# Embedded Pentium Comes on Board

*Modules From Intel, MMS, Radisys, Fujitsu Offer Size, Speed Options*

*by Jim Turley*

Like death and taxes, Pentium's eventual appearance in embedded systems was inevitable. But unlike most other embedded processors, Pentium brings with it a host of design challenges. Its complex, high-speed bus and variable, selectable voltages make Pentium tougher to use than most embedded microprocessors. Although thousands of embedded 386 and 486 users are eager for Pentium's performance, they're also wary of its design challenges.

Four companies have developed Pentium modules to address these issues. The newest entry, Intel, offers the fewest options and the least performance. In all four cases, these plug-in "macro chips" isolate the Pentium's local bus on a daughtercard, typically providing just PCI and DRAM interfaces to the outside.

## Intel Module Parallels Earlier Mobile Module

Intel's Embedded Module is identical in concept, though not in detail, to the company's recently announced Mobile Module for notebook PCs (see MPR 2/17/97, p. 9). As the upper half of the block diagram in Figure 1 shows, the Embedded Module contains a 133-MHz P54C processor, L2 cache SRAMs, tag RAM, and a "north bridge" chip to convert Pentium's local bus to PCI. The module also contains clock-generation and power-regulation circuitry, removing these tasks from the base, or carrier, board.

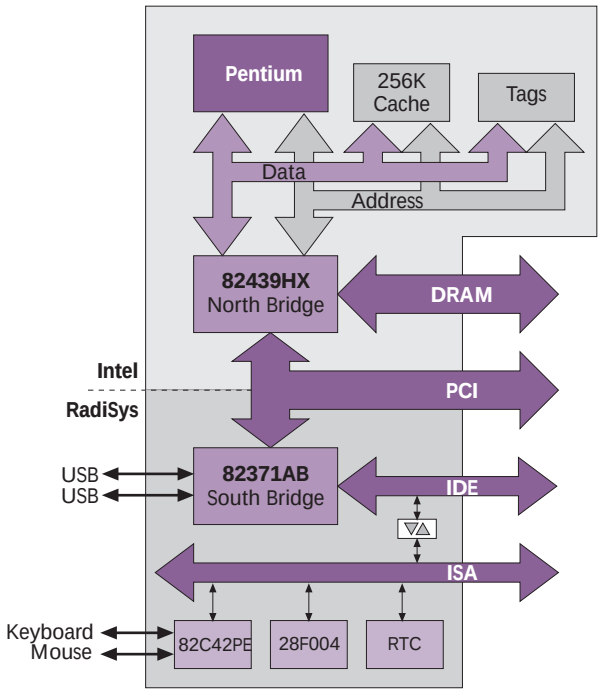


**Figure 1.** Intel's first Embedded Module combines a 133-MHz P54C Pentium, 430HX north bridge, 256K of SRAM, clock, and power regulation. The RadiSys EPM-1 combines those features with a south bridge and several PC-compatible peripherals.

The Embedded Module differs from its Mobile twin in its physical dimensions and core-logic chip set. The Embedded Module's 3.0" × 4.0" outline is 0.5" wider than the Mobile Module but just as long. Intel used different connectors in different locations on the two modules, guaranteeing the impossibility of interchangeability.

Intel has chosen to offer only the MMX-less P54C on its embedded module—and, at 133 MHz, a slow one at that. We expect the company to add a 166-MHz version by early next year, probably with MMX.

Whereas the Mobile Module is based on Intel's latest 430TX core-logic chip (see MPR 2/17/97, p. 4), the embedded version carries the older 82439HX north bridge (see MPR 2/12/96, p. 5), which does not have the power-management and DMA improvements of the newer device. On the other hand, the 'HX supports ECC main memory, which may be more useful to embedded designers than the power-conservation features of the 'TX. Unlike with the Mobile Module, Intel includes the 82371SB "south bridge" with the Embedded Module, which designers can choose to use or throw away if ISA, IDE, and USB aren't needed.

## Too Tall for OEM Boards, Too Slow for PCs

When the interboard connectors are fully mated, the Embedded Module rises exactly 0.567" from the top of the underlying carrier board to the top of the small clip-on heat sink. As the photograph in Figure 2 shows, there is a modest amount of free space under the module for low-profile components on the carrier board.

