STM32 PMSM FOC SDK v3.2

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MCU Application

Great China

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Agenda

- 1st day – Morning
  - Overview
    - Key message
    - Basics
    - Feature
    - Performance
    - Hardware support
  - Tools
  - STM32 MC Workbench
  - SDK components
    - Architectural Layer
    - MC Library
      - OOP – Object Oriented Programming
      - Our implementation of OOP
      - Interrupt Handling
      - Classes and interaction

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Agenda

- 1^{st} day – Afternoon
  - MC Application
    - Interface
    - Tuning
    - Tasks
    - Classes interaction
      - Current regulation
      - Ramp-up
      - Encoder alignment
  - Speed sensors updates
    - Sensorless algorithm improvement
  - How to create User Project Interacting with MC Application
  - Dual motor control
    - Resources sharing
    - Supported configurations
    - Code size efficiency
  - Current reading sensor update

Agenda

- 2nd day – Morning
  - User interface
    - Serial Protocal
    - DAC
    - LCD
    - DAC customization
  - STM32 MC Workbench presentation in detail

- 2nd day – Afternoon
  - Quick Start
    - Config the firmware lib with Workbench
    - LCD User Interface
    - IAR IDE – MC Workspace
  - Practical hints in motor tuning
    - Draw an arbitrary sensorless start-up waveform
    - Open loop feature
    - Faults generation
    - Motor start-up
  - Demo, Q&A

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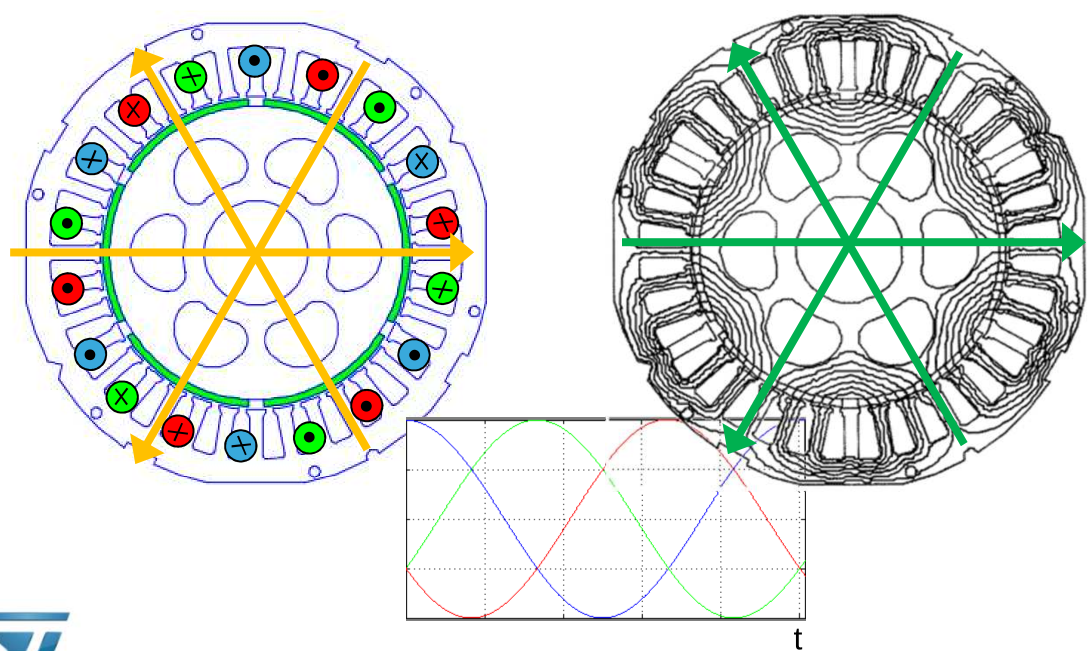
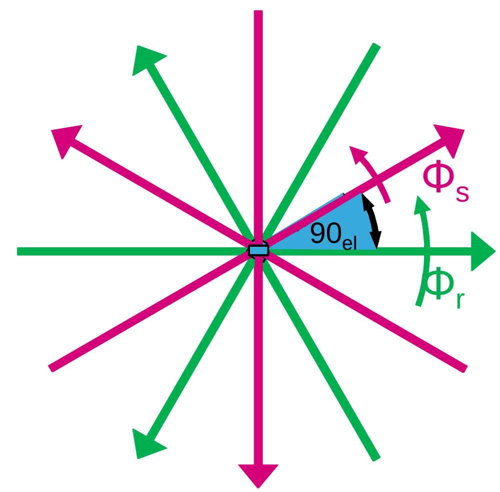
Key messages

