with graphics	OK
SpeedPac 286	$595	½ length	Cable to 8088 socket	80286	7.2	5 to 6	8K	525%	Disables cache with jumper	Yes	Yes	OK	OK
PC TinyTurbo 286	$695	½ length	Cable to 8088 socket, old 8088 on board	80286	7.16	5	8K	525%	Toggle switch	Yes	Yes	OK	OK
PC 286 TurboCache	$595	½ length	Cable to 8088 socket, old 8088 on board	80286	7.16	5	8K	525%	Toggle switch	Yes	Yes	OK	OK
TurboEGA	$945	Full length	Cable to 8088 socket, old 8088 on board	80286	7.16	5	8K	525%	Toggle switch	Yes	Yes	OK	OK
SuperSprint	$595	Full length	Cable to 8088 socket	8086	10	6 to 7	128K	550%	Software	Yes	No	OK	OK

"Large" Accelerator Boards: Summary of Features

	Price	Card length	Installation	Micro-processor	Clock speed (Mhz)	Wait states	Memory on board	Emulates normal speed	8087/80287 option	8087 Exception Interrupt works	EGA compatibility	Intel Above Board compatibility
PC Number Smasher/ECM	$699	Full length	Cable to 8088 socket	8086	9.54	5 on lower 256K writes	1 Mbyte	Toggle or software	Yes	Yes	OK	OK
Turbo Accel-286	$995	Full length	Cable to 8088 socket	80286	8	1 to 2	640K	Toggle switch	Yes, but not functional	No	Error on boot	OK
286 Speed Pak	$995	Full length	Cable to 8088 socket, old 8088 on board	80286	8	Crashed test program	1 Mbyte	Toggle switch	Yes	Yes	Error on boot	OK
PC-elevATor	$1,195	Full length	Software drivers	80286	10	Problem with test program	2 Mbytes	Software	Yes	Yes	No enhanced graphics in fast mode	Uses board EMS only in fast mode
PC Turbo-286a	$1,195	Full length	Software drivers	80286	8	3	1 Mbyte	Software	Yes	No	No enhanced graphics in fast mode	Uses board EMS only in fast mode

PC—Indicates Editor's Choice

to happen as soon as we went upstairs. The most frequent of these caused our tests to terminate and the PC-elevATor to fall immediately downstairs, accompanied by the cryptic error message "unexpected interrupt #303." Another intermittent condition inappropriately caused the operating system to return a "not enough memory" message to any nonresident command, forcing us to reboot.

These and a variety of similar problems suggested to us that our particular board or its software might be corrupted—a suspicion shared by the staff at Applied Reasoning. So, 2 days and one replacement board later, PC Labs reran all the tests, as well as the manufacturer's diagnostics. We were glad to discover that most of the intermittent problems had disappeared, but the new board still had problems running some of the PC Labs benchmark tests. During the memory-access benchmark test, for example, the system hung completely when expanded memory was addressed. And during the *1-2-3* spreadsheet benchmark test, our old nemesis, "unexpected interrupt #303," reappeared, once again throwing us out of the program and back downstairs. It was a very small comfort to know that these errors could now be generated more predictably.

■ PC-elevATor installed easily and, like a skyscraper lift, whizzed through most of the PC Magazine Labs tests at ear-popping speeds.

A third board corrected the *1-2-3* prob-

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lem. A properly functioning PC-elevATor can run *1-2-3*, but it's clear that Applied Reasoning has some quality-control problems.

The PC-elevATor is certainly very fast, and we might be willing to overlook its limitations in the graphics area. However, we were very disturbed that we could generate so many errors with our rather vanilla-flavored benchmark tests; we shudder to think what might happen to some really exotic programs, copy-protection schemes, or multitasking utilities. There are certainly reasons to consider this product, but we suggest users test it carefully on their specific applications before making a firm commitment, or else the PC-elevATor will leave them stranded in the basement.—**Michael K. Guttman**

■ PC Turbo-286e

Orchid Technology's PC Turbo-286e is unique. In some ways, it recalls the days of single-board S-100 computers in that it ultimately provides you with a second computer inside your XT. In other respects, it presages the advent of parallel processing by promising the ability to connect four PC Turbo-286e's in the future. Its design is so flexible that you may purchase it to turbocharge your system but end up using it as a coprocessor. As an accelerator card, the 286e offers relative ease of use. However, if you intend to make use of the board's advanced coprocessing feature, you need not only expertise but also patience, since the present incarnation of the board's system software (Version 1.2) is less than perfect.

