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Graphics Chips Debut at VESA Meeting

Many Vendors Demonstrate VL-Bus Products

By Linley Gwennap

Last issue, we examined recently-announced graphics chips from Weitek, S3, Avance, and Chips and Technologies (see **061202.PDF***). This article discusses other graphics chips that appeared at last month's VL-Bus announcement and includes a summary of all products from both articles.*

Many graphics chip vendors appeared at VESA's formal announcement of the VL-Bus to demonstrate their latest products. IIT announced the AGX-015, a new high-end chip. ATI demonstrated a fast VRAM-based graphics chip that competes with Weitek's Power 9000 and S3's new 86C928. S3 showed a '928 fresh from its first fab run and has begun sampling the chip. Oak and LSI had new low-cost graphics chips, while Western Digital demonstrated the venerable 90C31.

IIT Provides a Growth Path to XGA

Integrated Information Technology (IIT) announced the new AGX-015, a 32-bit upgrade to the AGX-014. Both chips are VRAM-based accelerators similar to S3's '928 chip and include a wide range of graphics functions in hardware. The '014, which is sampling today, connects only to the ISA bus. The '015 allows connection to the EISA or VL-Bus *(see* **060902.PDF***)*, but IIT does not expect to ship the part until the end of the year.

Although the '014 delivers about 17 WinMarks, the '015 is said to be a screamer at over 30 WinMarks.* To match the performance of the local bus, the '015 has an efficient VRAM interface that uses page mode for optimal performance. The internal engine combines the typical three-operand raster operation (see sidebar below) with a fourth operand ("mask"), which improves application performance but is seldom used in the WinBench tests.

The AGX chips are designed to offer an easy upgrade path to XGA. The chips will be pin-compatible with a planned XGA chip from IIT, and its registers are a subset of the XGA standard so that AGX drivers can be more easily extended to full XGA compliance. They are also compatible with the VESA XGA Extensions (VXE 1.0). Even the AGX name is backwards-compatible with XGA.

Few vendors (other than IBM) are selling XGA boards today, and the success of Microsoft Windows may remove the need for register-level graphics standards due to Windows' driver-based graphics architecture. Still, the AGX-015 will be an impressive product if it meets its performance and production targets.

ATI Joins the Chip Fray

ATI is the leading supplier of add-in graphics boards for personal computers. The 68800 is ATI's first foray into the component business, as the company attempts to build on its success with add-in boards and grab design-ins on the motherboard itself. ATI will not offer the chip to other add-in board vendors, as it is using the 68800 in its own line of graphics boards.

The chip is aimed at mid- to high-end applications. It includes a full-fledged acceleration unit and supports up to 2M of VRAM or 4M of DRAM. With VRAM, the 68800 reaches a speedy 26 WinMarks. Performance will be about 30% lower on the baseline configuration with DRAM due to the screen refresh cycles. As with other chips, performance will decline in larger DRAM configurations, particularly for non-interlaced displays, although a 64-bit DRAM interface helps somewhat. With a $70 price tag, the chip is best suited for high-end VRAM configurations.

The 68800 is the first member of ATI's "mach32" family of graphics chips. Besides high WinMark numbers, the chip includes features that assist in other areas. Using a technique called font anti-aliasing, the chip takes TrueType outline fonts and uses gray-scaling

* Although WinMarks can be measured in any configuration, all the results given in this article are for a 1024×768, 8-bit color, 70-Hz refresh, non-interlaced display using a 33-MHz 486 CPU with cache and WinBench 2.5, unless otherwise indicated. See part 1 (µPR 9/16/92, p. 9) for more details.

to enhance the edges. This results in improved readability of the displayed text, although it reduces performance by about 15%. For imaging and video playback applications, the 68800 provides a StretchBLT function that quickly scales images in hardware. The chip uses color interpolation, another form of anti-aliasing, to enhance the appearance of these scaled images. These techniques are particularly useful with Microsoft AVI applications, which create small video images that are enlarged when displayed.

Another area of differentiation for ATI is its software support. Besides Windows and the popular DOS and CAD programs, the company also provides drivers for the preliminary versions of Windows NT and Solaris on x86 platforms. The 68800 is also compatible with the 8514 register set, allowing it to be used with software that supports the popular IBM chip.