- The STM32 PMSM FOC Library v3.2 is a:
  - Motor Control Software Development Kit
  - for 3-phase Permanent Magnet Synchronous Motors
  - supporting the whole FOC drives family
- It allows:
  - Single / Dual simultaneous vector control (FOC)
    - Sensored/sensorless
  - Energy efficient, quite, motor drive
  - Outstanding dynamic performances, speed range
  - Full customization through GUI
  - Wide range of hardware support, system configurations, to address applications from Home Appliances to Factory Automation

PMSM FOC - Basics

- Permanent Magnet Synchronous Motors:
  - Stator:
    - three phase windings: symmetrical, displaced 120° electrical, Y / Δ connected
  - Rotor:
    - ➢ Surface mounted permanent magnets
    - ➢ Internal permanent magnets (anisotropic magnetic structure)
    - ❖ Sinusoidal
    - ❖ BLDC



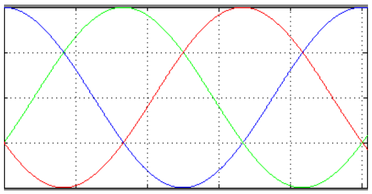


T_e maximized if…

PMSM FOC Overview

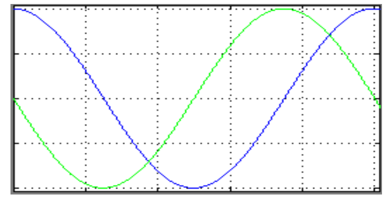
- Field Oriented Control: stator currents (Field) are controlled in amplitude and phase (Orientation) with respect to rotor flux
  - current sensing needed (3shunt/1shunt/ICS)
  - rotor angle sensing needed (encoder/Hall/algorithm)
  - current controllers needed (PI/D,FF)
    - not easy… high frequency sinusoidal references + stiff amplitude modulation..
    - reference frame transformation allows to simplify the problem:

- clarke transformation: transforms ia,ib,ic (120º) to iα,iβ(90º); (consider that ia+ib+ic=0):

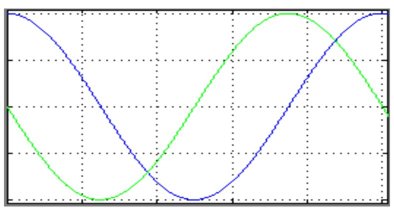


$$i_\alpha = i_{as}$$

$$i_\beta = -\frac{i_{as} + 2i_{bs}}{\sqrt{3}}$$

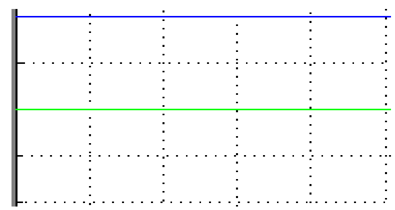


- Park's transformation: currents i_α, i_β seen from a reference frame rotating with rotor and become i_d, i_q (90º):

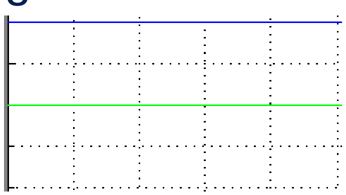


$$i_{qs} = i_\alpha \cos\theta_r - i_\beta \sin\theta_r$$

$$i_{ds} = i_a \sin\theta_r + i_\beta \cos\theta_r$$

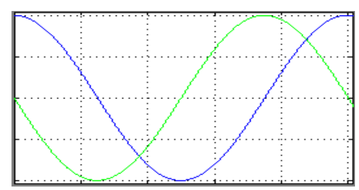


- Rev Park's transformation applied to stator voltages v_q, v_d and become Vα , Vβ: PI regulators now can work efficiently in a 'DC' domain;