The 286e comes with an 8-MHz 80286 and 1 megabyte of 120-nanosecond, 16-bit RAM. Also on board are its own set of interrupts, I/O addresses, two 40-pin buses for add-ons, and a socket for an 80287 math coprocessor. For the memory hungry, an optional 1-megabyte daughterboard, configurable as extended or expanded memory, is available. All of this hardware furnishes computing power you dream about but do not usually see on a single board. Each PC Turbo-286e also comes with system software for running the board and swapping between modes, as well as productivity software for print spooling, creating RAMdisks, and operating cache memory and drives. For the adventurous, there is the coprocessing version of the system software.

■ Orchid seems intent on fixing problems. If it does, it will have a product that should redefine the way many of us use computers.

INSTALLATION Because the PC Turbo-286e works in tandem with your system's native 8088, installation can be as simple as inserting the card into an empty socket—no cable-connecting, no chip-pulling. Unfortunately, life is never ideal, and you will probably have to reconfigure the jumper settings. In fact, you may have to reset the jumpers more than once before you stumble upon the exact combination that is compatible with your system.

In contrast, installing the software is much easier. The menu-driven program prompts for the board's jumper settings and I/O addresses, installs the daughterboard as expanded or extended memory, and adjusts the screen updating for your particular monitor. It then rewrites your AUTOEXEC.BAT and creates two new batch files: one for the turbo mode, the other for the host mode. It also creates a TURBO.SYS file (turbo's equivalent of CONFIG.SYS).

You swap from one mode to another by issuing the commands Turbo and Unturbo. If you add an argument to the Unturbo command, it is copied to the host's keyboard buffer and then executed once the swap is made. When the turbo mode is executed, the 286e copies DOS and the PC's ROM BASIC area to their respective locations in the PC Turbo-286e memory. This means you have two independently running versions of DOS—each maintaining separate keyboard buffers, working drives and directories, and pathnames. While you're in turbo mode, the system's native 8088 is relegated to I/O processing. You can configure some of the 8-bit memory to print spooling and RAMdisks, and the remaining memory is used as cache.

EXPANDED MEMORY The 286e's use of expanded memory is dependent upon the board and mode in which it is installed. While you can configure an Intel Above Board for the host, turbo mode requires Orchid's own memory management driver and daughterboard. Turbo mode can use Above Board RAMdisks, but it does not recognize the expanded memory. Daughterboard memory is accessible only in the turbo mode. As far as the host knows, any RAMdisks installed on the daughterboard do not exist. When running applications in EMS, either the Above Board or the daughterboard will be accessed, depending upon the mode you are running in.

EXTENDED MEMORY While the procedure for installing the daughterboard and RAMdisks is fairly straightforward, it is not idiot-proof. For example, you can install the daughterboard for extended memory and then create RAMdisks in both extended and expanded memory. The system checks only to see that the device drivers are present; it does not check to see whether the memory exists. Evidently, when the TURBOEMM.SYS is loaded, it uses the reserved extended memory. It does not go back to Orchid's BIOS and readjust the amount of extended memory accordingly. Copying files to both drives effectively trashes them because, essentially, the data

PC MAGAZINE FACT FILE

PC Turbo-286e
Orchid Technology Inc.
47790 Westinghouse Dr.
Fremont, CA 94539
(415) 490-8586
List Price: $1,195: daughterboard, $395
Requires: IBM PC, XT, or AT; a full slot.
In Short: Orchid's PC Turbo-286e promises everything you ever wanted in an accelerator card. It delivers on speed and coprocessing. However, some of its other features, such as EGA compatibility and parallel processing, are still just promises.

