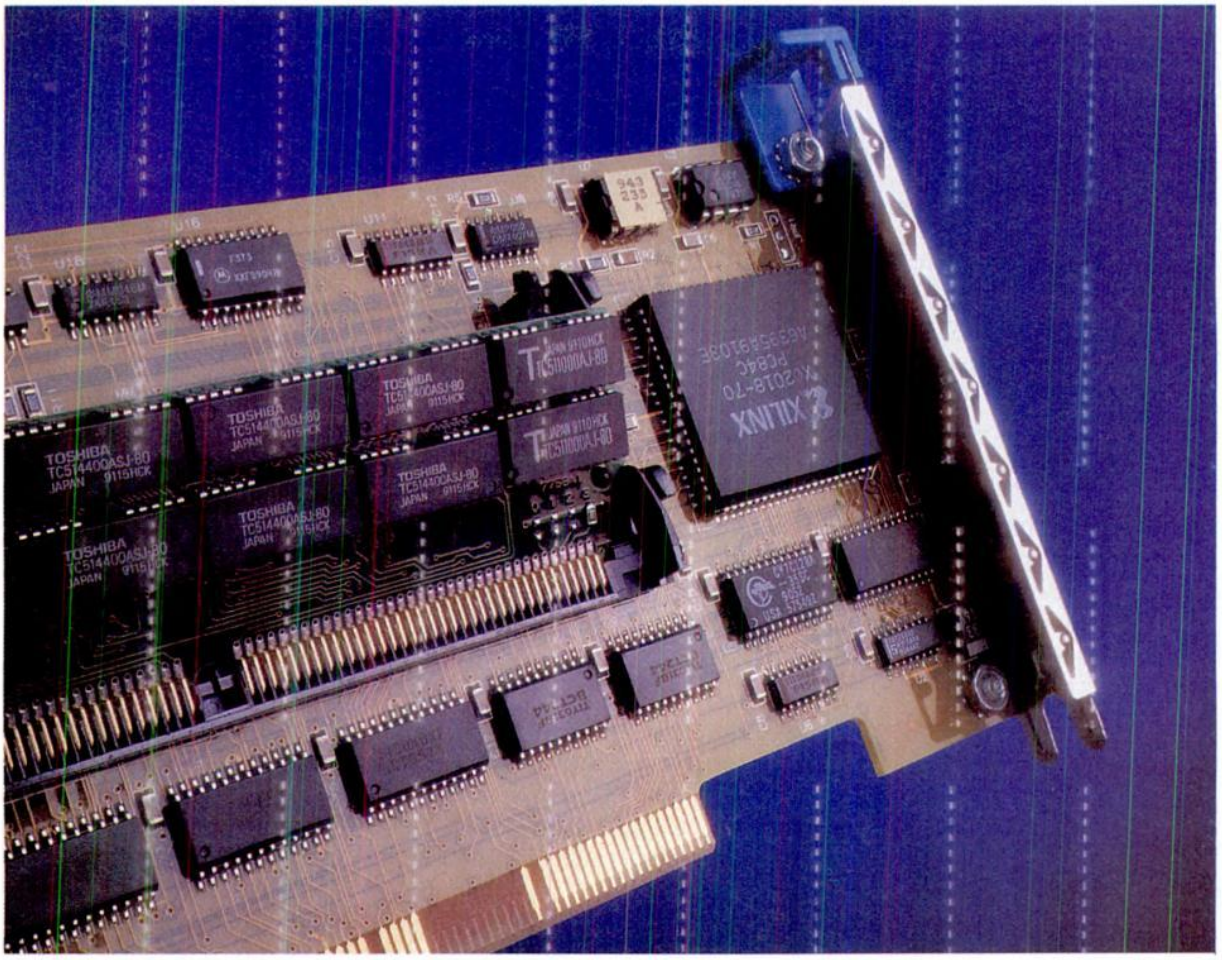


MCA Memory Boards

EXPANSION WITHOUT DELAY

Need more memory than the system board in your Micro Channel machine can hold? Moving to expansion board RAM is not the sacrifice it can be with ISA- and EISA-based systems. MCA expansion memory benefits from the architecture's faster bus and from features such as asynchronous operation. We review 11 MCA memory boards from 9 vendors.

PHOTOGRAPHY: BOB WOLFSON

by Winn L. Rosch

Slow poison—that's how expansion-bus memory on Industry Standard Architecture (ISA) and Extended Industry Standard Architecture (EISA) systems has been regarded traditionally. But memory on the Micro Channel is different. Rather than being sloughed off as second-rate, Micro Channel architecture (MCA) expansion-bus memory deserves serious consideration.

Unlike the 8-MHz bus in ISA and EISA systems, which poisons your machine with laggardly performance, the MCA bus offers a

faster base operating speed of 10 MHz. In IBM PS/2 Model 80s, where matched-memory-mode transfers are possible, the MCA bus can run as fast as 16 MHz. An added advantage of the MCA bus is that memory boards designed for it typically support data transfers at zero wait states on any PS/2 system. With ISA and EISA products, that is less likely to be the case.

Memory on the MCA bus actually can speed up some PS/2 systems. You will see a performance increase in 16-bit machines with one wait state, such as the IBM PS/2 Models 50 and 60. The boost comes from using zero-wait-state memory boards on the MCA bus in addition to the one-wait-state memory on the system boards of those machines. In other PS/2 machines, the penalty for going to the bus instead of the system board for memory is substantially less than with other expansion buses. According to PC Magazine Labs' tests using a 25-MHz IBM PS/2 Model 70-A21, with one of the top-performing MCA memory boards you can expect a loss of only 20 to 25 percent of system board memory throughput. In contrast, with memory boards for 33-MHz EISA machines, there might be as much as a 75 percent throughput loss.

DESIGN WITH A DIFFERENCE

The difference is by design. When MCA was originally conceived, it was supposed to handle expansion-bus memory with the same dispatch as system board RAM: 10 MHz on the original IBM PS/2 Models 50 and 60. Only when 386 microprocessors raced beyond 16 MHz did the speedy MCA bus not keep up. Even so, MCA expansion memory on a 16-MHz Model 80 still can run at least twice as fast as RAM on 8-MHz EISA or classic ISA buses (this is not true for the 16-MHz version of the Model 70).

On all PS/2 systems, the Micro Channel is designed to operate asynchronously; it need not be locked to the system clock. Theoretically, asynchronous operation could allow MCA expansion boards to operate at nearly unlimited speeds: say 40 MHz instead of 10 MHz. But in the real world no company fully takes advantage of the asynchronous functions of MCA, though some may take advantage of the capability to provide sporadic bursts of somewhat higher bus-speed operation.

For example, to achieve higher access rates, some boards allow matched memory transfers in Model 80s. Matched memory transfers speed up bus operations

ISA AND EISA EXPANSION-BUS MEMORY: Some Points to Consider

Undeniably, there are drawbacks to using expansion-bus memory on ISA or EISA machines. But there are also valid reasons for why you might find it useful—or necessary.

by Winn L. Rosch

If any one word describes bus memory for the classic AT (ISA) and EISA buses, it is *anathema*. With today's more powerful systems, nothing short of a 100-pound ball and chain could slow down your workday more. Bus memory operates so much slower than current machines' system board memory that your system can be bogged down to 25 percent or less of its potential speed.