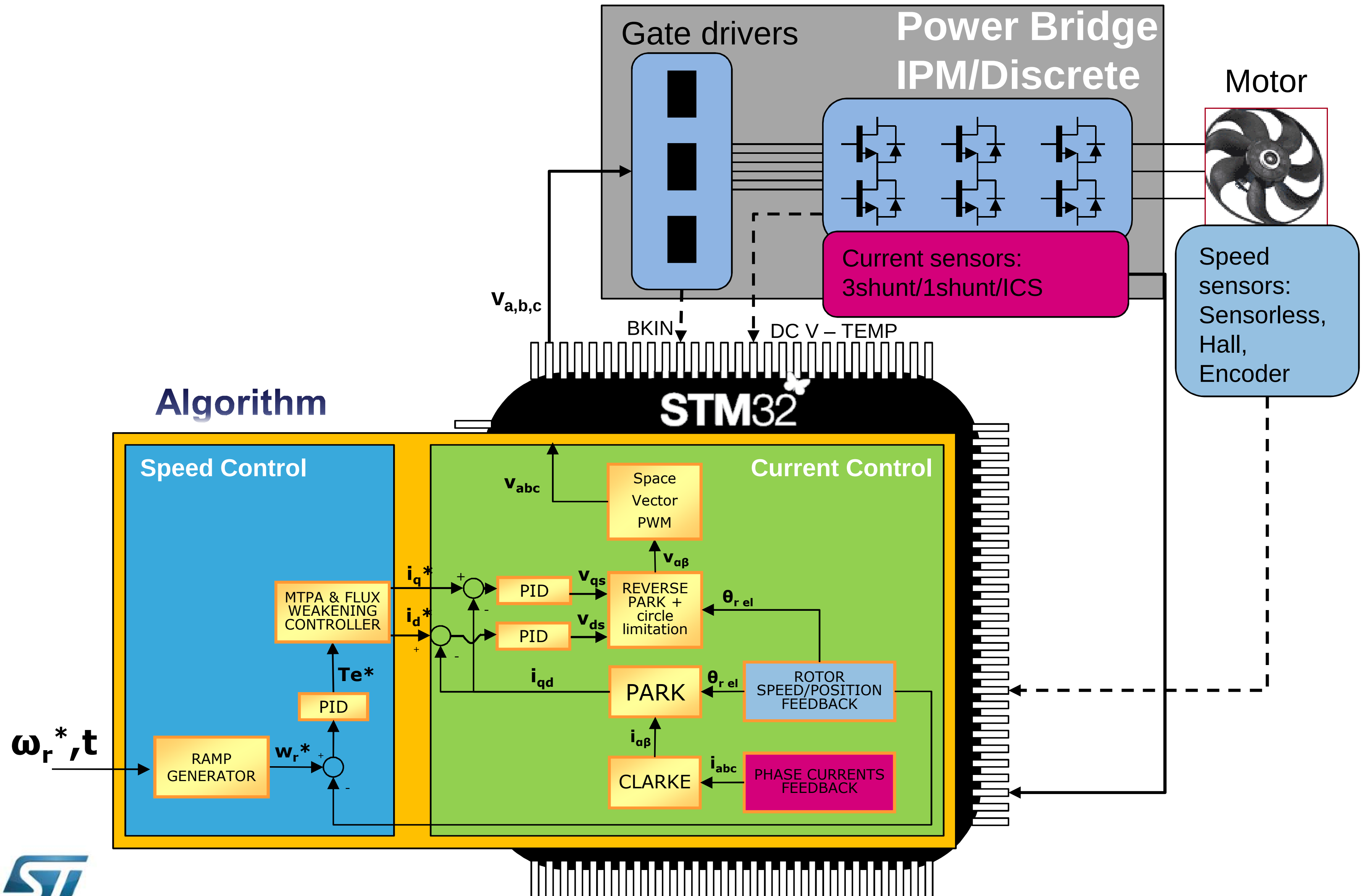


$$v_\alpha = v_{qs} \cos\theta_r + v_{ds} \sin\theta_r$$

$$v_\beta = -v_{qs} \sin\theta_r + v_{ds} \cos\theta_r$$



PMSM FOC – Block Diagram



