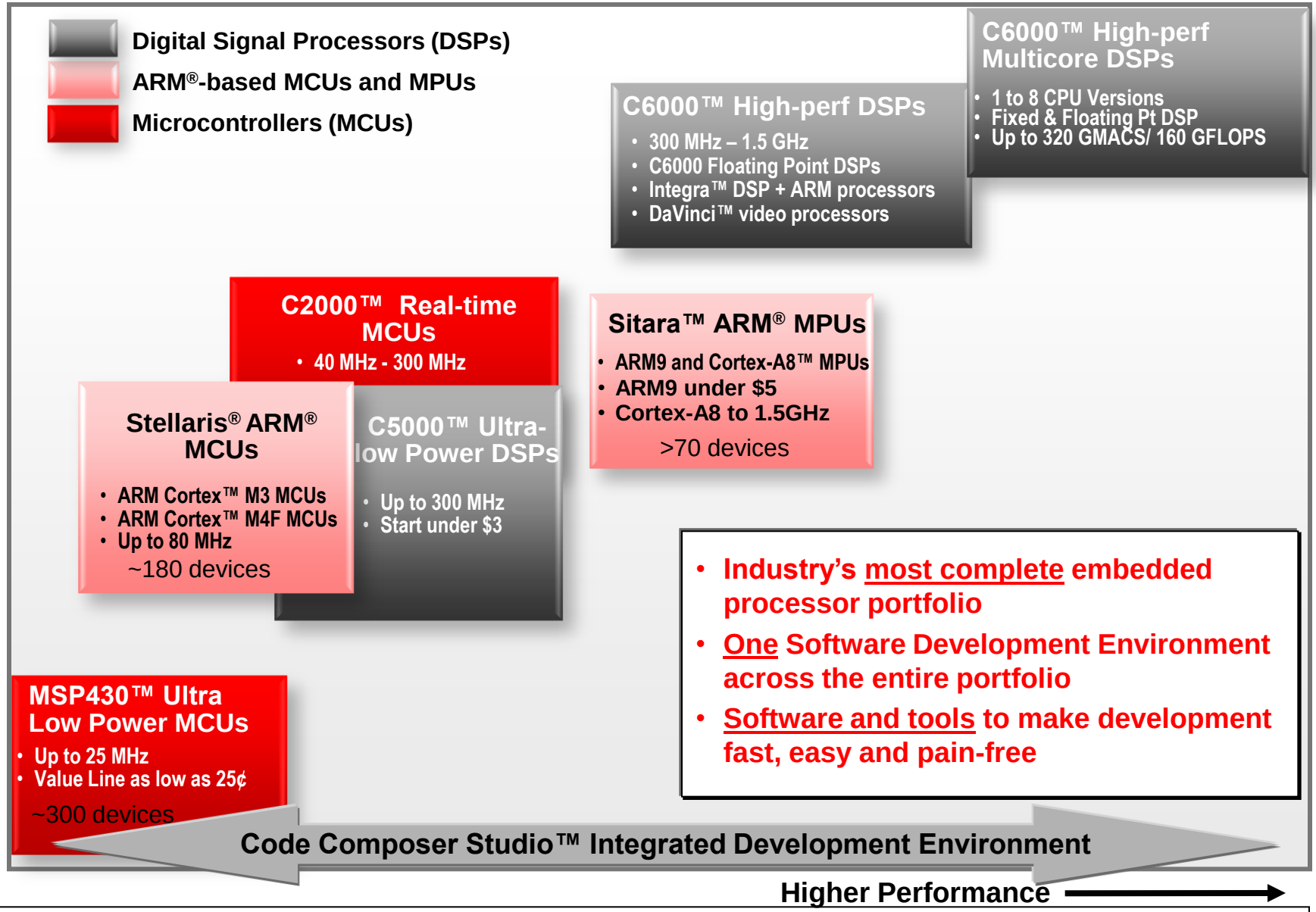
Introduction to the Stellaris ARM Cortex-M4F

A TI embedded processor to meet your needs



* Active power based on performance range for the product family

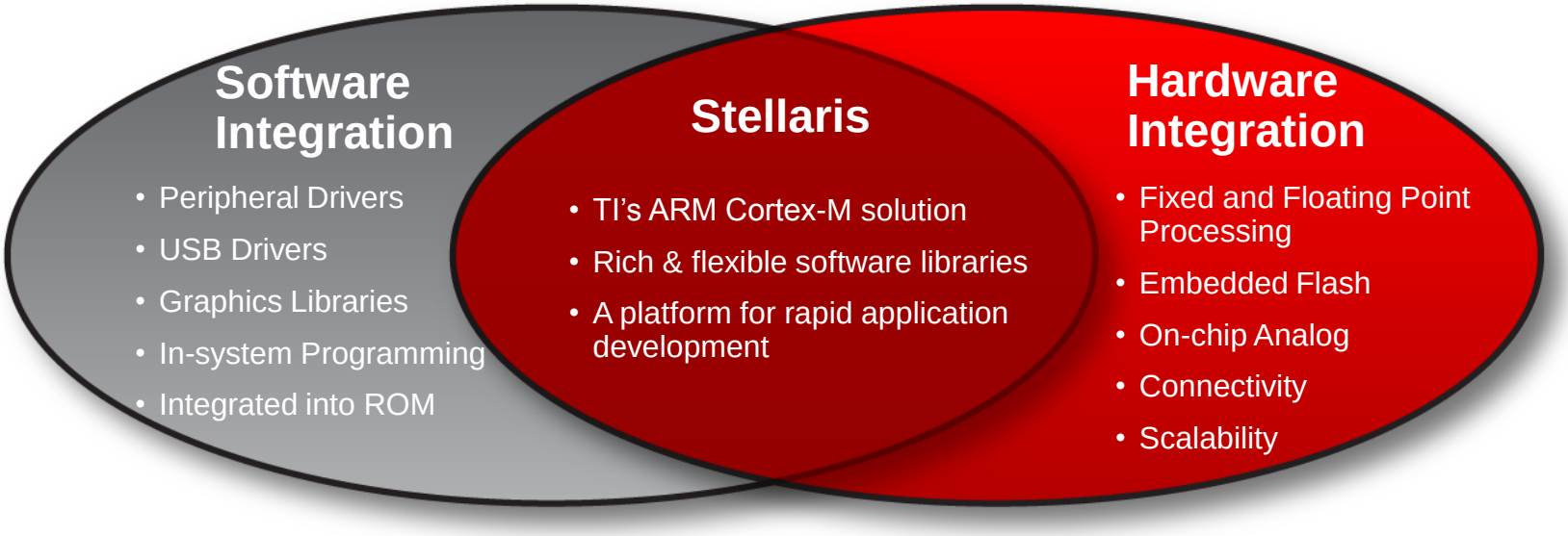
Texas Instruments

Agenda

- Stellaris LM4F Devices
  - Cortex-M4F core
  - Peripherals
  - Power consumption
  - Evaluation Kits
- StellarisWare
- Development Tools

What is Stellaris®?