In some cases, however, sliding a few megabytes of RAM into an expansion slot of an ISA or EISA machine makes sense. The primary instance is when your PC's bus speed closely matches its microprocessor speed. With such a system, you should face no penalty in using expansion-board memory because there will be no slowdown in accessing the bus. But this match works only in a few cases—generally 286 machines with CPU speeds between 6 and 12 MHz. With newer systems, as the CPU speed increases, the 8-MHz bus speed of ISA and EISA machines falls farther and farther behind.

All the wonders of EISA do not help the memory speed situation. Even EISA's fastest transfer rate—33 megabits per second (Mbps), used for Type C DMA operations—moves information at only one-quarter of the speed that a 33-MHz 80386 or 80486 microprocessor expects. These 32-bit microprocessors want information at 132 Mbps because they deal with data 4 bytes at a time. Since typical system board memory transfers do not use Type C, performance lags even more on EISA buses.

REASONS FOR ADDING RAM

The bottom line is that expansion-board memory will definitely handicap the performance of any ISA or EISA system with a microprocessor running faster than 12 MHz. Nevertheless, you may still have several viable reasons to put RAM on your ISA or EISA PC's expansion bus, such as a lack of other expansion capabilities. Some system boards have limited expansion capabilities, and slotted memory may be the only kind you can add. An all-too-common scenario arises when the system board uses a proprietary memory expansion board but you cannot acquire that board because the manufacturer is unreachable, is out of business, or never bothered to make the board in the first place.

You can also use expansion-board memory for a RAM disk. While the RAM drive will not be as fast as one created using system board memory, it will still easily outrace any mechanical disk drive.

As long as you configure the memory on the board to be addressed above the top of all system board memory (as it typically would be), it will be the last to be used by your applications. Only when a program needs every last byte will it reach into slowdown territory. Certainly performance will suffer at that point, but you will be able to run software you would not otherwise be able to use.

If you are using an environment that takes advantage of virtual memory techniques, such as Microsoft Windows 3.0, the slow slotted memory will still outperform the virtual memory that is emulated by a mechanical disk drive. While such slotted memory is not an ideal solution, it is affordable and practical. ■

during reads and writes by accelerating the bus timing to 16 MHz from its normal 10 MHz.

REVIEW CRITERIA

The nine manufacturers represented here—Acculogic, Advanced Microcomputer Systems, Capital Equipment, Cumulus, Intel, Kingston Technology, Memrel, Orchid Technology, and Tecmar—offer a variety of memory boards to fill MCA expansion needs. To be included in this review, products had to be able to store at least 8MB of 32-bit memory and work in an IBM PS/2 Model 70-A21, which served as the test-bed. IBM is not represented because it was unable to deliver its product, the IBM Memory Expansion Option, in time for this review. We learned about RYBS Electronics' HICARD MC AMS too late to include it in this review.

Most of the boards delivered 80 percent of the PS/2 system board memory throughput in reading data, and about 71 percent in writing data.

PC Magazine Labs' Memory Read and Memory Write tests checked the performance of the boards by writing to every 4K block of memory on each board and checking transfer times for reading and writing. Because these boards all use clocked logic, you might expect that operations would occur at the same rate; any memory board you put in the system should operate in lockstep with the bus clock. But design differences gave some boards performance advantages. For example, most boards operated at zero wait states, while a few imposed memory wait states. Most of the boards were able to deliver 80 percent of the PS/2 system board memory throughput in reading data, and about 71 percent in writing data.

One board that imposes one memory wait state, Advanced Microcomputer Systems' AMS Memory 32 DI, performed at 66 percent of the system board speed in reading data. Cumulus's CuRAM-MC32 performs memory reads at zero wait states but memory writes at one wait state (according to the company); it performed at 50 percent of system board speed in writing data. This was only slightly better than the AMS Memory 32 DI's writing speed. Interestingly, Orchid Technology claims that its RamQuest 16/32 operates at zero wait states for all operations, but the RamQuest actually performed poorly on our Memory Write test.

In many cases, the board's ability to use the Model 70's RAM cache helped its performance. While the memory on most of these boards can take advantage of the Model 70's RAM cache, boards that initialize memory after the host system's self-test generally cannot.

ADVANCED SUPPORT

Only a few boards claim support for any of the advanced features of the Micro Channel-2 specification published with the release of the original RS/6000 chip: boards that could speed transfers by a factor of 4 to 8 as well as ensure the integrity of such transfers. Kingston Technology claims that its boards are compatible with all advanced modes; Advanced Microcomputer Systems claims that its AMS Memory 32 DI allows multiplexed data transfers. These functions could not be tested because no PS/2s currently use these modes. (Cumulus has announced plans to deliver the first PC-class machine to use these modes in the first quarter of 1992.) None of the boards evaluated here are recommended by their manufacturers for MCA computers outside the PS/2 line that use these advanced modes today, such as the RS/6000 and AS/400.

Beyond speed and advanced modes, a number of other differences distinguish these products. Prices for these boards range from $275 (for the AMS Memory 32 DI with only 1MB of RAM) to $2,429 (for the Capital OS/RAM 32 Plus stuffed with 32MB of memory). Some manufacturers, such as Acculogic and Tecmar, prefer to sell you their boards with no memory at all. Other differences of principal concern include the following:

■ **Capacity.** You'll want as much capacity as possible for future expansion. The Capital OS/RAM 32 Plus lets you add 128MB of RAM to your system, although 32MB is actually a more common figure

PC MAGAZINE EDITORS' CHOICE

■ **MicroRAM SC**

Speed is not an issue among the better MCA memory boards. Most of the products in this review combine fast SIMM chips with zero wait states to achieve the same level of top-flight performance.

The important qualities to consider for MCA memory boards include a product's flexibility and smooth integration into the Micro Channel architecture. Tecmar's MicroRAM SC exemplifies both those qualities. In an arena where the products differ from each other only slightly, this board is the standout performer.