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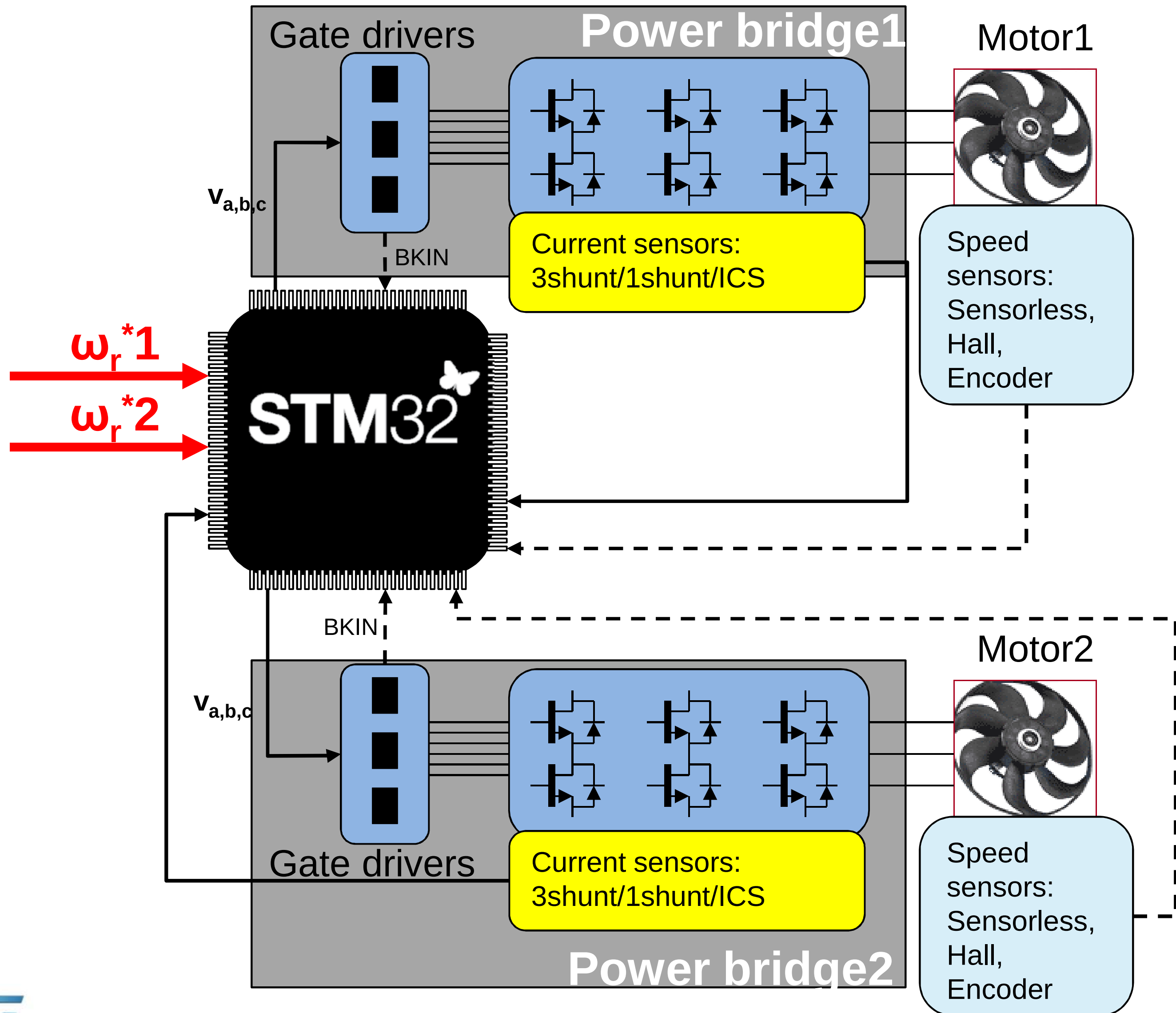
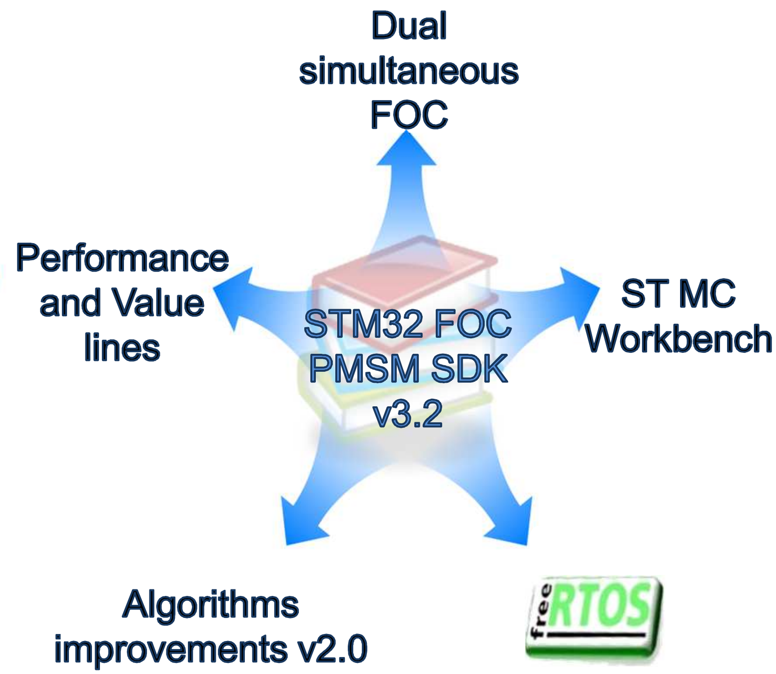
Dual PMSM FOC – Block Diagram



