EDN'S ALL-STAR PC

PART 3: HUMAN INTERFACE

Nothing in computer design depends more on fuzzy factors, such as touch, feel, or shade, than the PC's human interface. Yet no ingredients affect the PC's utility more. A few standards exist for defining such human-interface factors as keyboard angle, key layout, and screen contrast, but these standards establish an ideal environment for that mythical person: the Typical User.

Designing the human interface is the toughest job in computer design. Every computer user has a valid opinion regarding the touch and placement of a keyboard's keys, the size and color of letters on the computer's display, and the feel of the linkage between the computer's mouse (or other graphics-input device) and the cursor on the screen. It is impossible for any one design to accommodate every user's preferences, so computer designers must compromise. PC-based workstations offer the best of all possible worlds regarding the user interface. A PC designer may standardize a computer's design around one keyboard, mouse, and display, but the PC's flexible architecture allows each user to change any of these elements for a more harmonious work environment. Because computers are supposed to enhance your ability to work, this flexibility is a key advantage for the PC-based workstation.

Selections made for the human-inter-

STEVEN H LEIBSON,
Senior Regional Editor

face components of EDN's All-Star PC reflect my own preferences. As a long-time microcomputer user whose experience predates the introduction of IBM's original PC, I've developed habits that the "average" or "standard" PC's user interface simply can't satisfy. Nowhere is the need for selection by personal preference more apparent than in the selection of the All-Star PC's keyboard, a Honeywell 101RX43S-12E. I evaluated several PC keyboards before selecting Honeywell's. Keyboard characteristics important to me include key placement and size, keystroke length, and tactile feedback.

Microcomputer users that started with RS-232C terminals expect to find the *Control* key next to the *A* key. Yet the standard PC/AT keyboard places the *Caps Lock* key in that location and consigns the *Control* key to the lower-left nether regions of the keyboard. Honeywell's keyboard is configured for the standard PC/AT placement, but the company also provides two key caps and a DIP switch on the back of the keyboard that allow you to switch the *Control* and *Caps Lock* keys (**Fig 1**). Individual users need that kind of flexibility. After all, there is no compelling reason why a computer cannot adapt to the user instead of the other way around.

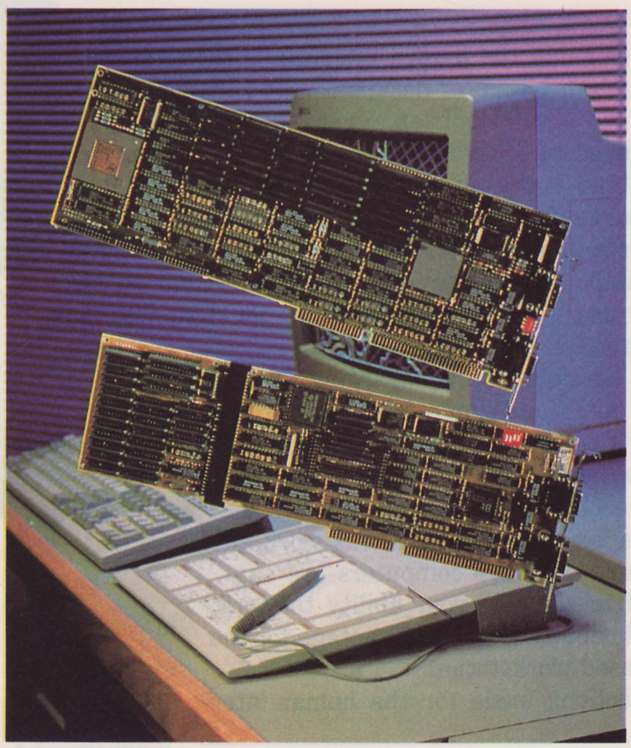
The function keys are another example of keyboard-design elements that demand flexibility. IBM arranged the 10 function keys on the original PC keyboard in two columns running down the keyboard's left side. Many users, who first learned to use a computer by working with IBM's original PC, developed typing skills that included single-handed, 2- and 3-key chords combining the *Shift*, *Alt*, and/or *Control* keys with the 10 function keys. These users were disappointed when IBM moved the function keys on its PC/AT keyboard to a single row along the top, making those keyboard skills obsolete. Third-party keyboard vendors used that customer disappointment as an opportunity to sell add-on equipment and introduced PC/AT keyboards that retained the original double-column arrangement.