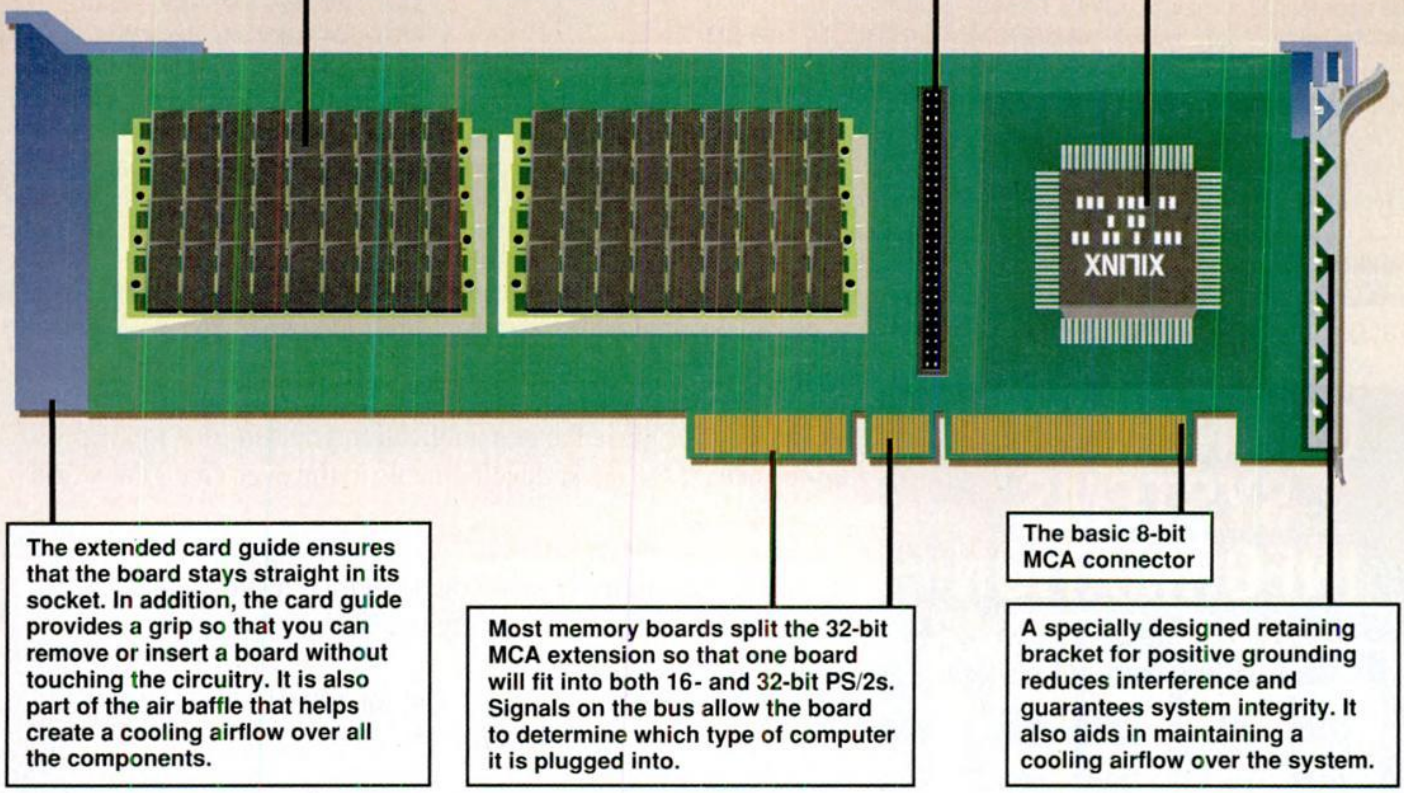
In addition to the top-tier ratings the MicroRAM SC achieved on our PC Labs performance tests, the board uses any size of 36-bit SIMMs in any combination of 1MB, 2MB, 4MB, and 8MB capacities, allowing corporate inventory to be streamlined. The MicroRAM SC also makes installing additional memory in your 16- or 32-bit PS/2 as pain-free as possible. For example, you do not have to fill sockets in numerical order, with larger-capacity SIMMs going into lower-numbered sockets, as you must do with some other boards reviewed here.

The MicroRAM SC seamlessly melds with your PC: no need to worry about operating system–specific drivers or added complications in the configuration process. The package is neatly put together, using primarily surface-mount circuitry, while many other boards are still using pin-in-hole technology.

With 8MB of RAM installed, the MicroRAM SC is not the least expensive product reviewed here, but you can opt to buy the board bare for $360 and fill it up on less expensive memory chips from other sources. In whatever configuration you buy the MicroRAM SC, you will be glad you made the investment.

ANATOMY OF A MICRO CHANNEL MEMORY BOARD

The memory boards in this review are easily recognizable by their 32-bit connectors, four or eight SIMM sockets (generally 9- or 36-bit), and large ASIC memory controller. Some memory boards also possess an optional I/O daughterboard, which can contain parallel and serial ports.



with most of the products. While today's MCA computers do not allow DMA (direct memory access) transfers beyond 16MB, the added memory can be used by other operating systems, such as *NetWare*, or other functions not needing DMA, such as EMS (expanded memory specification) memory or disk caches.

■ **Integration.** To be useful, the memory on MCA boards must be integrated with the rest of the memory in the system. Two principal methods are used for doing so. The Track Zero method loads a special driver from the first track on the host's hard disk before the operating system loads. BIOS-compatible boards, on the other hand, integrate memory before or during the self-test.

Because Track Zero memory is not found during IBM's self-test, it may not be understood by the rest of the system and might not be cached.

BIOS-compatible boards are better for several reasons. Track Zero is incompatible with some operating systems that reserve that track for other functions, such as *NetWare*. The Track Zero technique relies on the quality of the memory board manufacturer's diagnostics to find and reserve bad bytes, a function normally handled by IBM's self-test. Because Track Zero memory is not found during IBM's self-test, it may not be understood by the rest of the system hardware and, more importantly, might not be cached. In

addition, memory integrated with Track Zero drivers may be invisible to some programs. And such memory just disappears when you boot from a floppy disk because the necessary Track Zero driver does not load.

■ **SIMM type.** Several types of SIMMs are used on various memory products. The two most common are 9-bit and 36-bit (the latter are generally referred to as IBM motherboard–style SIMMs). The 9-bit chips must be added in banks—banks of two for 16-bit operation, banks of four for 32-bit. This limits the number of different memory configurations available on a board. While most boards allow you to mix different capacities of 9-bit SIMMs in the appropriate bank size, Intel's Above-Board MC allows only a single 9-bit SIMM size on a board. On the other hand, IBM-style 36-bit modules can be expanded in increments of one module, and any variety of SIMM capacities can be used on a single board.

■ **Backfill.** Some of these MCA memory boards can backfill system board memory—that is, use memory from the expansion board to flesh out the base system board memory to the full 640K. While this seems a dubious virtue when all PS/2s have at least 1MB on their system boards from the factory, it has important implications for the 286-based PS/2 Models 50 and 60. Backfilled memory operating at zero wait states can replace those models' one-wait-state system board memory, potentially improving throughput by 50 percent. In these systems, a simple memory board acts like a turbocharger.

Backfilled memory operating at zero wait states can replace one-wait-state system board memory, improving throughput by 50 percent.

Certainly the best way to begin adding memory to most PS/2s is on the system board, where it will always operate at full microprocessor speed no matter what the class of machine. But if you need more, you can plug in one of these MCA memory boards without worrying that it will have a lethal effect on your PC.

ACCULOGIC INC.
SIMMply-RAM for the PS/2-32

The name—SIMMply-RAM for the PS/2-32—certainly describes Acculogic's marketing intent: nothing but memory in the form of SIMMs. The board's $459 list price (you can find it for about $360 on the street) includes no memory; you or your dealer stuff the card with SIMMs. According to Acculogic, an 8MB version would cost about $1,099.

The specifications of Acculogic's SIMMply-RAM are versatile enough to

MCA MEMORY BOARDS: SUMMARY OF FEATURES

Products listed in alphabetical order

	AboveBoard MC	AMS Memory 32 DI	Capital OS/RAM 32	Capital OS/RAM 32 Plus	CuRAM-MC32	Kingston KTM 3011-4
List price (tested configuration)	$999	$625	$786	$798	$1,574	$2,425
MEMORY						
Installed RAM (tested configuration)	4MB	8MB	8MB	8MB	8MB	8MB
Maximum RAM capacity	32MB	16MB	8MB	128MB	32MB	16MB
SIMM type	9-bit	36-bit	9-bit	9-bit	36-bit	36-bit
Maximum number of SIMMs installable	8	4	8	8	4	4
SIMM sizes supported:						
256K	■	❑	■	❑	❑	❑
1MB	■	■	■	■	■	■
2MB	❑	■	❑	❑	■	■
4MB	■	■	❑	■	■	■
8MB	❑	❑	❑	❑	■	❑
16MB	❑	❑	❑	■	❑	❑
Method of integration	BIOS	BIOS	BIOS	BIOS	BIOS, Track Zero	BIOS
Memory recognized during POST	❑	■	❑	❑	■	■
Can backfill system board memory	■	❑	❑	■	❑	❑
Ports	1 parallel, 1 serial ($149)	1 parallel, 1 serial ($50)	None	None	None	None
COMPATIBILITY						
PS/2 Models 50 through 65SX	■	❑	■	■	❑	❑
PS/2 Models 70 through 80	■	■	■	■	■	■
PS/2 Models 90 through 95	❑	■	■	■	■	■

PC—Editors' Choice ■—Yes ❑—No

make it a viable contender for any PS/2 Model 70, 80, 90, or 95, the models for which Acculogic recommends the board. The four sockets for IBM-style 36-bit SIMMs will accommodate any standard-size module; you can snap in 1MB, 2MB, 4MB, or 8MB in any place or order. The board can yield from 1MB to 32MB in a single slot.

