STM32L0 Series

Ultra-low-power ARM Cortex-M0+

STM32 L0

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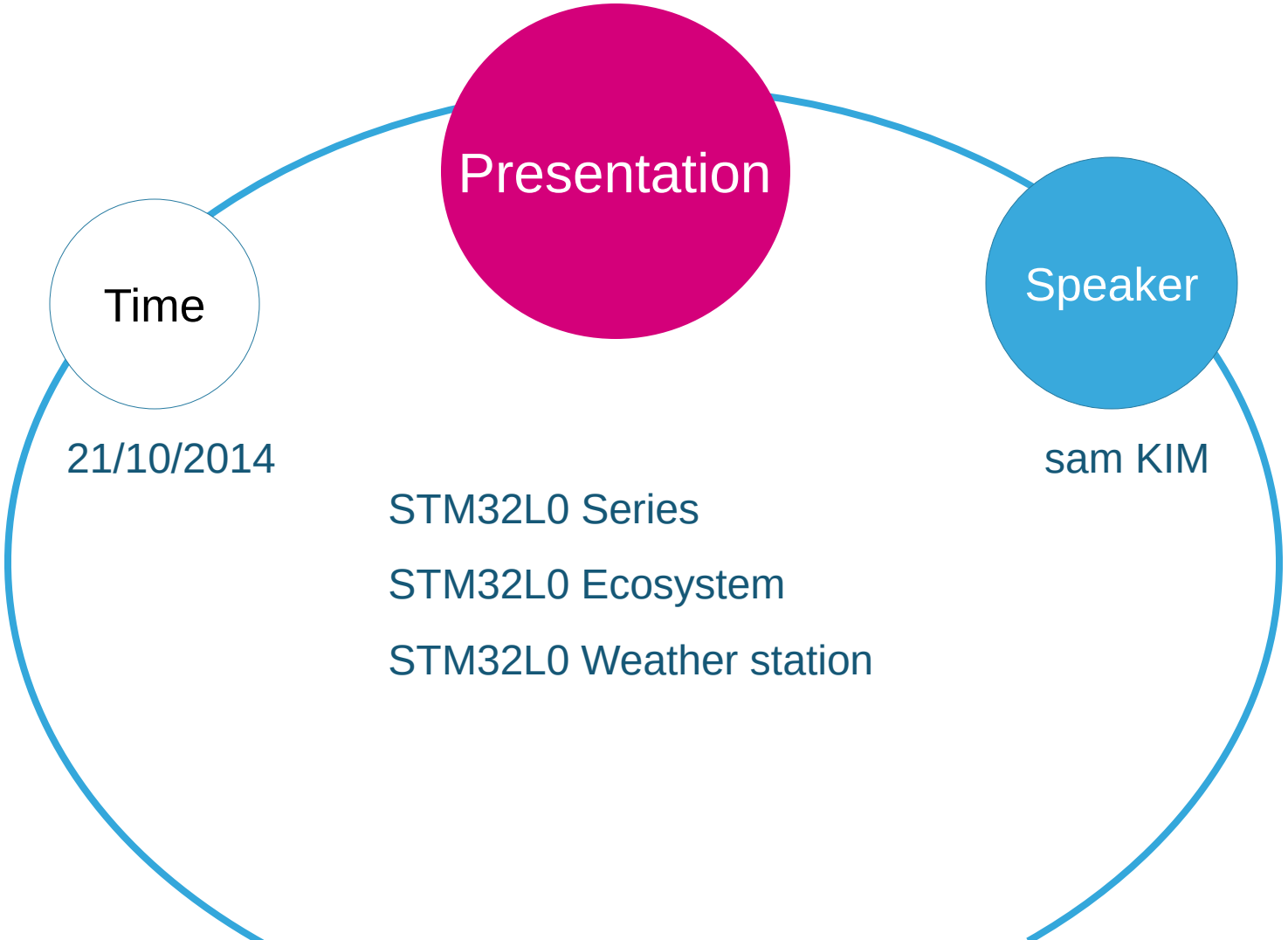
Agenda


Presentation
Time
21/10/2014
Speaker
sam KIM
STM32L0 Series
STM32L0 Ecosystem
STM32L0 Weather station

STM32 – 7 product series

Common core peripherals and architecture:

- Communication peripherals: USART, SPI, I²C
- Multiple general-purpose timers
- Integrated reset and brown-out warning
- Multiple DMA
- 2x watchdogs Real-time clock
- Integrated regulator PLL and clock circuit
- Up to 19x 12-bit DAC
- Up to 4x 12-bit ADC (Up to 5 MSPS)
- Main oscillator and 32 kHz oscillator
- Low-speed and high-speed internal RC oscillators
- -40 to +85 °C and up to 105 °C operating temperature range
- Low voltage 2.0 to 3.6 V or 1.65/1.7 to 3.6 V (depending on series)
- Temperature sensor

STM32 F4 series - High performance with DSP (STM32F401/405/415/407/417/427/437 and 429/439)

Up to 180 MHz Cortex-M4 DSP/FPU	Up to 2-Mbyte Flash	Up to 256-Kbyte SRAM	2x USB 2.0 OTG FS/HS	1x 12-bit AMC timer	2x CAN 2.0B	SDIO 2x I²S audio Camera IF	Ethernet IEEE 1588	LCD-TFT SDRAM I/F

STM32 F2 series - High performance (STM32F205/215 and 207/217)

120 MHz Cortex-M3 CPU	Up to 1-Mbyte Flash	Up to 128-Kbyte SRAM	2x USB 2.0 OTG FS/HS	1x 12-bit AMC timer	2x CAN 2.0B	SDIO 2x I²S audio Camera IF	Ethernet IEEE 1588	Crypto

High-performance

+

STM32 F3 series - Mixed-signal with DSP (STM32F301/302/303/373/x8)

72 MHz Cortex-M4 with DSP and FPU	Up to 512-Kbyte Flash	Up to 80-Kbyte SRAM CCM-SRAM	USB 2.0 FS	3x 16-bit AMC timer (144 MHz)	CAN 2.0B	Up to 7x comparator 4x 12-bit DAC 4x PGA	HDMI CEC	3x 16-bit ΣΔ ADC

STM32 F1 series - Mainstream - 5 product lines (STM32F100/101/102/103 and 105/107)

Up to 72 MHz Cortex-M3 CPU	Up to 1-Mbyte Flash	Up to 96-Kbyte SRAM	USB 2.0 OTG FS	1x 12-bit AMC timer	Up to 2x CAN 2.0B	SDIO 2x I²S audio	Ethernet IEEE 1588

STM32 F0 series - Entry-level (STM32F030/x1/x2 and x8)

48 MHz Cortex-M0 CPU	Up to 128-Kbyte Flash	Up to 16-Kbyte SRAM 20-byte backup data	USB clock free	USB 2.0 FS Crystal less	CAN 2.0B	DAC Comparator	CEC

Mainstream

STM32 L1 series - Ultra-low-power (STM32L100/151/512/162)

32 MHz Cortex-M3 CPU	Up to 512-Kbyte Flash	Up to 80-Kbyte SRAM	Up to 16-Kbyte EEPROM	USB 2.0 FS device	LCD 8x40 4x44	Op-amps comparator	BOR MSI VScal	AES 128-bit

STM32 L0 series - Ultra-low-power (STM32L0x1/x2/x3)

32 MHz Cortex-M0+ CPU	Up to 64-Kbyte Flash	Up to 8-Kbyte SRAM	Up to 2-Kbyte EEPROM	USB 2.0 FS Crystal less	LCD 8x28 4x32	True RNG	BOR MSI VScal	AES 128-bit

