Freescale Technology Forum

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November 2008

Hands-on Workshop: Driving Displays Part 4 - The Latest ColdFire® MCU, the MCF5227x

PZ111

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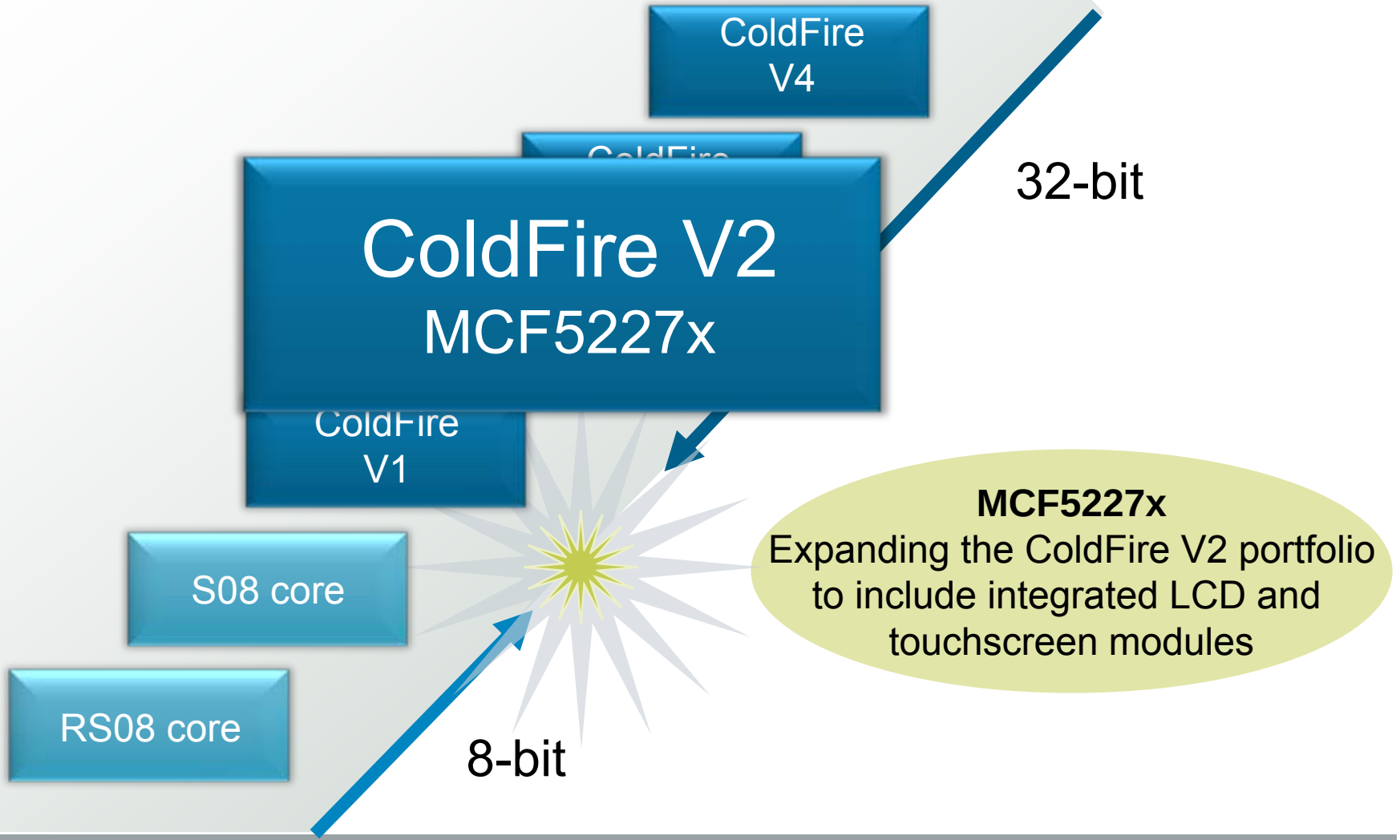
Agenda

- MCF5227x Intro
- MCF5227x Tools Overview
- LCD Controller Details
- Lab
- Touchscreen Controller
- MCF5227x Demos
- Q&A
- Summary

The Freescale Controller Continuum



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The MCF5227x microprocessor is the first ColdFire device to feature an integrated LCD and touch screen module, allowing more control and connectivity options for industrial control applications.

