FLAT PANEL DISPLAY CONTROLLERS FOR PC APPLICATION

The popularity and demand for flat panel displays replacing CRTs grows annually. With the increasing popularity of these display devices, there is an ever increasing challenge to have the flat displays maintain the same advanced performance characteristics as the CRT with little to no concession. The fact remains, however, that the flat panel display is widely different from the CRT. In addition, all of the flat display technologies, LCD, EL and Plasma, differ greatly from each other. Since all of the displays have different operational and cost differences, there is no obvious display for all applications. A state-of-the-art controller must be able to run all of the displays, maximizing their particular strengths while minimizing their weaknesses. This has been the ultimate challenge for the leading chip manufacturers.

The key in maximizing the operation of the various displays is the understanding of the differences between the CRT and the various flat display technologies. A CRT has a large active area that can display different resolutions, given it's timing parameters. The CRT gun can place pixels and rows of data anywhere it is directed by the control signals. In this way, low resolution displays are placed on high resolution CRTs and the "blank" areas of the displays can be "filled" or compensated. The flat display is different because they all have a fixed matrix of rows and columns of pixels. This means that lower resolution video cannot give the panel the necessary signals to drive the display. Apart from the physical differences between the CRT and flat displays, another major obstacle is the "translation" of color CRT information to monochrome displays. Color to grayscale representation must be transparent to the software and the video controller, while at the same time, be accurate for the viewer. That is to say that the color representation in black and white must have the same tone quality and intensity so the video information is not compromised. Finally each flat technology exhibits different performance variances that prevent the display from appearing identically like a CRT. Response timing, contrast, and phosphors properties require unique handling to either minimize a performance liability or as a method of enhancing a displays characteristics.

In the 1986 time frame, the chip industry tackled the driving of the flat display with the early introduction of the CGA compatible laptop computers. Due to poor operational characteristics, LCD displays had only limited demand prior to that point. Given comparable resolutions, the timing requirements for EL and Plasma technologies were only slightly different than the CRT. As the demand for LCD CGA controllers grew, early chip manufacturers succeeded in lowering the component count of the CGA function and were able to add the required control lines to operate the LCD display. It had to have a unique controller that could drive the display while being totally transparent to the host PC. From this beginning, new families of controller chips for the PC compatible, was born. Later, controllers grew to meet the requirements of the EGA specification. In this case, the LCD models from Japan were all 640 x 400. The EGA specification was 640 x 350, so the first tack of the new controllers had to compensate for this resolution/timing difference. The flat display EGA controller was designed to map out the 350 lines of data onto the 400 line display by double writing every seventh line. This filled the 400 display with 400 lines of data but the PC worked with the standard 350 of data from its standpoint.

Resently, the demands on video controllers have increased. VGA is now the ubiquitous video standard. Because of this, it is all but impossible to buy a monochrome LCD in any other resolution but 640 x 480. The other technologies; TFT color LCD, passive duty-drive LCD color displays, EL and Plasma need to be driven in the VGA environment. To keep up with these new display technologies while not "playing favorites" by not supporting one display type, the modern chip manufacturers have to introduce entirely new families of display controllers. These new controllers have the latest architecture that allows them to keep up with panels that have not yet been released.

The trends in display controllers dictate that the display controller must be able to operate all of the current displays and be demanded by the market to drive soon-to-be-released models and technologies. Secondly, the manufacturers must respond to the con-

stant pressure from the market to be competitively priced while increasing performance. Other concerns for today's controllers manufacturers are the migration to 3.3 V operation, supporting higher resolutions with the XGA-compatible specification, simultaneously operating a CRT with a flat display, supporting very large color palettes and the ability to be bus compatible for the newest trends in PC architecture. All the while, the performance and compatibility of the hardware and the software cannot be jeopardized.

To these ends, the modern chip manufacturer is introducing families of controllers rather than just one device. Each family has a core design that is code and register compatible with all the other members. This core design was developed to have all of the design features that are required in today's market, while maintaining a competitive price. For scaled back, limited operation applications a chip is offered with reduced specifications, primarily targeted towards black and white LCD operation in a notebook operation. This device typically offers less function but at a reduced price. In some cases, a subset of this device is offered in extremely low power/chip count operation

for limited LCD only VGA function. This is the number one market demand by the notebook industry. On the other extreme, there is a superset of the basic device that maximizes colors, speed and upward compatibility with the next generation of video standards. These devices will cost more than the base device but will out perform them as well.

The purpose of this application note is to outline the display controllers currently released to the market by the top video controller manufacturers. Each manufacturer, presented in alphabetical order, has prepared by themselves, a one page overview of their leading devices. Following this section is a matrix of specifications. This will allow the engineer to better evaluate each device from the manufacturer as well as comparing them to other manufacturers in an "apple to apple" comparison. This document has been reviewed by its participants for fairness and accuracy. As any specification document, various parameters may change over time. Though every effort was taken to be correct and thorough, Sharp Electronics cannot guarantee the accuracy of the information presented.