Ultra-low-power

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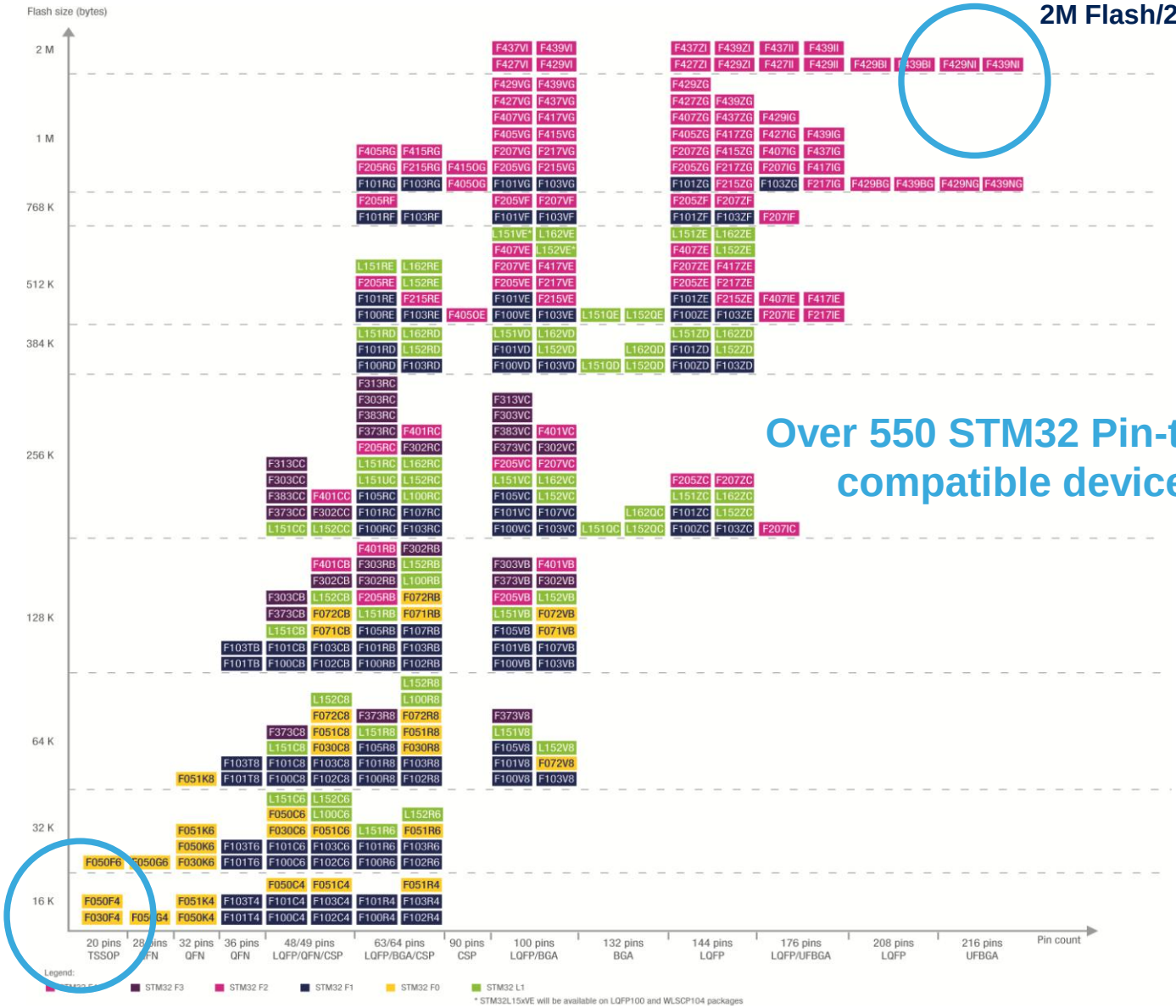
A rich & reliable product base and…

2M Flash/256KSRAM



Over 550 STM32 Pin-to-pin compatible devices

20 PIN / 16KFlash

STM32 L0x – Product lines

Common features
Cortex™-M0+ 32 MHz speed with MPU and MUL
AES 128-bit
Firewall protection[2] (Flash and RAM)
Built-in 16 MHz, 4,2MHz and 38 kHz RC oscillators
Multiple USART, SPI, I2C Low-power UART
Multiple 16-bit timers Low-power 16-bit timer
2x watchdogs
Reset circuitry POR/PDR
Brown Out Reset Program Voltage Detector
2x comparators
Dynamic Voltage Scaling

STM32L0x3 – USB & LCD line – 32-K to 192-Kbyte Flash

Up to 192-KB Flash[1]	Up to 20-KB SRAM	Up to 6-KB EEPROM	Main osc. input 1-24 MHz	RTC with 32 kHz osc.	7 ch DMA	ADC 12-bit 1Msps 16-ch	DAC Up to 2x 12-bit	USB2.0 Crystal Less, LPM, BCD	Touch Sense	True RNG	LCD 8x48 4x52

STM32L0x2 – USB line - 32 to 192-Kbyte Flash

Up to 192-KB Flash[1]	Up to 20-KB SRAM	Up to 6-KB EEPROM	Main osc. input 1-24 MHz	RTC with 32 kHz osc.	7 ch DMA	12-bit ADC 1Msps 16-ch	2xDAC 12-bit	USB2.0 Crystal Less, LPM, BCD	Touch Sense	True RNG

STM32L0x1 – Access line - 16-K to 192-Kbyte Flash

Up to 192-KB Flash[1]	Up to 20-KB SRAM	Up to 6-KB EEPROM	Main osc. input 1-24 MHz	RTC with 32 kHz osc.	4 ch DMA	12-bit ADC 1Msps 16-ch

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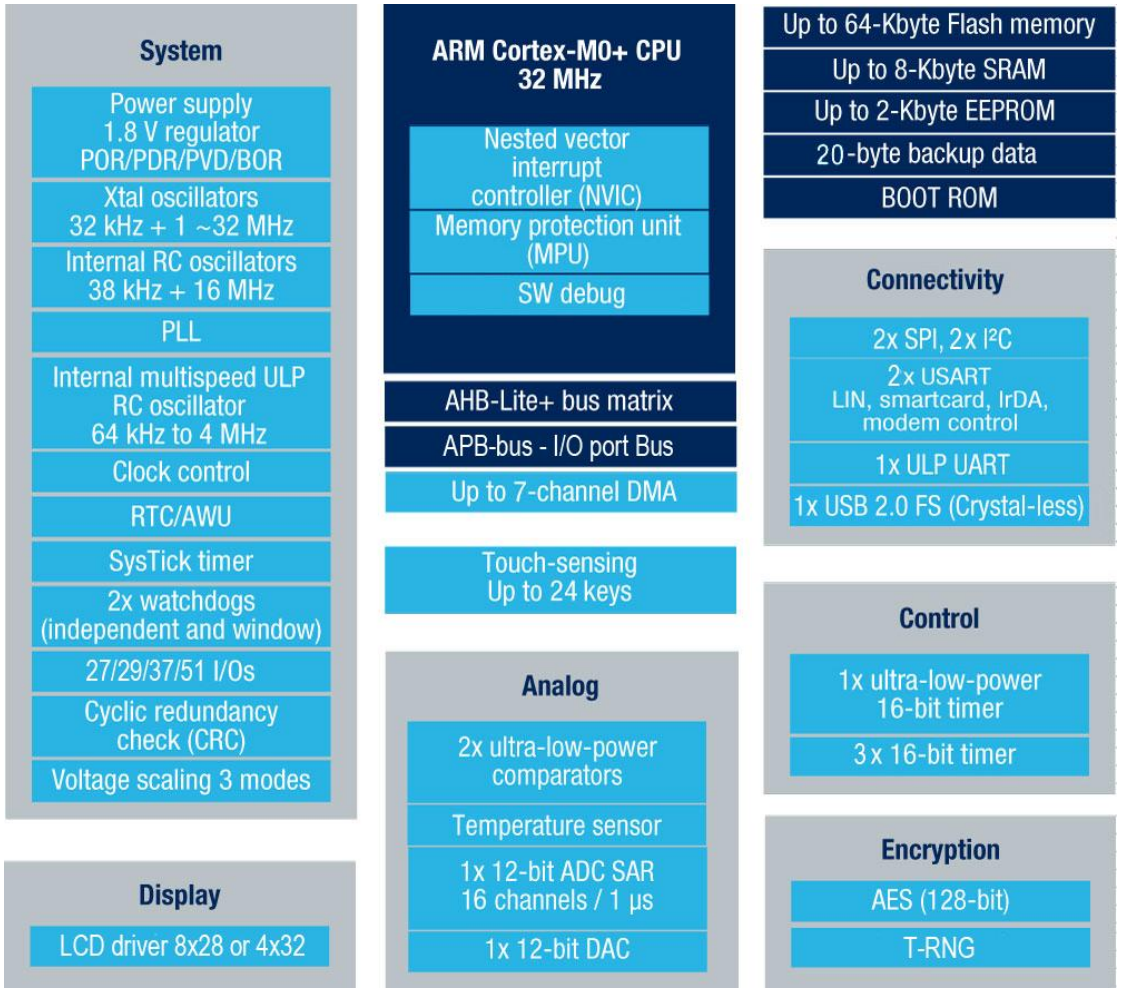
1. Dual bank flash with Rww feature from Flash to EEPROM (on part number STM32L07x/08x))
2. Only on STM32L0x2 and L0x3 line