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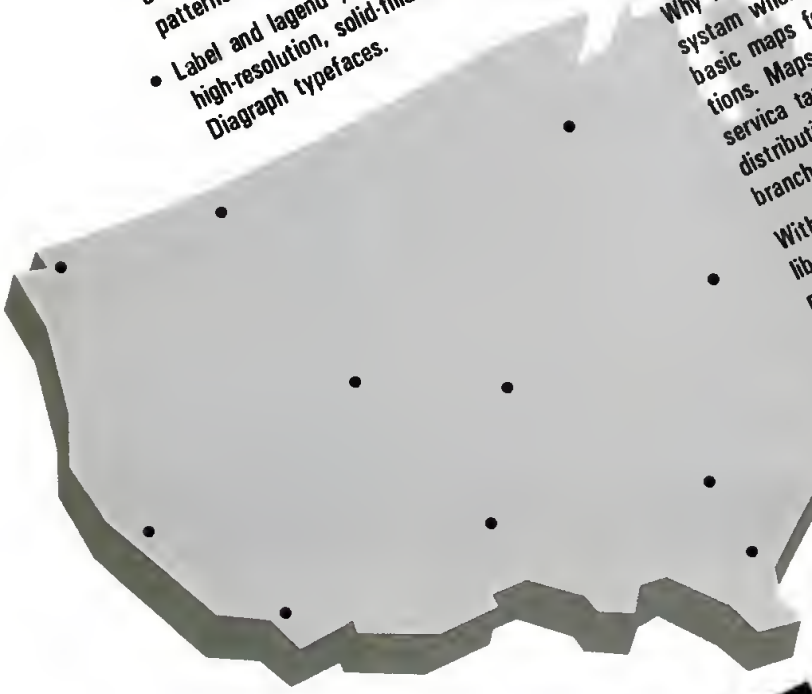


CIRCLE 318 ON READER SERVICE CARD

is occupying the same memory. While this is a serious flaw, it is avoidable by following the instructions in the manual (and hopefully Orchid will rewrite the memory manager so that such an installation is no longer possible).

Speed improvements with a PC Turbo-286e range from 200 to 900 percent, with most operations displaying an increase of four or five times that of the standard XT. If you want even more speed, you could replace your 8088 with another accelerator card, such as Orchid's TinyTurbo 286. It will not increase the executing speed of any memory-intensive tasks, but it will cut the time it takes to perform a sequential (or random) read by quite a bit because the TinyTurbo's 286 rather than the XT's 88 is accessing the disk cache.

COMPATIBILITY PROBLEMS The 286e has two compatibility problems: it cannot recover from an 8087 Exception interrupt properly, and it is not EGA compatible. The former problem means the board may have difficulty running programs that use floating point compiled under Microsoft C, FORTRAN, and Pascal. The latter means you use it with an EGA board, but only in CGA-compatible mode. According to Orchid, the EGA's unbuffered, I/O context-sensitive addressing is inherently incompatible with the 286e's screen updating algorithms. Orchid is presently working on an EGA-compatible card that connects directly to the PC Turbo-286e bus.

COPROCESSING VERSION While Orchid supplies the hardware for coprocessing, the supporting software is lacking. The coprocessing version of TURBO .COM and the demonstration programs (source and compiled) appear to be beta versions: the documentation is in READ.ME files, there are only minimal concessions to a user interface, and bugs run as rampant as ants at a picnic. (To be fair, some of the bugs occur only when you attempt to use the board for concurrent processing rather than coprocessing.)

One of the demonstration programs sets up an application on each processor and displays the output of the first mode in a window of the second. When run, the displayed output proved to be unreadable, and when I swapped to the other mode (using a predefined "hot key"), the window remained on-screen until it scrolled off. The lack of screen updating is definitely frustrating, especially if you run off-the-shelf applications—such as *WordStar*—on both processors. (When running the coprocessing version, the manual points out that there is a danger of cross-linking files when saving them to the same disk and directory.)

Of more concern, though, is a bug that occurs when you crash out of an application. On at least three occasions after a warm boot from within the program—once with EDLIN, twice with *WordStar*—the system said the program may be incompatible with the 80286 and then dropped back down into host mode. When I tried running them in host mode, they also refused to load. A DEBUG dump showed that text had been written into the program files. This implies that the coprocessing version has a problem closing files when you do not exit from them properly.

■ You can use the PC Turbo-286e if you are careful. Remember, though: speed kills.

Equally troublesome is a tendency of extended memory RAMdisks to create bad FATs. Each time I built three RAMdisks totaling 920K in the 1-megabyte extended memory area and then filled them with files, the last disk invariably collapsed. If you run CHKDSK /F, the system reports an unacknowledged keystroke interrupt and then crashes, dropping you down into host mode. According to the people at Orchid, they have located the bug and are in the process of exterminating it.