This height makes Intel's Embedded Module nearly twice as tall as its Mobile Module—and too big for popular OEM board specifications. The module won't fit on either CompactPCI or VMEbus boards without violating the maximum component-height restriction. Boards that use Intel's module will have to take up two slots in the card cage.

Intel charges $375 for its Embedded Module—nearly double the price of the processor and chip set alone. Of course, the cache and PCB account for some of this cost. In comparison, a 150-MHz Mobile Module lists for $440—only a 22% premium over its component cost for a faster, MMX-enabled processor with newer system logic on a smaller, lower daughtercard that fits onto OEM boards. In all, Intel's first foray into the embedded Pentium market has little to recommend itself.

## MicroModule Systems Gets Small

At just 49 × 54 × 6 mm, Gemini, from MicroModule Systems (MMS), is only 35% the size of Intel's Embedded Module, as Figure 3 illustrates. Functionally, though, the two are the same, with just the DRAM and PCI interfaces available at the module's perimeter. The Gemini module includes a 120-, 133-, or 150-MHz Pentium (P54C or P55C), National's Vesuvius chip set, and 256K of L2 cache.

Gemini achieves its small size by using unpackaged die. The seven chips that make up the module are mounted face up on an aluminum substrate and covered with an aluminum lid. MMS uses conventional wire-bonding techniques to connect the chips to each other and to the module's lead frame. The metal substrate draws heat away from the chips and also shields the components from electromagnetic interference.

At $399 for the 120-MHz version, Gemini is a bit more expensive than Intel's module, but far smaller and with better EMI and thermal characteristics. More important, Gemini is small enough to be used in notebook PCs, one of MMS's major markets.

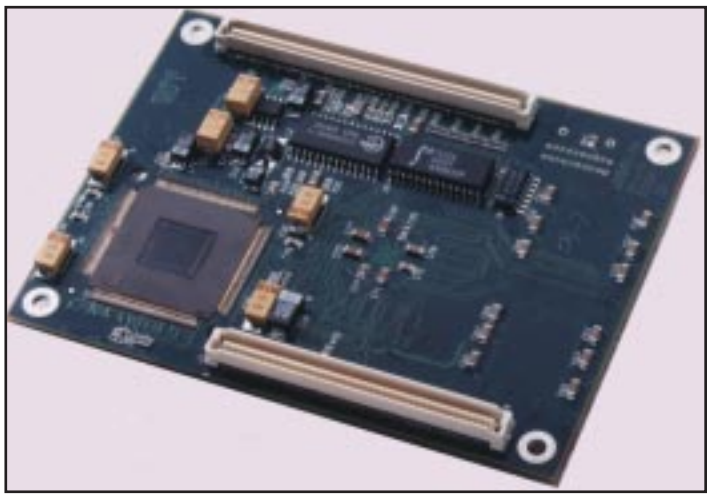

**Figure 2.** Intel's Embedded Module measures 3.0" × 4.0" and stands 0.57" high above the carrier board. The Pentium is mounted on the underside of the board, shown here; thermal vias carry heat to the other side, where a heat sink clips onto the module.

## Fujitsu Flaunts Its Tiny Packaging

Fujitsu's Pentium modules are the smallest available, yet they got off to a slow start in the market. The company initially seemed more interested in using these impressive concoctions as demonstrations of its packaging prowess than as production platforms.

The company builds two versions of its MCM. Both are functionally identical to the Intel module but packaged more like the MicroModule Systems offering. Fujitsu mates a 150- or 166-MHz Mobile Pentium/MMX with the 430TX north bridge and 256K of cache. Like Intel and MMS, Fujitsu runs PCI and DRAM signals to the outside. Although Intel and Fujitsu use the exact same 280-pin connector, their pinouts differ by just three pins, destroying any compatibility between them and keeping Fujitsu out of Intel's crosshairs.

The ceramic MCM is just 40 × 42 mm. A laminate "build-up" version using flip-chip attachment is slightly more rectangular, at 32 × 44 mm. Both modules are just 5 mm high. With no lead frame or bond wires, Fujitsu's module even smaller than Gemini. Like the MMS module, internal metal layers help conduct heat away from the bare die, although there's no convenient attachment point for a heat sink, as in the Gemini module.

