From industrial Gateway to functional safety with TI Cortex based MCU

Texas Instruments Inc.
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TI Cortex® based MCU Portfolio

- **Cortex-R4**
  - 220MHz / 2 - 3MB
  - 220MHz / 1 - 1.25MB
  - 220MHz / 768KB – 1MB
  - 100MHz / 384kB
  - 80MHz / 128kB
  - RM41, RM42, RM44, RM46, RM48

- **Cortex-R5**
  - High Next
  - 330MHz
  - 4MB Flash
  - RM57L

- **Cortex-R4**
  - 180MHz / 2 - 3MB
  - 180MHz / 1 - 1.25MB
  - 180MHz / 768KB – 1MB
  - 80MHz / 256 – 384kB
  - 80MHz / 128kB
  - TMS570LS02x, TMS570LS04/03x, TMS570LS09/07x, TMS570LS03/02x

- **Cortex-R5**
  - High Next
  - 300MHz
  - 4MB Flash
  - TMS570LC4x

- **Cortex-M4**
  - 120MHz
  - 1MB
  - 48MHz / 256kB
  - 80MHz / 256kB
  - TM4C129x
  - MSP432

- **Cortex-M3**
  - 80MHz
  - 320 – 640KB
  - TMS470MF 06/04/03x

- **Cortex-M3**
  - Connect, Communicate & Control

- **Performance**

- **Feature**
  - Industrial
  - Medical
  - Energy
  - Availability
  - Automotive
  - Aerospace
  - Railway
  - Offroad

- **Availability**
  - 330MHz
  - 4MB Flash

- **Texas Instruments**
TM4C Applications

Connect
- Industrial HMI control panels/displays
- Solar inverters
- Industrial Automation / PLC
- Lighting Control

Communicate (IoT)
- Industrial sensors
- Sensor & Communications Gateway
- Communications adapters/concentrators
- Networked industrial meters/controllers
- Networked residential/SoHo systems

Control
- Test & Measurement systems

Industrial computing
- Industrial PC
- Microservers

Technology
- ARM
- TM4x Microcontrollers
How do things connect to the IoT?

Via IoT Gateways:
- Internet Router
- IoT Gateway
- ZigBee Node
- BLE Node
- Wired Node
- Sensors & Actuators

Directly - IoT Nodes:
- Internet Router
- IoT Agent
- Wi-Fi Node
- Ethernet Node
- Sensors & Actuators

Directly - Lite IoT Nodes:
- Internet Router
- 6LoWPAN Edge Router
- 6LoWPAN Node
- Sensors & Actuators
TM4C Connected LaunchPad

**Evaluation Kit**

EK-TM4C1294XL

Connect with end customers!

Based on TM4C Series TM4C1294NCPDTI

- 120 MHz ARM® Cortex™-M4F CPU
- 1MB Flash | 256K SRAM | 6K EEPROM
- 8x32-bit timers (16x16-bit), plus SysTick & WDGs
- 10 I²C, 8 UART, 4 QSPI, 2 CAN, EPI, USB FS | HS
- CRC accelerator, Tamper inputs, Data protection
- 10/100 Ethernet MAC & PHY
- 128 TQFP w/ up to 90 GPIOs

- RJ45 Ethernet jack
- Dual BoosterPack XL connection sites
- USB Host | Device | OTG port
- I/O connection grid (board interconnect)
- User buttons & LEDs, reset switch & power indicator LED
- In-Circuit Debug Interface (ICDI)
- Tool chains: CCS, Keil, IAR, Mentor & GCC
- TivaWare DriverLib under TI BSD-style license
- MSRP $19.99 USD
TM4C129 IOT Gateway Concept

- TRF7970A BP
- CC3100 BP
- CC2650 EMK
- CC2538 EMK
- Sensor Hub BP

- TRF7970
- CC3100 WiFi stack
- CC2650 BT/BLE stack
- CC2538 ZigBee stack
- CC2538 6LowPAN
- Sensor Hub

- SPI
- SPI
- i2c
- i2c
- i2c
- i2c

- Single or Stacked BoosterPack(s)

- Data Aggregation
- Data Encryption
- Protocol Translation

- TM4C129 Launchpad

- Ethernet

- Analog Digital Sensors

- Texas Instruments
Our Commitment to Your Success!

