STM32L5 MCU series excellence in ultra-low-power with more security
### STM32 MCUs and MPUs portfolio

**STM32 High Perf MCUs**
- STM32F2
  - Up to 398 CoreMark
  - 120 MHz Cortex-M3

- STM32F4
  - Up to 608 CoreMark
  - 180 MHz Cortex-M4

- STM32F7
  - 1082 CoreMark
  - 216 MHz Cortex-M7

- STM32H7
  - Up to 3224 CoreMark
  - Up to 550 MHz Cortex-M7

**STM32 Mainstream MCUs**
- STM32F0
  - 106 CoreMark
  - 48 MHz Cortex-M0

- STM32G0
  - 142 CoreMark
  - 64 MHz Cortex-M0+

- STM32F1
  - 177 CoreMark
  - 72 MHz Cortex-M3

- STM32F3
  - 245 CoreMark
  - 72 MHz Cortex-M4

- STM32G4
  - 569 CoreMark
  - 170 MHz Cortex-M4

**STM32 Ultra-low Power MCUs**
- STM32L0
  - 75 CoreMark
  - 32 MHz Cortex-M0+

- STM32L1
  - 93 CoreMark
  - 32 MHz Cortex-M3

- STM32L4
  - 273 CoreMark
  - 80 MHz Cortex-M4

- STM32L4+
  - 409 CoreMark
  - 120 MHz Cortex-M4

- STM32L5
  - 443 CoreMark
  - 110 MHz Cortex-M33

**STM32 Wireless MCUs**
- STM32WL
  - 162 CoreMark
  - 48 MHz Cortex-M4
  - 48 MHz Cortex-M0+

- STM32WB
  - 216 CoreMark
  - 64 MHz Cortex-M4
  - 32 MHz Cortex-M0+ [Radio co-processor only]

**STM32 MPUs**
- STM32MP1
  - 4158 CoreMark
  - Up to 800 MHz Cortex-A7

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  - 4158 CoreMark
  - Up to 800 MHz Cortex-A7

- STM32MP1
  - 4158 CoreMark
  - Up to 800 MHz Cortex-A7

**STM32 Latest product generation**
- STM32MP1
  - 4158 CoreMark
  - Up to 800 MHz Cortex-A7

- STM32MP1
  - 4158 CoreMark
  - Up to 800 MHz Cortex-A7

- STM32MP1
  - 4158 CoreMark
  - Up to 800 MHz Cortex-A7
Main concerns for embedded design

- **Security**
  - Increase the robustness against attacks

- **Low power consumption**
  - Long life time, small battery size

- **Integration, performance, ecosystem**
  - Best fit versus the application requirements
First STM32 based on Cortex-M33

STM32L5 is the answer

• More security with TrustZone and ST security implementation
  • HW to increase resistance to logical and board level attack

• Lower Power consumption
  • STM32 ultra-low-power technology

• Integration, performance, ecosystem
  • More performance, choice of packages and wide ecosystem
Security: TrustZone for isolation

ST implementation provides a high granularity of isolation

- Each GPIO or peripheral, DMA channel, clock configuration register, ART or small part of Flash memory or SRAM can be configured as **Trusted** or **un-Trusted**

- **Full isolation** of trusted and non-trusted worlds
Security: TrustZone for isolation

TrustZone provides full isolation

Example of IoT application implementation

STM32L5

Un-Trusted

RF

Trusted

Un-Trusted Application

Sensors

Trusted Application
Security: TrustZone and privileged zones

- More partitioning
- Possibility to separate the trusted and un-trusted area with privileged and un-privileged zone
- Strong granularity to define each part of memory or each peripheral, DMA channel as privileged or un-privileged
TrustZone: example

STM32L5

Un-Trusted

Trusted

Privileged

Un-Trusted & Privileged

RTOS

Trusted & Privileged

Secured Keys

Secured Boot

Un-Trusted & Un-Privileged

RF Stack

Trusted & Un-Privileged

Secured data

Sensor IP

RF

Sensors
A full set of security

Encryption
- AES-128/256 Encryption
- SHA-256 Authentication
- Public Key Acceleration (PKA): for RSA, Diffie-Hellmann or ECC (Elliptic Curve Cryptography)
- Certified Crypto library
- True Random Number Generator
- Unique ID
- OTP Zone