However, I prefer having the function keys across the top because I never developed those chording skills. My initial experience with function keys was on RS-232C terminals with the function keys across the top of the keyboard, like the "new" PC/AT arrangement. PC users can obtain keyboards that position the function keys either way.

Many different returns

Similarly, PC keyboards sport various types of return (*Enter*) keys. Some, like the original PC's, are unreasonably small; some look like an inverted letter "L" and resemble the return key on IBM's Selectric typewriters; and still others, among them the Honeywell 101RX43S-12E, have extra-large return keys for fumble-fingered typists like me. Other models in Honeywell's 101RX keyboard series have the inverted-L or small-size return keys, thus satisfying all preferences.

Obviously, PC users have a wide choice of keyboards, thanks to third-party manufacturers and the PC's de facto standard keyboard interface. Because the PC enjoys large sales volumes in the business market, you can pick from dozens of keyboard designs from several vendors with a range of key placements, sizes, and tactile feels. You can also find keyboards that incorporate graphics-positioning devices such as mice, trackballs, and finger digitizers. PC-based workstations do not force the user to type on the



Only a few components comprise a PC's human interface, but the keyboard, the mouse or digitizer, and the display card and monitor can make or break the computer's value. (Photo courtesy Hewlett-Packard Co)

EDN's PC All-Stars

101RX43S-12E Keyboard

Honeywell Keyboard Div, 4171 N Mesa Bldg D, El Paso, TX 79902. (915) 544-5511.

Circle No. 675

Honeywell Inc

STATS:
COMPATIBLE WITH: PC, PC/AT, PS/2
SWITCH TYPE: membrane
STATUS LEDs: num-, caps-, and scroll-lock
AUDIBLE FEEDBACK: electronic, switchable
FUNCTION KEYS: 12, arranged as one row
PEAK ACTUATION FORCE: 55g

BIO: The 101RX43S-12E features an enlarged return (**ENTER**) key, adjustable tilt, and switchable **CAPS-LOCK** and **CONTROL** keys, which allow an end user to tailor the keyboard for maximum comfort.

keyboard selected by the workstation's designer. Other computer workstations don't offer this advantage because their low sales volumes do not encourage keyboard-replacement offerings from third-party vendors.

EDN's All-Star PC doesn't use a keyboard with an integral-positioning device because that configuration would reduce some of the system's flexibility. By keeping the keyboard and positioning device separate, you allow your choice for each to be made independently of the other. Some users prefer mice, others like pen-and-pad digitizers, and some prefer trackballs. Even for one user, different applications may work better with different types of pointing devices. Mice make poor digitizers, but digitizers themselves may consume too much desk space for constant use. Even within a class of pointing devices, users have different preferences. Take mice, for example. Apple Computer would have you believe that all mice should have one button. Yet other companies sell 2- and 3-button mice, and at least one company sells a mouse with an entire keyboard built in. Which design is right? That depends on the application and the user. Once again, the choices available in the PC marketplace give you the most flexibility.

I prefer mice over trackballs and digitizing pads, so the All-Star PC uses a mouse for graphics input. PC mouse selection involves choices between mechanical, optomechanical, and optical versions with two, three, or more buttons. EDN's All-Star PC employs the optical PC Mouse II from Mouse Systems Corp. I like optical mice because of their feel and reliability. They have no moving parts and consequently don't fill up with dirt or lint and then stop working. Many people reject optical mice because they require a gridded mouse pad for operation and the pad consumes desk space. These same people often put a rubber mouse pad on their desk to improve traction for their mechanical mouse. Either way, mechanical or optical, the user—not the PC designer—can make the most suitable choice.

