ST MC SDK 5.x 概览

STM32电动机控制应用系列讲座之一

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电动机分类

- 电动机
  - 无需变频器驱动
    - 交流
      - 异步
      - 电励磁同步
    - 直流
  - 需变频器驱动

通用

●ST 有基于STM8,STM32的样例程序　●● ST MC SDK　电压频率比为常数方式

电动机 \ 控制方法	相控	V/f	矢量控制	方波控制	斩控	微步
异步	●	●	●			
永磁同步（直流无刷）		●	●●	●		
开关磁阻			●			●
步进						●
直流					●	

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方波控制与矢量控制方法对比

控制方法	方波控制	矢量控制 正弦波
固件复杂度	☺	☹
硬件需求	☺	☹
换相退磁	☹	☺
转矩波动	☹	☺
低速噪音	☹	☺
启动转矩	☹	☺
电动机效率	☹	☺

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内容

- 什么是ST MC SDK5.x
- ST MC SDK5.x支持的MCU及硬件评价板
- ST MC SDK5.x固件介绍
- ST MC SDK5.2图形化人机界面 MotorControl WorkBench
- ST MC SDK5.x 电动机参数测试
- ST MC SDK5.x 参考资料列表

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什么是ST MC SDK5.x

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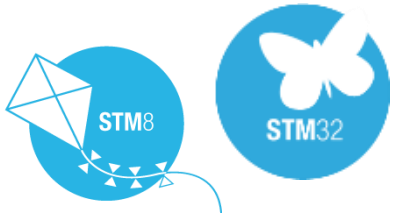
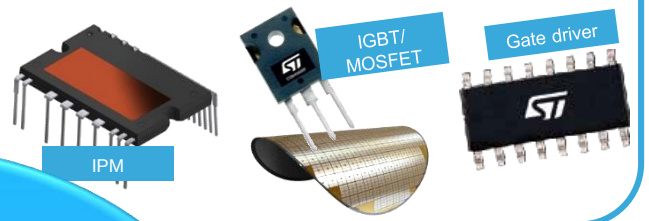
ST 电动机控制方案
相关产品、评价硬件、开发调试工具及软件包和固件库

3-Phase Motors PMSM FOC SDK

用于电动机控制的MCU包括8位机与32位机



功率器件
IPM / 分立器件



Motor Control Ecosystem

ST MC Workbench

人机图形化界面
完整的用户设置和实时监控功能

硬件Demo板

ST MC SDK

固件库
完善的FOC算法库适用于多种应用领域

ST MC SDK 分为
- X-CUBE-MCSDK
- X-CUBE-MCSDK-FUL

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ST MC SDK5.x支持的MCU及硬件评价板

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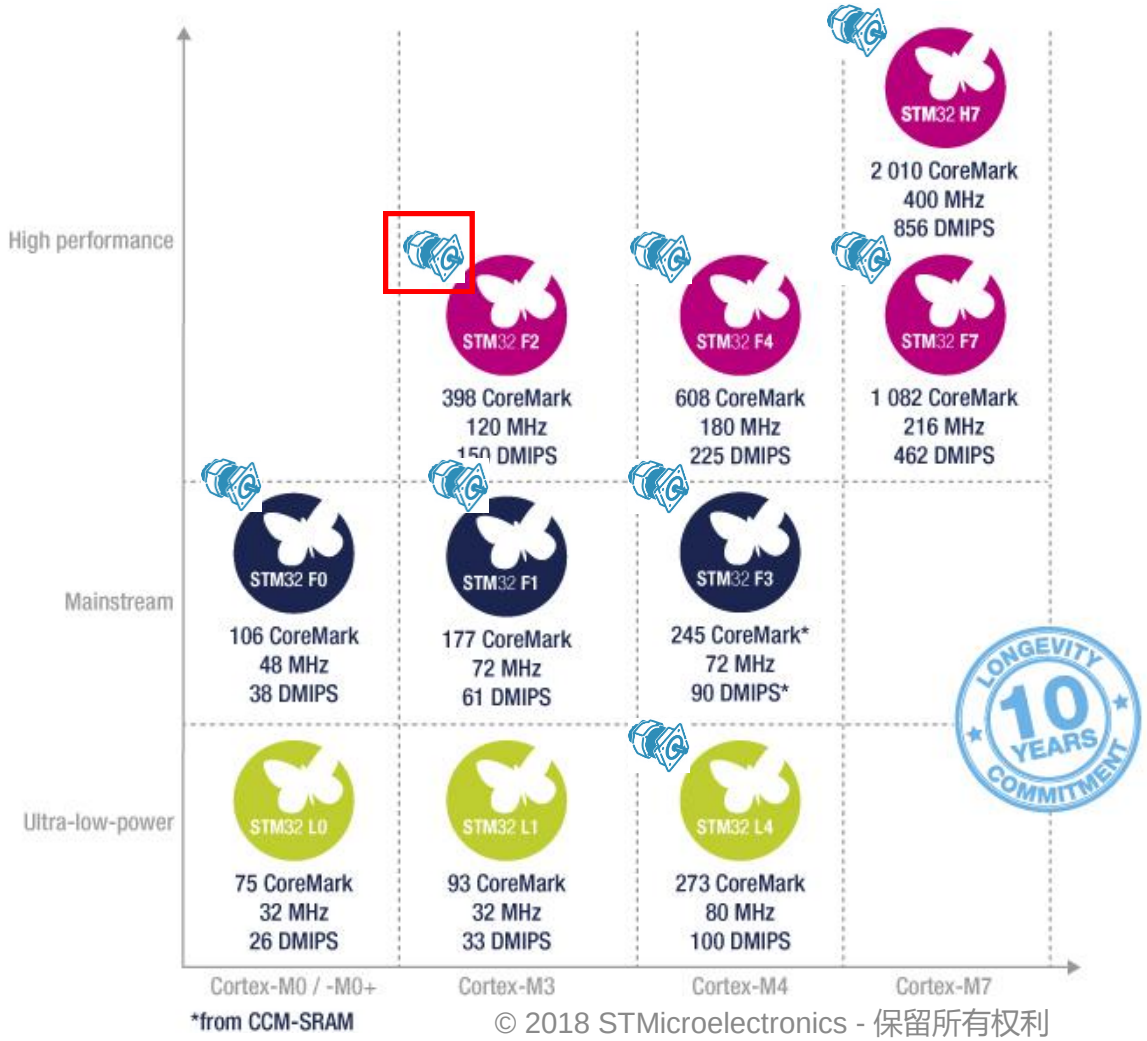
适用于电动机控制的STM32产品线

8 个系列/超过31条产品线



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ST MC SDK5.2支持的芯片型号

STM32F7	STM32F746ZG / STM32F769NI
STM32F4	STM32F417IG / STM32F415ZG / STM32F407IG / STM32F446ZE / STM32F446RE / STM32F401RE
STM32L4	STM32L452RE / STM32L476RG
STM32F3	STM32F302VB / STM32F302VC / STM32F302R8 / STM32F303VB / STM32F303VC / STM32F303ZE / STM32F303VE / STM32F303RE
STM32F1	STM32F103 High, Medium and Low Densities
STM32F0	STM32F030RC / STM32F030R8 / STM32F031C6 / STM32F051R8 / STM32F051C8 / STM32F072VB / STM32F072RB

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ST MC SDK5.2支持的功能（1/2）

STM32 series	F0	F1	F3	F4	F7 (v5.3)	L4 (V5.3)
• 1 Shunt单电阻检测	✓	✓	✓	✓	✓	✓
• 3 Shunt三电阻检测	✓	✓	✓	✓	✓	✓
• Hall sensors/Encoder • 霍尔传感器/增量编码器	✓	✓	✓	✓	✓	✓
• ICS 电流传感器	✗	✓	✓	✓	✓	✓
• Flux weakening • 弱磁控制	✓	✓	✓	✓	✓	✓
• MTPA 单位电流最大力矩输出算法	✓	✓	✓	✓	✓	✓
• Sensorless (PLL / Cordic)无位置传感（锁相环/Cordic算法）	✓	✓	✓	✓	✓	✓
• Feed Forward电流前馈	✓	✓	✓	✓	✓	✓
• Single FOC单电机控制	✓	✓	✓	✓	✓	✓
• Dual FOC双电机控制	✗	✗	✓	✓	✓/✗	✗

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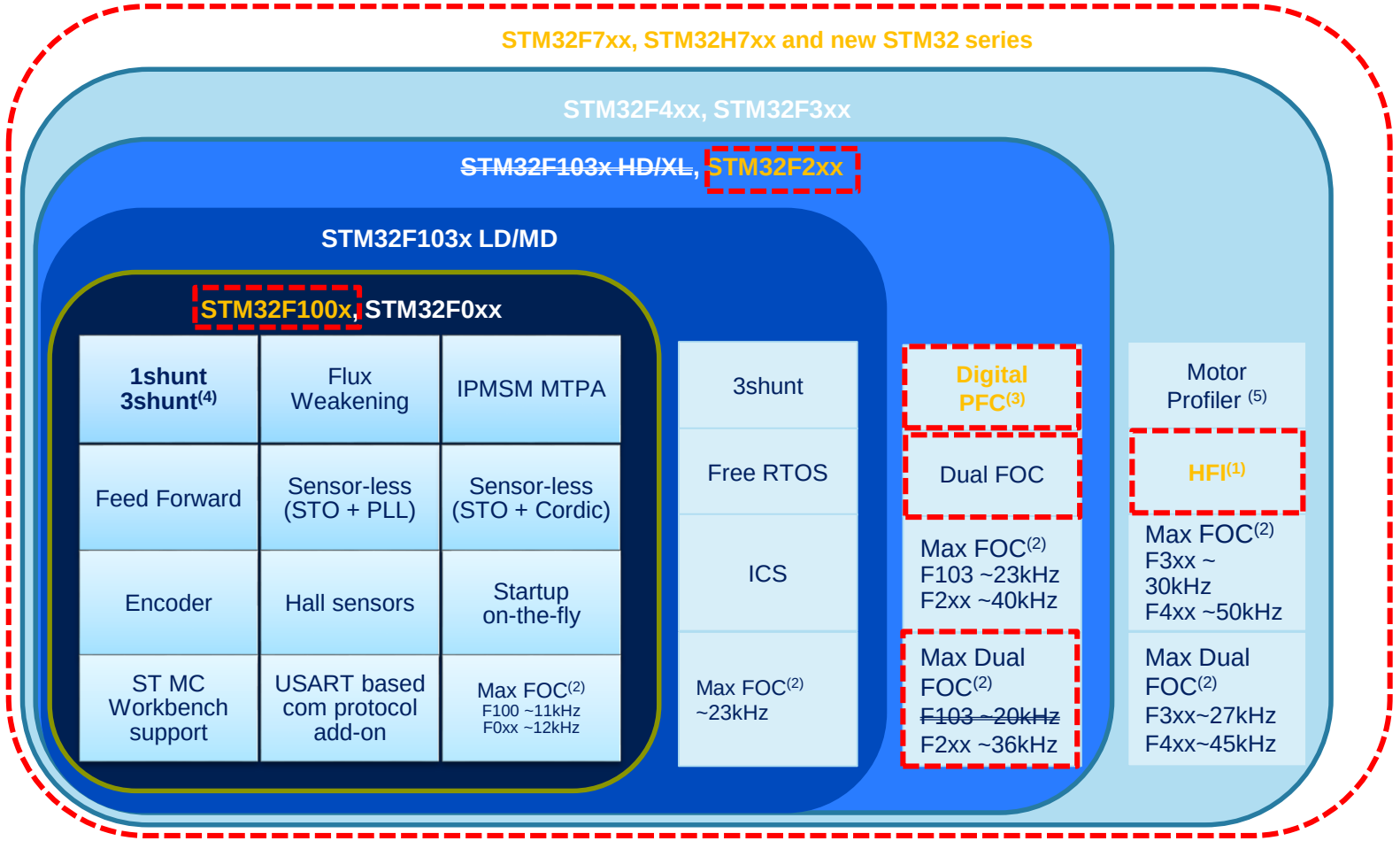
ST MC SDK5.2支持的功能（2/2）



