Article for Nikkei : Graphics Controller SSD190x
Title: A need of Graphics Controller in Portable system

Introduction:
There are two mainstreams of Operating System (OS) for hand-held devices in the world, i.e. PalmOS and WindowCE. Both of these OS got more than 85% Total Available Market (TAM) of Pocket PC and PDA market in year 2000, expecting to reach 14 million units this year.

No matter what kind of OS they are using in their devices, they are all facing to the changing of customers' need: Speed, Features, Power consumption, Performance, etc.

Color requirement is no doubt one of the must to the future hand-held devices. From mono black/white to gray scale; from gray scale to color; from 256 colors to 4096 colors; from 4096 colors to 64k colors; from 64k colors to 262k colors. It does imply the strong demand of display data bandwidth and power consumption too.

In order to get the balance point of cost and performance, let's take a look of the power distribution of hand-held device first.

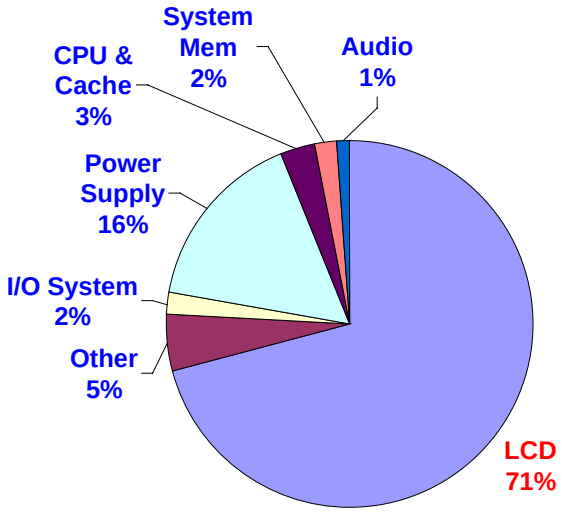


Figure 1. Power distribution in PDA <source: ITRI 2000>

Under the result of ITRI's research on PDA power distribution, more than 70% of power in hand-held is consumed by display sub-system. To tackle the power consumption issue in PDA, LCD display system will be the major focus.

System Architecture

When the first generation of palmtop computer was released, limited by the speed of MCU and size of memory, the major application was writing memorandum or telephone lists. A 4 gray scale monochromic STN display was good enough since there was no need for motion pictures. At that time the display controller was simple enough to be integrated into the MCU.

