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Xilinx Devices in Flat Panel Displays

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According to CIBC World Markets, Equity Research, the Flat Panel Display (FPD) industry has achieved sufficient critical mass for its growth to explode. Thus, it can now attract the right blend of capital investments and R&D resources to drive technical innovation toward continuous improvement in view quality, manufacturing efficiency, and system integration. These in turn are sustaining consumer interest, penetration, revenue growth, and the potential for increasing long-term profitability for industry participants. CIBC believes that three essential conditions are now converging to drive the market forward. They are:

- The technological and commercial readiness of FPDs
- Substantial capacity investment
- Lower end-selling prices

Competition in the display industry will intensify due to innovations and technological breakthroughs. Dataquest estimates that about 7 million flat panel TVs were produced in 2002. Production will exceed 8 million in 2003 and is expected to reach 13 million in 2007, with Japan and AsiaPac being the major production bases. LCD TV production in AsiaPac has surpassed that in Japan, and plasma TV production will also be relocated to there for cost reduction.

Introduction

This white paper discusses the FPD market and looks in closer detail at Plasma Display Panels and Liquid Crystal Displays in particular. Because of the competitive nature of this industry, and the presence of newer types of displays, such as Liquid Crystal on Silicon and Organic Light Emitting Displays, manufacturers are under pressure to ensure excellent time-to-market, cost and image quality in their product. The very nature of Xilinx programmable logic devices makes it a perfect fit in this system (i.e., it is highly programmable and thus flexible, it has no NRE, it guarantees a fast-time-to-market, it reduces the BOM, and it ensures an efficient life-cycle product management).

This white paper starts with an overview of where Xilinx devices fit in digital video systems. It then presents a market overview of the flat panel display industry. PDPs and LCDs are discussed in some more detail, before the value proposition for Xilinx devices is presented. Finally, a more detailed discussion of the relationship of product features and resources to FPD system requirements is presented before the document concludes.

Xilinx and Video in General

Digital video can be split into two distinct categories: consumer digital video and professional video broadcast. The first includes applications such as flat panel displays, digital light projectors, home video editing equipment, and so on. The latter includes those applications that are mostly found in studios such as video switching equipment, special effects generators, and so on. Irrespective of the category of digital video being discussed, each can be split into the same three distinct processes: capture, process, and display. These processes are complex in nature and many challenges exist in their design.

In the past, Xilinx has been able to play a role in Digital Consumer Video and Professional Video Broadcast in all three processes.

Capture

The first step in digital video is that of capture. An example of a consumer application is a digital still camera; a professional broadcast video application is the professional camera in the studio. This process begins with some form of light to data conversion and ends with a binary data file.

Examples of consumer applications that require image capture are:

- Digital Camcorder
- Digital Cinema
- Digital Scanner
- Video Conferencing
- Video Screenphones
- Digital Still Camera

Process

Digital image processing is a key component in ensuring superior image quality. Through more powerful encoding techniques more efficient use of available bandwidth is achieved, and through a myriad of other digital techniques, unique and invaluable capabilities are enabled (such as on screen display overlays, interactivity, and so on). Virtually all digital video products incorporate some form of image processing.

Examples of applications that benefit from digital image processing are:

- Digital Camcorder
- Digital Projector
- DVD R/W
- PDA
- Video Conferencing
- Digital Cinema
- Digital Still Camera
- GPS Navigation
- Plasma Display
- Video Screenphones
- Digital Scanner
- Digital TV
- LCD Monitors
- Telematics
- Web Pad

Display

A display accepts a digital video data stream and converts it into the technology specific format necessary to drive that display. Before being displayed generally the data is scaled, colors are corrected, and processing is applied to remove imperfections and to suit the viewer's taste. Digital display technology is the result of a convergence between digital television and computing. This convergence, along with the increasing availability of digital video content, has driven the development of digital transmission formats, flat panel form factors, and ever-higher resolutions and image quality.

Xilinx in the Consumer Digital Video Domain

From the discussion above, it is clear that any Consumer or Professional Broadcast digital video system can be split into three distinct processes: capture, process, and display. However, the question remains as to how, in the past, has Xilinx been able to fit into these distinct phases, and how will it continue to do so in the future. Furthermore, it is not simply a question of being able to perform functions in these phases; it is imperative that a strong value proposition exists for a Xilinx product to be used. Therefore, the following discussion shows how Xilinx FPGA and CPLD products can perform a host of functions in digital video capture, process, and display applications.

System Bus Interface and Networking

Digital video display products are faced with an ever-increasing list of desirable, but complex, connectivity options in order to participate in the greater market of digital consumer electronics. For instance, it may be necessary to connect internally to PCI, AGP, or an LVDS interface. At the same time, it may be necessary to add an IEEE 1394 or USB 2.0 link, Ethernet, HomePNA, or HomePlug network connection, or IEEE 802.11b/g/a, HiperLAN, Bluetooth wireless connection. For any or all of these applications, Xilinx programmable logic has been demonstrated, time after time, to provide efficient and flexible bridging solutions to a myriad of ASSPs.

Component Interconnectivity

Component integration is the traditional strength of programmable logic, and is more so today than ever before. Xilinx can support any or all of chip-to-chip, chip-to-memory, and chip-to-backplane interconnection requirements. Solutions exist with native support for 24 signaling standards, block and distributed RAM structures for FIFOs and buffers, and a wide range of standard IP for industry standard connectivity standards such as AGP and PCI.

Digital Video Processing

When performing digital video processing, programmable logic enables a designer to achieve the necessary performance and retain the flexibility to support geographically specific and continuously evolving standards. Some of the issues that must be covered include formatting and display standards, technology specific color behaviour, user perceptual preferences, and so on. These tasks are simple in principle, however, at real-time video data rates, they become quite challenging. A key enabler of the FPGA solution is the exceptional DSP performance of Xilinx products, including the embedded 18x18 multipliers, which is fundamental to all digital video processing functions. Furthermore, the Xilinx DSP toolset is tightly integrated with MATLAB™, and thus, provides an ideal combination for these types of applications.

User Interface

Technology and features emerging in digital capture products make the user interface a significant challenge. Furthermore, a unique user interface can be a key selling point and product differentiator in the highly competitive consumer industry. Xilinx FPGAs and CPLDs provide maximum flexibility to address this need.

System Control

Fully programmable system control is an emerging strength for programmable logic, and can be achieved using the MicroBlaze™ 32-bit soft RISC processor or the 8-bit programmable microcontroller, PicoBlaze™. With these tools it is now possible to deploy highly integrated systems that assimilate complete control into FPGA based solutions.

System Power Management

Handheld digital video products are comprised of an increasingly complex mix of technologies. Integrating these technologies while achieving efficient power management is an increasingly complex challenge. However, low power CPLDs, such as CoolRunner™-II are the answer to this challenge, and enable the implementation of custom tailored power management architecture specific to a particular design. CoolRunner CPLDs feature the lowest power consumption in the programmable logic industry, are available in ultra compact chipscale packaging, and are an ideal platform to address this demanding challenge.

File Encoding / Decoding

There are numerous encoding / decoding standards available for digital AV data including MPEG1, MPEG2, MPEG4, JPEG2000, MJPEG, TIFF, and so on. Furthermore, many systems in a variety of industries such as Industrial, Scientific and Medical, may use proprietary formats. In order to cope with different and changing standards, a programmable solution can provide the flexibility and performance necessary to cope with this uncertainty. As discussed previously, the high performance parallel processing of an FPGA in conjunction with the flexibility of the microprocessor provides a platform that is suitable for this type of application.