XXX MC SDK5.x将要支持的功能

(1) High Frequency Injection
(2) Max FOC estimated in sensorless mode
(3) STM32F103xC/D/E/F/G and STM32F303xB/C
(4) Not for STM32F100
(5) For STM32F30x

适用于电动机控制的ST硬件评价板

覆盖不同的需求

控制板 + 功率板
Control + Power

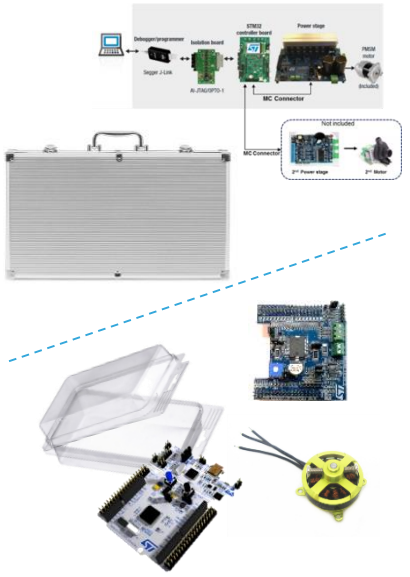
Eval/Nucleo + Power/Expension

Control stages

Power stages

控-驱一体板
(Complete Drive)

电动机开发套件
Motor Control Kit



另外，还有一类Inverters未在上面列出。

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硬件评价板- 电动机控制套件
Motor Control kit

P-NUCLEO-IHM001 or 2

- 廉价套件
  - 用于评价利用STM32驱动电压最高不超过36[V]，电流不超过1.4[A]的小电动机。
- 套件组成:
  - NUCLEO-F302R8
    - Microcontroller board based on STM32F302
  - X-NUCLEO-IHM07M1
    - Driver board based on L6230
  - BLDC Motor

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EVB到Nucleo的转换板

X-NUCLEO-IHM09M1

- ST 电机控制板标准接口(34 pins) 兼容主流ST功率驱动板
- 支持 STM32 Nucleo板, 用 ST morpho connectors
- 兼容ST 6步控制和FOC控制对应的硬件
- 具备DAC/GPIO的调试功能
- 所有连接点都有相应的测试点
- LED 可用于故障显示
- 板上有电位器(可用于速度指令给定)

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MC SDK5.2支持的 Control Boards (1/4)

Control Boards Type	Family	MCU	Board	Description
NUCLEO	F0	F030R8	NUCLEO-F030R8	STM32 Nucleo-64 development board with STM32F030R8 MCU, supports Arduino and ST morpho connectivity
		F072RB	NUCLEO-F072RB	STM32 Nucleo-64 development board with STM32F072RB MCU, supports Arduino and ST morpho connectivity
	F1	F103RB	NUCLEO-F103RB	STM32 Nucleo-64 development board with STM32F103RB MCU, supports Arduino and ST morpho connectivity

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MC SDK5.2支持的 Control Boards (2/4)

Control Boards Type	Family	MCU	Board	Description
NUCLEO	F3	F302R8	NUCLEO-F302R8	STM32 Nucleo-64 development board with STM32F302R8 MCU, supports Arduino and ST morpho connectivity
		F303RE	NUCLEO-F303RE	STM32 Nucleo-64 development board with STM32F303RE MCU, supports Arduino and ST morpho connectivity
	F4	F446RE	NUCLEO-F446RE	STM32 Nucleo-64 development board with STM32F446RE MCU, supports Arduino and ST morpho connectivity
		F401RE	NUCLEO-F401RE	STM32 Nucleo-64 development board with STM32F401RE MCU, supports Arduino and ST morpho connectivity

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MC SDK5.2支持的 Control Boards (3/4)

Control Boards Type	Family	MCU	Board	Description
NUCLEO	F7	F746ZG	NUCLEO-F746ZG	STM32 Nucleo-144 development board with STM32F746ZG MCU, supports Arduino, ST Zio and morpho connectivity
	L4	L453RE	NUCLEO-L452RE	STM32 Nucleo-64 development board with STM32L452RE MCU, supports Arduino and ST morpho connectivity
		L476RG	NUCLEO-L476RG	STM32 Nucleo-64 development board with STM32L476RG MCU, supports Arduino and ST morpho connectivity

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MC SDK5.2支持的 Control Boards (4/4)

Control Boards Type	Family	MCU	Board	Description
EVB	F0	F072VB	STM32072B-EVAL	Evaluation board with STM32F072VB MCU
	F3	F303VE	STM32303E-EVAL	Evaluation board with STM32F303VE MCU
	F4	F407IG	STM3240G-EVAL	Evaluation board with STM32F407IG MCU
		F417IG	STM3241G-EVAL	Evaluation board with STM32F417IG MCU
		F446ZE	STM32446E-EVAL	Evaluation board with STM32F446ZE MCU
		F415ZGT	STEVAL-IHM039V1	Dual motor drive control stage based on the STM32F415ZG microcontroller
	F7	F769NI	STM32F769I-EVAL	Evaluation board with STM32F769NI MCU
	L4	L476ZG	STM32L476G-EVAL	Evaluation board with STM32L476ZG MCU

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MC SDK5.2支持的 Power Boards (1/3)

Interface	Board	Description
EVB	STEVAL-IHM023V3	1 kW 3-phase motor control evaluation board featuring L6390 drivers and STGP10H60DF IGBT
	STEVAL-IHM028V2	2 kW 3-phase motor control evaluation board featuring the STGIPS20C60 IGBT intelligent power module
	STEVAL-IHM045V1	3-phase high voltage inverter power board for FOC based on the STGIPN3H60A (SLLIMM™-nano)
	STEVAL-IPM10F	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
	STEVAL-IPM15B	Motor control power board based on the SLLIMM™ 2nd series of IGBT IPMs
	STEVAL-IPM05F	500 W motor control power board based on STGIF5CH60TS-L SLLIMM™ 2nd series IPM
	STEVAL-IPM08B	800 W motor control power board based on STGIB8CH60TS-L SLLIMM™ 2nd series IPM
	STEVAL-IPM10B	1200 W motor control power board based on STGIB10CH60TS-L SLLIMM™ 2nd series IPM
	STEVAL-IPM10F	1000 W motor control power board based on STGIF10CH60TS-L SLLIMM™ 2nd series IPM

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MC SDK5.2支持的 Power Boards (2/3)

Interface	Board	Description
EVB	STEVAL-IPM15B	1500 W motor control power board based on STGIB15CH60TS-L SLLIMM™ 2nd series IPM
	STEVAL-IPMNG3Q	300 W motor control power board based on STGIPQ3H60T-H SLLIMM™-nano IPM
	STEVAL-IPMNG5Q	450 W motor control power board based on STGIPQ5C60T-HZ SLLIMM™-nano IPM
	STEVAL-IPMNG8Q	600 W motor control power board based on STGIPQ8C60T-HZ SLLIMM™-nano IPM
	STEVAL-IPMNM1N	60 W motor control power board based on STIPN1M50T-H SLLIMM™nano IPM MOSFET
	STEVAL-IPMNM2N	100 W motor control power board based on STIPN2M50T-H SLLIMM™nano IPM MOSFET

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MC SDK5.2支持的 Power Boards (3/3)

Interface	Board	Description
NUCLEO	X-NUCLEO-IHM07M1	Three-phase brushless DC motor driver expansion board based on L6230 for STM32 Nucleo
	X-NUCLEO-IHM08M1	Low-Voltage BLDC motor driver expansion board based on STL220N6F7 for STM32 Nucleo
	X-NUCLEO-IHM11M1	Low voltage three-phase brushless DC motor driver expansion board based on STSPIN230 for STM32 Nucleo

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MC SDK5.2支持的 Inverters

Family	MCU	Board	Description
/	STM32	STEVAL_SPIN3201	STSPIN32F0 Advanced BLDC controller with embedded STM32 MCU evaluation board(3-shunt)
/	STM32	STEVAL_SPIN3202	STSPIN32F0A advanced 3-phase BLDC driver with embedded STM32 MCU single shunt evaluation board (1-shunt)
F1	F103RC	STEVAL_IHM034V2	Dual motor control and PFC demonstration board featuring the STM32F103 and STGIPS20C60
F3	F303RE	X-NUCLEO-IHM16 + NUCLEO-F303RE	Bundle used for EMEA workshop X-NUCLEO-IHM16：Three-phase brushless DC motor driver expansion board based on STSPIN830 for STM32 Nucleo
F3	F303	STEVAL-ESC001V1	Electronic speed controller reference design for drones