Decryption
Authentication

Memory & IP Protection
- Active and static Anti-tamper detection
- Memory Protection Unit (MPU)
- Secure Boot
- Read and Write Protection
- HDP (Hide Protect)
- Unique Boot Entry
- OTFDEC (On-the-fly decryption) on Octo SPI to protect external memory
- JTAG fuse
- TrustZone
- SFI (Secure Firmware Installation)
Extends battery lifetime

• STM32L5 reuses the STM32L4/L4+ technology achieving **best-in-class** power consumption

• STM32L5 integrates an optional **SMPS** (DC/DC buck voltage regulator) which can be enabled/disabled on the fly to avoid external noise for external RF or data acquisition.

• Proven by EEMBC test results:

  - **370 ULPMark-CP**
  - **54 ULPMark-PP**
### Ultra-low-power modes

#### Best power consumption numbers with full flexibility

<table>
<thead>
<tr>
<th>Wake-up time</th>
<th>$V_{BAT}$</th>
<th>Tamper detection: 3 I/Os, RTC</th>
</tr>
</thead>
<tbody>
<tr>
<td>250 µs</td>
<td>3 nA / 187 nA*</td>
<td>Wake-up sources: reset pin, 5 I/Os, RTC</td>
</tr>
<tr>
<td>14 µs</td>
<td>17 nA / 122 nA*</td>
<td>Wake-up sources: BOR, IWDG</td>
</tr>
<tr>
<td>14 µs</td>
<td>108 nA / 222 nA*</td>
<td>Wake-up sources: + all I/Os, PVD, COMPs, I²C, LPUART, LPTIM</td>
</tr>
<tr>
<td>5 µs</td>
<td>272 nA / 386 nA*</td>
<td>Wake-up sources: any interrupt or event</td>
</tr>
<tr>
<td>6 cycles</td>
<td>3 nA / 187 nA*</td>
<td></td>
</tr>
</tbody>
</table>

*Note:* * without RTC / with RTC

- **Sleep:** 26 µA / MHz
- **Run up to 110 MHz:** Down to 62 µA / MHz
More performance

Better responsiveness of the application

- **New** Arm® Cortex®-M33 performance: +20% versus Cortex-M4
  - 1.5 DMIPS/MHz
  - 4.02 CoreMark/MHz
  - 165 DMIPS
  - 442 CoreMark

- **New** ST ART Accelerator™: working both on internal and **external** Flash
  - 8 Kbytes of instruction cache
High integration and innovation

Large memory, USB Type-C™ w/ power delivery controller, CAN FD

- Parallel interface
  - FSMC 8-/16-bit (TFT-LCD, SRAM, NOR, NAND)

- Digital
  - 2x SAI, DFSDM (4 channels)

- Timers
  - 14 timers including:
    - 2x 16-bit advanced motor control timers
    - 2x LPUART timers
    - 3x 16-bit timers
    - 2 x 32-bit timers

- I/Os
  - Up to 115 I/Os
  - Touch-sensing controller

- Connectivity
  - USB Device Crystal-less
  - USB Type-C and PD
  - 1x SD/SDIO/MMC, 3 x SPI
  - 4 x I²C, 1x CAN FD
  - 1 x Octo-SPI
  - 5 x USART + 1 x LPUART

- ARM® Cortex®-M33 CPU
  - 110 MHz
  - TrustZone®
  - FPU
  - MPU
  - ETM

- DMA

- ART Accelerator™
  - Up to 512-Kbyte
  - Flash memory
  - Dual Bank

- Encryption
  - AES (256-bit), PKA, SHA-1, SHA-256, TRNG, CRC, OTFDEC

- Analog
  - 2 x 12-bit ADC 12/16 bits
  - 5 MSPS, 2 x DAC
  - 2 x comparators
  - 2 x op amps
  - 1 x temperature sensor
Large portfolio

