TMS470M
ARM® Cortex™-M3 based
Hercules™ Microcontrollers

1 Day Workshop
TMS470M 1 Day Workshop Agenda

- Introduction and Roadmap
- Development Tools: Hardware kits, Software tools
- Safety Overview and Modules
  - **Lab 1: TMS470M Safety MCU Demos**
- TMS470M Architecture: Memory Map, Clocking, Exceptions
- Embedded Flash Memory tools: nowECC, nowFlash, Application Programmer Interface (API)
- Real Time Interrupt (RTI)
- Vectored Interrupt Manager (M3VIM)
- General-purpose I/O (GIO)
- Programmable Timer Unit (HET)
  - **Lab 2: Using HET as GIO**
- Multi-Buffered Serial Peripheral Interface (MibSPI)
- Controller Area Network (DCAN)
- Local Interconnect Network (LIN) / Serial Communication Interface (SCI)
  - **Lab 3: PC to SCI Communication**
- Multi-buffered Analog-to-Digital Converter (MibADC)
- Support Structure: Web, Forum, WIKI
ARM Cortex Advanced Processors

Architectural innovation, compatibility across diverse application spectrum

- **ARM Cortex-A family:**
  - Applications processors for feature-rich OS and 3rd party applications

- **ARM Cortex-R family:**
  - Embedded processors for real-time signal processing, control applications

- **ARM Cortex-M family:**
  - Microcontroller-oriented processors for MCU, ASSP, and SoC applications
• **ARM® Cortex™**

• **Embedded Processing Cores at Texas Instruments**

• High-performance, low power core
• Multimedia, DSP acceleration capabilities
• Mobile computing capabilities
• Internet-enabled

• **ARM Cortex-A family:**
  - Interactive media and graphics experience
  - Neon optimization
  - Full-featured OS support (Linux, WinCE, etc…)

• **Hercules**
  - Real-time control
  - High-reliability
  - Built-in redundancies
  - Safety-focused
  - Commitment to enhancing performance and increasing memory footprint
  - System coherency

• **ARM Processor Family**

• **Sitara**
  - High-performance, low power core
  - Multimedia, DSP acceleration capabilities
  - Mobile computing capabilities
  - Internet-enabled

• **ARM Cortex-R family**

• **AMxx**

• **ARM Cortex-M family**

• **Stellaris®**
  - Active/sleep power efficiency
  - Efficient gate counts for better price/performance
  - Optimized price/performance
  - Interactive media and graphics experience
  - Neon optimization
  - Full-featured OS support (Linux, WinCE, etc…)

• **TMS470M for Transportation**

• **TMS570**
  - Hercules
  - RM4

• **Hercules**
  - TMS570
  - RM4

• **TMS470M for Transportation**

• **TMS470M for Transportation**

• **Proven processors cores with ongoing architectural innovation that simplifies the ease of use**
What is TMS470M?
Value Line of Safety MCUs

**What’s new**

- Efficient 16/32-bit ARM® Cortex™-M3
- Developed specifically for safety critical systems
- Configurations from 256KB to 640KB embedded flash with ECC
- Support for fast engineering ramp and time to market.

**Ideal for applications requiring**

- Performance in harsh environments
- Cost sensitive safety applications
- Safety oriented and high reliability
- And…
  - Scalability
  - System cost constraints
  - Software re-use and portability

**TMS470M – A good fit for Transportation & Safety**

- Automotive Safety Systems
- Offroad Vehicles
- Railway
- Hybrid & Electric Vehicles
- Industrial
- Medical
- Avionics

What's new

- Developed specifically for safety critical systems
- Configurations from 256KB to 640KB embedded flash with ECC
- Support for fast engineering ramp and time to market.

Ideal for applications requiring

- Performance in harsh environments
- Cost sensitive safety applications
- Safety oriented and high reliability
- And…
  - Scalability
  - System cost constraints
  - Software re-use and portability

TMS470M – A good fit for Transportation & Safety

- Automotive Safety Systems
- Offroad Vehicles
- Railway
- Hybrid & Electric Vehicles
- Industrial
- Medical
- Avionics

Texas Instruments
Cortex-M3 – The New MCU Standard

• An ARM7TDMI-S for the 21st century
  – For extreme cost and power-sensitive complex applications
  – Comparable or better \( F_{\text{MAX}} \) and gate count with r2p0 min config
  – 30% more DMIPS, 28% more geomean EEMBC
  – 85% more DMIPS per mW

