



Solving your embedded graphics conundrum with NXP LCD solutions



Choosing an MCU with graphic LCD interface

Graphic versus Segment LCD



7seg 15seg

Segment LCDs

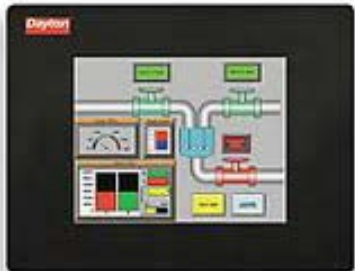
Advantages of segment-driven LCD displays are low communication overhead, low power, and virtually limitless but fixed display configurations.



Graphic LCDs

Preferred over the character LCDs for applications where both character and graphical representation are required.

Example Applications for Graphic LCDs

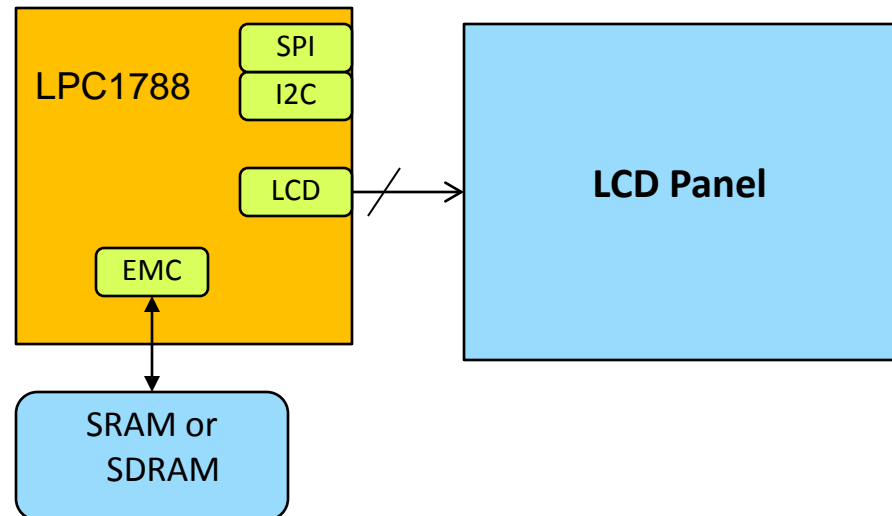
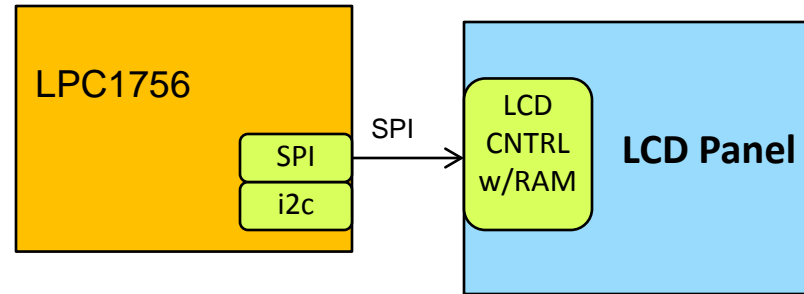


- ▶ Embedded applications for vibrant displays.
 - Home Automation and Security
 - Thermostats, security panel, intercom
 - Secure Transactions
 - POS Systems, Access Control, Ticketing
 - White Goods
 - High end Display and Human Interface
 - Industrial Human Machine Interface/Programmable Logic Controls
 - RPM monitor, temp monitor, alarms
 - Medical Systems
 - Portable meters, large monitoring equipment
- ▶ Typical resolutions from CGA (320x200) to XGA (1024x768) and <15fps

MCU with external or internal LCD controller

Example interfaces MCU to LCD

- Serial interfaces to reduce pin count to the LCD
 - Lower resolution due to limited SPI bandwidth
- MCU with graphic LCD controller onchip
 - Can support mid-range resolutions.