File Encryption / Decryption

As digital video technology proliferates there is a growing need for content protection. However, there is no unified standard and every solution is subject to the perpetual threat of being compromised. FPGAs are ideal platforms for this function with exceptional performance and the flexibility to support numerous and evolving formats.

Display Driving, System Timing, and Memory Control

The display driver, system timing, and integrating memory are key aspects to any display system design, and can mean that a solution becomes technology, and quite often, supplier specific. Xilinx FPGAs are an excellent platform for implementing these function for two reasons. Firstly, they are easily programmable to meet varying requirements. Secondly, they are flexible so that multiple versions can be implemented. This latter capability is unique, can increase the number of options with your supply chain, and can more than pay for itself through increased leverage for your purchasing department when negotiating with suppliers.

Xilinx in Professional Video Broadcast

Xilinx FPGAs have always been used at the leading edge of video research and development and are already widely used in professional and image processing applications. An analysis of the broadcast chain can be used to show how and where Xilinx products add value.

The broadcast chain starts in the studio, where video and multi-channel audio are captured by a wide range of cameras and microphones. Xilinx devices are being used in more and more professional broadcast cameras as their image processing and network capabilities expand. Image processing can include enhancement algorithms to produce better picture quality from any CCD imperfections, to scaling to suit 4:3 or 16:9 (widescreen) monitors or onboard displays.

Xilinx FPGAs are already being used for production interfaces to video network standards such as SDI, as well as wireless connectivity instead of the usual cumbersome cables. For power sensitive camera requirements, CoolRunner-II CPLDs are an ideal glue function for ASSP interfacing as well as expanding I/O and offering a novel way of saving overall system power by offloading menial processing tasks. Although monitors are not a direct link in the broadcast chain they are ubiquitous in the broadcast facility whatever their format. Xilinx has display driver and control solutions even for these and in high-end custom monitoring displays can offer a hardware acceleration to support multiple feeds to a high resolution.

The network router is the heart of all broadcast facilities because most media passes through the router on its way to various parts of the broadcast facility. Along with the main facility network router, traffic management and high throughput are also required in the Cable Modem Termination System (CMTS) for upstream communications from the subscriber. The key requirements of all routers are reliability, scalability, flexibility, and high performance and Xilinx FPGAs and CPLDs offer solutions to all these key requirements.

In the edit suite, high-performance servers are used for various graphics manipulation from picture quality improvements, color correction, and format conversion to higher/lower resolutions or different aspect ratios. Servers and storage systems as well as computing intensive image processing are the focus of editing suite applications. Xilinx FPGAs enable editing tool vendors to develop high-performance solutions that are flexible, reprogrammable, and scalable to meet their editing needs.

The gallery is typically where the director or production team ultimately views and controls which audio and video feeds get played out to the consumer or to storage for post-processing. Using the master control switcher, low level effects for overlay and various transitions can be made real-time between camera shots or soundtracks. Xilinx devices offer the ideal fit for mixers and master control switchers through unrivaled DSP performance and support for many channels of video and audio processing in fewer devices.

Video servers and storage are central components of all broadcast facilities. Disk arrays are tending to replace tape machines and have been enabled by the ever-increasing performance of compression, storage and network technologies. Xilinx has the programmable solution to help in offloading network and file handling so that the host processor can get on with the job of software processing. Xilinx FPGAs and CPLDs can also perform the basic system interfacing between processors and hard drive or tape mechanisms.

During transmission, the director is able to incorporate real time outside broadcasts for news and sports coverage – reporters in the field having professional but lower level editing and transmission equipment of their own. This is the area of news gathering, where outside broadcast vehicles become mini studios with their own encoders, modulators, and transmitters communications centers. Xilinx devices are the ideal choice for multi-channel video encoding and flexible, high performance error correction. With news gathering, there is a strong reliance on telecom technologies and Xilinx has vast experience in various applications including ISDN, Ethernet, ATM, satellite, VoIP, and more.

Encompassing the entire broadcast chain is the role of test equipment. Testing is done at all parts of the chain to ensure that requirements such as image quality and reception signal strength have not been compromised along way. Xilinx FPGAs are widely used in test equipment because we can adapt equipment to suit the environment it is testing as well as offering our own system analysis feature such as ChipScope™ Pro.

For transmission, an automatic management system typically ensures that playout occurs without interruption. After MPEG compression and statistical multiplexing, the data is framed, multiplexed and modulated for transmission over satellite, terrestrial (via a standard TV aerial), cable or even over the Internet. The chain ultimately finishes at the consumer receiver, usually via a set-top box for the increasingly common digital transmissions, to any one of a number of display technologies — a standard CRT digital TV, plasma display, LCD monitor, or projectors.

Summary of Xilinx Devices in Video Products

It is clear that Xilinx products play a large role in Digital Video Systems, Consumer and Professional Broadcast. The size of this role is set to expand rapidly as new products provide greater numbers of features and resources that are necessary for digital video applications. Some of these resources and features are discussed in more depth in a later section. Table 1 provides a summary of some of the main design challenges that a video system designer must contend with, and how Xilinx products can provide solutions to these problems.

Table 1: **Design Challenges and Xilinx Solutions**

Design Challenges	Xilinx Solutions
Link Layer Control	Xilinx devices solve high-throughput connections issues for audio, video, and data transfers into and out of a device. Encryption / Decryption — easily prevent unauthorised access, copying and sharing using the Xilinx extensive library of encryption / decryption IP cores including AES, DES, TDES, and so on.
Image and Video Processing	Move computationally intensive functions such as motion estimation and DCT from MPEG codecs into a high-speed programmable DSP for better performance. This can be done with Xilinx FPGAs and XtremeDSP technology.
Memory and Storage Interface	Implement real-time video buffering for HDTVs, PDPs, and LCDs that require high bandwidth memory with Xilinx block RAM, interface capabilities to external memories and more. Reference designs are available to help with memory interface challenges.
System Control	Using Xilinx 32-bit MicroBlaze soft processor core as a high-performance central hub for data flow, overall system control, interrupts, high-speed memory controllers and various peripherals, can be handled, thus, freeing up the central processor. All this without using up valuable silicon space on the board.
System Connectivity and Integration	With Xilinx FPGAs and system connectivity IP cores, chip-to-chip, chip-to-memory, and chip-to-backplane interconnection requirements can be implemented and many external discrete components can be integrated, reducing the number of discrete devices.

Flat Panel Display Market Overview

Flat Panel Displays (FPDs) include Plasma Display Panels (PDPs), Liquid Crystal Displays (LCDs), Rear Projection Displays, Organic Light Emitting Displays (OLEDs), and Liquid Crystal on Silicon (LCoS) Displays. The projected numbers of units for PDPs, LCDs, and rear projection displays is shown in Figure 1, courtesy of Gartner.