• State-of-the-art functionality
  – Code **everything** in C
  – Thumb-2 ISA \( \rightarrow \) 6X code density, 10X perf. v 8051
  – Integrated Nested Vectored Interrupt Controller (NVIC) with lowest interrupt latency of any ARM
  – Configurable/optimal memory protection, debug, trace
  – uA device stand-by enabled with integrated sleep modes, ULL libraries, state retention

• Broad adoption within microcontroller and embedded SoC markets
High Performance ARM® Cortex™-M3 CPU

- ARM v7M Cortex® ISA
  Upward compatible to Cortex-R4F/TMS570

- Superior Performance / Code Density
  Thumb-2 instructions

- 3 Stage Pipeline Delivers 1.25 DMIPS/MHz

- Single Cycle Hardware Multiplier and Hardware Divider

- Over 96 DMIPS of Performance
- Superior Code Density
- ARM-based: Broad Industry Adoption

High performance 80 MHz CPU

Integrated Nested Vectored Interrupt Controller (NVIC)

8 Region Memory Protection (MPU)
TMS470M Safety Features

- Developed for safety applications
- Built in self test for CPU and RAMs
- ECC for Flash and RAM

CPU Self Test Controller requires little S/W overhead

Error Signaling Module

Parity on all Peripheral RAMS, ECC protected
Interrupt Vector Table in Flash/RAM

Memory BIST on all RAMS allows fast memory test at startup

On-Chip Clock Monitoring

CRC, Calibration, ADC Self Test, …
Hercules™ Safety MCU Roadmap

Industrial & Medical
- TMS570LS202S
  - 2*R4F LS
  - 2MB, 160kB
  - 160MHz
- TMS570LS102S
  - 1MB, 160kB
- TMS570LS31x
  - 2*R4F LS
  - 3MB, 256kB
  - 180MHz
- TMS570LS21x
  - 2MB, 192kB
- TMS470MF031S
  - 320kB, 16kB
- TMS470MF042S
  - 448kB, 24kB
- TMS470MF066S
  - ARM® Cortex™-M3
  - 640kB, 48kB
  - 80MHz
- TMS570LS31x
  - 2*R4F LS
  - 3MB, 256kB
  - 180MHz

Production
- Sampling
- Development

Lockstep CPUs
- IEC 61508 SIL3
- ISO 26262 support planned

Stability Control
- Industrial Automation
- Safe Connectivity
- Medical

Value
- TMS570LS202S
  - 2*R4F LS
  - 2MB, 160kB
  - 160MHz
- TMS570LS102S
  - 1MB, 160kB
- TMS570LS31x
  - 2*R4F LS
  - 3MB, 256kB
  - 180MHz
- TMS570LS21x
  - 2MB, 192kB
- TMS470MF031S
  - 320kB, 16kB
- TMS470MF042S
  - 448kB, 24kB

Production 4Q 2012
- More memory options
- New peripherals

Production Feb 2012
- More memory options
- New peripherals

Smaller memory options
- New peripherals
- Lower cost

ABS
- Power Steering
- Passive Safety

Power Steering
- Vehicle Electrification

Industrial & Medical
- TMS570LS202S
  - 2*R4F LS
  - 2MB, 160kB
  - 160MHz
- TMS570LS102S
  - 1MB, 160kB
- TMS570LS31x
  - 2*R4F LS
  - 3MB, 256kB
  - 180MHz
- TMS570LS21x
  - 2MB, 192kB
- TMS470MF031S
  - 320kB, 16kB
- TMS470MF042S
  - 448kB, 24kB

Production 4Q 2012
- More memory options
- New peripherals
### TMS470M Series Configurations

