

DSP coupled with TFT-Liquid
Crystal Display: key to high-end
consumer electronics

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The immense utility of embedded systems in this era of electronic convergence has whetted its usage and appetite in consumer electronics, hi-end industrial product and defense market.

Information dissipation, to the possible level of efficiency cannot be achieved until human visual senses are exploited. Providing information visually, in appropriate format can make comprehension easier and efficient. Even text is quite cryptic, when judged with respect to visual and pictorial forms of information processed by the human brain. The need to display processed information, involving a great level of complex computing (signal processing) has become the overriding factor for success in a consumer, industrial, defense and electronic products today.

No wonder the demand for real color, high resolution, portable, low power consumer display technology is soaring heights. In the year 2004 TFT industry grew by 45% and industries revenue rose to \$48.5 bn. Look around and the probability is less than 0.2 that you find someone, not possessing a device working with a processor -LCD pair.

The prime catalyst of this phenomenal growth is the product design targeted towards hand held devices that are portable yet promising enough to visually communicate with high information density. The LCD-processor address a broad array of applications from Digital Cameras, Digital Video recorders, thermal imaging, futuristic smart mobiles, and wrist wearable ECGs to high precision navigation system.

LCD is an intrinsically digital device and produces images that are sharp and crisp. LCDs owing to its low operating power, high resolution, real color and reliability have out done the most popular display technologies emerging as the defacto standard in display technology. LCDs have no issues of linearity where one has to correct for pincushion or other artifacts that common to CRTs. LCDs are also catching up CRTs with response time that is under 10 milliseconds, which make them a fit for commercial application. LCDs being less reflective facilitate their use in places having varying brightness levels like ATM machines and kiosk.

Alongside, the need to process encoded or at times even raw digital data in real time, available to the consumer end via hi speed transmission modes have exponentially increased. The DSP LCD pair serves for the complex signal processing followed by a mode for visually communicating the extracted information to the user, in the most interactive ways.

Interaction between the DSP and the LCD take place through a LCD controller, which is a small micro controller. The LCD controller is a peripheral device to the DSP that helps in interfacing the DSP with the LCD. In cases wherein the I/O pins of the controller mismatches with those of the corresponding DSP, calls for using a CPLD (complex Programmable Logic Device) to compensate for the missing combinational logic and generate the required signal.

With the latest LCD controllers having an inbuilt flash memory upto 100Kb, the need for extra memory module has almost been eliminated. This flash memory serves to store the RGB data as a buffer so as to achieve a good frame rate. Loading data into the flash memory and then feeding appropriate control words into the SFR (Special Function Registers) can provide for the desired display.

LCD controllers are being made more intelligent, to support real time editing. The controller could come with a inbuilt facility for PiP (Picture in Picture) and swivel view modes, which have to be configured by writing appropriate SFR's. The SFR's are written using the memory maps available with the IDE (Integrated Development Environment) or via the Device Driver. The Driver, resides on the DSP during run-time, and transfers data/control signals to the LCD Controller.

This embedded device driver provides sequenced instructions to the controller for power up, initialization, configuration, control and power down. The driver takes into account hardware design of the LCD, the Controller as well as the DSP, and provides a comprehensive Chip Support Library (CSL) to make use off all the features of the LCD. The Chip Support Library forms the lowest tier for the driver. The extensiveness of the CSL depends totally on the Controller and the SFR's it provides. LCD driver is software that enables another program (typically, an operating system of the DSP) to interact with an external hardware device.

Drivers work as intermediary programs between the application and hardware while the hardware abstraction layer enables programmer to write drivers curtailing the detailing required for the hardware. Peripheral module device drivers take care of Initialization (Getting the device ready for operation e.g. setting up baud rate or timer periods) Run-time control (e.g. sending character strings or starting DMA transfers) Interrupt handling (responding to hardware events) while driver logic is normally implemented by modifying or testing Special Function Register (SFR) control and status bits in a suitable order.

A modern high-end micro controller can have several thousand SFR (Special Function Registers) bits, each of which must be carefully initialized and manipulated at run-time in proper sequence. Implementation of device drivers sometimes requires engineering tricks, such as using compiler-specific interrupt, low-level hardware access from assembly language, advanced use of the linker command file and so forth. The close relationship to the hardware, traditional software tools results into little support for device driver development.

With the numerous utilities that the DSP - LCD pair can provide for, there exists a scope for vast range of products, which are both economically viable and have the potential for commercial success. As this technology matures, we can look forward to entire electronic products integrated on a single substrate and ultra-compact 'System-on-Panel' products in the future.