TI's 32-bit ARM® MCU family for HMI, Motion Control, Smart Grid, and Connectivity



- **Industry-leading software**
  - StellarisWare libraries are free license & royalty free
  - Libraries are skillfully architected, provided in ROM
  - Develop in the environment of choice; compiled and proven on 5 separate IDEs
- **Advanced Integration**
  - Up to 24 channels of 1MSPS 12-bit ADCs
  - Only ARM MCU with an integrated ENET PHY
  - CAN and USB Host / Device / On-The-Go support
- **Broad Portfolio**
  - 180+ ARM Cortex-M3 & 40+ Cortex-M4 devices
  - Up to 512KB Flash, 96KB SRAM
  - 48-QFP up through 108-BGAs and 144-LQFP
  - Price points starting at just $1
- **Time to Market**
  - Get started in 10 min or less
  - Start development NOW using example applications
  - Leverage open-tooled reference designs

Industry’s first and only 65 nm Stellaris® ARM® Cortex™-M MCUs

Leading analog, best-in-class low power & floating-point performance delivered by TI’s new Stellaris® ARM® Cortex™-M4F MCUs

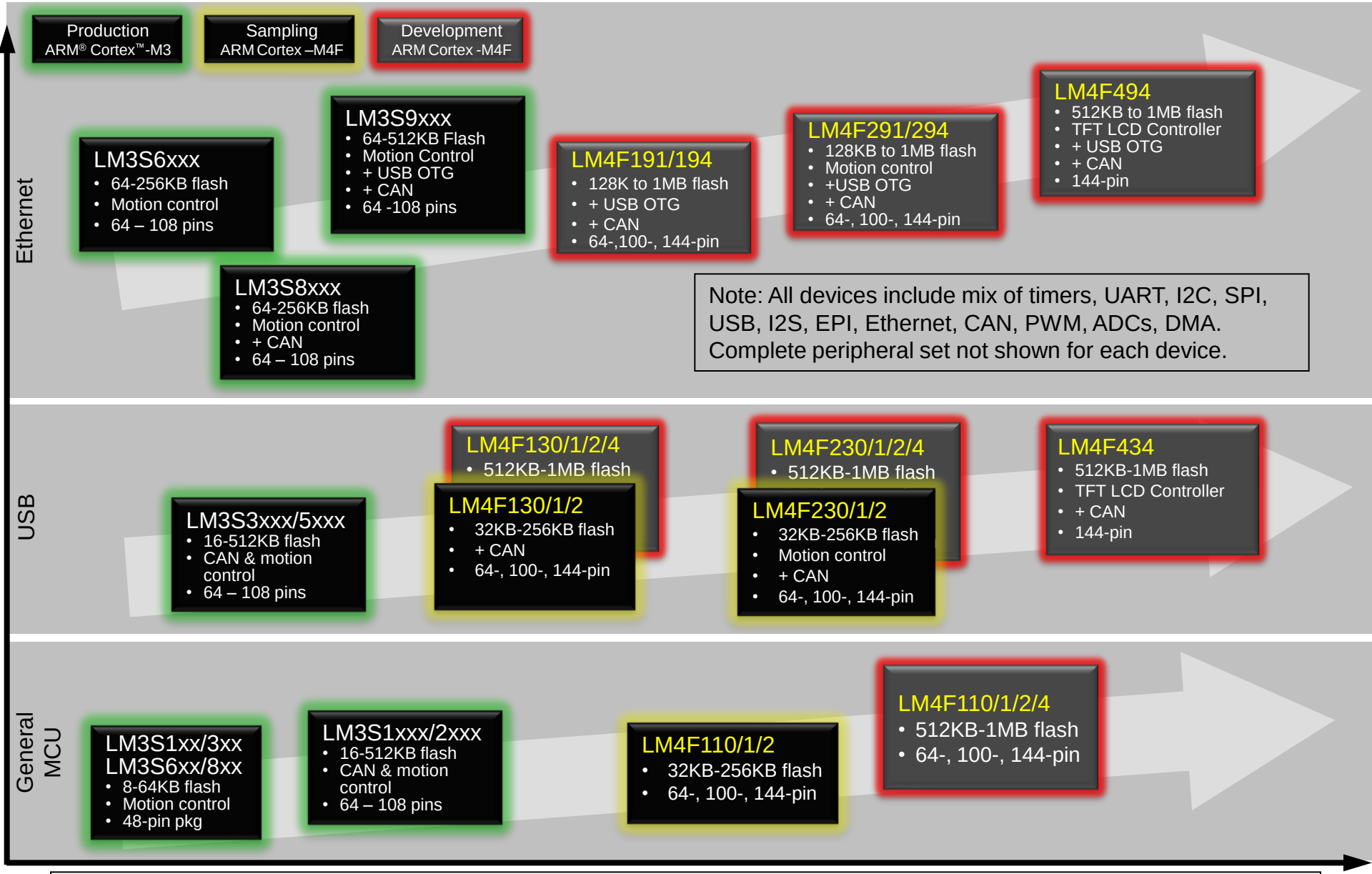
Industry’s first and only 65 nm Cortex-M MCUs are available today, providing advantages in performance, power, integration, and a solid Stellaris roadmap that offers even lower power & higher performance levels

Stellaris® Product Portfolio

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

Texas Instruments

Stellaris® Roadmap



Leading analog, best-in-class low power & floating-point performance delivered by TI's new Stellaris® ARM® Cortex™-M4F MCUs

Reduce system cost and increase performance with floating point and leading integration

Don't sacrifice performance for accuracy

- High-performance 12-bit ADCs and comparators for high accuracy
- Floating-point unit provides higher performance across all Stellaris Cortex-M4F MCUs
- Up to 256KB flash and 32KB SRAM
- Prolific connectivity peripherals: CAN, USB OTG, SPI, I2C, UARTs