STM32L05x block diagram

- Key features
  - ARM Cortex-M0+ at 32MHz
    - Single-cycle I/O access
    - Single-cycle multiplier (MUL)
    - 0.97 DMIPS/MHz
  - 1.71V to 3.6V, 32MHz full functional
  - Digital down to 1.65V
  - -40°C to +125°C temperature range
  - ADC with build-in HW oversampling
    - Down to 1.65V
  - Flash + Ram code sector lock
  - USB 2,0 FS certified
    - Build-in 48MHz oscillator
    - Battery Charger Detection
    - Link Power Management
  - Independent clock domain
    - I2C, USART/UART
    - USB
  - **3x** timers
    - 1x 16-bit (4ch)
    - 2x 16-bit(2ch)
    - 1x 16-bit LP[1] available in stop



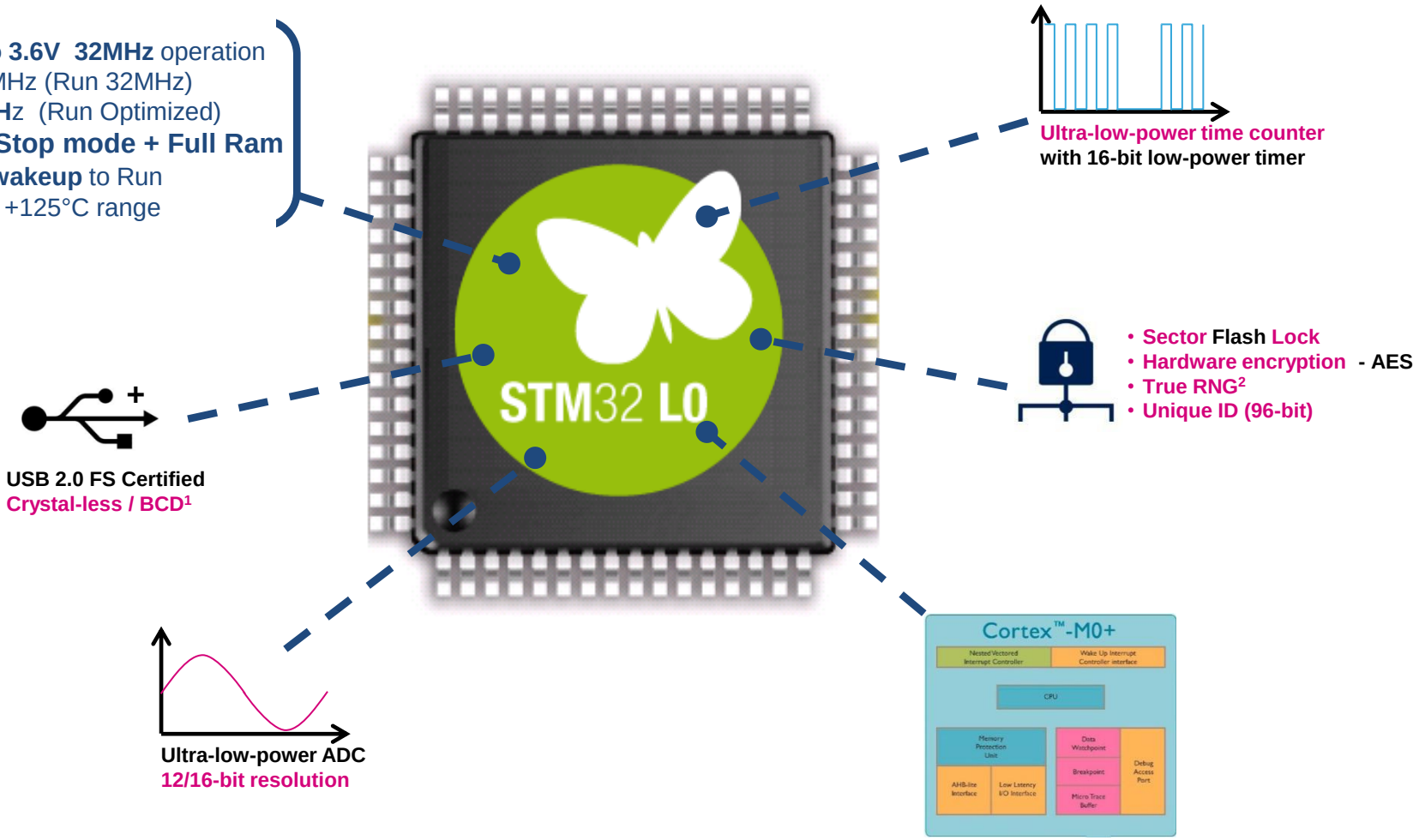
1. Low Power

NEW

Meet with STM32 L0 series

- **STM32® ultra-low-power DNA is now built with ARM Cortex-M0+**

- **1.71V to 3.6V 32MHz** operation
- 139µA/MHz (Run 32MHz)
- **87µA/MHz** (Run Optimized)
- **400nA Stop mode + Full Ram**
- **3.5 µs wakeup** to Run
- -40°C to +125°C range



1. Battery Charger Detection
2. True Random Number Generator

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A unique feature(1/2)

- Low-power timer (down to stop mode)
  - Ultra-low-power consumption
  - Low-power Pulse counter (available in stop mode)
    - Independent 16-bit timer, available also in Stop mode
    - Pulse counter with no clock running
    - Or clocked by LSE, LSI, HSI, APB.
    - It is able to wakeup the system from Stop mode.
    - Programmable digital glitch filter
    - Encoder mode

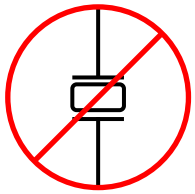
NEW

Low-power Sensor Scan

- USB 2.0 FS
  - **Battery Charging Detection (BCD)**
  - Standard Downstream Port (SDP)
  - Charging Downstream Port (CDP)
  - Dedicated Charging Port (DCP)
  - **Link Power Management (LPM)**

Equivalent to STM32 F0

- **Crystal-less solution (built-in 48MHz RC)**



Reduce BOM cost by removing the crystal

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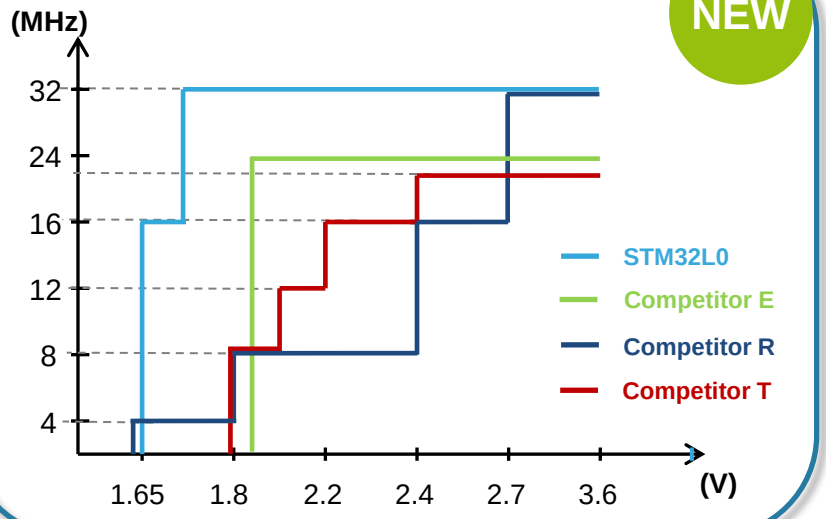
A unique feature(2/2)