The PC's Darwinian displays

The range of choices that PC displays exhibit is also wide, but for evolutionary reasons rather than convenience. Since its introduction, the PC's standard graphics displays have evolved from the hopelessly crude CGA (color graphics adapter), which is suitable for playing low-resolution video games, to the VGA (video graphics array), which is adequate for design work. The standard VGA resolution of 640×480 pixels certainly supports acceptable CAE displays, and the extended VGA modes, which some vendors' cards now support, generate 800×600- or 1024×768-pixel displays and bring parity between PC and workstation screens.

However, all of the standard PC graphics cards including the VGA

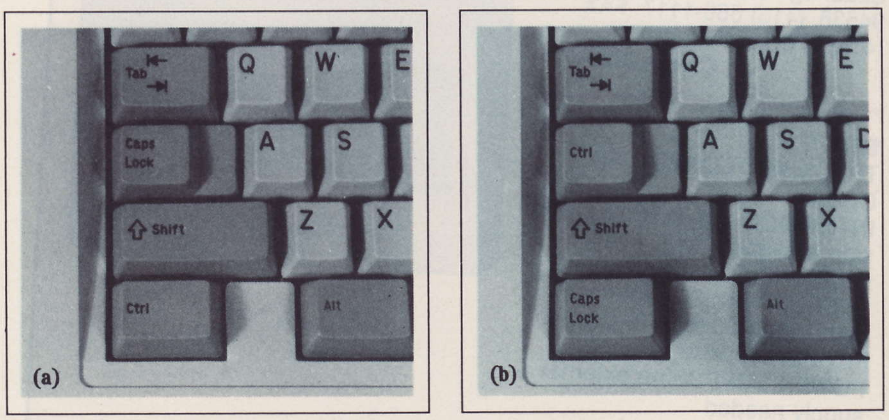


Fig 1—Conventional PC/AT keyboard layout places the caps-lock key next to the letter "A" key and banishes the control key to the lower-left corner of the keyboard (a). Honeywell's 101RX43S-12E PC-compatible keyboard allows you to exchange the positions of these two keys (b), making the keyboard less compatible but easier to use.

family suffer from a common failing: they're all dumb bit maps. The PC's CPU must paint every dot on the screen, one pixel at a time. Furthermore, the bit-map orientation of the PC's graphics-display cards has stymied the development of device-independent PC graphics. Two promising candidates to overcome these shortcomings are IBM's 8514/A and Texas Instruments' TIGA (Texas Instruments Graphic Architecture). Both of these designs employ display-list processing. An image to be displayed is stored as a list of graphics elements (such as lines, arcs, and polygons); the intelligent graphics card reads the display lists, clips the graphics elements to fit the screen, and then plots the resulting pixels on the display. Thus, an intelligent graphics card can perform zooms and pans without burdening the host CPU. For software written to take advantage of a graphics processor, the performance boost can be tremendous.

IBM's 8514/A graphics adapter card promises to become a de facto standard through the same mechanism that made the PC itself a standard: IBM's clout. Many companies have copied and improved upon PC products first introduced by IBM, but IBM didn't publish documentation for the 8514/A's hardware. In fact, it warned other companies that it might change the 8514/A's hardware design at some future time and asked software vendors to use the 8514/A's software interface, called the AI (adapter interface), to draw on the screen instead of writing directly to the 8514/A's hardware.

However, many PC-software vendors discovered that the 8514/A's AI was slow, so they bypassed the software interface and went straight to the display card's hardware. Accordingly, hardware vendors who wished to copy IBM's 8514/A display adapter reverse-engineered the board's hardware interface and settled on a common set of register-based specifications. These reverse-engineered specs freeze many elements of the 8514/A's design including the display's resolution and pixel depth, the interlaced scanning mode that IBM selected (which can produce flickering images), and most importantly, the display adapter's drawing commands.

Extensibility holds promise

IBM's 8514/A display adapter incorporates a µP, so it is an intelligent-graphics-display adapter. However, it is not programmable; its graphics routines are hard-coded into ROM, and its command set supports only one fixed resolution—1024×768 pixels. On the other hand, TIGA display boards based on Texas Instruments' 340 series of graphics µPs support many resolutions because TIGA's command set specifies resolution-independent graphics. TIGA also permits application-specific extensions to its command set for added performance. TIGA-based display cards keep their graphics code in RAM to support that extensibility. The TIGA-based display cards' range of flexibility makes them the right choice for the All-Star PC.