Despite the software bugs, I find the PC Turbo-286e an exciting product that warrants close observation. Orchid seems intent on fixing the problems; if it does—and adds a friendlier shell to the coprocessing software—it will have a product that should redefine the way many of us use our computers. If you can't wait for a debugged coprocessing version, you can use what is available if you are careful. Remember, though: speed kills.

—Vincent Puglia

PC MAGAZINE EDITOR'S CHOICE

The medium cards are generally half-length cards and rely upon memory caching for speed. The clear winner in this category is Orchid Technology's half-length ***TinyTurbo 286****, which is easy to use and highly reliable. The 80286 runs at 7.16 MHz, and the 8K cache provides a significant improvement in speed while maintaining nearly normal bus timings. The TinyTurbo 286 also has a true non-turbo normal mode that you can select.*

The board is also sold by MicroWay under the name ***286 TurboCache*** *and comes with software and technical information not available from Orchid. The TinyTurbo 286 also shows up as half of Orchid's TurboEGA, in which an accelerator and an Enhanced Graphics Adapter synergistically coexist.*

The large accelerator board ranks as one of the most complex pieces of hardware you can put in your PC or XT. These boards never seem to be quite finished or in final form, since their manufacturers must always scurry to fix yet another newly discovered problem.

The only reliable board in this category is MicroWay's ***Number Smasher/ECM****, but only if you pretend that the "ECM" (Expanded Conventional Memory) module that comes with the board does not exist. Aside from the regrettable ECM, the Number Smasher doesn't try to bite off a bigger chunk of your computer than it has to.*

M. David Stone and Vincent Puglia are frequent contributors to PC Magazine. *Michael K. Guttman is a computer consultant based in Marlton, New Jersey.*

The three-dimensional bar graph at the far right shows the normalized results of four representative performance tests and an average for the 18 boards reviewed here. For comparison, the graph also shows results for a stock 4.77-MHz PC or XT, a PC or XT with a NEC V20 installed, a 6-MHz PC AT, and an 8-MHz PC AT.

In all cases, the results are for the turbo boards running at the fastest speed we could manage. Any software enhancements that may have been provided with the boards (such as programs that transferred the contents of the ROM BIOS to memory on the board or filled up the lower 64K bytes of memory) were also loaded before running the tests. Boards that included a NEC V20 option were run with the V20 installed.

The accompanying table (upper-left corner) shows the raw times for these tests. For the bar graph, the times were normalized based on a 100 percent rating for a stock PC or XT.

NOP

The NOP benchmark test is designed to measure raw clock speed and memory access time while minimizing differences in microprocessors and the effect of memory caching. This test executes almost nothing but NOP (No Operation) machine code instructions in a big 128K loop. Because most other performance tests use small loops with complex instructions, they are inherently biased toward boards that use memory caching and the 80286 microprocessor. This test helps balance things out to make the average result more indicative of realistic instruction mixes.

Floating-point calculation

The floating-point calculation benchmark test (including logarithmic and trigonometric functions) is done on software *without* an 8087 math coprocessor. The benchmark test was programmed in C and compiled under the Microsoft C Compiler, Version 3.0. This test runs significantly faster on 80286-based turbo boards because software floating-point calculations require many multiplies and divides.

1-2-3 routine

The *1-2-3* routine (Release 1A) creates a large worksheet, moves rows and columns around, does recalculations, and ultimately erases the worksheet. This test is partially dependent upon the video adapter installed in the PC. All boards were tested with a Color/Graphics Adapter except for Orchid's TurboEGA, which used the Enhanced Graphics Adapter that is part of the board.

Screen display

We also measured screen display response time for text written through the BIOS "Teletype" function. DOS uses this BIOS routine for normal text output from the DOS command level (for instance, during a DIR command), so it is a commonly encountered part of PC use. Those boards that include a provision to copy the contents of the ROM BIOS into memory on the board will run this test faster. The TurboEGA is a special case, since it uses an EGA ROM BIOS installed on the accelerator board and optimized for Teletype output.

Average

Finally, we created a normalized average result of the four tests evenly weighted.

A separate bar graph (lower right) shows normalized results of the same floating-point test described above, run with an 8087 or 80287 math coprocessor on the accelerator board. In all cases, this test used the maximum 8087/80287 speed the board could be configured for. Some boards could not use an 8087/80287, so those boards are not included in this graph.

