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DSP Chips Enable PC Multimedia

New Capabilities Nearing for PCs and Workstations

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Of the many applications of DSPs (digital signal processors), the one having the most visible impact on the DSP industry today is personal computer multimedia. A practical view of PC multimedia encompasses hardware and software to implement applications such as data and fax modems, speech and audio processing, telephone answering machines, sound effects, and music synthesis.

All these applications are excellent fits for DSP chips: in their now-prevalent stand-alone implementations (sound cards, external and internal data and fax modems, etc.), many of the devices that perform these tasks are based on DSPs. To satisfy users' demands for increased capabilities and reduced cost, computer and board vendors are turning to multifunction and multitasking approaches using programmable DSP chips. The sense among DSP manufacturers is that the market for DSPs inside PCs (whether on add-in cards or on the motherboard) is potentially huge.

All major U.S. DSP manufacturers are working to position themselves as preferred suppliers for this emerging market. IBM's approach is based on its Mwave family, a 16-bit fixed-point architecture created specifically for PC multimedia, and its Mwave/OS DSP operating system. AT&T offers the DSP3210, a 32-bit floating-point processor (derived from its earlier DSP32C), and its VCOS DSP operating system. Motorola, Analog Devices, and Texas Instruments are all using their previously developed DSP chips (the DSP56002, ADSP-2101, and TMS320C50, respectively) with Spectron Microsystems' SPOX DSP operating system.

Four Parts to Good Multimedia Solution

Success in the PC multimedia field requires more than hardware. PC multimedia is a systems game, and the winner will be the company that can provide DSP silicon and software (for both the DSP and the PC) and sell the combination in volume to PC system and board manufacturers at low cost.

The components and characteristics of a successful PC multimedia system are:

- A powerful yet inexpensive DSP chip. The chip must be able to perform at least a basic set of sometimes demanding multimedia applications (see below) while remaining inexpensive. A simple, fixed-point DSP architecture reduces the cost of the DSP, while on-chip peripheral interfaces, an on-chip host bus interface, and hardware emulation of common PC peripherals (e.g., UARTs, SoundBlaster, MIDI) can reduce overall system cost by increasing integration and reducing the need for external parts. Good performance with low price is perhaps the most important consideration in this market.
- DSP application code. Users demand certain basic applications, including data modem (V.32bis or V.34), fax modem (V.17, V.27ter, V.29), speech/audio compression (G.728, TrueSpeech, MPEG), telephone answering machine, SoundBlaster emulation, MIDI interface, FM and wavetable synthesis, and JPEG image compression/decompression. To provide these with the least fuss, computer and board vendors want "one-stop shopping" for their DSP applications.
- DSP support software. This includes a DSP real-time operating system to switch between applications ("tasks") on the DSP, PC software to manage resources on the DSP (a "task manager"), and device drivers to permit existing applications to use the DSP
- Host applications to make use of the above.

These four requirements form a basis for evaluating the multimedia solutions being offered today. Relevant features of a number of DSPs that are contenders in the PC multimedia market are summarized in Table 1 and are discussed in more detail below.

Mwave Provides On-Chip Features

IBM's PC multimedia strategy is centered around its DSP and associated software, collectively known as Mwave. The first Mwave processor was introduced by IBM and Texas Instruments as the TMS320M500 *(see **061601.PDF**)* with software development tools provided

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by Intermetrics (Cambridge, Mass.). In January, Texas Instruments left the Mwave alliance to pursue its own PC multimedia strategy after IBM announced its entrance into the merchant semiconductor business *(see **0801MSB.PDF**)*. IBM renamed the chip the MDSP- 1012 and has subsequently introduced a number of other Mwave variants.

All Mwave processors share a common DSP core with 16-bit fixed-point data words and 24-bit instructions. The Mwave architecture lacks several features that are considered standard in most DSPs, such as a peak memory bandwidth of three memory accesses per instruction cycle (Mwave provides two) and zero-overhead hardware looping. Additionally, its address space is limited to 32K words of data and 32K words of program memory. These shortcomings complicate Mwave programming but simplify the architecture and should reduce its manufacturing costs.

