



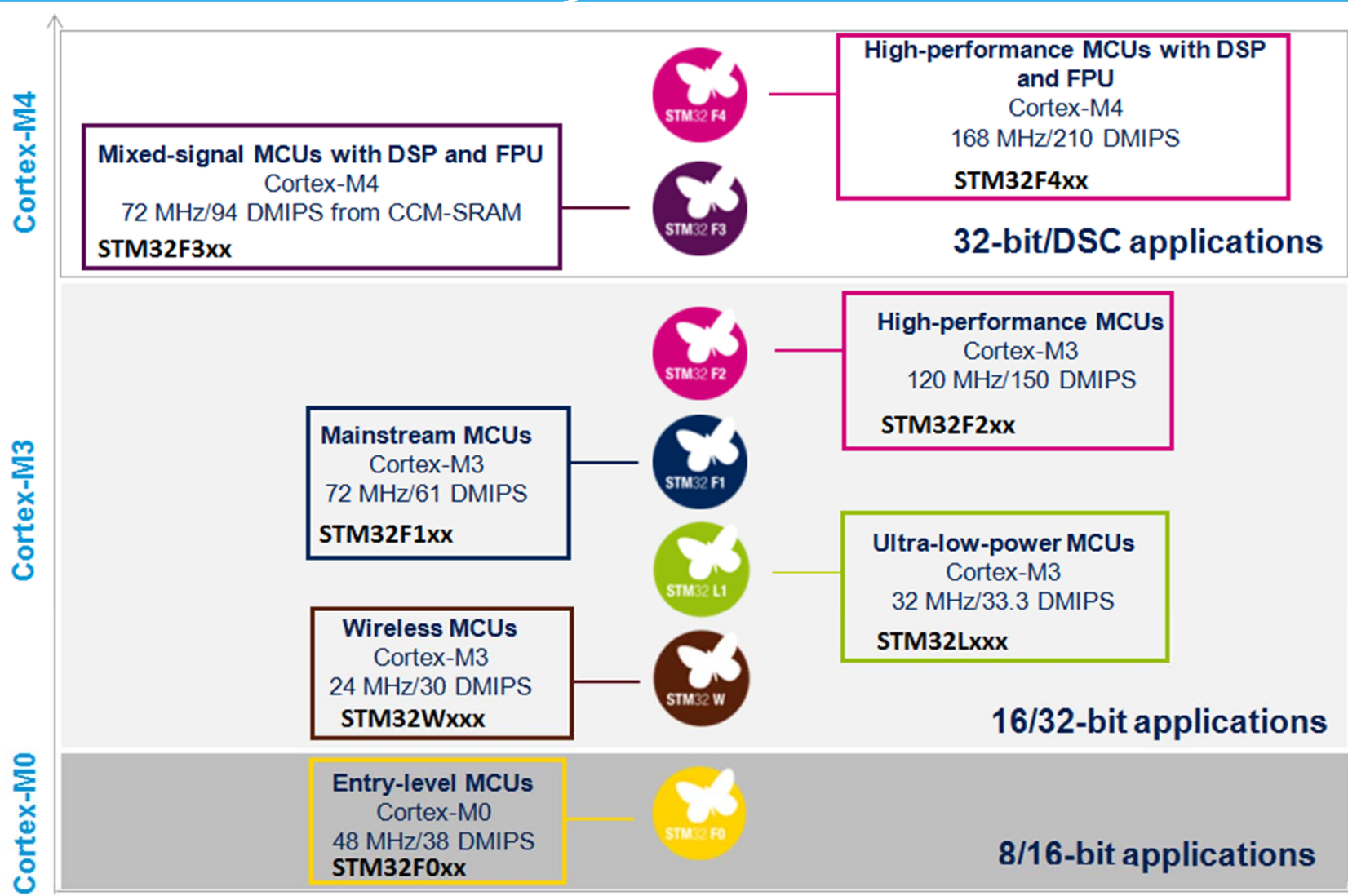
STM32F3

Cuauhtémoc Carbajal

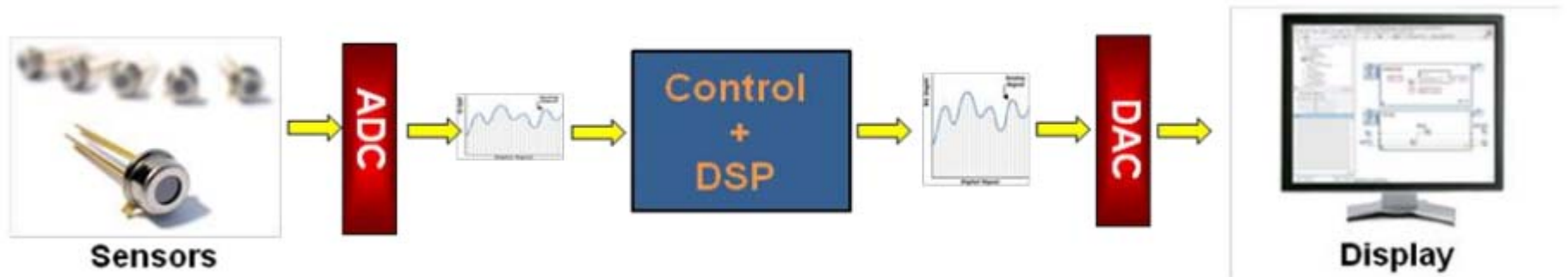
ITESM CEM

12/08/2013

STM32 Portfolio



32-bit/DSC Applications



A typical embedded system with both control and signal processing requirements



Digital Signal Controllers –efficient hybrid of MCU and DSP characteristics

STM32 F3 series

- * 32-bit MCUs with DSP instructions and FPU plus optimum analog integration to complement STM32 F1 and F4 series.
- * The STM32 F3 series of microcontrollers combines a 32-bit ARM® Cortex™-M4 core with DSP and FPU instructions running at 72 MHz with advanced analog peripherals for more flexibility at a competitive cost.
- * The STM32 F3 series innovates in embedded digital signal control (DSC) design by combining a Cortex-M4 core with fast 12-bit, 5 MSPS and precise 16-bit sigma-delta ADCs, programmable gain amplifiers, fast comparators and versatile time control units, giving optimum integration.