Increase portability and meet power budget

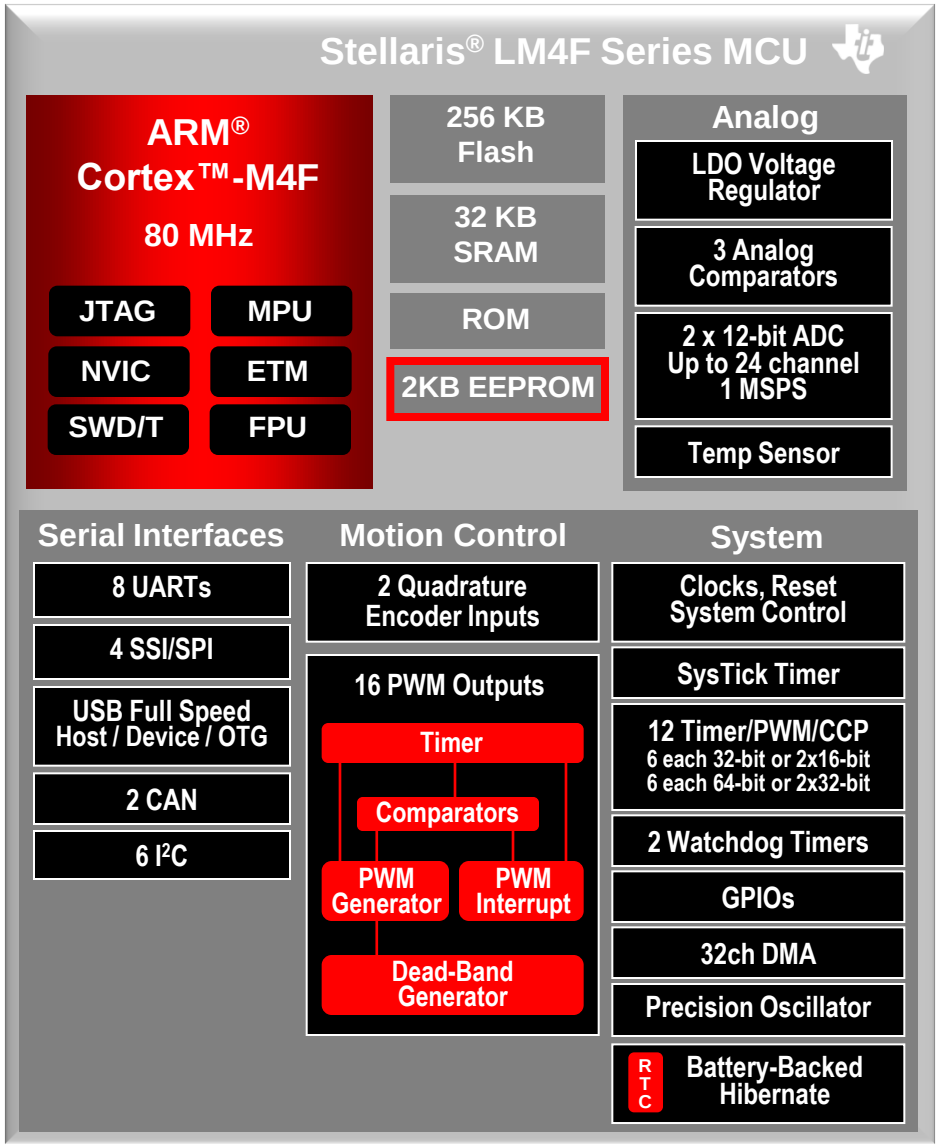
Best-in-class low power consumption

- Standby current as low as 1.6 µA
- Complementary TI analog for additional system efficiency

Easily scale designs across 220+ Stellaris MCUs and speed time to market with robust StellarisWare software and tools

- StellarisWare® software enables easy migration to new Cortex-M4F capabilities for maximum code reuse
- Preloaded software, including peripheral driver libraries, boot loader, and check sum
- Easy-to-use evaluation kits jumpstart design in 10 minutes or less
- Roadmap to higher speeds, larger memory and ultra-low power based on 65 nm

More than 40 MCUs starting at $1.50 @10K



Public Launch: 26 September 2011

High-performance analog integration

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

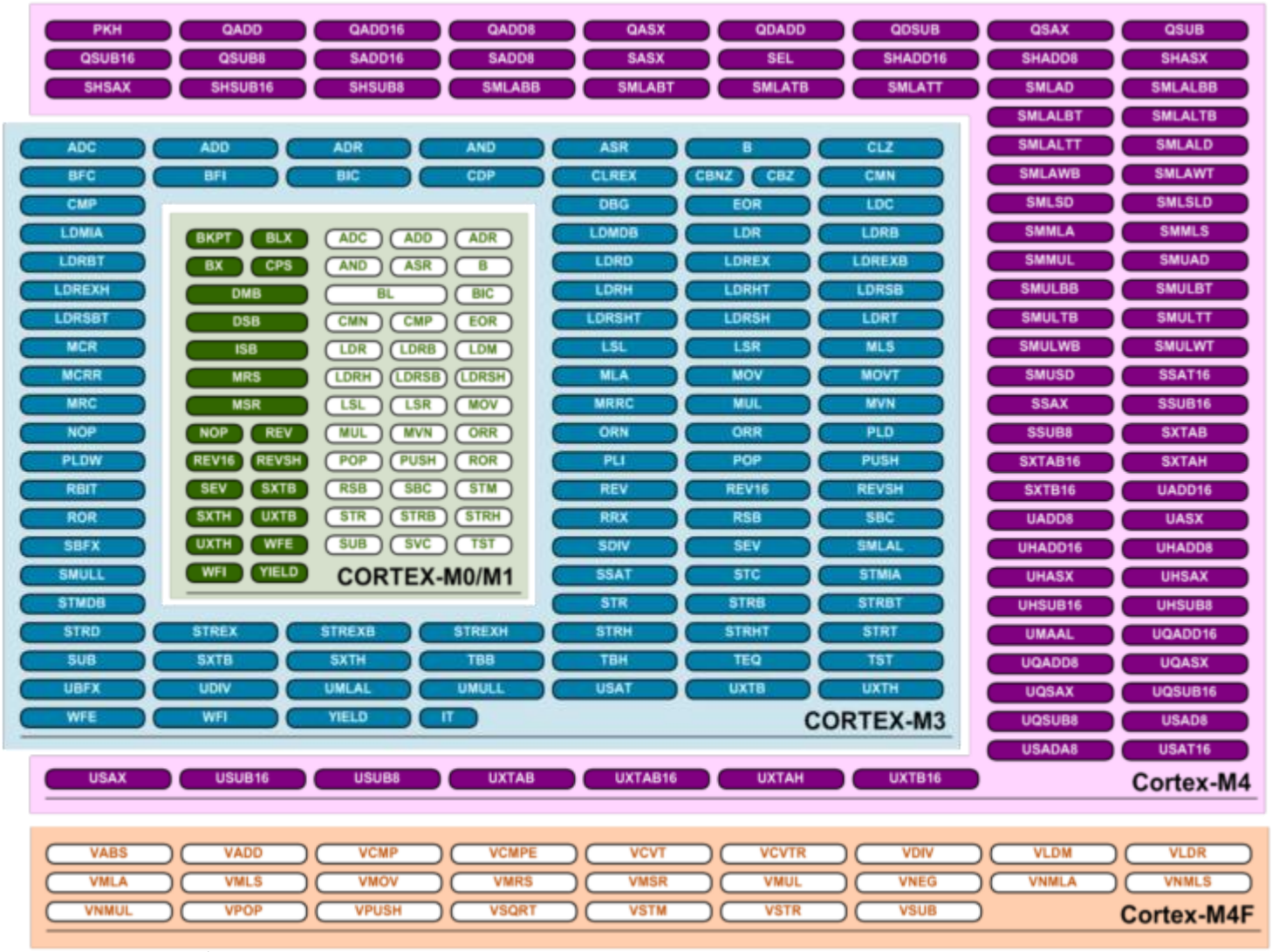
Prolific connectivity features:

- CAN, USB H/D/OTG, SPI, I²C, UARTs

Lowest-power Stellaris MCUs

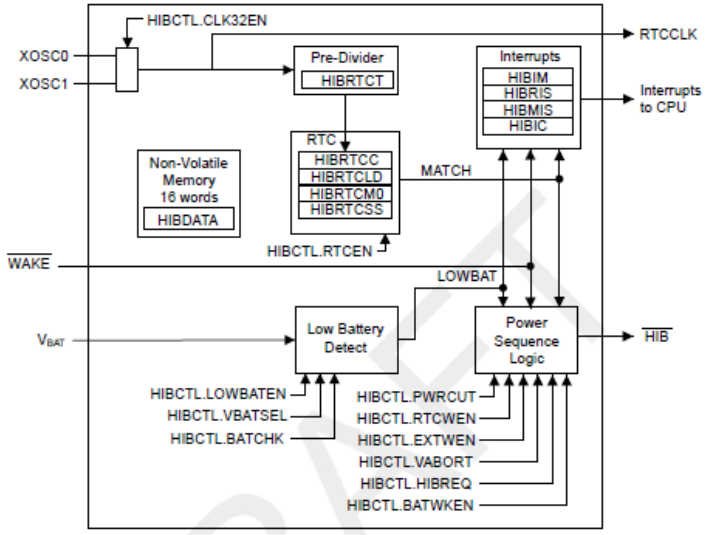
- Standby current as low as 1.6 µA
- Active RTC modes as low as 1.7 µA
- Wakeup times of 500µs or less
- Built on TI-proprietary 65nm technology

