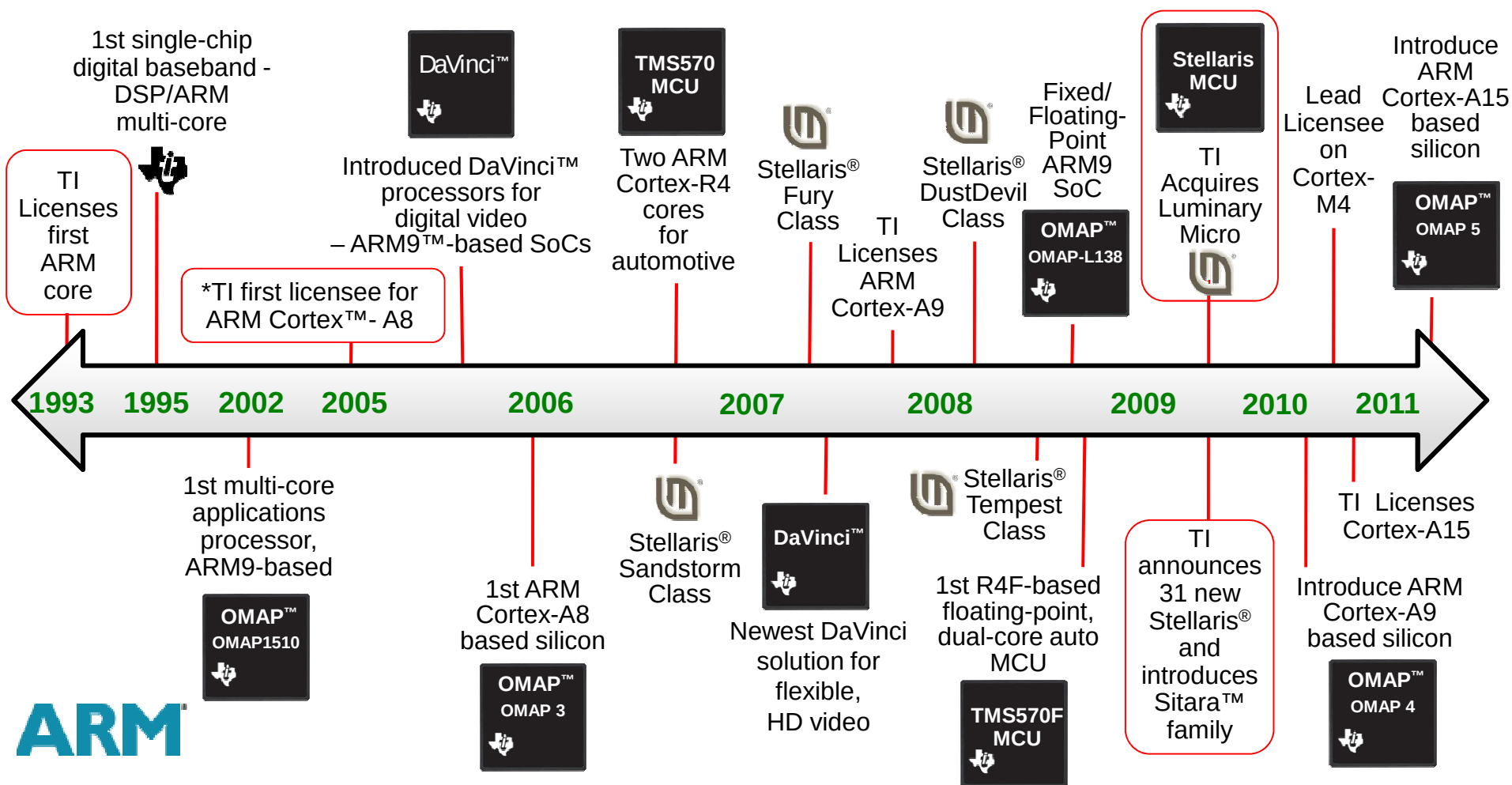




Stellaris® ARM® Cortex™-M4F

40 years with Microcontrollers!

TI ARM® investment and innovation



TI has shipped over 6 billion ARM-based products and continues to invest in a large portfolio of scalable platforms from \$1 to >1GHz

* TI licensed in July 2003, but publicly announced Oct 2005.



Introduction to the Cortex-M4F

Cortex M core: ARM series

- ARM Cortex provides a range of solutions
- Different series aligning technology around specific applications
- 3 series implementing the Thumb-2 instruction set:
 - **ARM Cortex-A Series (AM335x, etc)**
 - Applications processors for complex OS and user applications.
 - Supports the ARM, Thumb and Thumb-2 instruction sets
 - **ARM Cortex-R Series (TMS570, RM48, etc)**
 - Embedded processors for real-time systems.
 - Supports the ARM, Thumb, and Thumb-2 instruction sets
 - **ARM Cortex-M Series (Stellaris, TMS470, etc)**
 - Deeply embedded processors
 - optimized for cost sensitive applications.
 - Supports the Thumb-2 instruction set only

Note:

ARM Code 32-bit

Thumb Code 16-bit

Thumb-2 Code mostly 16-bit & some 32-bit (25% Faster, 26% Smaller)



Spanning the application range

- Forget traditional 8/16/32-bit classifications
 - ✓ Seamless architecture across all applications
 - ✓ Every product optimised for ultra low power systems

