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Display Trend – Information display

Display is the key component for all consumer electronic devices. Over 90% of consumer products developed today have a display. For home appliances, it includes LCD TV, Plasma TV, TFT Monitor, DVD player and AV/CD player. While in consumer electronics products, handheld applications adopt the display intensively as user interface, device control, information or status exhibition and amusement. Examples are mobile phone, PDA, automotive/industrial instrument, digital camera and video camera… etc. They all employ a display and display has become a major component of most handheld systems.

Display Application for Mobile

Mobile phone is the largest market amongst the handheld applications. In the year 2004, the global handset shipment is forecasted to be about 600 million units. It is more than ten times the market size compared to PDA or DSC (digital still camera), which is about 40 million units when shipped individually. Moreover, the PDA market will saturate and merge with the mobile phone market gradually. In the year 2007, the mobile phone will maintain its growth, but PDA will drop to 14 million units per year. It shows that the PDA market is difficult to grow in the long run and the development will move to focus on the PDA/smart phone strategy. On the other hand, the mobile phone with 1-2 mega pixel camera equipped capability highly indicates that the camera phone applications are growing fast and that they will dominate the display market in the coming years.

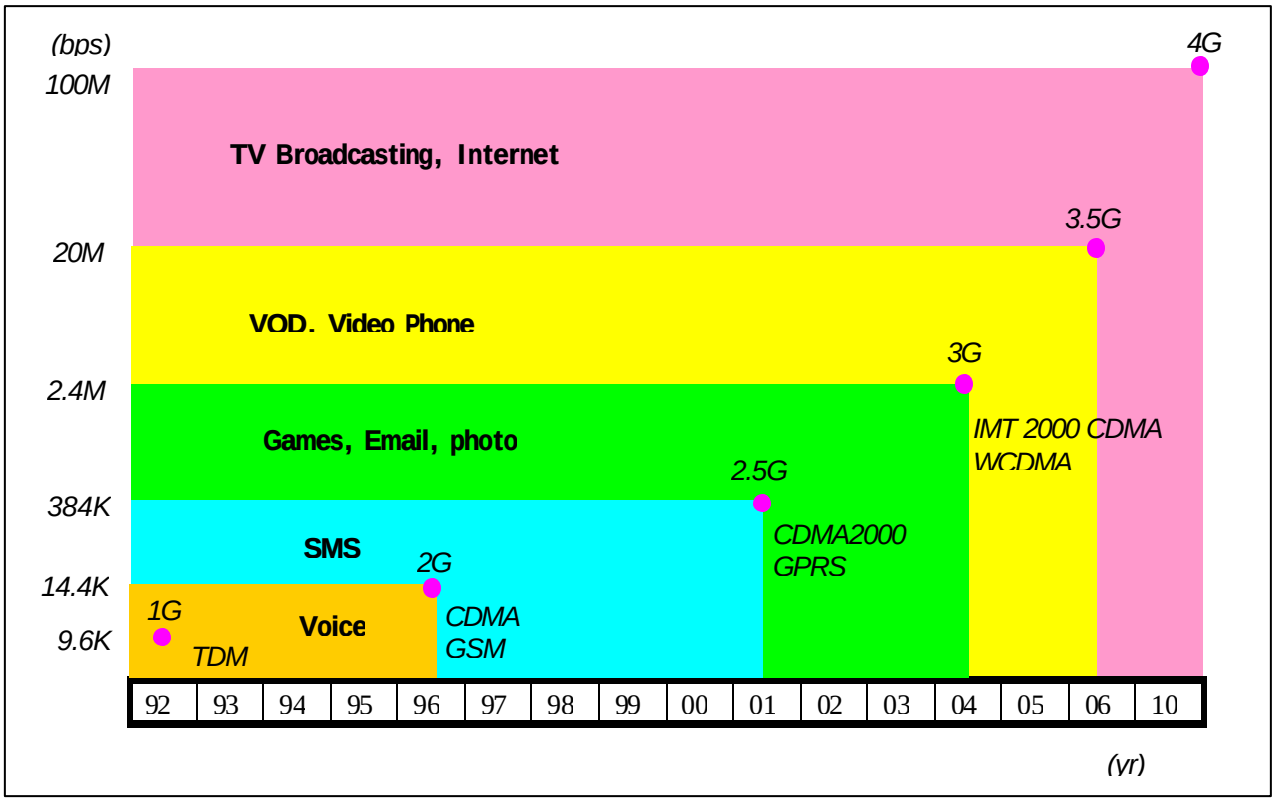
Table 1: Small to medium size demand till 2007