Mwave chips have several strong advantages for PC multimedia. First, all Mwave variants contain an on-chip ISA bus interface (some also contain a MicroChannel interface), eliminating the need for glue logic to connect to the PC. Second, all have a rich set of peripheral interfaces for connecting to A/D and D/A converters, telephone line interfaces, and MIDI devices. Third, they have on-chip hardware to help emulate various common IBM PC peripherals (e.g., an NS16550A UART or an MPU-401 MIDI interface). Although such emulation is not critical under Microsoft Windows (where applications communicate with hardware via loadable device drivers), it does allow Mwave to be used with DOS applications designed to use these common peripherals.

The most recent member of the Mwave family is the MDSP2780, introduced in June. In addition to the usual Mwave ISA bus interface and emulation of UART and MIDI interfaces, the 2780 adds on-chip emulation of the SoundBlaster register set. These features allow 2780-based cards to replace several fixed-function multimedia boards while remaining compatible with existing PC software. The 2780 can run at speeds up to 33 MIPS from a 3.3-V supply. However, the chip is commonly run at 25 MIPS, both to simplify clocking requirements and reduce memory costs.

IBM provides several pieces of well-integrated software for Mwave. The Mwave/OS real-time operating system handles task switching and communications among tasks on the DSP as well as communications between the host and DSP. The Mwave Manager runs on the PC and oversees operation of the Mwave DSP. Mwave also comes with a set of PC device drivers that provide standard software interfaces to Microsoft Windows applications. Mwave application software includes data modems (V.32bis, V.32, with V.42 and V.42bis and fallback modes), fax modems (V.17, V.29, V.27ter), and audio (PCM record and playback, SoundBlaster emulation, and 32-voice MIDI synthesis).

AT&T Delivers 32-bit Solution

AT&T is the other leading contender in the PC multimedia ring. Its strategy is based on the DSP32xx family of DSPs and the VCOS DSP operating system and its associated software. The DSP3210 (see MPR 11/7/90, p. 7), famous for its design-in to the Apple Centris 660AV and Quadra 660AV/840AV motherboards, differs markedly from its competitors in a number of ways. First is its use of 32-bit floating-point arithmetic: other DSPs targeting PC multimedia use 16- or 24-bit fixed-point math. Although the use of floating-point math eases application development (fixed-point applications being more difficult to develop than floating-point ones), it means that the 3210 core architecture is larger and more expensive than its competition.

A second difference is its 32-bit address space. In addition to allowing the DSP to address larger data sets, the large address space also allows the processor to more easily share the host processor's memory, potentially eliminating costly static RAM chips reserved for the DSP's use. To reduce accesses to host memory, the 3210's on-chip 2K×32 RAM is used to cache instructions and data.

Unlike Mwave, the 3210 provides relatively few on-chip peripherals, featuring only a timer and a synchro-

Vendor	Chip	Speed (MIPS)	Data Width	Instr. Width	Voltage	On-Chip Peripherals	Unit Price	Real-Time Operating System
Analog Devices	ADSP-2115	20	16 bits	16 bits	5 V	Timer, 1 codec i/f	$18/10K	SPOX
AT&T	DSP3210	17	32 bits	32 bits	5/3.3 V	Timer, 1 codec i/f	$37/10K	VCOS
IBM	MDSP2780	33	16 bits	16 bits	3.3 V	ISA bus i/f; MIDI i/f; 3 codec i/f; MIDI,UART, SoundBlaster emulation	$25/10K	Mwave/OS
Motorola	DSP56002	33	24 bits	24 bits	5/3.3 V	Timer, 1 codec i/f,1 MIDI i/f	$37/10K	SPOX
TI	TMS320C52	40	16 bits	16 bits	5/3.3 V	Timer, 1 codec i/f	$13/10K	SPOX

Table 1. Representative DSP chips for PC multimedia systems. Use caution when comparing MIPS ratings, since arithmetic formats and instruction word widths vary. "Codec i/f" is a codec interface, i.e., a synchronous serial port. A MIDI interface is essentially an asynchronous serial port.