The All-Star PC incorporates three display cards: a VGA card to ensure compatibility with most of today's PC software, and two boards based on Texas Instruments' 340 µP series to meet the needs of both today's most ad-

EDN's PC All-Stars

PC Mouse II

Mouse Systems Corp, 47505 Seabridge Dr, Fremont, CA 94538. (415) 656-1117. FAX (415) 770-1924.

Circle No. 676

STATS:
TRACKING TECHNOLOGY: Optical
INTERFACE: RS-232C (bus version available)
BUTTONS: 2
RESOLUTION: 200 counts/in. (hardware); 20 to 6400 counts/in. (with software)
POWER SUPPLY: no external supply needed

BIO: The PC Mouse II features full compatibility with Microsoft's mouse. It offers optical reliability and variable resolution through special driver software.

vanced software packages and future software products. The All-Star PC doesn't, however, use all three display cards at once. The Multisync Graphics Engine from NEC Technologies provides a single-card solution by combining VGA functions with a 34010-based graphics accelerator (**Fig 2**). NEC's card incorporates 1M byte of video RAM and 768k bytes of program RAM for the accelerator. The card's VGA section supports resolutions to 800×600 pixels. Its accelerator section generates a 1024×768-pixel image and displays as many as 256 colors at one time.

NEC supplies several software products with the board, including the direct graphics software standard (DGIS) and GSS*CGI (Graphic Software Systems' computer graphics interface), both developed by Graphic Software Systems (Beaverton, OR, (503) 641-2200). NEC also offers drivers for Microsoft Corp's Windows 286 and 386, drivers for Autodesk's Autocad 9 and 10, and an optional PC-Xview package, also developed by GSS, which transforms a PC equipped with the Multisync Graphics Engine into an X-Windows-based Unix terminal.

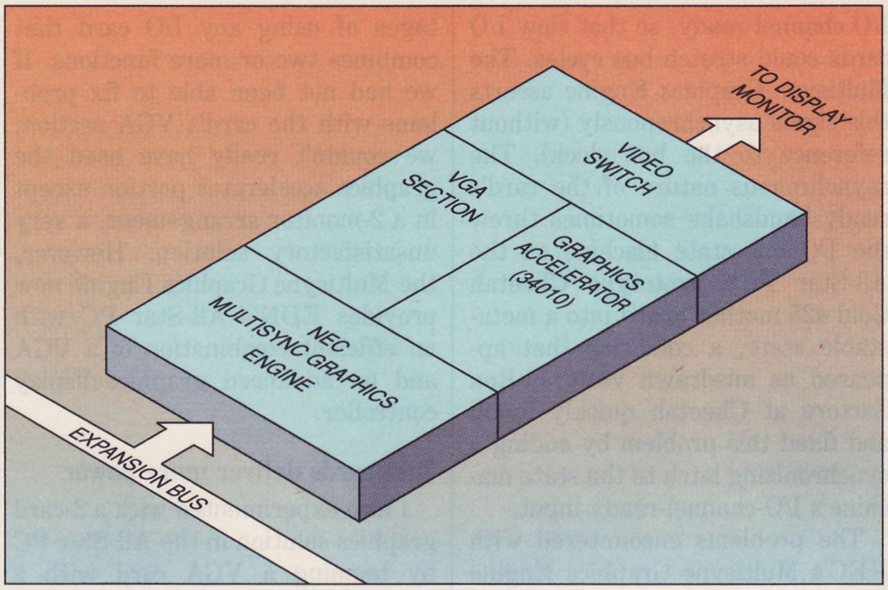


Fig 2—With a VGA controller and a graphics accelerator on one board, NEC's Multisync Graphics Engine provides multiple resources for display generation while consuming only one mother-board slot.