Unlike any of the other modules, the Fujitsu MCMs don't have a voltage regulator, so the user must provide a nominal 2.5-V supply for the processor. In fact, the module has four separate supply inputs for the processor core, processor pad ring, cache SRAM, and core logic. This last supply must remain constant at 3.3 V, while the others can be shut down to save power.

While Intel currently offers only the 133-MHz P54C, Fujitsu is delivering modules based on 150- and 166-MHz Pentium/MMX processors.

In large volumes (10,000/month), Fujitsu claims to charge a modest $35 premium over the cost of the CPU and system logic alone. That would put the price of its 150-MHz module at about $390, which is comparable to MMS's 120-MHz Gemini, although for much higher volumes.

After a slow start, Fujitsu has now shipped more than 100,000 of these units, primarily to one or two large customers, including itself. Its small size and aggressive pricing make the Fujitsu MCM appealing to makers of notebook PCs and other high-volume, PC-compatible applications.

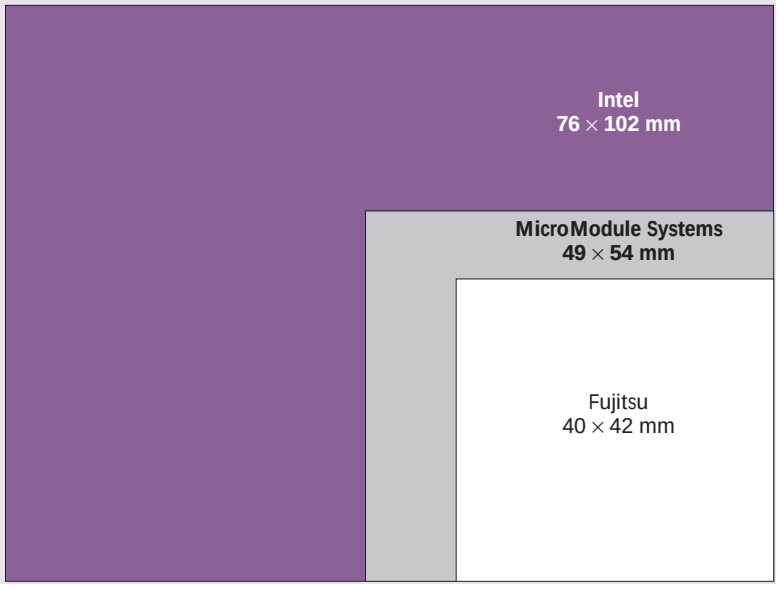


**Figure 3.** These modules offer roughly the same features but differ greatly in size, as these actual-size outlines show. (The outer box represents the Radisys module, which measures 107 × 135 mm.)

### Price & Availability

Table 1 summarizes price and availability information. Contact Intel (Chandler, Ariz.) at 602.554.5128 or visit *www.intel.com/design/intarch/prodbref/971978.htm.*

Contact MicroModule Systems (Cupertino, Calif.) at 408.864.7437 or at *www.mms.com.*

Fujitsu Microelectronics (San Jose, Calif.) can be reached at 408.922.9679 or *www.fujitsumicro.com.*

Call RadiSys (Hillsboro, Oregon) at 503.615.1100 or visit the Web at *www.radisys.com/products/component/epm1/epm2.html.*

## RadiSys Packs It All Onto One Board

In stark contrast to the diminutive MMS and Fujitsu modules, the RadiSys EPM-1 throws in everything a designer could want. The Oregon company's module goes considerably further than the others' but also sells for $100 more. In addition to the processor and 'HX chip set, the EPM-1's larger module comes with with south bridge already mounted, a battery-backed real-time clock with SRAM, two USB ports, 512K of flash memory (including Phoenix BIOS), an 82C42PE keyboard and mouse controller, and four DIMM sockets for main memory. The 133-MHz version is priced at $506, or about $130 more than Intel's.

At this price RadiSys, like Intel, offers the 133-MHz P54C, although RadiSys also offers faster and slower speeds (100 and 166 MHz). A high-end version with a 200-MHz P55C sells for $941—a bit pricey for all but the most dedicated embedded-Pentium designer.