STM32 F3 series

- * The STM32 F3 series supports the STM32 F1 series, keeping pinout compatibility, and enlarges the STM32's Cortex-M4 portfolio, which now offers both entry-level cost with the F3 series and highest performance with the F4 series.
- * The full STM32 portfolio now covers more than 350 devices.
- * The STM32 F3 series includes devices with 64 to 256 Kbytes of on-chip Flash memory, and up to 48 Kbytes of SRAM. WLCSP66 (< 4.3 x 4.3 mm), LQPF48, LQFP64, LQFP100, UFBGA100 packages are available.

STM32 F3 product lines

Cortex-M4 + FPU Fmax = 72 MHz
MPU
PLL
ETM
Reset + BOR PVD
Low and high speed internal oscillators
2x watchdogs + RTC (real-time clock)
HW CRC
Reset circuitry POR/PDR
Multiple DMA
Communication peripherals USART, SPI, I ² C
Multiple 16-bit timers
1x 32-bit timer
Temperature sensor
Backup registers

+

STM32F302/303/313 lines

Up to 256-Kbyte Flash	Up to 40-Kbyte SRAM	8-Kbyte code SRAM	2x DAC 12-bit	7x comparator	4x 12-bit ADC 5 MSPS SAR	4x PGA	CAN 2.0B	USB 2.0 FS	2x16-bit AMC timer
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STM32F372/373/383 lines

Up to 256-Kbyte Flash	Up to 32-Kbyte SRAM	3x 16-bit $\Sigma\Delta$ ADC	3x DAC 12-bit	2x comparator	1x 12-bit ADC 1 MSPS SAR	CEC	CAN 2.0B	USB 2.0 FS
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STM32F3xx



Features and benefits

Features	Benefits
Performance 72 MHz/62 DMIPS (from Flash) or 94 DMIPS (from CCM-SRAM*) Cortex-M4 with single cycle DSP MAC and floating point unit	<ul style="list-style-type: none"> • Boosted execution of control algorithms • More features possible for your applications • Ease of use • Better code efficiency • Faster time to market • Elimination of scaling and saturation • Easier support for meta-language tools
Real-time performance <ul style="list-style-type: none"> • CCM-SRAM* (core coupled memory): 8 Kbytes of SRAM mapped to the instruction bus; critical routines loaded in the 8-Kbyte CCM at startup can be completed at full speed with zero wait states, achieving 94 Dhrystone MIPS and CoreMark score 155 at 72 MHz • SRAM and CCM-SRAM with parity bit • 32-bit, AHB bus matrix • DMA controllers • Memory protection unit (MPU) 	More performance for critical routines with zero-wait state execution from safe CCM-SRAM
Outstanding power efficiency <ul style="list-style-type: none"> • Stop mode down to 5.1 μA typ • RTC down to 0.5 μA typ in V_{BAT} mode • 2.0 to 3.6 V or 1.8 V $\pm 8\%$ power supply range 	<ul style="list-style-type: none"> • Flexibility to reduce power consumption for applications requiring advanced analog peripherals and low-power modes • Running at low voltage or on a rechargeable battery

Features and benefits

Features	Benefits
Maximum integration Up to 256 Kbytes of on-chip Flash memory, up to 48 Kbytes of SRAM, reset circuit, internal RCs, PLLs, WLCSP package available	More features in space-constrained applications
Superior and innovative peripherals <ul style="list-style-type: none"> • Analog: 4x 12-bit ADC 5 MSPS* reaching 18 MSPS in interleaved mode, 3x 16-bit sigma-delta* ADC up to 50 KSPS, fast comparators* (50 ns), programmable gain amplifiers* (4 gains, 1% accuracy), 12-bit DACs • Up to 17 timers: 16 and 32 bits running up to 144 MHz* • Audio: simplex or full duplex I²S interfaces* • Up to 12 communication interfaces including 5x USART (9 Mbit/s), 3x SPI/I²S (18 Mbit/s), 2x I²C (1 MHz fast mode plus), CAN (1 Mbit/s), USB full speed • Consumer electronic control (CEC)* • Cyclic redundancy check (CRC) • RTC/AWU • Capacitive touch sensing (24 keys) 	<ul style="list-style-type: none"> • Full set of integration features on chip resulting in simplified board designs and fewer external components • BOM cost reduced
STM32 Compatibility Pin compatibility and same API for peripherals as F1 series	<ul style="list-style-type: none"> • More than 350 Cortex-M based compatible STM32 devices • More than 70 Cortex-M4 based compatible STM32 devices • Digital signal processing (DSP) capability at competitive price

ARM Cortex-M processors

- * Forget traditional 8/16/32-bit classifications
 - * Seamless architecture across all applications
 - * Every product optimized for ultra low power and ease of use

Cortex-M0

“8/16-bit” applications

Cortex-M3

“16/32-bit” applications

Cortex-M4

“32-bit/DSP” applications

Binary and tool compatible



What is Cortex-M0?

Cortex™ -M0

Nested Vectored
Interrupt Controller

Wake Up Interrupt
Controller Interface

ARMv6-M

CPU

AHB-lite
Interface

Data
Watchpoint

Breakpoint

Debug
Access
Port

What is Cortex-M3?

CortexTM-M3

Nested Vectored
Interrupt Controller

Wake Up Interrupt
Controller Interface

ARMv7-M

CPU

Code
Interface

Memory
Protection
Unit

SRAM &
Peripheral
Interface

Bus
Matrix

Data
Watchpoint

Flash Patch
& Breakpoint

ITM Trace

ETM Trace

Debug
Access
Port

Serial
Wire
Viewer,
Trace
Port

What is Cortex-M4?