PC LABS Benchmark Tests: Accelerator Boards

Performance Times

(All times given in seconds and decimal seconds)

Product	Normalized Average	Floating-point Calculation	1-2-3 Routine	Screen Display	NOP
Normal PC or XT	100	155.32	250	23.34	10.11
PC or XT with NEC V20	92	132.92	215	23.23	10.11
Surprise!	86	123.58	206	19.55	10.11
Quadsprint	80	77.77	147	23.34	11.42
SuperSprint	69	54.32	136	11.59	14.06
American Turbo	63	98.26	152	15.60	6.37
286 TurboCache	61	42.73	88	19.55	10.38
TinyTurbo 286	61	42.73	88	19.55	10.38
SpeedPac 286	61	42.84	88	19.55	10.38
87/88 Turbo Board	60	83.82	146	15.43	6.37
Fast86	59	83.87	136	15.49	6.37
Overthruster	58	83.87	136	15.49	6.32
SuperCharger	56	78.49	127	15.60	5.99
286 Express Card	55	42.73	67	13.95	10.38
TurboEGA	50	42.73	88	9.06	10.30
Turbo Accel-286	49	37.02	80	23.34	4.23
6-MHz PC AT	42	46.58	98	11.48	5.53
Number Smasher/ECM	40	54.82	109	11.53	3.52
286 Speed Pak	36	37.02	80	11.42	4.17
8-MHz PC AT	31	34.28	74	7.69	4.17
PC Turbo-286e	22	28.01	53	2.25	4.17
PC-elevATor	20	29.11	40	3.35	3.35