Stellaris LM4Fx is ISA-compatible with LM3Sx

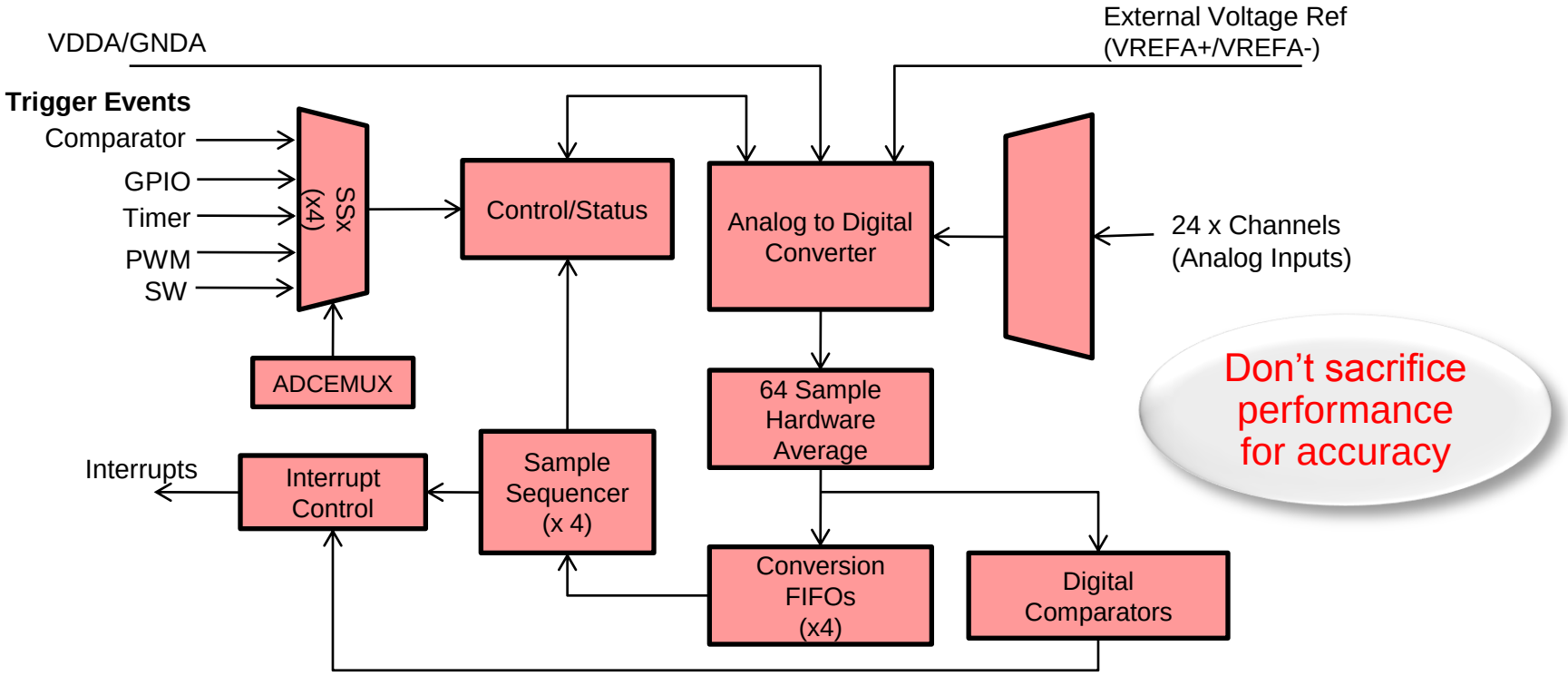


Low power on Stellaris LM4F

- **Lowest-power Stellaris MCUs**
  - Built on TI-proprietary 65nm technology
  - Wakeup times of 500 us or less
  - Standby modes as low as 1.6 µA
- **Intelligent Design**
  - Dedicated wake pin
  - Retain your application state using 64B 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 (± 5°C)
- Eight built-in digital comparators
- Supports single-ended & differential inputs
- Three built-in analog comparators (not shown)

Intelligent ADC design for lower power

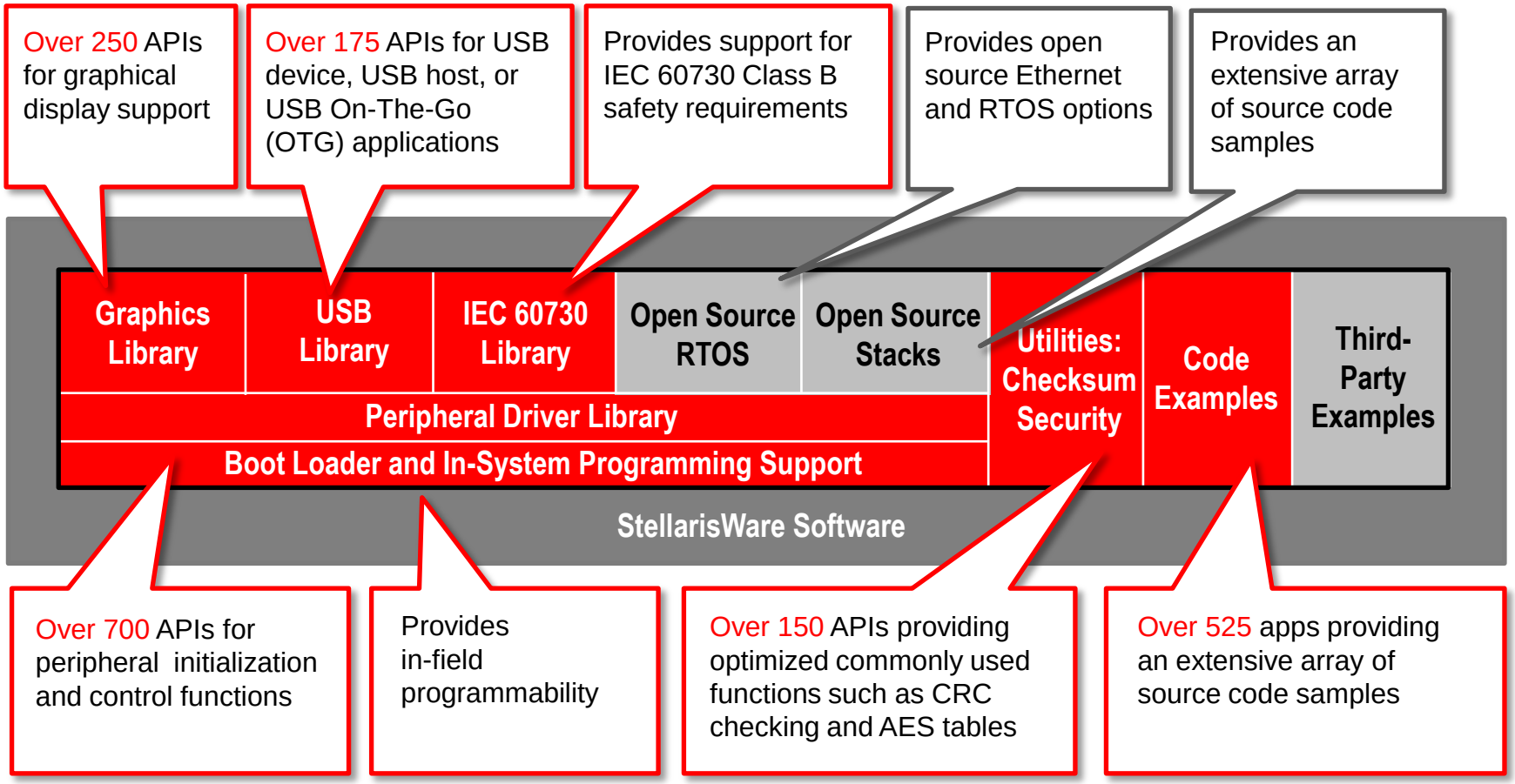
- Programmable sample sequencers (SSx)
- Conversion FIFOs to store conversions
- Internal triggering from other peripherals
- Automatic DMA transfers on completion