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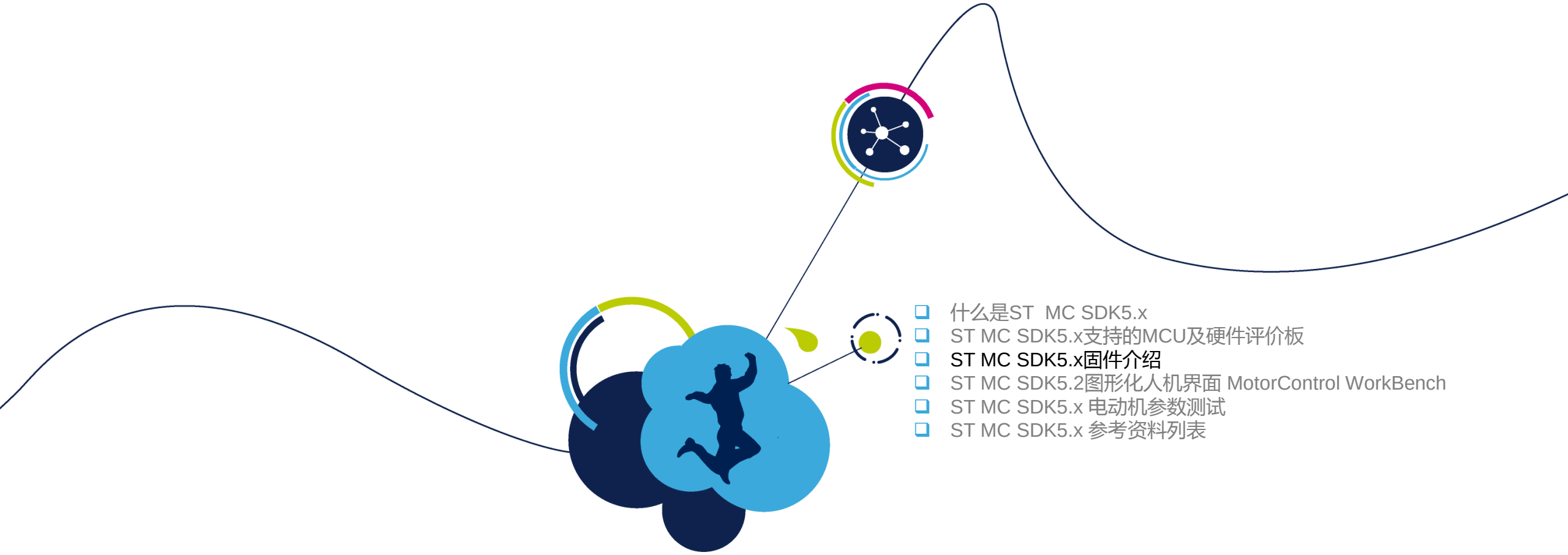

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ST MC SDK5.x固件介绍

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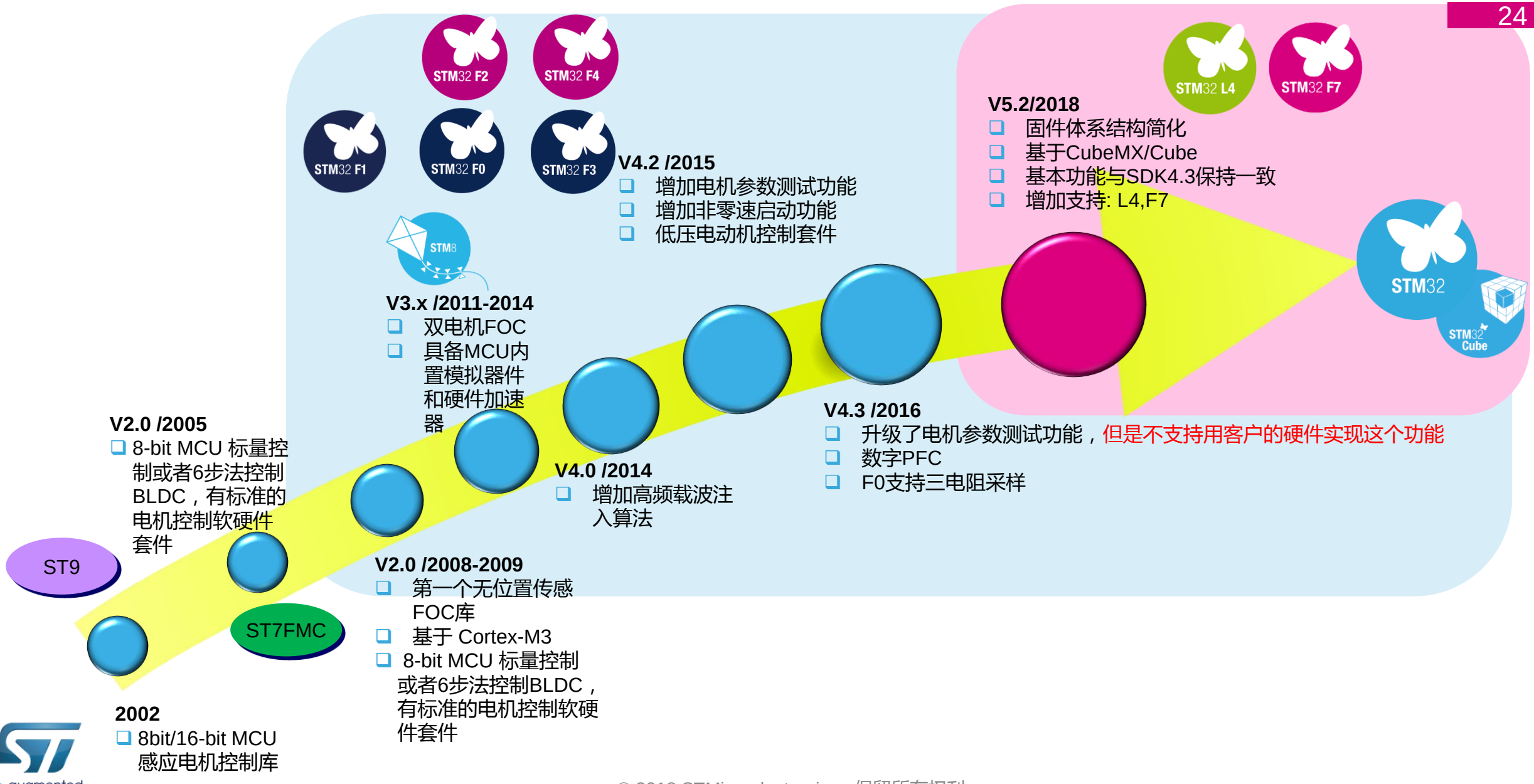
ST MC SDK 发展路线图



V5.2/2018
- 固件体系结构简化
- 基于CubeMX/Cube
- 基本功能与SDK4.3保持一致
- 增加支持: L4,F7

V4.3 /2016
- 升级了电机参数测试功能，但是不支持用客户的硬件实现这个功能
- 数字PFC
- F0支持三电阻采样

V4.2 /2015
- 增加电机参数测试功能
- 增加非零速启动功能
- 低压电动机控制套件

V4.0 /2014
- 增加高频载波注入算法

V3.x /2011-2014
- 双电机FOC
- 具备MCU内置模拟器件和硬件加速器

V2.0 /2008-2009
- 第一个无位置传感FOC库
- 基于 Cortex-M3
- 8-bit MCU 标量控制或者6步法控制BLDC，有标准的电机控制软硬件套件

V2.0 /2005
- 8-bit MCU 标量控制或者6步法控制BLDC，有标准的电机控制软硬件套件

2002
- 8bit/16-bit MCU 感应电机控制库

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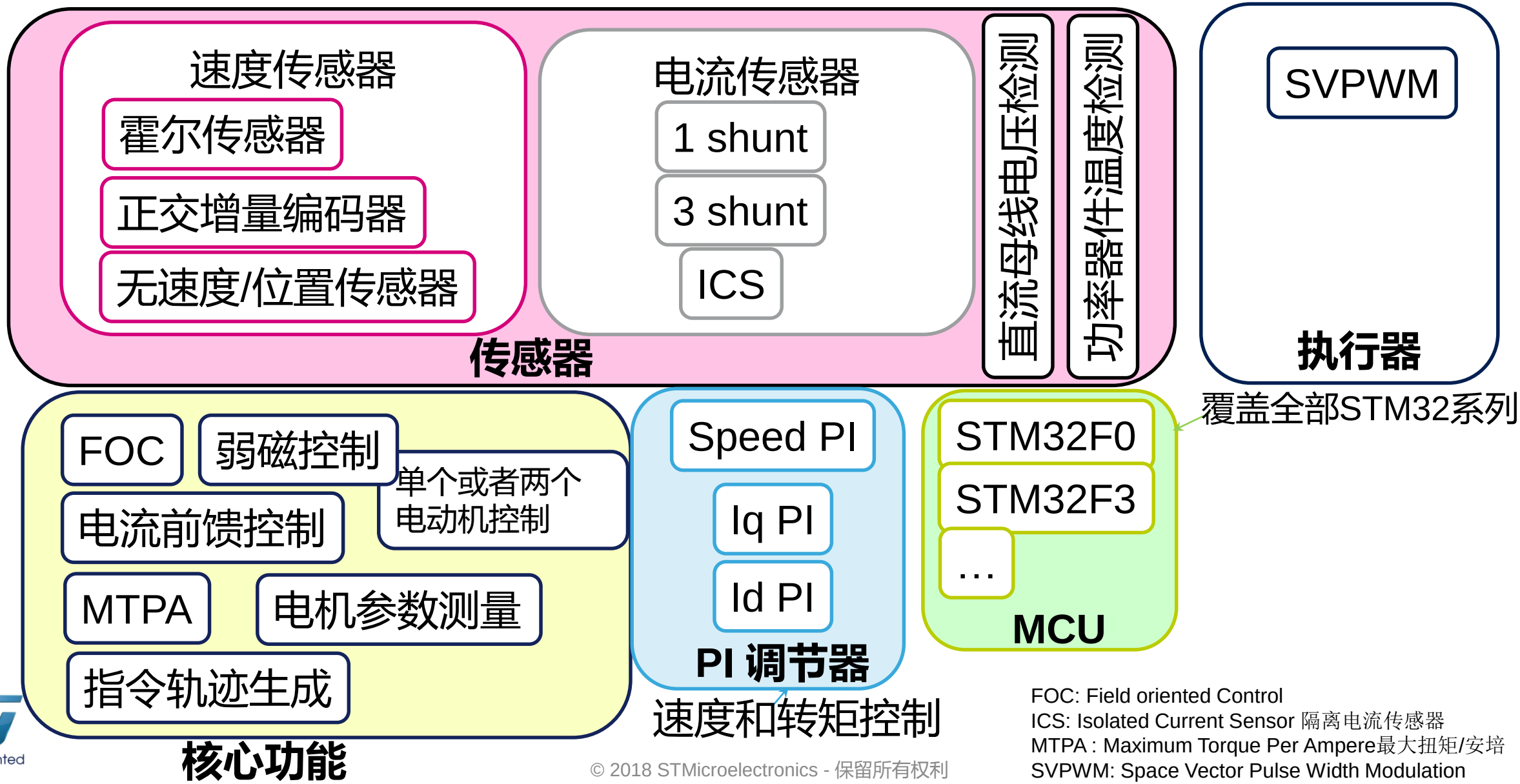
ST MC SDK5.2固件功能



