SUPPORTING GUIDE

INTERFACING YOUR SBC TO A DISPLAY

Introduction

Human beings are very visual creatures – pictures delight and inform us across all aspects of life. Text driven interfaces are giving way to a new generation of displays – slender, sharp, windows of communication that let us interact more closely with the world around us. In the workplace, we use graphic user interfaces to manage the machines and systems running our assembly lines, communications networks, public transport and hospital laboratories. The worldwide market for open-system human-machine interfaces (HMIs) is forecast to triple over the next five years, growing to $151.3 million in 2008.

There are three main areas where we see a computer teamed up with a display.

The PC market

DVI

In the desktop market the venerable CRT is bowing out to the slimmer LCD. Other than the obvious benefit of size, LCDs provide a brighter screen; offer clearer, crisper text and have even caught up to CRTs in the area of displaying moving images.

VGA

Most LCDs provide support for digital (DVI) and analog (VGA) signals, but less expensive LCDs may offer only analog. The advantage of digital signals for LCDs is of much less importance now than it was a few years ago. Analog signal processing has improved to the point where only the most discerning eye can notice any difference. Most LCDs that support digital signals also support analog signals, so you won't need a special graphics adapter to use DVI display.

The AV Industry

Historically, the broadcast industry has developed its own video signalling interfaces, the common standards being component video (YPbPr), composite video and s-video. However, t0he multimedia home and the digital signage industry are bringing together the world of broadcast and IT. The HDMI standard is looking for universal acceptance in this new arena, combining HDTV support, multi-channel audio, and inter-component control in a single digital interface. HDMI is backward compatible with the DVI interface, HDMI to DVI converter cables are appearing on the market.

Within this market, new power efficient, hi-performance processors like the Via C7 and Pentium M will make it possible to embed computers directly into plasmas and LCDs, creating hybrid intelligent displays.

HDMI

S-Video

Composite Video

Component Video

The Embedded Industry

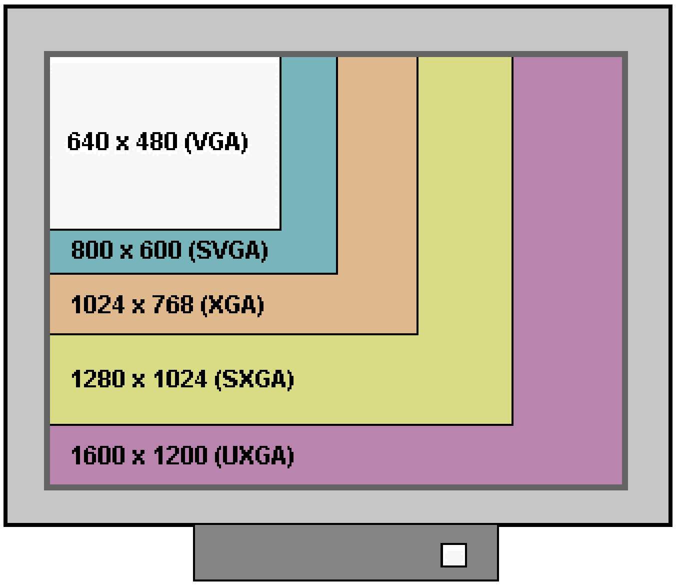
The role of the display in the embedded industry is the area this paper will confine itself to. By this we typically mean a single board computer driving a display in an integrated application such as a passport reader, blood analysis machine or vehicle control panel. If you are undertaking this sort of embedded development, it's essential to appreciate how a single board computer integrates with the multitude of LCD displays on the market. Notoriously dependant on proprietary interfaces and competing standards, connecting up your display is often not a simple 'plug and play'. The flexibility your SBC manufacturer offers in supporting different displays should play a key role in the commercial decision.

Integrating a SBC with a Display

There are a number of factors to consider when choosing the right combination of display and single board computer.

Display size and resolution

Open frame, OEM LCD panels come in a plethora of sizes from 1.5 to 21 inches and beyond, supporting defined sectors such as the cell phone, PDA, laptop and desktop market and everything in between. The display market is usually fairly volatile and can have price v size sweet spots, as supply and demand shifts in the volume consumer markets.



Along with selecting your display's size, you need to select its resolution. As the viewing area of a display decreases, so does a user's ability to distinguish individual pixels. You would usually expect to see VGA resolution on a 6.4" display, SVGA in 8-10" territory and XGA for 12" screens. There will always be speciality panels with odd resolutions, such as 480×234 or 320×96 pixels and an increasing choice in wide-screen resolutions. The diagram and table above illustrate the range of resolutions in current usage.

QVGA	320 x 240	4:3
VGA	640 x 480	4:3
WVGA	800 x 480	16:9
SVGA	800 x 600	4:3
XGA	1024 x 768	4:3
HDTV 720i/720p	1280 x 720	16:9
XGA+	1152 x 864	4:3
WXGA	1280 x 800	16:10
SXGA	1281 x 1024	5:4
UXGA	1600 x 1200	4:3
HDTV HDTV 1080i/1080p	1920 x 1080	16:9

Digital Display Type

Liquid crystals were first discovered in the late 19th century by the Austrian botanist, Friedrich Reinitzer, and the term "liquid crystal" itself was coined shortly afterwards by German physicist, Otto Lehmann. Generally there are two main types - twisted nematic (TN) and thin film transistor (TFT).