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

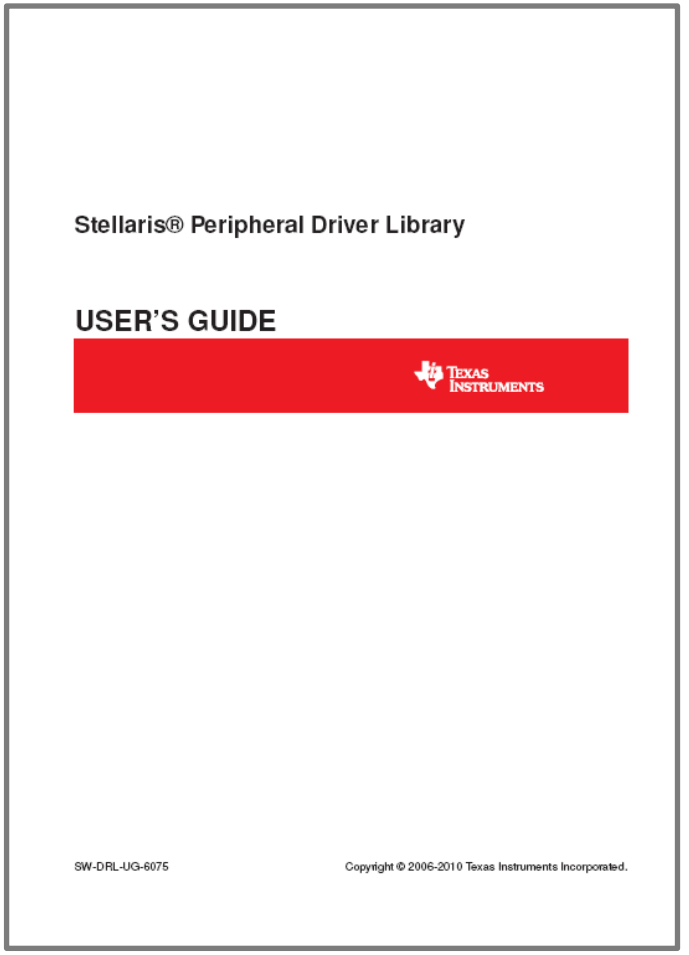
StellarisWare® software

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



Stellaris® Peripheral Driver Lib

- High-level API interface to complete peripheral set
- Free license and royalty-free use
- Simplifies and speeds development of applications
- Available as object library and as source code
- Works with all supported IDEs
  - TI CCS, Keil, IAR, Code Red, Code Sourcery
- DriverLib functions are preprogrammed in ROM on select Stellaris MCUs



Peripheral Driver Library: UART example

```
Int
main(void)
{
    // Set the clocking to run directly from the crystal.
    SysCtlClockSet(SYSCTL_SYSDIV_1 | SYSCTL_USE_OSC |
                   SYSCTL_OSC_MAIN | SYSCTL_XTAL_8MHZ);

    // Enable the peripherals used by this example.
    SysCtlPeripheralEnable(SYSCTL_PERIPH_UART0);
    SysCtlPeripheralEnable(SYSCTL_PERIPH_GPIOA);

    // Enable processor interrupts.
    IntMasterEnable();

    // Set GPIO A0 and A1 as UART pins.
    GPIOPinTypeUART(GPIO_PORTA_BASE, GPIO_PIN_0 | GPIO_PIN_1);

    // Configure the UART for 115,200, 8-N-1 operation.
    UARTConfigSet(UART0_BASE, 115200, (UART_CONFIG_WLEN_8 |
                  UART_CONFIG_STOP_ONE |
                  UART_CONFIG_PAR_NONE));

    // Enable the UART interrupt.
    IntEnable(INT_UART0);
    UARTIntEnable(UART0_BASE, UART_INT_RX | UART_INT_RT);

    // Loop forever echoing data through the UART.
    while(1)
    {
    }
}
```

```
void
UARTIntHandler(void)
{
    unsigned long ulStatus;

    // Get the interrrupt status.
    ulStatus = ROM_UARTIntStatus(UART0_BASE, true);

    // Clear the asserted interrupts.
    ROM_UARTIntClear(UART0_BASE, ulStatus);

    // Loop while there are characters in the receive FIFO.
    while(ROM_UARTCharsAvail(UART0_BASE))
    {
        // Read the next character from the UART and write it back to the UART.
        ROM_UARTCharNonBlockingPut(UART0_BASE,
                    ROM_UARTCharNonBlockingGet(UART0_BASE));
    }
}
```

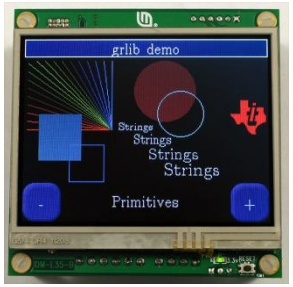
StellarisWare® USB Library

- 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**

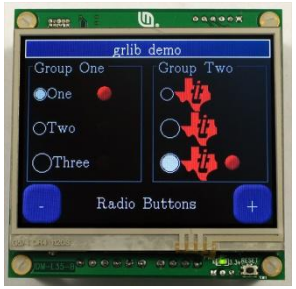
- **USB Device Firmware Update (DFU) now available in ROM; just plug-in and reprogram your firmware!**
- TI sub-licenses Stellaris VID & PIDs for customer use