- Offers control, integration, performance and flexibility
  - *Integrated LCD* and touch screen controller provides ***additional control*** options that are ideal for human interface applications
  - Integrated CAN and USB controller provides ***flexible communication*** options required for industrial control applications
  - 160MHz provides the ***additional performance*** needed for multi-functional embedded applications
- Expands low-end ColdFire MPU portfolio
  - First ColdFire device to feature integrated touch screen module for LCD controller
  - Features extensive 128K SRAM bank for enhanced application performance

MCF5227x Key Messages

The 32-bit ColdFire® microprocessor portfolio is expanding with lower system cost LCD solutions, giving more control, flexibility and performance options for human machine interface and industrial control applications

Control / Performance	Flexibility	Lower system cost
Introducing LCD and touch screen integration for more system control, USB "On the Go" for more serial control, and large integrated SRAM for higher performance	**Integrating USB otg and CAN modules gives the ability to upgrade or standardize serial communications**	**Serial boot flash, flexible external bus and on-chip touchscreen controllers reduce overall system cost**
Featuring an integrated LCD Controller and Touch Screen module, the MCF5227x family is designed to give developers an easy way to add support for graphical LCD interfaces to their systems.	Open source software tools help reduce development costs while open source application examples help reduce development time.	Serial Boot Flash lowers cost, and combined with large SRAM block (128K), lessens need for external memories.
Exceptional 128K of integrated SRAM enhances overall application performance	CAN connectivity addresses industrial reliability needs.	Flexible External Bus enables lower cost external memory configurations (DDR).
V2 ColdFire core offering up to 160MHz core performance helps ensure efficient operations	USB OTG enables Host capability, allowing for mass storage device downloads and uploads.	On-chip touchscreen controller functionality lessens BOM cost.

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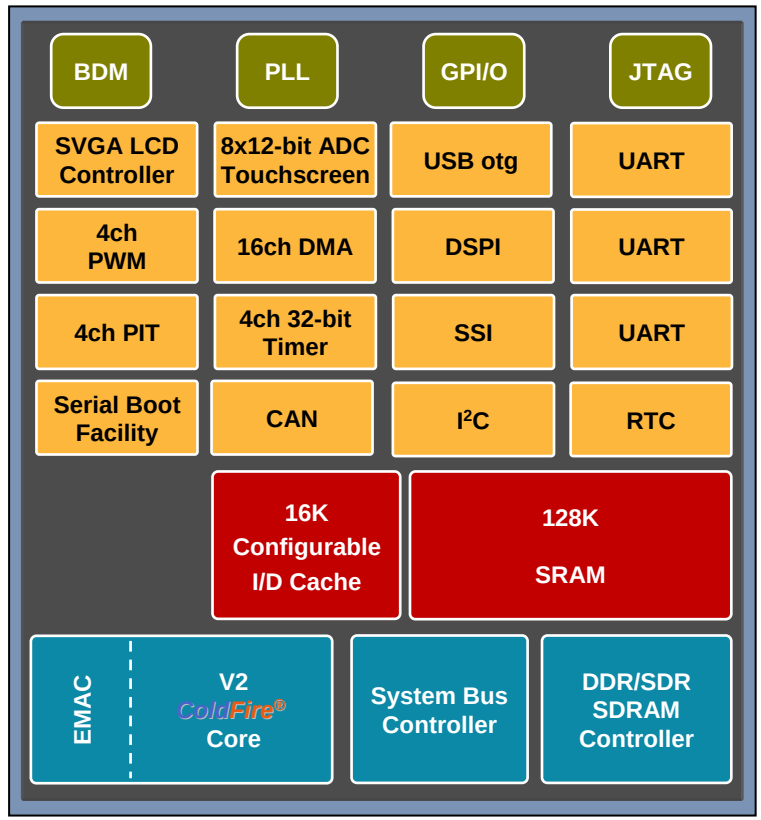
68K/ColdFire®: MCF5227x

68K/ColdFire® V2 Core

- Up to 158 Dhrystone 2.1 MIPS @ 160 MHz (Hip7A)
- Enhanced Multiply Accumulate and Hardware Divide

Integration

- 16K bytes Configurable I/D Cache
- **128K bytes SRAM**
- Integrated LCD Controller
  - CSTN and TFT w/ Up to 800x 600(SVGA) resolution
- **8x12-bit ADC w/ Touch-screen Controller**
  - ****Real touch screen controller****
- **USB 2.0 full-speed On-the-go Controller**
- **CAN 2.0B Controller (FlexCAN)**
- 3 UARTs
- DMA Serial Peripheral Interface (DSPI)
- I^2C bus interface
- Synchronous Serial Interface (SSI)
- 4 ch. 32-bit timers with DMA support
- Real Time Clock
- 16 ch. DMA controller
- 16-bit DDR / 32-bit SDR SDRAM controller
- Up to 55 General-Purpose I/O
- System Integration (PLL, SW Watchdog)
- **1.5V Core, 1.8V/2.5V/3.3V Bus I/O**



Availability

- Temperature Range: -40°C to +85°C
- Available packages: 176QFP and 196BGA
- Pricing starting at $7.50 10K suggested resale

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New ColdFire MCUs
At a glance