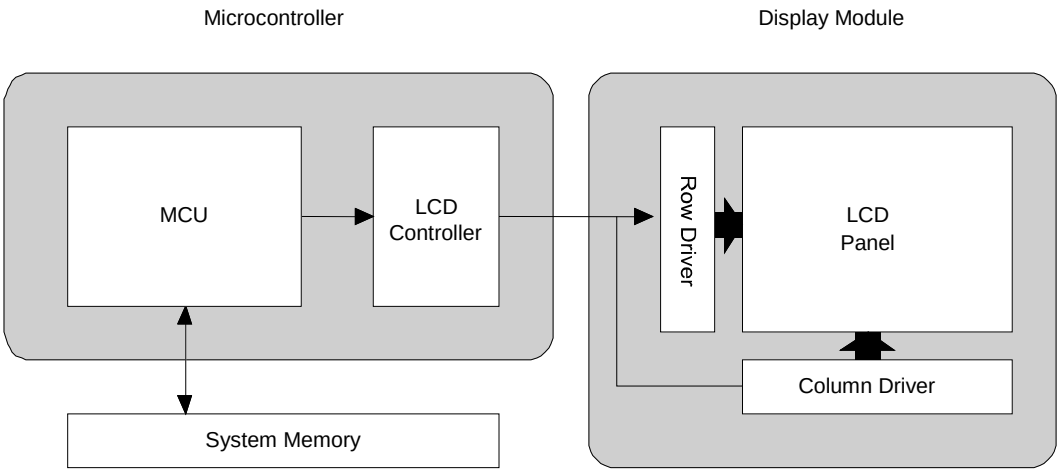


Figure 2. A tradition display system

The integrated LCD controller does not have its owned frame buffer. The display content is stored in the system memory that is shared with MCU. To avoid any visual error on the display, the MCU has to provide a sufficient bandwidth to the controller. Considering a panel of size 160 pixels by 160 pixels. If every pixel has 4 gray scales, and the frame frequency is 80Hz for frame rate control, the data bandwidth taken by the display system will be 512KB/s. If the number of gray scale is increased to 16, and frame frequency become 200Hz, the bandwidth will be greatly increased to 2.56MB/s. It is easy to understand this display system cannot fulfill the need of new multimedia applications. While power consumption is important to handheld applications, it is impossible to endlessly increase the data bus bandwidth for the display system. Otherwise the data bandwidth of display system will finally use up all the CPU time.

A modern palmtop computer system employs an independent LCD controller with frame buffer. Frame buffer stores at least one frame of display content so that the MCU is free from the display system unless there is display content update.

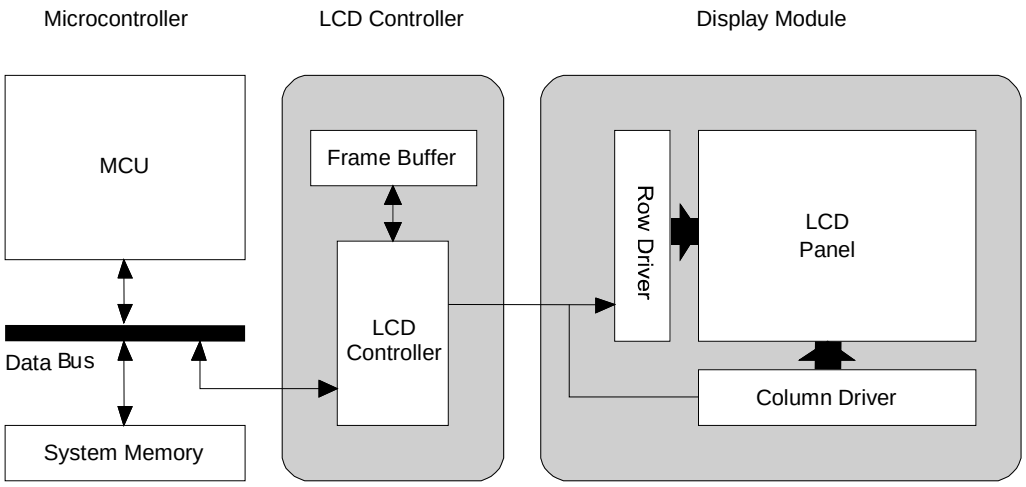


Figure 3. A modern display system

The frame buffer of the LCD controller holds a copy of display content. When the display is enabled, the LCD controller scans through the frame buffer and sends the display content to the display module. Since the frame buffer can be access directly via the system data bus, MCU can partially modify the display content instead of rewriting the whole frame. This can reduce the data bandwidth requirements between the MCU and the LCD controller.

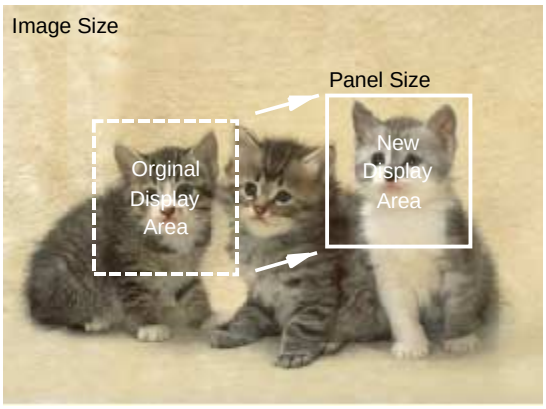
Features

Once the system architecture is fixed for the new design, features will be the next criteria for choosing graphics controller.