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

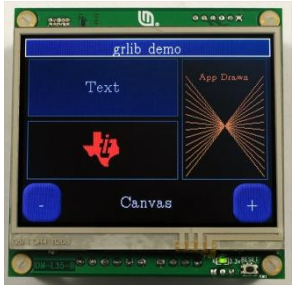


Radio Buttons

Checkbox

Container

Sliders



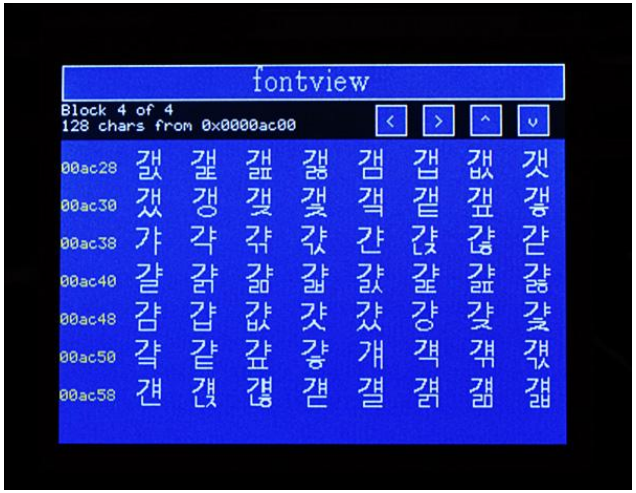
Canvas

Push Buttons

StellarisWare® Graphics Library

Special Utilities

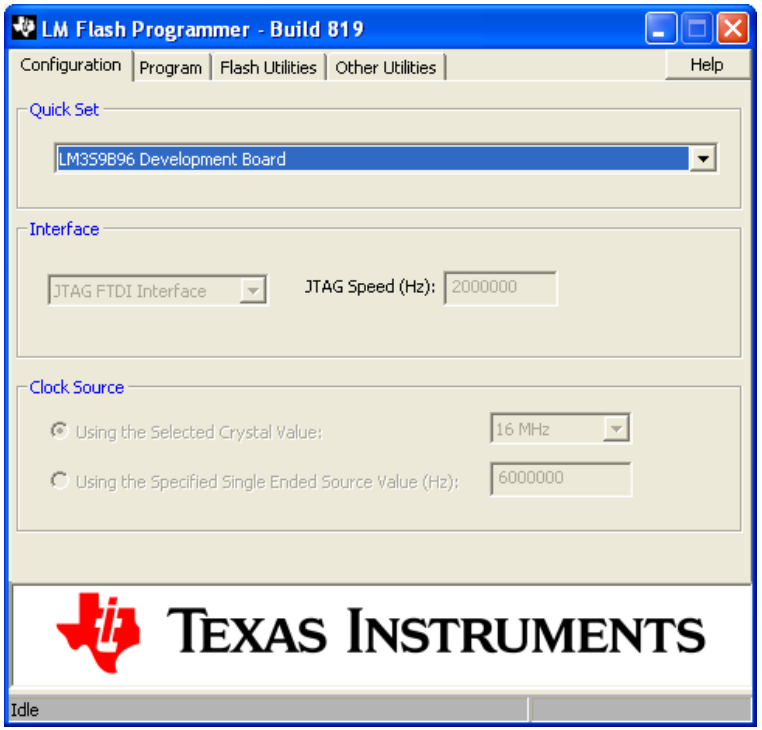
- *ftrasterize*: render your own font
- *mkstringtable*: build multi-language string tables
- *makefsfile*: dump binary files as C arrays
- *lmi-button*: predefined button with shadow and 3-D
- *pnmtoc*: Convert image file to GraphicsLib format



- **International Fonts;** program HMI in more languages
  - e.g. Chinese, Korean, Japanese ideographs, accented western European characters, etc.
  - Supports UTF8, ISO8859 and Unicode.

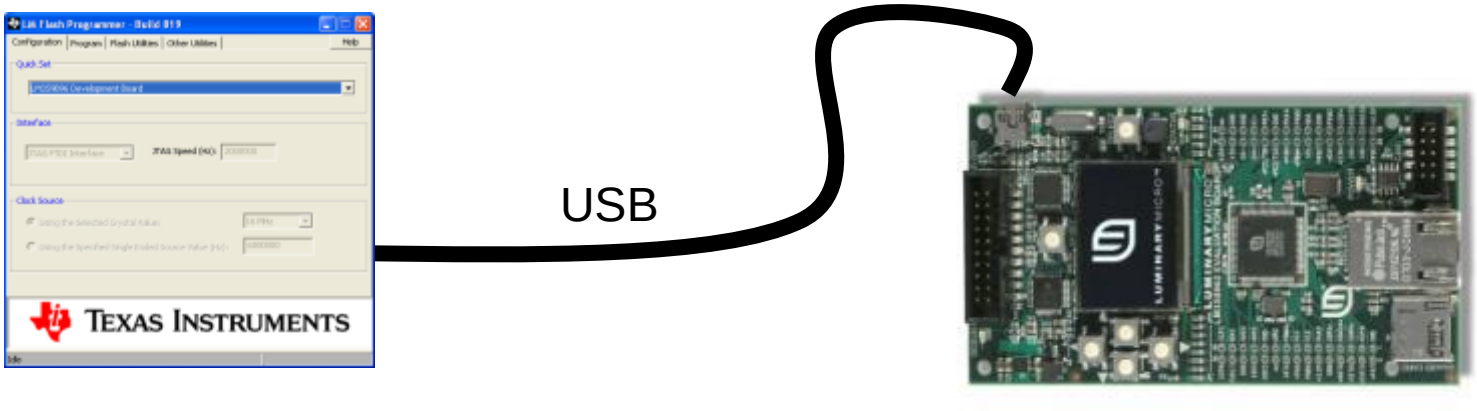
StellarisWare Serial Flash Programming GUI

- 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

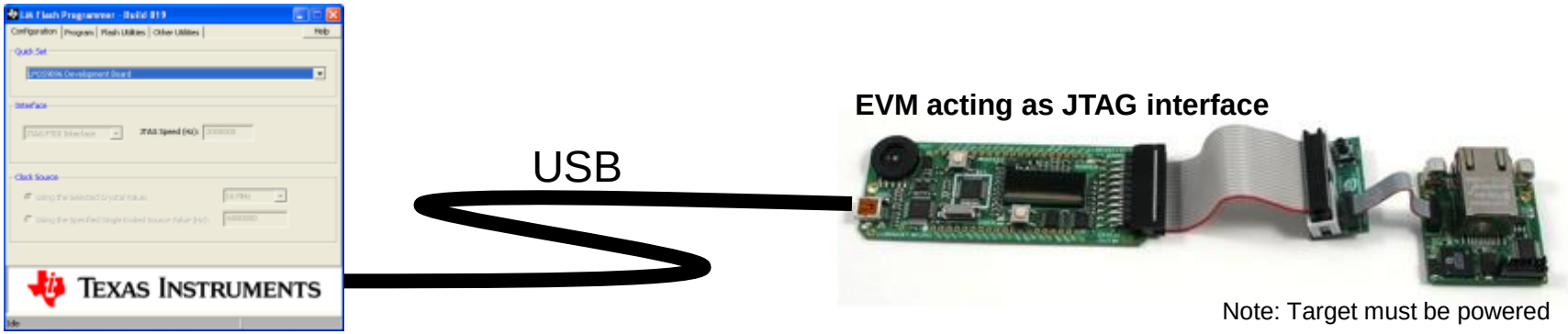


Flash Programming GUI Supports:

- Programming evaluation kits (EVM) directly

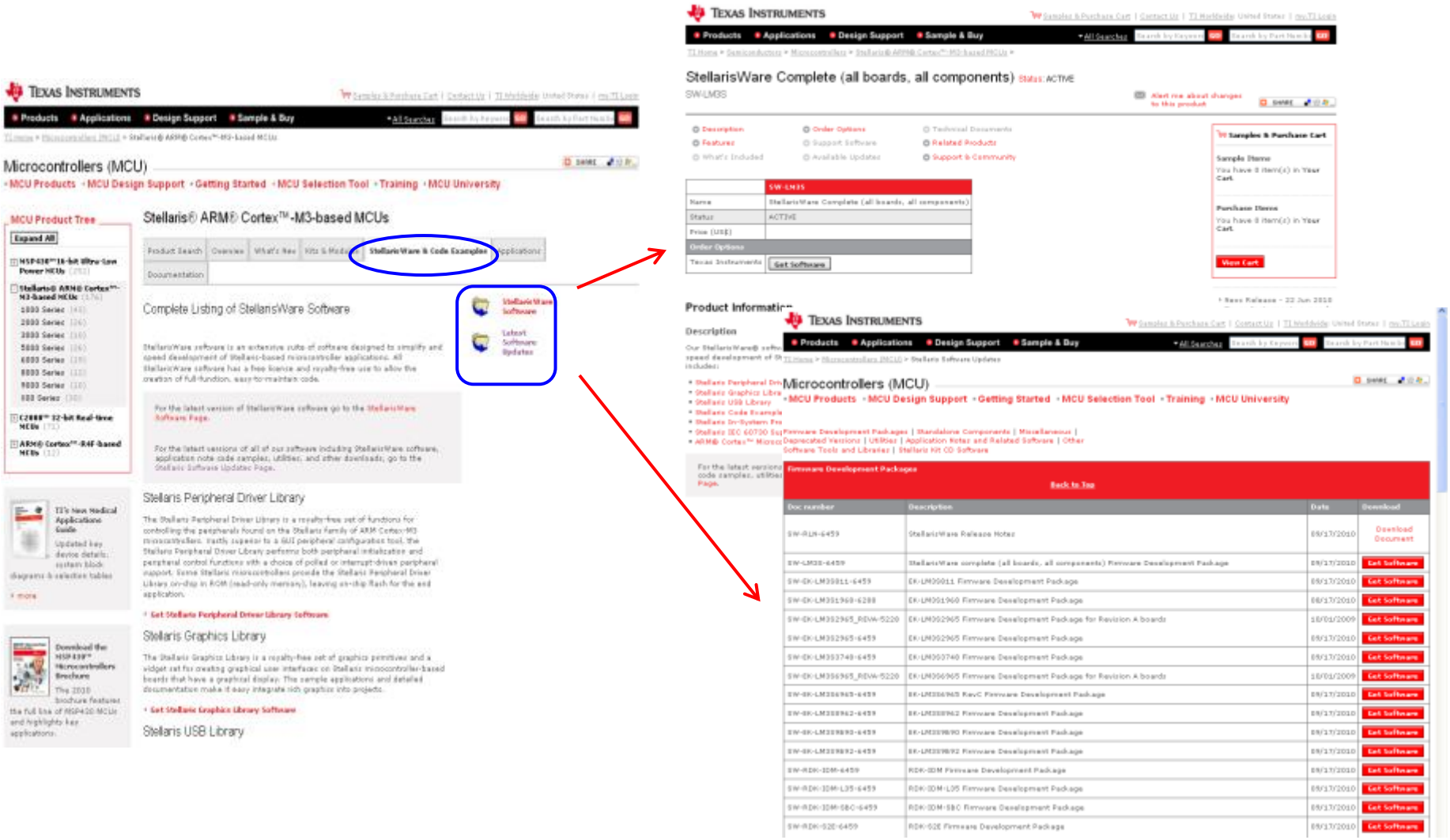


- Programming target HW indirectly via EVM



Note: Target must be powered

Introducing StellarisWare



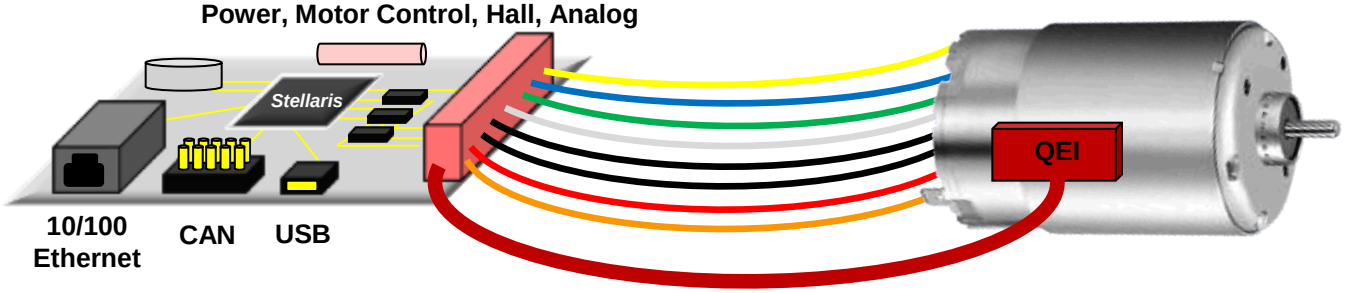
Full-solution approach

Fully Integrated Stellaris MCUs

- ARM Cortex-M3 core with single-cycle Flash
- Advanced Motion Control
- Integrated Deterministic Connectivity
- Easy adoption / learning curve through 10-min Out-of-the-Box Evaluation Kits

Production-ready Modules

- Customizable modules for drop-in implementation
- Multiple motors supported
- Multiple connectivity options
- Copy-exactly with Open-tooled HW and SW



Complete Open-tooled RDKs

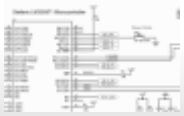
- Open-tooled HW/SW Reference Design Kits
- Motor included for out-of-the-box demonstration
- Fully documented, available for download, and in stock

Proof-of-Concept

- Stellaris MCUs / Modules
- Putting our Motion Control to the test before you do.

End-to-End Solution Source Files

Royalty-Free



Schematics

Placement

Bill of Materials

Gerbers

Motor App and StellarisWare™ Source

Control / Config GUI

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

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

KEIL™ Tools by ARM

CodeSourcery now part of Mentor Embedded

IAR SYSTEMS

code_red

Code Composer Studio™ IDE

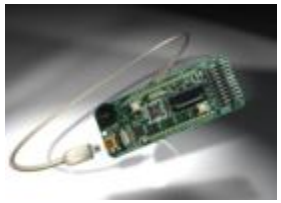
Stellaris® ARM® Cortex™-M3 development tools to accelerate your design

- **Open tools**
  Reference designs include schematics, software source code, BOMs and gerbers!
- **StellarisWare software examples**
  Begin programming at the application level
  Comprehensive examples for each kit!
- **Built-in debugging interface**
  No external hardware required for EKs, DKs
  Reuse kit HW as debug interface for custom designs
- **ARM ecosystem for software & tools**

Books & Bundles

+

+



Evaluation Kits (EKs)

- Available for all Stellaris series:
  - Basic MCU, CAN, USB, Ethernet, USB+CAN, ENET + CAN , ENET+CAN+USB
- Starting at only $49!

Development Kits (DKs)

- Full-featured DK-LM3S9B96 - $425
- Add-on boards :
  - SDRAM (included)
  - EPI breakout (included)
  - EM2 adapter
  - Flash/SRAM expansion
  - FPGA/Camera expansion
  - (and Wireless Kits below)

Reference Design Kits (RDKs)

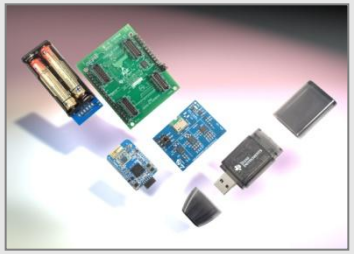
- Motor control
  - Stepper, ACIM, BLDC, Brushed DC
- Intelligent Displays
  - 2.8”, 3.5” touch-screen displays
  - Ethernet (with & without PoE), CAN, USB
- Serial-to-Ethernet
- Also available as modules!