HARDWARE DIFFICULTIES

Acculogic supplied a variety of SIMMs on the evaluation board to demonstrate this versatility. All of the supplied SIMMs were rated at 80 nanoseconds. The first SIMMply-RAM board we received and installed generated a system error, which could not be explained by the manufacturer but could have been attributed to shipping damage.

The replacement board proved to be a real disappointment when it came to installation. It did not fit correctly in a 32-bit MCA expansion slot; this problem should not occur if a board is properly designed with the dimensional reference at the center of the slot connector. With some effort, the board was successfully installed in its slot, but it balked when we tried to use the SIMMs from the old SIMMply-RAM board. Adding two 80-ns. 4MB SIMMs supplied by Kingston Technology finally brought the SIMMply-RAM to life, however.

Outside the dimensional problem, the working evaluation board was well laid out and entirely populated with surface-mount components (except for the BIOS chip). After installation, it proved to be a perfect match with the test-bed Model 70; the board was fully recognized by the system's POST (power-on self-test). The SIMMply-RAM fully conforms with IBM's software configuration procedure: After installing the board, you run the IBM Reference Disk and it executes the setup. The board's performance on our tests put it at the top of its class with most of its competitors.

Acculogic supplies a memory manager it codeveloped, called *QMAPS*, that converts extended memory to EMS or XMS (extended memory specification), allows drivers and TSRs to be loaded into high DOS memory, and includes a RAM disk, disk cache, and print spooler. The MCA board itself, however, is covered by only a rather skimpy two-year warranty.

It is unfortunate that the Acculogic SIMMply-RAM simply does not fit better in a PC slot, but the memory board clearly has certain advantages—among them good and competitive performance—that make it worth considering.

FACT FILE

SIMMply-RAM for the PS/2-32
Acculogic Inc., 13715 Alton Pkwy., Irvine, CA 92718; 800-234-7811, 714-454-2441.
List Price: Without memory, $459.
Works With: IBM PS/2 Models 70 through 95.
In Short: Acculogic's SIMMply-RAM for the PS/2-32 is long on performance and long in the slot—too long for a good fit. Although tough to slide into a PS/2, the board will add up to 32MB to any 32-bit system.

CIRCLE 412 ON READER SERVICE CARD

MicroRAM SC	MicroRAM 386	Parity+Plus P32010	RamQuest 16/32	SIMMply-RAM for the PS/2-32
$1,160	$1,190	$795	$1,229	$459
8MB	8MB	8MB	8MB	None
32MB	32MB	8MB	8MB	32MB
36-bit	9-bit	9-bit	9-bit	36-bit
4	8	8	8	4
❑	■	■	■	❑
■	■	■	■	■
■	❑	❑	❑	■
■	■	❑	❑	■
■	❑	❑	❑	■
❑	❑	❑	❑	❑
BIOS	BIOS	Track Zero	BIOS	BIOS
■	■	❑	■	■
■	■	❑	■	❑
None	1 parallel, 2 serial ($120)	None	1 parallel, 1 serial (included)	None
■	❑	❑	■	❑
■	■	■	■	■
■	■	❑	❑	■

ADVANCED MICROCOMPUTER SYSTEMS INC.

AMS Memory 32 DI

The AMS Memory 32 DI from Advanced Microcomputer Systems (AMS) harks back to olden days, with a price that recalls the era before inflation. Unfortunately, performance leaves something to be desired, partly because the Memory 32 DI suffers from added wait states.

As a bare board, the $225 Memory 32 DI is the least expensive product in this review; its maker estimates a street price as low as $180. Add $50 per megabyte for as much RAM as you need, up to 16MB; an 8MB board lists for only $625.

The Memory 32 DI is designed for 32-bit systems only; AMS claims its product is compatible with all PS/2s from the Model 70 to 95. At the heart of the Memory 32 DI board are four SIMM sockets, each of which accommodates a 72-pin, 36-bit IBM-style SIMM of either 1MB, 2MB, or 4MB capacity. Different module sizes can be mixed on a single board with two provisos: Sockets must be filled in numerical order from bank one to bank four, and larger-capacity SIMMs must go in the lower-numbered banks.

The Memory 32 DI requires 80-nanosecond or better SIMM chips (which are necessary for Model 80 matched memory timing); for testing, the company delivered its 80-ns. SIMMs in the form of two 4MB modules. Notwithstanding the quick SIMMs, the board plodded along as one of the slowest in the roundup.

ADDED I/O CAPABILITY

If you need extra I/O in your PS/2, the Memory 32 DI gives you the option of adding one serial and one parallel port using a $50 L-shaped daughterboard. Connections are brought out as a single female 37-pin D-shell connector. AMS supplies an 8-inch two-headed adapter cable to provide a conventional 25-pin male D-shell for the serial port and a female 25-pin D-shell for the parallel port.

The board's construction is vintage pin-in-hole, made mostly from discrete components. Workmanship is nevertheless very good, though protected by only a two-year warranty. The board follows the standard IBM software configuration procedure and flawlessly mates with the host system using BIOS code.

Though the price is right, the performance of the AMS Memory 32 DI clearly is not. Select elsewhere if speedy throughput is your prime concern.

FACT FILE

AMS Memory 32 DI
Advanced Microcomputer Systems Inc., 1321 NW 65th Pl., Fort Lauderdale, FL 33309; 800-972-3733, 305-975-9515.
List Price: Without memory, $225; with 8MB RAM, $625. One parallel and one serial port, $50.
Works With: IBM PS/2 Models 70 through 95.
In Short: The AMS Memory 32 DI is the cheapest but one of the slowest of the MCA boards we tested. It is built with older technology and can add 16MB only to 32-bit systems.

CIRCLE **413** ON READER SERVICE CARD

CAPITAL EQUIPMENT CORP.

Capital OS/RAM 32
Capital OS/RAM 32 Plus

Simple SIMMs and flexibility are the hallmarks of the Capital OS/RAM 32 and Capital OS/RAM 32 Plus, from Capital Equipment Corp. Both boards use standard 9-bit SIMMs for inexpensive memory expansion, yet deliver top speed. The OS/RAM 32 Plus adds extra versatility for mixing and matching various SIMM types, so you can upgrade modestly or extravagantly.

Capital Equipment's pricing helps keep your memory investment on the modest side. With 8MB, the boards bear closely matching list prices: $786 for the OS/RAM 32 and $798 for the OS/RAM 32 Plus. The basic OS/RAM 32 with no memory costs $299, while a similarly configured OS/RAM 32 Plus is $349.

ADAPTABLE SIBLINGS

The twins share the ability to adapt to either 16-bit or 32-bit computers. When two or six SIMMs are installed in the eight available SIMM sockets, the boards are forced into 16-bit operation, compatible

IBM PS/2s: A SURVEY OF MEMORY CAPACITIES

The table below illustrates the memory capabilities of the systems that comprise IBM's PS/2 Micro Channel line. We have included information on currently shipping machines as well as on discontinued models. Note that when originally introduced, the Models 90 XP 486-0J5, -0J9, and -0KD, and the 95 XP 486-0J9, -0JD, and -0KD came with only 4MB of RAM and were rated at a maximum system board capacity of 32MB. The shift to the values shown in the table was made in September of 1991.