Cortex-M0

“8/16-bit” applications

Lowest cost
Optimised connectivity

Cortex-M3

“16/32-bit” applications

Performance efficiency
Feature rich connectivity

Cortex-M4

“32-bit/DSP” applications

MCU plus DSP
Accelerated SIMD, FP & DSP



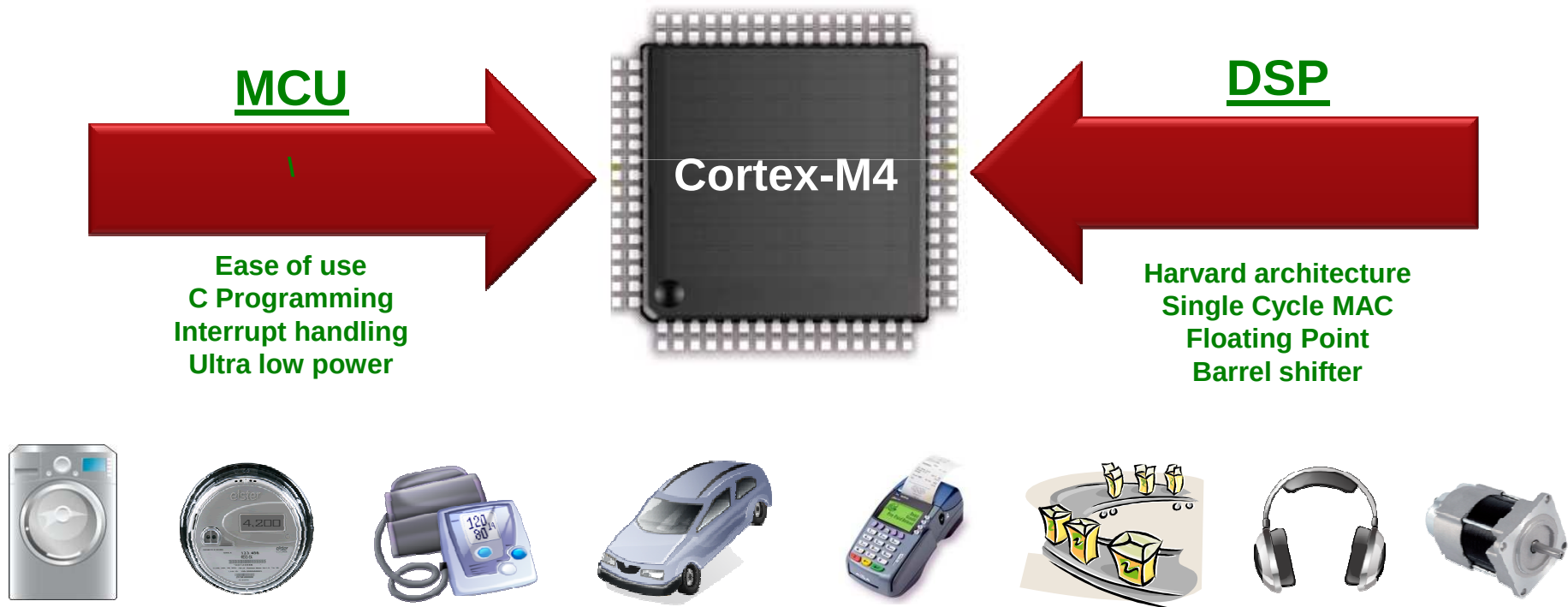
ARM Cortex-M class processors

- Developed to meet the needs of MCU users
 - *Designed from scratch to meet low power, high performance market requirements*
- ARM7TDMI is an excellent processor
 - *But developed over 15 years ago, and user expectations continue to evolve*

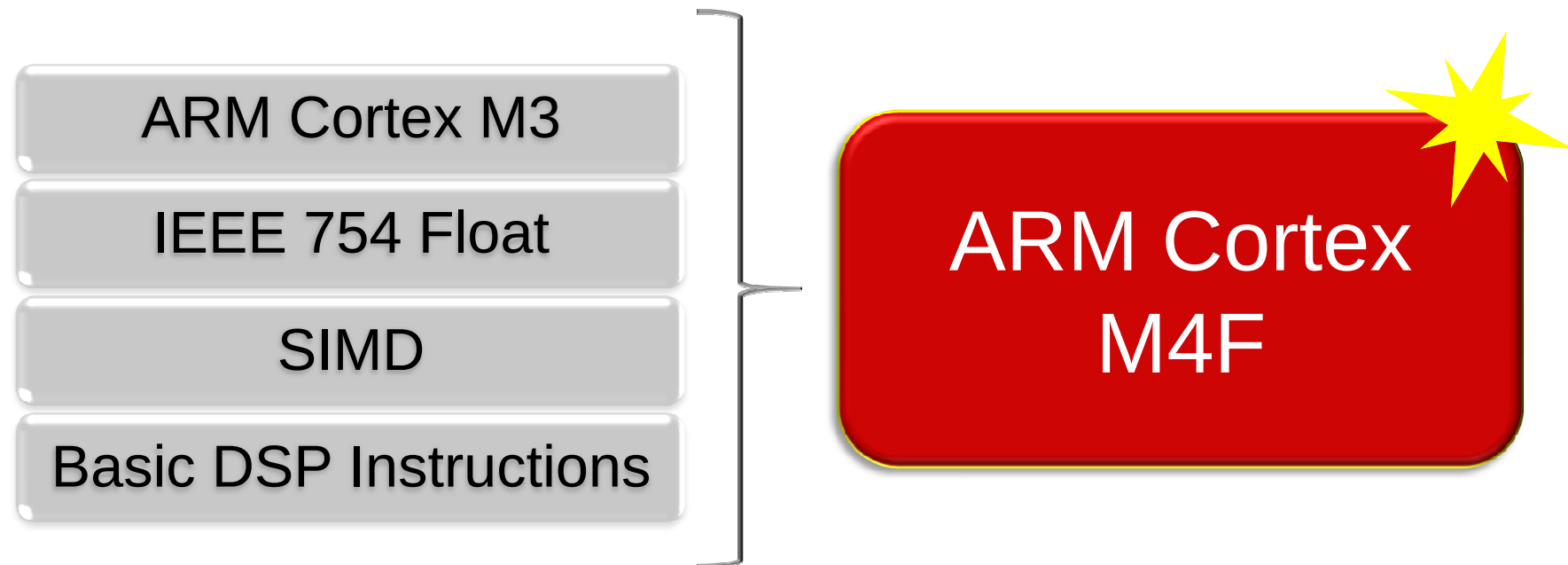
ARM7TDMI	Cortex-M class
No standard interrupt controller IRQ and FIQ interrupts too limited.	Integrated Nested Vectored Interrupt Controller Configurable up to 240/32 interrupts ✓
Entering ISRs is not deterministic Takes between 20 - 50 cycles.	H/W stacking ensures deterministic ISR entry LSMs are interruptible and continuable. ✓
Significant assembler code required for all interrupts, exceptions and start-up code	No assembler required State manipulation handled in hardware. ✓
Software development requires interworking Compile and transition between ARM and Thumb code	Thumb-2 simplifies development ✓
Lack of standardization inhibits apps porting No standard Memory Map or Interrupt Controller	NVIC, SysTick & Memory Map defined Integrated into core enabling better code reuse ✓