Graphics LCD Controller

► Key features

- Support for STN single and dual and TFT panels
- **Up to 1024x768 resolution**
- 24-bit LCD interface supports 24bpp (16M colors)
- Palette table allows display of up to 256 of 64K colors
- Adjustable LCD bus size supports various panel bus configurations
- Dedicated LCD DMA controller
- Hardware cursor support

► Free industry-leading Segger emWin graphics library

► NXP supplied BSPs

- Significantly reduces your software porting efforts
- Porting guide available for non-standard LCDs



NXP MCUs with Built-in LCD Graphic Controllers

LPC435x

- ▶ Cortex-M4/M0 204 MHz 1 MB Flash/ 264 kB SRAM

LPC185x

- ▶ Cortex-M3 180 MHz 1 MB Flash/ 200 kB SRAM

LPC408x

- ▶ Cortex-M4 120 MHz 512 kB Flash/ 96 kB SRAM

LPC178x

- ▶ Cortex-M3 120 MHz 512 kB Flash/ 96 kB SRAM

LPC2400/LH7

- ▶ ARM7 80 MHz 96 kB SRAM

LPC3100/3200/LH7A

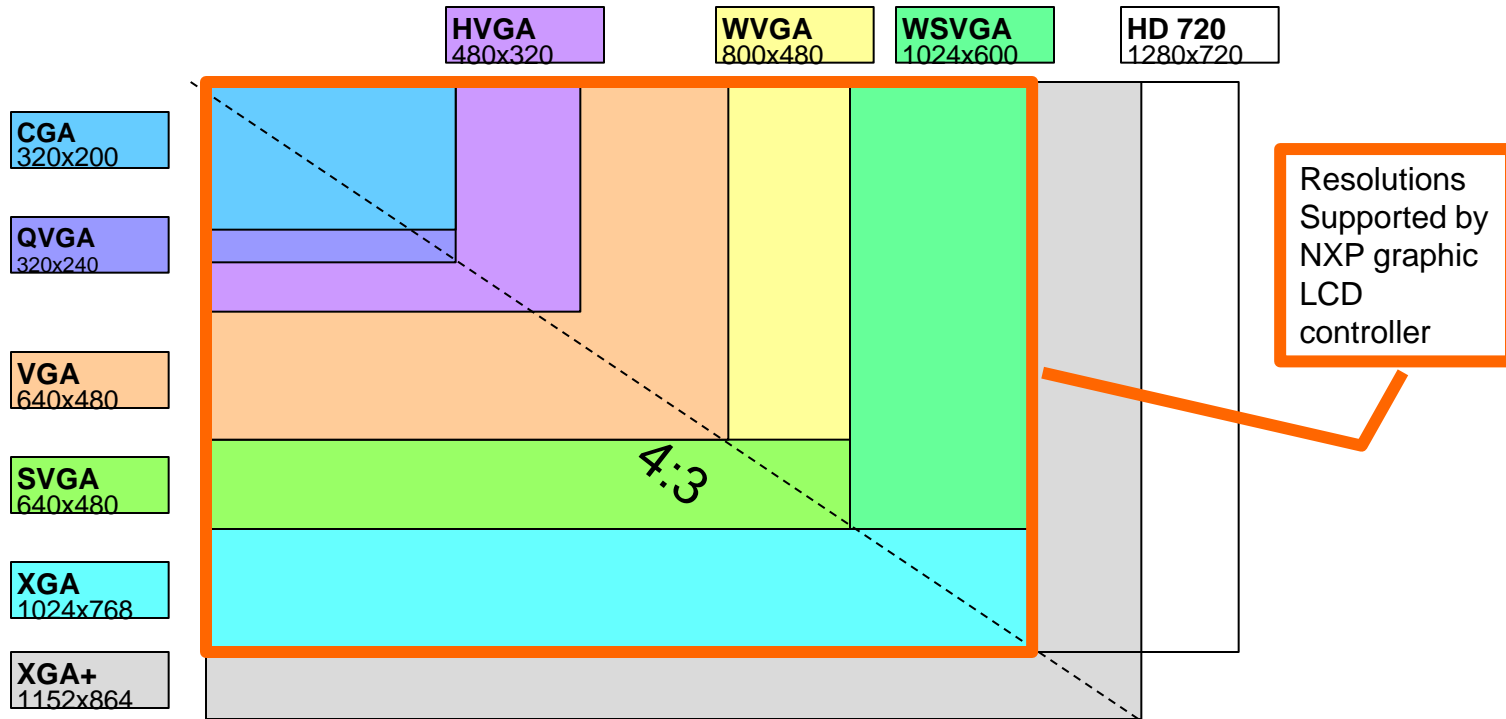
- ▶ ARM9 266 MHz 256 kB SRAM





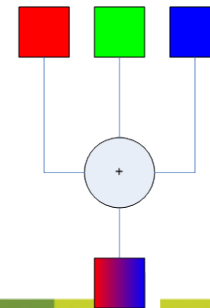
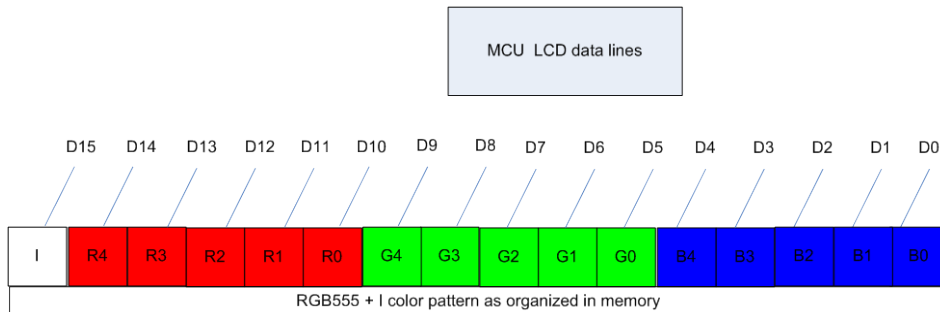
Key parameters & Configuration of LCD

Choosing an LCD: Resolution: Resolution is not measured in inches!



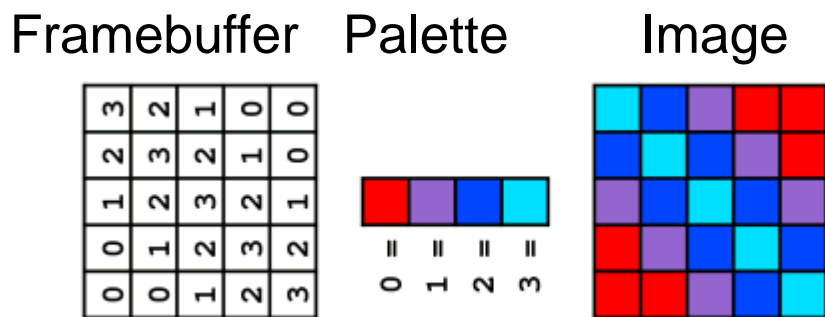
Choosing an LCD: Color Depth

► Color depth or bits per pixel (bpp)



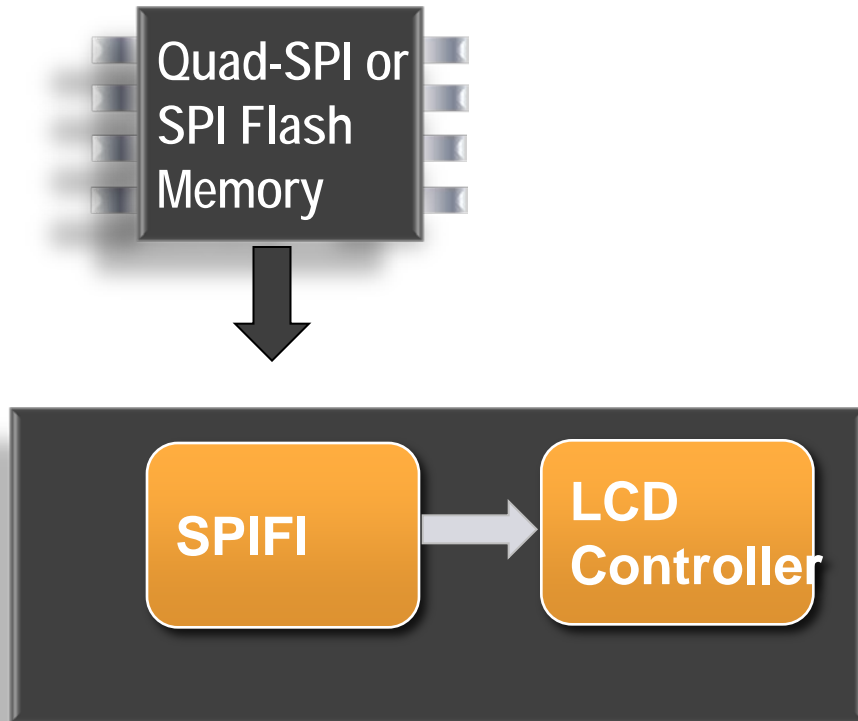
Palette Based Frame Buffer

- ▶ The frame buffer will contain an index value for each pixel
- ▶ Palette RAM is pre-filled with 16-bit color value for each index