Major Small-to-Medium-size Applications till 2007			
Rank by Growth	**CAGR**	**RANK by Market Scale**	**Market Scale (million units)**
Digital Photo Album	200%	Mobile Phone	710
E-Book	37%	DSC	57.5
DSC	16%	Digital Video Camera (DVC)	19.7
Car Navigation	12%	PDA	14
DVD	10%	Car Navigation	9
Source: ITIS, April 2004			

The market consolidation of handheld devices embosses the growth of the mobile handset segment. The consumer is encouraged to re-new its handset with more

multimedia functions equipped. New features become the momentum to support the market growth. The mobile handset application can be simply classified as voice, text messaging (MMS), email, still image/photos and video messaging (EMS). The voice and text messaging service attracts new subscribers to enjoy the convenience of mobile communication. Email and MMS provide a service to customers to enjoy instant news/financial updates during travel and outdoor activities. Images, photos and video messaging are the multimedia features for interactive communication and amusement. There are all the standard features nowadays to fulfill various interests/needs of people. A smartphone or a PDA phone enhances your daily personal information management. It offers a limited processing capability to let you handle simple word and spreadsheet operation. You can transfer the completed data over the network. Of course, it has to align with different Service Providers (SP) to subscribe for different services. Most of the SPs adopt the basic messaging service, except the email and video features. With the wider use of GPRS and 3G service like Wideband CDMA, CDMA2000 and TD-SCDMA (Time Division Synchronous Code Divison Multiple Access), more and more multimedia services are available for consumers' choices. All the services/applications demand on display panel performance and features. And therefore, the specification of display size and driver controller features is then determined.

Table 2: Mobile system trend and its applications



The display size for consumers

Display in handheld applications is classified as small and medium size within Flat Panel Display (FPD). It ranges from 1.5", 1.7"/1.8" as low tier phone; 1.9"-2.4" as mid to high tier phone and 3.0"-3.5" as high tier PDA or smart phone. The 1.0"-1.5" has been recently popular for caller ID subdisplay applications. It was introduced to provide caller information in order to reduce system power during standby mode. In the meantime, it does not satisfy the need for bigger screens for information access during operation. The clamshell phone, with main and sub display, is the optimized handset size, has system power and no need for a bigger screen. That's the reason why the clamshell phone has become more popular over the past two years.

On the other hand, 2.4" is the widest limitation for consumers to operate the handset with one hand. You can enjoy the simple messaging and update information with the resolution ranging from 96x64 to 128x160. Resolution such as 132x176, 176x220 (QCIF+), and 240x320 (QVGA) offer reasonable quality for photo taking and Java games playing. The size with 3.5" or higher is no longer a single hand-operating device. It usually requires touch panel or voice control to

access the phone. It is useful for pocket word, spreadsheet and even internet browsing operations, but it is definitely not convenient when making simple calls during shopping or when outdoors playing sport. Another concern from consumers is the weight of the handset will increase accordingly as the display size increases.

New panel technologies are developing to improve the resolution to provide more fun with the handset applications. Consumers will get finer pictures or graphics, but there are still limitations to recognizing the smallest characters in the mini-meter range. Therefore, the resolution for 2.4" panel of low to mid tier handsets will not go higher than QVGA resolution in the coming few years. On the other hand, manufacturers are developing VGA resolution for 3.7" PDA or smartphone, but we can see the limitations this may have on our eyesight.

FPD Technologies

The monochrome and grayscale display has been used in handsets for over a decade. Color display is the trend to cope with the multimedia capabilities. The black and white (BW) display demand drops from 90% market share in 2000 to below 40% market share in 2004. The color technology is forecasted to go higher than 70% market share in 2006. Numerous technologies are becoming popular in the market. There are the passive matrix technology like Color STN LCD, UFB (Ultra Fine & Bright) LCD, UFS (Ultra Fine and high speed) LCD and PM-OLED (Passive Matrix Organic Light Emitting Device). LCDs are the economic display solutions, but they have some limitations on the response time for video applications. PM-OLED is a good technology with fast response display, wide viewing angle and high contrast. It is a light emitting material, which can eliminate the use of backlight as in the STN LCD and TFT LCD technology. Unfortunately, it still has limitations in resolution and panel size. The market acceptance is now on the caller display or the MP3 player for the PM-OLED application. Major active matrix panel technologies are a-Si–TFT (amorphous Silicon TFT), LTPS (Low Temperature Poly Silicon), and AM-OLED (Active Matrix OLED). Some technology developers also invest on CGS (Continuous Grain Silicon), FED (Field Emission Device) and PDP (Plasma Display Panel). CGS is the technology with further enhancement on the electron mobility of silicon ($300cm^2/Vs$ max), compared to the TFT and LTPS. It is most suitable for mid-size panels as in the handheld applications. FED and PDP can only be employed in large panel applications like TV/monitor owing to its high power consumption and large pixel pitch. Even though the active matrix consumes higher power than the passive technologies, the active matrix devices provide advantages such as good response time, high contrast, large viewing angle, high color depth and purity for the multimedia platform of handheld applications.