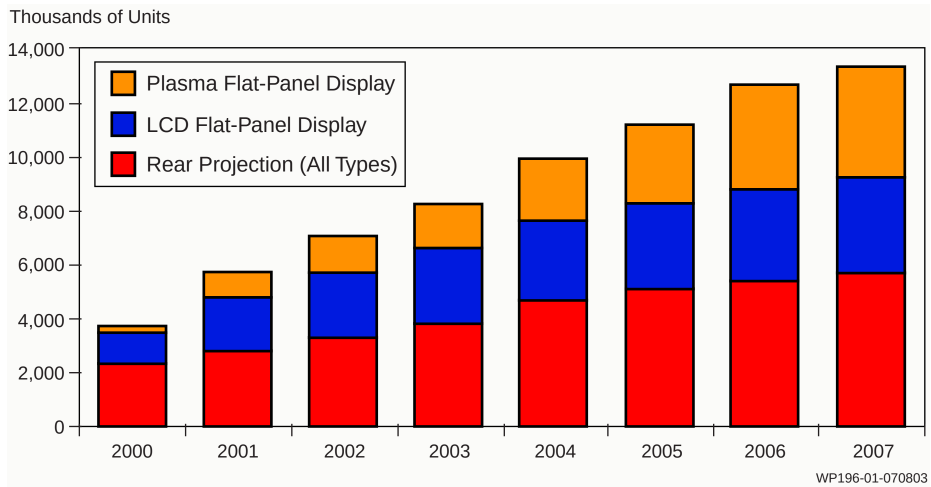

Figure 1: **Projected Number of FPD Units, 2000-2007, (Gartner 2003)**

While Japanese producers pioneered FPD manufacturing, they have had limited success in holding on to market share relative to the more aggressive Korean manufacturers, who have unquestionably benefited from a second mover advantage. Furthermore, other shifts in region are also occurring as can be seen with Philips, Samsung, and Sharp investing in display centers in Taiwan and moving design and manufacturing centers to China (Table 2).

Table 2: **Major Display Manufacturers in China (Gartner, March, 2003)**

Company	Displays	CAGR (%) 2003-2007
Fefan	Notebook PC	39
Matsuchita	LCD TV	45
CPT	LCD Monitor	29
AUO	PDP TV	41
Hitachi	-	-
HannStar	-	-
Samsung	-	-
Sharp	-	-

According to CIBC, it is difficult for PDPs to compete effectively with TFT-LCDs in form factors below 30-inch because of the low manufacturing cost of TFT-LCDs. This is confirmed by the larger LCD shipments in unit terms for the smaller form factors. It is still unknown as to which solution will win for form factors exceeding 30-inch. However, TFT-LCD suppliers such as Sharp and Samsung are devoting substantial resources to overcoming technology and cost hurdles that could propel TFT-LCD towards becoming the mainstream TV display technology. Furthermore, it is estimated that TFT-LCDs only have a 5% penetration within the TV market, and therefore, the growth path appears to be extremely promising for the second half of this decade.

TFT-LCDs account for an estimated 66% of total FPD sales, and CIBC's belief is that the high resolution, color, and refresh rate further accelerated by the integration of driver circuits upon the transistor array continue to position the LCD as the best solution for mainstream applications. However, LCD is lagging behind plasma in the large-screen flat panel TV market as 50-inch plasma models are already in volume production (according to Gartner Dataquest). Non-Japanese vendors led by Samsung and LG Philips are moving to supply large-screen LCD TVs as they exhibit 46-inch thin-film (TFT) models at electronic shows. Samsung's 46-inch model has picture quality equivalent to HDTV with a Wide Extended Graphics Array (WXGA) standard resolution (1,280 x 720). It has high specs equivalent to those of the plasma model, i.e., a wide field angle (170º vertically and horizontally), a contrast ratio of 800:1, and a maximum brightness of 500 candles. Furthermore, Samsung has overcome the slow response time issue of LCD TV with a fast response time of 12 ms – the minimum response rate requirement to allow a viewer to watch an animated picture with comfort is 15 ms.

Other companies are innovating in different ways, such as Sharp, which has developed leading edge technology with a 4-inch TFT color display using a plastic substrate. This substrate enables a thinner, lighter, and stronger display, which is suitable for mobile applications. It will be 1/3 the glass-based substrate one in thickness, ¼ in weight, and more than 10 times in shock resistance.

The main criticisms for PDPs include the relatively short lifetimes and high power consumption, however, they have superior picture quality and an attractive form factor, and therefore, may be entrenched as the premium technology platform within the ultra-large-area display market.

In summary, to survive in the competitive flat panel market vendors must continue to improve production technology. In addition to the need for yield improvement of the panel, other components and parts in the TV system must be integrated as they account for the major cost portions. For instance, in the case of LCD TV, no single vendor has a technical edge over the others, and reduction of component cost holds the key to competitiveness and profitability.

Liquid Crystal Displays

Predictions

DisplaySearch predicted that LCD TV sales would accelerate in 2003 with 182% growth predicted for 2003 after 113% growth in 2002. And in fact, according to DisplaySearch in its Quarterly Large-Area TFT LCD Shipment Report, June 2003, TFT LCD shipments exceeded expectations in Q1-2003 to a record high of 20 million units. The improved availability of larger panel sizes and a wealth of new LCD TV technological advances facilitate this growth. Some of the main predictions for LCD TVs include:

- LCD TVs are forecast to have steady growth, rising from 338K in Q3-2002 to more than 2 million in Q3-2004
- LCD TV modules are anticipated to grow from $132 million in Q3-2002 to $732 million in Q3-2004.

The optimism regarding the potential growth is based on a number of factors including:

- Larger substrate fabs in which larger sized panels will be better optimised and more cost effective
- Lower panel and set prices
- Added competition

- The rapid emergence of HDTV
- Improvements in numerous enabling technologies

Companies Involved

At the end of 2001, total market revenue had declined by 12% to 13.5 billion, which, according to IDC contributed to the overall recession in the PC industry and price erosion. The top 10 vendors for 2001 are shown in Table 3.

Table 3: **Top Ten LCD Vendors, 2001**

LCD Vendor
AUO
CMO
CPT
Hitachi
IDT
L. G. Philips
NEC
Samsung
Sharp
Toshiba

Outside of the top 10, a total of 12 vendors earned a combined share of 21%. Due to the improved performance of Taiwanese vendors, three Japanese vendors – Matsushita, Sanyo and ADI – were pushed out of the top 10.

In 2002, Sharp dominated the market, representing 50% of branded LCD TV sales, and Samsung surpassed LG Electronics to capture second place with 12.5% market share. Sharp also led the market in terms of LCD TV display module shipments, representing 57% of the market in Q3-2002. LG Philips was second with 19% market share.

Table 4 lists the Japanese consumer LCD manufacturers along with the brands under which these displays are sold.

Table 4: **The Japanese Consumer Display Vendors for LCD TV**

Display Manufacturer	Brand
Sharp	Sharp
LG Philips	Sony
Samsung	Matsushita (Panasonic)

Digital TV LCD Monitors

High Definition TV (HDTV) is the highest resolution supported by DTV broadcasts. Consumers can choose between three different levels of quality, which are defined by CEA as:

- High Definition TV (HDTV)
- Enhanced Definition TV (EDTV)
- Standard Definition TV (SDTV).

Besides the quality level supported by the receiver box, this quality level must be supported by the display as well. The accepted segmentation is:

- SDTV – "usable picture"
- EDTV – 480p, 480i (if input is also 480i), or higher
- HDTV – 720p, 1080i, or higher

Table 5 shows companies that provide HDTV LCD monitors.