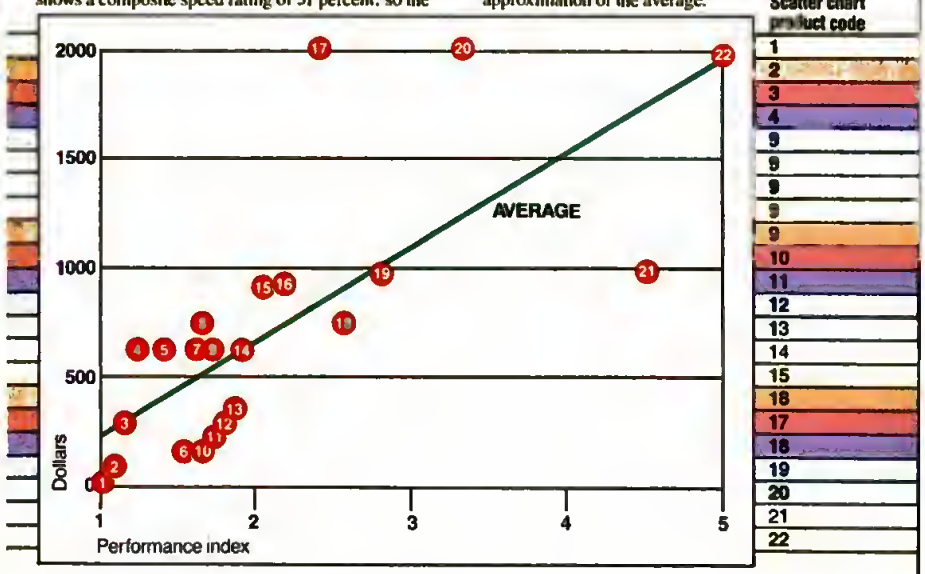
Bang per Buck

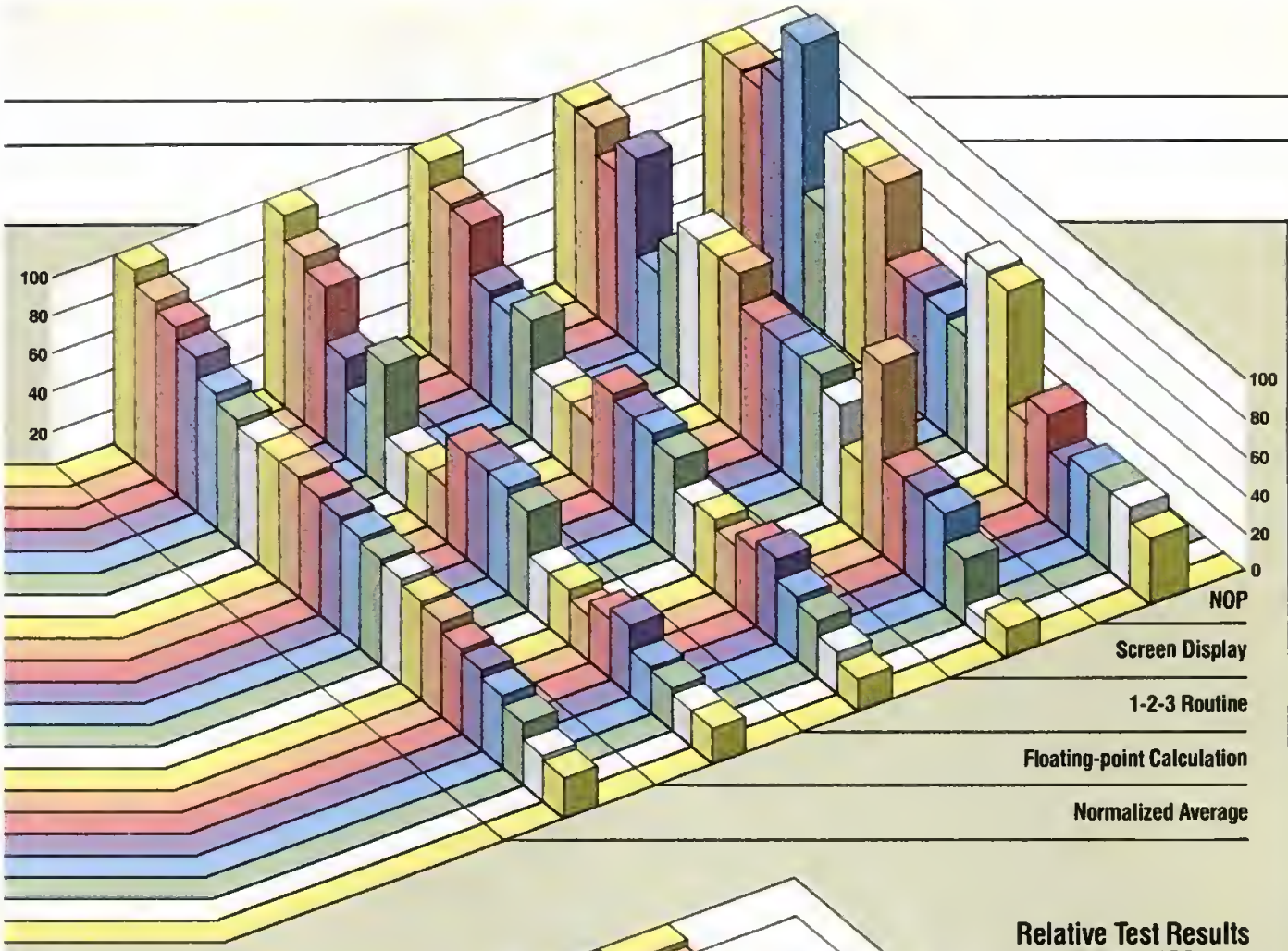
Of course, accelerator boards cost money, but this cost may not be directly proportional to the speed improvement they provide. You can get an idea of the value of each accelerator board from the "Bang per Buck" scatter plot shown below.

The Performance Index axis of this graph is simply the inverse of the Average Speed shown in the three-dimensional bar graph. For instance, an 8-MHz PC AT shows a composite speed rating of 31 percent, so the Performance Index is 3.23.

The Price axis is generally the base price of each accelerator board without additional memory or an 8087 option. However, since we measured the speed with a NEC V20 for no-slot boards that included it as an option, the prices for these boards include the V20.