Complimentary Enablement	Part Number	Key Features	Package	LCD	Performance	Pricing*
▶CodeWarrior for ColdFire v7.0 with Processor Expert ▶Linux BSP with Nano X	•MCF52277	▶ColdFire V2 Core, LCD Controller, 8ch 12-bit ADC, Touch screen controller, 128K SRAM, USB otg, CAN	▶196BGA	▶18-bit	▶160MHz	▶$7.50

Enhanced Out of Box DVD Code Examples App. Notes	M52277EVB *MCF5227x Full EVB*	$449

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MCF5227x Example Applications

Consumer

Operator interfaces • security systems • HVAC control systems • digital picture frames

Industrial / Medical

Factory maintenance systems • diagnostic equipment • medical monitoring equipment • handheld point of sale • badge printers

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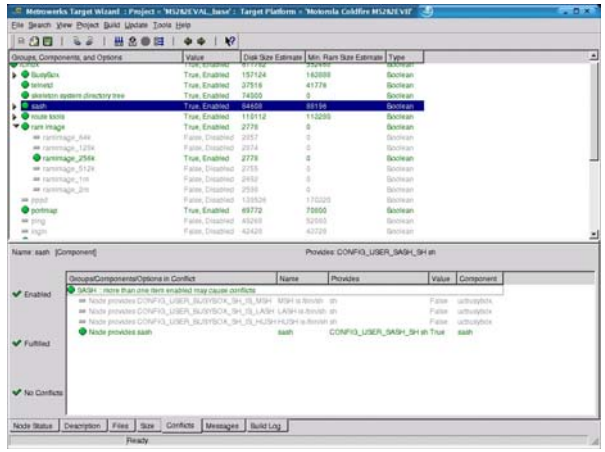
Freescale Complimentary Linux BSP

MCF5227x
Freescale Linux BSP

RTC	USB Host & Device	General Purpose Timers	LCD (NanoX)
NOR Flash	NFS	UART	JFFS2
1.3 Uboot	ADC / Touchscreen	ROMFS	eDMA

Kernel Linux 2.6.23	GNU Tools GCC binutils	User Space Busybox Gdbserver Strace



Interfaces with CodeWarrior Linux Tools

CodeWarrior for ColdFire ISA Linux Professional Edition

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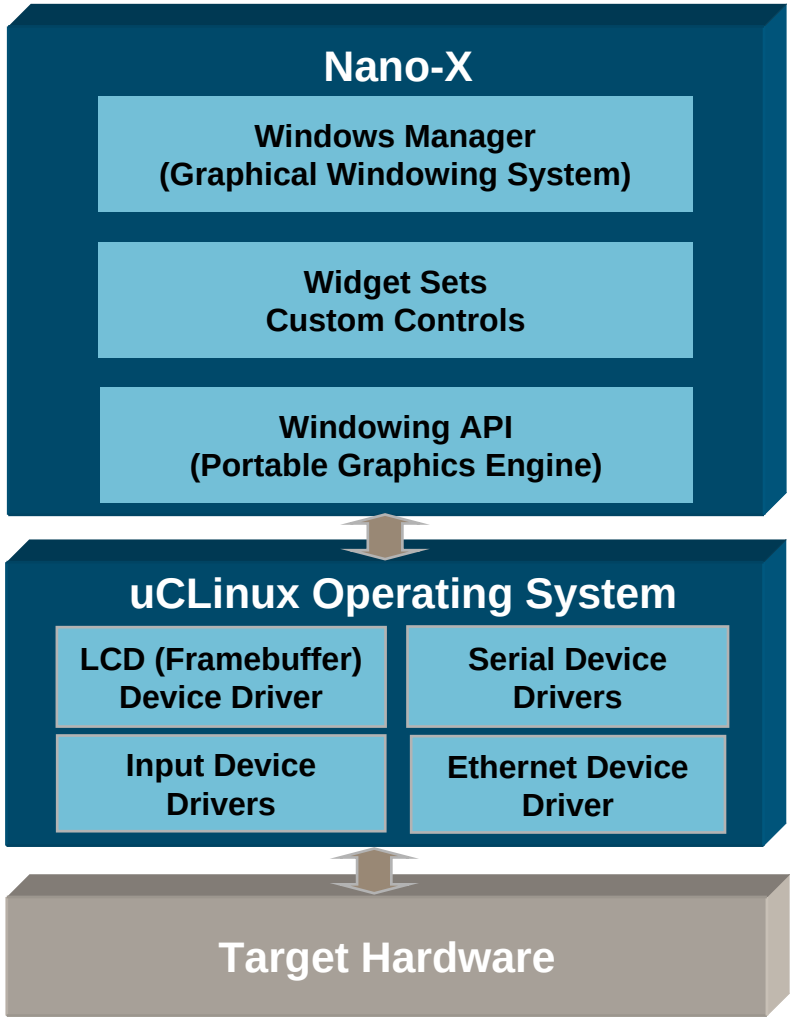
MCF5227x Open Source LCD Development Solutions