ATI will soon announce a lower-cost chip called the 68800LX. The LX version is differentiated by a smaller (32-bit) memory interface and does not support high-end RAMDACs, allowing the package to be reduced to 160 pins. At about half the price of the 68800, the LX is priced for DRAM configurations, although it also supports VRAM. Performance should be around 15-20 WinMarks when used with DRAM and over 20 with VRAM. The LX is expected to be in production in December.

ATI also markets its RAMDACs and clock chips. Current versions offer industry-standard functionality, but future RAMDACs will include extensions for multimedia applications. Future "mach32" chips will also include additional multimedia support, and they may double in performance by mid-1993. ATI also expects to support Intel's PCI bus in its next-generation chips.

What Accelerators Accelerate

Graphics accelerators perform many commonly used graphics functions in hardware. Here are the basics of these functions.

BitBLT stands for bit block transfer, and simply means moving a group (or "block") of pixels from one place to another. A BitBLT can occur from system memory to video memory or from one part of video memory to another. A chip with a BitBLT engine can move a block of pixels within its video memory using only a simple command from the processor indicating source address, destination, and size. Fast BitBLTs are the key to good scrolling performance as well as many other areas.

ROPs, or raster operations, refer to a set of logical operations combining the pixels being drawn on the screen with pixels that are already in video memory. Microsoft Windows defines 256 raster operations producing all possible Boolean operations on source, destination, and pattern data. Many chips perform most or all of these operations in hardware, often in combination with BitBLT or other drawing operations.

Color expansion is another feature that can improve BitBLT and drawing. Instead of loading the color (up to 24 bits) for each pixel, the CPU can load a register with a color value to be applied to a group of pixels. This feature is particularly useful for displaying text in color, or for drawing solid objects. A related function is pattern fill, which applies a repeated pattern of two or more colors using the third operand in the standard ROP.

Hardware cursor support is popular since all GUIs display a mouse cursor. This feature allows a cursor of any shape to be stored (usually in off-screen memory). The graphics chip can then provide all cursor movement simply by receiving the X-Y location of the cursor from the CPU. Most chips limit the cursor size to either 32 × 32 or 64 × 64 with either two or three colors.

Line draw and polygon draw allow the software to specify the start and end points of the line (or corners of the polygon) and let the graphics engine do the rest. Polygon fill is just a variation of color expansion and pattern fill. Clipping, or "scissoring", involves detecting objects that go over the edge of a window or behind another object, and handling them properly.

LSI Adds 32-bit Interface

Headland Technology, now a division of LSI Logic *(see **0612MSB.PDF**)*, is sampling the HT216-32, a low-cost accelerator chip. The new chip extends the previous-generation HT216 by adding a 32-bit system interface, improving performance on data-intensive memory-to-screen copies. The 216-32 is intended for inexpensive graphics accelerators with up to 1M of DRAM.

The new chip uses a simpler accelerator than more expensive chips. Only a few key operations are done in hardware; even basic BitBLT and line drawing must be handled by the processor. To assist software in performing BitBLTs, the graphics chip performs raster operations and data alignment. The chip also maintains a hardware cursor. The 216-32 gets a significant speed-up by connecting to the local bus.

The lack of more sophisticated graphics hardware prevents the 216-32 from reaching the performance levels of fully accelerated chips. Like Wingine, LSI's chip relies on the CPU to do much of the graphics work, but the 216-32 suffers in performance because of its use of less efficient (but less expensive) DRAM.

Although the chip was planned to be in production by now, the first version topped out at 33 MHz on the local bus. The chip is being revised to support 40-MHz 386 processors and should be in production by November.

The 216-32 is currently running at 9 WinMarks using 16-bit software. LSI is developing a new 32-bit driver that takes advantage of the chip's linear addressing mode, and it hopes that performance will improve to around 11 WinMarks. At that rating, the chip outperforms all other low-cost solutions, although it is still significantly slower that S3's '801, which is slightly more expensive. LSI plans to extend the product line with a new mid-range chip, expected in 1Q93.

Other Low-End Chips

Western Digital offers the WD90C31 as a low-cost graphics accelerator. The C31 is pin-compatible with the WD90C30, a non-accelerated single-chip VGA controller, offering a simple upgrade path. The C31 provides hardware support for BitBLT and a cursor, but software must handle all other functions. It supports up to 1M of DRAM and attaches to either ISA or Micro Channel. Built in a mature 0.9-micron CMOS process, the chip is priced below $25.