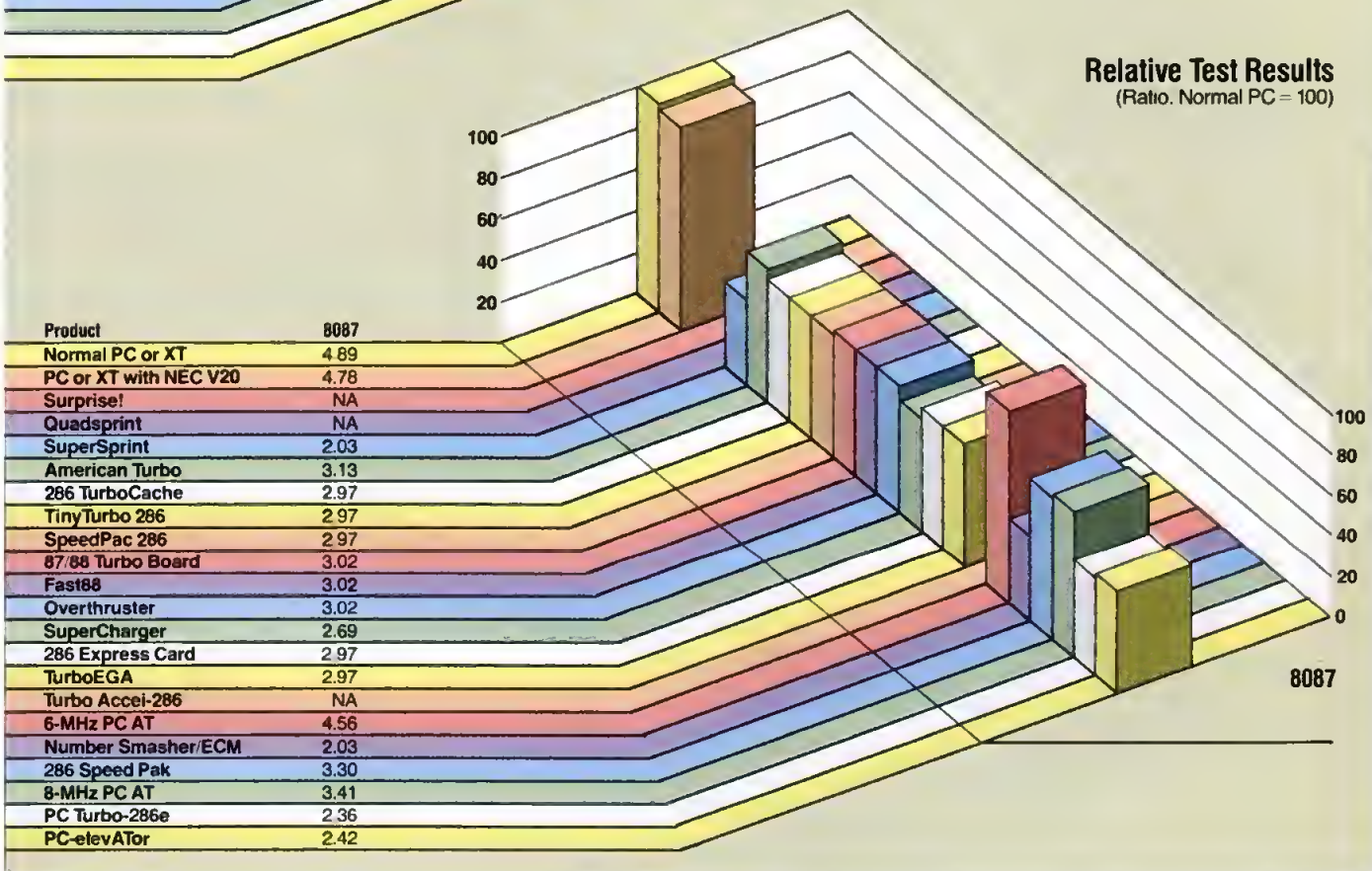
Based solely on speed improvement, the better values in accelerator boards are those furthest below and to the right of the straight-line approximation of the average.





Relative Test Results

(Ratio. Normal PC = 100)



Product	8087
Normal PC or XT	4.89
PC or XT with NEC V20	4.78
Surprise!	NA
Quadsprint	NA
SuperSprint	2.03
American Turbo	3.13
286 TurboCache	2.97
TinyTurbo 286	2.97
SpeedPac 286	2.97
87/88 Turbo Board	3.02
Fast88	3.02
Overthruster	3.02
SuperCharger	2.69
286 Express Card	2.97
TurboEGA	2.97
Turbo Accel-286	NA
6-MHz PC AT	4.56
Number Smasher/ECM	2.03
286 Speed Pak	3.30
8-MHz PC AT	3.41
PC Turbo-286e	2.36
PC-elevATor	2.42