- Nano-X Windows System is a Linux/uCLinux based open source tool to support GUI development on Embedded systems
- Nano-X allows applications to be built and tested on the Linux desktop, as well as cross-compiled for the target device.
- Designed to be portable and run on a variety of hardware and software environments



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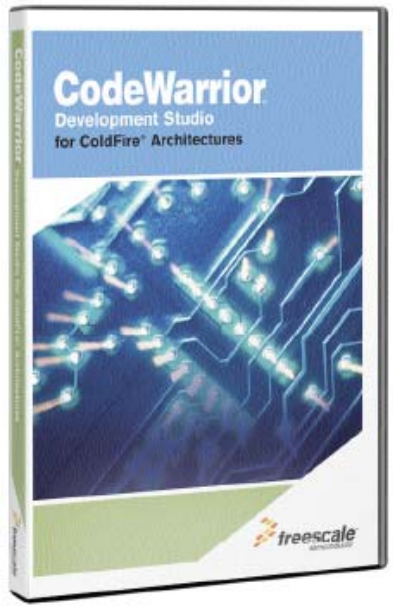
CodeWarrior® Development Studio for ColdFire Architectures V7.0

► Ease development with CodeWarrior® for ColdFire 7.0

- ***Startup Dialog*** – provides immediate access to Project Wizard, Example projects and Previous projects
- ***Project Wizard*** – allows quick project setup for specific derivative or evaluation board
- New ***build system*** with optimizing compiler and embedded libraries increases code density and performance
- ***Device Initialization*** – provides graphical interface to configure CPU and peripheral registers and then generates the necessary initialization code
- ***Processor Expert™*** – provides rapid application design and eases migration between Freescale devices



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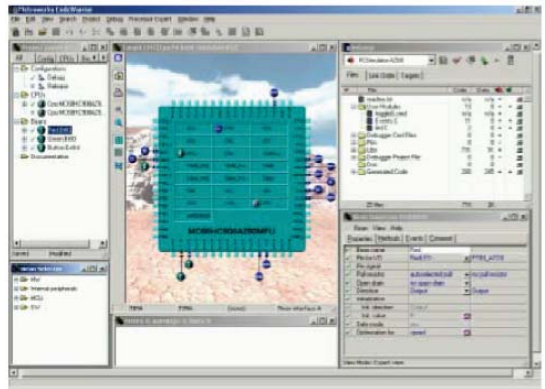
Processor Expert™ now supports ColdFire

Processor Expert™is a rapid application design tool integrated into the CodeWarrior V7.0 tool suite which combines easy-to-use component-based application creation with an expert knowledge system.

- Includes:
  - Graphical User Interface – allowing applications to be specified by the functionality needed
  - Automatic code generator – creating tested, optimized C code tuned to your application needs and selected Freescale device
  -
  - Built-in knowledgebase – immediately flagging resource conflicts and incorrect settings, so errors are caught early in design cycle allowing you to get to market faster with higher quality product



- Hardware Abstraction Layer (HAL) eases migration between Freescale devices

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Development Tools and Support

See for yourself – Evaluate the performance of ColdFire

- M52277EVB Full Evaluation Platform
  - Includes 3.5" TFT LCD display with 4-wire touch screen
  - Memory:
    - 16 MBytes of NOR Flash
    - 16 MBytes of 1.8V mobile DDR SDRAM
    - 2 MByte serial boot flash
  - USB, serial, CAN, and audio interfaces

Learn Quicker, Develop Faster – right out of the box

- Evaluation platforms come with everything you need to jump start development
- In-box DVD enhances the experience with an easy to use interface
  - CodeWarrior for ColdFire 7.0 Special Edition
  - Access to complimentary Open Source Linux BSP
  - Out of the Box Walkthroughs – get up and running in minutes
  - Application Examples and Application notes