FOC: Field oriented Control
ICS: Isolated Current Sensor 隔离电流传感器
MTPA : Maximum Torque Per Ampere最大扭矩/安培
SVPWM: Space Vector Pulse Width Modulation

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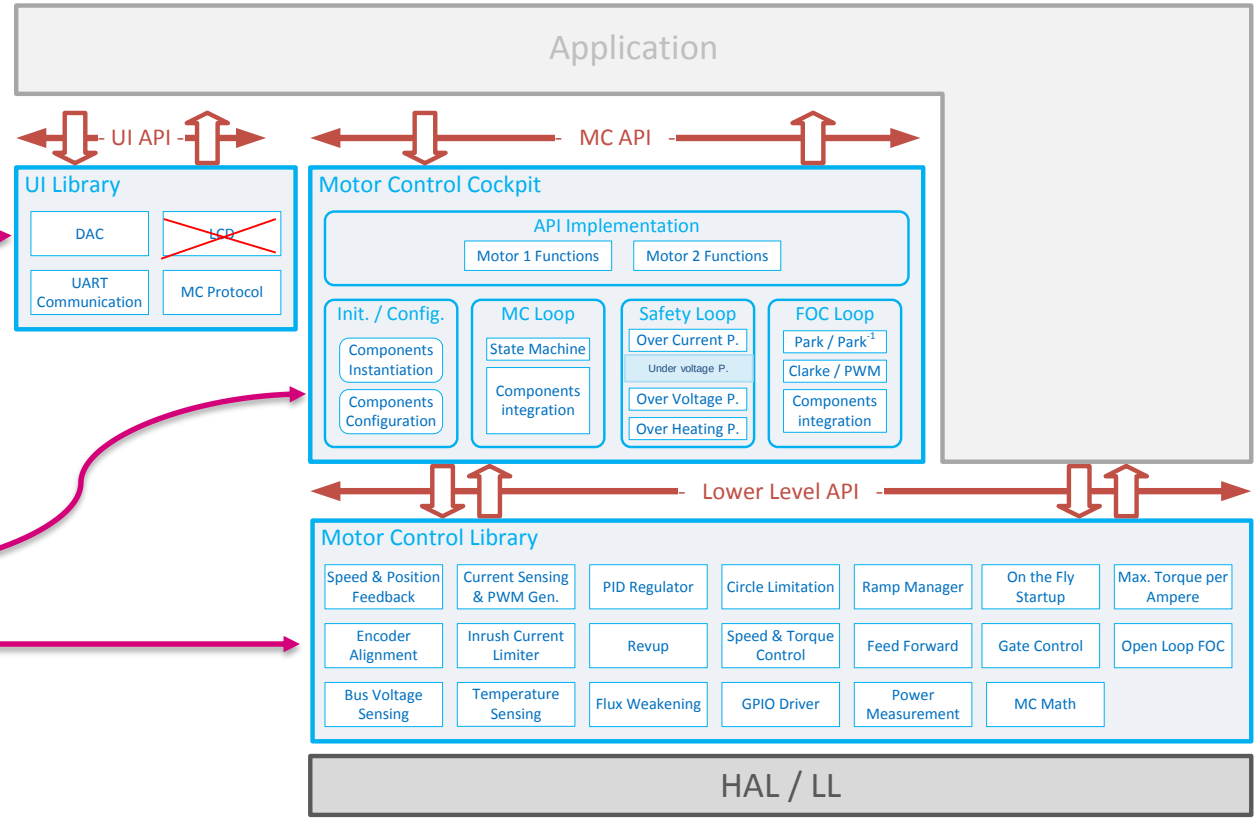
ST MC SDK5.2固件体系结构(1/3)

固件包含三部分:

- 用户接口库
- Motor Control Cockpit
- 电机控制库



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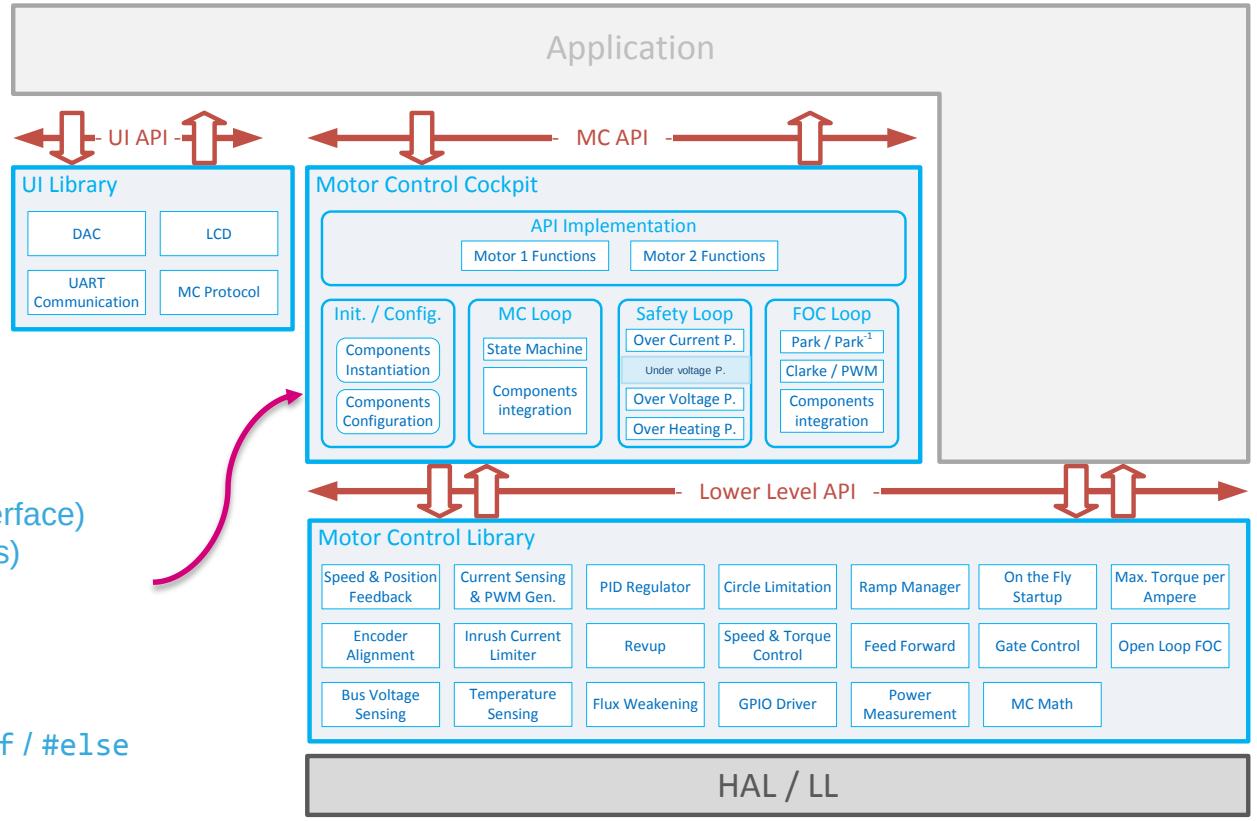
ST MC SDK5.2固件体系结构(2/3)
与SDK4.3的主要区别(1/2)

Motor Control Cockpit

- ≈ SDK4.3 MCApplication
- 包含:
  - MC API (SDK4.3 MCInterface)
  - Loops (SDK4.3 MCTasks)
  - 固件初始化
- 代码生成
  - WB直接输出
  - 只输出需要的代码
  - 不再使用条件编译`#ifdef` / `#else` / `#endif`



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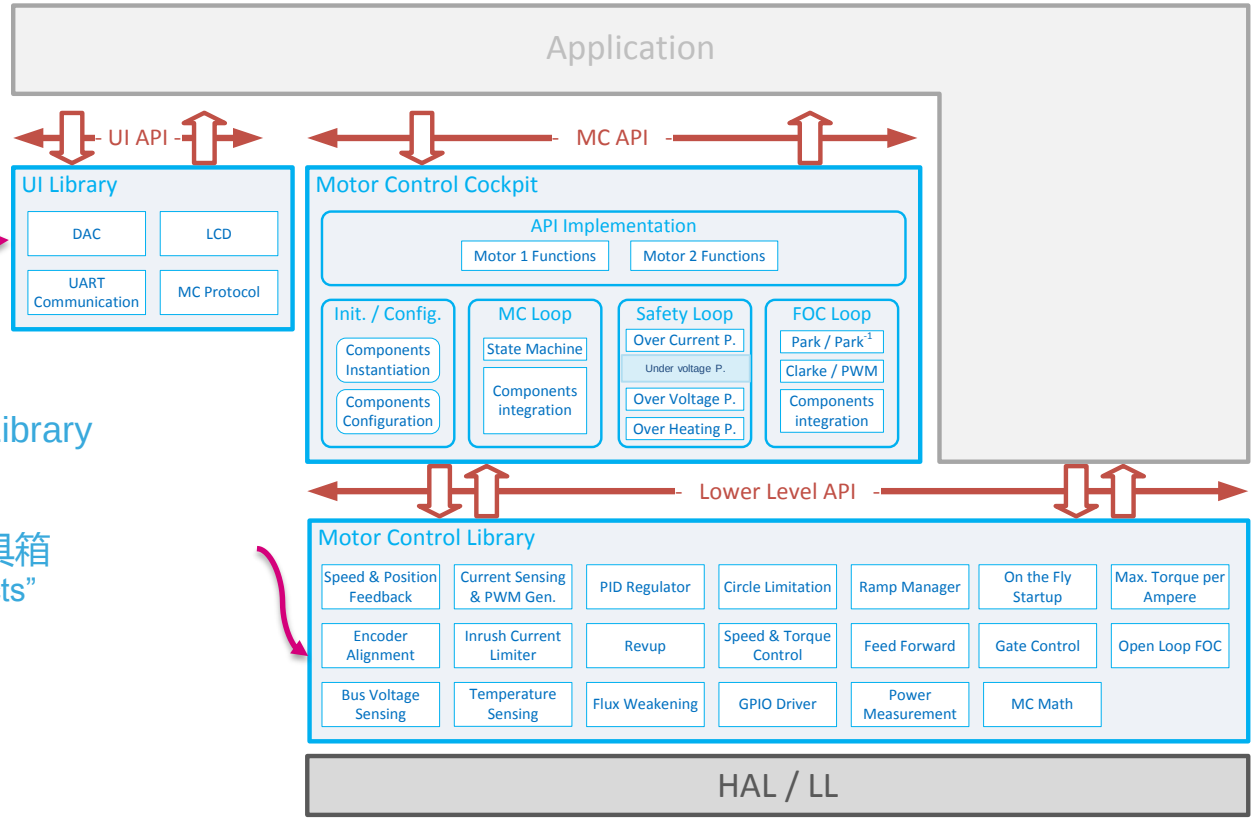
ST MC SDK5.2固件体系结构(3/3)
与SDK4.3的主要区别(2/2)