The more basic type of LCD is the twisted nematic (TN) display, a passive matrix display created by twisting the polarisation plane of the liquid light crystals. This technology has undergone several improvements such as the super twisted nematic (STN), double supertwist (DSTN); in general, the more twists, the higher the contrast. The film compensated super twisted nematic (FSTN) provides for a higher contrast and wider viewing angle.

However, STN displays typically suffer from lower image quality and slower response time than TFT displays. STN displays are used in some inexpensive mobile phones and informational screens of some digital products.

Short for thin film transistor, TFT screens are sometimes called active-matrix LCDs - one transistor for each colour (RGB) of each pixel. These transistors drive the pixels, eliminating at a stroke the problems of ghosting and slow response speed that afflict non-TFT LCDs.

The TFT technology provides the best resolution of all the flat-panel techniques, but it is also the most expensive. The complete matrix of transistors has to be produced on a single, expensive silicon wafer and the presence of more than a couple of impurities means that the whole wafer must be discarded. However as fabrication techniques are improving and TFTs become more popular, the price differentiation between TN and TFTs is decreasing, displacing TN in the embedded market place.

Organic Light Emitting Diode (OLED) technology is one to be watched carefully, OLED displays do not require a backlight and can be made thinner than any other technology used today. The technology is being honed and we're beginning to see OLED screens incorporated into consumer electronics like MP3 players. However, the screens are prone to failure at higher temperatures and carry a considerable risk of burn-in, making general use in the embedded sector unlikely in the short term.

Colour depth

Colour depth	Description	No. of colours	Bytes per pixel
4-bit	Standard	16	0.5
8-bit	256-colour mode	256	1.0
16-bit	High colour	65,536	2.0
24-bit	True colour	16,777,216	3.0

Each pixel of a screen image is displayed using a combination of three different colour signals: red, green and blue. The more bits that are used per pixel ("bit depth"), the finer the colour detail of the image. An LCD display is specified to a certain colour depth which may or may not be supported by your single board computer.

For a display to fool the eye into seeing full colour, 256 shades of red, green and blue are required; that is 8 bits for each of the three primary colours, hence 24 bits in total. However, some applications actually require 32 bits for each pixel to display true colour, due to the way in which they use the video memory - the extra 8 bits generally being used for an alpha channel (transparencies). Your single board computer designer can work with you to accommodate your display colour depth. For example, by adjusting the cable interfacing between the display and SBC, an 18bit single board computer can display a good approximation of an 24bit image. This is done by discarding the relatively insignificant bottom end of the 24bit spectrum. Another technique is to "double clock" an 18bit SBC to support 36bit display images, this would involve a minor build option and adjustments in the video BIOS.

Display Signalling

An embedded display will usually support a TTL or LVDS interface. TTL is a single-ended signalling technique, in which the transmitter generates a single voltage that the receiver compares with a fixed reference voltage.

Today, we are seeing readily available Low Voltage Differential Signaling (LVDS) based displays being used. Unlike TTL, LVDS is a differential signalling system, which means that it transmits two different voltages, which are compared at the receiver. This provides the advantage of being able to send signals over a relatively long distance through a cable.

LVDS has been incorporated into a number of competing flat panel interfaces standards including LVDS Display Interface (LDI), OpenLDI and Flat Panel Display (FPD) Link (also known as Flatlink). The Japanese laptop manufacturers backed Flatlink and the majority of embedded LVDS displays use this standard. Another set of interfaces exist for video applications, where video interfaces such as NTSC, PAL and RGB are built into the display. They are quite different from conventional PC graphics interfaces and tend to be used in niche markets such as in-vehicle displays.

Power and Cabling

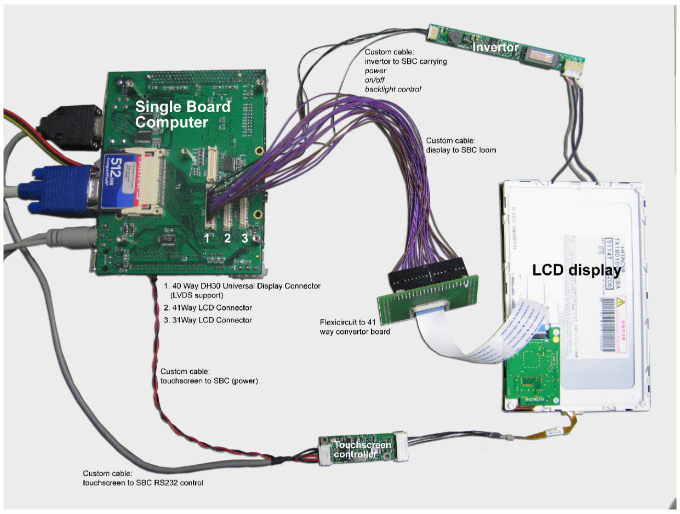
The power supply for the display can be routed directly from the SBC or from the power supply. If you take it directly from the PSU, this effectively means the backlight is operated whenever the power is switched on, which can interfere with display signalling. Flat panel displays can be extremely sensitive to conditions where full biasing voltage is applied to the liquid crystal material before the control and data signals to the panel are stable. If possible, it's preferable to have power directly off the board, keeping the wiring loom/harness simpler and increasing display control by incorporating dim control and power sequencing. Unfortunately, LCDs follow no uniform signal profile, so different LCD panels from different manufacturers will frequently have different pin arrangements and naming conventions. Invariably, cabling will need to be designed for the specific combination of SBC and display you've chosen. Pairing a Controller with an LCD initially requires manually wiring against the signal and pin description from the LCD manual.