7 packages, several options
## STM32L ULP portfolio

### STM32L5 completes the ultra-low-power subclass

<table>
<thead>
<tr>
<th>Cost-smart ULP champion</th>
<th>Broad-range foundation</th>
<th>ULP With performance</th>
<th>ULP with more performance</th>
<th>Advanced security</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>STM32L0</strong></td>
<td><strong>STM32L1</strong></td>
<td><strong>STM32L4</strong></td>
<td><strong>STM32L4+</strong></td>
<td><strong>STM32L5</strong></td>
</tr>
<tr>
<td>Cortex-M0+ at 32 MHz</td>
<td>Cortex-M3 at 32 MHz</td>
<td>Cortex-M4 w/ FPU at 80 MHz</td>
<td>Cortex-M4 w/ FPU at 120 MHz</td>
<td>Cortex-M33 w/ FPU at 110 MHz</td>
</tr>
<tr>
<td>1.65 to 3.6V</td>
<td>1.65 to 3.6V</td>
<td>1.71 to 3.6V</td>
<td>1.71 to 3.6V</td>
<td>1.71 to 3.6V</td>
</tr>
<tr>
<td>8-/16-bit applications</td>
<td>Wide choice of memory sizes</td>
<td>High-performance, advanced analog circuits</td>
<td>Wide choice of memory sizes</td>
<td></td>
</tr>
<tr>
<td>Wide range of pin-counts</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

- **STM32L0**
  - 3 product lines,
  - Cost-effective,
  - Smaller packages,
  - USB, LCD, Analog
  - 8 to 192 Kbytes of Flash,
  - Up to 20 Kbytes of SRAM

- **STM32L1**
  - 3 product lines,
  - USB, LCD, AES,
  - Rich Analog
  - True EEPROM,
  - Dual-bank Flash memory (RWW),
  - 32 to 512 Kbytes of Flash,
  - Up to 80 Kbytes of SRAM

- **STM32L4**
  - 5 product lines,
  - 5-MSPS ADC,
  - PGA, Compar.,
  - DAC, Op Amp, USB
  - OTG, LCD, AES
  - 64 Kbytes to 1 Mbyte
  - Up to 320 Kbytes of SRAM

- **STM32L4+**
  - 3 product lines,
  - 5-MSPS ADC,
  - PGA, Compar.,
  - DAC, Op Amp, USB
  - OTG, LCD, AES
  - 1 to 2 Mbytes of Flash,
  - Up to 640 Kbytes of SRAM

- **STM32L5**
  - 1 product line,
  - 5-MSPS ADC,
  - PGA, Compar.,
  - DAC, Op Amp,
  - USB Type C, AES
  - 256 to 512 Kbytes of Flash,
  - Up to 256 Kbytes of SRAM
A Complete Ecosystem
STM32CubeL5
One-stop-shop software package

STM32Cube MCU Packages

STM32Cube MCU Middleware

- FreeRTOS
- FatFS file system
- mbedTLS and mbedCrypto
- USB Device stacks

STM32Cube HAL & LL drivers

Peripheral drivers

- HAL API
  Hardware Abstraction Layer, highly portable and easy to use
- LL APIs
  Low-Layer APIs, light weight and highly optimized for runtime efficiency

STM32Cube Middleware

- Generic Middleware
  - FreeRTOS
  - FatFS file system
  - mbedTLS and mbedCrypto
  - USB Device stacks
- Dedicated Middleware
  - Secure Boot and Secure Firmware Update
  - TF-M for trusted execution environment
  - USB-PD device driver
  - STM32 Touch Sensing library

STM32Cube HAL & LL drivers

Project Examples

- STM32CubeMX ready
  More than 300 project examples for KEIL, IAR and STM32CubeIDE toolchains, with a STM32CubeMX configuration file

www.st.com/stm32cubel5
SBSFU and TF-M in STM32CubeL5

Reference code framework for a trusted Execution Environment

STM32L5

- Un-Trusted Un-Privileged
- Un-Trusted Privileged
- TF-M (Application Root of Trust)
- TF-M (PSA Root of Trust)
- SBSFU TF-M (PSA Immutable Root of Trust)