General features

- Single or simultaneous Dual PMSM FOC sensorless / sensored (Dual PMSM FOC only when running on STM32F103xx High-Density, STM32F103xx XL-Density

- Speed feedbacks:
  - Sensorless (B-EMF State Observer, PLL / CORDIC);
  - Hall sensors;
  - incremental encoder;
  - for each motor, dual simultaneous speed feedback processing;



- Currents sampling methods:
  - 2 ICS (only when running on STM32F103xx);
  - 1shunt resistor (ST patented);
  - 3shunt resistors(only when running on STM32F103xx);

- Flux Weakening, I-PMSM, FeedForward;

- Torque mode / speed mode;

- When running Dual FOC: any combination of the above-mentioned speed feedback, current sampling, control mode, optional algorithm

New features

- Support for dual and single MC for STM32F103 HD
- Support for single MC for STM32F100
  - 1 shunt current reading supported
  - All type of speed/position sensors are supported
- Increase code safety through
  - MISRA C rules 2004 compliancy
  - Strict ANSI C compliancy
  - New object oriented FW architecture (better code encapsulation, abstraction and modularity)
  - Auto-detection of errors due to FOC execution overrun
- Serial communication with PC
- Applicative example based on FreeRTOS available
- Full library customizability with a new PC GUI configurator
  - input parameters: analog and digital GPIO choice, timer selection, digital filters, clock freq selection, power board features…

Some performances figure example... 1/3

- STM32F100 (Value Line)
  - 1shunt/sensorless @20kHz PWM,10kHZ FOC USART enabled
  - Motor Control **code size is 15.82Kb**
  - Motor Control RAM usage is 2.77Kb
  - FOC Total execution time is 65.22us (ADC ISR + TIM1 Update ISR)
  - FOC introduced **CPU load is 65.2%**
  - Total CPU load is <70%

Some performances figure example... 2/3

- STM32F103 HD, dual FOC
  - Motor 1, 1shunt/sensorless @8kHz PWM/FOC. Flux Weakening enabled
  - Motor 2, 1 shunt/sensorless @16kHz PWM, 8kHZ FOC.