CHIPS AND TECHNOLOGIES
CHIPS 65520/530 MONOCHROME/COLOR FLAT PANEL/CRT CONTROLLER

OVERVIEW

The 65520 or pin-compatible 65530 supports up to 1280 x 1024 16 grayscales or 800 x 600 64 grayscales on Sharp's monochrome LCD and EL panels. The 65520 increases the color palette of Sharp's 512-color TFT LCDs to 24,389 colors. The pin-compatible 65530 supports Sharp's single or dual-drive color STN LCDs with a 226,981 color palette and 512-color TFT LCDs with a 185,193 color palette. The 65520 or 65530 provides a variety of fully programmable options to enhance display quality, such as:

- Gray scaling algorithm to reduce flicker on fast-response,"mouse quick" LCDs

- Vertical compensation techniques to completely fill the panel with lower resolution software via line replication, blank line insertion or TallFonts™

- SMARTMAP™ color to grayscale conversion to optimize the foreground/background contrast in text modes

- The 65520 or 65530 provides simultaneous CRT display with single or dual-drive LCDs (3 MHz or faster).

The 65520 or 65530 requires only three external components - CHIPS' 82C404 programmable clock synthesizer and two memories - for a complete VGA sub-system on the motherboard. Memory options include two or four 256K x 4 DRAMs or 256K x 4 VRAMs or two 512K x 8 DRAMs. VRAMs provide significantly higher performance and lower power consumption than DRAMs for video memory.

The 65520 and 65530 provide high performance for Graphics User Interface (GUI) application software. The controllers employ a FIFO and write buffer architecture providing zero wait-state operation with the ISA bus. The 65520 supports the 386SL's "PI" local bus, and the 65530 supports the 386SL's "PI" and 386DX/SX's local CPU buses.

The 65520 and 65530 are both optimized for minimum power consumption. The 65530 provides "mixed" 3.3 V and 5.0 V operation, so that the VGA, video memory and bus interface operate 3.3 V and the panel interface operates at 5.0 V. The 65520 operates at either 5.0 V or 3.3 V. Both the 65520 and 65530 supports self-refresh 256K x 4 DRAMs and 512K x 8 DRAMs during suspend/resume power down.

Table 1.
CHIPS 65520/530 Monochrome/Color Flat Panel/CRT Controller

FEATURES	BENEFITS
Drives Monochrome & Color LCD, EL & Plasma Panels	Flexible Panel Support
1024 x 768 16 Colors/800 x 600 256 Colors On CRTs	Super VGA Resolution Support
Simultaneous LCD/CRT Display	Facilitates Making Presentations
Programmable Gray Scaling/Color Generation Algorithm	Supports "Mouse Quick" LCDs
Four (4) Chip VGA Sub-System	Minimum Chip Count/Board Space
Supports Various Video Memory Configuration	Range of Price/Performance Options
Local Bus Support; Write Buffer/FIFO; 0-Wait State Pin	High Graphics Performance
3.3 V or 5.0 V Operation	Extends Battery-Base Operation
Full VGA and Backwards Compatibility	Runs All Application Software

CHIPS AND TECHNOLOGIES
CHIPS 82C9001A PC VIDEO WINDOWING CONTROLLER

OVERVIEW

CHIPS PC Video controller provides real-time video data acquisition, scan rate conversion and display windowing control for displaying live video with VGA graphics on flat panel displays and CRT monitors. PC Video supports the industry-standard video formats (NTSC, PAL, SECAM, S-VHS & RGB). The size of the video window is controlled by PC Video's input cropping and scaling features. The position of the video window is controlled by independent X-Y coordinates and by color keying. PC Video's ability to save and restore acquired data to/from system disk or memory enables a PC Video sub-system to serve as a low-cost frame grabber. PC Video and the 82C457 provide a cost-effective method for displaying video from a tape, CD-ROM, camera of digital tuner in a VGA graphics window on a CRT monitor and Sharp's color TFT LCD.

Table 2.
CHIPS 82C9001A PC Video Windowing Controller

FEATURES	BENEFITS
Merges Video Input With VGA Graphics	Provides Cost-Effective Multi-Media Solution
Very Cost Effective	Reduces End-User Price From > $2,000 to < $500
Still Frame Capture & Display	Serves As Frame Grabber
Programmable Window Size & Position	Provides End-Users With Full Control
Direct Interface With CHIPS 82C457	Supports Simultaneous Display on LCDs & CRTs

CHIPS AND TECHNOLOGIES
CHIPS 82C457 Full-Color VGA Flat Panel/CRT Controller

OVERVIEW

The 82C457 along with CHIPS' 82C9001A Video Windowing Controller displays a live video image with VGA graphics simultaneously on a CRT monitor and Sharp's color TFT LCD. The 82C457 increases the color palette of Sharp's 512-color TFT LCDs to 24,389 colors. The 82C457's programmable vertical compensation techniques stretch lower resolution software to completely fill 640 x 480 resolution LCDs.

