Phd Brainstorming Day

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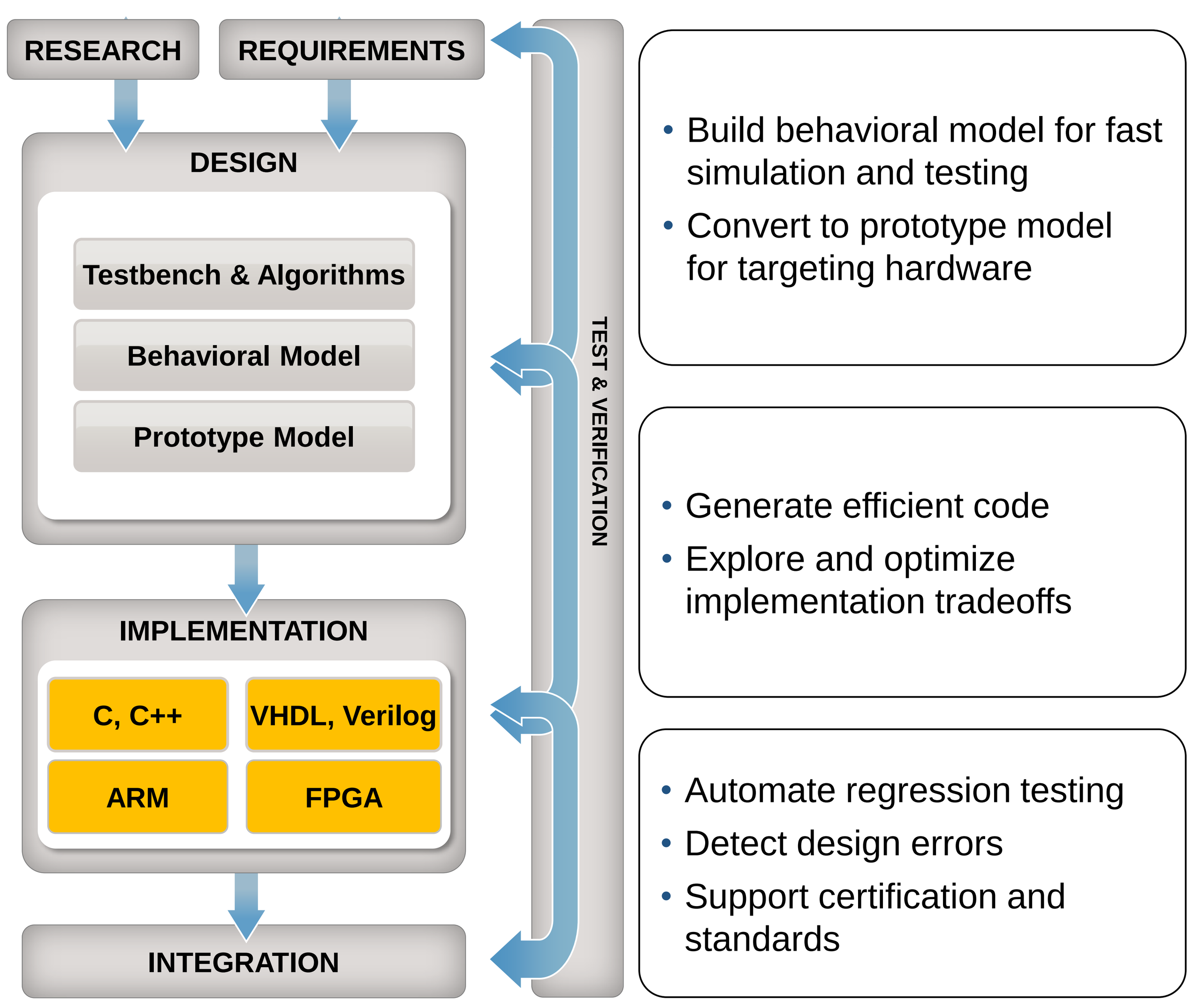
A Model-Based Design approach for embedded system development on STM32 microcontrollers