	Installed RAM (megabytes)	Maximum system board RAM (megabytes)	Total system RAM (megabytes)
16-BIT SYSTEMS			
50-031	1	2	16
50-061	1	2	16
50-Z31	2	8	16
50Z-061	2	8	16
55LS-LE0	4	8	16
55LS-LT0	4	8	16
55SX-031	4	8	16
55SX-041	4	8	16
55SX-061	4	8	16
55SX-081	4	8	16
57SX-045	4	16	16
57SX-049	4	16	16
60-041	1	1	16
60-071	1	1	16
65SX-061	2	8	16
65SX-121	2	8	16
65SX-321	2	8	16
32-BIT SYSTEMS			
70-061	2	6	16
70-081	4	6	16
70-121	2	6	16
70-161	4	6	16
70-A16	4	8	16
70-A21	2	8	16
70-A61	2	8	16

CONTINUES

with all PS/2s except those with memory caches (such as the test-bed 25-MHz IBM PS/2 Model 70-A21). With four or eight SIMMs, the boards will operate in either 16- or 32-bit mode in any PS/2, Model 50 through 95.

The basic OS/RAM 32 accommodates only 256K or 1MB SIMMs, allowing a minimum of 1MB of expansion and a maximum of 8MB on a single board. The OS/RAM 32 Plus accepts 1MB, 4MB, or 16MB SIMMs for a minimum 32-bit capacity of 4MB and a maximum of 128MB. Different sizes are allowed on the board but not within the same banks.

To ease the management tasks of such an extreme amount of memory, Capital Equipment includes a RAM disk driver that allows the creation of four 32MB RAM disks.

Besides offering chip versatility, the OS/RAM 32 Plus adds 8,192 page-mapping registers to the basic features. These registers allow the board to emulate EEMS and backfill system board memory (but only as a single 640K block). Memory operations in slower 16-bit PS/2s could benefit from the board's zero-wait-state performance.

Both products abstain from IBM's Track Zero integration scheme. The boards support *NetWare* as well as DOS, OS/2, and Unix. Capital Equipment includes its own automatic installation program to manage the setup, which you must run before performing IBM's normal system configuration. (With products that follow the IBM spec to the letter, software installation should occur automatically as part of the IBM configuration sequence.) This results in board initialization not being completely integrated into IBM's POST. Still, the boards' performance indicates top-flight zero-wait-state activity and the use of system RAM cache.

Included with the setup program are EMS and XMS driver software, diagnostics, and utilities (the RAM disk and a memory and I/O mapping program). The boards are protected by a two-year warranty in an arena where many of the products offer five-year warranties.

While the boards are affordable and fast, integration of their equipment memory was not seamless; one of our test programs failed to recognize all the memory on the boards. Similarly, some application software might encounter problems recognizing this memory. But the speed and price of the Capital OS/RAM 32 and the Capital OS/RAM 32 Plus still make the pair compelling choices.

FACT FILE

Capital Equipment Corp., 76 Blanchard Rd., Burlington, MA 01803; 800-234-4232, 617-273-1818.

Captital OS/RAM 32
List Price: Without memory, $299; with 2MB RAM, $389; with 4MB, $559; with 6MB, $689; with 8MB, $786.
Works With: IBM PS/2 Models 50 through 95.
In Short: The fast and affordable Capital OS/RAM 32 will add up to 8MB RAM to any PS/2 from Models 50 through 95. But like the Capital OS/RAM 32 Plus, it lacks complete IBM integration into the MCA design.

Capital OS/RAM 32 Plus
List Price: Without memory, $349; with 4MB RAM, $598; with 8MB, $798; with 10MB, $998; with 12MB, $1,129; with 16MB, $1,389; with 18MB, $1,519; with 20MB, $1,649; with 24MB, $1,969; with 32MB, $2,429.
Works With: IBM PS/2 Models 50 through 95.
In Short: A board for those with megabyte madness, the Capital OS/RAM 32 Plus adds up to 128MB RAM to any IBM PS/2 from Model 50 through 95. The OS/RAM 32 Plus lacks only complete IBM integration into the MCA design. Its performance is first-class and its price is right.

IBM PS/2s: MEMORY CAPACITIES

	Installed RAM (megabytes)	Maximum system board RAM (megabytes)	Total system RAM (megabytes)
32-BIT SYSTEMS (continued)			
70-A81	4	8	16
70-E61	2	6	16
70 486-B21	2	8	16
70 486-B61	2	8	16
80-041	1	2	16
80-071	2	2	16
80-081	4	4	16
80-111	2	4	16
80-121	2	4	16
80-161	4	4	16
80-311	2	4	16
80-321	2	4	16
80-A16	4	8	16
80-A21	4	8	16
80-A31	4	8	16
90 XP 486-0J5	8	64	64
90 XP 486-0J9	8	64	64
90 XP 486-0KD	8	64	64
90 XP 486SX-0G5	4	64	64
90 XP 486SX-0G9	4	64	64
90 XP 486SX-0H5	8	64	64
90 XP 486SX-0H9	8	64	64
90 XP 486SX-0K9	8	64	64
90 XP 486SX-0KF	8	64	64
95 XP 486-0G9	4	64	64
95 XP 486-0GF	4	64	64
95 XP 486-0J9	8	64	64
95 XP 486-0JD	8	64	64
95 XP 486-0JF	8	64	64
95 XP 486-0KD	8	64	64
95 XP 486-0KF	8	64	64
95 XP 486SX-0H9	8	64	64
95 XP 486SX-0HF	8	64	64
32-BIT PORTABLE SYSTEMS			
P70 386-031	2	8	16
P70 386-061	4	8	16
P70 386-121	4	8	16
P75 486-161	8	16	16
P75 486-401	8	16	16

ENDS

CUMULUS CORP.

CuRAM-MC32

Think of the CuRAM-MC32, from Cumulus Corp., as a chameleon. To match your state of mind, the 32-bit-only board allows a choice of operating modes: an IBM emulation that is compatible with IBM's Memory Expansion Option board and a higher-capacity native mode. The CuRAM is compatible with IBM PS/2 Models 70 through 95.

The basic CuRAM that Cumulus sells is stocked with 2MB and retails for $899. The company sells 1MB ($100), 2MB ($225), 4MB ($450), and 8MB ($900) SIMMs to increase the capacity of the CuRAM. The board we tested, with 8MB, sells for $1,574.

TWO OPERATING MODES

The chief difference between the CuRAM's two operating modes is SIMM support. In the high-capacity native mode, the CuRAM holds up to 32MB. In conventional or IBM mode, the CuRAM's capacity is limited to 16MB (the IBM board accepts less than that, however). You will choose the latter only if you want the peace of mind of knowing your memory expansion follows the IBM configuration standard right down to running IBM's diagnostics.

To accommodate the 36-bit IBM-style SIMMs, the CuRAM holds four sockets. Each of these can be stocked with 1MB, 2MB, 4MB, or 8MB SIMM chips, allowing a minimal board capacity of 1MB and a maximum of 32MB (in native mode). In IBM-emulation mode, 8MB SIMMs are prohibited. Otherwise, different-size SIMMs can be mixed indiscriminantly on the board, any size in any socket. The evaluation sample was stuffed with four 2MB SIMMs, each rated at 80 nanoseconds.

