STM32L5 MCU series excellence in ultra-low-power with more security
<table>
<thead>
<tr>
<th>STM32L0</th>
<th>STM32L1</th>
<th>STM32L4</th>
<th>STM32L4+</th>
<th>STM32L5</th>
<th>STM32U5</th>
</tr>
</thead>
<tbody>
<tr>
<td>75 CoreMark</td>
<td>93 CoreMark</td>
<td>273 CoreMark</td>
<td>409 CoreMark</td>
<td>443 CoreMark</td>
<td>651 CoreMark</td>
</tr>
<tr>
<td>32 MHz Cortex-M0+</td>
<td>32 MHz Cortex-M3</td>
<td>80 MHz Cortex-M4</td>
<td>120 MHz Cortex-M4</td>
<td>110 MHz Cortex-M33</td>
<td>160 MHz Cortex-M33</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STM32L0+</th>
<th>STM32L1+</th>
<th>STM32L4+</th>
<th>STM32L5+</th>
<th>STM32U5+</th>
</tr>
</thead>
<tbody>
<tr>
<td>183 CoreMark</td>
<td>213 CoreMark</td>
<td>409 CoreMark</td>
<td>443 CoreMark</td>
<td>651 CoreMark</td>
</tr>
<tr>
<td>48 MHz Cortex-M0+</td>
<td>64 MHz Cortex-M4</td>
<td>48 MHz Cortex-M0+</td>
<td>48 MHz Cortex-M0+</td>
<td>48 MHz Cortex-M0+</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STM32F2</th>
<th>STM32F4</th>
<th>STM32F7</th>
<th>STM32H7</th>
</tr>
</thead>
<tbody>
<tr>
<td>Up to 398 CoreMark</td>
<td>Up to 608 CoreMark</td>
<td>1082 CoreMark</td>
<td>Up to 3224 CoreMark</td>
</tr>
<tr>
<td>120 MHz Cortex-M3</td>
<td>180 MHz Cortex-M4</td>
<td>216 MHz Cortex-M7</td>
<td>Up to 550 MHz Cortex-M7</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>STM32MP1</th>
</tr>
</thead>
<tbody>
<tr>
<td>4158 CoreMark</td>
</tr>
<tr>
<td>650 MHz Cortex-M0+</td>
</tr>
<tr>
<td>A7</td>
</tr>
</tbody>
</table>

**Optimized for mixed-signal Applications**
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

Un-Trusted Application

Trusted Application

Trusted

RF

Sensors
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 & Privileged

Un-Trusted

RTOS

Trusted & Privileged

Trusted

Secured Keys

Secured Boot

Un-Trusted & Un-Privileged

Un-Trusted

RF Stack

Un-Privileged

RF

Trusted & Un-Privileged

Secured data

Sensor IP

Sensors

Secured Keys

Boot
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**

**STM32L5**

**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)
• 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 ( \mu )s</td>
<td>3 nA / 187 nA*</td>
<td></td>
</tr>
<tr>
<td>14 ( \mu )s</td>
<td>17 nA / 122 nA*</td>
<td></td>
</tr>
<tr>
<td>14 ( \mu )s</td>
<td>108 nA / 222 nA*</td>
<td></td>
</tr>
<tr>
<td>14 ( \mu )s</td>
<td>Standby + 4-Kbyte RAM 272 nA / 386 nA*</td>
<td>Wake-up sources: + BOR, IWDG</td>
</tr>
<tr>
<td>5 ( \mu )s</td>
<td>Stop 2 (full retention: 256-Kbyte RAM) 3.0 ( \mu )A / 3.1 ( \mu )A*</td>
<td>Wake-up sources: + all I/Os, PVD, COMPs, I²C, LPUART, LPTIM</td>
</tr>
<tr>
<td>6 cycles</td>
<td>Sleep</td>
<td>26 ( \mu )A / MHz</td>
</tr>
<tr>
<td></td>
<td>Run up to 110 MHz</td>
<td>Down to 62 ( \mu )A / MHz</td>
</tr>
</tbody>
</table>

**Note:** * without RTC / with RTC
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
  - 2x 32-bit timers

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

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

DMA

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

256-Kbyte RAM

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

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

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

7 packages, several options

Flash memory size / RAM size (bytes)

Legend:  without HW crypto  with HW crypto

STM32L562CE  STM32L562RE  STM32L562ME  STM32L562VE  STM32L562QE  STM32L562ZE

STM32L552CC  STM32L552RC

STM32L552VC  STM32L552QC  STM32L552ZC

Pin count

48-pin LQFP/QFN  64-pin LQFP  81-pin WLCSP  100-pin LQFP  132-pin UFBGA (0.5 mm pitch)  144-pin LQFP
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>Wide choice of memory sizes</td>
</tr>
<tr>
<td>Wide range of pin-counts</td>
<td></td>
<td></td>
<td></td>
<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

<table>
<thead>
<tr>
<th>Generic Middleware</th>
<th>Dedicated Middleware</th>
</tr>
</thead>
<tbody>
<tr>
<td>FreeRTOS</td>
<td>Secure Boot and Secure Firmware Update</td>
</tr>
<tr>
<td>FatFS file system</td>
<td>TF-M for trusted execution environment</td>
</tr>
<tr>
<td>mbedTLS and mbedCrypto</td>
<td>USB-PD device driver</td>
</tr>
<tr>
<td>USB Device stacks</td>
<td>STM32 Touch Sensing library</td>
</tr>
</tbody>
</table>

#### 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

#### Project Examples

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

[www.st.com/stm32cubel5](http://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
Partners IDEs development flow

Arm V8-M TrustZone architecture support

STM32CubeMX
- STM32CubeMX enhanced for TrustZone
  - Peripherals/middleware configuration
  - Resources allocation to security domains

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

STM32CubeProgrammer
- Device and memory configuration
- Program the application
- Secure Firmware Install

Optional step

STM32 Programming Tool
Configuration tool

- Power Consumption Calculator
- MCU or board Selector
- Code Generation
- TrustZone support
- Middleware Parameters
- FreeRTOS
- FatFS
- USB device
- Peripherals Configuration
- Clock Tree Initialization
- Pinout Configuration
- Load an Example .ioc file

TrustZone configuration and GPIOs, memories, DMA, peripherals allocation to security domains
All-in-one programming software tool

- MCU Internal Flash and external Flash services
- MCU configuration (Option bytes)
- 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)
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

Costs:
- Evaluation Boards: $275
- Discovery Kit: $76
- Nucleo Boards: $20
Discovery kit

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

Fan-out expansion board included
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
- Store encryption key and production counter into HSM
- ST Hardware Secure Module (HSM)

**Untrusted environment**
- STM32L5 SFI
- Authenticate target STM32
- Generate installation license

**Encrypted FW transfer**
- HSM physical transfer

**Number of products controlled**
- 27
STM32L5 helps designers to answer IoT challenges

- More security
- Lower power consumption
- Integration, performance, ecosystem
Thank you