Table 3.
CHIPS 82C457 Full-color VGA Flat Panel/CRT Controller

FEATURES	BENEFITS
Direct Interface To PC Video CHIPSet	Full Motion Video Capability on LCD/CRTs
24,389 Color On TFT LCDs	Direct Interface To Sharp's Color TFT LCDs
800 x 600 x 16 Colors On CRT Monitors	Super VGA Resolution Support
Full VGA and Backwards Compatibility	Runs All Application Software
Five (5) Chip VGA Sub-System	Low Chip Count/Board Space

CHIPS AND TECHNOLOGIES
CHIPS F8680 SINGLE CHIP PC

OVERVIEW

The F8680 integrates into a single chip all of the functionality required to implement a PC compatible computer except memory. The chip integrates a high-performance 8086 compatible CPU, CGA Graphics Controller, PC Systems Logic, 16C450-Compatible UART, and Power Management into a single 160 PQFP.

The CGA controller supports 640 x 400, 640 x 200 and smaller resolution single drive LCDs. The controller features programmable Frame Rate Control and "Visual Map". Visual map provides excellent visual contrast on any LCD Panel. All 256 possible foreground/background contrast combinations are programmable. Only one 32K x 8 120 ns SRAM is required for the video memory.

Table 4.
CHIPS F8680 Single Chip PC

FEATURES	BENEFITS
16 Programmable grayscales using Visual Map	Excellent Visual Contrast
Programmable Frame Rate Control	Reduced Flicker
Sleep/Suspend Mode Support	Increased Battery Life
Small Panel Support	Non-Standard LCD Display
High Integration	Reduced Power and Board Size

CHIPS AND TECHNOLOGIES
CHIPS 82C426 CGA LCD/CRT CONTROLLER

The 82C426 provides eight flicker-free grayscales or colors on LCD panels with up to 640 x 400 resolutions on CRT monitors. The 82C426's SMARTMAP™ feature improves the contrast of text on monochrome LCDs. The 82C426 employs a single 32K x 8 SRAM for video memory, enabling a highly integrated CGA sub-system.

Table 5.
CHIPS 82C426 CGA LCD/CRT Controller

FEATURES	BENEFITS
Up to 640 x 400 Resolution LCDs	Direct Interface To Small, Low-Cost LCDs
Up to 8 grayscales or Colors	Flicker-Free Display Quality
SMARTMAP™	Improvides Contrast of Text on LCDs
8 x 8 or 8 x 16 Font	VGA Quality Text In CGA Sub-System
SLEEP Mode	Extends Battery LIfe

CIRRUS LOGIC
CL-GD6410 LCD VGA CONTROLLER
FOR NOTEBOOK COMPUTERS

OVERVIEW

The CL-GD6410 is a single-chip VGA controller optimized for use in notebook computers, where reduced form factor and low power consumption are critical design objectives. With the CL-GD6410, a complete motherboard VGA controller requires only four or five ICs, and can fit within four square inches (excluding power sources and connectors). A true two-DRAM video memory (256K x 4), on chip RAMDAC, direct-connect ISA (PC AT) bus interface, and direct-connect LCD interface all help to minimize the form factor.

By using Cirrus Logic's Frame Accelerator technique, the CL-GD6410 is able to provide a high vertical refresh rate for dual-scan LCD panels while operating at approximately one-half the clock speed of other LCD controller solutions; this provides a significant reduction in full-active power consumption and extends battery life. In addition, standby and suspend modes are supported in the hardware of the CL-GD6410 to enable multiple levels of system power management.

The CL-GD6410 provides 64 shades of gray on monochrome LCD panels. Duty-cycle modulation, combined with dynamic pattern-management algorithms, provide 640 x 480-resolution grayscales with no apparent flicker. Pixel-doubling and stripping techniques provide increased grayscale in the VGA high-color Mode 13. In all cases, the Cirrus Logic gray scale provides consistent linear-step functions, making smooth transitions from black, through the grayscale, to white. With a direct connection to 512-color TFT LCD panels, the CL-GD6410 provides a single-controller solution for monochrome and TFT color portable computers. The CL-GD6410 also provides a direct interface to the CL-GD6340, Cirrus Logic's color LCD interface controller, for STN color LCD panels.

The CL-GD6410 supports SimulSCAN™, a technique introduced by Cirrus Logic for achieving simultaneous CRT and LCD operation. SimulSCAN™ supports both single and dual-scan LCDs, and both fixed and multifrequency analog CRTs. Monochrome LCDs may be operated in reverse video (pagewhite) simultaneously with normal CRT operation.