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nous serial port for interfacing to A/D and D/A converters. A derivative part, the DSP3207, even eliminates the serial port. The 3210 and 3207 execute at 17 MIPS from a 66-MHz clock with 5-volt supply. Slower versions are available at 3.3 volts.

The centerpiece of the 3210's software ensemble is VCOS, AT&T's "visible caching operating system." A DSP task executing under VCOS begins execution from off-chip (or host) memory. It then copies its important portions into the 3210's on-chip memory, where it can run at least a factor of two faster. This explicit copying is the source of the term "visible caching": each task must explicitly load its time-critical parts into on-chip memory when it runs. While this speeds execution, the programmer must be careful to avoid spending too much time copying code into on-chip memory and too little time executing. In typical applications, copying overhead can range from 3% to 15% of execution time.

Standard 3210 DSP applications bundled with VCOS include data modems (V.32terbo, V.32bis, V.42, V.42bis, and fallback modes), fax modems (V.17 and V.29), several speech and audio coders (MPEG, sub-band, and business audio), SoundBlaster emulation, MIDI music synthesis (using either FM or wavetable synthesis), DTMF (touch-tone) generation and detection, and several sample rate conversion routines. Libraries available at extra cost include speech processing and audio coding.

The PC task manager software for VCOS is VCAS, the VCOS Applications Server. Similar to the Mwave Manager, VCAS is responsible for controlling and communicating with the 3210. The VCOS Resource Manager (VRM) keeps track of which resources on the DSP are in use. AT&T also provides several Microsoft Windows device drivers to interface to Windows applications.

Others Use General-Purpose Parts

Texas Instruments, Motorola, and Analog Devices all offer multimedia solutions based around their existing fixed-point parts: the ADSP-2101, the DSP56002, and the TMS320C50 family. Though they are competent DSP processors, none of these parts was designed specifically for PC multimedia applications.

Texas Instruments' 16-bit C50 family is potentially a strong competitor in this market. Processors in the family can execute at up to 40 MIPS, and some variants cost as little as $13 each in 10K quantities. Additionally, TI DSPs have extensive software support from third-party algorithm providers. While this does not offer the one-stop shopping provided by AT&T and IBM, it is a considerable resource. Additionally, TI's DSP core program *(see **081001.PDF**)* allows its larger customers to design ASICs based on the C50 core, potentially surrounding it with Mwave-like peripherals. TI claims it will announce a major design win in the PC multimedia market in the next few months.

Price & Availability

All DSP chips mentioned in this story are currently shipping; see Table 1 for prices. For more information, contact Analog Devices at 617.461.3672; AT&T Microelectronics at 800.372.2447; IBM Microelectronics at 800.426.0181, x500; Texas Instruments at 214.644.5580. For Motorola, contact your local sales office.

Motorola announced its PC Media program earlier this year. PC Media bundles together a DSP56002 reference design with DSP/host software and applications. The DSP56002 offers a relatively orthogonal 24-bit instruction set, but its 24-bit instruction and data words use more memory than its 16-bit competitors. Additionally, the quoted price for the part in 10K quantities is high, rivaling the DSP3210. The DSP56002 can execute at up to 33 MIPS.

Analog Devices has a number of design wins in the fixed-function PC sound-card business, using its ADSP-2101 or ADSP-2115 processors and a bus interface/SoundBlaster emulation ASIC. Analog Devices has unveiled a single-tasking reference design, also based on these processors. The ADSP-2100 family uses 24-bit instructions and 16-bit data words. Execution speeds are relatively slow at 20 MIPS.

TI, Analog Devices, and Motorola all plan multitasking systems using version 2.0 of Spectron Microsystems' SPOX DSP operating system. SPOX is the oldest real-time DSP operating system, and version 2.0 builds on lessons learned from previous versions. For example, a minimum configuration of SPOX 2.0 takes about one-fourth of the memory consumed by the minimum configuration of SPOX 1.4. It would also not be surprising to find these three vendors using Spectron's WinSPOX software (see sidebar, "Microsoft DSP RMI").