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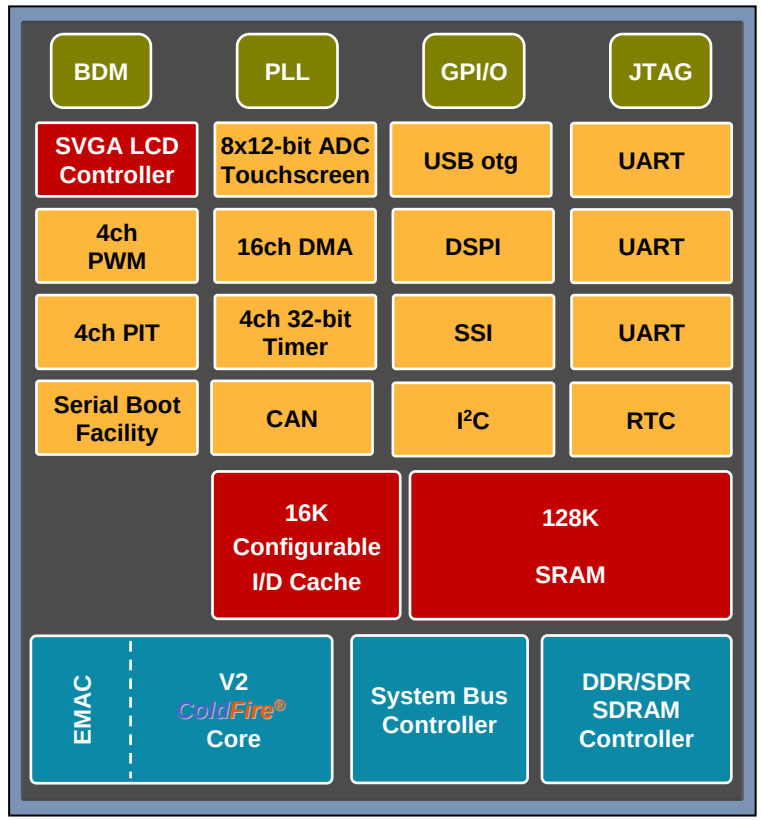
68K/ColdFire®: MCF5227x LCD Controller

- Support for single screen monochrome or color LCD panels:
  - Black and white
  - Grey-scale
  - Passive-matrix color (passive color or CSTN)
  - Active-matrix color (active color or TFT)
- Support for Self-refresh type LCD panels
- Maximum supported panel size of 800x600 pixels
- 128KB on-chip SRAM can be used as the graphic buffer for QVGA panels with 8bpp color or less



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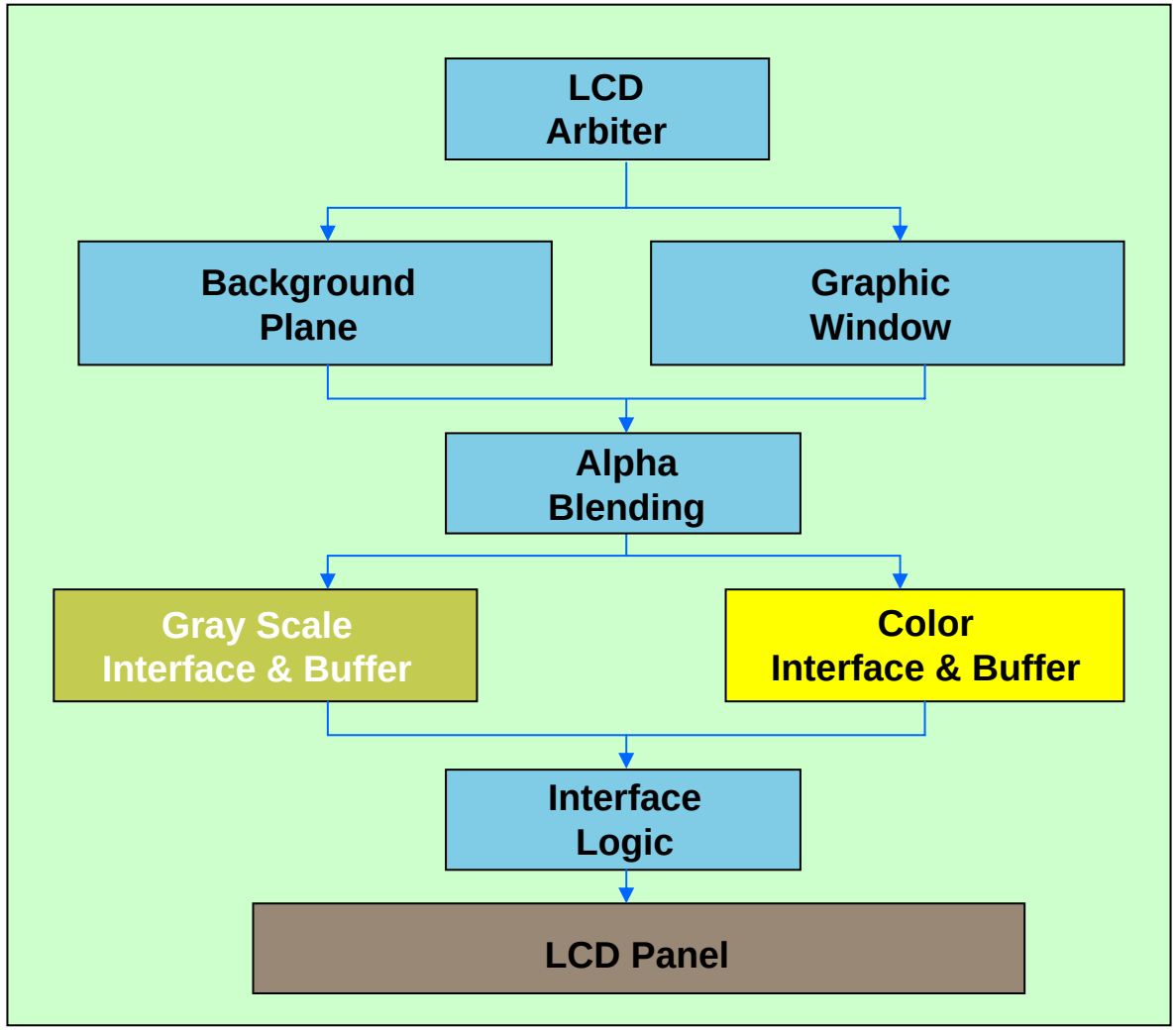
LCD Controller Block Diagram