- **TI's Cutting Edge 65nm Technology**
- **State of Art Software Libraries**
- **Scalable Evaluation Platform & Kits**
- **Vast Ecosystem of IDE & Tools**
- **Support & Training**
- **Documentation**
- **Web Resources**
- **Global Presence**
Functional Safety: Important for Many Industries

- Safety critical systems are everywhere
- Systems need to manage hazardous failures
- Many systems need to be safety-certified
TI Hercules™ MCU Platform
ARM® Cortex™ Based Microcontrollers

Hercules™ MCU Platform

Industrial and Medical Safety MCUs
- Industrial Applications
- Medical Applications
- -40 to 105°C Operation
- ENET, USB, CAN & UART
- Developed to Safety Standards
  - IEC 61508 SIL-3
  - Cortex-R – over 550 DMIPs

RM

TMS570

Transportation and Safety MCUs
- Transportation Applications
- Automotive Q100 Qualification
- -40 to 125°C Operation
- FlexRay, ENET, CAN, LIN/UART
- Developed to Safety Standards
  - ISO 26262 ASIL-D
  - IEC 61508 SIL-3
  - Cortex-R – over 500 DMIPs

SafeTI™ Design Packages for Functional Safety
Hercules™ MCUs
Scalable Platform For Functional Safety Applications

- External certification: ISO 26262, IEC 61508
- Documentation: Safety Manual, FMEDA reports
- Software: Drivers, libraries, RTOS, Autosar, tools, debug
- Development Kits: LaunchPad, HDK, Motor Control Kit, SafeTI™ Kit

Texas Instruments
SafeTI™ design packages help speed time to market

**SafeTI™ & Companion ICs**

SafeTI design packages for functional safety provide standards-specific solution bundles:
- SafeTI-61508
- SafeTI-26262

**Hercules™**

TPS65381
TMS570LS12

http://www.ti.com/safeti

**Power Management**

**Safety Architecture**

- CPU Self Test
- Controller requires little S/W overhead
- Physical design optimized to reduce probability of common cause failure
- Lockstep CPU & Lockstep Interrupt Fault Detection
- ECC or Parity on select Peripheral, DMA and Interrupt controller RAMS
- Parity or CRC in Serial and Network Communication Peripherals
- ECC for flash / RAN evaluated inside the Cortex M
- Memory Protection Unit
- Memory BIST on all RAMS for fast memory test
- Error Signaling Module w/ External Error Pin
- On-Chip Signaling Module
- Protected Bus and lockstep Interrupt Manager
- IO Loop Back, ADC Self Test, ...
- Dual ADC Cores with shared channels

**Safety Documentation**

Documents provided by TI assist end product developers in the safety certification process:
- **Device Safety Manual (SM)**
  Details product safety architecture and recommended usage
- **Safety Analysis Report (SAR)**
  FIT rate and device FMEDA
- **Safety Case Report (SCR)**
  FIT Summary of compliance to IEC 61508 and/or ISO 26262

**Software Compliance Support Packages**

- **SafeTI Compiler Qualification Kit**
- **SafeTI Diagnostic Library**
- **SafeTI Compliance Support Package**
Cortex-R: Ideal for safety critical applications

Safety features
- Supports Lockstep
- Memory Protection Unit (MPU)
- Error-Correcting Code (ECC)

Higher performance
- 8-stage processor pipeline
- Dual issue – two instructions can execute in parallel
- Load store unit reduces stalling
- Pre-fetch and Branch Prediction Units
- Cached*

Real-time / Determinism
- Tightly Coupled Memory (TCM)
- Fast interrupt response
- Deterministic interrupt response

*Cortex R5 based products
Flash / RAM ECC Protection

- ECC evaluated in the Cortex R4 CPU
  - Single Bit Error Correction and Double Bit Error Detection (SECDED)
  - ECC evaluated in parallel to processing data/instructions
  - No latency or performance impact
  - Protects Busses from CPU to Flash and RAM
- Address / Control parity from CPU -> Memory
- Diagnostic in Flash / SRAM wrappers
Hercules Product & Process Certification

- First devices certified by exida for IEC 61508 SIL-3 use in 2011

- TÜV-SÜD certified the SafeTI Hardware functional safety development process for:
  - IEC 61508 SIL-3
  - ISO 26262 ASIL-D

- Hercules MCUs certified for IEC 61508 SIL-3, ISO 26262 ASIL D by TÜV-SÜD:
  - Hercules MCU Safety Architecture
  - Device - TMS570LS12x/11x, TMS570LS3x/2x, TMS570LS04x/03x, RM48x, RM46x, RM42x

- TÜV-Nord certified the SafeTI Software functional safety development process for
  - IEC 61508 SIL-3
  - ISO 26262 ASIL D
# Hercules Software Offering