Cortex-M4 extends MCU market range

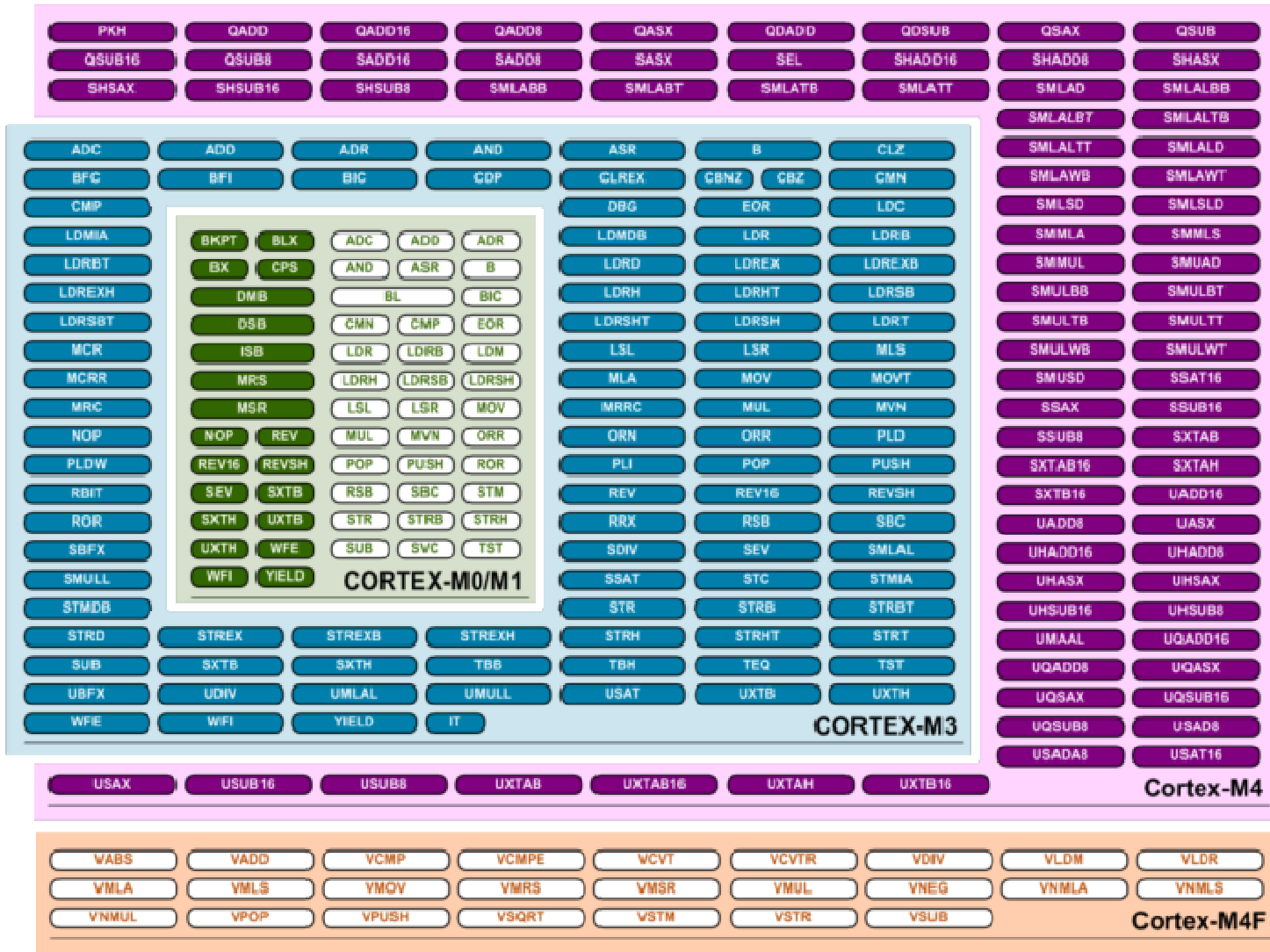
- Cortex-M4 expands opportunities up and to the right
 - ✓ Leverages all existing Cortex-M technology, capabilities, benefits
 - ✓ Adds differentiating signal processing technology, floating point



Cortex-M4F Benefits (wrt M3)



Stellaris LM4Fx is ISA-compatible with LM3Sx



Cortex M4F Enhances Audio

Application	Cortex-M4F vs. Cortex-M3
Audio – window overlap & add	1.8-2.6x Faster
FIR Filter	2x Faster
IIR Filter	2x-3x Faster
MP3 Decode	2x Faster, 15% code reduction
WMA Decode	1.6x Faster, 9% code reduction
Audio Post Processing	2x Faster, 20% code reduction

Cortex M4F Enhances Motor Control

Application	Cortex M4F vs. Cortex M3
Motor Control – Clarke Transform	5x Faster
Motor Control – Park's Transform	7x Faster
PID	4x Faster

Cortex M4F Enhances DSP

Application	Cortex M4F vs Cortex M3
FFT	2x Faster
Matrix Multiplication	4x Faster
Correlation (Floating Point)	10x Faster

Cortex-M feature set comparison

	ARM7TDMI	Cortex-M0	Cortex-M3	Cortex-M4
Architecture Version	v4T	V6M	v7M	v7ME
Instruction set architecture	ARM, Thumb	Thumb, Thumb-2 System Instruction	Thumb + Thumb-2	Thumb + Thumb-2, DSP, SIMD, FP
DMIPS/MHz	0.72 (Thumb), 0.95 (ARM)	0.9	1.25	1.25
Bus interfaces	None	1	3	3
Integrated NVIC	No	Yes	Yes	Yes
Number interrupts	2 (IRQ and FIQ)	1-32 + NMI	1-240 + NMI	1-240 + NMI
Interrupt priorities	None	4	8-256	8-256
Breakpoints, Watchpoints	2 Watchpoint Units	4/2/0, 2/1/0	8/4/0, 2/1/0	8/4/0, 2/1/0
Memory Protection Unit (MPU)	No	No	Yes (Option)	Yes (Option)
Integrated trace option (ETM)	Yes (Option)	No	Yes (Option)	Yes (Option)
Fault Robust Interface	No	No	Yes (Option)	No
Single Cycle Multiply	No	Yes (Option)	Yes	Yes
Hardware Divide	No	No	Yes	Yes
WIC Support	No	Yes	Yes	Yes
Bit banding support	No	No	Yes	Yes
Single cycle DSP/SIMD	No	No	No	Yes
Floating point hardware	No	No	No	Yes
Bus protocol	Use AHB bus wrapper	AHB Lite	AHB Lite, APB	AHB Lite, APB
CMSIS Support	No	Yes	Yes	Yes



Introduction to the *Stellaris* ARM Cortex-M4F

Stellaris® MCUs – Versatile, Connected, Compact

Connectivity



Data Acquisition



Home Automation



Medical Connectivity



Serial-to-Ethernet
Bridge

Automation



Automated Motor Control



Home Automation



Human Machine Interface



Advanced
Remotes



Touch Interface

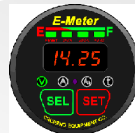


Graphics Displays

Point of Sale



White goods



Electricity and
Flow metering

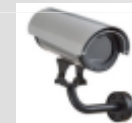
Exercise
Equipment



HVAC
Pump inverter
Compressor motor



Security Monitoring



Biometric
Scanning



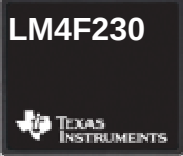
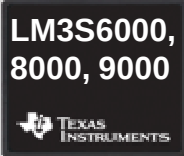
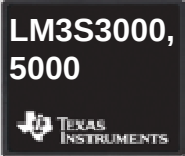
Networked
Access Control