Cortex™ -M4

Nested Vectored
Interrupt Controller

Wake Up Interrupt
Controller Interface

ARMv7E-M

CPU (with DSP Extensions)

FPU

Code
Interface

Memory
Protection
Unit

SRAM &
Peripheral
Interface

Bus
Matrix

Data
Watchpoint

Flash Patch
& Breakpoint

ITM Trace

ETM Trace

Debug
Access
Port

Serial
Wire
Viewer,
Trace
Port

Cortex-M Powerful & scalable instruction set

Floating Point Unit

DSP (SIMD, fast MAC) ●

Advanced data processing

Bit field manipulations

General data processing I/O control tasks

Cortex-M0/M0+/M1

ADCS	ADDS	VCMP	VCMPNE	VCVT	VCVTR	VDIV	VLDM
VLDR	VMLA	VMLS	VMOV	VMSR	VMSR	VMUL	VNEG
VNMLA	VHMLS	VNMUL	VPOP	VPUSH	VSQRT	VSTM	VSTR
VSUB	VFMA	VFMS	VFNMA	VFNMS			

Cortex-M3

PKH	QADD	QADD16	QADD8	QASX	QDADD	QDSUB	QSAX
QSUB	QSUB16	QSUB8	SADD16	SADD8	SASX	SEL	SHADD16
SHADD8	SHASX	SHSAX	SHSUB16	SHSUB8	SMLABB	SMLABT	SMLATB
SMLATT	SMLAD	SMLALBB	SMLALBT	SMLALTB	SMLALTT	SMLALD	SMLAWB
SMLAWT	SMLSDD	SMLSDD	SMMLA	SMMLS	SMMUL	SMUAD	SMULBB
						SMULBT	SMULTT
						SMULTB	SMULWT
						SMULWB	SMUSD
						SSAT16	SSAX
						SSUB16	SSUB8
						SXTAB	SXTAB16
						SXTAH	SXTB16
						UADD16	UADD8
						UASX	UHADD16
						UHADD8	UHASX
						UHSAX	UHSUB16
						UHSUB8	UMAAL
						UQADD16	UQADD8
						UQASX	UQSAX
						UQSUB16	UQSUB8
						USAD8	USADA8
						USAT16	USAX
						USUB16	USUB8
						UXTAB	UXTAB16
						UXTAH	UXTB16

Cortex-M4

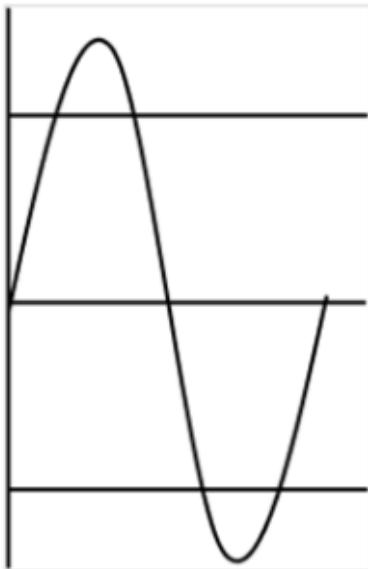
ADC	ADD	ADR	AND	ASR	B
CLZ	BFC	BF1	BIC	CDP	CLREX
CBNZ	CBZ	CMN	CMP	DBG	EOR
LDMIA	LDMDb	LDR	LDRB	LDRBT	LDRD
LDREX	LDREXB	LDREXH	LDRH	LDRHT	LDRSB
LDRSBT	LDRSHT	LDRSH	LDRT	MCR	LSL
LSR	MCRR	MLS	MLA	MOV	MOVT
MRC	MRRc	MUL	MYN	NOP	ORN
ORR	PLD	PLDW	PLI	POP	PUSH
RBIT	REV	REV16	REVSH	ROR	RRX
			RSB	SBC	SBCFX
			SDIV	SEV	SMLAL
			SMULL	SSAT	STC
			STMIA	STMDb	STR
			STRB	STRBT	STRD
			STREX	STREXB	STREXH
			STRH	STRHT	STAT
			SUB	SXTB	SXTH
			TBB	TBH	TEQ
			TST	UBFX	UDIV
			UMLAL	UMULL	USAT
			UXTB	UXTH	WFE
			WFI	YIELD	IT

ARM Cortex-M Instruction Set Architecture

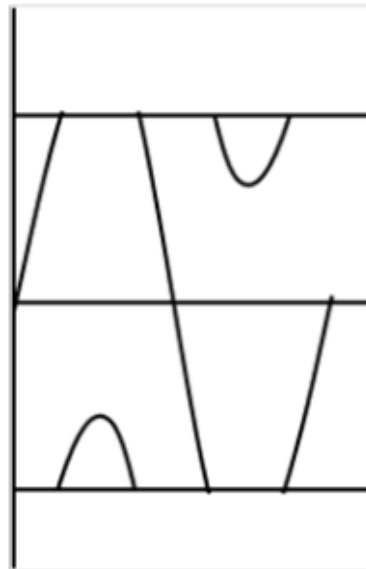
ARM Cortex-M	Thumb	Thumb-2	Hardware Multiply	Hardware Divide	Saturated Math	DSP Extensions	Floating Point	ARM Architecture	Core Architecture
Cortex-M0	Most	Subset	1 or 32 cycle	No	No	No	No	ARMv6-M	Von Neumann
Cortex-M0+	Most	Subset	1 or 32 cycle	No	No	No	No	ARMv6-M	Von Neumann
Cortex-M1	Most	Subset	3 or 33 cycle	No	No	No	No	ARMv6-M	Von Neumann
Cortex-M3	Entire	Entire	1 cycle	Yes	Yes	No	No	ARMv7-M	Harvard
Cortex-M4	Entire	Entire	1 cycle	Yes	Yes	Yes	Optional	ARMv7E-M	Harvard