PIN NO.	SYMBOL	I/O	FUNCTION
1	GND		Ground
2	CK	I	Data Sampling Clock
3	HSync	I	Horizontal Synchronizing signal (negative-going)
4	VSync	I	Vertical Synchronizing signal (negative-going)
5	GND		Ground
6	R0	I	Red Data Signal (LSB)
7	R1	I	Red Data Signal
8	R2	I	Red Data Signal
9	R3	I	Red Data Signal
10	R4	I	Red Data Signal
11	R5	I	Red Data Signal (MSB)
12	GND		Ground
13	G0	I	Green Data Signal (LSB)
14	G1	I	Green Data Signal
15	G2	I	Green Data Signal
16	G3	I	Green Data Signal
17	G4	I	Green Data Signal
18	G5	I	Green Data Signal (MSB)
19	GND		Ground
20	B0	I	Blue Data Signal (LSB)
21	B1	I	Blue Data Signal
22	B2	I	Blue Data Signal
23	B3	I	Blue Data Signal
24	B4	I	Blue Data Signal
25	B5	I	Blue Data Signal (MSB)
26	GND		Ground
27	ENAB	I	Horizontal Display Position Set Signal
28 - 29	VCC		+3.3 V
			Horizontal Display Direction Select Signal
30	R/L	I	L = Normal
			H = Reverse
			Vertical Display Direction Select Signal
31	U/D	I	L = Normal
			H = Reverse
32	V/Q	I	VGA/QVGA Mode Select Signal
33	GND		Ground

Sharp's LH9520 LCD Interface Pin Assisgnments

The actual cabling work may be quite simple, such as linking up two relatively standard connectors such as a Hirose 41 pin. Alternatively, as shown in the example photograph overleaf, you could be connecting a Flexicircuit cable to a 41 pin connector, requiring some intricate soldering or an interface board. In addition to the board to display connection, you may need bespoke cabling between the single board computer and display inverter. With the increasing popularity of touchscreen applications, it's possible you will need to cable up a touchscreen controller board to the single board computer.

Although a board manufacturer will already have established a back library of pre-configured display kits, these can only ever address a small section of an extremely diverse market. Consequently, a new model or more niche display will initially require a cabling prototype against a sample display, followed by the technical documentation that lets you produce the cable kits in production volume. It's important



to assess whether your SBC manufacturer provides full support, they may limit the range of displays they configure to or charge additional costs to accommodate 'non standard' displays.

Video BIOS

The video BIOS controls the display image signalling - how, where and when each pixel arrives on your screen. Unsurprisingly, there is little universality in this area, each embedded platform will have a different video BIOS depending on its graphics chip. Within the video BIOS there are a large number of registers, which control the time wave signalling to the display. Each display model has a its own Signal Timing Waves profile which needs to be precisely set within the video BIOS. Even displays which share the same screen resolution and size may deviate in their signalling profile and have to be manually adjusted for a pixel perfect placement.

The video BIOS registers define dozens of different display parameters including display borders, synchronisation, polarity and mode. For example the Horizontal Synchronization signal is a pulse that is activated when one line of data has been transmitted to the LCD. The Vertical Synchronization signal is a pulse that is activated when one page (or frame) of data has been transmitted to the LCD. The clock frequency must be correct and the Synchronization signal polarities must be correct, otherwise the image on the LCD will exhibit image shift or 'sparkling' pixels. Again, an established embedded designer will have accumulated a database of standard video BIOS settings against a range of display types. However, there will always be odd resolutions, increasing display bit rates and wide screens settings – a flexible SBC designer will be able to manually configure their board for your display of choice. Once configured, your SBC supplier can deliver your board with a custom BIOS defaulting to your display settings.

Summary

The embedded world has long recognised the value of long product lifecycles and industry standards, bringing stability to complex design projects. The display market is inherently fast-moving and often divisive. Possibly the convergence of IT and Broadcast will drive the call for standard interfacing but we're a long way from this utopia. This makes it difficult for an SBC manufacturer to accommodate every display via some universal, quick fix solution. The graphics performance of today's processors is improving all the time but setting up a display will require some effort and tailoring. Don't leave display support as an afterthought in assessing your embedded supplier.

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