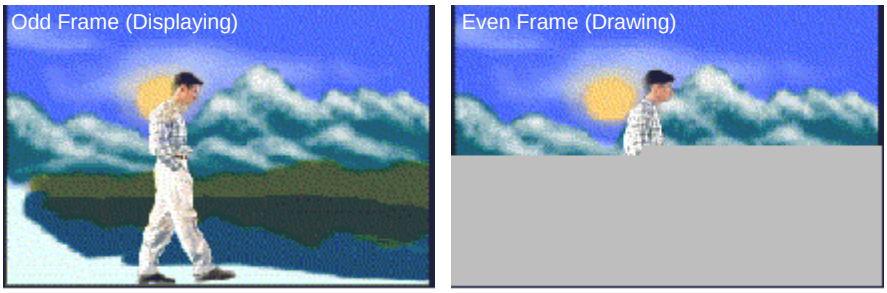
The new display system allows with new features that save application development time and CPU loading. These features are coped with commands and these commands are stored in registers that are directly accessible by the data bus. For example, Solomon Systech Limited's graphics controller, SSD1901, has a 17-bit address bus for 128KB addressable space. Address 00000h to 13FFFh are frame buffer and 14000h to 1FFFFh are registers for graphic features. SSD1905 employs a dedicated pin M/R# and a 17-bit address bus for command and frame buffer addressing.

Using the display features, users can easily achieve some graphics manipulation on display, which are very difficult to be done by pure software implementation.

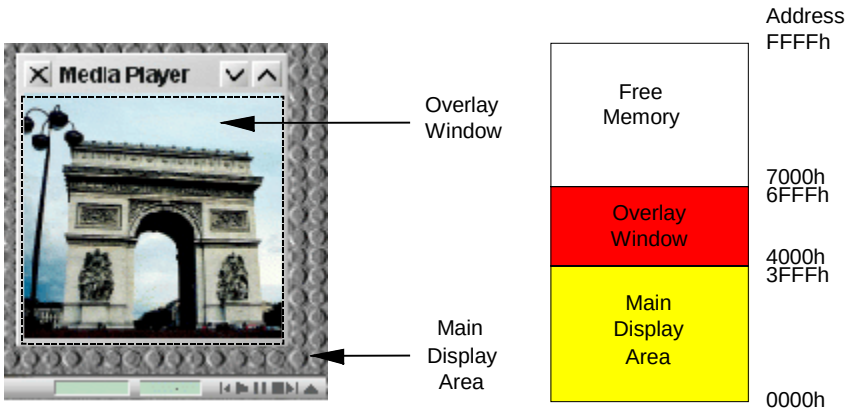
Virtual display feature allows users to store a picture where the picture is larger than the panel. Users can freely move the viewing window by declaring the starting location of display. This feature is perfect for a palmtop digital gallery. If this feature is done by software, the MCU has to rewrite the entire display buffer during the movement of viewing window.



Double buffering offers users displaying moving pictures without visual error. The controller can divide the frame buffer memory into pages. Developers can redraw the even frame on page 2 when the odd frame is being displayed on page 1. When the even page is finished, page 2 is enabled and the odd frame is ready for redrawing. Switching between pages can remove the flickering caused when rewriting the display.



Window feature is extremely useful when developing multi-tasking graphical applications. Developers can define a separated area in the frame buffer as a window overlay on the main screen.



Frames of motion pictures can be stored in a separated and continuous memory area and overlay it on the main display area. When the data stream is continuously dumped to the

window, the background display will remain the same while overlay video is being shown. If double-buffering features described above is also enabled, it is easy to achieve a very smooth motion pictures playback.