Processing with Saturation

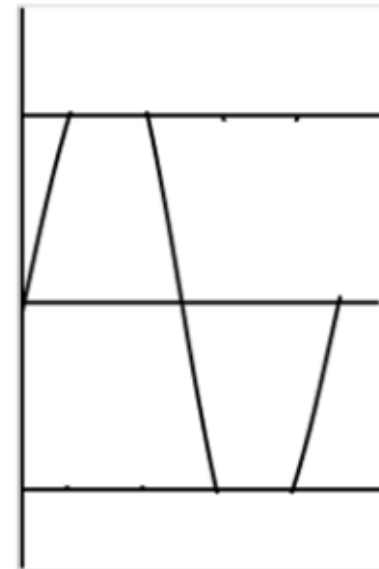
Signal



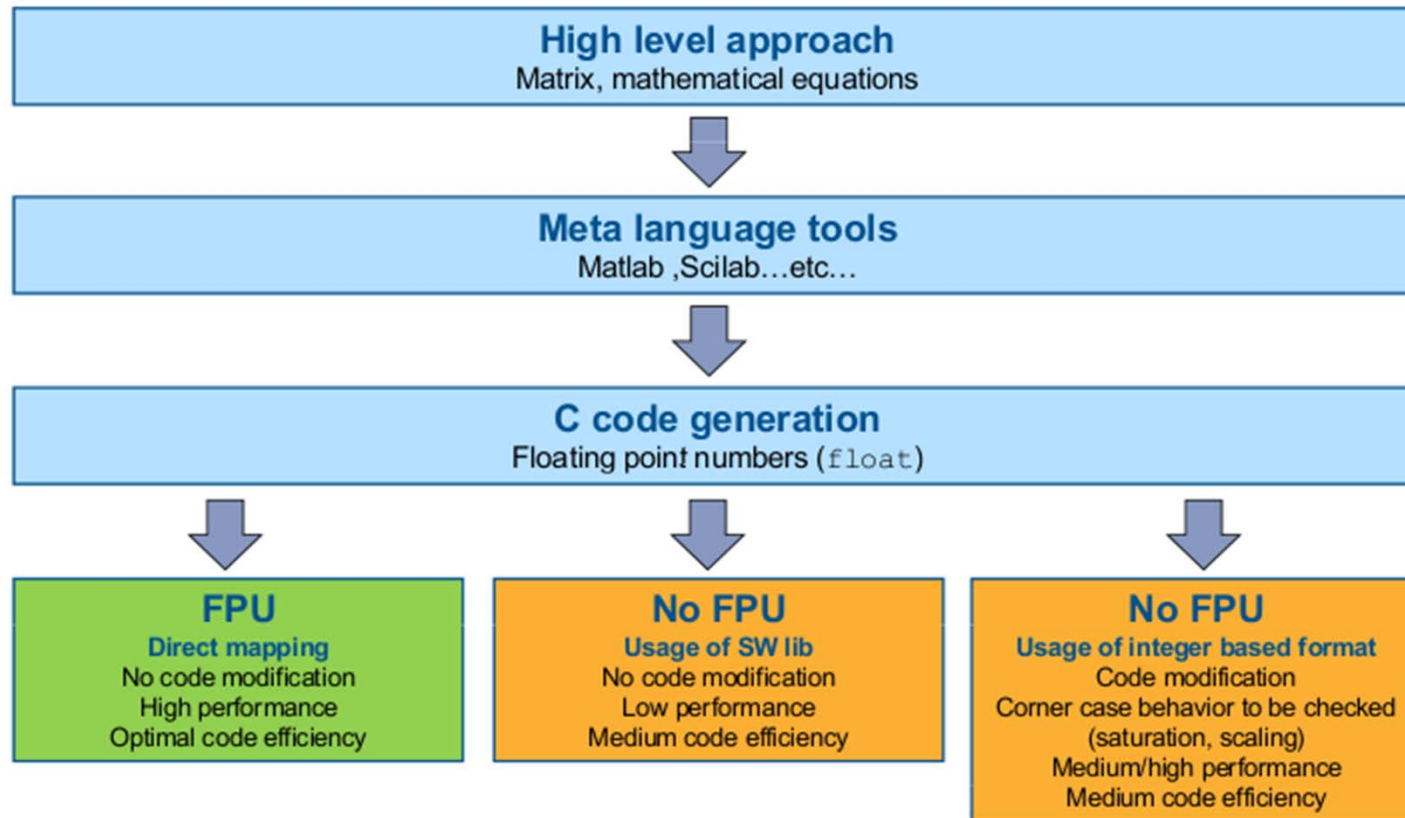
Processed without saturation



Processed with saturation

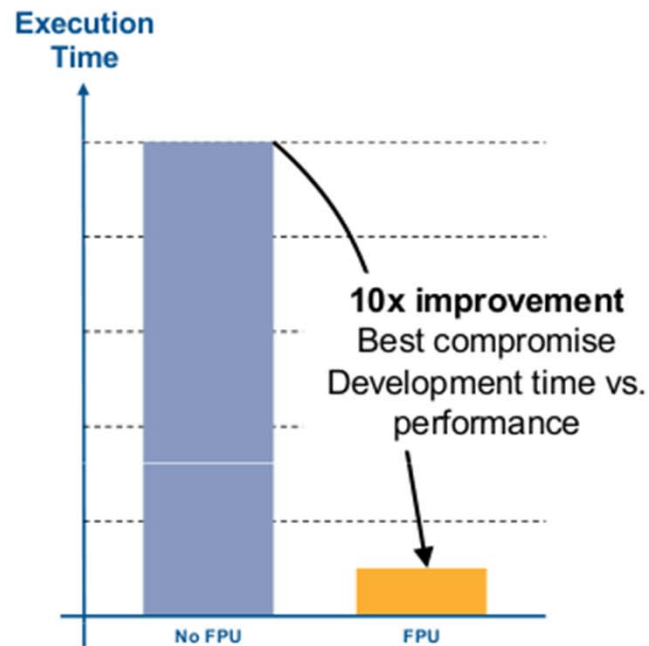


FPU - Floating Point Unit benefits



FPU - Floating Point Unit benefits

Time execution comparison for a 29 coefficient FIR on float 32 with and without FPU (CMSIS library)



Microcontroller characteristics of the Cortex processor

RISC processor core

- High performance 32-bit CPU
- Deterministic operation
- Low latency 3-stage pipeline