#### Value Line of Safety MCUs:
- Aerospace
- Railway
- Automotive
- Industrial
- Medical

#### TMS470MF03107
- ARM® Cortex™-M3
- 320kB, 16kB
- 80MHz

#### TMS470MF04207
- ARM® Cortex™-M3
- 448kB, 24kB
- 80MHz

#### TMS470MF06607
- ARM® Cortex™-M3
- 640kB, 64kB
- 80MHz

### MEMORy

<table>
<thead>
<tr>
<th>Device</th>
<th>Speed</th>
<th>Flash</th>
<th>EEPROM Or Flash*</th>
<th>RAM</th>
<th>CAN</th>
<th>MibSPI/CS</th>
<th>UART (LIN)</th>
<th>HET (ch)</th>
<th>MibADC 10-bit (ch)</th>
<th>GIO</th>
<th>Voltage</th>
<th>Package</th>
<th>Temp</th>
<th>Q100</th>
</tr>
</thead>
<tbody>
<tr>
<td>TMS470MF03107</td>
<td>80MHz</td>
<td>256kB</td>
<td>64kB</td>
<td>16kB</td>
<td>2</td>
<td>2 (12)</td>
<td>2(2)</td>
<td>16</td>
<td>16</td>
<td>4</td>
<td>3.3V</td>
<td>100QFP</td>
<td>-40..+125C</td>
<td>Yes</td>
</tr>
<tr>
<td>TMS470MF04207</td>
<td>80MHz</td>
<td>384kB</td>
<td>64kB</td>
<td>24kB</td>
<td>2</td>
<td>2 (12)</td>
<td>2(2)</td>
<td>16</td>
<td>16</td>
<td>4</td>
<td>3.3V</td>
<td>100QFP</td>
<td>-40..+125C</td>
<td>Yes</td>
</tr>
<tr>
<td>TMS470MF06607</td>
<td>80MHz</td>
<td>512kB</td>
<td>128kB</td>
<td>64kB</td>
<td>2</td>
<td>2 (12)</td>
<td>2(2)</td>
<td>16</td>
<td>16</td>
<td>4</td>
<td>3.3V</td>
<td>100QFP</td>
<td>-40..+125C</td>
<td>Yes</td>
</tr>
</tbody>
</table>

* Can be used as program flash or as emulated EEPROM

---

SAMPLING NOW!
TMS470M Block Diagram
TI Automotive Qualified ARM Cortex-M3 MCU

**Performance / Memory**
- 80 MHz ARM Cortex-M3
- Up to 640KB Flash (128KB can be used as emulated EEPROM)
- Up to 64KB Data SRAM
- EEPROM Emulation Capability

**Features**
- **Safety**
  - CPU Self Test Controller
  - Flash & RAM w/ ECC
  - Memory Built-in Self Test
  - Cyclic redundancy checker module (CRC)
- **Reliability**
  - Low PPM Production Flow Support
  - Extended Temp and AEC-Q100 Qualification
- **On-chip VREG (only 3.3v required)**
- **Enhanced I/O Control**
  High End Timer Coprocessor (HET)
  - 16 I/O Channels
  - All pins can be used as PWM or Input Capture
  - Hardware Encoders & Time Stamping
  10-bit MibADC (16 channels)
  - Continuous Conversion Channels
  - Buffered FIFO
  - Self Test on ADC
- **Strong Communication Networks**
  - 2 x CAN Interfaces
  - 2 Multi-Buffered SPI
  - 2 x LIN / UART (SCI)

**Targeted Applications**
- General Safety Applications
- Automotive/Aerospace
- Industrial/Medical

100pin QFP - 14x14mm
-40 to 125°C Temperature Range
TMS470M Development Tools
**TMS470M Software Tools**

**Code Composer Studio IDE**

Program & debug code using Code Composer Studio:
- Full Featured Debugger
- Compiler
- Linker
- Integrated Flash Programming

**GUI Demos & Code Examples**

Safety MCU Demos:
- Safety Feature Highlight
- Ambient Light Demo
- Temperature Sensor Demo
- LED Light Show
- Source Code Viewable via CCS

**GUI-based Code Generation Tools and Other SW Tools**

HALCoGen
- User Input on High Abstraction Level
- Graphical-based code generation
- Easy configuration
- Quick start for new projects

HET IDE
- Graphical Programming Environment
- Output Simulation Tool
- Generates CCS-ready software modules
- Includes functional examples from TI

FMzPLL Calculators
Easily configure the FMzPLL in the TMS470M Phase Lock Loop modules.

**now ECC™ ECC Generation Tool**
Command line program for generating Error Correction Code for TMS470M devices. Can be used in conjunction with CCSv4

**now Flash™ Flash Programming Tool**
GUI and command line programmer for loading code into TMS470M devices without an IDE.
HALCoGen: Hardware Abstraction Layer Code Generator

Features

- **User Input on High Abstraction Level**
  - Graphical-based code generation
  - Easy configuration
  - Quick start for new projects

- **Generates C Source Code**
  - ANSI Conforming
  - Clear, structured, coding style
  - Customizable code for user maintenance

- **Supported Peripherals**
  - System Module
  - RTI
  - GIO
  - SCI/LIN
  - CAN
  - SPI
  - ADC
  - Timer Co-processor (HET)

- **Interactive Help System**
  - Describes tool features and functions
  - Provides detailed dependency graphs
  - Provides useful example code
  - Tool tip help available
HALCoGen GUI Overview

- Menus and Icons
- Module Selection/Configuration
- Help
- Device Block Diagram
- Device/Output File Explorer
- Output/Status
Code Composer Studio v4.x