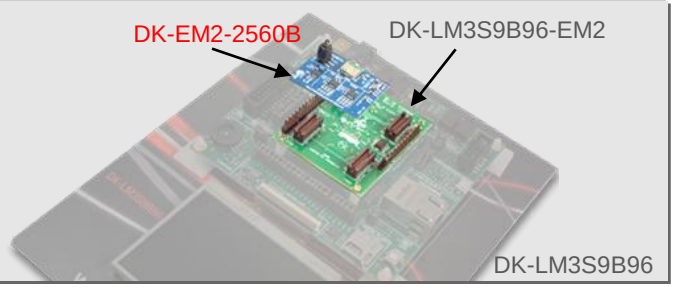
Leverage Full TI solutions

- Wireless Kits featuring:
  - SimpliciTI
  - Zigbee
  - MIFARE
- All include full heterogeneous network nodes
- Starting at $99

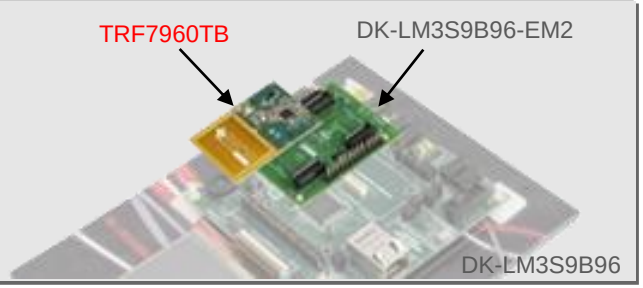
Complete, modular wireless solutions

Stellaris®
2.4 GHz CC2560
***Bluetooth*® Kit**

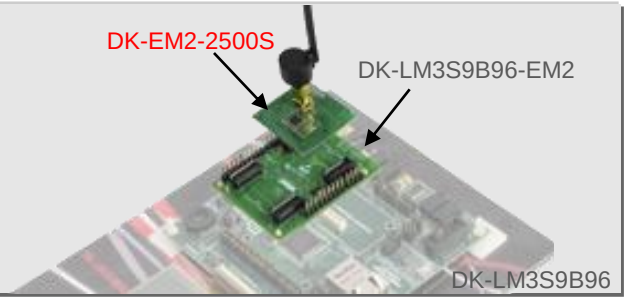




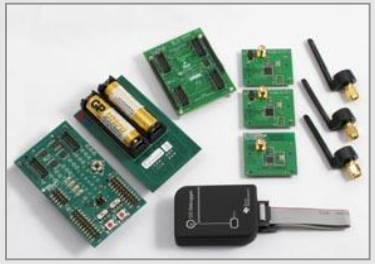
Stellaris
13.56MHz RFID
Wireless Kit

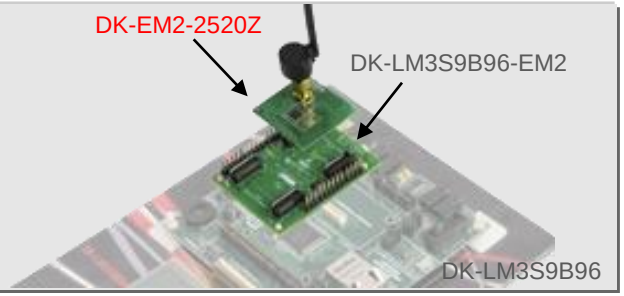


Stellaris
2.4 GHz SimpliciTI™
Wireless Kit



Stellaris
ZigBee®
Networking Kit





Texas Instruments

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

Stellaris 13.56MHz RFID Wireless Kit

DK-EM2-7960R

Key features

- TI TRF7960TB HF RFID Reader Module target board
- Stellaris DK-LM3S9B96-EM2 Expansion Board
- 2 ISO/IEC 14443A (MIFARE®-1K) contactless smart cards and additional TRF7960-supported tags/inlays
- Example ISO/IEC 14443A (MIFARE) application, firmware documentation
- Support for additional protocols coming soon

Performance advantages

- **Pre-pay capability for smart meters**
- **Access control for smart building systems**

$99 USD

Texas Instruments

Stellaris ZigBee® Networking Kit

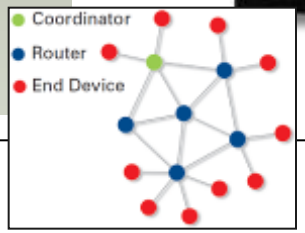
DK-EM2-2520Z

Key features

- Z-Stack™ 2.4 software and example coordinator application software to address the growing portfolio of IEEE 802.15.4 products and platforms
- Multiple heterogeneous network nodes with one CC2520 evaluation module, two battery operated sensor modules and two CC2530 evaluation modules pre-programmed with a temperature sensor application
- Example ZigBee application, StellarisWare software and documentation
- Stellaris DK-LM3S9B96-EM2 Expansion Board

Performance advantages

- **Smart appliance communications to smart metering**
- **Backup communication system for plant engineering**



$249 USD

Texas Instruments

Stellaris 2.4 GHz SimpliciTI™ Wireless Kit

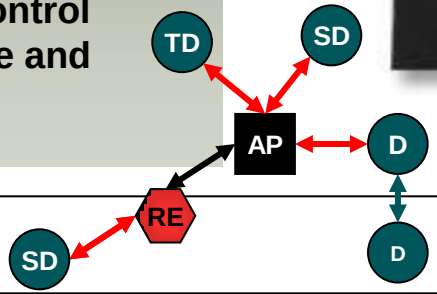
DK-EM2-2500S

Key features

- Multiple heterogeneous network nodes via TI's eZ430-RF2500 kit and CC2500 evaluation module
- Multi-platform software support including access to binaries for low-power RF solutions from sub-1 GHz to 2.4 GHz
- Firmware, documentation and example SimpliciTI application supporting simple star network and point-to-point configuration
- Stellaris DK-LM3S9B96-EM2 Expansion Board

Performance advantages

- **In-home networking and bridge to smart meters**
- **Scalable access control and alarm for home and commercial**



$125 USD

Texas Instruments

Do more with TI microcontrollers!

- TI is growing in MCU!
- Stellaris® is the fastest-growing segment of TI's MCU portfolio
- New Stellaris LM4F family brings new advantages in
  - Reduced cost
  - Higher integration
  - StellarisWare® software
  - Lower power footprint
  - Along with a strong roadmap with higher speeds, larger memory, and ultra-low power devices

Texas Instruments

The End

Stellaris® MCUs –
Versatile, Connected, Compact

Connectivity

Serial-to-Ethernet Bridge

Data Acquisition

Home Automation

Medical Connectivity

Automation

Automated Motor Control

Home Automation

Security

Biometric Scanning

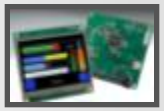
Security Monitoring

Networked Access Control

Human Machine Interface

Advanced Remotes

Touch Interface



Graphics Displays

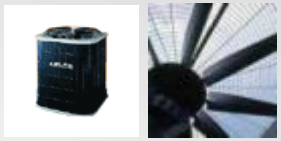
Point of Sale

Energy

White goods

Electricity and Flow metering

Exercise Equipment



HVAC
Pump inverter
Compressor motor

LED signage

Stellaris Evaluation Kits: “Zero-to-32bits” in 10 minutes

- **Everything a developer needs to get up and running in 10 minutes or less**
  - Each kit includes: evaluation board(s), all required cables, a choice of evaluation tools suites for popular development tools, documentation, StellarisWare® software, and applications notes

EK-LM3S811
Low pin count
49 USD

EK-LM3S1968
High pin count
59 USD

EK-LM3S2965
CAN Functionality
79 USD

EK-LM3S3748
USB Host/Device
109 USD

EK-LM3S6965
Ethernet MAC+PHY
69 USD

EK-LM3S8962
Ethernet+CAN
89 USD

EK-LM3S9D90
Ethernet+USB OTG
99 USD

EK-LM3S9D92
Ethernet+OTG+MC
99 USD

EK-LM4F232
USB + CAN
149 USD

- **Five versions of each kit:**

EKK-LM3Sx
- ARM RealView Microcontroller Development Kit tools with 32KB address Limit

EKI-LM3Sx
- IAR Embedded Workbench KickStart with 32KB address limit

EKC-LM3Sx
- Sourcery CodeBench G++ GNU with 30-day evaluation license

EKT-LM3Sx
- Code Red Technologies Red Suite with 90-day evaluation license

EKS-LM3Sx
- TI Code Composer Studio with full evaluation license locked to board