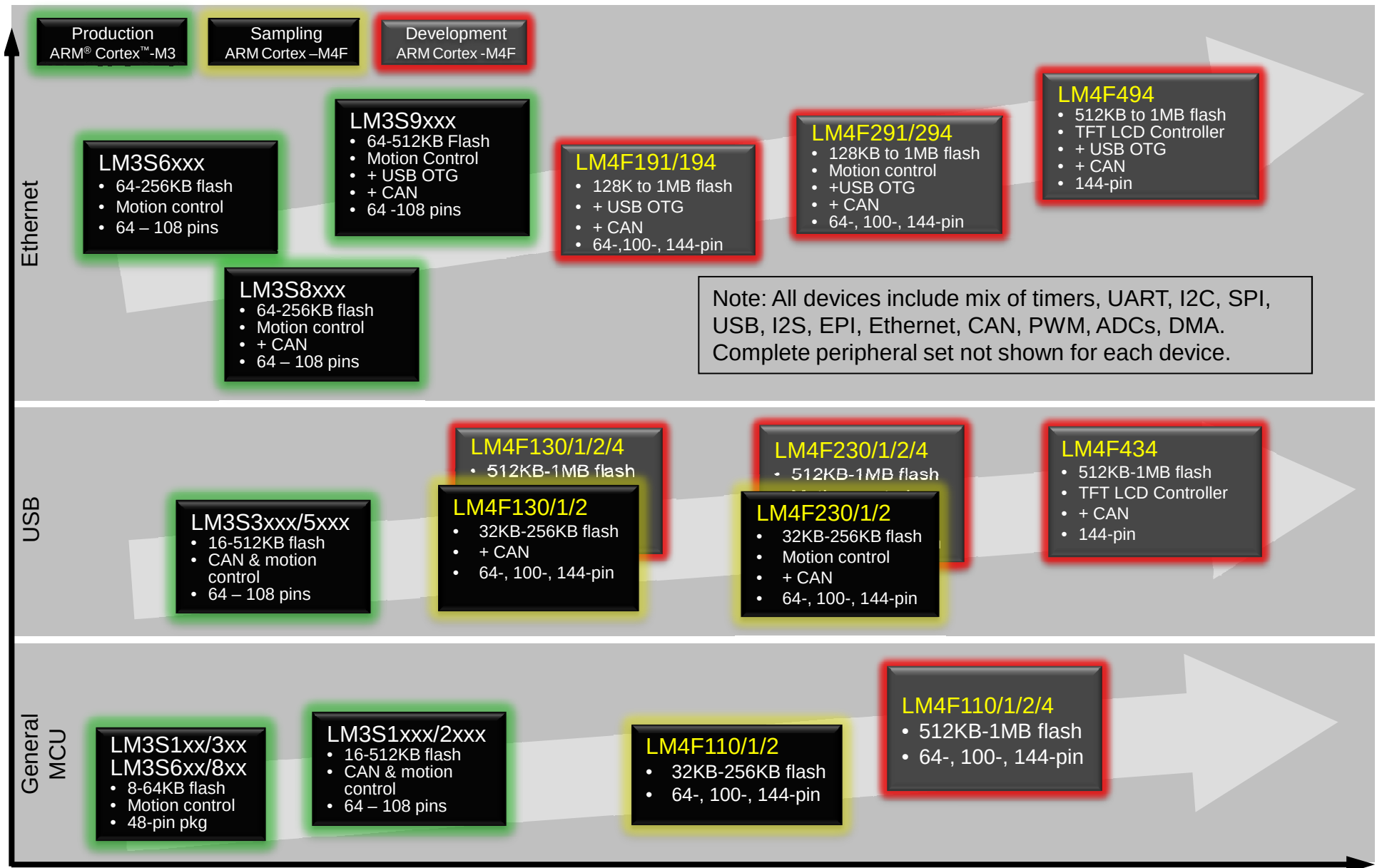
LED signage



Stellaris[®] Product Portfolio

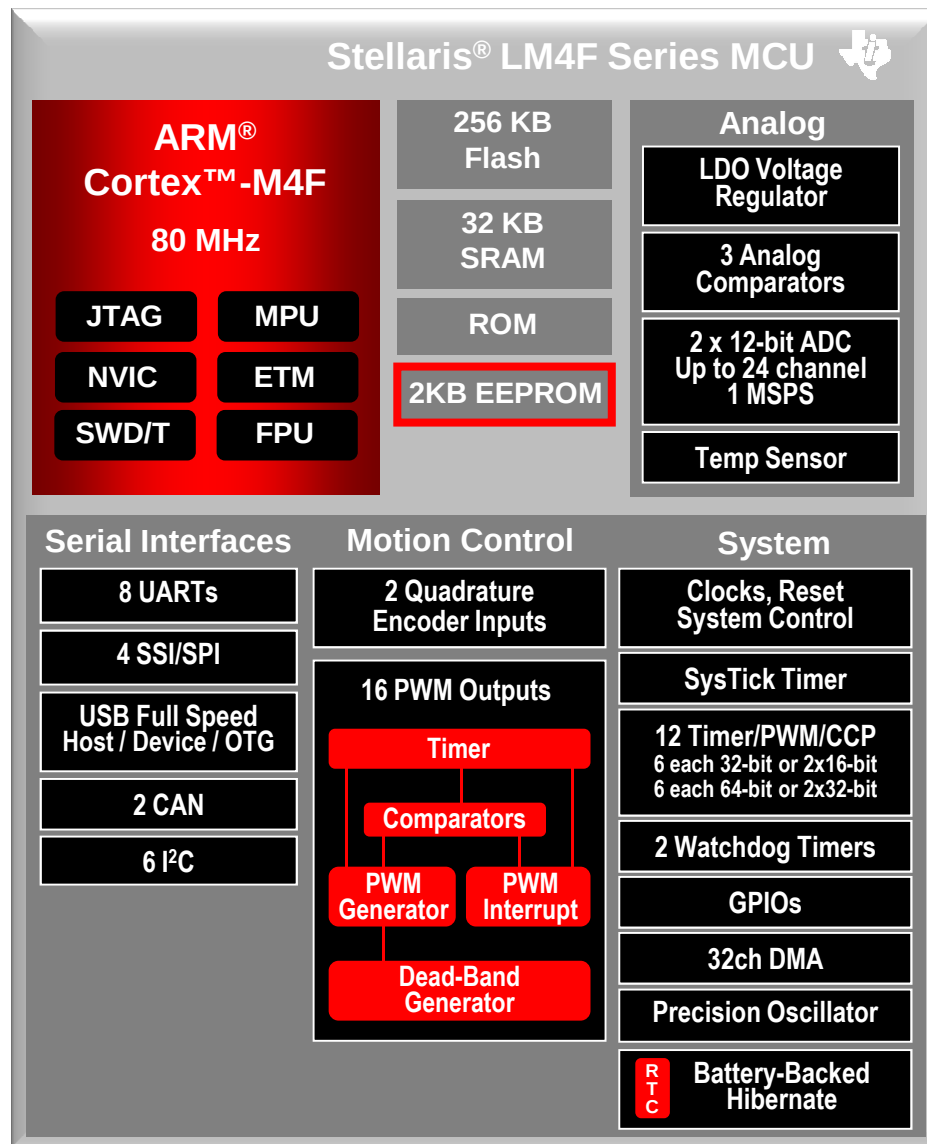
Stellaris [®] ARM [®] Cortex [™] -M4F	 LM4F230 Motion Control [+CAN, +USB] (\$3.61- \$4.84) [10KU pricing]	Key Features - Floating point perf. - Best-in-class power - Up to 12-bit ADCs - Full-speed USB - CAN Open support - Motion control PWMs	Applications - Industrial Automation - Microprinters - Motor control - Low-end Digital Power Control	SW & Kits  EK-LM4F232 For the full list visit www.ti.com/stellariskits
	 LM4F110, 120, 130 Gen Purpose [+CAN, +USB] (\$1.53- \$4.74)	Key Features - Floating point perf. - Best-in-class power - Up to 12-bit ADCs - Full-speed USB - CAN Open support	Applications - System Management Control - Portable Medical - Data logging - Lighting control - Scanners	
Stellaris [®] ARM [®] Cortex [™] -M3	 LM3S6000, 8000, 9000 ENET [+CAN, +USB] (\$4.35- \$9.15)	Key Features - Integrated 10/100 ENET MAC & PHY - Up to 12-bit ADCs - Full-speed USB - External Bus Interface	Applications - HMI displays - Industrial Automation - Communication Gateways - Point of Sale	 DK-LM3S9D96
	 LM3S3000, 5000 USB [+CAN] (\$2.05- \$6.70)	Key Features - Full-speed USB - Up to 12-bit ADCs - I2S audio - CAN Open support - External Bus Interface	Applications - Gaming accessories - MFI-OS accessories - HMI displays - Motor control - Scanners	 EK-LM3S3748
	 LM3S100, 1000, 2000 Gen Purpose [+CAN] (\$1.90- \$5.50)	Key Features - Up to 12-bit ADCs - External Bus Interface - Small footprint - CAN Open support - Motion control PWMs	Applications - Home appliances - Industrial automation - e-Metering - Motor control - LED signage	 EK-LM3S811