These SIMMs were enough to put the CuRAM's read performance at the top of the list. Cumulus claims that the CuRAM writes to memory at one wait state; its write performance did clearly show a drop-off from its zero-wait-state read performance. But the board still performed a little better on our Memory Write test than the other one-wait-state products.

The design and construction of the CuRAM are very good. The board uses surface-mount technology; the sockets are angled downward and project out to make the board no more than 0.6 inches thick. The only out-of-place element on the board is the one jumper used to select between native and IBM-emulation modes. The CuRAM integrates well with the standard PS/2 procedure in either of its operating modes. It is able to run any standard operating system from DOS to AIX, *NetWare,* OS/2, and Unix. The board is protected by a five-year warranty.

From all standpoints except write performance, the CuRAM-MC32 ranks as a choice worth considering for enhancing any 32-bit PS/2.

FACT FILE

CuRAM-MC32
Cumulus Corp., 23500 Mercantile Rd., Beechwood, OH 44122; 216-464-2211.
List Price: With 2MB RAM, $899; with 8MB, $1,574.
Works With: IBM PS/2 Models 70 through 95.
In Short: The CuRAM-MC32 is a chameleon board that faithfully emulates the IBM original or goes its own way to add up to 32MB to 32-bit PS/2s. Its main weakness is slow performance in memory writing.

CIRCLE **415** ON READER SERVICE CARD

PERFORMANCE TESTS: MCA MEMORY BOARDS

Our tests show that the difference between the top-performing MCA memory boards and the slowest entrants is almost nonexistent when it comes to reading blocks of data. But when the system is writing blocks of data to the board, there is a much greater difference between the boards with the fastest and the slowest throughput rates. The best performers are those that employ zero wait states and take advantage of system cache.

WHAT THE NUMBERS MEAN

Among the 11 MCA memory boards tested, the results on PC Magazine Labs' Memory Read and Memory Write tests were fairly consistent. The fastest boards read and wrote at zero wait states and took advantage of the Model 70's RAM cache. While the expansion boards cannot match the speeds achieved with motherboard memory, the decline in throughput was only about 20 to 25 percent.

Only a few products fell below the top range on one or both of the memory tests. The AMS Memory 32 DI, for instance, had trouble sensing 32-bit operations and defaulted to 16-bit speed. This, along with the board's operating at one wait state, resulted in poor performance for memory reads and memory writes. AMS identified a circuitry design problem and plans to correct it.

The CuRAM-MC32 performs memory reads at zero wait states. Cumulus says that its CuRAM *writes* to memory at one wait state, but our test results indicate that memory writes occurred at a slightly faster rate. This was possibly due to the CuRAM's use of system caching or Cumulus's employment of memory access techniques. But the CuRAM's throughput on our Memory Write test was still below that of zero-wait-state boards.

Orchid claims that its RamQuest 16/32 performs both memory reads and writes at zero wait states. The board's speed on the Memory Read test can be attributed to that use of zero wait states and to its use of system cache for memory reads. But its poor results on our Memory Write test imply that it does not use system caching for memory writes.

The Parity+Plus P32010 uses memory interleaving techniques that allow alternating banks of SIMMs to run at either zero or one wait state. This results in a hybrid memory access somewhere between zero and one wait state. The Parity+Plus also initializes memory after the host system's self-test, which on our tests prevented it from using system cache.

All boards passed PC Labs' test for LIM 4.0 Expanded Memory driver compatibility when using the DOS 5.0 memory manager.

HOW WE TESTED

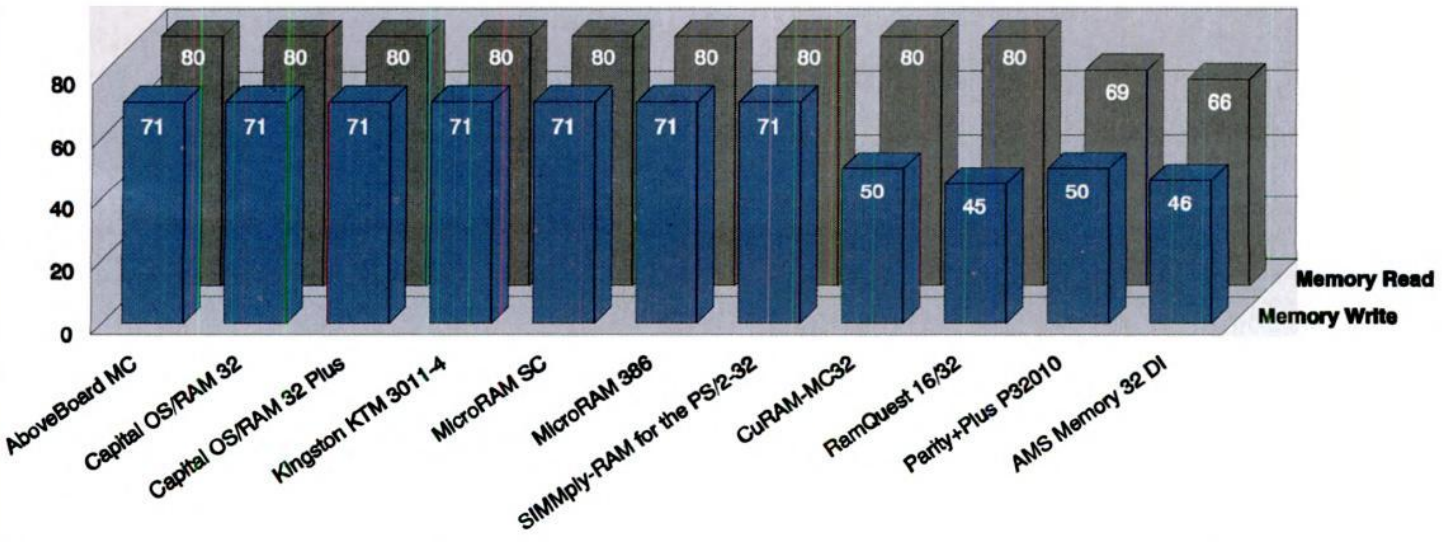
For our MCA memory board tests, we used a 25-MHz IBM PS/2 Model 70-A21 equipped with 8MB of motherboard memory and a 64K RAM cache, and running IBM DOS 5.0 as the operating system. Each of the memory boards we reviewed included 8MB of 80-nanosecond SIMMs and was installed for 32-bit operation.

For comparison, as part of our test-bed, we also ran PC Labs' Memory Read and Memory Write tests on the Model 70-A21 motherboard. When run on the motherboard, the Memory Read and Memory Write tests accessed memory between 1MB and 8MB.

The **Memory Read** test performs memory reads in blocks of 4K; the test accesses memory in sequence from 0MB to 16MB. The results reported represent expansion board memory throughput as a percentage of motherboard memory throughput.

The **Memory Write** test performs memory writes in blocks of 4K; the test accesses memory in sequence from 1MB to 16MB. We do not write to memory below the 1MB boundary in order to avoid overwriting the operating system. The results reported represent expansion board memory throughput as a percentage of motherboard memory throughput.

Percentage of System Board Memory Throughput
(System board memory = 100)
Taller bars represent better performance.



INTEL CORP.
AboveBoard MC

The AboveBoard MC has nice features, including its EEPROM and a clean design, but it lacks flexibility in some respects.

If Intel Corp., the makers of the AboveBoard MC, may be accused of anything, it is misguided wizardry. Although the board shows the technical prowess of the semiconductor giant's design engineers, the board's advanced technology fails to make the AboveBoard MC more useful than any other MCA memory board. And it does make the board a bit more confusing to install. The board could also use better SIMMs.