库

- ≈ SDK4.3 MCLibrary & UILibrary
  - 变更了数据结构
  - 算法保持不变
- Library == Components 工具箱
  - Components 不是“Objects”
  - 代码不再隐藏数据
  - 不再定义虚函数
- 库的结构得到了简化



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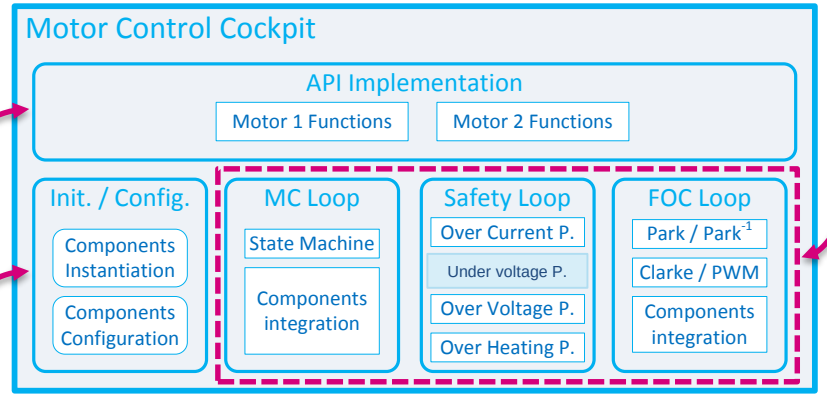
ST MC SDK5.2 Motor Control Cockpit介绍(1/2)

- MC Cockpit 由以下三个部分组成

MC Interface
实现MC Cockpit与其他部分的接口 MC API

电机控制配置
实例化和初始化所有需要的Component



MC Dynamics
实现电动机控制的逻辑
- 矢量控制循环 (High Freq)
- 电动机控制循环(Med Freq)
- 保护循环(Safety Tasks)

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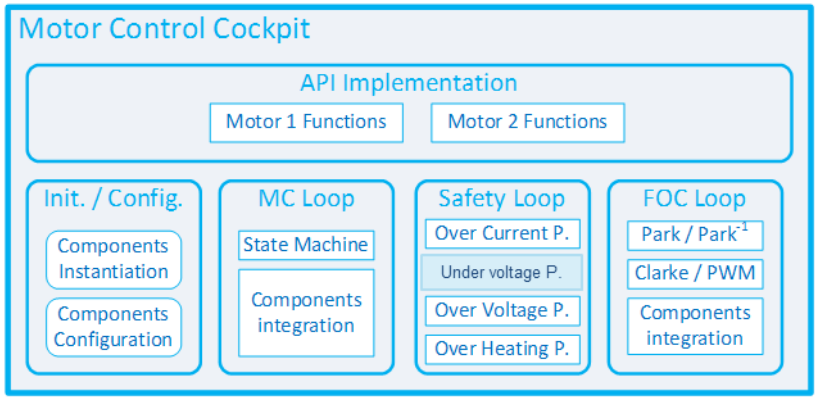
ST MC SDK5.2 Motor Control Cockpit介绍(2/2)

- Motor Control Cockpit 代码是由WB后台调用CubeMX自动生成的
  - 基于用户在WB中的配置
- 生成代码的特性
  - **短小**: 只生成项目所需要的代码。
  - **简单**: 没有条件编译。(#ifdef / #else / #endif)
  - **高效**: 无虚函数. 代码直接调用定义的函数，无需函数指针。



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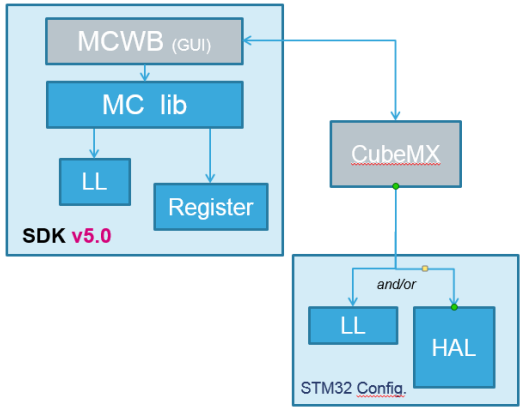
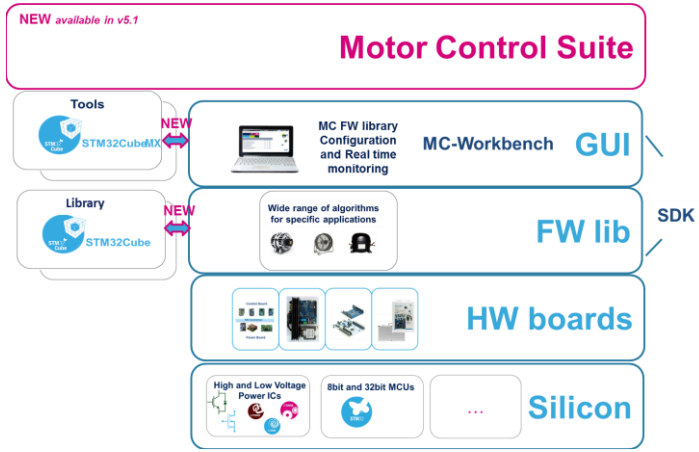
改进：从v4.3 到 v5.x

- 简化固件程序架构
  - 不再面向对象
- 固件基于STM32Cube
  - 用HAL/LL代替SPL
- 建立了MC_workbench 对 CubeMX (Tool)的调用
  - Cube MX => 用于初始化MCU的外围设备
- Motor Control Suite (Tool)
  - *涵盖全部MCU及硬件评价板的选择*
  - *统一到CubeMX/Cube的框架下*
  - *WB成为CubeMX的调用*
  - *针对具体应用有对应的固件库可以选择*





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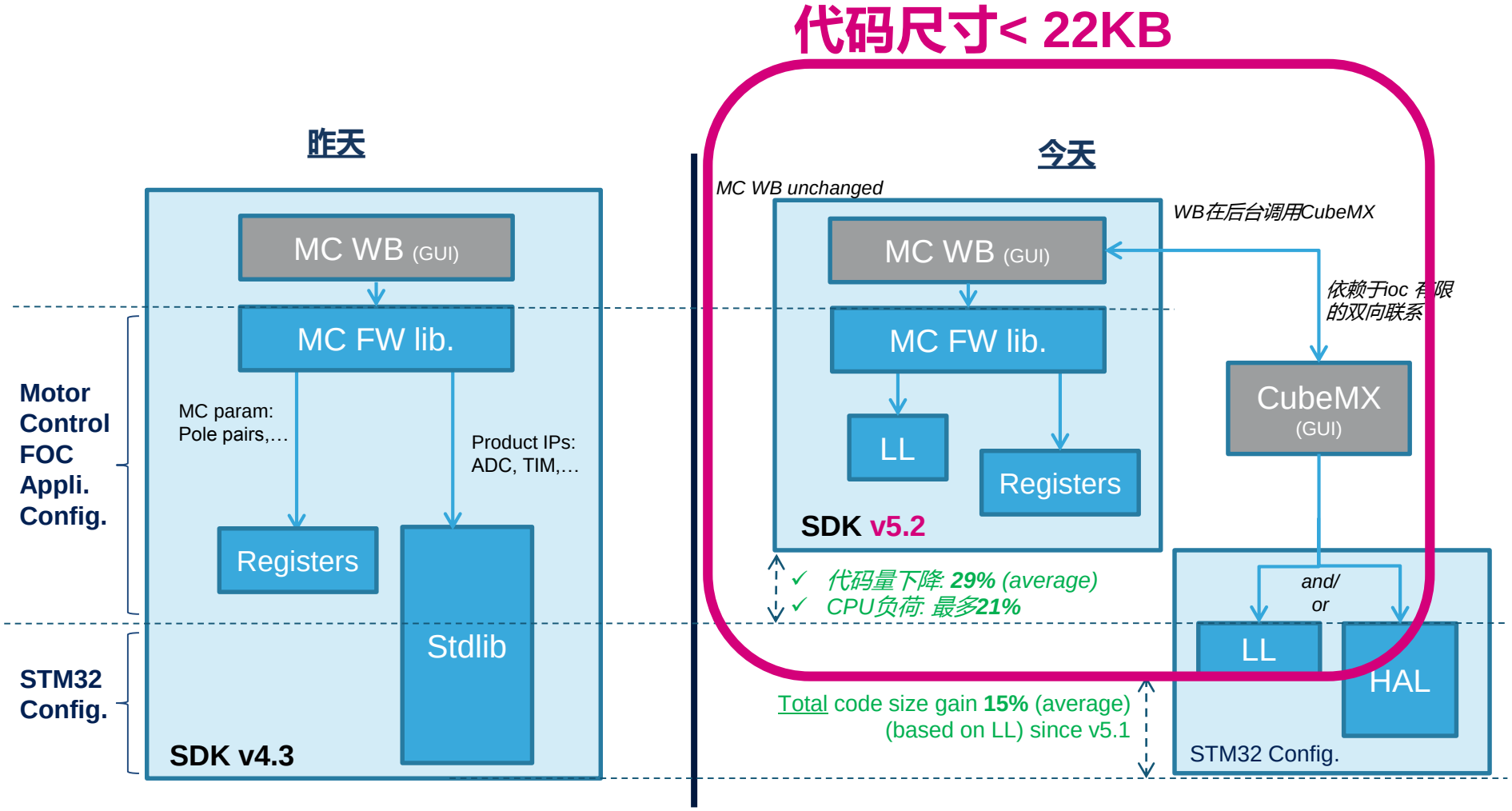
ST MC SDK5.2 与 SDK4.3固件库的体系结构对比



15% code size gain from v4.3 to V5.2 !