Stellaris® Roadmap



Product Preview – Subject to Change

More than 40 MCUs starting at \$1.50 @10K



High-performance analog integration

- Two 1 MSPS 12-bit ADCs
 - No hardware averaging required
- Three analog comparators

Prolific connectivity features:

- CAN, USB H/D/OTG, SPI, I²C, UARTs

Lowest-power Stellaris MCUs

- Standby current as low as 1.6 μ A
- Active RTC modes as low as 1.7 μ A
- Wakeup times of 500 μ s or less
- Built on TI-proprietary 65nm technology

TI's 65nm Flash Process for Stellaris LM4F

- The LM4F family of devices is based on TI's 65nm flash and analog process
- TI's 65nm CMOS process
 - Developed for optimal performance and high density products
 - Qualified in 2005
 - >200M units shipped from six 300mm fabs
- Flash Process vs. the CMOS process
 - Development began in 2007
 - Driven by automotive, 0DPPM, Q100 product requirements
 - First 2MB flash samples delivered 4Q2009 to a large OEM with high quality standards
 - Auto qualification - 4Q2011
 - Commercial products from TI, announced in 2011:
 - **Concerto (Cortex-M3 + C2000 double core MCUs)**
 - **Blizzard (Cortex-M4F)**
 - **Hercules (Cortex-R4F double core MCUs)**

Low power on Stellaris LM4F

- **Lowest-power Stellaris MCUs**

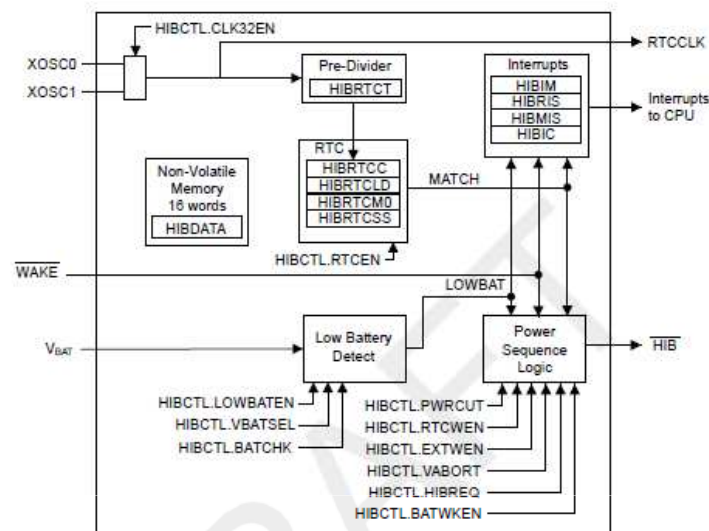
- Built on TI-proprietary 65nm technology
- Wakeup times of 500 us or less
- Active currents as low as 370 $\mu\text{A}/\text{MHz}$
- Standby modes as low as 1.6 μA

- **Intelligent Design**

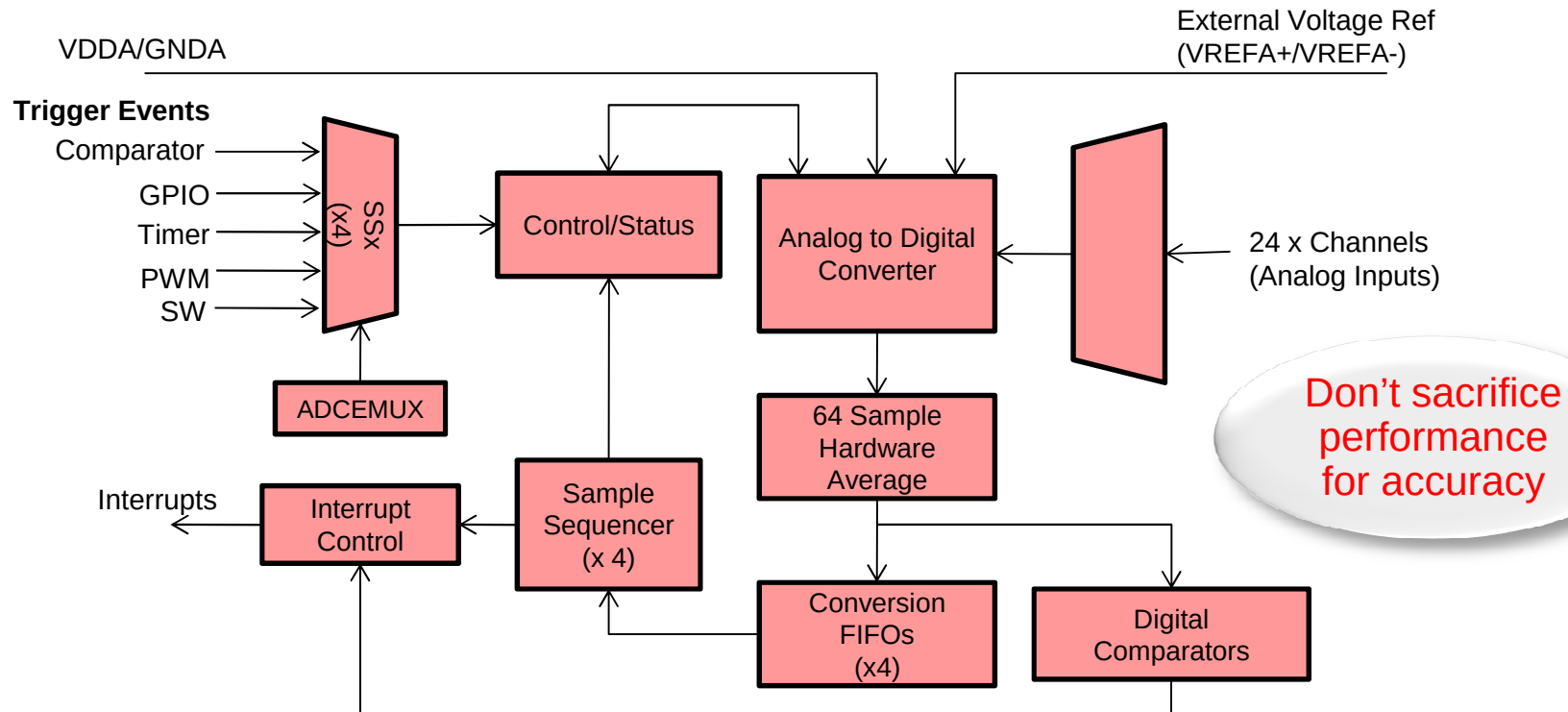
- Dedicated wake pin
- Retain your application state using 64 bytes of backup battery RAM
- Maintain your system state by retaining the state of the GPIO pins

- **Easy to use**

- Pick your wake events: RTC match, external wake, or low-battery detect
- Best-practice reference design available on evaluation kit



