# Survey and Evaluation of Color-Display Terminals for VLSI

**Jonathan B. Rosenberg**, Duke University
**Henry Fuchs**, University of North Carolina

*The following survey and evaluation of commercially available color display terminals was conducted by the authors for the recently established Microelectronics Center of North Carolina (*LAMBDA*, Fourth Quarter 1980). They intend to use the display terminal as a key hardware element in their VLSI CAD tool research and development activities. We at LAMBDA believe that the requirements they identified, and the evaluation process that Rosenberg and Fuchs went through, would be of great interest to our readers, even though the specific requirements and constraints of other groups might be different. The choice made by the Microelectronics Center depended greatly on the following:*

1) *The base requirements identified below. (Of course, other groups could decide that they have different or additional requirements.)*
2) *Cost*
3) *Delivery schedules*
4) *Track record of the vendor*
5) *Financial condition of the vendor*

*This study was done during December 1980, and in a fast-moving field such as this one, six months is a long time. Recent product announcements might have modified the results of this evaluation. Readers are encouraged to use this survey as a starting point in their own display evaluation, rather than as a final statement on the subject. We are particularly interested in hearing from readers who have other suggestions or comments based on their experiences with these or other display systems.*

## The Base Requirements

These requirements are based on an evaluation of the needs of a VLSI design system, and on the recommendations of individuals at several VLSI design centers visited in California. Hands-on experience gained by one of the authors (Henry Fuchs) during the VLSI design course taught this past fall semester clearly indicated the huge advantages of high-resolution capability. In addition, the other author (Jonathan Rosenberg) visited several VLSI design centers in California, including the University of Southern California's Information Sciences Institute (ISI), Caltech, and Stanford. Experienced VLSI designers and administrators at these centers strongly recommended that we buy high-resolution (1024x1024) terminals with a minimum of 8 bit planes, if at all possible. These users of VLSI design systems currently use lower-resolution systems because high-resolution versions were not available when they made their purchases. The solution to this problem for the people at Stanford was to begin designing their own high-resolution terminal, which they call the SUN terminal.

The following are the basic requirements that we established for our system:

| | |
|---|---|
| Resolution: | 1024x1024 pixels. |
| Monitor: | 19", 30-Hz refresh rate, slow phosphor. |
| Memory: | 1024x1024 x 8 bits; color map (any resolution); bit-mask to write to single planes. |
| Zoom: | By pixel replicate; preferably x1, x2, x3 . . . |
| Pan: | By memory byte; preferably by pixel. |
| Vector draw: | 3 microseconds/pixel maximum; prefer 1 microsecond/pixel. |