Intel offers the AboveBoard MC in three capacities: with no memory for $399, with 1MB using 256K SIMMs for $599, and with 4MB for $999. It does not sell the board with 8MB. Adding 4MB more of RAM at a typical street price of $50 per megabyte would bring the unit to a total of $1,199.

The board itself can pack up to 32MB into any IBM PS/2 short of the Model 90 series. It is flawlessly laid out with only surface-mount components. It incorporates advanced technology in the form of an EEPROM that stores configuration information such as the addresses to use, matching the board to your system. The EEPROM allows the board to remember its configuration after the power goes off so that it does not have to rely on the limited battery-backed memory in a PS/2. But in testing the EEPROM required an extra configuration step to optimize the speed of the board, which led to POST memory-recognition problems.

INSTALLATION RESTRICTIONS

The constraints on the memory modules you can install on the AboveBoard MC are severe. All must have the same capacity, either 256K, 1MB, or 4MB SIMMs. These devices must be 1 byte wide plus parity (the board accepts both 9-bit linear and page-mode SIMMs, according to Intel). The sockets you use are strictly defined two-module banks for 16-bit PS/2s and four-module banks for 32-bit machines. Possible board capacities range from 512K (two 256K SIMMs in a 16-bit machine) to 32MB (fully populating the board with 4MB SIMMs). The evaluation board was equipped with eight 1MB SIMMs rated at 80 nanoseconds.

The Intel software configuration program, which adds an extra step to the normal MCA configuration process, allows the board to operate at either one or zero wait states depending on the speed of the SIMMs installed. Those with 80-ns. ratings should allow zero-wait-state operation, while slower SIMMs (up to 120 ns.) require adding a wait state. The AboveBoard MC using zero-wait-state operation was among the top performers.

Beyond memory, Intel also allows adding an optional $149 parallel port and serial port to the AboveBoard MC. In addition to setup and diagnostic software, Intel includes an EMS driver, print spooler, and RAM disk. The board is protected by a five-year warranty.

The AboveBoard MC has some nice features going for it, including its EEPROM and a clean design, but it lacks flexibility in some respects. If you are looking for a board with good performance and the assurance of a big name behind it, however, this one may be worth your consideration.

FACT FILE

AboveBoard MC
Intel Corp., 5200 NE Elam Young Pkwy., C03-07, Hillsboro, OR 97124-6497; 800-538-3373, 503-629-7354.
List Price: Without memory, $399; with 1MB RAM, $599; with 4MB, $999. One parallel and one serial port, $149.
Works With: IBM PS/2 Models 50 through 80.
In Short: The engineering feats of the AboveBoard MC include an EEPROM for matching it to your system, but the board is more constrained regarding memory module expansion than most systems we reviewed. Still, the AboveBoard MC measures up to the best in performance.

CIRCLE **416** ON READER SERVICE CARD

KINGSTON TECHNOLOGY CORP.
Kingston KTM 3011-4

Kingston Technology's Kingston KTM 3011-4 is a fast and optimal choice in the MCA memory board arena—if you can overlook some of the tallest list prices in the business.

The list price structure pegs Kingston as a company with a truly vivid imagination. The KTM 3011-4 sells for $1,450 with 4MB of RAM. Add another 4MB to make the 8MB tested configuration and the list price climbs to a whopping $2,425. But Kingston claims the street price will be more like $850 to $995—an unbelievable discount of almost 70 percent.

The KTM 3011-4's hardware is more down-to-earth than the board's pricing, and it is fast. The basic board can hold from 1MB to 16MB and can be installed in 32-bit PS/2s of the Model 70, 80 and 90 series. Kingston also offers a line of 16-bit boards for lesser PS/2s.

The KTM board is rigid in the way it requires you to install SIMMs in its four oddly placed sockets. The foundation board

CONTINUES

FACT FILE

Kingston KTM 3011-4
Kingston Technology Corp., 17600 New Hope St., Fountain Valley, CA 92708; 800-835-6575, 714-435-2600.
List Price: With 4MB RAM, $1,450; with 8MB, $2,425; with 16MB, $4,375.
Works With: IBM PS/2 Models 70 through 95.
In Short: The Kingston KTM 3011-4 boasts top performance on our tests and supports all advanced data-transfer modes. The oddly placed but functional sockets limit the KTM 3011-4 to accepting up to 16MB of RAM for the IBM PS/2 Model 70, 80, and 90 series.

CIRCLE **417** ON READER SERVICE CARD

CONTINUED

will accommodate 36-bit IBM-style SIMMs with 1MB, 2MB, or 4MB of capacity, but sockets must be filled in numerical order from one to four, with the larger-capacity SIMMs going into the lower-numbered sockets. The four 2MB SIMMs on the evaluation board were rated at 80 nanoseconds. These SIMMs were more than enough to help push Kingston's unit into the high end of the performance spectrum.

MEETING MCA STANDARDS

Kingston is one of those companies that take a step away from normal MCA board installation by requiring you to install first the software and then the hardware. (With most of the other boards, you can install the hardware first and then run the configuration software.) According to Kingston, the KTM 3011-4 supports all of IBM's advanced MCA modes, including streaming data, multiplexed data transfers, and bus parity.

Apart from the SIMM placement—three unequally spaced SIMMs on the left of the board and one on the right—the board's design and construction are good if uninspiring, all pin-in-hole. It is nicely laid out, with only one engineering change-order jumper. The board is backed by a five-year warranty.

If you can ignore the list price, the KTM 3011-4 offers good performance in a neat if oddly designed package.

MEMREL CORP.

Parity+Plus P32010

If you just want more memory without bells, whistles, or fire alarms, the Parity+Plus P32010, from Memrel Corp., may be what you are looking for. A basic memory board, the Parity+Plus adds only up to 8MB to PS/2 Models 70 and 80. (A companion product, the Parity+Plus P16010, adds similar capacities to 16-bit machines.)

The price is intriguing. A bare board lists for just $235. Filling it to 8MB, as in the evaluation board, pushes the price to only $795. Unfortunately, the performance of the Parity+Plus proved short of the mark.

Memrel is not stringent on the speed ratings of the SIMMs used with the Parity+Plus, and it allows just about anything rated faster than 150 nanoseconds. The evaluation board was equipped with eight 80-ns. 1MB SIMMs. Despite the fast rating of these SIMMs, the performance of the Parity+Plus was among the slowest tested.

The Parity+Plus P32010—though not cutting edge—has excellent construction quality.

Eight SIMM sockets on the Parity+Plus accommodate byte-wide linear 256K or 1MB SIMMs with parity checking. The sockets are divided into two four-module banks, in each of which all modules must have the same capacity, although the two banks need not match. A single board can thus deliver 1MB, 2MB, 4MB, 5MB, or 8MB.

PIN-IN-HOLE BUT EXCELLENT QUALITY

Although the design of the Parity+Plus will not win any awards for cutting-edge technology (it is all pin-in-hole components dominated by two large ASICs), the construction quality is excellent. The board integrates into the IBM software configuration scheme using the Track Zero method to allow the system to recognize its memory at boot-up time. The only annoying feature is the speed at which the board's self-test counts through its capacity, adding an inordinately long delay to booting up cold.

Memrel supplies its own EMS driver, MEMRLEMM.SYS, to take advantage of the board's built-in translation RAM. The accompanying instructions are not easy to follow and are badly printed. The Parity+Plus is backed by a five-year warranty.

If you are willing to give up speed and some setup flexibility for a low price, the Parity+Plus is worth a look.