- A wide range operation

NEW

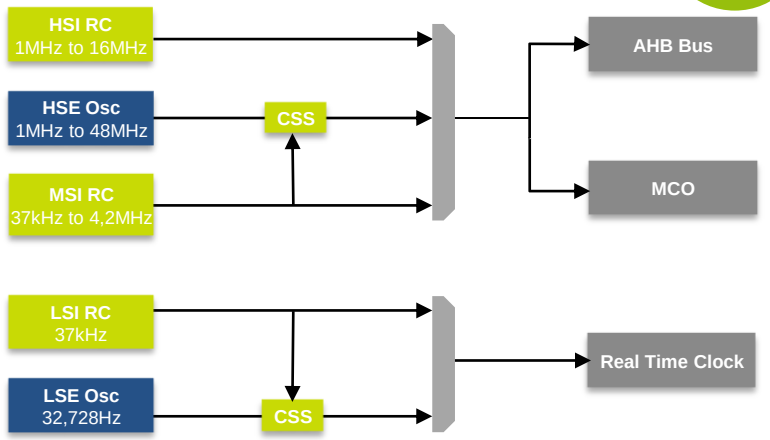


Low voltage and High speed platform

Why to comprise CPU speed vs. power supply ?

- Clock Security System (CSS)
  Automatic clock switch to internal RC

NEW



Design robustness is our concern

Clock Security System will ensure a very fast switch (couple of clock pulse) between external oscillator and internal one in case of malfunction detection.

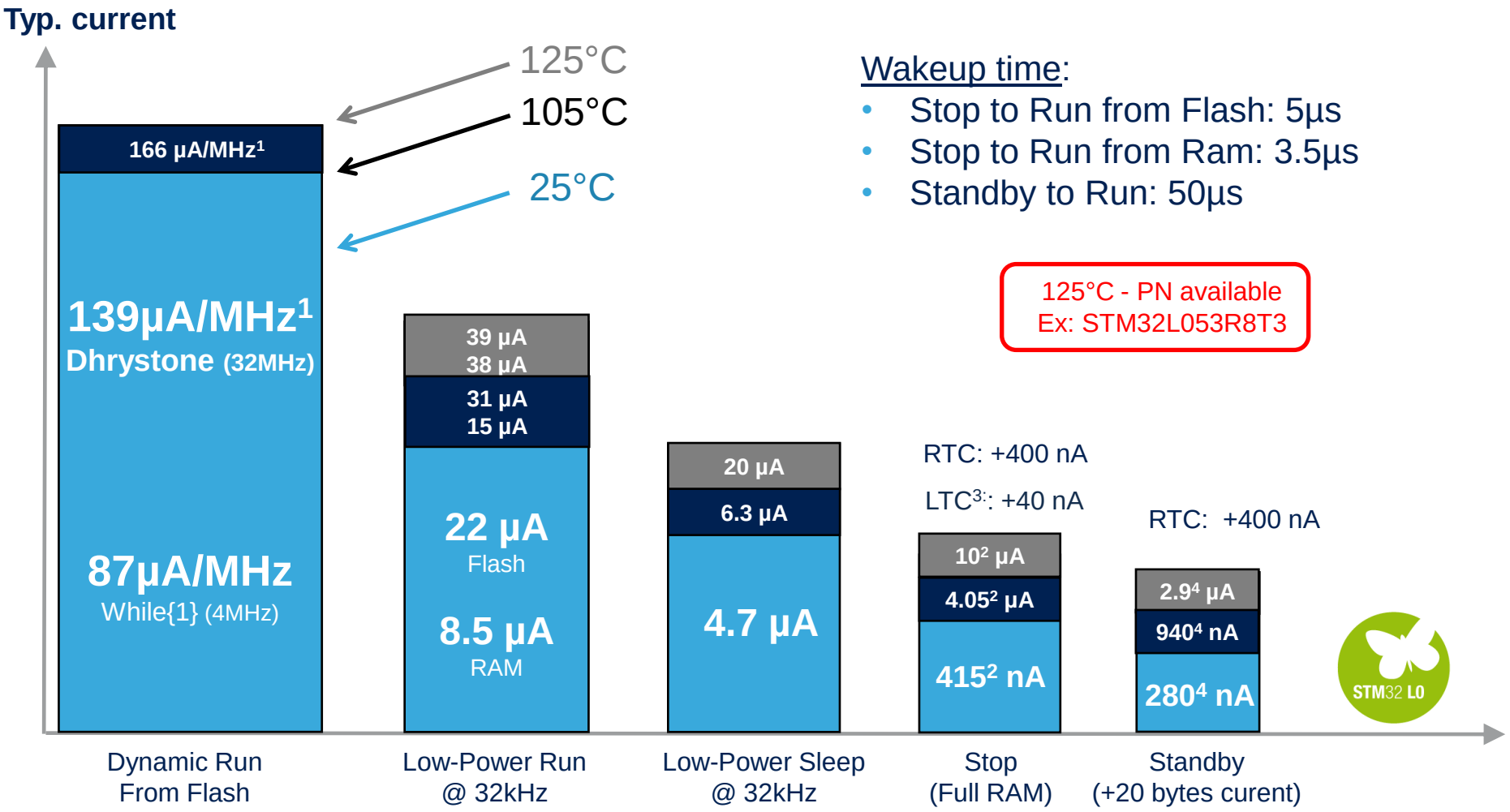
This unique feature will allow your application working were other MCUs will let you down.

System Operation Modes

- **RUN**
  - clocks gating, FLASH can be put in power-down mode
- **SLEEP**: CPU stopped
  - optional automatic clocks gating, FLASH can be put in power-down mode
- **LP RUN**: power regulator in LP mode, 131kHz Max
  - clocks gating, FLASH can be put in power-down mode
- **LP SLEEP**: CPU stopped + power regulator in LP mode, 131kHz Max
  - optional automatic clocks gating , FLASH can be put in power-down mode
- **STOP**: power regulator in LP mode + all clock stopped except LSI (LSE)
  - **HSI can be kept running, FLASH can be kept in power-down mode after Wake-Up**
  - **LPTIM, LPUART, can be kept running in STOP mode**
- **STANDBY**: power regulator stopped

STM32L05x - power consumption

From 25°C to 125°C (typical)



Wakeup time:

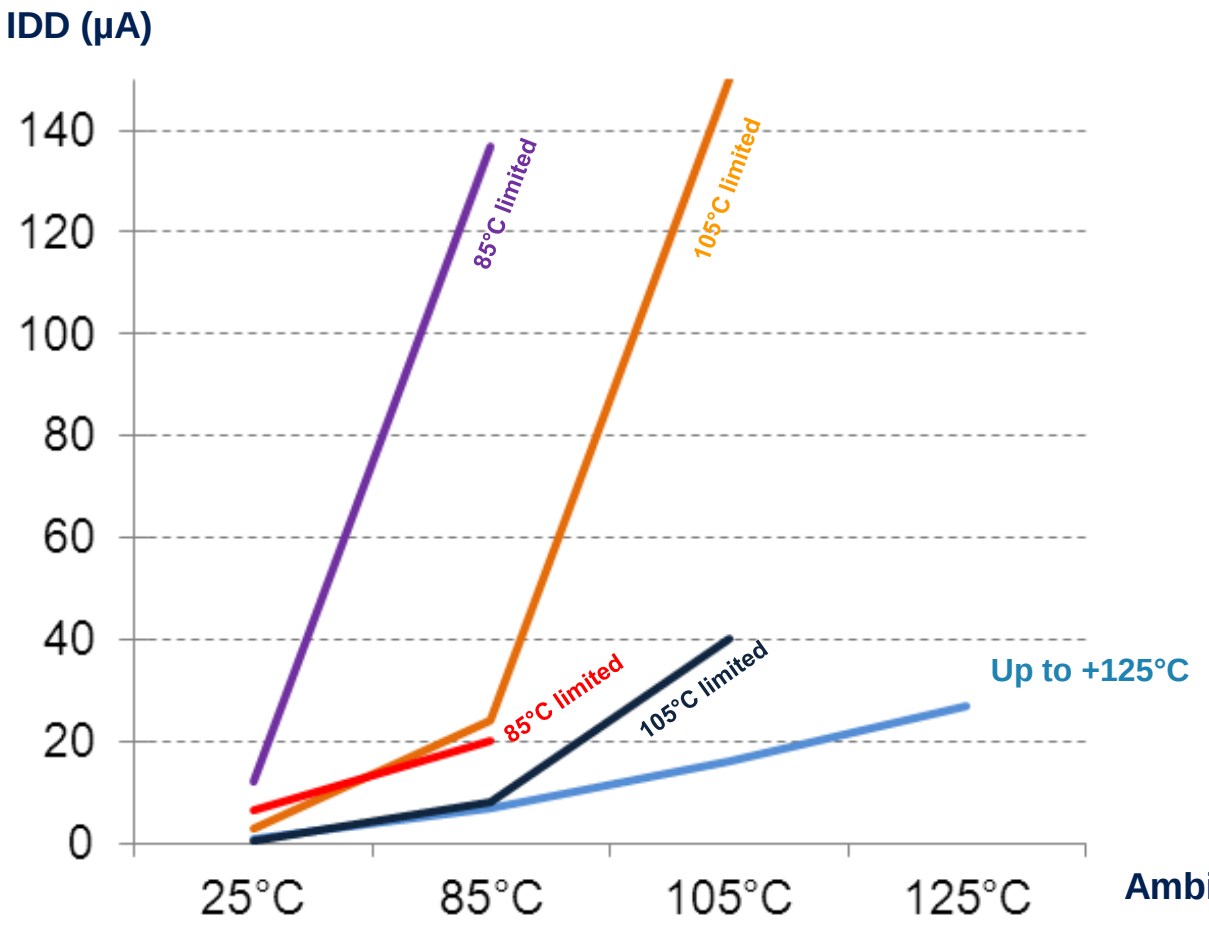
- Stop to Run from Flash: 5µs
- Stop to Run from Ram: 3.5µs
- Standby to Run: 50µs

125°C - PN available
Ex: STM32L053R8T3

1. Dhrystone power consumption value executed from Flash (Prefetch off) with VDD=3.3V
2. STOP mode consumption with **Full Ram data retention** (RTC value given with LSE low-drive using 32,768kHz crystal)
3. LTC**:** Low-power Time Counter @ 100Hz with external oscillator (LSE)
4. STANDBY mode consumption with **20Byte of backup register and Power supply monitoring**

Leader at high temperature

- Max. current value at lowest power mode vs. temperature capability



- STM32L0 platform offers the lowest power consumption for the highest temperature range.
- This capability to control leakage current makes STM32L0 the premium choice for industrial application,

Note: Value based on competition datasheet, looking at lowest power mode with full RAM retention at VDD 3.0V.
All datasheet give same value for -40°C/+25°C temperature range.

Watchdogs

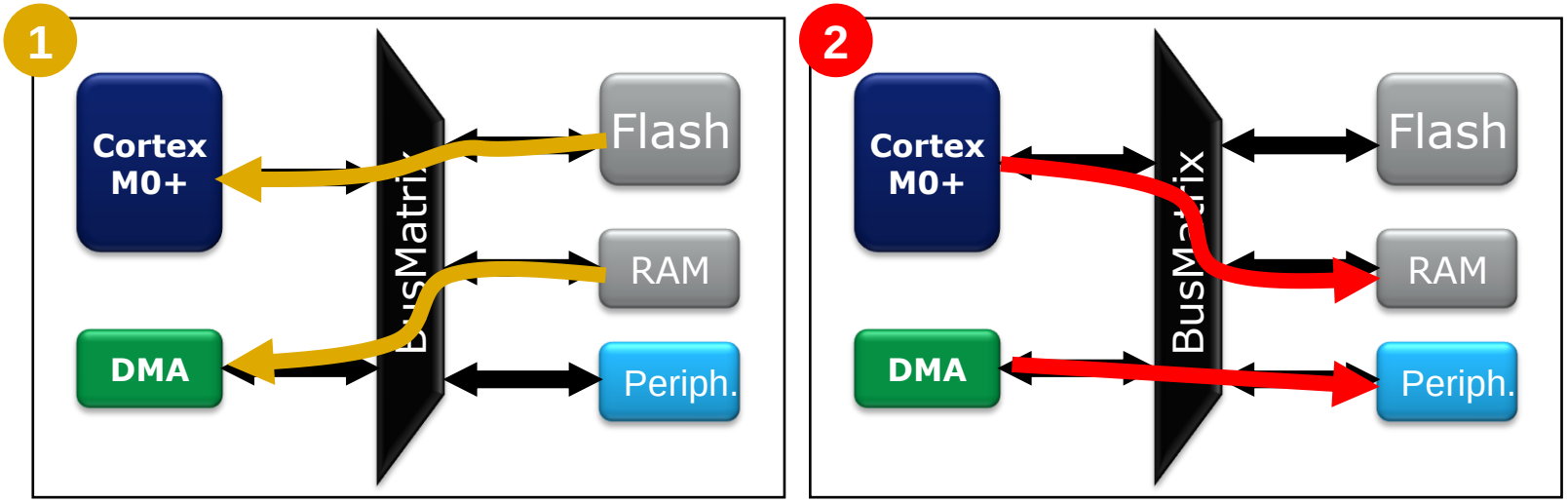
- Independent Watchdog (IWDG) → **IWWDG**
  - Dedicated low speed clock (LSI)
  - HW and SW way of enabling
  - IWDG clock still active if main clock fails
  - Timeout values @37kHz: **108us …28s**
  - **Window Functionality**

- Window Watchdog (WWDG)
  - Configurable Time Window
  - Can detect abnormally early or late application behavior
  - Conditional Reset
  - WWDG Reset flag
  - Timeout value @32MHz: **128us … 65.54ms**

DMA Controller Features

Equivalent to STM32 F0

- Up to **7** independently configurable **channels** (requests)
- 4 configurable levels of priority
- Independent source and destination transfer size (**byte / half word / word**)
- Support for **circular buffer** management
- **Half-Transfer** and Transfer complete **event**s
- Programmable number of data to be transferred: up to **65536 (16-bit counter)**



Analog-to-digital converter (ADC)

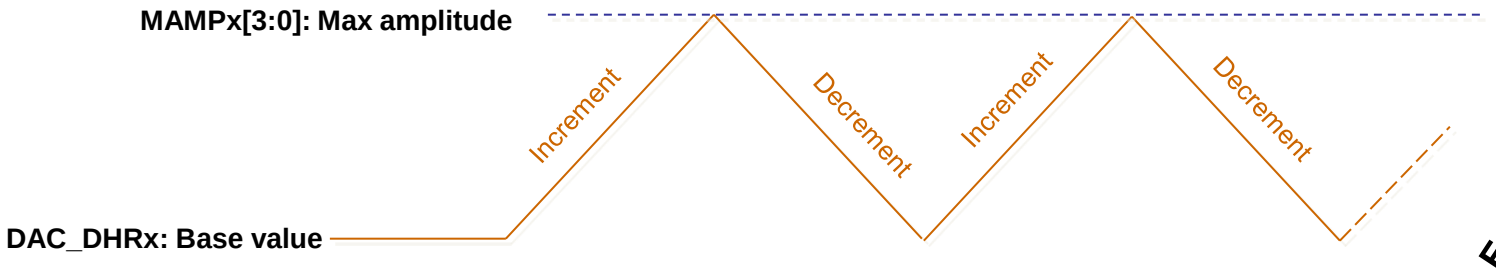
- **12-bit, 10-bit, 8-bit** or **6-bit** configurable resolution
- 0.87µs for 12-bit resolution, 0.81µs conversion time for 10-bit resolution
- 16 external analog inputs, temperature sensor, reference voltage, external VLCD power supply pin
- ADC can be selected between two different clock sources(PCLK, ADC asynchronous clock)
- Auto off mode : ADC is automatically powered off except during the active conversion phase.
- Analog watchdog
- A build-in HW oversampler (16-bit data register)