The C31 has been in production since last year and is due for an upgrade. At the VESA conference, the company demonstrated a VL-Bus interface chip for the C31 and intimated that this function would be included in a new version available by the end of the year. Along with local-bus attachment, the new chip will probably include some performance tweaks but no major changes are planned.

Oak Technology announced its OTI-087 chip, which also provides low-cost acceleration. More versatile than the C31, the '087 connects to local bus, ISA, or EISA. Although it can handle up to 2M of DRAM, the only 2M configuration supported is 1280 × 1024 × 8, and only with interlaced displays. It can provide 24-bit color for 640 × 480 displays with 1M of DRAM. Like the LSI chip, the '087 does not have a full BitBLT engine but includes features such as color expansion, patterning, and 64-bit read and write buffers to accelerate software BitBLTs. The chip costs just $18 and reaches 7 WinMarks. New versions of the chip and driver are expected in 1Q93 and should improve performance to 8 WinMarks.

Market Acceptance

S3 chips have been quite popular in the past with companies such as Artist Graphics and Diamond. These companies will probably use the new S3 chips, and both Orchid and STB have already announced boards using S3's '805. ATI will be its own biggest customer, and the company has already signed up Gateway, which will include the 68800 in its 486 PCs. The low-cost 90C31 is used in Western Digital's own Paradise boards as well as in Diamond's Speedstar 24X. The AGX-014 will be used in a board from VidTech, a less established vendor. Other new chips have not yet attracted major board vendors.

Problems with WinMark

Just as WinMark is becoming an accepted metric, several vendors are complaining about its usefulness and about "cheating" by other vendors. Some of this is sour grapes, no doubt, but it is true that WinMark numbers should be taken with several grains of salt. Like any

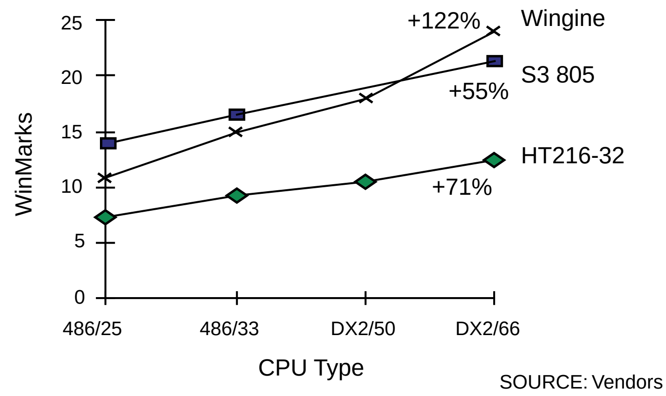

Figure 1. Graphics performance scaling versus CPU type.

single-number benchmark, WinMark does not correspond to performance on all applications. It is useful to look at the full WinMark report, as chips that perform well on memory-to-screen transfers will usually do well on image and video applications, while chips that do well on line drawing will excel in CAD applications. Some programs include operations, such as masking and StretchBLT, that WinMark does not test at all.

WinMarks also vary depending on the type of CPU used and the type of display (resolution and color depth). The WinMark numbers in this article are for a baseline configuration, but performance does not scale the same way for different chips. As shown in Figure 1, a pure frame-buffer design such as Wingine gets more benefit from a faster CPU than chips that perform many graphics operations in hardware. This is because the CPU bears more of the burden for graphics calculations when used with a frame buffer.

In configurations larger than the 1M baseline, DRAM-based designs will quickly lose performance due to screen-refresh overhead, but VRAM designs will continue to perform efficiently. Also, some chips only accelerate 4-bit and 8-bit color, resulting in a significant performance drop on high-color configurations. With all of these factors, it is difficult to estimate performance on one configuration based on WinMarks from another.

Finally, there are opportunities to artificially boost WinMark ratings. The individual tests are so simple that they can be defeated by an optimized driver. (This is akin to the Dhrystone benchmark, which a good optimizing compiler can reduce to nothing.) For example, vendors disagree about whether they can use off-screen memory to increase performance on the memory-to-screen test. Hardware can also be tweaked. Since many of the results are measured on test boards, it is possible to use very expensive memory or RAMDAC parts to increase performance. Numbers quoted by board vendors are more reliable in this regard.

Price & Availability

Part 1 of this article *(see **061202.PDF**)* includes price and availability information for the Avance GUI-Ultra; C&T 82C481 and Wingine; S3 86C801, 86C805, and 86C928; and Weitek W5286 and Power 9000.