Analog Integration on Stellaris LM4F



Integration that saves customers \$

- 12-bit ADC @ 1 MSPS
- Built-in temperature sensor ($\pm 5^{\circ}\text{C}$)
- Eight built-in digital comparators
- Supports single-ended & differential inputs
- Three built-in analog comparators (not shown)

Intelligent ADC design for lower power

- Programmable sample sequencers (SSx)
- Conversion FIFOs to store conversions
- Internal triggering from other peripherals
- Automatic DMA transfers on completion

Integrated EEPROM on Stellaris LM4F

- **Integration that saves customers \$**
 - 2KB of integrated EEPROM
 - Customer BOM savings up to \$0.30 cents
- **Intelligent Design**
 - Avoid SW polling by utilizing an interrupt indicating write completion
- **Secure and Reliable**
 - Up to 96-bit password protection for stored information
 - Built in wear-leveling allows up to 500K erasures of a single word



Get started in 10 minutes or less



EK-LM4F232: \$149

Easy to use evaluation kits

- All hardware and software to get started in 10 minutes or less
- Full peripheral functionality
- 96 x 64 color OLED display showcasing StellarisWare™ free license graphic libraries
- Example projects

Design in your preferred environment:

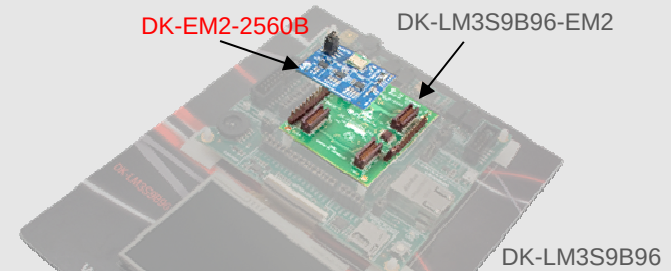
- Supported by 5 popular IDEs



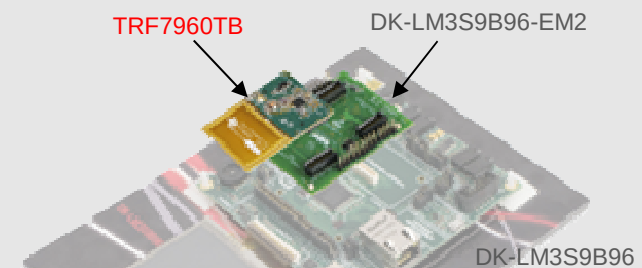
Code Composer Studio™ IDE

Complete, modular wireless solutions

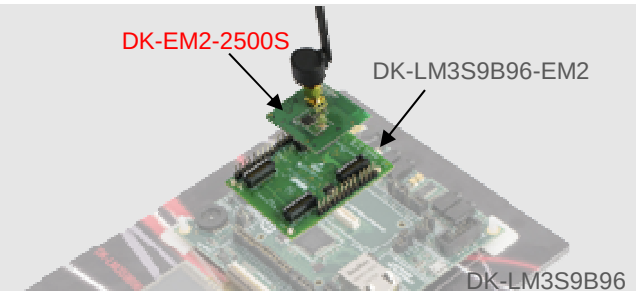
Stellaris® 2.4 GHz CC2560 *Bluetooth®* Kit



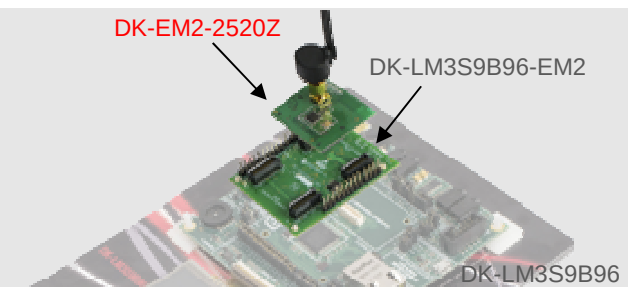
Stellaris 13.56MHz RFID Wireless Kit



Stellaris 2.4 GHz SimpliciTI™ Wireless Kit



Stellaris ZigBee® Networking Kit



Stellaris® Bluetooth® Networking Kit

DK-EM2-2560B

Key features

- Proven protocol software, example applications, and StellarisWare® support for Bluetooth v2.1+EDR
- Advanced Audio Distribution Profile (A2DP) with Example Application
 - Connect and stream audio from your Android™, Blackberry®, or iPhone®
- Serial Port Profile (SPP) Wire Replacement Example Application
 - Transmits accelerometer position data enabling drawing on DK-LM3S9B96 LCD screen
- Pairs with best-in-class performance Bluetooth transceiver
 - CC2560-PAN1325 module by Panasonic

Applications



- Cell phone accessories
- Mobile device accessories (iPod®, iPad®, etc.)
- Medical data aggregator
- Short-range serial communication replacement