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LCD Panels Supported by the MCF5227x

Panel Type	BPP	Panel Interface (bits)	Number of Levels
Monochrome	1	1, 2, 4, 8	Black-and-white
	2	1, 2, 4, 8	4 grayscale levels
	4	1, 2, 4, 8	16 grayscale levels
CSTN	4, 8	12	16, 256 out of a palette of 4096
	12	12	4096
TFT	4, 8	18	16, 256 out of a palette of 256K
	12, 16, 18	12, 16, 18	4096, 64K, 256K

LCD System Considerations

- There are two main system considerations when designing with an LCD
  - Memory usage
    - The panel size and bits per pixel determine the amount of memory needed to hold the graphic buffer.
    - In some cases twice as much memory (or more might be needed). It is typical to use one graphic buffer to store the current image while a second buffer containing the next image is prepared.
  - Bus bandwidth usage
    - While enabled the LCD will continuously fetch data from the graphic buffer.
    - The bandwidth required by the LCD is based on the pixel clock rate (LSCLK) and the number of bits per pixel

LCD Memory Requirements

Panel Resolution	Total Pixels	BPP (MemoryPP)	Required Memory
800x600 (SVGA)	480K	18bpp (32bpp)	1920KB
		16/12bpp (16bpp)	960KB
		8bpp (8bpp)	480KB
		4bpp (4bpp)	240KB
		2bpp (2bpp)	120KB
		1bpp (1bpp)	60KB
640x480 (VGA)	307.2K	18bpp (32bpp)	1228.8KB
		16/12bpp (16bpp)	614.4KB
		8bpp (8bpp)	307.2KB
		4bpp (4bpp)	153.6KB
		2bpp (2bpp)	76.8KB
		1bpp (1bpp)	38.4KB

LCD Memory Requirements (continued)

Panel Resolution	Total Pixels	BPP (MemoryPP)	Required Memory
320x240 (QVGA)	76.8K	18bpp (32bpp)	307.2KB
		16/12bpp (16bpp)	153.6KB
		8bpp (8bpp)	76.8KB
		4bpp (4bpp)	38.4KB
		2bpp (2bpp)	19.2KB
		1bpp (1bpp)	9.6KB

LCD Bus Bandwidth Usage

Panel Resolution	Typical LCD pixel clock frequency	Color Depth (BPP)	Max LCD Bus Bandwidth	SDRAM Read Through-put	Percentage of SDRAM Throughput Used by LCD
800x600 (SVGA)[1]	35-42 MHz (26.66 MHz)	18 bpp	140-168 (106.64)	128	**109.4%–131.25% (83.3%)**
		12/16 bpp	70–84 (53.32)	128	**54.7%– 65.6% (41.66%)**
		8 bpp	35–42 (26.66)	128	**27.3%–32.8% (20.8%)**
		4 bpp	17.5–21 (13.33)	128	**13.67%–16.4% (10.4%)**
640x480 (VGA)	24.3–26.1 MHz	18 bpp	97.2–104.4	128	**75.9%–81.56%**
		12/16 bpp	48.6–52.2	128	**37.9%—40.8%**
		8 bpp	24.3–26.1	128	**18.98%–20.4%**
		4 bpp	12.15–13.05	128	**9.5%–10.2%**
320x240 (QVGA)	4.5–6.8 MHz	18 bpp	18–27.2	128	**14.1%–21.3%**
		12/16 bpp	9–13.6	128	**7.0%–10.6%**
		8 bpp	4.5–6.8	128	**3.5%–5.3%**
		4 bpp	2.25–3.4	128	**1.76%–2.66%**

1 Currently, the ColdFire processors that include the graphical LCDC support a maximum pixel clock frequency of 26.66MHz; therefore, most SVGA panels cannot be configured for the recommended screen refresh rate. Bus bandwidth calculations for the max allowable 26.66MHz clock rate are shown in parentheses.