Thumb-2 technology

- Optimal blend of 16/32-bit instructions
- Very high code density
- No compromise on performance

Low power modes

- Integrated sleep state support
- Multiple power domains
- Architected software control

Nested Vectored Interrupt Controller (NVIC)

- Low latency, low jitter interrupt response
- No need for assembly programming
- Interrupt service routines in pure C

Tools and RTOS support

- Broad 3rd party tools support
- Cortex Microcontroller Software Interface Standard (CMSIS)
- Maximizes software effort reuse

CoreSight debug and trace

- JTAG or 2-pin Serial Wire Debug (SWD) connection
- Support for multiple processors
- Support for real-time trace

Signal processing characteristics of the Cortex

Harvard architecture

- 32-bit AHB-Lite interface for instruction fetches
- 32-bit AHB-Lite interface for data and debug accesses

Single cycle 16,32-bit MAC

- Wide range of MAC instructions
- Choice of 32 or 64 bit accumulator
Instructions execute in a single cycle

Single cycle SIMD arithmetic

- 4 parallel 8-bit adds or subtracts
- 2 parallel 16-bit adds or subtracts
- Instructions execute in a single cycle

Single cycle dual 16-bit MAC

- 2 parallel 16 bit MAC operations
- Choice of 32 or 64 bit accumulator
- Instructions execute in a single cycle