IBM at the Pole Position

IBM's Mwave system is well-positioned to win the first round of the PC multimedia race. The 2780's interfaces to off-chip peripherals (A/D and D/A converters for audio, speech, and telephony) combined with its on-chip ISA bus interface and emulation of common PC peripheral devices significantly reduces component counts. It enjoys a good deal of software support, in terms of both a DSP operating system and DSP applications software. Its price of $25 (in 10,000-unit quantities) is somewhat high compared to that of some potential competitors, but a portion of this cost is offset by its above-average on-chip features. It is also troubled by a DSP architecture that is harder than usual to program and a wide instruction word, increasing memory usage.

The key strength of AT&T's strategy is that the 3210 can execute out of either host memory or on-card

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Microsoft's DSP RMI

Microsoft recently unveiled its Windows DSP Resource Manager Interface (RMI), a standard programming interface between Windows applications (actually, device drivers) and DSP resources in a PC. The RMI includes functions for loading code into a DSP, executing programs, and communicating messages and data between the host and DSP.

The RMI specifies neither which DSP should be used nor what operating system should run on the DSP. Chip and OS vendors are issuing press releases left and right to the effect that their multimedia offerings will be RMI-compliant.

The DSP RMI is part of Chicago, not Windows 3.1, and Microsoft won't be shipping Chicago until 1995. In the meantime, Spectron Microsystems has announced WinSPOX, an RMI-like interface for Windows 3.1. Not surprisingly, WinSPOX supports the SPOX DSP operating system.

DRAM, reducing system cost by eliminating the expensive SRAM common to other DSP designs. Additionally, software support (both host and DSP) for the 3210 is quite good. However, the 3210 is a 32-bit floating-point part, and relatively few multimedia applications actually need floating-point arithmetic. The 3210 is more expensive than most of its fixed-point competitors at $37 (in 10,000-unit quantities), which offsets its advantage of not requiring SRAM. Additionally, the VCOS requirement that applications copy themselves into the 3210's on-chip memory poses a number of problems. These problems include overhead due to copying as well as memory contention problems, such as unpredictable delays in executing DSP code or slowing host execution due to the DSP accessing host memory. Finally, the DSP3210 is fairly slow, executing at 17 MIPS compared to the 25 to 40 MIPS of its competition, and the 3210 executes more slowly still from external memory.

As for Motorola, Analog Devices, and Texas Instruments, it's too early to tell their chances for success. They all use off-the-shelf chips for multimedia applications and should be able to leverage the lower price that results from volume sales of these chips into other markets. Because these chips are not specialized to PC multimedia, however, the overall cost of systems employing them may be higher due to increased costs and parts count from extra interface logic for the host CPU and external peripherals. Additionally, as of this writing, none of these vendors has production multitasking solutions available, although all have them in some stage of development.

It is interesting to compare the two emerging integration strategies. The first, typified by Mwave, integrates common peripheral interfaces and emulation circuitry onto the DSP. The second, typified by the other vendors, uses an external ASIC for these functions. While the former certainly reduces part counts, it's not clear that it is necessarily less expensive: in large quantities, 10K–20K-gate ASICs cost only a few dollars, including amortized development costs. If the DSP is cheap enough, the resulting combination may be cheaper than an integrated solution. TI's customizable DSP program *(see **081001.PDF**)* combines these strategies by allowing the system designer to customize logic around a standard DSP core. As PC multimedia applications become better defined, it would not be surprising to see other vendors offer multimedia-oriented spins of their standard processors in the future.

PC Multimedia Will Boost DSP Sales

From a market perspective, PC multimedia is poised to become the next DSP "killer application." The vast number of existing PCs and those that will be sold in the next decade, coupled with the increasing demand for DSP-intensive multimedia capabilities, makes this outcome virtually certain. Perhaps more than fundamental DSP chip technology, software and system cost will play a critical role. The vendor that can provide a high-performance DSP with appropriate software at the lowest cost will reap the riches of this market. ♦

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