LCD Bus Bandwidth

- The amount of data the LCD needs to move is based on the pixel clock frequency and the number of bits per pixel.
- The SDRAM read throughput is the measured throughput for continuous read bursts from a 32-bit wide single data rate (SDR) SDRAM with a CAS latency of two clocks.
- These throughput calculations assume that the burst control register (BCR) is set to 0x3FF to allow non-core bus masters to request burst accesses. If the BCR is not set to 0x3FF the SDRAM read throughput available to the LCD controller is significantly decreased (about half what is shown in the table).

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MCF5227x LCD Lab

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MCF5227x Lab Objectives

- Lab 1: LCD Demo
  - Working LCD demo code to see what screen should look like
- Lab 2: LCD and DMA
  - See how two bus masters (LCD controller and DMA) interact to use the available system bus bandwidth
- Lab 3: Crossbar Switch
  - Demonstrate how the crossbar priority affects the allocation of system bus bandwidth
- Lab 4: Burst Control Register
  - Learn how enabling bursting for non-core masters impacts the system bus bandwidth

MCF5227x Lab Results

- Once DMA is added, the LCD stops working. This happens because, by default, the DMA is given a higher priority for obtaining mastership of the bus than the LCD controller.
- The crossbar switch can be reprogrammed to give the LCD controller priority. The LCD will work correctly in this configuration, but the DMA will have less bandwidth available (almost a 60% decrease in bandwidth for the DMA).
- Writing to the burst control register to allow bursting by non-core masters helps to increase the bus bandwidth available to the LCD and DMA. Now the DMA only loses about 35% of the bandwidth from the first LCD and DMA test.

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MCF5227x Touchscreen Controller

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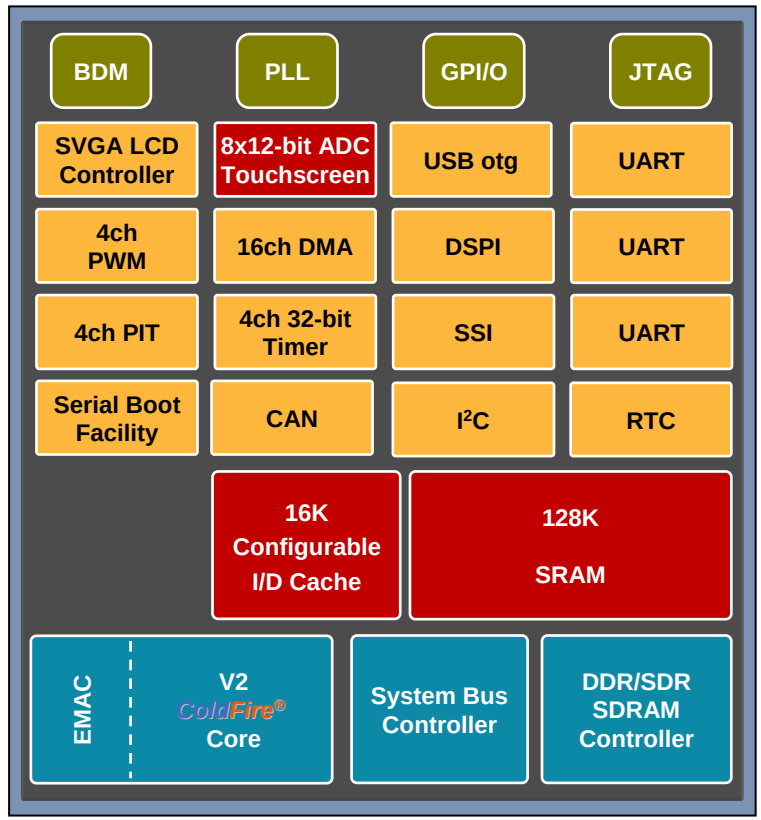
68K/ColdFire®: MCF5227x Touchscreen Controller

- Full touchscreen controller including an 8-channel, 12-bit ADC and digital logic to bias touchscreens
- Supports commonly found resistive touchscreen interfaces:
  - 4-wire
  - 5-wire
  - 7-wire
  - 8-wire
- Channels that aren't used for touchscreen can be used as general ADC inputs



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Touchscreen Controller Connections

MCF5227x Pin	4-wire	5-wire	7-wire	8-wire
ADC_IN0	X+/XL[1]	UL	ULforce	X+sense[1]
ADC_IN1	X-/XR	UR	UR	X-sense
ADC_IN2	Y+/YU[1]	LL	LL	Y+force
ADC_IN3	Y-/YD	LR	LRforce	Y-force
ADC_IN4		Wiper/Sense[1]	Wiper/Sense[1]	Y+sense[1]
ADC_IN5			ULsense	Y-sense
ADC_IN6			LRsense	X+force
ADC_IN7				X-force

1 This pin is used for input channel measurement of the X coordinate, Y coordinate, or both.

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MCF5227x Demos

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MCF5227x Demos

- Touchscreen demo
  - This CodeWarrior project is a simple drawing application demonstrating the use of the touchscreen.