DMA

Digital to Analog Converter (DAC)

- **One DAC** converter
- **8-bit** or **12-bit** monotonic output (left or right data alignment)
- DMA capability
- **External triggers for conversion (Timers)**
- Conversion range: 0.5mV (**0.2V**) to VDDA-1LSB (**VDDA-0.2V**)
- **Noise-wave** and **Triangular-wave** generator
- **Integrated buffer** to reduce the output impedance

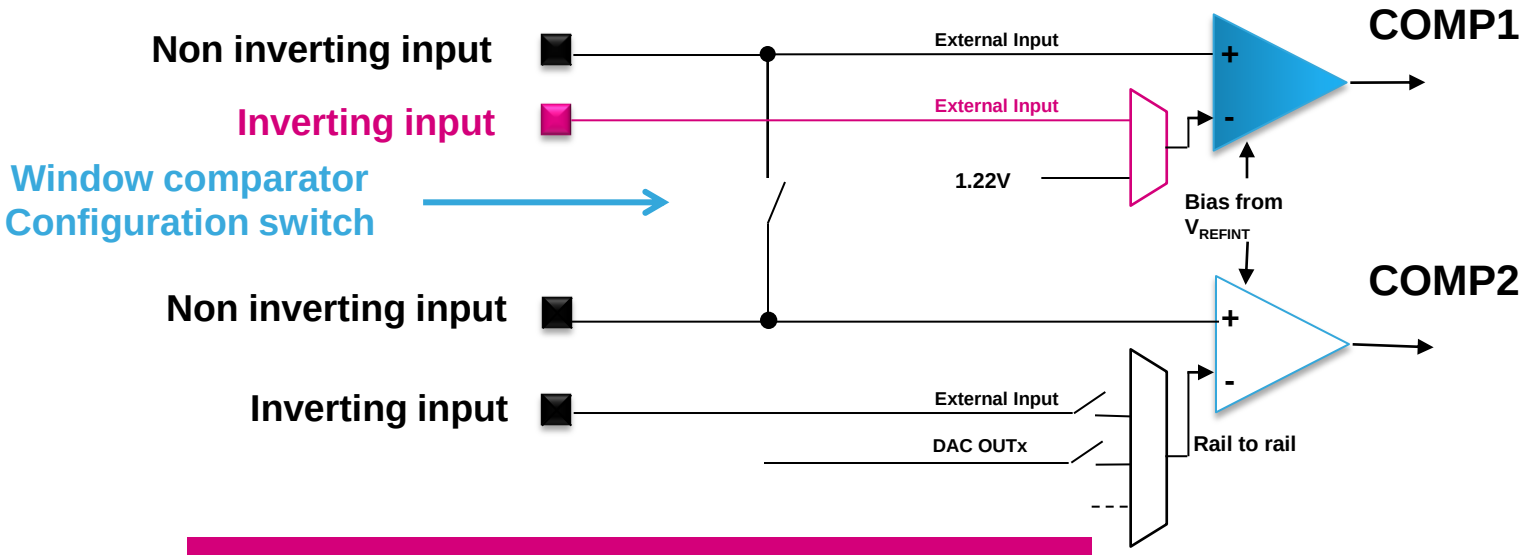
DMA



Equivalent to STM32 L1

Analog Comparators (COMPx)

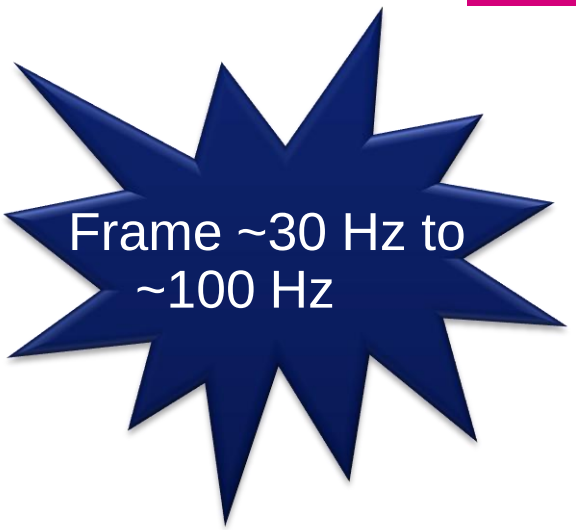
- two zero-crossing comparators COMP1 and COMP2 sharing the same current bias
- COMP1 with fixed internal reference voltage **/ external** threshold
- COMP2 has Rail-to-Rail inputs with selectable threshold
- Can be combined into a **window comparator**



COMP1 and COMP2 outputs are available on GPIO

LCD Main features

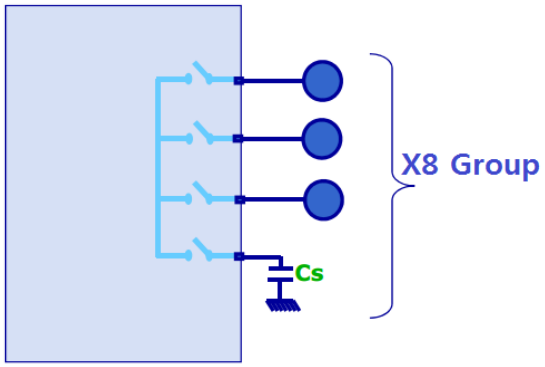
- High Flexibility Frame Rates
- Drive up to **384 (8x48)** or **232 (4x58)** picture elements (pixels)
- Programmable duty and bias
  - Duty: Static, 1/2, 1/3, 1/4, 1/8
  - Bias: Static, 1/2, 1/3, 1/4
- Low Power Waveform to reduce consumption
- External (VLCD) or internal (**STEP-UP**) voltage source
- Double buffer memory
- Contrast Control whatever power supply voltage source
- Blinking programmable pixels and frequency
  - 1, 2, 3, 4, 8 or all pixels at programmable frequency
  - Adjustable blink frequency: 0.5 Hz, 1 Hz, 2 Hz or 4 Hz
- Unused segments and common pins can be used as I/O



Touch sensing controller (TSC)

Equivalent to STM32 F0

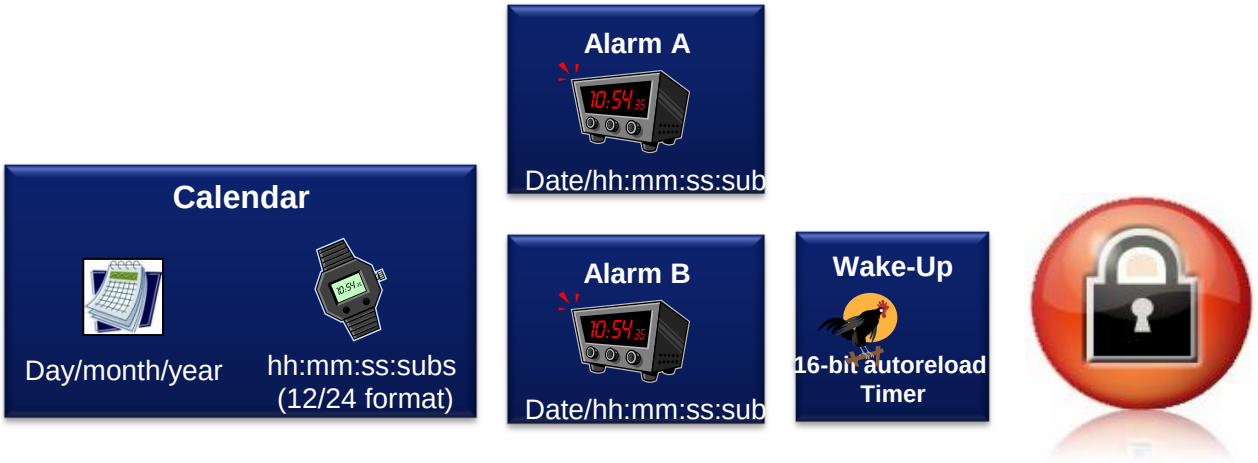
- Proven and robust **surface charge transfer acquisition principle**
- **One sampling capacitor for up to 3 capacitive sensing channels** to reduce the system components
- Supports up to **24 capacitive sensing channels** split over **8** analog I/O groups
- Up to **8 capacitive sensing channels can be acquired in parallel** offering a very good response time
- **Full hardware management** of the charge transfer acquisition sequence
- **Spread spectrum** feature to improve system robustness in noisy environments (minimum step of 20.8ns)
- Compatible with proximity, touchkey, linear and rotary touch sensor implementation
- Designed to operate with STMTouch touch sensing firmware library