FEATURES

- Single-chip VGA controller
- IBM-VGA-hardware-compatible
- Simultaneous CRT and LCD (SimulSCAN™) operation
- Two 265K x 4 DRAM video memory for small form factor
- Integral RAMDAC
- Integral LCD panel interface
    - Control and data buffering
    - Power sequencing logic
- Direct connection to ISA (PC AT) bus
- Frame-Accelerator for low active power
- Standby and suspend modes to save power
- Expanded operational range: 5 V ±0%
- 64-shade grayscale on monochrome STN LCD
    - NTSC sum-to-gray color mapping
    - Multiple sum-to-gray weighting options
- Direct connection to 512-color TFT LCD panels
    - Single-controller design for STN monochrome and TFT color LCD's
- Graphics and text expansion of VGA modes on LCD
- 800 x 600 x 16 color on analog CRT
- 8- or 16-bit CPU interface
- Packaged in 160-pin (EIAJ-standard) QFP package
    - Pin-out optimized for efficient board layout

CIRRUS LOGIC
CL-GD6412 LCD VGA CONTROLLER
FOR MIXED-VOLTAGE NOTEBOOK COMPUTERS

OVERVIEW

The CL-GD6412 is a single-chip VGA controller optimized for use in systems with a mix of 3.3 V and 5.0 V components, where quick implementation of a notebook computer with reduced power consumption is the critical design objective. In a design using the CL-GD6412, the internal logic can use a 3.3 V power supply for reduced power consumption. The video memory, host bus interface, panel interface, and clock interface may each be implemented at either 3.3 V or 5 V. The voltages of these interfaces may be mixed in virtually any combination.

Multiple levels of system-power management are supported in the hardware of the CL-GD6412. Standby mode can be driven by software, or an internal counter. Suspend mode can be driven by software or hardware by means of a suspend pin. The hardware suspend pin allows a nearly complete shutdown of the device, with no bus decoding for very low power consumption. The CL-GD6412 is based on the proven CL-GD6410 architecture, one of the industry's most popular LCD VGA controllers. Basic design and programming models are unchanged. This allows for the highest confidence in quick development schedules.

With the CL-GD6412, a complete motherboard VGA controller requires only four or five ICs, and three external pull-up/pull-down configuration resistors. It can be designed in less than four square inches (excluding power sources and connectors). A two-DRAM video memory interface (256K x 4), on-chip RAMDAC, direct-connect ISA (PC AT) bus interface, and direct-connect LCD interface, all help to minimize the form-factor.

The CL-GD6412 has enhanced algorithms for dynamic pattern-management within the Frame Rate Duty Cycle, providing a grayscale with minimum apparent flicker, even on 4 MHz or quick response 'mouse-quick) panels. In all cases, the Cirrus Logic grayscale provides smooth transitions from black, through the grayscale, to white, for maximum display quality of realistic images.

The CL-GD6412 supports SimulSCAN™, a technique introduced by Cirrus Logic for achieving simultaneous CRT and LCD operation. Reverse video is controlled separately for the LCD display data path, so that page-white LCD operation may occur simultaneously with normal CRT operation.

FEATURES

- Single-chip VGA controller

- Mixed voltage: 3.3 V or 5.0 V on any major interface
  - Supports JEDEC Number 8 low voltage CMOS standard 3.3 V ±0.3 V
  - Mix 3.3 V or 5.0 V system components with no external-level converters

- IBM VGA hardware-compatible

- Two 265K x 4 DRAM video memory for small form-factor

- Integrates RAMDAC

- Integrates LCD panel interface
  - Control and data buffering
  - Power sequencing logic

- Direct connection to ISA (PC AT) bus

- Frame-Accelerator for low-active power

- 64 shade grayscale on monochrome STN LCD
  - NTSC sum-to-gray color mapping
  - Multiple sum to gray weighting options

- Enhanced flicker-reduction algorithms for 4 MHz and quick response LCDs

- Direct connection to 512-color TFT (Thin Film Transistor) LCD
  - Single-controller design for STN momochrome and TFT color LCDs

- Graphics expansion and compression maps CRT modes to fixed-resolution LCD

- Packaged in 160-pin (EIAJ-standard) QFP package

CIRRUS LOGIC
CL-GD6420 LCD VGA CONTROLLER
FOR HIGH-RESOLUTION NOTEBOOK COMPUTERS

OVERVIEW

The CL-GD6420 is a single-chip VGA controller optimized for use in high-end notebook computers, where high resolution CRT capabilities and high performance are critical design objectives. The CL-GD6420 is based on the proven architecture of the CL-GD6410. The CL-GD6420 adds a scaleable video memory capability, supporting up to eight 265K x 4 DRAMs.

By using the Cirrus Logic Frame-Accelerator technique, the CL-GD6420 is able to provide a high vertical refresh rate for dual-scan LCD panels while operating at approximately one-half the clock speed of non-accelerated LCD controller solutions. This provides a significant reduction in full-active power consumption, extending the battery life of notebook computers. Standby and Suspend Modes are supported in the hardware of the CL-GD6420, to enable mutiple levels of system power management. Standby mode can be initiated by software, by a programmable on-chip timer, or a separate standby pin.

The CL-GD6420 provides 64 shades of gray monochrome LCD panels. Duty cycle modulation, combined with improved dynamic pattern management algorithms, provide 16 shades of gray with minimum perceivable flicker, even on 4 MHz and fast response (mouse-quick) LCD panels. Grayscale enhancement provides 64 apparent shades of gray on the LCD for 640 x 480 x 265 color extended mode operation. Pixel-doubling and stippling techniques provide increased grayscale in the VGA Mode 13H.