Table 5: **HDTV LCD Monitor Suppliers**

HDTV Monitors (external DTV-decoder required)	Daewoo	Elitevision	Philips	ReVox
	Runco	Sony	Studio Experience	Toshiba
	Viewsonic	Zenith		

Table 6 shows companies that provide EDTV LCD monitors.

Table 6: **Enhanced Definition TV LCD Monitors Suppliers**

Enhanced Definition TV Monitors (external DTV-decoder required)	Elitevision	Panasonic	Philips	SharpVision	Zenith

Panel Sizes

- The prices of 14.1-inch and 15-inch LCDs declined by 26% and 40%, respectively, during 2001.
- 15-inch LCD TVs captured 42.2% of the market in 2001, and 20-inch grabbed more than 20% of the market.
- The average panel size increased from 14.4-inch in Q1-2000 to 17.3-inch in Q3-2002.
- Currently, VGA (640x480) dominates with 61.5% of the market, but is down from 90% in Q3-2001. As HDTV is beginning to gain market share, WXGA (1,280x768) rose from 0.6% in Q1-2001 to 15.5% in Q3-2002.

Principal LCD Advantages

- *Sharpness:* the image is said to be perfectly sharp at the native resolution of the panel. LCDs using an analogue input require careful adjustment of pixel tracking / phase.
- *Geometric Distortion:* zero geometric distortion at the native resolution of the panel. Minor distortion is apparent for other resolutions because images must be re-scaled.
- *Brightness:* high peak intensity produces very bright images. This works best for brightly lit environments
- *Screen shape:* screens are perfectly flat.
- *Physical dimension:* thin, with a small footprint. They consume little electricity and product little heat.

Principal LCD Disadvantages

- *Resolution:* each panel has a fixed resolution format that is determined at the time of manufacture, and that cannot be changed. All other image resolutions require re-scaling, which can result in significant image degradation, particularly for fine text and graphics, depending upon the quality of the image scaler. Therefore, most applications should only use the native resolution of the panel.

- *Interference:* LCDs using an analogue input require careful adjustment of pixel tracking / phase in order to reduce or eliminate digital noise in the image. Automatic pixel tracking / phase controls seldom produce the optimum setting. Timing drift and jitter may require frequent readjustments during the day. For some displays and video boards, it may not be possible to entirely eliminate the digital noise.
- *Viewing Angle*: every panel has a limited viewing angle. Brightness, contrast, gamma and color mixtures vary with the viewing angle. This can lead to contrast and color reversal at large angles, and therefore, the panel needs to be viewed as close to straight ahead as possible.
- *Black-level, contrast and color saturation:* LCDs have difficulty producing black and very dark greys. As a result they generally have lower contrast than CRTs and the color saturation for low intensity colors is also reduced. Therefore, they are less suitable for use in dimly lit and dark environments.
- *White Saturation:* the bright-end of the LCD intensity scale is easily overloaded, which leads to saturation and compression. When this happens the maximum brightness occurs before reaching the peak of the gray-scale or the brightness increases slowly near the maximum. It requires careful adjustment of the contrast control.
- *Color and gray-scale accuracy:* the internal Gamma and gray-scale of an LCD is very irregular. Special circuitry attempts to fix it, often with only limited success. LCDs typically produce fewer than 256 discrete intensity levels. For some LCDs, portions of the gray-scale may be dithered. Images are pleasing but not accurate because of problems with black-level, grey-level and Gamma, which affects the accuracy of the gray-scale and color mixtures. Therefore, they are generally not suitable for professional image color balancing.
- *Bad pixels and screen uniformity:* LCDs can have many weak or stuck pixels, which are permanently on or off. Some pixels may be improperly connected to adjoining pixels, rows or columns. Also, the panel may not be uniformly illuminated by the backlight resulting in uneven intensity and shading over the screen.
- *Motion Artifacts:* slow response times and scan rate conversion can result in severe motion artifacts and image degradation for moving or rapidly changing images.
- *Aspect Ratio:* LCDs have a fixed resolution and aspect ratio. For panels with a resolution of 1280x1024 the aspect ratio is 5:4, which is noticeably smaller than the 4:3 aspect ratio for almost all other standard display modes. Some applications may require switching to a letterboxed 1280x960, which has a 4:3 aspect ratio.
- *Cost:* considerably more expensive than comparable CRTs.

3D LCDs

3D displays can be used to realistically depict the positional relationships of objects in space, and will find uses in medical applications requiring detailed viewing of body areas, as well as in computer-aided manufacturing and design, retail applications, electronic books and games and other forms of entertainment. Therefore, several Japanese companies have announced that they will establish a consortium to promote products and applications for 3D stereographic LCDs in an effort to bring the technology into the commercial mainstream. The consortium, which is spearheaded by Itochu, NTT Data, Sanyo, Sharp, and Sony, will aim to standardise hardware and software to produce stereographic 3D displays requiring no additional viewing aids, and build an industry infrastructure to develop and distribute 3D content.

However, analysts remain sceptical about how successful the technology can be, and therefore believe that the market will remain a niche for at least a few more years. The price premium for 3D displays over standard displays will be a hurdle until the production volumes increase and technology advances cut cost.

Many existing components such as glass and drivers can be adapted to 3D displays, however, suppliers of GFX chipsets may have to re-design their products to support the viewing of stereo-graphic display signals.

Further Requirements of a Display

- **Contrast Ratio**
  - The contrast ratio (the brightness of an image divided by the darkness of an image) contributes greatly to visual enjoyment, especially when watching a video or television. The LCD panel determines the contrast ratio by blocking out light from the backlight – the blackness of the black, the brightness of the white define a monitor's contrast ratio.
- **Color Depth and Purity**
  - The color filters of the LCD panel – the red, green, and blue sub-pixels – establish the colors shown on a flat panel display. The number of colors a panel can display is a function of how many bits of information make up each pixel on the screen.
- **Response Time**
  - When you are looking at full motion video, if the scene is going to look sharp and crisp, you need an LCD that has very fast response time. Otherwise, you would see "comet tails" streaming behind moving images. LCDs with slow response times are unacceptable for video and fast animation applications.

Video Processing Algorithms

The following lists the most common algorithms that will be used for LCD-TVs.

- Aspect ratio conversion
- De-interlacing
- Color compensation
  - Compensates for variations in the color performance of a display, and allows any color to be addressed independently and adjusted without impacting other colors.
  - For example, the color depth of an LCD panel may be only six bits per pixel, providing 262,144 different colors – but an incoming analogue computer signal may be eight bits per pixel, providing 16.7 million colors.
- Noise reduction
- Motion artifact reduction
- Video sample rate conversion

Plasma Display Panels

According to CIBC, sharp price reductions over the next two years, driven in part by supply glut and in part by accelerating manufacturing efficiencies, should help catalyse adoption of PDPs and unit growth within the consumer TV application. In 2001, consumer applications already accounted for 51% of PDP unit sales, up from 19% in 1999.

Overall, PDPs are believed to offer superior cost-to-view for TV applications in form factors greater than 30-inches in the near term. TFT-LCD and LCoS (Liquid Crystal on Silicon) alternatives are yet to match the combination of picture quality, price, form factor, or availability offered by PDPs, and OLED (Organic Light Emitting Diode) technology has yet to gain critical mass in the small format segments alone. iSuppli/Stanford Resources believes that while PDPs face serious competition from LCD systems in the sub-40-inch range and from rear- and front-projection in the 60-inch size range, they will find a sweet spot in the 40- to 60-inch range.