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ST MC SDK v5.2– 性能测试结果

PWM 载波频率 20kHz / 10kHz FOC

			MCSDK4.3				MCSDK5.2						Compare 4.3 vs 5.2			
MCU	Nb Motor	Config	CPU Workload (%)	Total Code size (kB)	MC Lib (kB)	STD Lib (kB)	CPU Workload (%)	Grand Total Code Size (+ HAL) (kB)	Grand Total Code Size (+ LL) (kB)	MC Lib (kB)	HAL (kB)	LL (kB)	CPU Workload (%)*	MC Lib (%)	Grand Total Code Size (+ HAL) (Kb)*	Grand Total Code Size (+ LL) (%)*
F072RB	Single	1x Shunt	52.0	19.3	17.3	2.0	46.4	18.0	16.9	13.1	5.2	3.2	-10.6%	-24.1%	-6.9%	-12.6%
F072RB	Single	3x Shunt	49.0	19.6	17.7	2.0	42.6	17.1	16.3	12.5	4.6	3.2	-13.0%	-29.2%	-12.8%	-17.0%
F303RE	Single	1x Shunt	20.0	21.2	18.2	3.0	20.4	22.4	19.9	14.9	8.1	4.4	2.2%	-18.0%	5.6%	-6.2%
F303RE	Single	3x Shunt	18.5	23.0	20.6	2.4	17.8	23.4	19.3	16.1	7.7	2.6	-3.5%	-21.9%	1.9%	-16.1%
F446RE	Single	1x Shunt	10.5	20.1	17.7	2.4	10.2	20.1	19.0	14.7	5.5	3.3	-3.1%	-17.0%	-0.3%	-5.8%
F446RE	Single	3x Shunt	8.9	17.8	15.8	2.0	8.2	18.2	15.7	13.2	4.8	2.0	-8.1%	-16.4%	2.3%	-12.1%
F303VE	DUAL	3x Shunt	38.9	25.2	22.8	2.4	38.2	25.5	21.8	18.6	7.9	2.6	-1.8%	-18.6%	1.0%	-13.5%
F415ZG	DUAL	3x Shunt	23.1	19.9	17.9	2.0	18.3	19.6	17.7	15.2	4.8	2.0	-20.8%	-14.9%	-1.2%	-11.1%

- 代码尺寸（应用程序+电动机控制库+驱动程序）最多下降了17%。（SDK5.x: F0+3-shunt+LL)
- 电动机控制库的代码尺寸下降的幅度从 14% 到 29%不等

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ST MC SDK5.2图形化人机界面 MotorControl WorkBench

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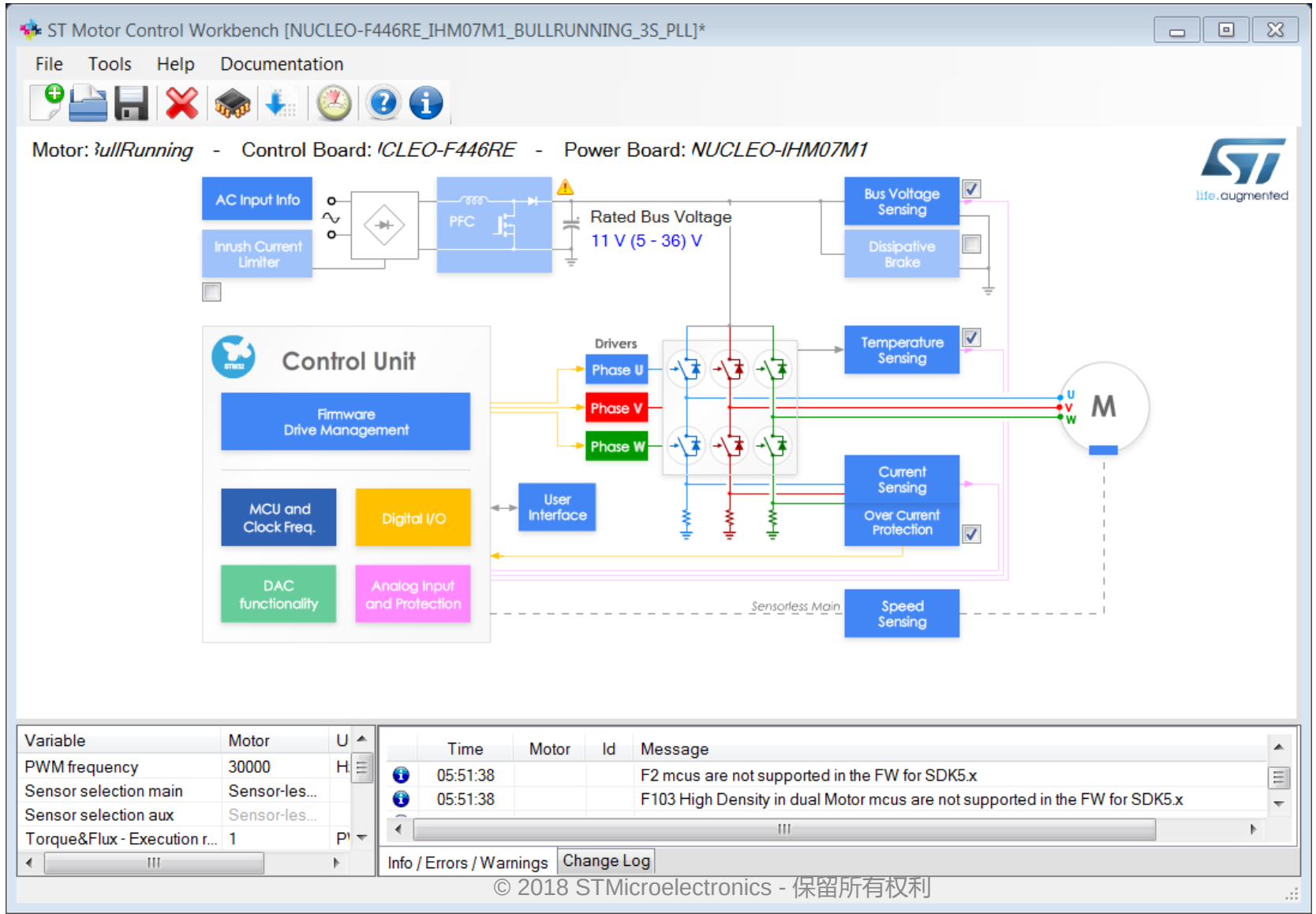
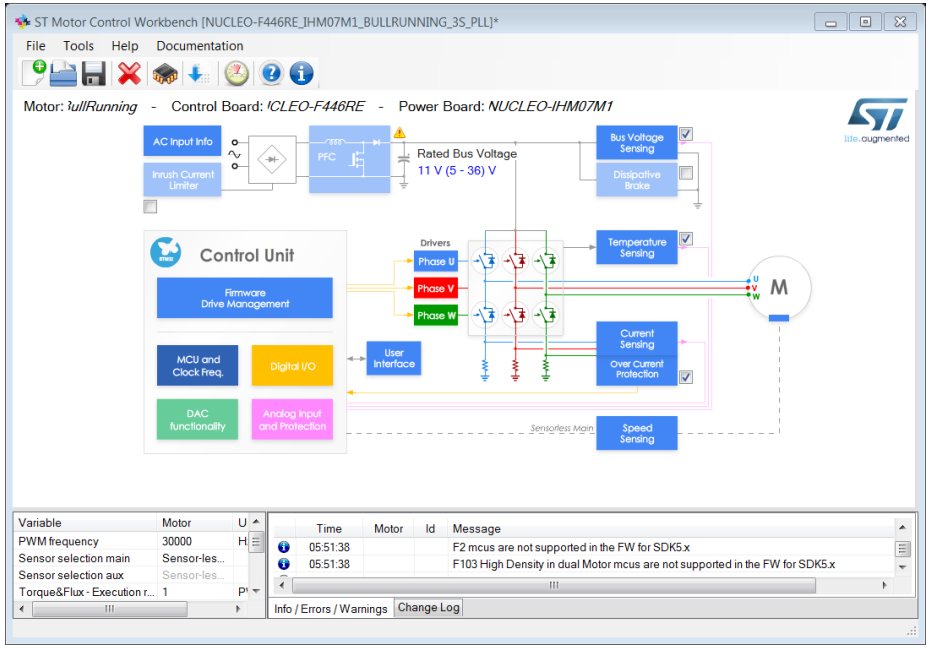
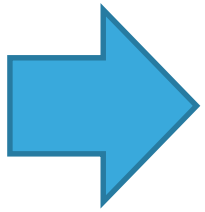
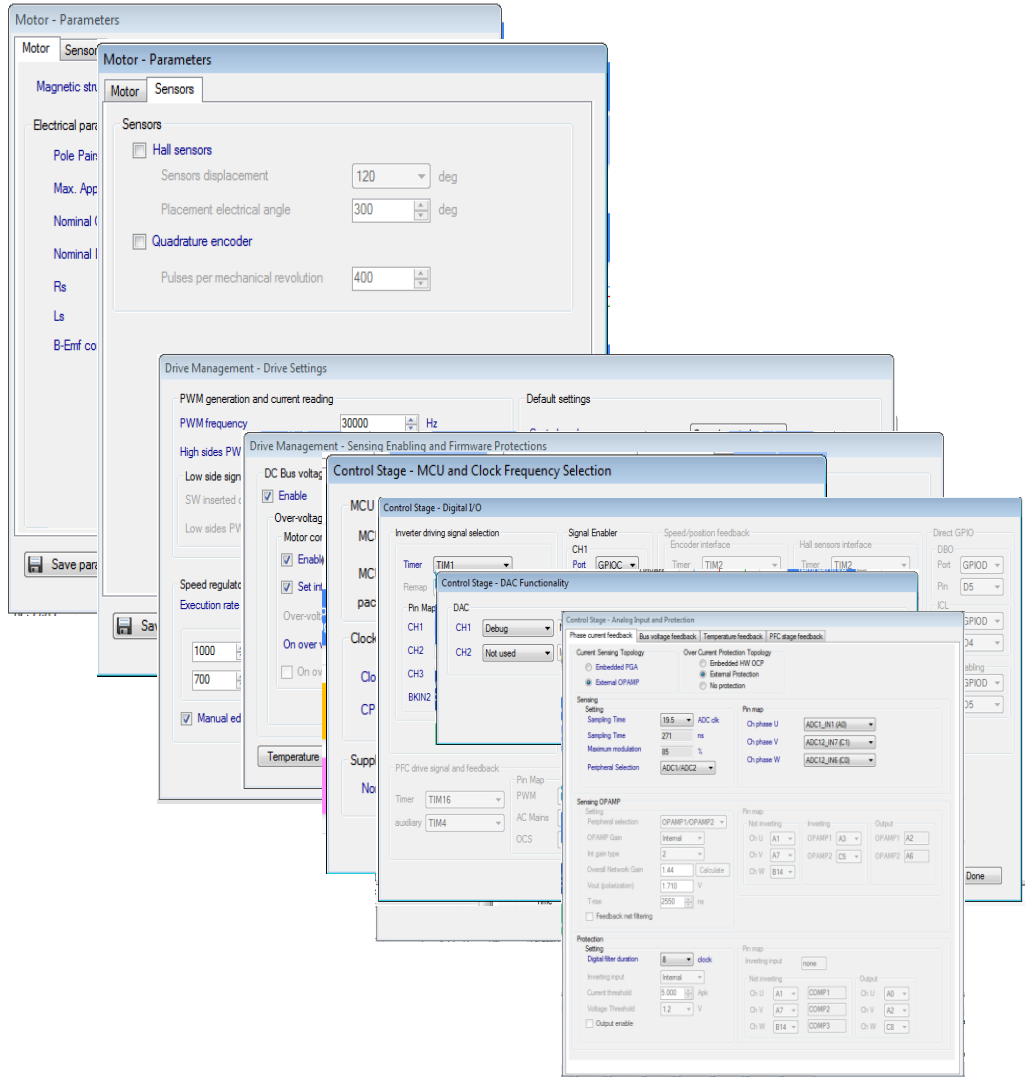
ST MC SDK5.2图形用户界面(1/3)
Motor Control Workbench 参数配置界面