FACT FILE

Parity+Plus P32010
Memrel Corp., c/o SGS-Thomson, 1000 E. Bell Rd., Phoenix, AZ 85022; 800-255-2328.
List Price: Without memory, $235; with 2MB RAM, $395; with 4MB, $535; with 8MB, $795.
Works With: IBM PS/2 Models 70 and 80.
In Short: A reliable board that can add up to 8MB to PS/2 Models 70 and 80, the Parity+Plus P32010 falls a bit short in performance, capacity, and integration.

CIRCLE **418** ON READER SERVICE CARD

ORCHID TECHNOLOGY INC.

RamQuest 16/32

Orchid Technology's RamQuest 16/32 offers you added value in the parallel and serial ports it provides as standard equipment (along with a 6-foot adapter cable). But the board is not as generous in other respects. It lets you add only up to 8MB of RAM to your PS/2, and its performance is not top-tier. The RamQuest matched the competition in memory read times but proved truly laggardly in memory writes.

The basic RamQuest, with ports but shorn of memory, lists for $349. Add the full 8MB capacity and the price climbs to $1,229. The board can slide into either 16- or 32-bit MCA computers.

Memory can be added in the form of up to eight readily available 9-bit SIMMs. Either 256K or 1MB modules qualify. The byte-wide modules must be installed in pairs of the same size and speed for 16-bit transfers and in banks of four for 32-bit transfers. Within those limitations, you can mix 256K and 1MB chips on the board. The evaluation board was equipped with 80-nanosecond RAM, which should deliver zero-wait-state operation.

In testing, however, zero-wait-state operation could not be confirmed. While the RamQuest was among the fastest boards in read performance, it proved among the slowest of all boards tested in memory writing.

On the other hand, its construction quality rates as very good. The board is built from a mixture of pin-in-hole and surface-mount components dominated by a

FACT FILE

RamQuest 16/32
Orchid Technology Inc., 45365 Northport Loop West, Fremont, CA 94538; 510-683-0300.
List Price: Without memory, $349; with 1MB RAM, $459; with 2MB, $569; with 4MB, $789; with 8MB, $1,229.
Works With: IBM PS/2 Models 50 through 80.
In Short: The RamQuest 16/32 can add a parallel and a serial port—but only up to 8MB of RAM—to any PS/2 short of a Model 90. Its main flaw is slow memory-write speed. With its combination of pin-in-hole and surface-mount components, the RamQuest is well constructed, if not state-of-the-art.

CIRCLE **419** ON READER SERVICE CARD

large, proprietary ASIC. On the card retaining bracket, the RamQuest offers a miniature DIN connector with a proprietary pin-out for the serial port and a female 25-pin D-shell connector for its parallel port; hence the necessity of the included adapter cable, which terminates in a standard male 25-pin D-shell.

TRUE INTEGRATION

The RamQuest integrates well with the IBM software configuration process, requiring only that you copy the option disk before you install the Orchid hardware. Once the board is set up, without jumpers or DIP switches, it mates perfectly with the IBM POST procedure.

Orchid supplies an EMS driver, RAM disk, disk cache, and a set of printer tools (including spooler) along with the adapter description files on the accompanying floppy disk. The instructions are particularly clear and well organized.

Orchid guarantees the RamQuest's compatibility with IBM PS/2 Models 50, 50Z, 60, 70, and 80. The board has a two-year warranty, which Orchid extends to four years when you return the warranty card. If you can overlook the write-speed flaw, the RamQuest is a well-made, affordable way to add RAM to any PS/2.

TECMAR INC.

MicroRAM SC
MicroRAM 386

Although they may cost more than some of the competition, the pair of memory expansion boards from Tecmar rank as two of the best that you can add to your PS/2. The MicroRAM SC and the MicroRAM 386 combine top speed, good workmanship, and excellent integration with the IBM standard.

Of the two, the MicroRAM SC is more versatile; it is compatible with any PS/2 from Model 50 upward. It is also more affordable, listing for $360 without memory—which is how Tecmar prefers to sell it. The company will add SIMMs for $100 per megabyte, making the 8MB board cost $1,160, although you can do much better if you add the memory yourself.

The MicroRAM 386 is more limited in application, rated to fit only 32-bit PS/2s, Models 70 through 95. The board lists for $390 without memory. Adding 8MB pushes the price up to $1,190.

The MicroRAM SC uses IBM-style (36-bit, 72-pin) system board SIMMs in any combination of 1MB, 2MB, 4MB, and 8MB capacity. Using 80-nanosecond SIMMs, the MicroRAM SC operates with zero wait states; with 100-ns. or 120-ns. SIMMs, it imposes one wait state.

The Tecmar MicroRAM boards rank as two of the best that you can add to your PS/2.

The MicroRAM 386 accommodates up to eight fast page-mode SIMMs with capacities of either 256K, 1MB, or 4MB. Due to the board's 32-bit design, SIMMs must be installed in banks of four of equal size, allowing total board capacities of 1MB, 2MB, 4MB, 8MB, 16MB, or 32MB. The board accepts 85-ns. or faster SIMMs for matched memory operation, 100-ns. SIMMs for zero-wait-state operation, and 120-ns. SIMMs for one-wait-state operation.

On our tests, both boards were equipped with 80-ns. SIMMs and delivered top performance.

Both of Tecmar's boards integrate with IBM's automatic configuration system and link to the host system without needing Track Zero support. The MicroRAM SC adds an automatic SIMM search routine to the configuration process, posting on the screen its run-through of sockets and chip capacities.

FACT FILE
EDITORS' CHOICE

Tecmar Inc., a division of Rexon Corp., 6225 Cochran Rd., Solon, OH 44139; 800-624-8560, 216-349-1009.
MicroRAM SC
List Price: Without memory, $360; with 8MB RAM, $1,160.
Works With: IBM PS/2 Models 50 through 95.
In Short: One of the best memory boards to add up to 32MB to any PS/2, the MicroRAM SC is as fast as the MicroRAM 386 and more versatile. The MicroRAM SC offers the same high-quality integration as its sibling, and it adds an automatic SIMM search routine to the configuration process. Though not the least expensive board reviewed here, the MicroRAM SC provides a range of features that warrants the investment.
MicroRAM 386
List Price: Without memory, $390; with 8MB RAM, $1,190. One parallel and two serial ports, $120.
Works With: IBM PS/2 Models 70 through 95.
In Short: The MicroRAM 386 is a fast, well-built memory board that can add up to 32MB to any 32-bit PS/2. It offers excellent integration and workmanship.

CIRCLE **420** ON READER SERVICE CARD

MORE I/O PORTS

The MicroRAM 386 also includes a 44-pin header, to which an optional $120 port board can be attached to add one parallel and two serial ports to your PC.

On both boards, most of the circuitry is surface-mounted, with the MCA interface developed in a Xilinx ASIC. While the MicroRAM 386 squeezes into just over 0.6 inches of slot, the MicroRAM SC fills the full 0.8-inch slot space, chiefly because of the wider 36-bit SIMMs. In addition to configuration and diagnostic utilities, Tecmar includes a print spooler and RAM disk with its MicroRAM boards. Inexplicably, these boards have niggardly two-year warranties.

While either Tecmar board will add fast, high-quality storage to your PS/2, the MicroRAM SC is the better choice: It's more versatile and more affordable. In fact, the MicroRAM SC—with its standard integration and configuration procedures, flexibility regarding memory, and good performance—is one of the best choices you can make from among all the memory boards reviewed here. ■

Winn L. Rosch is a contributing editor of PC Magazine.