## RTOS Support

**Real-Time Operating Systems:**

- **FreeRTOS:** FreeRTOS.org
  Portable, open source, royalty free, mini Real Time Kernel.
- **SafeRTOS:** High Integrity Systems
  Design assurance package for IEC61508, others
- **µC/OS:** Micrium
  Certifiable design package for IEC61508, others
- **SCIOPTA:** SCIOPTA RTOS
  Kernel certified by TUV for IEC 61508 and EN50128 Hercules to SIL-3
- **CoDeSys:** Smart Software Solutions
  Control and safety runtime system for Industrial PLCs
- **SMXRTOS:** Micro Digital
  Modular RTOS that meets the needs of small to medium-size embedded systems
- **AUTOSAR OS/RTE:**
  - Vector MICROSAR Safe
  - ElektroBit tresos
  - ETAS RTA-OS & RTA-RTE

## MiddleWare

- **HCC**
- **Simma Software**
- **lwIP**
- **USB**
  - Ethernet Driver and light weight IP Stack
  - USB Device Driver & CDC Class
  - Many MiddleWare options available from RTOS providers

## TI Peripheral Drivers and Libraries

### Peripheral Drivers

- **HALCoGen** – Hardware Abstraction Layer, GUI based code generation
- **TI MCAL** for AUTOSAR v4.0.3

### Libraries

- **SafeTI Diagnostic Library** – executable form of safety manual
- **MotorWare** – InstaSPIN BLDC
- **CMSIS library** – DSP + Math functions
Hercules Development Tools

### IDEs & Compilers

- TI Code Composer Studio – compiler qualification kit
- Embedded Workbench for ARM is certified by TÜV SÜD as suitable for use to IEC 61508 and ISO 26262
- ARM Development Studio (DS-5) and C/C++ Compilation Tools
- MULTI IDE and Green Hills Compiler certified to ISO 26262 and IEC 61608
- Tantino-Cortex-R4 with professional HiTOP Debugger/IDE
- CoDeSys programming system and runtime system for IEC 61131-3 programmable logic controllers
- TargetLink code from MathWorks Simulink/Stateflow, certified for IEC 61508
- Embedded Coder Cortex-M/R optimized code from MATLAB, Simulink, Stateflow; Processor-In-the-Loop (PIL) testing; certified to IEC 61508 and ISO 26262
- HET IDE with Synapticad WaveViewer or WaveFormer Pro

### JTAG Emulators & Trace

- Spectrum Digital XDS510 & XDS560
- Blackhawk XDS510 & XDS560
- Segger J-Link
- TI XDS100v2
- Lauterbach TRACE32 PowerView for program and data trace
- iSYSTEM winIDEA IDE, iC5000 emulator and trace hardware

### Flash Programming

**Automated offline Programmers:**
- Data I/O
- BP Micro Systems

**In Circuit JTAG Programmers:**
- SMH Technologies
- Checksum
- XJTAG
- CCS UniFlash + JTAG Emulator
Hercules™ Kits

**High Performance LaunchPad**
- Evaluate Hercules Highest Performance MCUs
  - *Includes Ethernet Connectivity*
  - $29.99
  - TMS570LC
  - RM57

**Low Cost LaunchPad**
- Lowest cost option to evaluate Hercules MCU platform
  - $19.99
  - TMS570LS12x, TMS570LS04x, RM42, RM46

**Hercules Development Kit**
- Get started on development with Hercules MCU platform
  - $199
  - TMS570LC4/LS31/LS12/LS04
  - RM57, RM48, RM46, RM42

**Hitex Safety Kit**
- Evaluate Hercules MCU and TPS65381 combination for safety-critical applications
  - $499
  - TMS570LS31
  - RM48

**HDK PROTRACE**
- Real-time, non-intrusive code debug, profiling and coverage analysis
  - Starting at $3700
  - TMS570LC4
  - RM57

**Motor Control Kit**
- Spin 3 phase Brushless DC and brushless AC motors
  - Starting at $499
  - TMS570LS31/LS12
  - RM48, RM46
Hercules MCUs: Accelerating Safety Products to Market

- Software
- Development Tools
- Consulting & Training

**Unique Tools for Safety Development**
- Ease development
- Aid certification

**Certified Safety Hardware Architecture**
- Pre-approved for ISO 26262, IEC 61508
- Proven in use
- Device FMEDA, FIT reports

**Only Lockstep ARM supplier**
- Non-proprietary
- Market accepted
- Respected heritage

**Broad Eco-system**

**Production Quality Safety Software**
- Usable by customer
- Certification Ready
- ISO 26262, IEC 61508 compliant

**Comprehensive Portfolio Complementary Analog**
- Pin & SW Compatible
- Safety Chipset
- SafeTI Program

**Texas Instruments**