Table 3 summarizes the characteristics of various handheld display technologies and the current module price. Obviously, the price gap between passive and active technology determines the market acceptance by the low-tier voice centric and the high tier PDA/smartphone applications. The phenomenon will change accordingly as the FPD has a yearly 10-20% price reduction. With the opportunity to improve yield and stability, the active-matrix FPD for 176x220 resolution will drop the price and continue to grow its market share to above 50% of the handheld device market.

Table 3: Comparison of different small to medium size panel technology

	Color STN LCD	UFB STN LCD	UFS STN LCD	a-Si TFT LCD	LTPS TFT LCD	PM-OLED	AM-OLED
Prices (USD/pc)	10 ~ 15	20 ~ 24	-	27 ~ 33	28 ~ 35	7 ~ 14	-
Color depth	4096 ~ 65K	65K	262K	65K ~ 262K	262K	256 ~ 65K	65K ~ 262K
Color purity	20%	-	87%	40%	40%	-	-
Respond Time	200ms	60ms/200ms	13.5ms	30ms	20ms	<1ms	<1ms
Viewing Angle /^{o}C	90 ~ 120	120	-	120 ~ 160	160	165 ~ 180	165 ~ 180
Contrast	1:30	-	1:150	1:150	1:150	1:200	-
Power Consumption	3mW	> 3mW	-	25 ~ 30mW	1.5 ~ 25mW	2mW	-
Lifetime	> 10K hrs	> 10K hrs	> 10K hrs	> 10K hrs	> 10K hrs	G/B: > 10K hrs R: 10K	~20K hrs

Integration into silicon

All the handheld applications require not only a powerful processor, but also a fast response display with high-speed interface. The multimedia applications require high display refresh rate and massive data transfer (over 2Mbps) to support the camera or stream video services such as videophone and TV broadcasting. Handset makers are making choices about which low-power, high-bandwidth chip interconnects can support next generation camera phones. As many as eight different interconnects have been proposed at various levels for linking CMOS sensors, graphics chips, baseband processors and displays in camera phones.

Several brand name supplier groups have issued specifications for the development of their own standard. This includes the Mobile Video Interface (MVI), the Mobile Pixel Link (MPL), the Mobile Display Digital Interface (MDDI) and the Mobile Industry Processor Interface (MIPI). New devices are required to reduce the power consumption, electromagnetic interference (EMI), voltage swing and current to lower system noise level and number of interconnection wires. The interfaces will enhance the data transfer reliability and mechanical compactness especially on the hinge type clamshell design. As in the various proposals, serial interface with low voltage differential outputs are used.

The existing LCD driver controllers include the power generator, gate driver, source driver and simple glue logic. The fast data rate drives the need of lower geometry of IC process. The most currently used mix-signal process of display drivers employ 0.35um and 0.25um technology for different voltage requirements of gate, source driver and graphic controller logic. 0.18um technology will be adopted and become more popular from 2005 onward to fulfill the data rate and encourage the integration of value added features.

Value added features

The functions available in camera handsets will be one of the criteria consumers look at before purchasing. Such functions include voice recognition and synthesis, MP3 playback and 3D graphics animation. To bring these functions together at low cost requires a high level of integration by driver controller ICs in display modules. With the current wafer technology, Solomon Systech has embedded the 2D Graphic Acceleration Engine into its driver controller ICs. It can support mobile handsets in graphic animations like drawing lines, rectangles, circles and copying block images. It can help to speed up the whole application system to avoid heavy traffic on display content update from the baseband processor. Instructions are implemented in the IC controllers at the display module and release the processor's computing power for other non-display related features. The offload of baseband IC will allow a wider range of choice on the selection of baseband processors. It also releases the pressure on the maximum speed of interconnection that makes room for upgrade of higher resolution.

Moving towards the advanced IC process below 0.18um allows the possibility to integrate more features such as the CMOS sensor timing controller, the 2D/3D

graphics acceleration engine and JPEG/MPEG decoding. They all display memory related features and fully utilize the embedded SRAM build in. Starting from the use of TFT and LTPS technology, the high panel tooling fee set out an entry barrier to low end handset or panel makers. The display panel will have a standard physical dimension and resolution to serve the second tier manufacturers. This will help the display module to be developed as a platform solution or a stand alone peripheral. By that time, the driver controller ICs will be a standard core of the handheld display module interface. Maybe, it will become a universal instrument for plug and play applications such as handheld consoles.