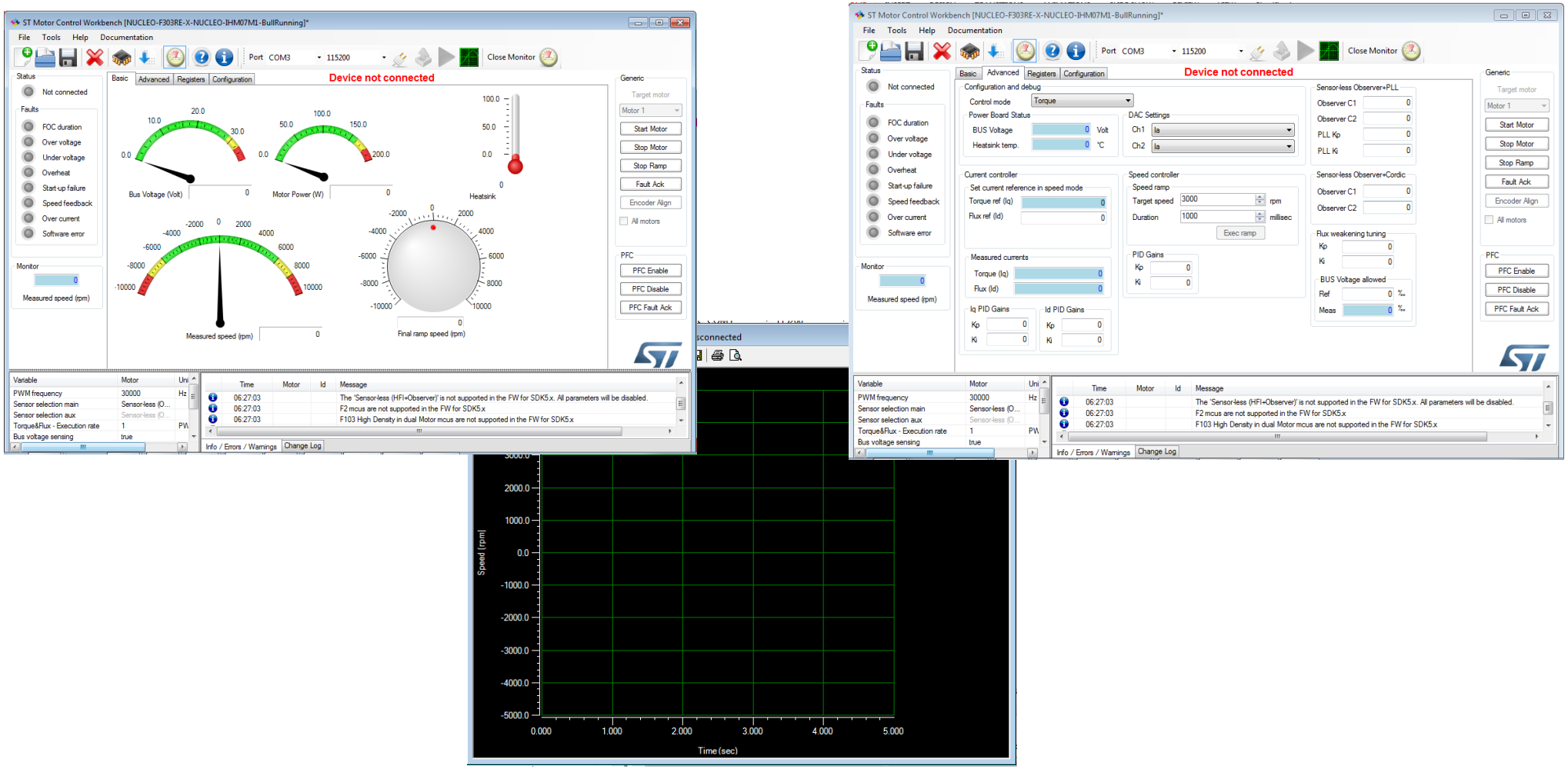
ST MC SDK5.2图形用户界面(2/3)
Motor Control Workbench 参数配置界面



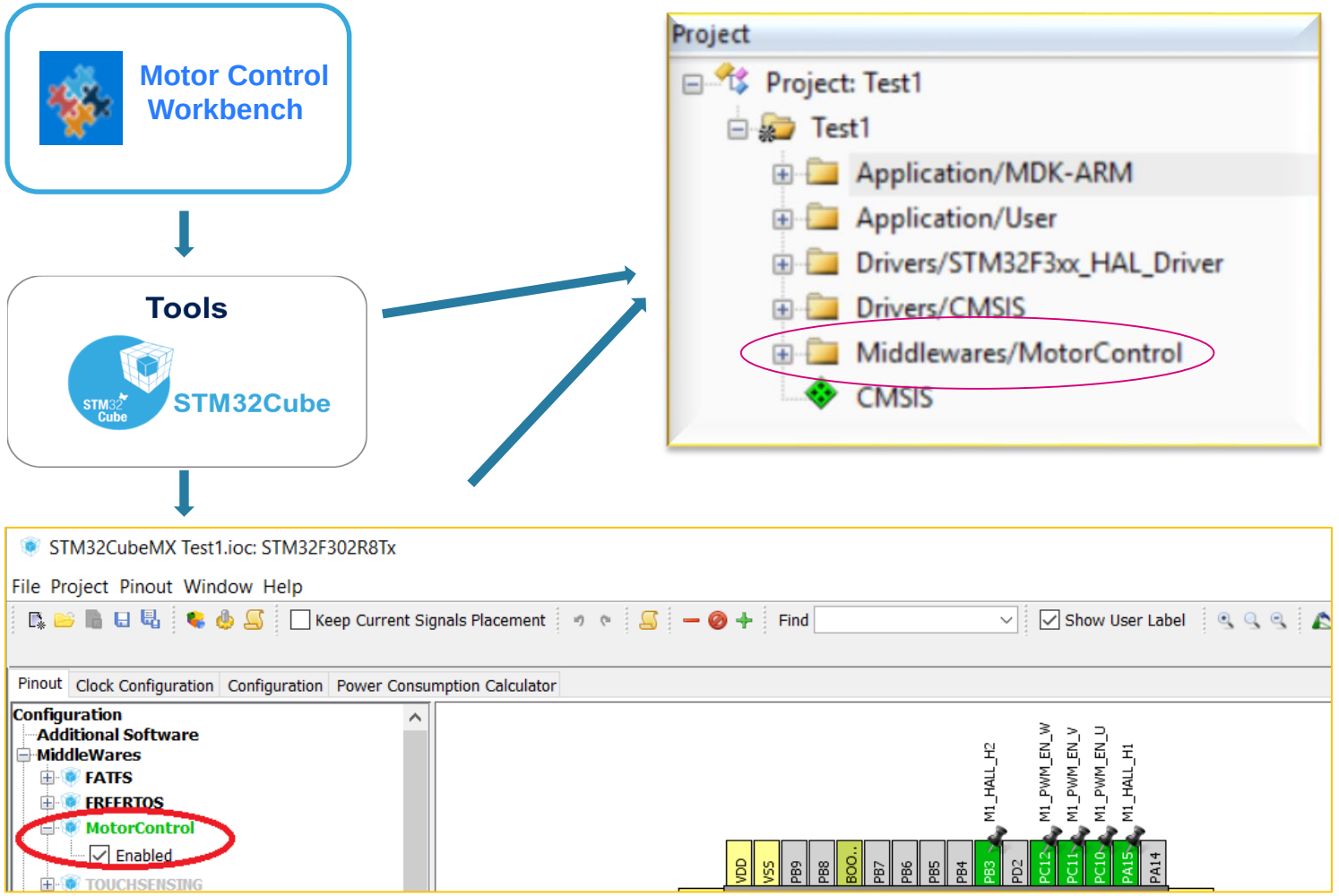




ST MC SDK5.2图形用户界面(3/3)
Motor Control Workbench 与固件交互界面



ST MC SDK5.2代码生成流程



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ST MC SDK5.x 电动机参数测试

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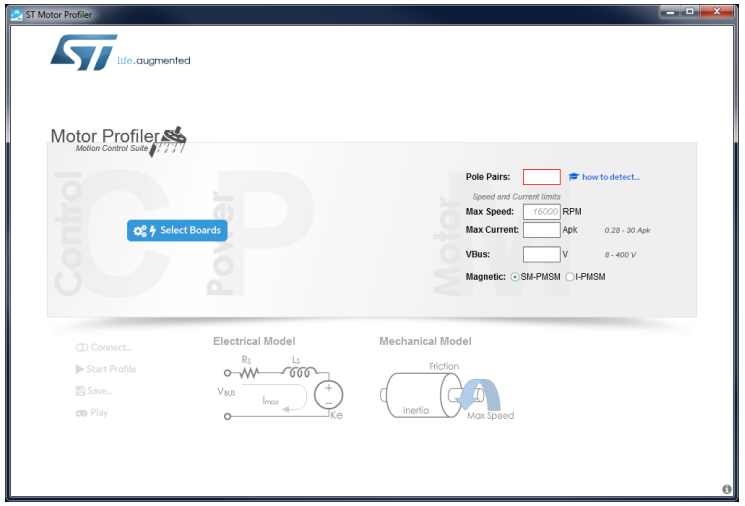
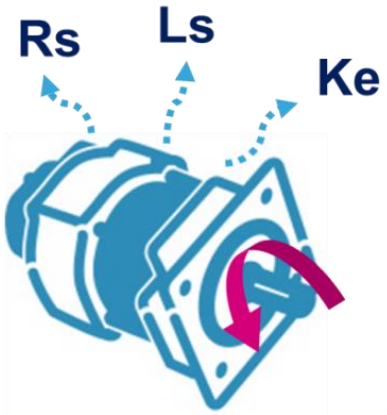
ST MC SDK5.2 电动机参数自动检测