Speed problems rise again

During initial system-integration attempts at Cheetah International's R&D lab, the NEC Multisync Graphics Engine exhibited two particularly vexing problems. First, the VGA section wouldn't initialize properly more than half of the time. Second, the accelerator section didn't always draw vectors correctly during AutoCAD redraw operations. Cheetah's engineers and I suspected that the 80486's speed was causing these problems. As you recall, it wouldn't have been the first speed-related I/O problem for the All-Star PC Project. During the video initialization sequence (after turning on the power or resetting the PC), the Multisync Graphics Engine produced a double-sized cursor on the display, and the computer booted (as indicated by the integral power-on self-test display on the Cheetah Gold 425 mother board), but nothing else appeared on the PC's screen. The double-sized cursor indicated that the Multisync Graphics Engine's VGA section was improperly identifying the type of CRT monitor connected to the system.

This problem sometimes occurs with autoswitching VGA cards, and we felt that the speed of the 80486 code could cause a latent firmware bug to become a full-blown problem. We conferred with the card's designer at GSS and eventually obtained a new video BIOS ROM that fixed the problem. Chips and Technologies Inc (San Jose, CA, (408) 434-0600) designed the VGA chip on the Multisync Graphics Engine and also supplied the video BIOS. Because of the possibility of interaction between the VGA and mother-board BIOS ROMs, we discussed this problem with GSS (and thus, indirectly, with Chips and Technologies) and Award Software. Award also supplied a VGA BIOS ROM for the Chips and Technologies VGA controller chip, and that ROM cured the problem, too.

The undocumented nature of the PC/AT bus indirectly caused the Multisync Graphics Engine's 34010-related bug. Fortunately, it was easy to squash. IBM gave the PC/AT bus a handshake signal, called

I/O channel ready, so that slow I/O cards could stretch bus cycles. The Multisync Graphics Engine asserts this signal asynchronously (without reference to the bus clock). The asynchronous nature of the card's ready handshake sometimes threw the I/O bus state machine on the All-Star PC's prototype Cheetah Gold 425 mother board into a metastable state, a condition that appeared as misdrawn vectors. Ron Sartore at Cheetah quickly found and fixed this problem by adding a synchronizing latch to the state machine's I/O-channel-ready input.

The problems encountered with NEC's Multisync Graphics Engine illustrate the potential disadvantages of using any I/O card that combines two or more functions. If we had not been able to fix problems with the card's VGA section, we couldn't really have used the graphics accelerator portion except in a 2-monitor arrangement, a very unsatisfactory solution. However, the Multisync Graphics Engine now provides EDN's All-Star PC with an efficient combination of a VGA and an advanced graphics-display controller.

Two cards deliver more power

I also experimented with a 2-card graphics solution in the All-Star PC by teaming a VGA card with a 34020-based TIGA controller board (**Fig 3**). Because this design approach uses enough circuity for two pc boards, both the VGA and TIGA sections could include more capabilities than the corresponding sections on NEC's card. A VGA/NTSC recordable video card from US Video provides standard VGA functions. This card features a 16-bit bus interface for maximum performance. In addition, the board sports a 3-position switch that allows you to change its video timing from normal VGA frequencies to NTSC frequencies. When switched to NTSC, the video card generates a standard RS-170 color TV signal so you can display VGA graphics on standard TV monitors. You can