Like the others, the EPM-1 provides access to PCI, but the DRAM and all of its signals remain on the module. The EPM-1 also provides ISA and USB buses as well as dedicated keyboard and mouse ports. The EPM-1 is less of a processor daughterboard than a complete single-board computer. While the Fujitsu, MMS, and Intel modules are clearly intended to be modular plug-ins for a larger system, the EPM-1 essentially is that system.

Obviously, with all the extra onboard logic, the RadiSys module is the bulkiest. Measuring 107 × 135 mm, the module stands an imposing 38 mm (1.48") high from the bottom of its connectors to the top of its processor-mounted fan. Clearly, compactness was not RadiSys' primary goal.

## The Beginning of the End of Chip-Level CPUs

Fujitsu and MicroModule Systems are chasing the growing notebook PC market; RadiSys designed its Pentium module for embedded designers who are put off by Pentium's bus interface; Intel has taken both paths. All four lay the groundwork for future module-based designs. With the announcement of Pentium II, Intel's roadmap is now clear: single-chip packaging will no longer be an option, even for the desktop.

For embedded designers, this change is a mixed blessing. While isolating or eliminating high-speed signals from their designs is a welcome relief, losing control over cache and core logic grates on many designers accustomed to more control over their systems. Finally, the physical size of some of these modules can prohibit their use in many systems.

Intel seems to have been asleep at the switch in this regard. If its Embedded Module were just 0.027" shorter, it could have been used on VMEbus and CompactPCI boards worldwide. Instead, those systems will have to sacrifice a precious card slot to solve clearance problems or opt for a notebook CPU module, as some OEMs have already done.

The alternative is to abandon the Intel roadmap. AMD, Centaur, Cyrix, and others promise P6 performance in a Pentium package. For embedded designers unable to tolerate the power, airflow, or space requirements of Pentium in whatever form, the 486 may simply be the end of the road.

It may also be a point of departure. There are several CPU alternatives that offer better price/performance and lower power consumption with equivalent levels of integration. NEC's R4300, for example, runs at 133 MHz and sells for just $32; the VRC4371 bridge chip adds PCI and DRAM control functions for $20 more. The whole package offers the same functions, at least superficially, as any of the Pentium modules for one-tenth the cost and one-fifth the power. Galileo's companion chips for IDT processors offer similar cost savings; upcoming core-logic chips for Digital's SA-110 will extend the same benefits to ARM.

It's ironic that, as semiconductor processes shrink and microprocessors pack more performance into less space, new CPUs should become so bulky. The 486 and earlier x86 generations were available as chips; the P6 generation will be only in modules. The current crop of Pentium-class parts marks the last opportunity for a designer to choose between these two extremes. M

| | Intel | MMS | Fujitsu | Fujitsu | RadiSys |
|---|---|---|---|---|---|
| **Processor** | P54C | P54C/P55C | P55C | P55C | P54C/P55C |
| **Clock speed** | 133 | 120–150 | 150–166 | 150–166 | 100–200 |
| **CPU package** | TCP | Bare die | Bare die | Bare die | PGA |
| **Substrate** | FR4 | Ceramic | Ceramic | Laminate | FR4 |
| **North bridge** | 82439HX | Vesuvius | 82439TX | 82439TX | 82439HX |
| **South bridge** | 82371SB* | None | None | None | 82371AB |
| **L2 cache** | 256K | 256K | 256K | 256K | 256K |
| **Voltage reg** | Yes | Yes | No | No | Yes |
| **DRAM speed** | 66 MHz | 66 MHz | 66 MHz | 66 MHz | 66 MHz |
| **PCI speed** | 33 MHz | 33 MHz | 33 MHz | 33 MHz | 33 MHz |
| **Dimensions (mm)** | 76 × 102 | 49 × 54 | 40 × 42 | 32 × 44 | 107 × 135 |
| **Area ($cm^2$)** | 77.42 | 26.46 | 16.80 | 14.08 | 144.45 |
| **Height (mm)** | 14.4 | 6 | 5 | 5 | 37.6 |
| **Availability** | October | Now | Now | Now | Now |
| **Price (1,000)** | $375 | $399– | $390–$562† | $390–$562† | $478–$941 |

**Table 1.** Even within similar modules, the choice of processor, core logic, and voltage regulation changes. *supplied separately. †10,000/month quantity.