- 自动测量电动机参数(Rs,Ls,Ke)
- 不需要额外的测量仪器
- 1[min]之内让电动机运转起来
- 当Rs ≥ 1 Ω 并且 Ls ≥ 1 mH时,这个工具参数检测的精度最高

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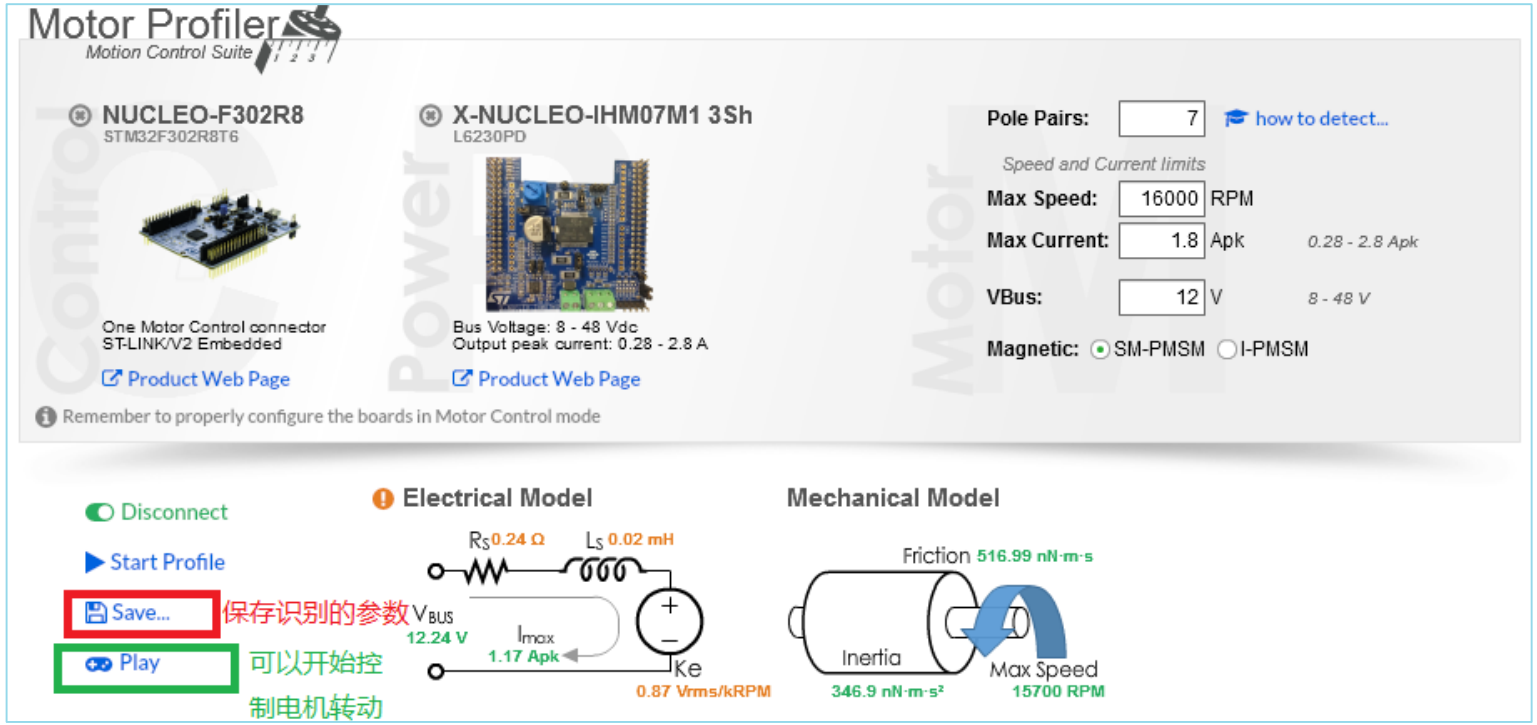
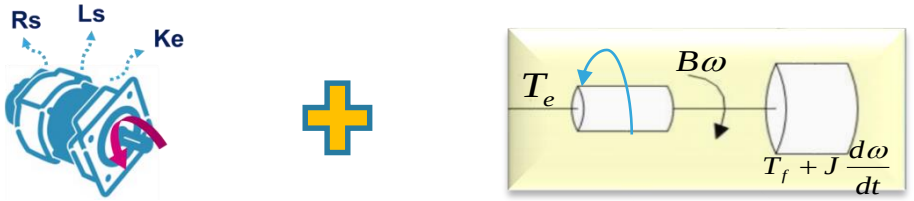
ST MC SDK5.2电动机参数测试界面

电动机电参数识别 + 电动机机械参数识别





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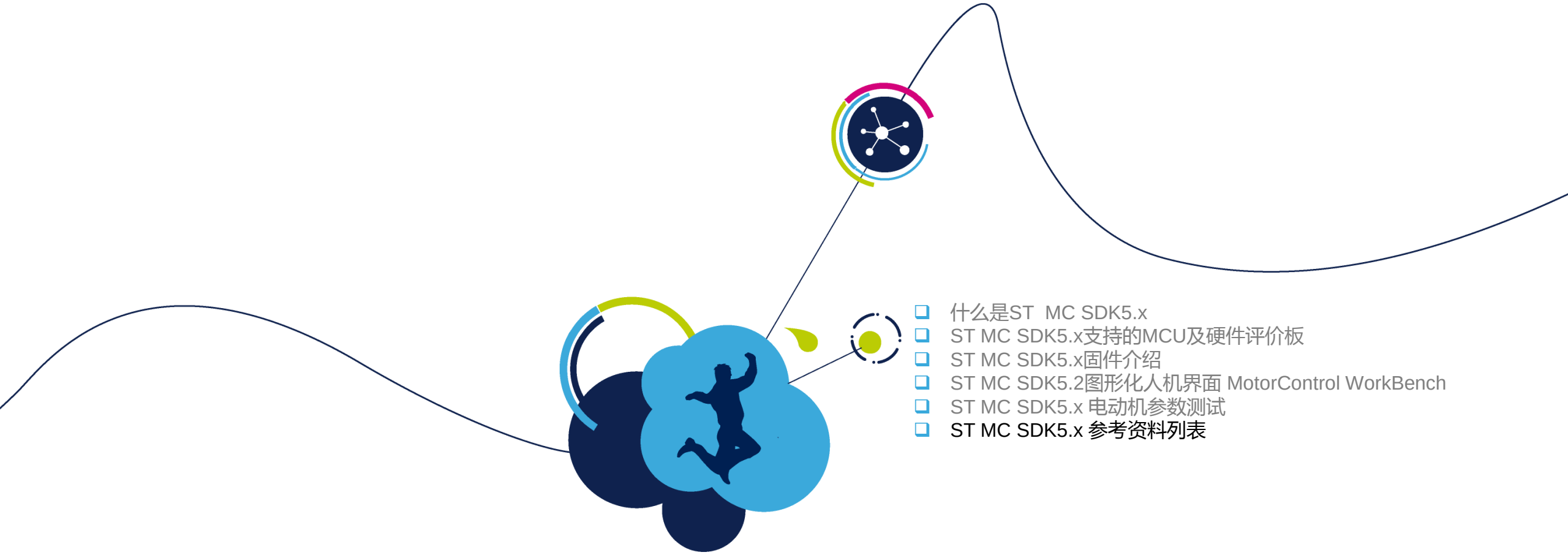

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SDK5.x 技术文档(1/2)

	Title	Type	Contents
DB3548	STM32 MC SDK software expansion for STM32Cube	Data Brief	数据手册，说明MC SDK作为STM32Cube的扩展部件所具备的基本特性、功能、产品信息及版权等内容
UM2374	Getting started with STM32 motor control SDK v5.0	User Manual	用户手册——入门。
UM2392	STM32 motor control SDK5.x - Firmware	User Manual	用户手册——固件。 作为内容补充，也请继续参考UM1052。未来，UM2392将会全面替代UM1052。
UM2380	STM32 motor control SDK v5.2 tools	User Manual	用户手册——工具。 介绍如何使用MC SDK的工具：Motor Profiler, WB
AN5143	How to migrate motor control application software from SDK v4.3 to SDK v5.x	Application note	应用文档。介绍如何从SDK4.3的应用移植到SDK5.x。
AN5166	Guidelines for control and customization of power boards with STM32 MC SDK v5.0	Application Note	应用文档。帮助用户快速用自己的目标硬件来调试MC SDK。

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SDK5.x 技术资料(2/2)

随机资料:

Title	Type	Path	Description
Release note	html	..\STMicroelectronics\MC_SDK_5.2.0\Release Notes for X-Cube-MCSDK.html	版本发布说明
Getting start(UM2374)	PDF	..\STMicroelectronics\MC_SDK_5.2.0\Documentation\en.DM00484271.pdf	用户手册——入门。
MotorControlSDKFirmware	CHM	..\STMicroelectronics\MC_SDK_5.2.0\Documentation\MotorControlSDKFirmware.chm	固件参考手册

视频:

Title	Type
MC SDK5.0 getting started	Video

培训资料:

Title	Type
STM32 Motor Control training materials(Chinese)	Training materials

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