With a direct connection to 512-color TFT LCD panels, the CL-GD6420 provides a single-controller solution for 64 grayscale monochrome and 256-simultaneous-color portable computers. Extended color mode support allows 640 x 480 resolution with 256 colors TFT LCD panels. For color STN LCD panels, the CL-GD6420 provides a direct interface to the CL-GD6340 color LCD interface controller. The CL-GD6420 supports SimulSCAN™ operation, a technique introduced by Cirrus Logic for achieving simultaneous CRT and LCD operation. SimulSCAN™ supports both single and dual-scan LCDs, and both fixed multifrequency analog CRTs. Monochrome LCDs may be operated in reverse video (page-white) simultaneously with normal CRT operation.

FEATURES

- Single-chip IBM VGA hardware-compatable controller

- Up to 1 MByte (2, 4, or 8) 256K x 4 DRAM Video Memory

- Extended resolution up to 1024 x 768 with 265 colors on CRT

- Simultaneous display on LCD panel and CRT

- Integral RAMDAC

- Integral LCD panel interface

  – Control and data buffering

  – Power sequencing logic

- Direct connection to ISA (PC AT) bus

- Standby and Suspend Modes to save power

  – Internal standby counter or hardware standby pin

- Expanded operational range: 5 V ±10%

- 64-shade grayscale on monochrome STN LCD

  – NTSC sum-to-gray color mapping

  – Multiple sum-to-gray weighting options

- Enhanced flicker-reduction algorithms for 4 MHz and quick response LCDs

- Direct connection to 512-color TFT LCD panels

- Graphics and text expansion on LCD

- Packaged in 160-pin (EIAJ standard) QFP package

CIRRUS LOGIC
CL-GD6340 COLOR LCD INTERFACE CONTROLLER

OVERVIEW

The CL-GD6340 is a flat-panel interface chip for use with the CL-GD64xx family of LCD VGA graphics chips to provide full-color displays on color LCD panels. By using multiple techniques for color shading, the CL-GD6340 is able to increase the number of colors an LCD can display. This interface controller can also produce up to 64 shades of gray on monochrome LCD panels. The CL-GD6340 supports active matrix panels with up to 1, 2, 3, or 5 bits per pixel (8, 512, 4K, or 32K-color panel capability). It supports color passive (STN) LCD with single and dual-scan architectures.

The CL-GD6340 handles subtle graduations of shade and hue, expanding an LCD panel's total color (or grayscale) capability, and providing a display quality that compares with CRTs. With a complete Cirrus Logic color LCD VGA solution, even eight-color panels can support all VGA modes (including mode 13), displaying 256 simultaneous from a palette of thousands.

The CL-GD6340 features a highly-programmable panel interface, with timing and power-sequencing logic. The CL-GD6340 can provide SimulSCAN™ operation, driving analog CRT and digital LCD in parallel. SimulSCAN™ supports both single and dual-scan LCDs, and both fixed and multifrequency analog CRTs. Monochrome LCDs may be operated in reverse video (page-white) simultaneously with normal CRT operation.

FEATURES

- On-chip support for active-matrix LCD panels
    - 8, 512, 4K, or 32K-color panels
    - Monochrome panels with or without grayscaling capability
- On-chip support for passive-matrix LCD panels
    - Dual scan
    - Single-chip
- On-chip buffers and logic to support monochrome- and color-passive LCD panels (single- and dual-panel displays)
- Provides full-color VGA on color panels
    - 256 simultaneously displayed colors in VGA mode 13
    - 16 simultaneously displayed colors in VGA mode 12
    - Selected from palette of thousands of colors
- Supports all VGA modes on monochrome LCD panels
    - 64 shade grayscale on passive monochrome panels
    - 16 shade grayscale on active-matrix panels without grayscaling capability
- Simultaneous displays on analog CRT and LCD
- Easy interface with Cirrus Logic VGA controller chips
- On-chip RAMDAC and RAMDAC extension registers
- 32 MHz operation
- Packaged in EIAJ-standard 100-pin plastic Quad Flat Pack (QFP) package