PDP technology is gaining acceptance in consumer TV because of:

- Wide viewing angle
- High brightness levels
- color gamut
- Thin profile

However, the limiting factor continues to be price, with further improvements necessary in picture quality, including contrast ratio and brightness levels.

According to Gartner Dataquest, the Plasma TV market has been growing side by side with the DVD-based home theatre system, although these displays continue to be expensive. This is because key components are fabricated using photolithographic or thick-film deposition technology, and thus, yield improvement holds the key to further cost reduction. Furthermore, a large number of driver ICs are required to create light emissions from each cell, the plasma discharges consume a high voltage (150-200V) and a lot of power (300W). Finally, there continue to be technical challenges relating to picture quality e.g. contrast tends to deteriorate over time because of a continuous occurrence of slight plasma discharge.

Predictions

Plunging prices, improving quality and enhanced features have enabled PDP systems to make major inroads into the consumer market, thus, paving the way for rapid growth over the next several years according to iSuppli/Stanford Resources. 2002 brought dramatic gains in PDP sales with revenue increasing by 62% and units sold increasing by 143%. The average factory price of a PDP system fell to $2,743, down 33% from $4,100 in 2001, with the drop in PDP system pricing a result of declines in panel pricing and material costs as well as a reduction in channel costs.

Some of the predictions for the PDP market include:

- Worldwide PDP system factory revenue will grow to $11.2 billion in 2007, up from $2.2 billion in 2002.
- Unit shipments will rise to 8 million in 2007, up from 807,096 in 2002.
- The cost per diagonal inch fell from in excess of $200 to $150 in 2001, down to $100 by the end of 2002, and is predicted to fall to $75 by year-end 2003.
- By 2007 it is predicted that the consumer sector will account for 81% of systems.

Table 7 shows that PDPs in consumer applications are gaining ground on PDPs in business applications, with the reasons for this given below.

Table 7: **Distribution of PDP Modules and Module Market Value**

	PDP Modules		Module Market Value	
	TV Applications	**Business Applications**	**TV Applications**	**Business Applications**
2002	49%	51%	36%	64%
2003	58%	42%	44%	56%

The main reasons for the increasing popularity of PDP systems among consumers are:

- Declining prices as shown in Table 8:

Table 8: **Declining Prices**

50" PDP Cost Reduction	Year	Cost ($)
	2001	10,000
	2003	3,400
	2010	1,200

- Performance benefits, such as better viewing angles, improved picture quality and thin form-factors compared to competing technologies like CRTs, LCDs, and projectors.
- Availability of PDP TVs in a variety of sizes that appeal to consumers' needs. PDPs are available in screen sizes ranging from 32-inch to 63-inches, covering the needs of different markets and geographies.
- Availability of PDP TVs at mainstream consumer electronics outlets rather than only at speciality electronics stores or through audio-video integrators.
- Worldwide migration toward Digital TV through cable and satellite networks and HDTV format. PDPs, with their progressive scanning format, work well with DTV content.

Companies Involved

PDP manufacturing is now well established which is driving down costs. The early players in Japan have migrated their production to second-generation lines, while newer entrants in South Korea and Taiwan are increasing their production capacity using established processes. In 2002, 79% of PDP systems were manufactured in Japan, 17% in AsiaPac, and 4% in Europe.

According to iSuppli, the top five plasma panel manufacturers are:

- Fujitsu Hitachi Plasma
- Matsushita Electric Industrial Co.
- Pioneer Corp.
- NEC Corp.
- LG Electronics

The top five OEMs in terms of worldwide PDP systems sales are:

- Sony Corp.
- Panasonic (Matsushita)

- Pioneer Electric Co.
- NEC Crop.
- Fujitsu General Ltd.

Table 9 lists the Japanese consumer PDP manufacturers along with the brands under which these displays are sold.

Table 9: **Japanese Consumer Display Vendors – Plasma TV**

Display Manufacturer	Brand
Pioneer	Pioneer
FHP (Fujitsu Hitachi Plasma)	Fujitsu
	Hitachi
	Sanyo
	Sony
NEC	JVC
	Mitsubishi
	Toshiba
	Sony
Matsushita	Matsushita (Panasonic)

Table 10 shows companies that provide HDTV PDP monitors.

Table 10: **HDTV PDP Monitor Suppliers**

HDTV Monitors (external DTV-decoder required)	Bang & Olufsen	Daewoo	Electrograph	Elitevision
	Fujitsu	Hitachi	Integra	Marantz
	NetTV	Panasonic	Pioneer	Pioneer Elite
	Photonics Systems	RCA Scenium	ReVox	Runco
	Samsung	Sony	Toshiba	Viewsonic
	Zenith			

Table 11 shows companies that provide EDTV PDP monitors.

Table 11: **Enhanced Definition TV PDP Monitor Suppliers**

Enhanced Definition TV Monitors (external DTV-decoder required)	Elitevision	Fujitsu	Marantz	NetTV
	Philips	Photonics Systems	ReVox	RCA
	Runco	Samsung	Sampo	Zenith

PDP Performance Issues

Many of the performance issues associated with PDPs are very similar to those associated with LCDs and are listed below:

- Luminance
- Contrast Ratio
- Power Efficiency (luminous efficiency)
- Elimination of motion artifacts
- Increased resolution for advanced TV
- Driving voltage reduction
- Poor dynamic range and black levels
- High pixel count

Advantages of PDPs

The following is a list of the major advantages of PDPs:

- Large screen size
- Thin form factor (< 4-inch)
- Full color with good color parity
- Fast response time for video capability
- Wide viewing angle (>160º in all directions)
- Insensitive to ambient temperatures

Disadvantages of Plasma Displays

The following lists the major disadvantages of PDPs:

- Low luminance for outdoor applications (non-sunlight readable)
- Low contrast in high ambient light
- High power consumption and heat generation
- Short panel lifetime due to phosphor degradation (amount of time to 50% luminance)
- Latent image (image sticking)

Reasons for High Prices

A combination of factors is responsible for the high prices, including:

- Cost of driver ICs, unless some way of significantly reducing the operating voltage can be found
- Column driver chips are less expensive, however, a large number are required, for instance, 60 are needed to drive a 1920x1080 display, and thus, this is of significant cost
- The power supply
- The glass substrates
- The interconnects
- EMI filters
- Metal electrode parts
- Manufacturing yield (although it is now approaching 80%)

- PDPs are driven by material costs such as low-cost ceramic and packaging materials.

PDP Cost Reduction Possibilities

A number of cost reduction possibilities exist for plasma displays and are listed below:

- Use ordinary soda-lime, float-process window glass, however, this suffers substantial dimensional change during high-temperature processing.
- Use all-metal electrodes instead of either transparent indium-tin-oxide or tin-oxide electrodes in parallel with high conductivity, opaque metal bus bars.
- Replace one of the glass substrates with a sheet of metal laminated with a ceramic layer
- Use single-scan addressing rather than dual-scan designs, which requires half the number of data address drivers. However, the increased number of horizontal lines requires more precise address time during the fixed frame time.