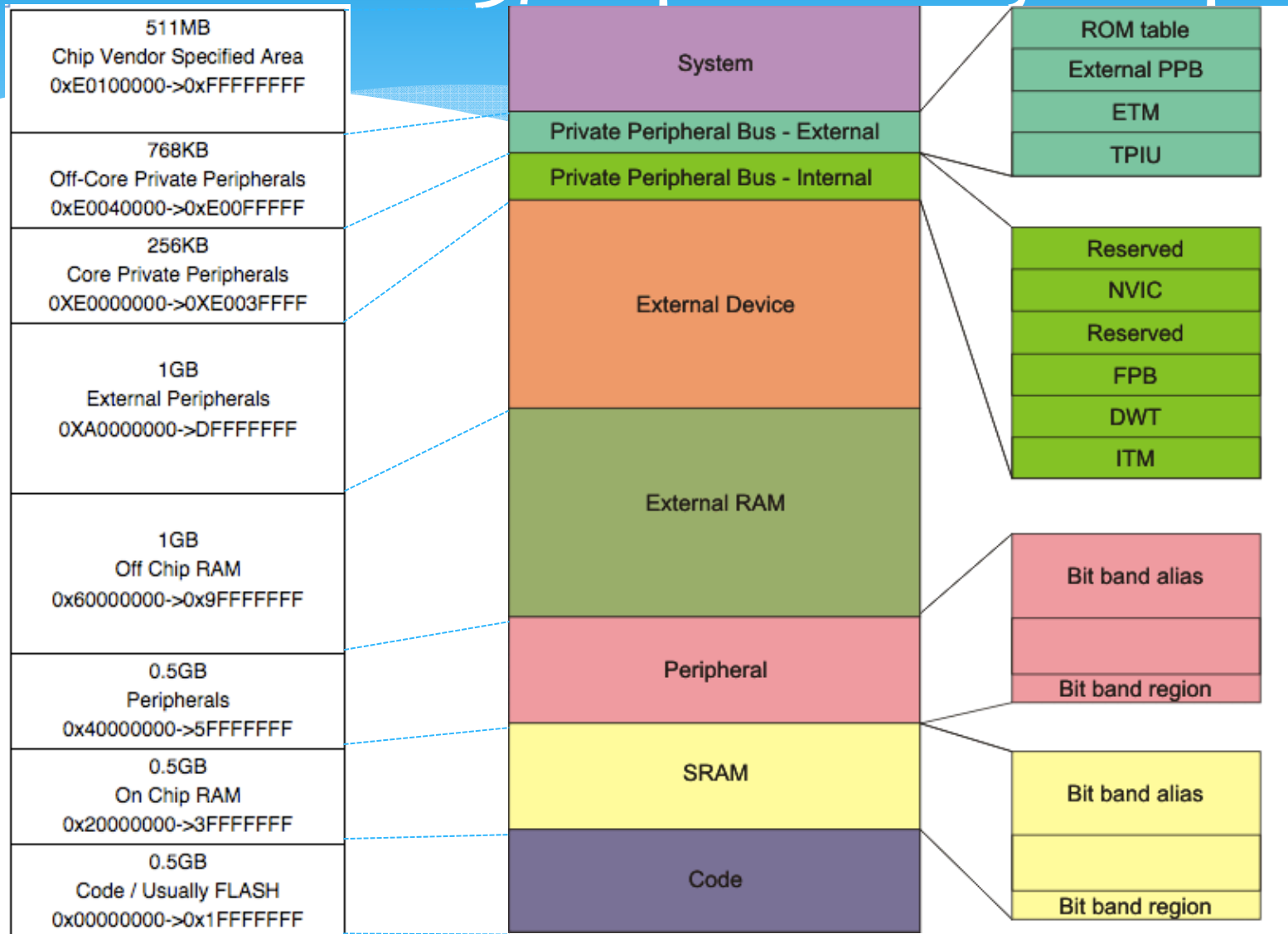
Floating point unit

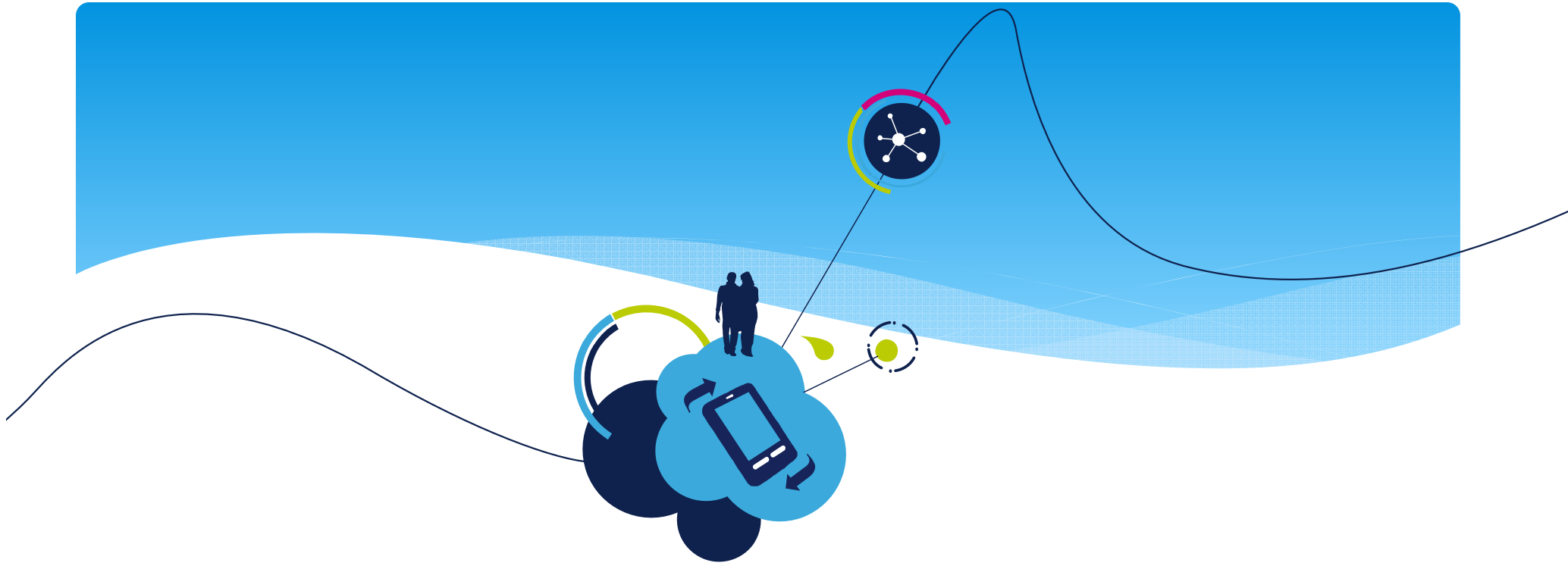
- IEEE 754 standard compliant
- Single precision floating-point unit
- Fused MAC for higher precision

Others

- Saturating math
- Barrel shifter

Cortex-M3/M4 Memory Map





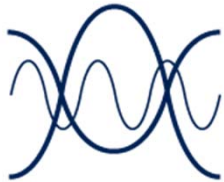
Great fit for applications

Great fit for appliances



Dual motor control and power-factor correction (PFC)

- BOM reduction, thanks to complete analog integration on chip
- Board simplification



Advanced analog IP for efficient control and monitoring

- Fast **comparators** (50 ns)
- **Op amps** with **4 built in gains** (PGA) with **1% accuracy**
- 12-bit **DAC**
- **200 ns**, 12-bit **ADC** with **39 channels** (up to **18 MSPS** in interleaved mode)



Safety ready: optimized self-test routines for EN/IEC 60335-1 Class B

- Real-time hardware **RAM parity** check and 16-bit **CRC** for Flash-memory integrity checks
- CCM-SRAM with **write protection**
- **Double watchdog system**
- Memory protection unit (**MPU**)

Great fit for consumer devices



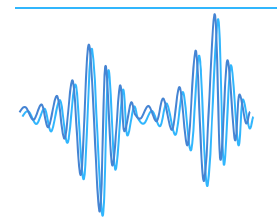
Connectivity

- **USB 2.0** full speed interface
- **CEC** with dual clock domain allows flexible wake-up and synchronization
- **I²S interface** with internal clock prescaler for **entry-level audio**



Advanced analog IP for accurate signal measurement

- **16-bit $\Sigma\Delta$ ADC** with **11 differential** input pairs **or** **21 single-ended channels** and **built in amplifiers** for biometric sensors



Easy interface with 1.8 V IC

- Application processors, for example – keeps ADC, DAC and CMP advanced **analog 3.6 V excursion** via dual-voltage domains on STM32 F3



- **Capacitive touch sensing:** Touch-controller IP allows zero CPU load with charge transfer method
Supporting up to **24 keys and slider/ wheel capability**

Great fit for digital power



Solar inverters (microinverter topologies)

- Use multiple PWM timers (clocked at **144 MHz** -> **6.9 ns resolution**) with ADCs and other analog peripherals



LED lighting (high-end)

- Use multiple PWM timers (clocked at **144 MHz**), ADCs and other analog peripherals



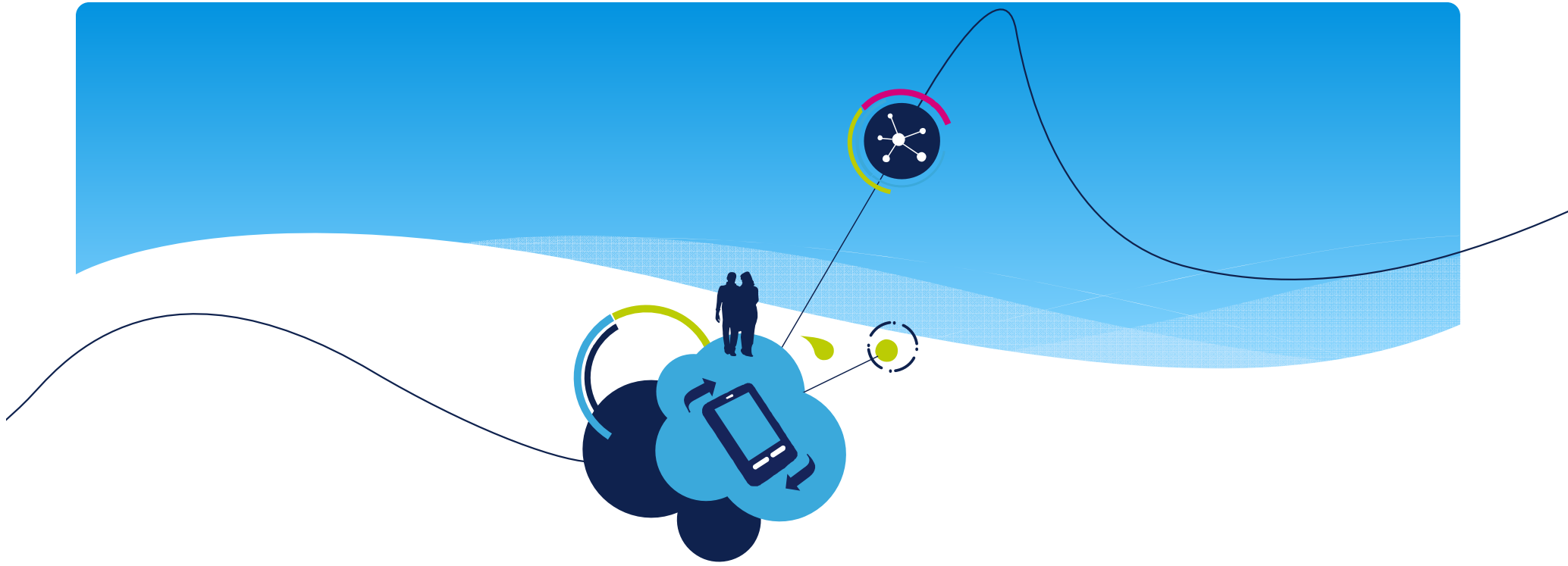
Digital power conversion (entry-level digital power supplies)