- Based on Eclipse industry standard for embedded debug tools
  - Modern window environment
  - Advanced source code editor
  - Scalable multi-core/processor environment
  - Program and Debug Application via JTAG
  - Test Automation via Scripting

- TMS470M Debug Features
  - 6 Hardware Breakpoints
  - Unlimited Software Breakpoints
  - Integrated Flash Programming
Code Composer Studio Components:

- Source Code View
- Target Connection
  - Source & object files
  - File dependencies
  - Compiler, assembler & linker build options
- Disassembly Window
- CPU Window
- Memory Window
- Watch Window
- Menus and Icons
- Help

![Code Composer Studio v4](image-url)
HET IDE (Timer Co-Processor Development Tool)

HET Device Configuration
- HET/NHET/N2HET
- Clock configuration
- Number and direction of pins
- XOR, AND and SHARE configuration on pins

HET Program Development
- Library with common predefined algorithms
- Insert functionality for algorithms and instructions
- *.c and *.h file creation for given *.het file

HET Program Simulation
- View resulting signal waveforms (WaveViewer, WaveFormer Pro)
- Various debugging options
- Memory and register windows
- Input stimuli (stimulus creator or VCD files)
The HET IDE works in conjunction with SynaptiCAD’s WaveFormer Pro (license necessary or 90-day trial) or WaveViewer (free). Both are installed with HET IDE and can be used to watch and check HET signals.
HET IDE – User Interface

HET IDE Program Development View

- Menu
- Debug Icons
- HET Program Code Window
- Device Configuration Window
- Project Window
- Console Output Window
- HET/NHET Register Window
External Tools:

- **IDE’s**
  - Lauterbach, iSystems, CCS
- **Compiler**
  - ARM, CCS
- **Emulator**
  - Spectrum Digital, Lauterbach, iSystems, Blackhawk, Signum Systems, XDS100, XDS560 ...
- **Operating System**
  - ETAS
- **CAN**
  - Vector
- **Trace / Calibration**
  - Lauterbach, iSystems
- **Production Flash Programming**
  - BP Microsystems, Data-IO
TMS470M Evaluation and Development Kit Overview

**TMDX470MF066USB** ($79) – Low Cost TMS470M Evaluation Kit
- USB Powered
- On Board USB XDS100v2 JTAG Debug
- On Board SCI to PC Serial Communication
- Access to Select Signal Pin Test Points
- CAN transceiver
- LEDs, Temp Sensor, Light Sensor
- QFP Packaged MCU

**TMDX470MF066HDK** ($179) - Full Featured TMS470M Development Kit
- USB Powered
- On Board USB XDS100v2 JTAG Debug
- On Board SCI to PC Serial Communication
- External high speed emulation via JTAG
- CAN Transceivers
- LEDs, Temp Sensor, Light Sensor
- Access to all peripheral pins
- Communications Expansion Board Compatible
- QFP Packaged MCU

**Software Included in Each Kit:**
- CCStudio v4.x IDE: C/C++ Compiler/Linker/Debugger
- HALCoGen Peripheral Driver Generation Tool
- CCS and nowFlash™ Flash Programming Tools
- HET GUI/Simulator/Assembler
- Demo Project/Code Examples
TI Suggested ABS System

- **Power Management Module**
  - Supervisor
  - Buck/LDO

- **ABS IC**
  - TPIC7218

- **ABS**
  - MCU
  - TMS470M/570

- **CAN Bus**
  - Transceiver

- **Wheel**
  - Speed
  - Sensor x4

- **Chassis**
  - CAN

- **Diagnostic Systems**
  - ISO K-Line

- **Charge Pump**
  - Monitor

- **Watchdog**
  - PWM x4

- **Wheel Speed**
  - Sensor
  - Interface

- **K-Line**

- **Main Relay Driver**

- **LS Switch Driver**
  - x4

- **PWM**

- **Lamp Driver**
  - x2

- **Battery**

- **Warning Lamp**

- **M**

- **Solenoid**

- **Diagnostic Systems**
  - ISO K-Line

- **Charge Pump**

- **Wake up**

- **Pump Motor Driver**

- **Main Relay Driver**

- **LS Switch Driver**

- **PWM**

- **Lamp Driver**

- **Buck/LDO**

- **Supervisor**

- **Solenoid**

- **Supervisor**

- **Charge Pump**

- **Watchdog**

- **SPI**

- **K-Line**

- **Lamp Driver**

- **Buck/LDO**

- **Supervisor**

- **Charge Pump**

- **Watchdog**

- **SPI**