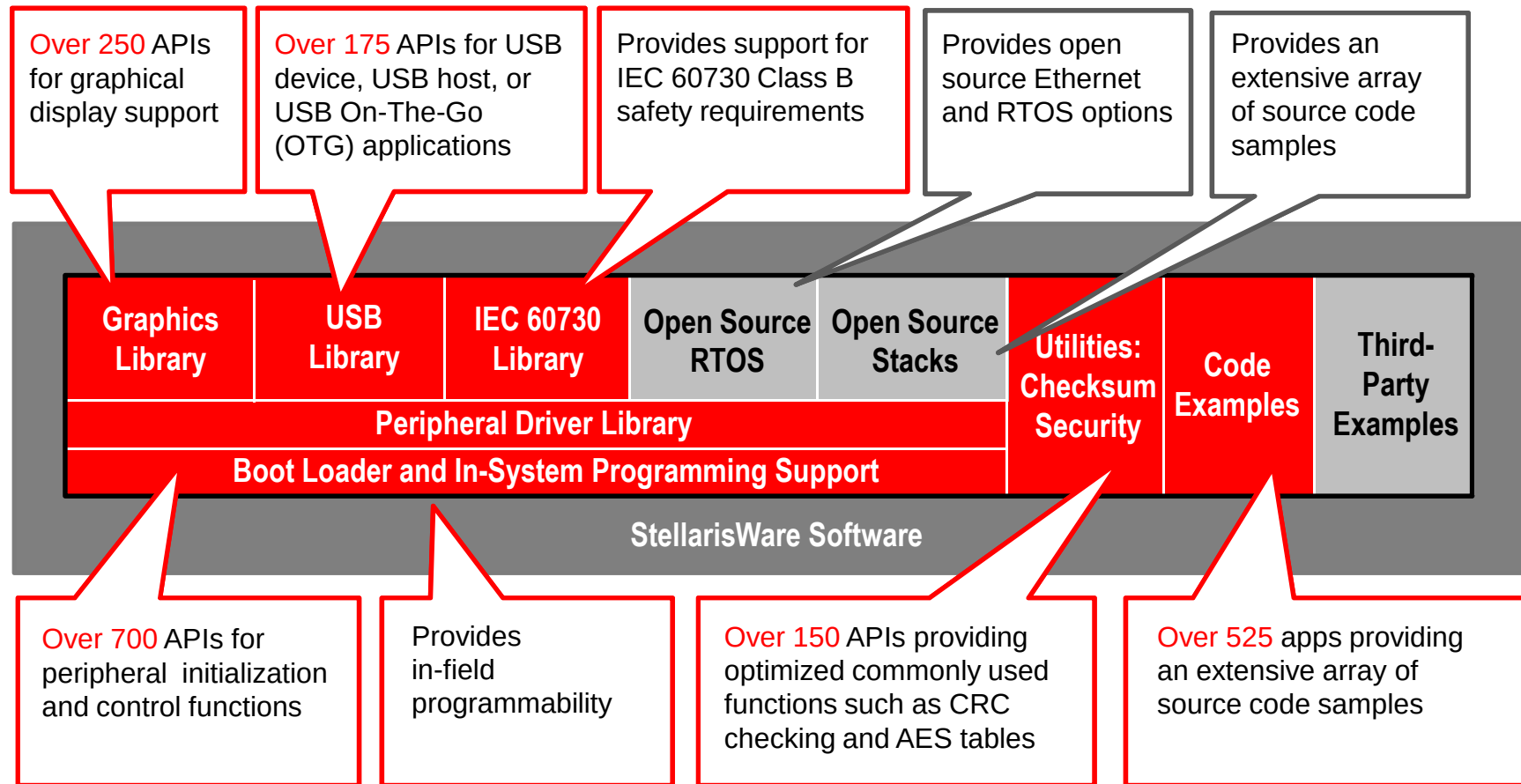
\$199 USD



StellarisWare® software



- All programming can be in C/C++, even interrupt service routines & startup code
- Includes code and royalty-free libraries for applications support



Peripheral Driver Library (DriverLib)

- High-level API interface to complete peripheral set
- *Free license and royalty-free use*
- Simplifies and speeds development of applications
- Can be used for application development or as programming example
- Available as object library and as source code
- Compiles on ARM/Keil, IAR, Code Red, and GNU tools
- Includes **Stellaris Graphics Library** and **Stellaris USB Library**
- **StellarisWare** is preprogrammed in ROM on most Stellaris MCUs

	<i>Analog Comparator</i>
www.ti.com	
3	Analog Comparator
Introduction	13
API Functions	13
Programming Example	19
3.1	Introduction
The comparator API provides a set of functions for dealing with the analog comparators. A comparator can compare a test voltage against individual external reference voltage, a shared single external reference voltage, or a shared internal reference voltage. It can provide its output to a device pin, acting as a replacement for an analog comparator on the board, or it can be used to signal the application via interrupts or triggers to the ADC to cause it to start capturing a sample sequence. The interrupt generation and ADC triggering logic is separate, so that an interrupt can be generated on a rising edge and the ADC triggered on a falling edge (for example). This driver is contained in driverlib/comp.c, with driverlib/comp.h containing the API definitions for use by applications.	
3.2	API Functions
Functions	
■ void ComparatorConfigure (unsigned long ulBase, unsigned long ulComp, unsigned long ulConfig) ■ void ComparatorIntClear (unsigned long ulBase, unsigned long ulComp) ■ void ComparatorIntDisable (unsigned long ulBase, unsigned long ulComp) ■ void ComparatorIntEnable (unsigned long ulBase, unsigned long ulComp) ■ void ComparatorIntRegister (unsigned long ulBase, unsigned long ulComp, void (*pfnHandler)(void)) ■ tBoolean ComparatorIntStatus (unsigned long ulBase, unsigned long ulComp, tBoolean bMasked) ■ void ComparatorIntUnregister (unsigned long ulBase, unsigned long ulComp) ■ void ComparatorRefSet (unsigned long ulBase, unsigned long ulRef) ■ tBoolean ComparatorValueGet (unsigned long ulBase, unsigned long ulComp)	
3.2.1	Detailed Description
The comparator API is fairly simple, like the comparators themselves. There are functions for configuring a comparator and reading its output (ComparatorConfigure(), ComparatorRefSet() and ComparatorValueGet()) and functions for dealing with an interrupt handler for the comparator (ComparatorIntRegister(), ComparatorIntUnregister(), ComparatorIntEnable(), ComparatorIntDisable(), ComparatorIntStatus(), and ComparatorIntClear()).	
SW-DRL-UG-4781 - June 30, 2009	<i>Analog Comparator</i> 13

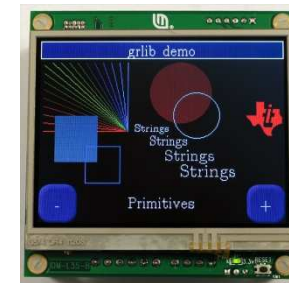
StellarisWare® USB Library

- **Free license & royalty-free** drivers plus example applications to accelerate USB implementation on Stellaris MCUs
- Examples available:
 - **Device Examples:**
 - HID Keyboard
 - HID Mouse
 - CDC Serial
 - Mass Storage
 - Generic Bulk
 - Audio
 - Device Firmware Upgrade
 - Oscilloscope
 - **Host Examples:**
 - Mass Storage
 - HID Keyboard
 - HID Mouse
 - Isochronous Audio Input
 - **OTG Examples:**
 - SRP (Session Request Protocol)
 - HNP (Host Negotiation Protocol)*
 - **Windows INF for supported classes**
 - Points to base Windows drivers
 - Sets config string
 - Sets PID/VID
 - Precompiled DLL saves development time
 - **Device framework integrated into USBLib**
- **USB Device Firmware Update (DFU) now available in ROM; just plug-in and reprogram your firmware!**
- TI sub-licenses Stellaris VID & PIDs for customer use

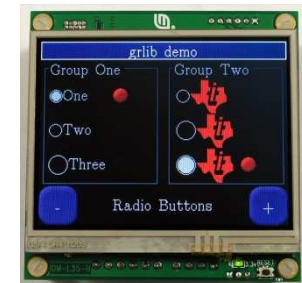


StellarisWare® Graphics Library

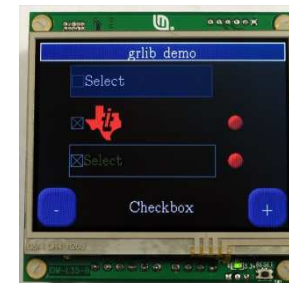
- Written entirely in C, easy-to-use, efficient.
- Three layers of functionality, each directly callable:
 - Display Driver Layer (Lowest Level)
 - Graphics Primitives Layer ...
 - Widget Layer (Highest Level)
- Graphics Primitives:
 - Point, Line, Rectangle, Circle, Font, Image, Context, Buffer
 - 134 Computer Modern predefined fonts
 - Western European and Asian fonts
 - Support for 24-bit color
- Widgets:
 - Canvas, Checkbox, Container, Push Button, Radio Button, Slider, ListBox