Image rotation is a hard-coded feature built in the Graphic Controller to provide 90°, 180° and 270° portrait and landscape viewing. For example in figure 4, a presenter and an audience are sitting face to face in the meeting. The presenter wants to rotate the image by 180° such that the audience can view the image in same orientation. The image rotation can be performed by the Graphic Controller rather than to rewrite the entire display buffer. Then this feature offers a performance advantage over software rotation of the displayed image. Therefore, horizontal images can be viewed in a vertical configuration without haggling with software. With this feature, user can choose different orientation of LCD freely.

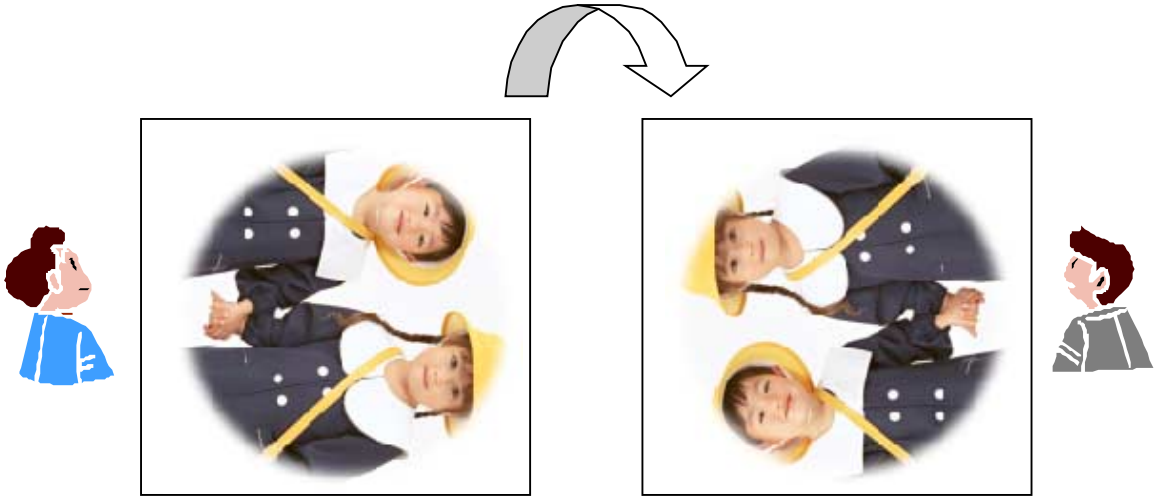


Figure 4: Image rotated by 180°

Hardware cursor is a mechanism inside the Graphics Controller that is dedicated for cursor shape drawing. The cursor shape covers the original frame at the cursor position. As shown in Figure 5, an application displays a real-time clock and a control cursor overlaying the main display area simultaneously. By providing one extra more cursor (Total: 2 cursors), it can further reduce the CPU loading.

Figure 5: Two cursors implementation

Based on the application and the display resolution, the memory and display interface may have to operate at different frequencies. Consider a case in which the memory control requires higher bandwidth to accommodate high display resolutions. The SSD1905 Graphic Controller operates two clock sources to provide more flexibility. The memory clock can be tuned for lowest power consumption while minimizing the effect on the user's perception of display performance.

To reduce power consumption, a partial display function is incorporated that allows part of the screen area to be driven.

Interfaces

A well-designed LCD graphics controller should possess integrated MCU interface and eliminate glue logic. This minimizes the number of components on the product and also lessens the design effort of engineers. For example, SSD1905 can directly interface to more than 11 types of MCU where some of them are dominated the PDA and pocket PC market.

Moreover, SSL's graphics controller can match with 13 types of LCD panel which including STN, CSTN, TFT, HR-TFT and D-TFD with different color-depth.

Conclusion

Undoubtedly multimedia application will be the future of palmtop application. Games, video conferencing and music playing push the display system to a complete multimedia system. There must be advanced graphic engines and digital signal processors that share the heavy workload from the MCU. Graphics Controller will be no doubt a must component in the future Color handheld devices.

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