# COLOR GRAPHICS DISPLAY OPTIONS

| MANUFACTURER | MODEL | RESOLUTION (base = 1024 x 1024) | COLOR CAPABILITIES (base = 8-bit planes w/color lookup table) | ZOOM (by pixel replicate) PAN (by memory byte) | SPEED (VECTOR DRAW <10μs/pxl) (RECT. FILL <2μs/pxl) | LOCAL INTELLIGENCE (16-bit programmable by user) | INTERFACE (RS-232 9600 baud) (DMA-DR11BX data-tablet) | PRICE ($25K–$35K) |
|---|---|---|---|---|---|---|---|---|
| DEC | GIGI | 768 x 240 | 8 fixed colors no LUT | Neither | N/A | LSI-11 based; 8K user memory; uses BASIC or FORTRAN routines | RS-232 9600 baud no DMA no Data tablet | $ 10,000 |
| TEKTRONIX | 4027 | 640 x 480 | 8 colors out of 64 has LUT | Neither | N/A | 9K special processor; uses FORTRAN based PLOT-10 library | RS-232 9600 baud no DMA no Data tablet | $ 10,000 |
| HEWLETT-PACKARD | 45C | 560 x 455 | 3 bit planes 4913 colors | Neither | N/A | 450K HP processor using HP BASIC routines or assembly routines | RS-232 9600 baud no DMA no Data tablet | $ 35,000 |
| SANDERS | Graphic 8 | 1024 x 1024 | Can support 8-bit planes; 256 colors min; has LUT (256 x 8) | Neither | 16-bit x 16-bit multiplication in 115 nanoseconds | 256K, 16K bit-slice processor FORTRAN or assembly graphics routines | RS-232 9600 baud; DMA or interrupt driven 500K words/sec; Data tablet interface | $150,000 |
| AYDIN | 5216 | 1024 x 1024 | Can support 8-bit planes; 256 colors; LUT is 8 x 8 | pixel replicate zoom & pan available in March | vector draw and rectangle fill: 1 microsec/pixel | 16-bit 8086 processor; up to 512K addressable downloadable from host cross-assembler | RS-232 9600 baud; DMA DR11B to UNIBUS or DG; Data tablet interface | $ 39,000 |
| RAMTEK | 9400 | 1024 x 1024 | Can support 8-bit planes; 16 Meg colors; LUT is 2048 x 13 | clipping, pan zoom by pixel replicate | 1 μsec/pixel | AMD 2900+ Z-80A; micro with 32K RAM, 32K PROM | 14 Port DMA; no RS-232 for Data tablet interface | $ 60,000 |
| AED | 512 | 512 x 488 | Can support 8-bit planes; 256 colors; LUT is 256 x 8 | pan and zoom by pixel replicate | vector draw: 10 microsec/pixel rectangle fill: 250 nanoseconds | 6502A processor (8-bit); up to 26K addressable | RS-232 19.2K baud DMA DR11B to UNIBUS Data tablet interface | $ 25,000 |
| IDT | 2000 | 512 x 512 | 3 bit planes max 8 colors fixed no LUT | Neither | N/A | 8085 processor (8-bit); up to 32K addressable | RS-232 19.2K baud; 2nd RS-232 for Data tablet available; DMA may be available | $ 17,000 |
| GENISCO | GCT-3000 | 1024 x 1024 | Can support 8 bit planes; 256 colors LUT is 256 x 12 | pan and zoom by pixel replicate | vector draw and rectangle fill: 1.5 microsec/pixel | Z8000 16-bit micro comes w/cross-assembler for DEC machines; addresses 512K | RS-232 19.2K baud; DMA interfaces for PDP-11, VAX, not DEC-10; Data tablet interface | $ 53,700 |
| TELECRAFTERS | CDT-7001 | 640 x 288 | 8 fixed colors no LUT | Neither | N/A | N/A | N/A | — |
| INTECOLOR | 8000 | 480 x 384 | 8 fixed colors no LUT | Neither | N/A | N/A | N/A | $ 5,000 |
| LEXIDATA | 3400 | 1280 x 1024 | Supports 4-bit planes; 4096 colors; LUT is 4096 x 8 each of REB | zoom by pixel replicate; pan by 1 vertically, 2 horizontally | vector draw and rectangle fill: 3 microsec/pixel | Lexidata processor; 2K PROM, 1K writeable control store | RS-232 9600 baud; DMA interface; Data tablet | $ 30,000 |
| COMTAL | Vision One/20 | 1024 x 1024 | Supports 8-bit planes; 4096 colors; LUT is 4096 x 8 each of REB | pan and zoom by pixel replicate | vector draw and rectangle fill: 800 nanosec/pixel | LSI-11/02 or 11/23 w/full complement of memory addressable | DMA interface | $100,000 |
| GRINNELL | GMT-27 | 1024 x 1024 | Supports 8-bit planes; 1024 colors LUT is 1024 x 12 bits | pan and zoom by pixel replicate with and without wraparound | Vector draw and rectangle fill: 1.5 microsec/pixel | special purpose Schottky processor not user programmable | no RS-232 must be specifically made; DMA via DR11B; no Data tablet— "must connect to host" | $ 31,000 |
| DE ANZA | ID 1100 | 1024 x 1024 | Supports 8 bit planes; LUT is 1024 x 8 for each of REB | pan and zoom by pixel replicate | Vector draw and rectangle fill: 1.2 microsec/pixel | LSI-11 based with full complement of memory addressable | designed compatible w/UNIBUS; no RS-232 and some Data tablet | $ 50,000 |
| CROMEMCO | Z-2H/GS | 754 x 484 | Cannot support 8-bit planes; 12 colors out of 4096 has LUT = 256 x 12 | Neither | N/A | Z-80A based (8-bit) with 64K bytes memory | RS-232 9600 S-100 bus, no DMA | $ 15,000 |
| CHROMATICS | — | 512 x 512 | Cannot support 8 bit planes; 8 fixed colors; no LUT | N/A | N/A | N/A | N/A | — |

| | |
|---|---|
| Rectangle fiill: | 2 microseconds/pixel maximum; prefer 250 nanoseconds/pixel. |
| Host interface: | RS-232 at 9600 baud (preferably 19.2K baud); DMA via DEC DR11B interface or DEC Unibus adapter. |
| Data tablet: | Data tablet interface required. |
| Processor: | 8- or 16-bit user-programmable; (preferably 16-bit). |
| Demo: | Require in-house demo for serious contenders. |

### Reasons for Elimination

Following is a summary of the reasons we found to eliminate several of the terminals under consideration.

A large group of terminals were eliminated because they failed to meet our base-resolution requirement (1024x1024). These were the entries from Digital Equipment Corporation, Tektronix, Hewlett-Packard, Advanced Electronics Design, Industrial Data Terminals, Telecrafters, Intecolor, Cromemco and Chromatics. The Lexidata 3400 had the high-resolution capability, but did not support enough memory for 8-bit planes, and did not have a very fast vector drawing speed. The Lexidata, at high resolution, can support only 1- to 4-bit planes of memory. This much of the evaluation process left only seven entries, five of which were eliminated on the basis of very high cost. Three devices were eliminated because they are strictly imaging systems that are not pixel-addressable. These systems also tended to be more expensive than our target price range (*i.e.* $100,000). These three terminals were the Sanders, Comtal and De Anza offerings.

The Grinell GMR-27 was under consideration, but it had a relatively high price ($40,000) for a terminal without user programmability. To make this device usable, we would have had to add something like an LSI-11, that costs at least $8000. The delivery time on this system was also an issue.

The final two systems under consideration were the Aydin 5216 and the Ramtek 9400. Both offer 1024x1024 resolution and support 8 or more bit planes with a color look-up table. Each has zoom and pan by pixel-replicate. Vector drawing speed and rectangle fill speed are comparable at around 1 microsecond per pixel. Both come with a DMA interface suitable for Digital Equipment Corporation or Data General computers. The Aydin is less expensive, but when and if we add a second workstation, the Aydin requires an additional outlay of $39,000 plus data tablet, while the Ramtek requires approximately $20,000 plus data tablet. In the final analysis, both devices met our requirements and they are the only two that did. The Ramtek 9400 finally won out.

Since this evaluation was done, two new systems have been announced that prospective buyers ought to consider: the Lexidata and the Chromatics CGC 7900. New offerings from other vendors are also likely.