- ▶ NXP microcontrollers have 256 entries to support
 - ▶ 1, 2, 4, or 8 bpp palletized color displays for color STN and TFT
 - ▶ 1, 2, or 4 bits-per-pixel (bpp) palletized displays for mono STN

Image Storage Solution with SPIFI



- Image stored in external serial Flash (Quad-SPI or SPI Flash)
- High speed SPIFI allows images to be transferred directly to LCD controller using DMA

Advantage of a SPIFI solution:

- QSPI Flash is a viable replacement for external NAND/NOR flash: saving board space, easing routing to external memory and reducing system costs

Using SPIFI on LPC1800/4088/4300 as the LCD Frame Buffer App

Note: <http://www.nxp.com/documents/software/AN11206.zip>

Choosing an LCD: STN vs TFT

▶ STN (Super-Twisted Nematic)

- Slower response compared to TFT technologies
- Lower cost and power than TFT
- Variations include Color STN (CSTN) and Dual STN (DSTN)
- STN displays only turn segments on and off
- STN screens have limited color range, and viewing angle (~15 degrees max).

▶ TFT (Thin-Film transistor)

- Fast response
- Higher cost than STN, Uses more power than STN
- Variations include Advanced TFT (ADTFT) and Highly Reflective TFT (HRTFT)
- TFT technology provides more accurate color control, allowing it to display more colors
- TFT screens also offer a wider viewing angle range (30 to 70 degrees)

Type	Passive	Active
Contrast	10-20	100+
Viewing Angle	Limited	Wide
Gray Scale	16	256
Response Time	100-200ms	<50ms
Multiplex Ratio	~480	>1000
Cost	Moderate	High

Can the MCU drive my LCD panel?

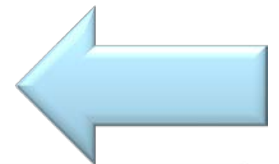
- ▶ Bandwidth calculator on LPCware calculates the external bus bandwidth used
- ▶ For example, VGA panel with 12 bits per pixel color depth at 60 Hz uses only 28% of the external memory controller bandwidth

LPC178x Bus Bandwidth on Various LCD Resolutions and Color Depths at Various Refresh Rate

Bus Clock (MHz):	80
Static External Memory Configuration -	
Bus Width:	32
Read Delay, WAITRD:	1
Dynamic External Memory Configuration -	
Bus Width:	32
Precharge Command Period, tRP:	2
RAS Latency (Active to Read/Write Delay), RAS (tRCD):	2
CAS Latency, CAS:	2
LCD Resolution -	
Horizontal (Pixels):	640
Vertical (Pixels):	480
Refresh Rate -	
Refresh Rate (Hz):	60
LCD Color Depths -	
Color Depth (bpp):	12
Frame Buffer -	
Frame Buffer (KB):	64
LCD Data Rate -	
Data Rate (Mpixels/s):	18.432
Data Rate (MWords/s):	6.912
Data Rate (Mbursts/s):	1.728
Static External Memory Burst -	
Burst (clocks):	13
Dynamic External Memory Burst -	
Burst (clocks):	15
Bus Bandwidth Needed by LCD:	
Static External Memory (%):	28.08
Dynamic External Memory (%):	32.4

Notes:

1. Burst size: 4 words.



Steps to configure the LPC4357 integrated LCD controller

- Timing

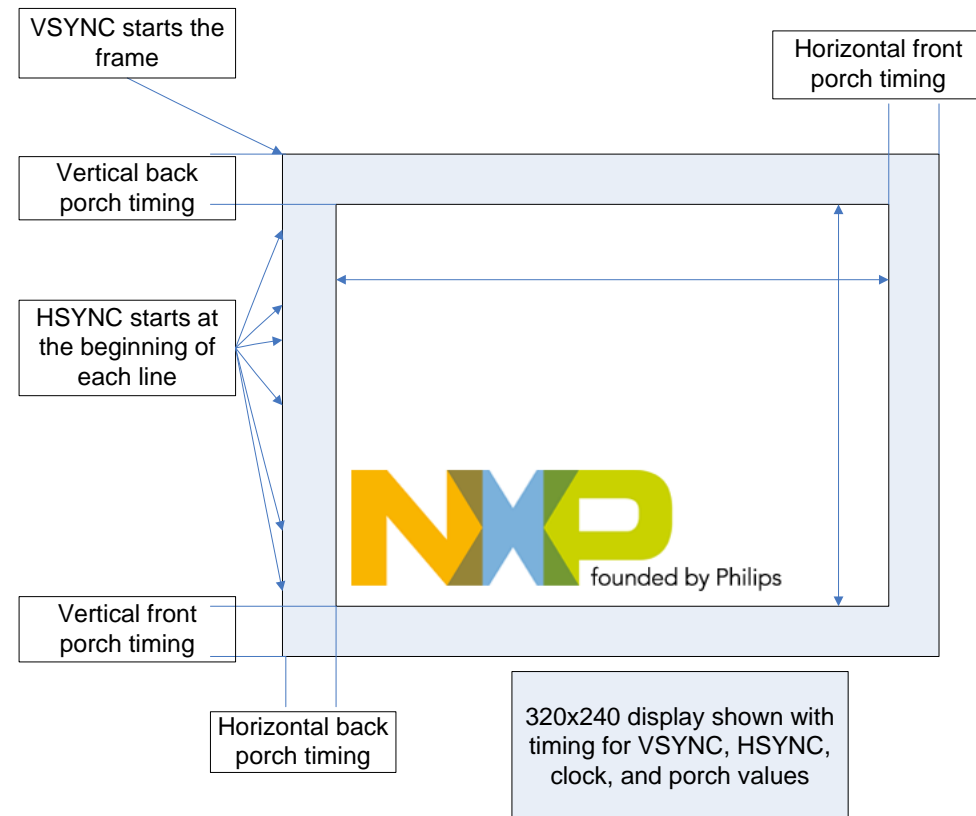
- ▶ Set the Screen width, HSYNC, porch timing - LCD_TIMH register
- ▶ Set the Screen height, Vsync, porch timing - LCD_TIMH register
- ▶ Generate the clock and signal polarity control word

- Compute clocks per line based on panel type (Mono, CSTN, TFT)

- Panel clock divisor (based on LCDCLK)

- Bits per pixel

- Color format – RGB, BGR

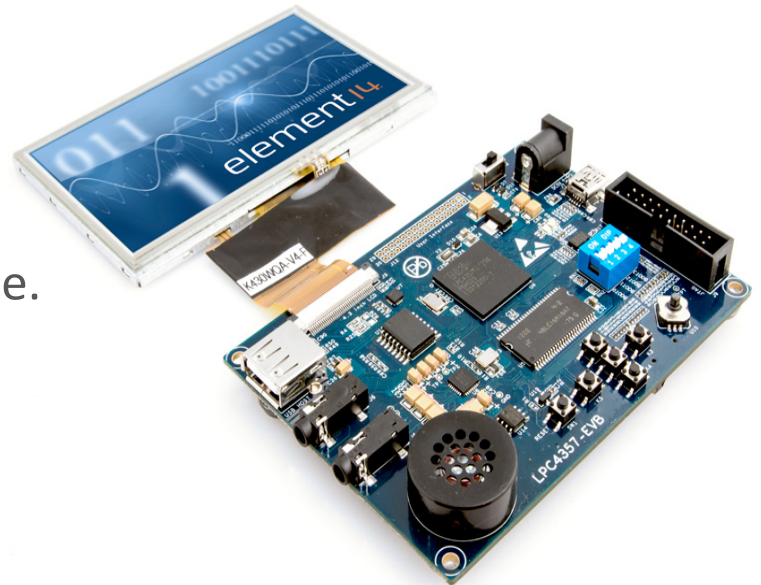


The built in-LCD controller on the LPC4357 provides all of the necessary control signals to interface directly to various color and monochrome LCD panels. Both STN (single and dual panel) and TFT panels can be operated.