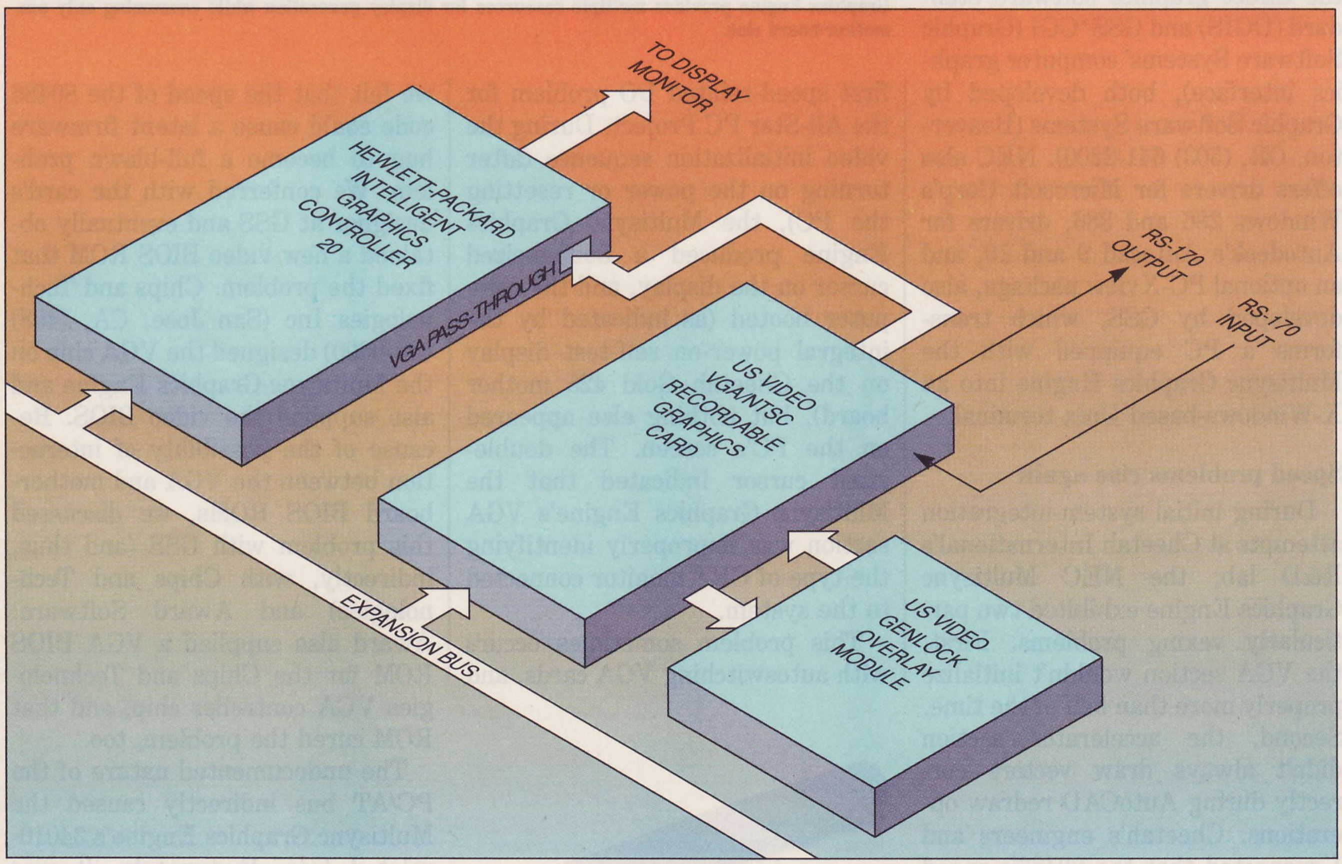


Fig 3—Using two display cards, you can obtain vast improvements in PC graphics. In this version of the All-Star PC's graphics subsystem, a US Video VGA/NTSC recordable video card delivers PC-compatible displays with resolutions to 1024×768 pixels, and a Hewlett-Packard IGC 20 graphics accelerator provides high-speed, intelligent graphics.

also record this signal on any standard US videocassette recorder for later playback.

IBM's CGA card for the PC also had a video-output jack that could display a color picture on a standard TV, but with only 200 lines of resolution. US Video's NTSC recordable video card can display more than 400 lines on a conventional television monitor. (Note that most US TV sets cannot display VGA's full 480-line resolution.) With the addition of a daughter card, the US Video controller can synchronize the PC's graphics with an incoming video signal, a feature called genlock. Recordable VGA graphics with genlock capabilities help media moguls create dandy animated video productions, but the reason the All-Star PC has a US Video card is an engineering one. It's not merely a frivolous addition.