Real-time clock (RTC)

- Calendar with subseconds, seconds, minutes, hours, day (day of week), date (day of month), month, and year.
- Daylight saving compensation programmable by software
- Smooth digital calibration – 0.954ppm resolution
- The RTC clock source can be any of the following:
  - LSE oscillator clock
  - LSI oscillator clock
  - HSE 1MHz max (HSE divided by ***/32*** in clock controller).
- Maskable interrupts/events:
  - Alarm A / Alarm B
  - Wakeup interrupt
  - Time-stamp
  - Tamper detection

Equivalent to STM32 L1



Timers(TIMx)

- 16-bit up, down, up/down, auto-reload counter
- Input capture/output compare, PWM or one pulse mode output.
- Synchronization circuit to control the timer with external signals and to interconnect several timers
- DMA request generation(TIM2, TIM6)
- Supports incremental (quadrature) encoder and hall-sensor circuitry for positioning purposes(TIM2)
- Trigger input for external clock or cycle-by-cycle current management(TIM2)
- Time bases and be clocked by the LSE clock source to provide time bases independent from the main CPU clock(TIM21/TIM22)

NEW

Low power timer (LPTIM)

- 16 bit upcounter
- Up to 5 clock sources to achieve lowest power consumption
  - APB clock
  - LP oscillators: LSE, LSI, HSI
  - External clock
    - With configurable active edge: Rising edge, Falling edge and Both edges
    - When both edges configuration is chosen, an auxiliary clock source is needed with a frequency 4 times bigger, at least, than the external signal
- Up to 8 external triggers
  - With configurable active edges: Rising edge, Falling edge and Both edges
  - With digital glitch filter to avoid spurious triggers
- Up to 2 operation modes
  - Continuous mode: free running mode; many counter overruns are possible
  - One Shot mode: Counter stops counting when the overrun value is reached

USART

- Full-duplex asynchronous communications
- Programmable data word length (7 or 8 or 9 bits)
- Configurable stop bits (1 or 1.5 or 2 stop bits)
- Even, odd, none PARITY
- LIN Mode support
- IrDA SIR encoder decoder support
- Smartcard mode
- Support for Modbus communication
- DMA support
- HW flow control (RTS, CTS lines)
- **Wake-Up from STOP mode**

NEW

LPUART

- Full-duplex asynchronous communications
- from 300 baud/s to 9600 baud/s using a 32.768 kHz clock source
- Higher baud rates can be reached when the LPUART is clocked by clock sources different from the LSE clock
- Programmable data word length (7 or 8 or 9 bits)
- Configurable stop bits (1 or 2 stop bits)
- Even, odd, none PARITY
- DMA support
- **Wake-Up from STOP mode**

DMA

- **I²C Version 3.0** compatibility
- Standard-Mode, Fast-Mode (up to **400 kHz**), **Fast-Mode+** (up to **1 MHz**)
- Slave and master modes with multi-master capability
- 7-bit and 10-bit addressing mode, dual addressing capability
- Programmable timing, **optional clock stretching**
- **Easy to use event management,** 1-byte buffer with DMA capability
- SMBus ver. 2.0 and PMBus ver 1.1 standards compatibility
- Programmable analog and digital **noise filters**
- **Wakeup from STOP** on address match

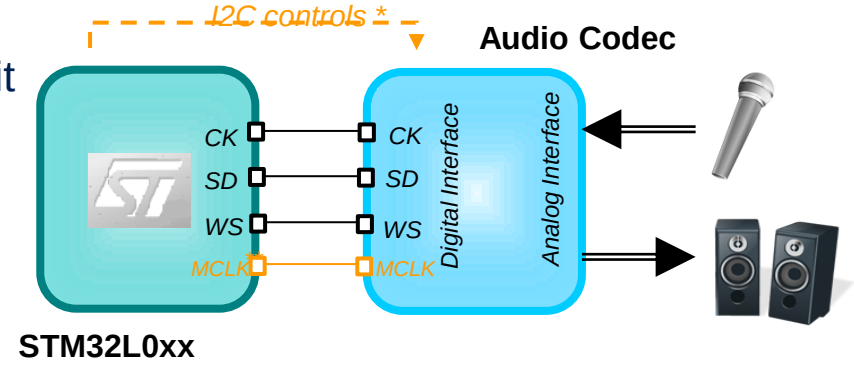
SPI / I²S

- **SPI**
  - Speed up to **16 Mbits/s**
  - Full-duplex (3 wires), half-duplex (2 wires) or simplex synchronous transfers (2 wires, unidirectional data line)
  - **8-bit or 16-bit** data size selection
  - MASTER or SLAVE operation, Multi-master mode capability
  - **NSS management** by HW or SW for both MASTER and SLAVE modes
  - **CRC calculation** and check for reliable communication

Equivalent to STM32 L1

DMA

- **I²S**
  - **Sampling frequency : 8Khz to 192kHz**
  - Data format may be 16-bit, 24-bit or 32-bit
  - I²S Philips
  - Left-Justified(MSB) / Right-Justified(LSB)
  - PCM standard



USB Interface

- *Crystal-less** USB 2.0 FS interface (12Mbit/s) with D+/D- registors

  * Integrated on-chip 48 MHz oscillator with clock recovery system. No external resonator/ crystal needed (cost saving is in range of 0.10$).

- Complies with *Link Power Management feature* (LPM) and *Battery Charger Detection* (BCD) specification 1.2

- USB FS Device Library with intuitive USB device class drivers API
  - Examples and demo based on a set of 6 classes (Audio, CCID, CDC, HID, VCP, MSC).
  - Easy development of applications using USB full speed transfer types (control, interrupt, bulk and isochronous).

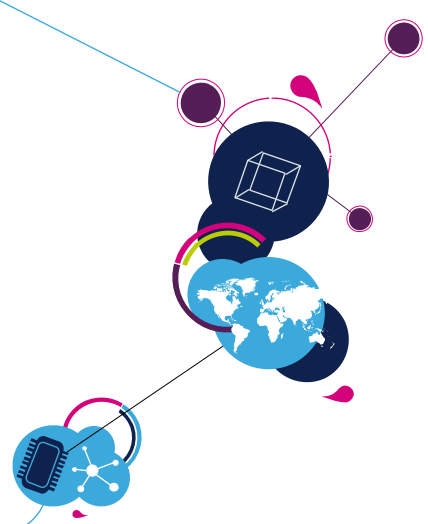
- Device Firmware Upgrade on the field over USB (boot loader)

- USB VID/PID sublicensing service for free

Encryption

- AES 128-bit key encryption(Hardware Encryption Engine)
  - 214 clock cycles only to encrypt 1 block (128 bits)
- Key Schedule and Key derivation for decryption
- Supported algorithm (compliant NIST FIPS 197)
  - ECB – Electronic Code Book
  - CBC – Cipher Block Chaining
  - CTR – Counter mode
  - GGCM – Galois counter mode (many competitors does not support it while it is the most requested)
- Faster than software AES-128
- AES 256-bit, DES, 3DES, RSA and ECCC are supported by a specific software library.