Video Processing Algorithms

As for LCD TV, there is a number of commonly used video processing algorithms that are used with PDP TVs and are listed as follows:

- Post-processing:
  - Gamma correction
  - Sharpness enhancement
  - Color correction
- Aspect Ratio Conversion
- De-interlacing
- Noise Reduction
- Motion Artifact Reduction
- Video Sample Rate Conversion

PDP versus LCD Characteristics

Table 12 gives a brief comparison of some of the main characteristics for PDPs and LCDs.

Table 12: **Characteristics of PDPs vs LCDs**

Characteristics	PDP	LCD
Current max. size	63-inch, 65-inch, 70-inch	54-inch (demo), 40-inch (in reality)
Cost / Area	>40-inch becomes cheaper	Very high
Set Volume	3-5-inch thick	Very thin
Video capability	Approaching CRT video quality	Needs improvement – transition speeds, black levels
Lifetime	30k hours. Lifetime issues will drop as efficiency increases, and voltage decreases	Limited by backlight – not enough experience with large panels yet
Materials	Both as competitive as each other, with PDP having slight advantage (~10%)	

Table 12: **Characteristics of PDPs vs LCDs *(Continued)***

Characteristics	PDP	LCD
Capital Cost	Lower amortised cost.	LCD factory is similar in cost to wafer fab (~$1.5 billion). Very risky if limited to mkt with few k units. Anything >40-inch is very expensive to fab
Viewing Angle	160^{o}+ horizontally (typically less)	Up to 160^{o} (typically 90^{o} vertically)
Lightsource	Emissive (internal)	Transmissive (External backlight)
color Technology	Phosphor (natural TV colors)	color Filters (different color system to TV)

Other Types of Flat Display

Liquid Crystal on Silicon Displays

LCoS rear-projection TVs reached the end-market consumer in 2002 in very small volumes. There is potential for significant growth because of the extremely high resolution, picture quality, scalability above 30-inch and competitive long-term pricing to build a sizeable niche within the flat panel TV market. According to CIBC, this is likely to occur somewhere between PDPs at the premium high-end and TFT-LCDs, which are likely to become the mainstay technology. Furthermore, they believe that LCoS can gain momentum by 2005 due to the existing commercial success of two other microdisplay rear projection systems, i.e., Digital Light Processing (DLP), from TI and High Temperature Polysilicon (HTPS) TFT-LCD.

However, this form of display is not as slim as a PDP, but is of equivalent weight and offers superior power consumption and substantially longer operating lifetimes. Compared with the CRT rear projection set, the form factor is far superior, offers better picture quality, is far brighter and provides wide aspect ratios at HDTV resolution.

Organic Light Emitting Displays

OLEDs will become a major competitor to the TFT-LCD market due to the promise of significantly lower power consumption, much lower manufacturing cost, thinner and lighter form factors, as well as potentially sharper and brighter images and greater viewing angles. The light emitting properties of AM-OLEDs eliminate the need for backlight units, backlight lamps, inverters, color filters, liquid crystal, alignment film, and the manufacturing steps associated with these in LCD production.

A large number of companies are investing in R&D as well as manufacturing capital in this emerging market and on last count was approximately 85. Furthermore, there is a large willingness to cross-licence technology in order to speed up commercialisation. OLEDs are also highly appealing in the upcoming 2.5G and 3G wireless markets.

According to CIBC, it is unlikely that OLEDs will be able to compete with incumbent technologies for large display applications until the second half of the decade. Some of the companies involved in OLED development include Pioneer, Motorola, Samsung, Sanyo, Kodak, and TDK.

The Xilinx FPD Value Proposition

The FPD market is poised for growth, and to date there is no clear winner amongst the various types of display, including Plasma Display Panels (PDPs), Liquid Crystal Displays (LCDs), Liquid Crystal on Silicon (LCoS) displays, or Organic Light Emitting Diodes (OLEDs). However, it currently appears that PDPs are leading for form factors greater than 30-inches and LCDs for form factors less than 30-inches.

Therefore, many display manufacturers are hedging and investing in more than one type of display. Using an FPGA within any display system can add intrinsic value as it is essential for a manufacturer to firstly, remain as flexible as possible with any platform development, secondly, ensure the fastest time-to-market, and thirdly, rapidly include any improvements to the design that will enhance their competitive advantage.

The key requirements of any display manufacturer include:

- Competitive advantage through product differentiation, which can be achieved through various means such as:
  - Superior image quality – consumers are becoming more aware, and demanding, of superior image quality with increasing access to larger displays and higher quality source material, such as DVD. Therefore, it is imperative that image improvement is possible, where the source material may not be high quality, such as that often broadcast.
  - Flexibility – the ability to improve upon existing solutions rapidly and with ease
- Fast time to market
- Low Cost of Ownership – as the graph below shows, the use of Xilinx products maximizes profitability in the market. According to McKinsey & Co., products that are six months late and on budget earn 33% less profit over five years. Furthermore, every four weeks delay equals 14% loss in market share.

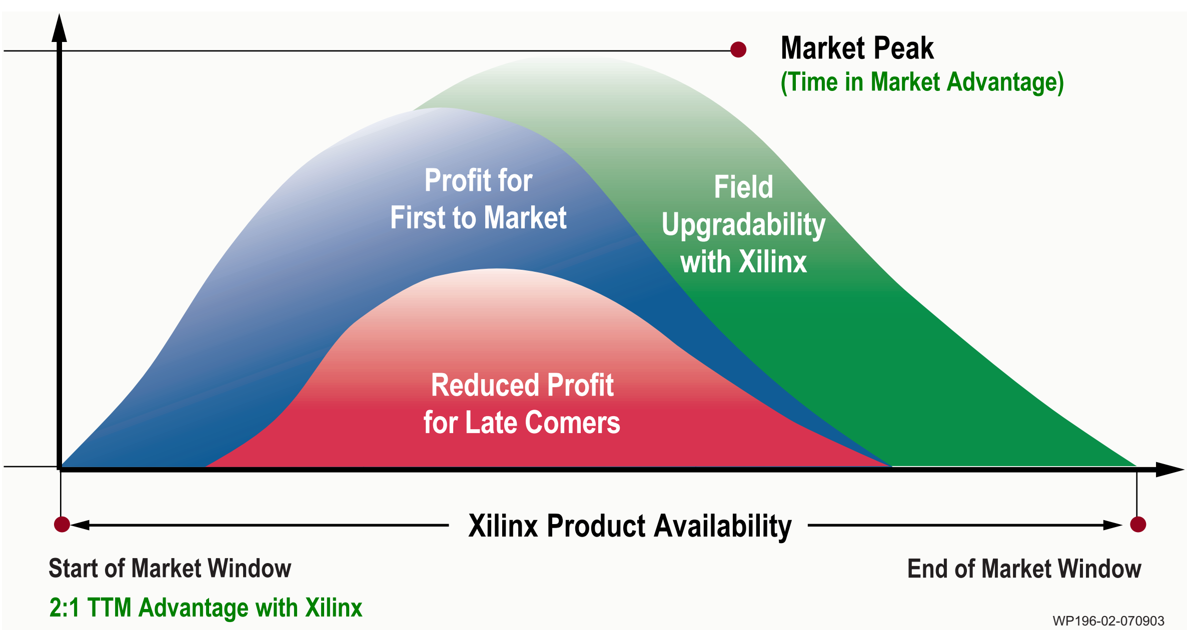

Figure 2: **Market Window**

- Flexibility – to have a platform that can be easily upgraded and can be potentially interchangeable for different types of display

The various properties of a good display, irrespective of type, should include:

- High static resolution
- High peak brightness
- High contrast
- High lumen efficacy
- Favourable dynamic behaviour – because the temporal aspects of a video display determine important properties like flicker, dynamic resolution and motion portrayal

Table 13 lists the benefits that can be achieved by using an FPGA in a system irrespective of the type of application that is being developed. And these can of course be applied to FPD systems with varying degrees of importance.