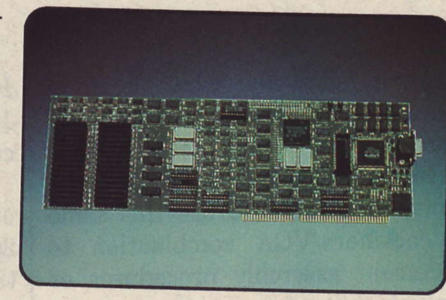
Engineering with videotape

Consider a test setup with a PC controlling the test apparatus and displaying the important test results using VGA graphics. The genlock/VGA video combination and a TV camera allow you to superimpose the test data on the image of your experiment and record the composite image on a VCR for later review. The superimposed test data would automatically be time-correlated with the recorded image of your experiment on the video tape. A T160 VHS cassette allows you to record eight hours of an unattended experiment, and you can review these results at your leisure. Like many engineers, I have conducted several experiments that required all-night stays at the environmental test chamber, just in case the prototype stopped working. If a design failed, I had to know

EDN's PC All-Stars — **Multisync Graphics Engine**

NEC Technologies Inc, 1255 Michael Dr, Wood Dale, IL 60191. (312) 860-9500.

Circle No. 677



NEC Technologies Inc

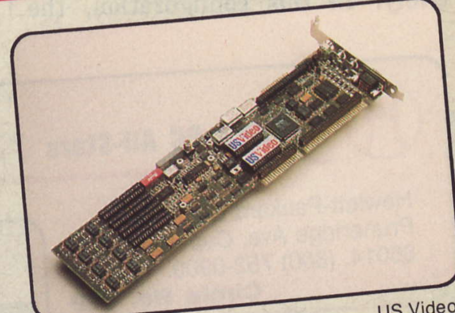
STATS:
µP: Texas Instruments 34010, 50 MHz
MEMORY: 1M byte of video RAM; 768k bytes of program memory
VGA DISPLAY RESOLUTIONS: 640×480, 800×600
ADDITIONAL DISPLAY RESOLUTIONS: 1024×768
COLOR PALETTE: 256k colors, 256 displayable

BIO: The Multisync Graphics Engine combines the functions of a VGA display adapter and a graphics accelerator. The graphics-accelerator section is compatible with several PC graphics packages and standards including Windows and DGIS.

EDN's PC All-Stars — **VGA/NTSC Recordable Graphics Card**

US Video, One Stamford Landing, 62 Southfield Ave, Stamford, CT 06902. (203) 964-9000. FAX (203) 964-1824.

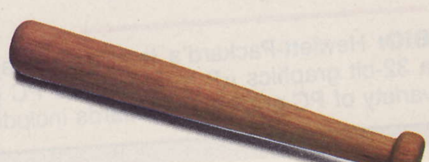
Circle No. 678



US Video

STATS:
BUS: IBM PC, PC/AT
OUTPUTS: VGA, NTSC RS-170
INPUT: RS-170
DISPLAY RESOLUTIONS: 640×480; 800×600; 1024×768
COLOR PALETTE: 256k colors, 16 or 256 displayable

BIO: US Video's VGA/NTSC recordable graphics card supports standard and enhanced VGA resolutions and generates standard RS-170 video signals for TV applications. An optional genlock overlay module allows the board to synchronize PC graphics with analog video.



when it failed and what the temperature was when the failure occurred. This video setup would have allowed me more pleasant evenings. You can also use this same videocamera/VGA combination to document assembly procedures or make training tapes.

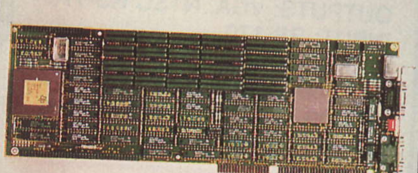
US Video's VGA/NTSC recordable video card certainly enhances the capabilities of today's PC software, but some of today's and many future software products will require intelligent graphics processing. Hewlett-Packard supplied the All-Star PC with a 34020-based Intelligent Graphics Controller 20 (IGC 20) display card for just such high-end graphics needs. The IGC 20 incorporates 2M bytes of video RAM and 3M bytes of RAM for the card's operating program and for the graphics-display list, respectively. In this configuration, the IGC-20 can display 1280×1024- or 1024×768-pixel images with 256 colors.