The ATI 68800 is in production and is priced at $70 in quantities of 1000. It uses a 208-pin PQFP. Contact ATI Technologies at 3761 Victoria Park Ave, Scarborough, Ontario, Canada M1W 3S2; 416/756-0718, fax 416/756-0720.

The AGX-014 is sampling today at a price of under $40. The AGX-015 is expected to sample in October, with production shipments in December. It is priced at under $45. Both chips use a 208-pin PQFP and are priced in quantities of 10,000. Contact Integrated Information Technologies (IIT) at 2445 Mission College Blvd, Santa Clara, CA 95054; 408/727-1885, fax 408/980-0432.

The HT216-32 is expected to reach full production in November. It is packaged in a 208-pin PQFP and is priced at $20 in quantities of 10,000. Contact LSI Logic at Mailstop F106, 1551 McCarthy Blvd, Milpitas, CA 95035; 408/433-8000.

WD90C31 is currently shipping in a 132-pin PQFP or a 144-pin MQFP (metric) package. Pricing is under $25 in large quantities. Contact Western Digital at 8105 Irvine Center Drive, Irvine, CA 92718; 714/932-4900.

The OTI-087 is in production. It is available in a 160-pin PQFP and is priced at $18 in quantities of 1000. Contact Oak Technology at 139 Kifer Court, Sunnyvale, CA 94086; 408-737-0888, fax 408-737-3838

Choosing the Right Chip

Selecting a graphics accelerator is a multifaceted problem that requires a good understanding of the target markets. Important issues are the expected cost of the graphics subsystem, the supported display types (screen size and color depth), the CPU(s) that will be used, and the target software applications. All of these issues affect the performance of different chips in differing ways.

The subsystem cost breaks down roughly into three categories, as shown in Table 1. The low-end chips are intended as VGA replacements. To keep the cost down, these chips are normally configured with 512K to 1M of DRAM and attached to the ISA bus, although some can be moved to the local bus for a bit more performance. They don't offer a complete set of acceleration functions, but they provide 4 to 5 times the performance of standard VGA. Some of the low-end chips do not offer linear addressing, which will hamper performance on imaging applications. The low-cost chips are best for users with 640×480 displays or those with 1024×768 displays who use no more than 256 colors.

For a bit higher cost, one gets a full-function hardware accelerator, up to 2M of DRAM support, and (except for the '801) local-bus support, resulting in 14 to 20 WinMarks or about twice the performance of the low-end chips. Wingine is in this price range because, even though the chip itself is relatively inexpensive, adding 1M or 2M of VRAM takes it out of the low end. These mid-range chips support up to 2M of video memory, allowing the use of larger displays with more colors. When using DRAM, however, performance on larger configurations will suffer, particularly at high refresh rates. Also, check the data sheets carefully to see if non-interlaced monitors are supported in the desired configurations.

When cost is no object, the high-end solutions provide a complete hardware accelerator with support for up to 4M of VRAM and over 20 WinMarks of performance. High-end chips generally use local bus for the best performance. They also use VRAM to allow high-resolution non-interlaced displays to be refreshed without slowing the graphics processor, even with 16- or 24-bit color. These high-end chips cost more, plus some require an additional chip for VGA emulation. VRAM is currently about twice the cost of DRAM, and these solutions may need lots of video memory; just 2M of VRAM will cost more than even the most expensive accelerator chip. These expensive designs are best for high-resolution color monitors that take advantage of the chip's full feature set.

After selecting an appropriate cost range, the designer must consider the target CPU. Simple frame buffers become more attractive as the CPU becomes powerful enough to handle graphics operations quickly. Motherboard designers in particular can select a graphics chip that is appropriate for the installed CPU.

A final consideration is the target software applications. For CAD applications, chips with fast line-drawing will do the best. Many chips perform line drawing in hardware; the Power 9000 includes two line-drawing engines, providing superior performance on CAD and similar programs. On the other hand, programs that deal with images will not benefit from basic hardware acceleration at all; Wingine is inexpensive and provides good performance with photographs, video, and other imaging software. The 68800 has some special features for scaling images that can assist these same applications. It is essential that the vendor supply drivers for the target software if it is not a Windows application.