Table 6.
Western Digital

FEATURES		90C26	90C26A	90C24	COMMENTS
Host Interface	Local Bus	NO	NO	INTEGRATED	True 32 bit local bus
	16-bit I/O	YES	YES	YES	
	16-bit Memory	YES	YES	YES	
	32-bit Memory	NO	NO	YES	
	Zero Wait State	YES	YES	YES	
	Write Buffer	YES	YES	YES	90C26/C26A - 2 cycles, 90C24 - programmable to 4 cycle depth
	Virtual Memory	YES	YES	YES	
	ISA Bus	YES	YES	YES	
	Micro Channel	NO	YES	YES	
	386SL PI Bus	NO	NO	YES	
	Intel PCI Bus	NO	NO	NO	
Display Memory	Memory Architecture	FAST PAGE	FAST PAGE	FAST PAGE	
	Maximum Memory data	16 BIT	16 BIT	32 BIT	
	Interface — CRT	2-256X4	2-256X4	1-256X16	C24 can support simultaneous display w/o additional buffer
	Minimum DRAM required — Flat Display	50 MHz	50 MHz	85 MHz	
	Maximum MCLK frequency	50 MHz	50 MHz	85 MHz	
Package		144 pin QFP	144 pin QFP	208 pin QFP	
Built-in RAMDAC		YES	YES	YES	90C24 built-in RAMDAC designed for 3.3V and 5.0V operation
Built-In Clock Generator		NO	NO	YES	Built-in clock is designed for both 3.3V and 5.0V operation, clock frequencies are programmable
Power Supply Voltages	5 VDC	YES	YES	YES	
	3.3 VDC	YES	YES	YES	
	Mixed Voltages	NO	YES	YES	3.3V (-10%) to 5.0V (+10%), Integrated level shifters
Power Down Modes	Panel Off- VGA active	YES	YES	YES	WD offers "Deep Sleep" mode: 50 micro-amps power consumption
	Standby- VGA Powered Down Memory maintained	YES	YES	YES	
Panel Power Sequence Control		NO	NO	NO	Panel power sequencing managed in conjunction with core logic
CRT Display (Simultaneous colors/Color Palette)	640 times 400	256/256K	256/256K	64K/256K	90C26 supports 16 bit True Color in modes up to 640 X 480
	640 times 480	256/256K	256/256K	64K/256K	90C24 supports 16 bit True Color in modes up to 640 X 480
	800 times 600	256/256K	256/256K	256/256K	
	1024 times 768	16/256K	16/256K	256/256K	1024 X 768 non-interlaced
Flat Panel Display Support	1/240 TSTN B/W LCD	YES	YES	YES	Directly drives color TFT panels, no additional logic required
	Monochrome EL	YES	YES	YES	
	Gray Scale EL	YES	YES	YES	
	Color TFT	YES	YES	YES	90C26/C26A interface to 90C55 STN interface device, 90C24 directly drives color STN
	1/480 STN Duty Color	YES	YES	YES	panels with no additional logic
	1/240 STN Duty Color	NO	NO	YES	

Table 6 (cont'd).
Western Digital

FEATURES			90C26	90C26A	90C24	COMMENTS
Panel Interface	8-bit		YES	YES	YES	
	9-bit		YES	YES	YES	
	12-bit		YES	YES	YES	
	16-bit		YES	YES	YES	
Monochrome Panels	640 x 400	# of Gray Shades	64	64	64	WD TrueShade grayscales utilize 64 distinct SGF pixel dithering patterns
	640 x 480	*	64	64	64	
	1024 x 768	*	N/A	N/A	64	
STN Duty Color 640 x 480	VGA Mode 13	Simultaneous colors/Color Palette	256/256K	256/256K	64K/256K	90C24 supports 16 bit true color. True color supported in 640 times 480 SVGA mode only
	Super VGA	*	255/256K	256/256K	256/256K	
TFT Color 640 x 480	VGA Mode 13	Simultaneous colors/Color Palette	256/185K	256/185K	64K/256K	90C24 supports 16 bit true color. True color supported in 640 x 480 SVGA mode only
	Super VGA	*	256/27K	256/27K	256/256K	
Simultaneous Display	CRT and Mono LCD		YES	YES	YES	90C26/C26A & 90C24 support simultaneous display with full support for full screen vertical expansion of displayed images. The optional frame buffer for simultaneous display may be powered off or used as video memory when not in simultaneous display mode. The 90C24 does not require a separate frame buffer for simultaneous display.
	CRT and EL		YES	YES	YES	
	CRT and 1/480 Duty Color		YES	YES	YES	
	CRT and 1/240 Duty Color		NO	NO	NO	
	CRT and TFT Color		YES	YES	YES	
Display Enhancement Features	Greyscale/Color Generation Algorithm		YES	YES	YES	Provides full prog. of grayscales. Select best 16/64 in std. VGA
	Color to Grayscale Reductions	NTSC	YES	YES	YES	
	Programmable mapping RAM	Equal	YES	YES	YES	
		Green Only	YES	YES	YES	
	Vertical Centering		NO	NO	NO	
	Horizontal Centering		YES	YES	YES	All devices support both hardware and software vertical expansion techniques. Proprietary line duplication algorithm provides superior display quality vs. competitive Nth line techniques.
	Vertical Stretching	Text Mode	YES	YES	YES	
	Tall Fonts	Text Mode	YES	YES	YES	
	Blank Line Insertion		NO	NO	NO	
	White Text Enhancement		YES	YES	YES	
Window Acceleration	BitBlt		NO	NO	YES	BitBlt w/packed pixel mode for improved performance. Programmable cursor size, 32 x 32 or 64 x 64. MS Line Assist & Bressenham
	Hardware Cursor		NO	NO	YES	
	Line Draw		NO	NO	YES	
Release To Market/Available			March/June	June/Sept	Aug/Nov	