- **144 MHz timers**, fast comparators and op amps, HW triggers to the four 5 MSPS ADCs



Metering

- **3x 16-bit $\Sigma\Delta$ ADCs** with 11 differential input pairs or 21 single-ended channels and built in amplifiers for current and/or voltage measurement

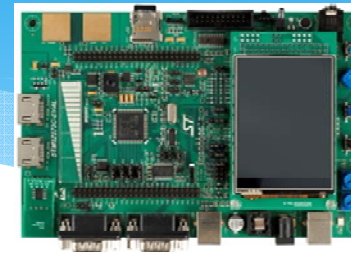


Tools and Software

Extensive tools and SW

- * Evaluation board for full product feature evaluation

- * **Hardware evaluation platform for all interfaces**
- * **Connection to all I/Os and all peripherals**



STM32303C-EVAL STM32373C-EVAL

Available in Q4-2012

(For any support before please contact our local ST office)

- * Discovery kit for cost-effective evaluation and prototyping



STM32F3DISCOVERY

Available End Q3-2012

(For any support before please contact our local ST office)

- Large choice of IDE solutions from the STM32 and ARM ecosystem :



STM32 debug capabilities

JTAG

- Standard Development & Test Tools
 - Standard JTAG connection for debug and embedded memory programming
 - Boundary Scan capability

SW
Serial Wire

- Optimized resources for in-situ debug
- Only 2 pins:
 - To program embedded memory
 - To run advanced debugging session with trace capability

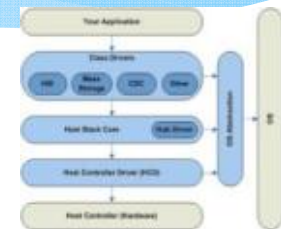
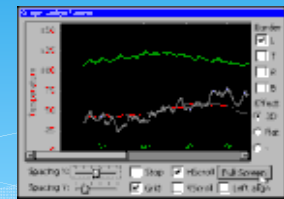
ETM

- Advanced real time in-situ debugging
 - Data and instruction TRACE capability
 - Profiling and code coverage



Third Party Software Stacks and RTOS

- Choice of complete software solutions
 - Real Time Operating Systems
 - USB Host/OTG and Ethernet stacks
 - Graphics libraries