Primitives



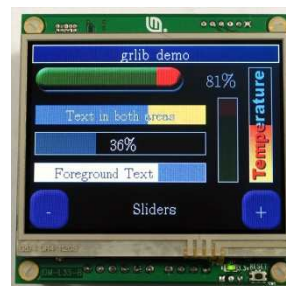
Radio Buttons



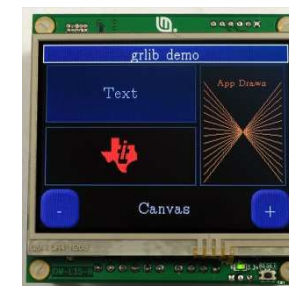
Checkbox



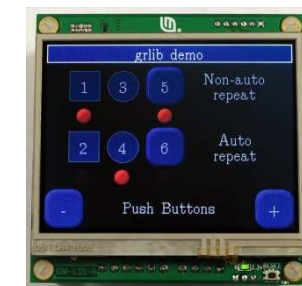
Container



Sliders



Canvas



Push Buttons

StellarisWare Graphics Library Examples



Primitives



Radio Buttons



Checkbox



Security Keypad



Canvas



Push Buttons



Container

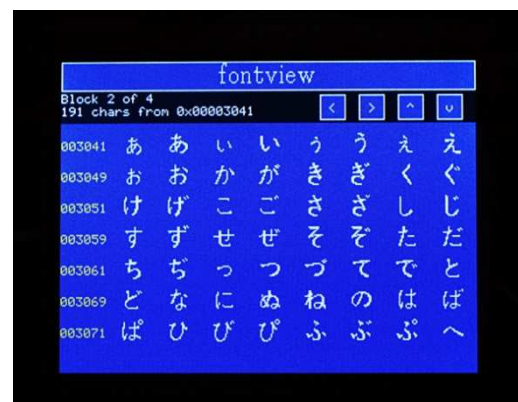
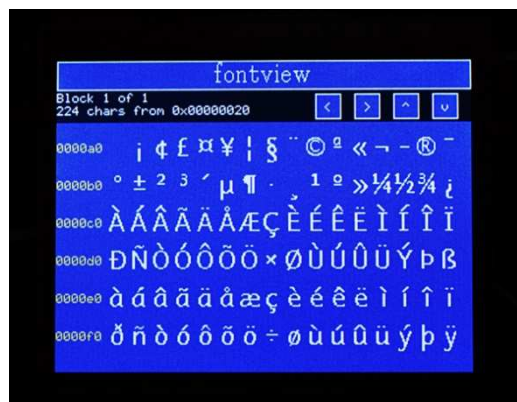


BLDC Touchscreen Motor Controller

StellarisWare® Graphics Library

Special Utilities

- *frasterize*: render your own font
 - *mkstringtable*: build multi-language string tables
 - *makefsfile*: dump binary files as C arrays
 - *lmi-button*: predefined button with shadow and 3-D
 - *pnmtoc*: Convert image file to GraphicsLib format
- **International Fonts**; program HMI in more languages
 - e.g. Chinese, Korean, Japanese ideographs, accented western European characters, etc.
 - Supports UTF8, ISO8859 and Unicode.

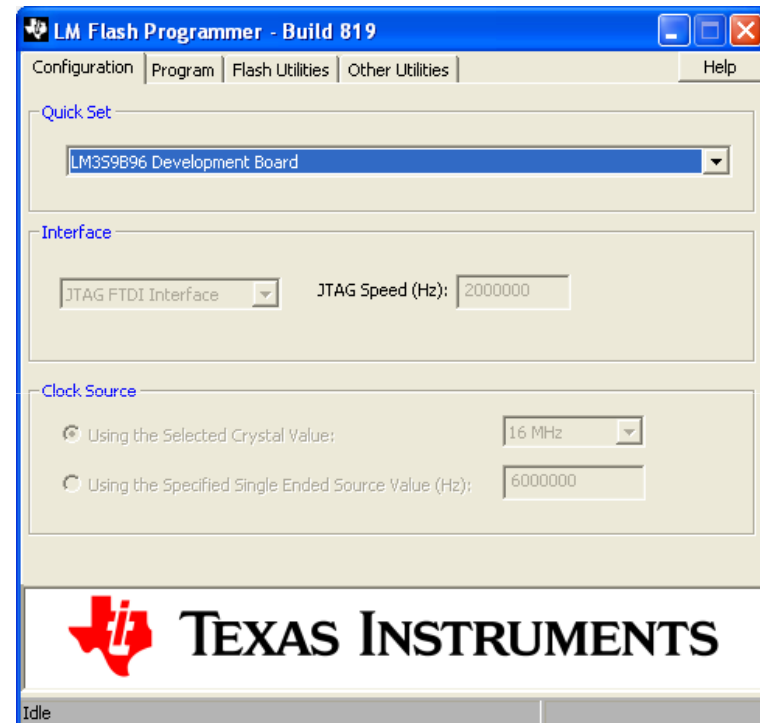


Development Tools for Stellaris LM4F MCUs

	 CODESOURCERY now part of Mentor Embedded	 IAR SYSTEMS	 ARM KEIL™ An ARM® Company	 code_red™	 Code Composer Studio™ IDE
Eval Kit License	30-day full function. Upgradeable.	32KB address- limited. Upgradeable.	32KB address- limited. Upgradeable.	90-day full function. Upgradeable.	Full functional; locked to board. Upgradeable.
Compiler	GNU C/C++	IAR C/C++	RealView C/C++	GNU C/C++	CCStudio
Debugger / IDE	gdb / Eclipse	C-SPY / Embedded Workbench	µVision	code_probe / Eclipse-based tool suite	CCStudio / Eclipse
Full Upgrade	199 USD personal edition / 3000 USD full support	2700 USD	MDK-Basic (256 KB) = €2000 (2895 USD)	999 USD (upgrade to run on customer platform)	445 USD (includes Stellaris, C2000, and MSP430 MCUs)
JTAG Debugger	Stellaris ICDI (on Stellaris EVK)	J-Link, ~299 USD	U-Link, ~199 USD	Red Probe+, 150 USD	Stellaris ICDI (on Stellaris EVK)
Availability	Now	Now	Now	Coming Soon	Now

StellarisWare Serial Flash Programming GUI

- **LM Flash Programming GUI**
 - Simple graphical user interface
 - Support for all Evaluation Kits
 - Key features include:
 - .Program
 - .Verify
 - .Erase
 - .Read memory
 - Available now
 - http://www.ti.com/software_updates



Stellaris Cortex-M4F MCUs are fully available

- Hands-on Training Materials for Quick Start
- Samples to order
 - LX4F230H5QR, 64-LQFP
 - LX4F231H5QR, 64-LQFP
 - LX4F232H5QC, 100-LQFP
 - LX4F232H5QD, 144-LQFP
- EVM to order
 - EKx-LM4F232 @ \$149
- Software on TI WEB Site
 - Full **StellarisWare** suite including code examples
 - CCS, Keil, IAR Supported
- Documentation On TI WEB Site
 - *White paper and brochure*
 - *Datasheets*
 - *Errata*
 - *Reference Manual*
 - *ROM Users Guide*
 - *Boot Loader Users Guide*
 - *Peripheral Driver Library Users Guide*
 - *USB Library Users Guide*
 - *Selection Guide*
 - *PIN Table*
 - EKx-LM4F232 Schematics Example
 - **Video:** Intro to Blizzard
 - **Video:** Getting started with the EK-LM4F232

Blizzard LM4F Errata Update

- Errata documents are available publically on TI WEB site
- Revision A1 errata
 - ~20 errata listed.
 - Overall, relatively minor.
 - Should not impact use for development and prototyping.
 - Most have workarounds.
- Revision A2
 - Fixes all but ~6 errata in Revision A2.
 - Revision intended for production

The End