Table 7.
Cirrus Logic

FEATURES		GD6410	GD6412	GD6420	GD6340	Comments
Host Interface	Local Bus	YES/ with PAL	YES/with PAL	YES/with PAL	YES/with PAL	Yes/ with PAL
	16-bit I/O	YES	YES	YES	YES	
	16-bit Memory	YES	NO	NO	YES	
	32-bit Memory	NO	NO	NO	YES	
	Zero Wait State	YES	YES	YES	YES	
	Write Buffer	YES	YES	YES	YES	
	Virtual Memory	YES	YES	YES	YES	
	ISA Bus	YES	YES	YES	YES	
	Micro Channel	NO	NO	NO	YES	
	386SL PI Bus	YES/ with PAL	YES/with PAL	YES/with PAL	YES	
	Intel PCI Bus	NO	NO	NO	NO	
Display Memory	Memory Architecture	DRAM	DRAM	DRAM	DRAM	
	Maximum Memory data Interface	256K BYTES	256K BYTES	1 MBYTE	1 MBYTE	
	Minimum DRAM required CRT Flat Display	(2) 256K x 4	(2) 256K x 4	(2) 256K x 4	(2) 256k x 4	
	Maximum MCLK frequency	44 MHz 32 MHz	40 MHz	44 MHz	44 MHz	
Package		160 QFR (EIAJ)	160 QFP (EIAJ)	160 QFP (EIAJ)	160 QFP (EIAJ)	
Built-In RAMDAC		YES	YES	YES	YES	
Built-in Clock Generator		NO	NO	NO	NO	
Power Supply Voltages	5 VDC	YES	YES	YES	YES	
	3.3 VDC	NO	YES	NO	YES	
	Mix Voltages	NO	YES	NO	YES	
Power Down Modes	Panel Off - VGA active	YES	YES	YES	YES	
	Standby - VGA Powered Down memory maintained	YES	YES	YES	YES	
Panel Power Sequence Control		YES	YES	YES	YES	
CRT Display	Simultaneous colors/Color Palette 640 x 400	256/256K	256/256K	256/256K	256/256K	
	640 x 480	16/256K	16/256K	16 or 256/256K	256/256K	
	800 x 600	16/256K	16/256K	16 or 256/256K	256/256K	
	1024 x 768	n/a	n/a	16 or 256/256K	16/256K	
Flat Panel Display Support	1/240 TSTN B/W LCD	YES	YES	YES	YES	
	Monochrome EL	YES	YES	YES	YES	
	Gray Scale EL	YES	YES	YES	YES	
	Color TFT	YES	YES	YES	YES	
	1/480 STN Duty Color	NO	NO	NO	YES	GD6340 is color companion chip for GD6410/12/20
	1/240 STN Duty Color	NO	NO	NO	YES	

Table 7 (cont'd).
Cirrus Logic

FEATURES		GD6410	GD6412	GD6420	GD6340	COMMENTS
Panel Interface	8-bit	YES	YES	YES	YES	
	9-bit	YES	YES	YES	YES	
	12-bit	NO	NO	NO	YES	
	16-bit	NO	NO	NO	YES	
Monochrome Panels	# of Gray Shades					
	640 x 400 *	16 or 64	16 or 64	16 or 64	16 or 64	
	640 x 480 *	64	16 or 64	16 or 64	16 or 64	
	1024 x 768	16	16	16 or 64	16 or 64	
STN Duty Color 640 x 480	Simultaneous colors/Color Palette *					
	VGA Mode 13	NO	NO	NO	256/226K	
	Super VGA	NO	NO	NO	256/4K	
TFT Color 640 x 480	Simultaneous colors/Color Palette *					
	VGA Mode 13	256/185K	256/185K	256/185K	256/185K	
	Super VGA	16/3K	16/3K	256/185K	256/185K	
Simultaneous Display	CRT and Mono LCD	YES	YES	YES	YES	
	CRT and EL	YES	YES	YES	YES	
	CRT and 1/480 Duty Color	NO	NO	NO	YES	
	CRT and 1/240 Duty Color	NO	NO	NO	YES	
	CRT and TFT Color	YES	YES	YES	YES	
Display Enhancement Features	Grayscale/Color Generation Algorithm — NTSC	YES	YES	YES	YES	
	Color to Grayscale Reductions	YES	YES	YES	YES	
	Programmable mapping RAM	6 OPTIONS	6 OPTIONS	6 OPTIONS	87 OPTIONS	
	Equal	YES	YES	YES	YES	
	Vertical Centering — Green Only	YES	YES	YES	YES	
	Horizontal Centering	YES	YES	YES	YES	
	Vertical Stretching	YES	YES	YES	YES	
	Tall Fonts — Text Mode	YES	YES	YES	YES	
	Blank Line Insertion — Text Mode	YES	YES	YES	YES	
	White Text Enhancement	YES	YES	YES	YES	Maximizes test foreground/background
Window Acceleration	Bitblt	YES	YES	YES	YES	Enhances contrast of test foreground.
	Hardware Cursor	YES	YES	YES	YES	Enhances contrast of test background
	Line Draw	YES	YES	YES	YES	Enhances test foreground and background
Release To Market/Available		Production	Sample 4/92	Sample Now	Sample 6/92	