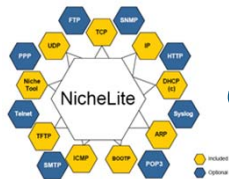


Free software solutions from ST



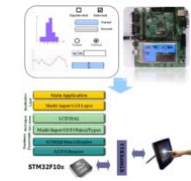
Standard Peripheral Library

USB device library & USB Host Stack



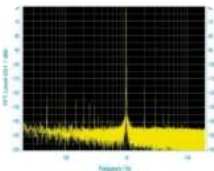
TCPIP Stack Library

STM32 graphic user interface library



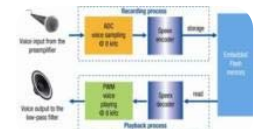
Motor Control Library

Self-test routines for EN/IEC 60335-1 Class B



DSP Library

SPEEX Codec



Encryption Library

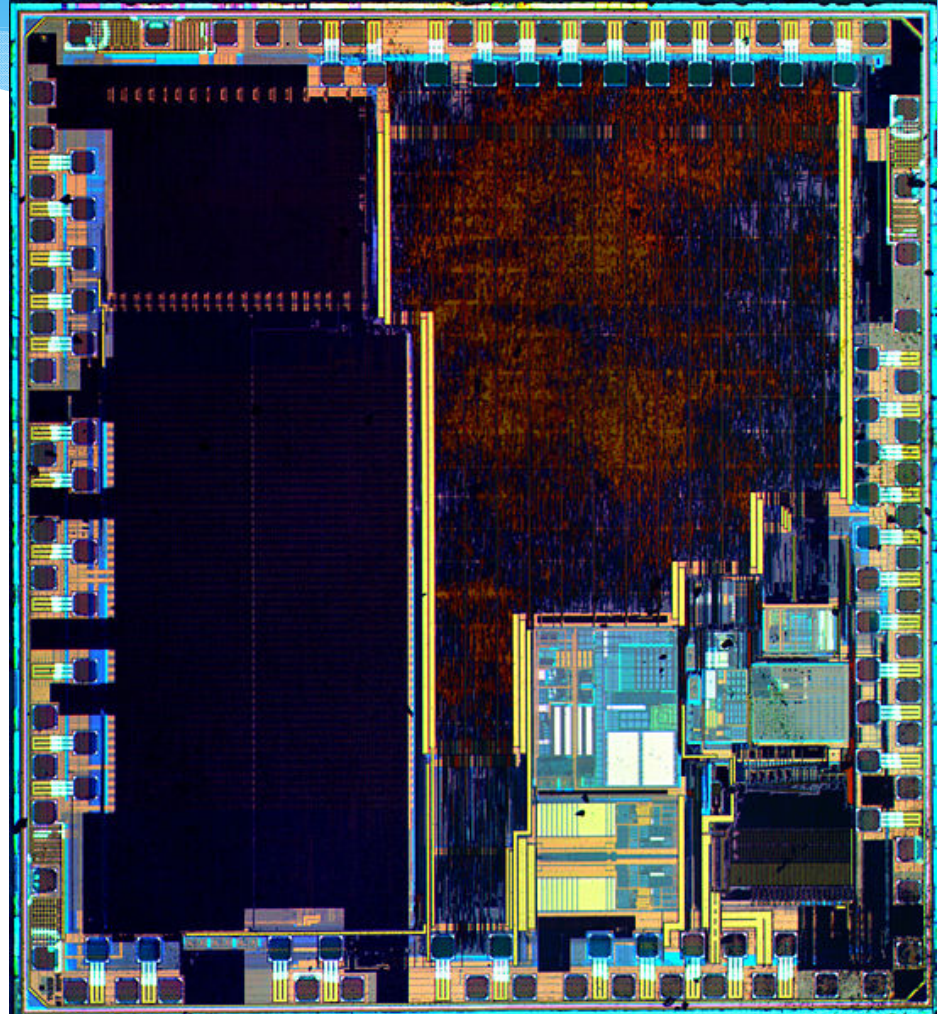
STM32 Audio Engine
iPod IAP software



STM32F100C4T6B Die

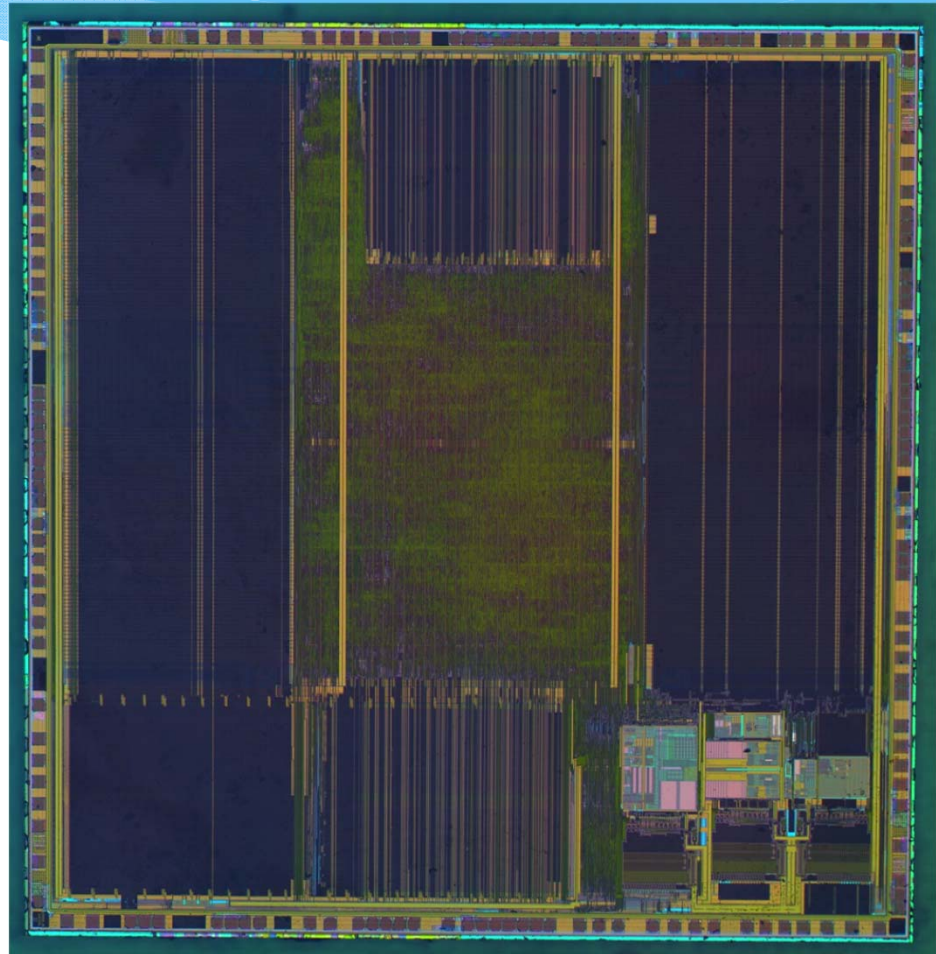
ARM Cortex-M3
microcontroller with

- * 16 kilobytes flash memory,
- * 24 MHz Central Processing Unit (CPU),
- * motor control and
- * Consumer Electronics Control (CEC) functions



STM32F103VGT6 Die

- * STM32F103VGT6 is one of the largest STMicroelectronics's Cortex-M3 microcontrollers.
- * 1Mb of flash and 96kb of SRAM consumes most of its enormous 5339x5188 μm die.



STM32 versus Arduino

	STM32VL Discovery	Arduino Uno	Arduino Mega 2560	Copper AVR32
Price	\$10	\$25	\$50	\$38
Processor	STM32F100 Cortex-M3	ATmega328P AVR	ATmega2560 AVR	AT32UC3B1256 AVR
Type	32 bit	8 bit	8 bit	32 bit
Flash (KB)	128	32	256	256
EEPROM (KB)	0	1	4	0
RAM (KB)	8	2	8	32
Max Speed (MHz)	24	20	16	60
Voltage (V)	2.0 – 3.6	1.8 – 5.5	1.8 – 5.5	3.0 – 3.6
User I/O Pins	51	20	70	28
SPI channels	2	2	5	3
I2C channels	2	1	1	1
UART channels	3	1	4	2
ADC channels	16	8	16	6
DAC channels	2	0	0	0
USB	no	no	no	yes