The 32-bit 32020 µP and 5M bytes of memory consume the entire IGC 20, leaving no room for a VGA controller on the board. Instead, the IGC 20 accommodates an external VGA card via a pass-through connector. You connect the output of a VGA card to the IGC 20's pass-through input connector and then connect your monitor to the IGC 20's video-output connector. At power up, the IGC 20 links the pass-through and video-output connectors, passing any incoming video signals to the display. Only when you activate the IGC 20's TIGA functions does the card assume control of the video-output connector.

This configurability permitted experimentation with two different 2-board configurations. You can connect either the VGA/NTSC recordable video card or NEC's Multisync Graphics Engine to the IGC 20's pass-through input connector. Both of these configurations provide VGA functions, and the second configuration jams two different graphics accelerators into the All-Star PC. The IGC 20 conveys the Multisync Graphics Engine's high-resolution video signals just as easily as the VGA signals. Although you can only use one accelerator at a time, the flexibility of the pass-through arrangement is apparent.

EDN's PC All-Stars | **Intelligent Graphics Controller 20**

Hewlett-Packard Co, 19310 Pruneridge Ave, Cupertino, CA 95014. (800) 752-0900.
Circle No. 679


Hewlett-Packard Co

STATS:
µP: Texas Instruments 34020
MEMORY: 2M bytes of video RAM, 3M bytes of program memory
STANDARD DISPLAY SUPPORT: pass-through connector
DISPLAY RESOLUTIONS: 1024×768, 1280×1024
COLOR PALETTE: 16.7M colors, 256 displayable

BIO: Hewlett-Packard's Intelligent Graphics Controller 20 card employs a 32-bit graphics µP to accelerate PC graphics and is compatible with a variety of PC graphics standards including TIGA and DGIS.

Balancing cost and resolution

The All-Star PC requires a very capable display monitor because it incorporates so much graphics-processing power. Because PCs now support several different display formats (CGA, EGA, and VGA, just to name a few) and because of the addition of a 1024×768-pixel resolution to this display menagerie, only a multifrequency monitor could meet the All-Star PC's display requirements. I tried three 16-in. multifrequency monitors, which all worked well. Once again, however, selections were based on preference rather than specifications. I picked the NEC Multisync 4D monitor because I like the way it displays text and I relish its simple operating controls. The Multisync 4D displays images with resolutions to 1024×768 pixels, and because it is an analog monitor, it can display a continuous range of colors.

Note that the Multisync 4D can't display the output of the IGC 20 in its highest resolution. You may wonder why the All-Star PC uses the IGC 20 at less than its maximum resolution. First, there's a big price jump between monitors that can display 1024×768-pixel images and monitors that operate at higher

EDN's PC All-Stars **Multisync 4D CRT Display Monitor**

NEC Technologies Inc, 1255 Michael Dr, Wood Dale, IL 60191. (312) 860-9500.
Circle No. 680

STATS:
RESOLUTION: 1024×768 pixels
HORIZONTAL FREQUENCY: 31.5 to 57 kHz
VERTICAL FREQUENCY: 50 to 90 Hz
VIDEO INPUTS: analog
SCREEN SIZE: 16 in., nonglare
DOT PITCH: 0.28 mm

BIO: NEC's Multisync 4D display monitor provides high-resolution graphics while consuming a reasonable amount of desk space. An integral µP synchronizes the display to various video sweep rates and adjusts the picture size for each display mode according to selections preset by the user.

resolutions. Those higher-resolution monitors generally employ 19-in. CRTs and consume a tremendous amount of desk space. Furthermore, my experience with CAD and CAE systems, acquired as a design engineer at Cadnetix Corp (now Dazix) in Colorado, taught me that a display with 1024×768 pixels is perfectly adequate for CAD and CAE applications and for graphics-user interfaces.

The NEC Multisync 4D completes the All-Star PC's user interface and its complement of hardware components. It's time for the 7th-inning stretch. The last two articles in EDN's All-Star PC series will discuss the project's software entourage. **EDN**

References

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