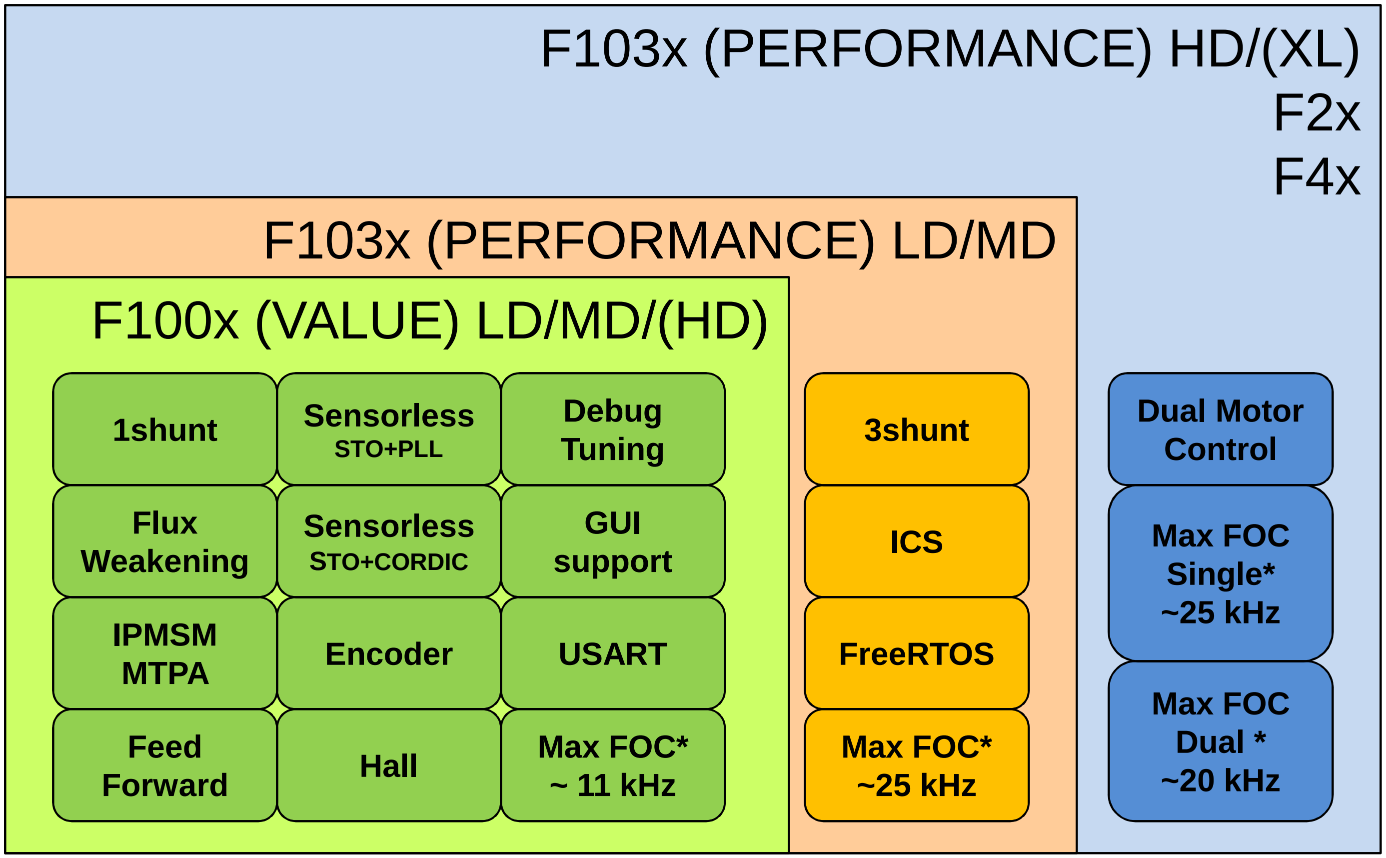
  - Motor Control **code size is 22.3Kb** (below 1.5 times single motor case)
  - Motor Control RAM usage is 4.01Kb
  - FOCs introduced **CPU load** (including TIMx Update ISRs) **is 44%**
  - Total CPU load ~50%

Some performances figure example... 3/3

- STM32F103 HD, dual FOC
  - Motor 1, 3shunts/sensorless @16kHz PWM/FOC. MTPA and Flux Weakening enabled
  - Motor 2, 1shunt/sensorless @16kHz PWM, 8kHZ FOC.