STM32L0 Ecosystem



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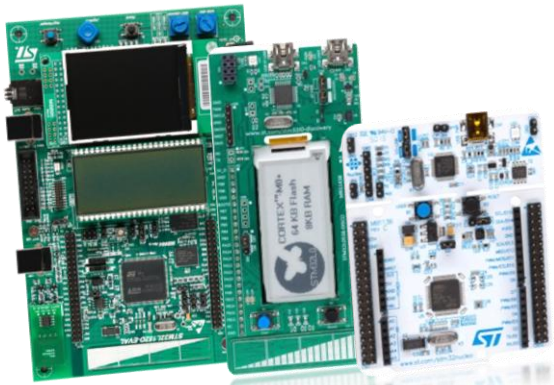
STM32L0x – Ecosystem

- Evaluate, Discover and Play



Evaluation	Discovery	Nucleo
Q4'14	Available	Available

- Feel free to choose your IDE

Click on the icon

IAR SYSTEMS

KEIL™ Tools by ARM

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GCC based toolchains

- Software offer

- STM32CubeMX Software: Optimize your design layout, configure MCU usage and estimate power consumption
- STM32CubeL0: Embedded Software, from Hardware Abstraction Layer (HAL) easing migration from any STM32 and middleware offer like FreeRTOS and USB library
- STM32L0 Snippets: 70+ free highly optimized C code examples. Reach lowest consumption, best performance and a minimum of memory footprint. CMSIS-compliant direct register access reduces code overhead to a minimum.

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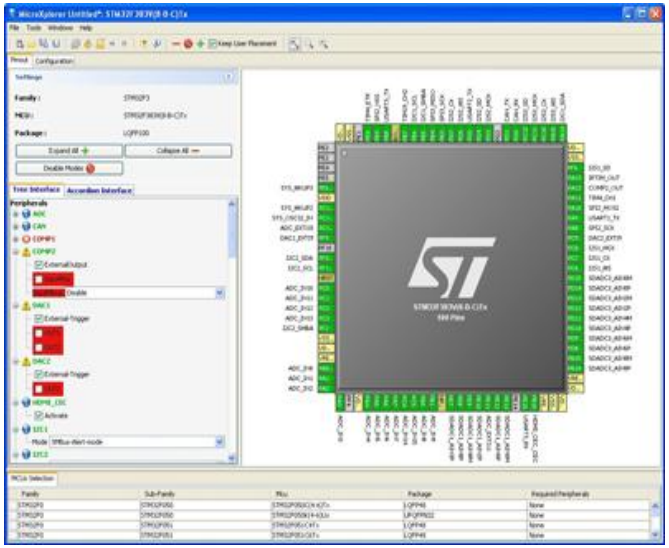
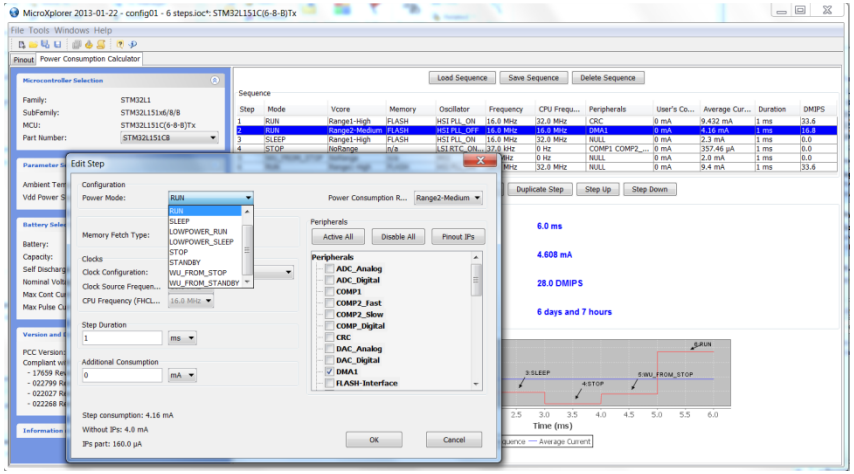
STM32CubeMX and PCC Tool

- STM32CubeMX (Free) Configuration Tool
  - Makes it easy to select one STM32 in the broad portfolio
  - Allows the user to check how the package pins will be configured, detecting potential conflicts, all done in a graphical way
  - Generates the code for IOs initializations, depending on user choice
  - Regularly extended with new features





- Power Consumption Calculator
  - Select battery type or build your own configuration
  - Define a sequence of steps representing your application
  - Get rid of extra µA and the most optimized battery life.

STM32L053 Weather Station

life.augmented

Components

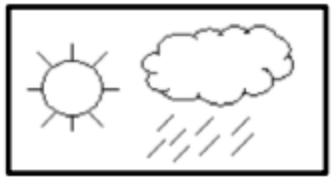
- MCU : STM32L053x from STMicroelectronics
- Humidity sensor : HTS221 from STMicroelectronics
  - Temperature measurement is extracted from the embedded temperature sensor of this humidity sensor
- Pressure sensor : LPS25H from STMicroelectronics
  - Pressure is given in hpa. The value provided by the sensor is not doing altimeter compensation. This one is processed by software to display a pressure equivalent at sea level (1013 hpa being the anticyclonic threshold)
- UV sensor : UVIS3 from STMicroelectronics
  - UV is displayed from 0 to 15 (in room condition the UV will be 0)
- Low light condition to put the application in low - mode. Component is VR90N1
- 3 EPD GDE021A1
- 32KHz quartz oscillator to pilot the RTC

MCU resources

- TIM2 : used as reference time to manage the display operation. Interrupt is used to manage the Autoreload phase
- RTC : used to keep running the time + the calendar , whatever the application operating mode
- SPI1 : used to pilot the command + data for the EPD
- I2C1 : used to communicate with all the sensors
- PVD : To detect low voltage in the application
- COMP2 : Used to detect the low light condition
- GPIO : Mainly PORT A, B, C to pilot EPDs or manage the buttons or to control the power switches of the EPD

EPD 1display – Weather forecast

- Altitude has to be set in the variable altitude into the global_def.h file. It is used to evaluate the weather forecast (absolute pressure is translate to sea level pressure based on the altitude)
- Possible pictures displayed :

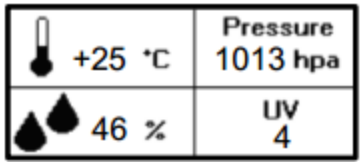


- Forecast based on pressure evolution measured each hour . (based on 4 hours data historic)
- Display when low light or low battery is detected by the application :

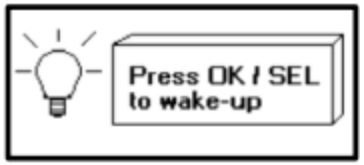
EPD 2 display – Parameters

- The displays is used in all modes in which the weather station is located . It contains all the measurement done with a rate of hour for the pressure, 60s or 30s for the temperature/humidity/UV measurements. 60s is nominal when there is no evolution on parameter otherwise the time in between 2 measurements speed-up to 30s

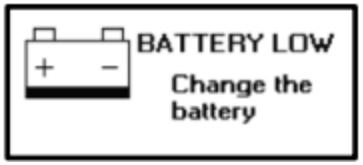
- In Normal mode (good light condition and enough power level)



- In Low light condition

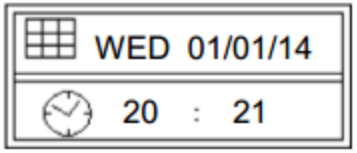


- When low battery detected



EPD 3 display – Time + Calendar

- This EPD display is refreshed each minute
- In Normal mode, it can display :



Date Europeen format
DD/MM/YY

24h Format

- Display when low light or low battery is detected by the application :

STOP MODE

- After each processing in which the CPU is running (NORMAL Mode, Low Battery mode or low light condition) the micro is put in STOP mode.
- RTC is running based on LSE 32.768KHz
- Internal reference voltage is OFF meaning that PVD and comparator are disabled in this mode. They are automatically re-enabled when MCU is waking up from STOP mode
- EPDs are in POWER DOWN mode

STM32L053 Weather Station

Thank you

www.st.com www.st.com/mcu www.st.com/stm32l0