Objectives

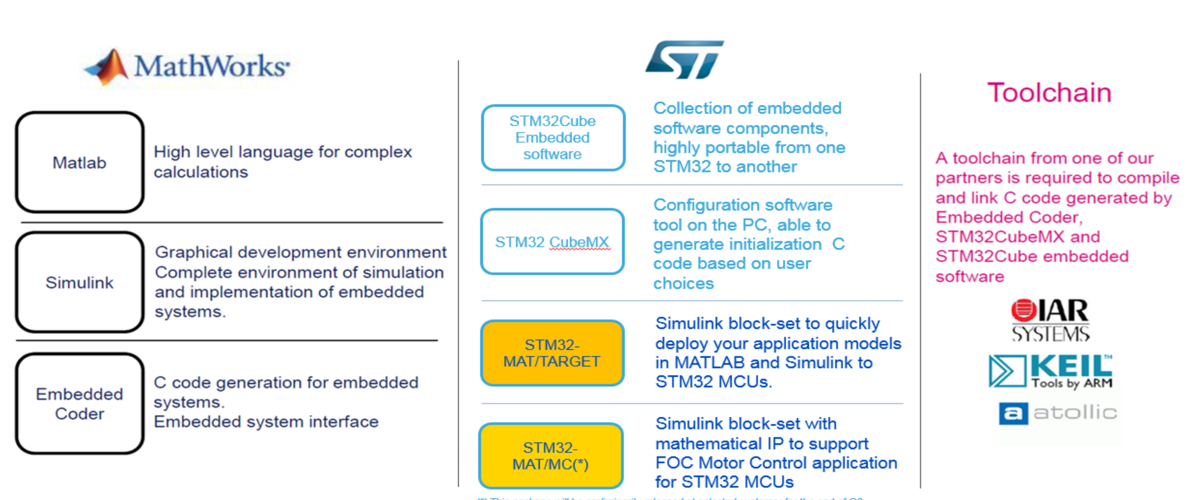
A new software tool is presented that allows exploiting Model-based design (MBD). It is suitable for running Simulink® application models for STM32 MCUs. A first Simulink® blockset library for STM32 peripherals allows us to implement Processor In the Loop (PIL) configuration and automatic code generation. A second Simulink® blockset includes extensive Math and Motor control functions that have been developed based on the STM32 Motor control library.

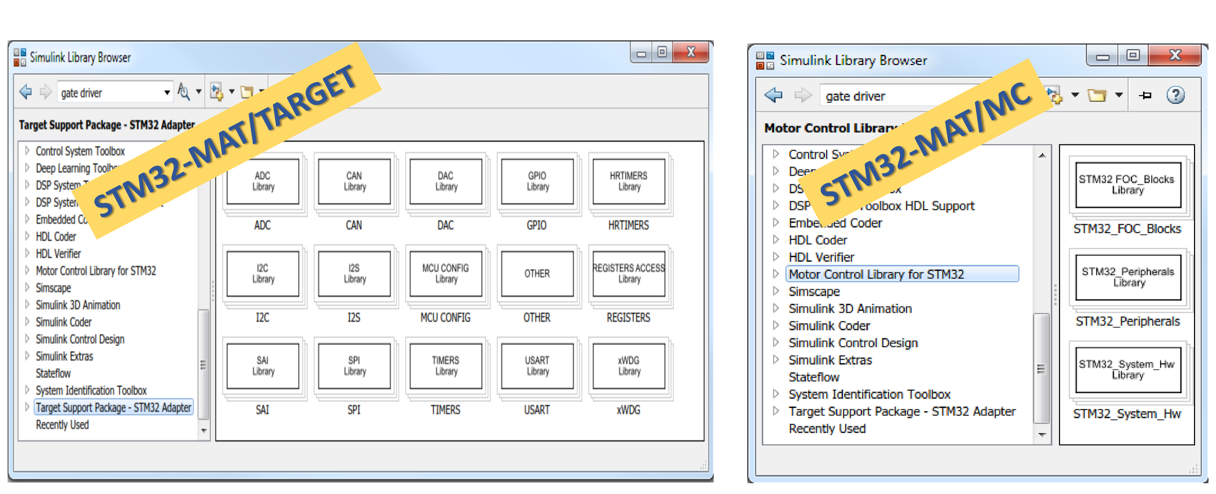
Model-Based Design Workflow

MBD modifies traditional methods adopted for models development process and use an overall efficient approach to better implement the following workflow:



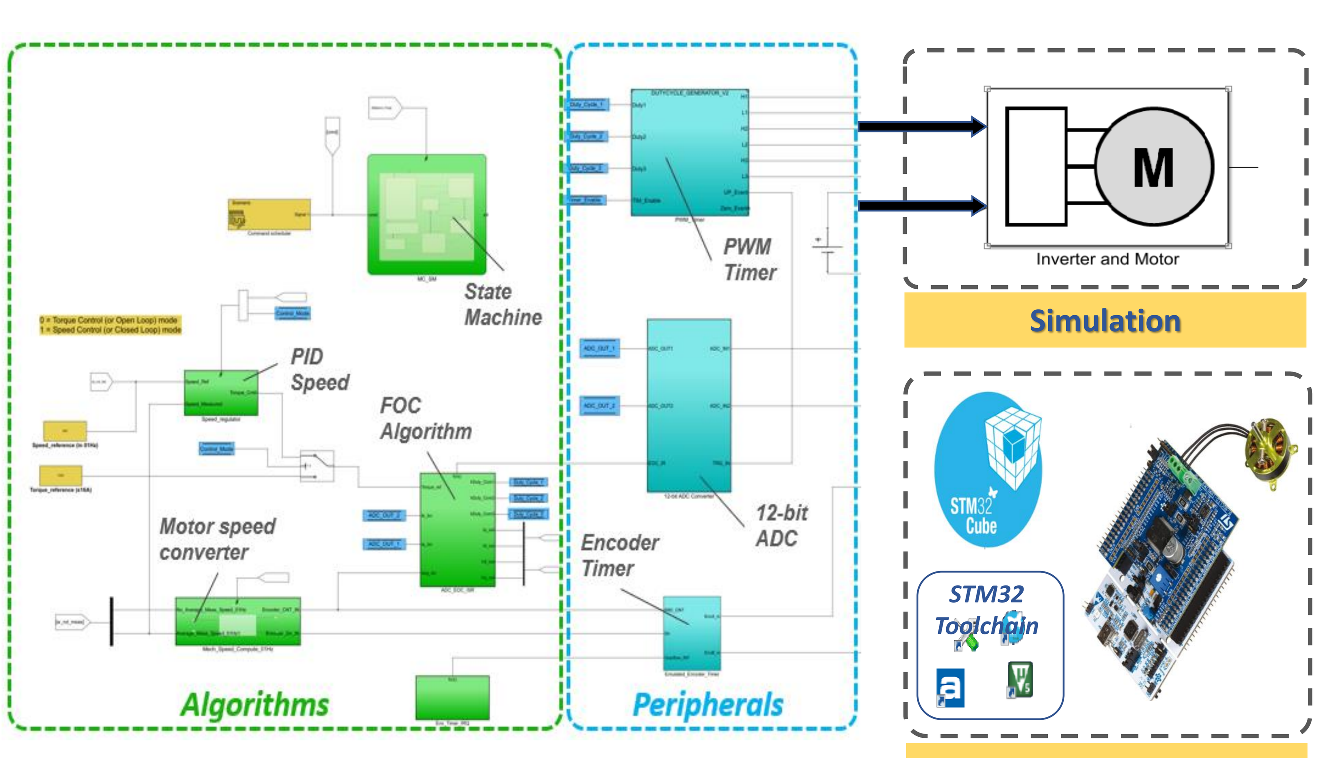
MBD tools for STM32 MCUs and FOC Motor Control





One model for simulation and auto-code generation

One single model for both simulation and autocode generation is the novel approach in this work. Both Algorithms and STM32 HAL libraries, respectively.



Stability of Time Delay Systems

Objectives

A new methods to analyze the stability of a commensurate multiple time delay systems. the first procedure is a numerical method to obtain the coefficients of the pseudo-polynomial characteristic equation. The second procedure is a graphical method to analyze the stability of LTI systems.

1#A Numerical procedure to obtain the pseudo-polynomial characteristic equation of a commensurate time-delay system

The characteristic equation of a commensurate Time Delay System can be written in term of coefficients as:

$$a(s;z) = a_0(s) + \sum_{k=1}^{m} a_k(s)\, z^k \quad \tau \geq 0, k = 1, \dots, m$$

$$a_0(s) = s^n + \sum_{i=0}^{n-1} a_{0i} s^i \, ; \; a_k(s) = \sum_{i=0}^{n-1} a_{ki} s^i \, , k = 1,2, \dots, m$$

The equation has r unknown coefficients, a_{0i}, a_{ki} with r is:

$r = r_0 + \sum_{i=1}^{n}(m * i)$, $r_0 = n+1$

In order to find the unknown coefficients, the following system of r linear equations should be solved:

C= H(s,τ). M $\longrightarrow$ $M = H^{-1}(s,\tau).C$

M is the coefficients of the pseudo-characteristic equation

- C= $[c_1, \dots, c_r]$
- $c_i = \; det(s_i I - A_0 - \sum_{k=1}^{m} A_k\, z_i{}^k)$
- $M = [a_{0n}, \dots, a_{00}, a_{1n} \dots, a_{11}, \dots, a_{kn}]$
- $H_i = \begin{pmatrix} s_1^{n-i} z_1^i & s_1^{n-i-1} z_1^i & \dots & z_1^i \\ s_2^{n-i} z_1^i & s_2^{n-i-1} z_1^i & \dots & z_2^i \\ \vdots & \vdots & \vdots & \vdots \\ s_r^{n-i} z_r^i & s_r^{n-i-1} z_r^i & \dots & z_r^i \end{pmatrix}$
- $H = (H_0 | \, H_1 | \cdots | \, H_q)$ i=0,…,q

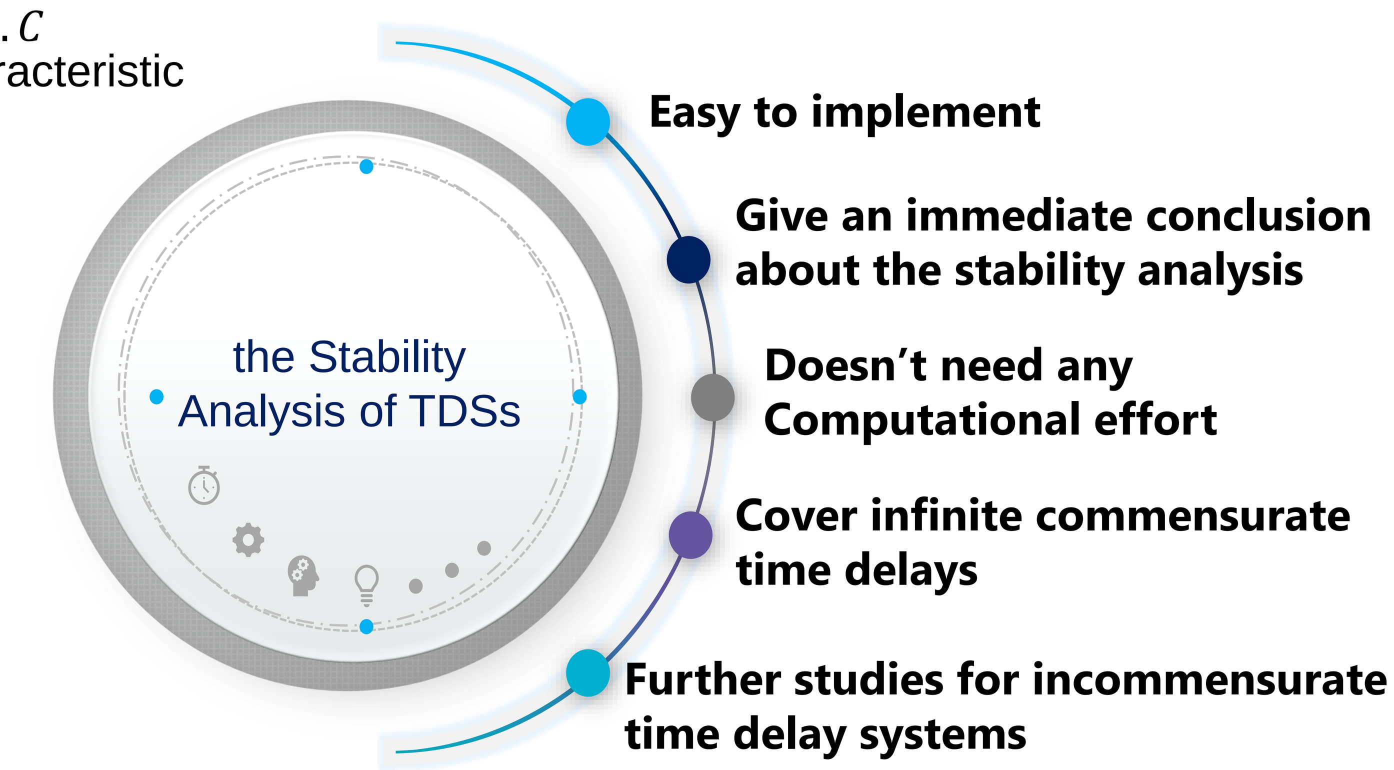
2# Graphical Method for the Stability Analysis of Commensurate Multiple Time Delay Imperfect Systems

To determine the system stability if delay dependent or independent, we consider s= $\pm j\omega$ in order to find if the characteristic equation has roots on the imaginary axis. We plot the eigenvalues of the characteristic equation by fixing the variable z.

$$\det\left(j\omega\, I - A_0 - \sum_{k=1}^{m} A_k\, z^k \right) = \det(\lambda\, I - A) = 0$$

$A = A_0 + \sum_{k=1}^{m} A_k\, z^k$; $z = e^{-j\theta}$
$\lambda = \pm j\omega$, where $\omega > 0$, and $\theta \in [0, 2\pi]$.