Table 13: **FPGA Key Benefits**

Key Benefits of an FPGA	As Applied to an FPD System
Flexibility	
Easily integrate the components that best meet needs	Can provide cost savings
The ability to support modular configurations	Required for high flexibility
Geographically driven features	
Price / performance “families” of products	Important – will have low-, mid-, and high-end displays
Fast Time to Market	
FPGAs are standard off-the-shelf components	No NRE; less likelihood of supply issues
An ideal mechanism to quickly and efficiently extend and enhance legacy hardware designs	Extremely important for platform upgrades
Rich features and off-the-shelf IP relevant to digital video applications	Slight importance – much will be proprietary, so ease of use, flexibility, and speed are key
Mature and efficient development tools	Very important for ease of use, flexibility, and speed
Robust third party ecosystem	
Fully Programmable and Reprogrammable	
Reduced exposure to risk - Bugs, component shortages, evolving standards, and so on	Extremely important
Field upgradeable hardware	Extremely important for competitive advantage
System Cost Management	

Table 13: **FPGA Key Benefits *(Continued)***

Key Benefits of an FPGA	As Applied to an FPD System
Many standard FPGA features can replace discrete devices - Clock management chips, LVDS transceivers, level shifters, and so on	Can provide cost savings
No NRE	Extremely important
Efficient Life-Cycle Product Management	
Extremely effective at enabling derivative designs	Very important – for time to market with next generation product
Enables the exploitation of new market opportunities before competition - Expands the market base for ROI	Extremely important – e.g., if can use platform replica for different display types
Greatly reduced forecasting and inventory exposure	Aids with high quality Supply Chain Management
An Assured Source of Supply	
FPGAs have long product life-cycles	Important – lowered risk of obsolescence
Xilinx is a world class supplier	Extremely important – for high quality Supply Chain Management

It is clear that the generic benefits of using an FPGA within any system can be transferred directly to an FPD system, and are fundamentally important to aid a display manufacturer to gain competitive advantage and build market share.

FPD Issues and Challenges

The key challenge facing any FPD manufacturer, whether it be PDP, LCD, OLED, or LCoS, is to build a sizeable market and quickly gain as much of the Potential Industry Earnings (PIE) as possible. The Flat Panel Display industry is still in its infancy, and thus, is still considered to be a niche market. However, many of the CRT incumbents are investing heavily in the market, and are relying upon product differentiation to provide the requisite competitive advantage that will allow maximum acquisition of PIE.

Therefore, one of the key challenges facing any player in this market is product differentiation. Not only does this depend upon engineering innovation in research and development, it also depends upon ensuring a high degree of flexibility and short product lifecycles with extremely fast time-to-market.

With any form of display, whether it is a CRT or an FPD, one of the major requirements is to have high image quality. For instance, weaknesses in the temporal behaviour of emerging displays result in spatial impairments such as distortions, blurring or even tearing of moving images. Furthermore, the effects are proportional to the velocity of the motion. Therefore, it makes sense that motion estimation algorithms are implemented for remedial processing.

It follows that much investment is made into the investigation and design of proprietary algorithms that can be used to improve upon image quality. This investment is continuous and as a result, so is the improvement. In order for a manufacturer to meet time-to-market, performance and quality criteria, it is imperative that any new algorithms be ported into a new design as quickly and as easily as possible. One means of ensuring a successful, fast and easy incorporation is to use a programmable solution, and an FPGA is the perfect fit.

The following tables list a number of tasks that can be used in an LCD-TV application and / or a PDP. Table 14 lists the various interfacing tasks that are required by an FPD system as is found on other digital video systems discussed above. Logically, and as shown in Table 14, standard interfacing, system clocking, and so on, are required by these systems, and FPGAs are already proven to be a strong fit for these tasks.

Table 14: **FPD System Interfacing Tasks**

Function	PDP	LCD-TV	FPGA Implementation Potential
Video interfaces / buses, e.g., LVDS, PCI / PCI-X, AGP	√	√	HIGH
High-speed video transport standards, e.g., IEEE 1394, IEEE 1355, USB2.0	√	√	HIGH
High-speed video memory, e.g., HSTL, SSTL	√	√	HIGH
High-speed system clocking, e.g., LVPECL, LVDS	√	√	HIGH
Glue Logic	√	√	HIGH
Display interface	√	√	HIGH

Table 15 goes into more detail on functions / algorithms that are needed within an FPD system.

Table 15: **FPD Functions/Algorithms**

Function	PDP	LCD-TV	FPGA Implementation Potential
Hardware acceleration of video algorithms	√	√	It is possible to use hardware acceleration to improve performance by offloading portions from media processors
Aspect Ratio Conversion	√	√	Can be done with high quality scaling, e.g., polyphase filter
De-interlacing	√	√	Can use low quality de-interlacing; high quality de-interlacing will need an external frame buffer State-of-the-art, e.g., 3D recursive block matching, uses Motion Estimation, and Motion Compensation
Motion Estimation	–	–	Accuracy of ME can be critical for video enhancement. However, complex ME may not always be practical from an implementation point of view. e.g., block-matching ME algorithm with full-search.

Table 15: **FPD Functions/Algorithms *(Continued)***

Function	PDP	LCD-TV	FPGA Implementation Potential
Noise Reduction	√	√	Filtering used to eliminate different types of noise, e.g., random, salt and pepper, gaussian, impulse
Motion Artifact Reduction	√	√	In PDPs, motion artifacts are caused by sub-field driving method for generating gray levels. Need to use motion compensation LCDs may benefit more from using methods like a flashing/scanning backlight, rather than video processing. However, motion compensated interpolation is a prerequisite to counteract motion artifacts
High Quality Scaling	√	√	For instance, polyphase filtering can be implemented and used for sample rate conversion.
Gamma correction	√	√	Easily done – straight forward non-linear operation that is actually implemented using a LUT
Sharpness enhancement	√	√	Generally, proprietary algorithms that are key for product differentiation Usually fall into two categories: Peaking – linear operation that uses the “Mach Band” effect to improve the sharpness impression. It increases the amplitude of the high-band and/or middle-band freq using linear filtering, e.g., FIR Transient improvement, e.g., LTI (luminance transient improvement) – non-linear approach that modifies the gradient of the edges to enhance the sharpness
Color Space Conversion	√	√	XAPP283, XAPP637
Video component conversion	√	√	Filter – takes advantage of parallel processing (XAPP294)
Median Filters	√	√	Can easily implement median filters

From this table it is clear that both types of flat panel require similar algorithms to counteract similar problems. Furthermore, these problems are similar to those found in CRT. However, CRT algorithm research and development is much more mature than that for FPDs. Because of the different physical properties of the different displays, the algorithms that were previously developed for CRTs cannot be used in the same format for FPDs. In fact LCDs and PDPs also will have different algorithm requirements based upon their different physical characteristics.