TF-M Framework

- Isolation and Secure execution
- Secure services (crypto, initial attestation, secure storage)
- Easy addition of user secure services
- Leveraging STM32L5 security features

SBSFU TF-M

- Secure Boot
- Secure Firmware Update
STM32L5 is one of the first MCU PSA Level 2 certified
STM32CubeIDE

All-in-1 STM32 development tool

Configure and generate code
STM32CubeMX integrated

Develop code, Compile and Link
TrustZone support
• TrueSTUDIO / SW4STM32 importer
• Advanced editor
• GNU C/C++ for Arm® toolchain

Program and Debug
TrustZone support
• GDB and OpenOCD debugger
• Support of ST-Link and J-Link debug probes
STM32CubeMX enhanced for TrustZone
- Peripherals/middleware configuration
- Resources allocation to security domains

IDEs
- Compile and Debug
- TrustZone Support
  - Partners IDE
  - STM32CubeIDE based on Eclipse
  - TrustZone debugging

STM32 Programming Tool
- Device and memory configuration
- Program the application
- Secure Firmware Install

Arm V8-M TrustZone architecture support

Optional step
Configuration tool

Power Consumption Calculator

MCU or board Selector

macOS®

Windows

Load an Example .ioc file

Pinout Configuration

Clock Tree Initialization

Peripherals Configuration

TrustZone configuration and GPIOs, memories, DMA, peripherals allocation to security domains

Code Generation

TrustZone support

Middleware Parameters

FreeRTOS
FatFS
USB device

STM32CubeMX
All-in-one programming software tool

- Intuitive GUI
- Command Line Interface for scripting
- API DLL for Custom Integration
- STLink (JTAG, SWD)
- STM32 Bootloader Interface (USB, UART, SPI, I2C, CAN)
- Secure Firmware install (SFI)

MCU Internal Flash and external Flash services
MCU configuration (Option bytes)
STM32L5 hardware solutions

Speed-up evaluation prototyping and design

**Evaluation Boards**
- Full feature STM32L5 evaluation
  - STM32L552E-EV

**Discovery Kit**
- Flexible prototyping & demo
  - STM32L562E-DK

**Nucleo Boards**
- Affordable and quick prototyping
  - NUCLEO-L552ZE-Q

$275
$76
$20
Prototype your wearable or sensor application with STM32L562E-DK

**Key Features**

- STM32L562 MCU with AES and PKA
- 240 x 240 pixel-TFT color Display
- state-of-the-art Energy Meter
- 3D accelerometer and 3D gyroscope
- Bluetooth® V4.1 low energy module
- Audio Codec and Headphone amplifier
- Digital microphone
- USB Type-C™ Sink device FS
- 512Mbit Octal Flash memory extension
- ST-Link V3
- STMod+ connector with fan-out expansion board for Wi-Fi®, Grove and mikroBUS™ compatible connectors
STM32CubeMonitor-power

State-of-the-art on-board power consumption measurement

STM32L562E-DK
On-board Energy Meter
300 nA to 150 mA measurement range
Secure your production flow with Secure Firmware Install (SFI)

Protect your code and control the number of products manufactured

Customer premises

- FW
- Encrypted FW
- HSM
- Store encryption key and production counter into HSM
- ST Hardware Secure Module (HSM)

Untrusted environment

- STM32L5 SFI
- Authenticate target STM32
- Generate installation license
- Number of products controlled

Encrypted FW transfer

HSM physical transfer

Number of products controlled
• More security
• Lower power consumption
• Integration, performance, ecosystem
Releasing your creativity

/STM32

@ST_World

community.st.com

www.st.com/STM32L5

STM32L5 Online Training

wiki.st.com/stm32mcu

github.com/STMicroelectronics

STM32L5 blog articles
Our technology starts with You

Find out more at www.st.com/STM32L5