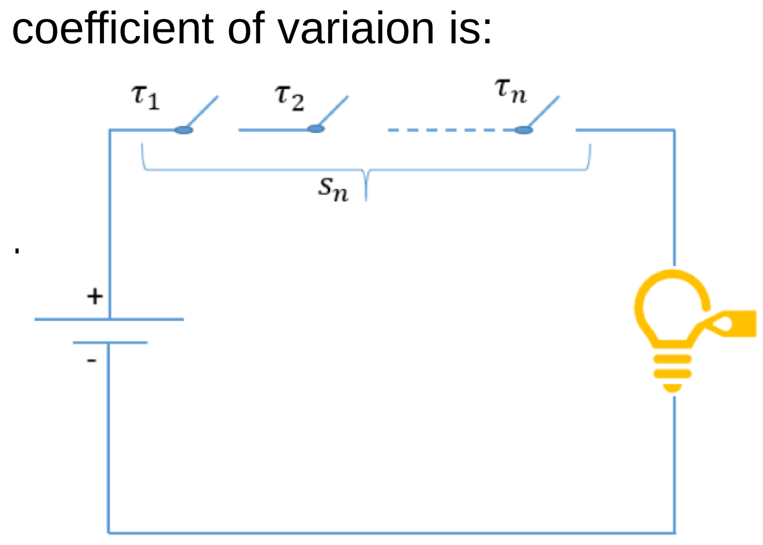
Advantages of the methods:



Modeling a population of switches via chaotic dynamics

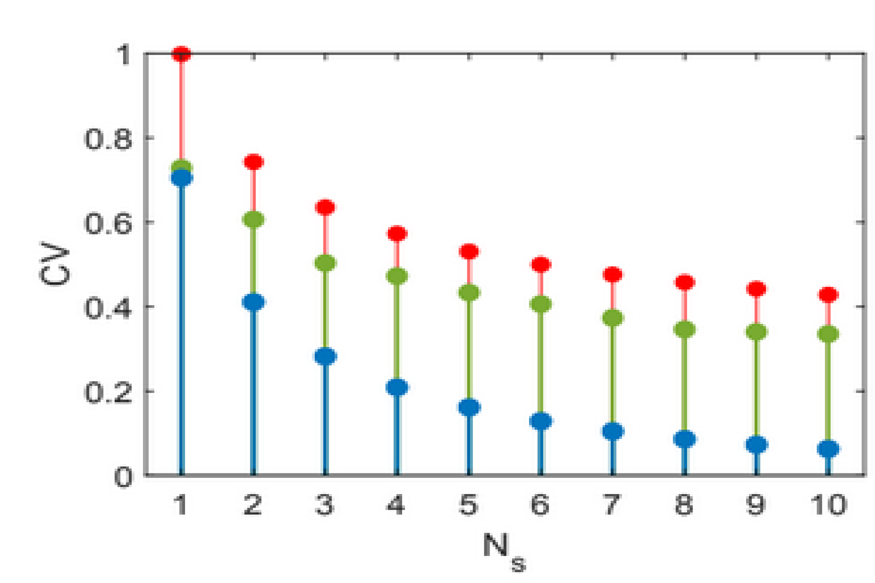
Objectives

A new method to model switching mechanisms using a deterministic switches instead of stochastic switches. The study takes into account two cases the logistic map and the time recurrence of chua's circuit. The main objective is to explain how the series connecting mode of switches affects the behavior of the entire switch population and in particular the degree of synchronization and how these connections can be used to reduce the random variability (i.e., the CV), thus increasing the synchronization level. The coefficient of variaion is:



$$CV = \frac{\sigma_{on}}{\bar{\tau}_s}$$

A composite switch, made of n independent irreversible switches connected in series, denoted sn-switch.



The Coefficient of variation calculated for Ns irreversible switches: stochastic switches (red), chaotic switches (blue:logistic map; green: Chua's circuit).

Modeling and simulation of N_s switches in series for Time recurrence chua's circuit with labVIEW