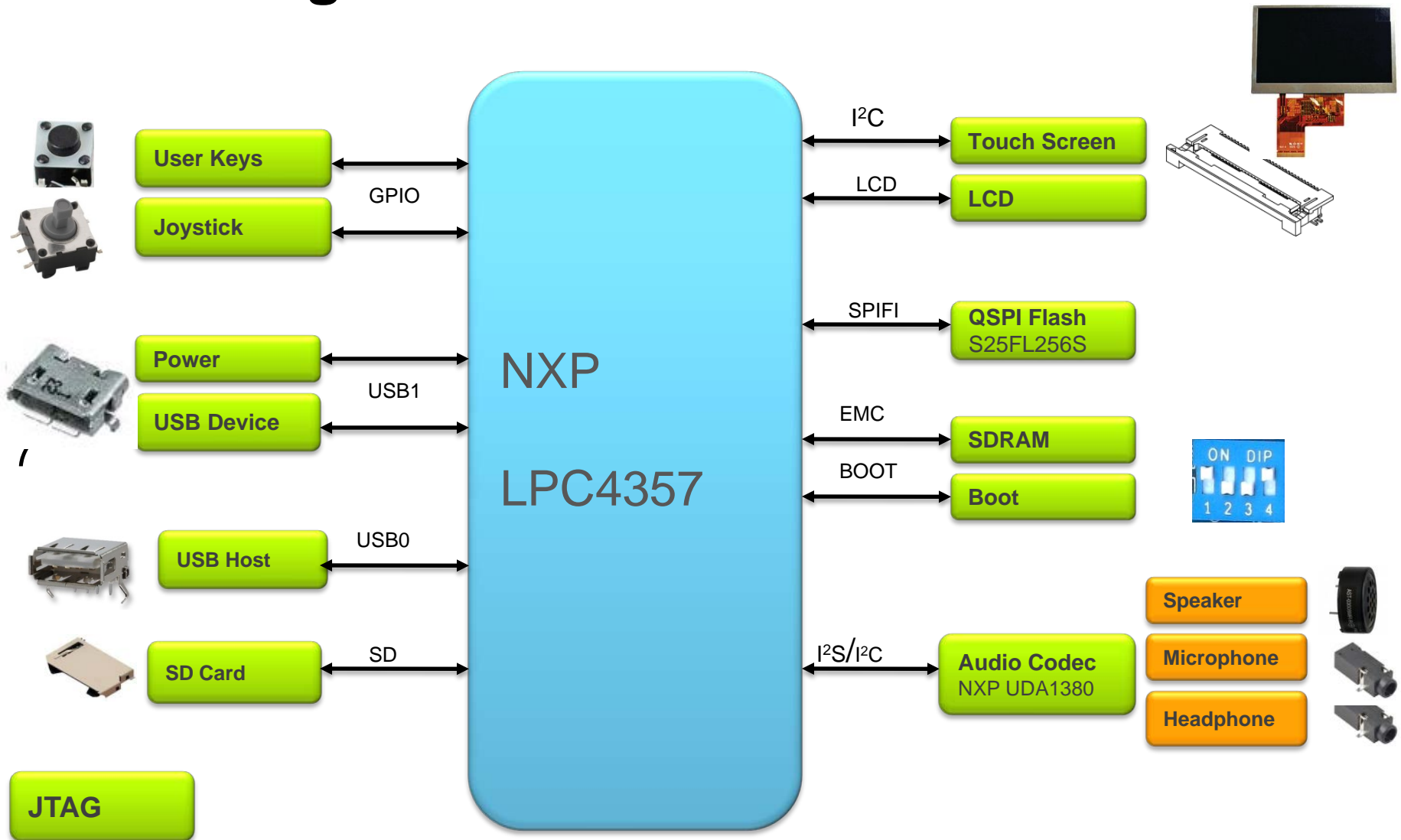
The display resolution is selectable and can be

- ▶ up to 1024 * 768 pixels.
- ▶ up to a 24-bit true-color non-paletized mode.
- ▶ on-chip 512 byte color palette

The LPC4357-EVB comes with an optional QVGA 320*240 LCD bundled with it.



Block Diagram of LPC4357-EVB

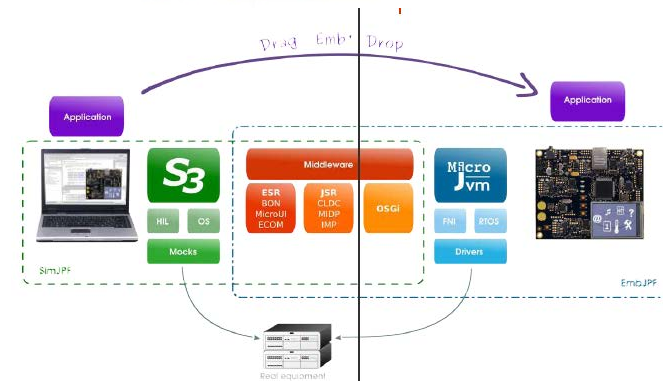




Graphics Library

Graphic Libraries

- ▶ Segger emWin – Free graphics library (LPCware.com)
- ▶ SWIM – Free graphics library from NXP (LPCware.com)
- ▶ Altia – User Interface Design Software and Services for Embedded Systems
- ▶ I2ST
 - Java virtual machine
 - Support for LPC2478 and LPC1788
 - <http://www.is2t.com>
- ▶ GHI
 - Microsoft .NET Micro Framework
 - FEZ support LPC1788 and LPC2478 devices
 - www.GHIElectronics.com