- Photo album demo
  - Shows use of the LCD controller's alpha blending capability. The background plane and graphic window are used to display two different images. Changing the alpha blending value allows for a smooth transition between the two images.

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Question and Answer

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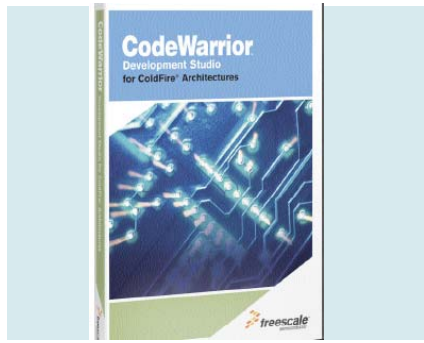
Additional Learning

- **Learn more at freescale.com/coldfire**
  - **AN3606: Understanding LCD Memory and Bus Bandwidth Requirements**
  - **AN3632: Using the Touch Screen Controller on the MCF5227x**



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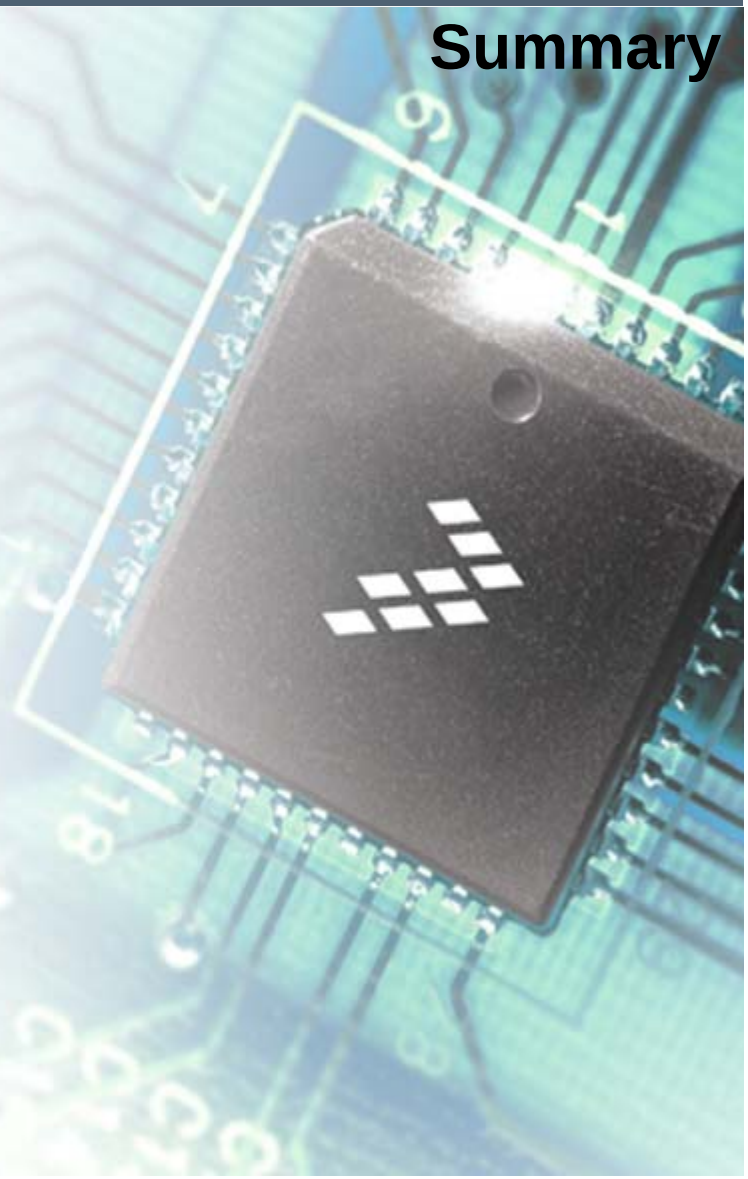
Summary

- MCF5227x solution provides:
  - LCD and touch screen **control** for human interface applications
  - Additional **performance** for embedded control applications (up to 160MHz)
  - **Flexibile communication** options for industrial control applications (CAN and USB controllers)
  - **Open source software** (Linux, NanoX, SDIO stack, etc.)
  - **Complete development tool suite**
    - CodeWarrior for ColdFire v7.0
    - Processor Expert
    - Evaluation Board
- LCD bus and memory usage have an impact on overall system performance. Care should be taken to understand the LCD requirements and minimize the impact to other bus masters.
- Development tools, samples, boards and additional support resources are available at http://www.freescale.com/coldfire



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Related Session Resources

Session Location – Online Literature Library

http://www.freescale.com/webapp/sps/site/homepage.jsp?nodeId=052577903644CB

Sessions

Session ID	Title

Demos

Pedestal ID	Demo Title


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