  - Motor Control **code size is 25.5Kb**
  - Motor Control RAM usage is 4.14Kb
  - FOCs introduced **CPU load** (including TIMx Update ISRs) **is 62.6%**
  - Total CPU load <70%

Feature set, uC support



STM32MCKIT, ST evalboards, HW support

- The STM32-MCKit is clearly supported, default parameters of the Library fit for purpose

- ST’s control boards supported (out-of-the-box):
  - STM3210B-EVAL
  - STM3210E-EVAL
  - STM32100B-EVAL
  - STM322xG-EVAL
  - STM324xG-EVAL
  - STEVAL-IHM022V1 (dual motor)
  - STEVAL-IHM034 + STEVAL-IHM035 (dual motor)

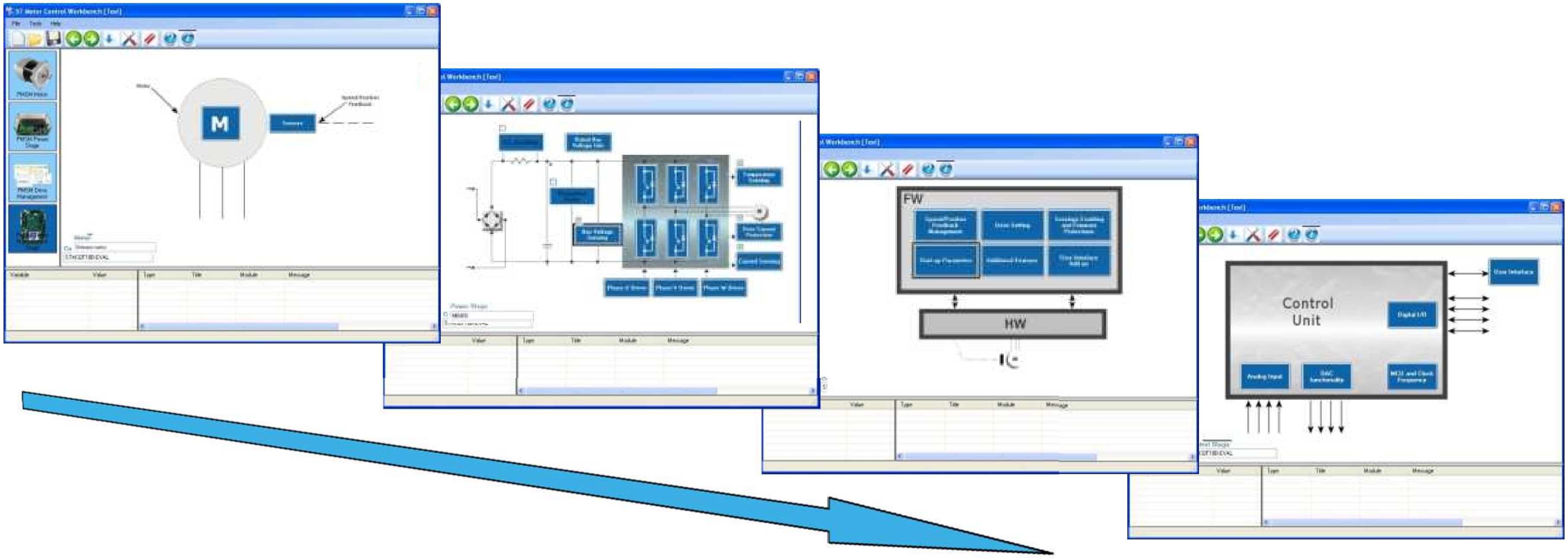
- ST’s power boards supported (GUI)
  - Any power board featuring the ST’s “MC connector”

- But, what’s more important to underline, is that, the MC library v3.2 can be fully configured– by means of ST MC Worbench GUI – so as to adapt to ANY customer’s Hardware Platform

Tools

- IDE and compiler: IAR EWARM V6.4
- MC Workbench V2.0
- ST-LINK V2
- ST-LINK V2-ISOL: good debugging/programing tool for motor control application because of opto-isolation
- J-LINK

ST Motor Control Workbench (STMCWB)



ST Motor Control Workbench, in this version, is a PC code generator tool that reduces the designer effort and time in the firmware development for all the ST Motor control FW library (starting from STM32 PMSM FOC FW library 3.0). The user through a graphical user interface (GUI) generate the parameter header files which configures the library according the application needs.

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STMCWB:evolution

Breaker – 10 min