emWin key Features

- ▶ Support for all types of LCDs, including monochrome, grayscale or active color (TFT) displays
- ▶ Works with LPC MCUs with LCD controller or with SPI-based LCD panels
- ▶ Board Support Packages for several development boards available on LPCware.com
- ▶ Projects available for Keil, IAR, and LPCXpresso
- ▶ Widely adopted in the industry
- ▶ Uses minimal resources:
 - Small system: RAM: 200 Bytes, ROM: 6 to 25kB
 - Large system: RAM 20-60kB, ROM 30-60kB



FREE when used on any NXP ARM MCU!

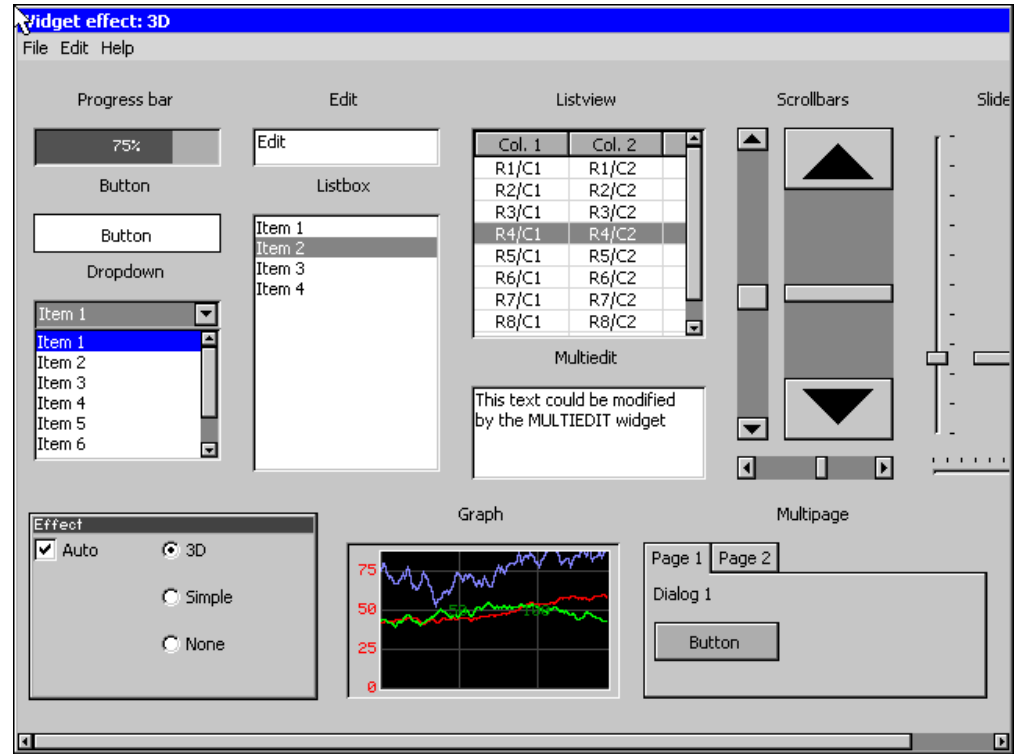
<http://www.lpcware.com/content/project/emwin-graphics-library>



emWin Widgets

The emWin Graphics Library comes with many widgets with also the option to support “Skinning”. Some examples are:

- ▶ Button
- ▶ DropDown
- ▶ Graph
- ▶ Listbox
- ▶ Radio

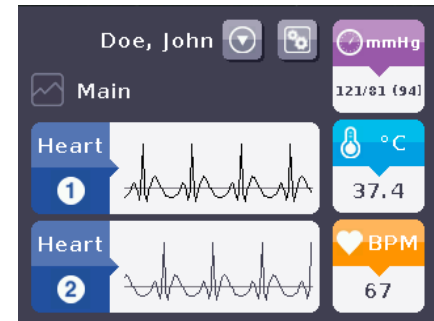
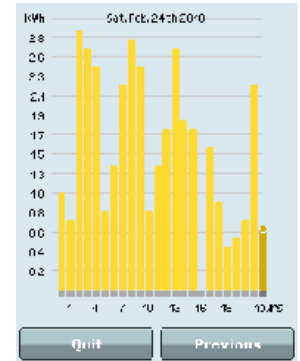
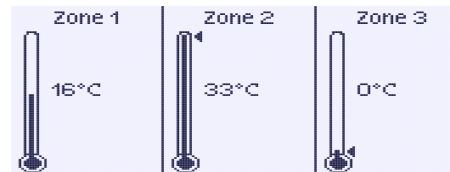
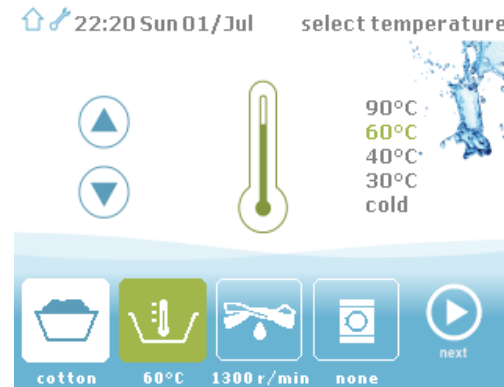


```
WM_CALLBACK * pCb;  
pCb = WM_GetCallback(hWidget);  
if (pCb == BUTTON_Callback) { // Widget is a button }  
else if (pCb == DROPDOWN_Callback) { // Widget is a dropdown }  
else if (pCb == LISTBOX_Callback) { // Widget is a listbox } else if (...) { ... }
```

LPC1700 – Java Graphical User Interfaces

▶ IS2T

- Email: sales@is2t.com
- Web: www.is2t.com



- ▶ Build prototypes to specify and evaluate costs
- ▶ Keep process iterative to change specifications anytime
- ▶ Leverage portability & capitalize on software investments
- ▶ Easy integration with existing application in C



DeepScreen GUI tools supports the NXP LPC1788. You can now use the production-proven C code generated by DeepScreen to create a first-class graphical user interface for your product. No more hand-coding or widget libraries with a 1990's look and feel.

- ▶ **Custom GUI development tool** beyond cookie cutter widgets
- ▶ Generates complete, efficient **C source code**
- ▶ No monolithic runtime engine
- ▶ **Create brand-building** user experience **without hand-coding** graphics
- ▶ **Services team** available to support GUI design and development

<http://www.altia.com/lpc1788/>



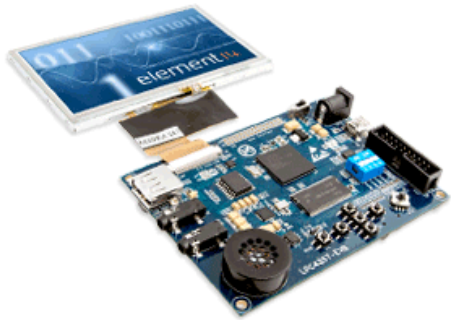
Demo

element14 Community

Get all your related information for the LPC4357-EVB here!!

<http://www.element14.com/lpcmm>

Home > the knode > Development Platforms and Kits > element14 Development Kits > NXP Development Kit



Buy Now

Learn more

*Picture represents bundle



element14 Exclusive - NXP Development Kit based on the dual-core LPC4357 microcontroller

The LPC4357-EVB from element14 is a low cost development board featuring a dual core configuration using an ARM Cortex-M4 MCU with an ARM Cortex-M0 as a co-processor. Also available as a bundle, including a 4.3" TFT LCD Module.

Quick Links:

[Schematics](#)

[Software](#)

[User Manual](#)

[Learn More](#)

Features:

- ▶ LPC4357, 256 pin BGA
 - ▶ 32-bit ARM Cortex-M4/M0
 - ▶ 1MB dual-bank Flash, 136 kB SRAM
 - ▶ 10/100 Ethernet, Support for IEEE 1588-2008 v2
 - ▶ 2x High-speed USB 2.0 Host/Device interface - one supports OTG
 - ▶ LCD controller with DMA support for STN/TFT color panels
 - ▶ External Memory Controller, SDIO card interface
- ▶ LCD interface for a QVGA LCD
- ▶ Audio codec and audio jacks
- ▶ Spansion 256Mb QSPI flash S25FL256SAGMF1001
- ▶ 32MB external SDRAM
- ▶ 3-axis accelerometer from Analog Devices
- ▶ SD Card socket