Summary

Table 1 summarizes all the chips from parts 1 and 2 of this article. The first columns show ISA, EISA, VL-Bus and Micro Channel support. The second group shows video memory support for DRAM and/or VRAM. The next columns indicate whether full VGA emulation

	Manufacturer / Chip Name	Bus Interfaces Supported				Maximum Memory		VGA Emul	Accelerated Functions	WinMarks	Chip Price
		ISA	EISA	VL	MCA	DRAM	VRAM				
HIGH	Weitek Power 9000	✔	✔	✔	—	—	4M	—	BitBLT, line draw, many more	33	$70+$10[†]
HIGH	IIT AGX-015	✔	✔	✔	—	—	4M	✔	BitBLT, line draw, many more	30	$45
HIGH	S3 86C928	✔	✔	✔	—	—	4M	✔	BitBLT, line draw, many more	27 (est.)	$65
HIGH	ATI 68800	✔	✔	✔	✔	4M	4M	✔	BitBLT, line draw, many more	26	$70
HIGH	C&T 82C481	✔	✔	—	✔	—	4M	—	BitBLT, line draw, many more	20	$32+$4[†]
HIGH	IIT AGX-014	✔	—	—	—	—	2M	✔	BitBLT, line draw, many more	17	$40
MID	Avance GUI-Ultra	✔	✔	✔	✔	2M	—	✔	BitBLT, line draw, many more	20	$25
MID	S3 86C805	✔	✔	✔	—	2M	—	✔	BitBLT, line draw, many more	16.5	$35
MID	C&T Wingine	C&T proprietary connect only				—	2M	✔	none	15	$18
MID	S3 86C801	✔	—	—	—	2M	—	✔	BitBLT, line draw, many more	14	$29
LOW	LSI HT216-32	✔	—	✔	—	1M	—	✔	ROPs, alignment, cursor	11 (est.)	$20
LOW	WD 90C31	✔	—	—	✔	1M	—	✔	BitBLT, cursor	9	$25
LOW	Oak OTI-087	✔	✔	✔	—	2M*	—	✔	Color expansion, patterning	7–8	$18
LOW	Weitek W5286	✔	✔	—	—	1M	1M	✔	BitBLT, line draw	7	$15

Table 1. Summary of PC graphics accelerator chips grouped by approximate subsystem cost. *Limited support for large configurations. [†]Cost of VGA emulation chip (not included on the main chip).

is included on the chip, and which graphics functions are accelerated in hardware; "many more" means that functions such as raster operations, polygon drawing and filling, clipping, and hardware cursor are included. The "WinMarks" column lists the benchmark rating in the baseline configuration. For chips that support multiple buses and/or different types of memory, the performance in the best configuration (usually local bus with VRAM memory) is given. Finally, the chip price is given for large quantities; see "Price and Availability" sidebar for details.

Weitek's Power 9000 is clearly the fastest chip on the market but it is also the most expensive. IIT's AGX-015 promises similar performance at a lower cost, but is so far unseen. S3's '928 should also be among the leaders but it has just started sampling. ATI's 68800 is already in production, has very good WinMark performance, and offers features such as StretchBLT and anti-aliasing that other chips do not include. C&T's '481 lags behind the leaders in performance and requires the use of C&T system-logic chip sets. The AGX-014 is hampered by its 16-bit interface.

In the middle group, Avance has impressive numbers but its absence from the VESA conference raises questions about the readiness of the chip. The S3 chips are available today and offer good performance. C&T's Wingine has a unique set of strengths and weaknesses, as discussed previously.

At the low end, the LSI chip should have the best performance once its new drivers are ready. The good old 90C31 from Western Digital has nearly the same performance as the LSI chip and does it without needing a local bus connection. Oak's OTI-087 and Weitek's W5286 offer very affordable upgrades from standard VGA chips.

Using the latest graphics chips, designers can build high-performance graphics subsystems using only a handful of chips: the accelerator, a RAMDAC, clock chip, and 1-2 DRAMs. Next-generation devices may combine the RAMDAC and clock with the accelerator, as is done on some VGA chips today. As the acceleration unit itself becomes a small part of the chip, high-performance graphics will become more affordable. Normal DRAM price trends will allow inexpensive support for high resolutions and true color in the next few years, tying in with user demands driven by the popularity of Windows and other GUIs. The graphics accelerator market, while crowded today, should be lucrative for the companies that offer good price/performance and broad feature sets. ♦