It is also clear from the table above that certain algorithms will benefit more from the features and resources of Xilinx devices than others, and therefore the following discussion will relate the algorithms to device features and show where a good fit exists.

Spartan 3 – The Ideal Fit for FPD Systems

Introduction to Spartan-3

The Spartan™-3 FPGA family is the most recent product launched and is built on the success of four previous generations of cost-optimised Spartan FPGAs. It offers platform capabilities with a wide range of I/O and density options, which enable a fast time-to-market and low unit cost, thus avoiding the long development time and the high NRE cost of ASICs. Table 16 shows the members of the Spartan-3 FPGA family and lists the features of each family member. The packaging and number of I/Os for each device is also shown.

Table 16: **Spartan-3 Family Features**

Feature/Product	XC 3S50	XC 3S200	XC 3S400	XC 3S1000	XC 3S1500	XC 3S2000	XC 3S4000	XC 3S5000
System Gates	50K	200K	400K	1000K	1500K	2000K	4000K	5000K
Logic Cells	1,728	4,320	8,064	17,280	29,953	46,080	62,208	74,880
18x18 Multipliers	4	12	16	24	32	40	96	104
Block RAM Bits	72K	216K	288K	432K	576K	720K	1,728 K	1,872 K
DRAM Bits	12K	30K	56K	120K	208K	320K	432K	520K
DCMs	2	4	4	4	4	4	4	4
I/O Standards	23	23	23	23	23	23	23	23
Max Differential I/O Pairs	56	76	116	175	221	270	312	344
Max Single Ended I/O	124	173	264	391	487	565	712	784
Package	**User I/O**	**User I/O**	**User I/O**	**User I/O**	**User I/O**	**User I/O**	**User I/O**	**User I/O**
VQ100	63	63	-	-	-	-	-	-
TQ144	97	97	97	-	-	-	-	-
PQ208	124	141	141	-	-	-	-	-
FT256	-	173	173	173	-	-	-	-
FG456	-	-	264	333	333	-	-	-
FG676	-	-	-	391	487	489	-	-
FG900	-	-	-	-	-	565	633	633
FG1156	-	-	-	-	-	-	712	784

Spartan-3 uses a 90nm process and as a result delivers the following:

- A new low cost standard which is a successor to Spartan-IIE
- Highest density and I/Os range for low cost solution

  - Up to 5m gates and 784 I/Os
  - Feature rich with no compromise
- Best FPGA for all low cost designs
  - Highest gates per dollar, highest I/Os per dollar
- Broad range ASIC alternative
  - Increased density and I/O coverage
  - Cost effective to higher volumes
- Best low cost solution for traditional and new markets

Spartan-3 and FPDs

The first point to stand out from the introduction to the Spartan-3 family is that the number of gates and number of I/Os being offered at low cost means that this family is becoming extremely competitive in the consumer domain. The Spartan-3 family has up to 5 million system gates, and this allows the implementation of system level function blocks, high chip connectivity and high-throughput.

All family members have Digital Clock Management (DCM) which eliminates on-chip and board-level clock delay, simultaneous multiply and divide, reduction of board-level clock speed and number of board-level clocks, and adjustable clock phase for ensuring coherency.

The Spartan-3 family provides single-ended signaling: GTL, GTL+, PCI; HSTL-I, II, III; SSTL3-I, II; SSTL2-I, II, which provides connectivity to commonly used chip-to-chip, memory (SRAM, SDRAM) and chip-to-backplane signaling standards. This eliminates the need for multiple level transistors.

Differential signaling (up to 622 Mbps) is also provided, LVDS, BLVDS, Ultra LVDS, RSDS, LDT, at low cost. The added value from this feature includes bandwidth management by saving the number of pins, reduced power consumption, reduced EMI, and high noise immunity.

There is also a Shift Register Mode (SRL16E), which is a 16-bit Shift Register that is ideal for capturing high speed or burst mode data and to store data in DSP and Encryption applications.

However, as mentioned in the discussion on algorithms used for FPDs, there are certain features of the device family that will enable an efficient and flexible, yet cost effective, implementation of particular algorithms.

Spartan-3 I/Os

As with all applications the number of I/Os along with the number of system gates will impact upon the amount of functionality that can be integrated into a single device. FPD systems are no different. Therefore, it may be possible to integrate discrete components into an FPGA and reduce the total number of components on a system board, thus, reduce the size of the board, and overall reduce the BOM.

Spartan-3 Multipliers

As with all applications that are heavy in Digital Signal Processing, video signal processing applications benefit from dedicated multipliers. From the table above we can see that the Spartan-3 family has a range of 4-104 18x18 multipliers, which allows for ultra-fast, parallel DSP operations. These are the key component of an FIR filter function, and certainly more than cover the video data bitwidths and filter coefficient bitwidths.

For instance, from the table above the list of algorithms that either use a direct form FIR filter or some variation of same is:

- Aspect Ratio Conversion
- Noise Reduction
- High Quality Scaling
- Sharpness Enhancement, i.e., Peaking
- Video Component Conversion

Spartan-3 Distributed RAM

It has already been stated that the key component of any filter is the multiplier block, however, its frequency response, and thus its coefficients define the filter. Distributed RAM are ideal for storing filter coefficients, and in the Spartan-3 family, all devices have DRAM ranging from 12K-520K. If a 64-phase 6-tap polyphase filter was being implemented, we could roughly say that a maximum of 6K of DRAM would be required. A flexible filter of this nature could be used for aspect ratio conversion, high quality scaling and so on, with the list of applications that will benefit from Distributed RAM being:

- Aspect Ratio Conversion
- Noise Reduction
- High Quality Scaling
- Sharpness Enhancement, i.e., Peaking
- Video Component Conversion

Spartan-3 Block RAM

Spartan-3 has block RAM in 18K blocks on all family members, ranging from 72K to 1,872K. For all filtering applications it is necessary to buffer data, and video is no different. Therefore, this enables the implementation of line buffers.

Conclusion

The flat panel display industry has achieved sufficient critical mass to snowball its growth. Thus, it can now attract the right blend of capital investments and R&D resources to drive technical innovation toward continuous improvement in view quality, manufacturing efficiency and system integration. These in turn are sustaining consumer interest, penetration, revenue growth and the potential for increasing long-term profitability for industry participants. Therefore, the FPD market is poised for growth, and to date there is no clear winner amongst the various types of display, including PDPs and LCDs.

Every FPD manufacturer is faced with the challenge of building a sizeable market and grabbing as much of the Potential Industry Earnings (PIE) as possible. Therefore, one of the key challenges facing any player in this market is product differentiation. Not only does this depend upon engineering innovation in research and development, it also depends upon ensuring a high degree of flexibility and short product lifecycles with extremely fast time-to-market. In order for a manufacturer to meet time-to-market, performance and quality criteria, it is imperative that any new algorithms or platform developments be ported into a new design as quickly and as easily as possible.

An excellent means of ensuring a successful, fast and easy incorporation is to use a programmable solution, and an FPGA is the perfect fit. Already, Xilinx programmable logic devices are employed by a number of flat panel display manufacturers who recognise the added flexibility and time-to-market benefits achievable through the use of programmable logic solutions. In the future, it is expected that programmable logic will play a larger role in flat panel displays with the advent of low-cost, high-feature products such as Spartan-3.

Revision History

The following table shows the revision history for this document.

Date	Version	Revision
07/24/03	1.0	Initial Xilinx release.