Table 8.
Chips and Technology

FEATURES		CHIPS 65530	CHIPS 65520	COMMENTS
Host Interface	Local Bus	YES	YES	65530 - direct; 65520 requires external PALs
	16-bit I/O	YES	YES	Direct interface
	16-bit Memory	YES	YES	Direct interface
	32-bit Memory	YES	NO	
	Zero Wait State	YES	YES	Increases performance
	Write Buffer	YES	YES	Increases performance
	Virtual Memory	NO	NO	Provides linear address space
	ISA Bus	YES/ with PAL	YES	Direct interface
	Micro Channel	YES	YES	Direct interface
	386SL PI Bus	YES	YES	Direct interface
	Intel PCI Bus	NO	NO	
Display Memory	Memory Architecture	DRAM/VRAM	DRAM/VRAM	Performance/power/cost flexibility
	Maximum Memory data Interface	1 MBYTES	1 MBYTES	
	Minimum DRAM required	(2) 256K x 4	(2) 256K x 4	
	Maximum MCLK frequency CRT	65 MHz	56 MHz	
	Flat Display	65 MHz	56 MHz	
Package		160 QFP	160 QFP (EIAJ)	
Built-In RAMDAC		YES	YES	
Built-in Clock Generator		NO	NO	Use external 82C404 clock synthesizer
Power Supply Voltages	5 VDC	YES	YES	
	3.3 VDC	YES	YES	
	Mix Voltages	YES	YES	
Power Down Modes	Panel Off - VGA active	YES	YES	
	Standby - VGA Powered Down memory maintained	YES	YES	
Panel Power Sequence Control		YES	YES	
CRT Display	640 x 400 Simultaneous colors/Color Palette	256/256K	256/256K	
	640 x 480 *	256/256K	256/256K	
	800 x 600 *	256/256K	256/256K	
	1024 x 768 *	16/256K	16/256K	65530 supports Non-interlaced & interlaced
Flat Panel Display Support	1/240 TSTN B/W LCD	YES	YES	Direct interface (no frame buffer required)
	Monochrome EL	YES	YES	Direct interface
	Gray Scale EL	YES	YES	Direct interface
	Color TFT	YES	YES	Direct interface
	1/480 STN Duty Color	YES	NO	Direct interface
	1/240 STN Duty Color	YES	NO	Direct interface

Table 8 (cont'd).
Chips and Technology

FEATURES			CHIPS 65530	CHIPS 65520	COMMENTS
Panel Interface		8-bit	YES	YES	Direct interface
		9-bit	YES	YES	Direct interface
		12-bit	YES	YES	Direct interface
		16-bit	YES	YES	Requires external 374 latch
Monochrome Panels	# of Gray Shades	640 x 400	64	64	At 640 x 400 and 320 x 200 resolutions
		640 x 480	64	64	At 640 x 400 and 320 x 200 resolutions
		1024 x 768	16	16	
STN Duty Color 640 x 480	Simultaneous colors/Color Palette	VGA Mode 13	256/226K	NO	At 320 x 200 resolution
		Super VGA	256/226K	NO	At 640 x 480 resolution
TFT Color 640 x 480	Simultaneous colors/Color Palette	VGA Mode 13	256/185K	256/24K	At 320 x 200 resolution
		Super VGA	256/185K	256/24K	At 640 x 480 resolution
Simultaneous Display		CRT and Mono LCD	YES	YES	Requires 100 ns 64K x 4 VRAM frame buffer
		CRT and EL	YES	YES	Direct
		CRT and 1/480 Duty Color	NO	NO	Direct
		CRT and 1/240 Duty Color			
		CRT and TFT Color	YES	YES	Direct
Display Enhancement Features		Greyscale/Color Generation Algorithm	Programmable	Programmable	Reduces flicker at low refresh rates
		Color to Grayscale Reductions	YES	YES	
	NTSC		YES	YES	
	Equal		YES	YES	
	Green Only		YES	YES	
		Vertical Centering	YES	YES	Automatic & programmable
		Horizontal Centering	YES	YES	Automatic & programmable
		Vertical Stretching	YES	YES	Programmable line replication
	Text Mode	Tall Fonts	YES	YES	Loads larger font
	Text Mode	Blank Line Insertion	YES	YES	Programmable
		White Text Enhancement	YES	YES	Swaps bright white and dim white
		Color Text Enhancement	YES	YES	Programmable color to grayscale mapping
Window Acceleration		BitBlt	NO	NO	
		Hardware Cursor	NO	NO	
		Line Draw	NO	NO	
Release To Market/Available			Now (From 11/91)	Now (From 4/92)	

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