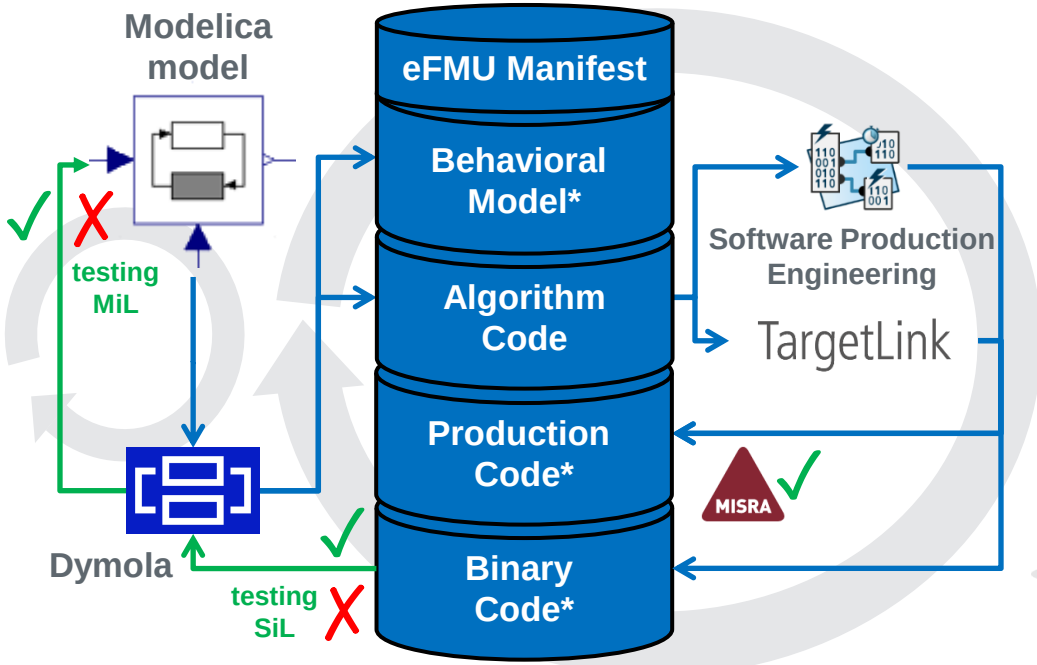
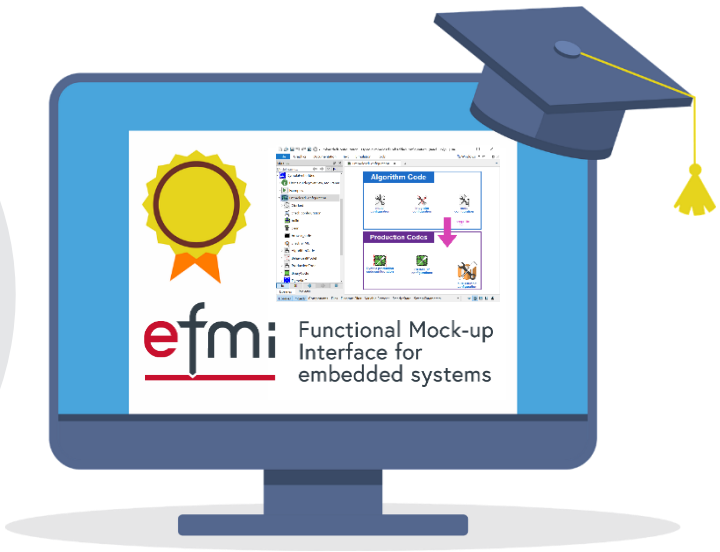




Part 2: Running use-case introduction

eFMI®: A beginner's overview and hands-on
– 16th International Modelica Conference – 8th of September 2025 –

Christoff Bürger
Dassault Systèmes
Christoff.Buerger@3ds.com

eFMI® tutorial – Agenda

Part 1: eFMI® motivation and overview (40 min)

Part 2: Running use-case introduction (10 min)

Part 3: Hands-on in Dymola and Software Production Engineering (25 min)

Coffee break (30 min)

Part 3: Hands-on in Dymola and Software Production Engineering (30 min)

Part 4: Advanced demonstrators (20 min)

Part 5 (industry case-study): eFMI based thermal management system (TMS) development for fuel cell electric vehicles (FCEV) (20 min)

Part 6: Outlook and conclusion (5 min)

Tutorial leader:
Christoff Bürger

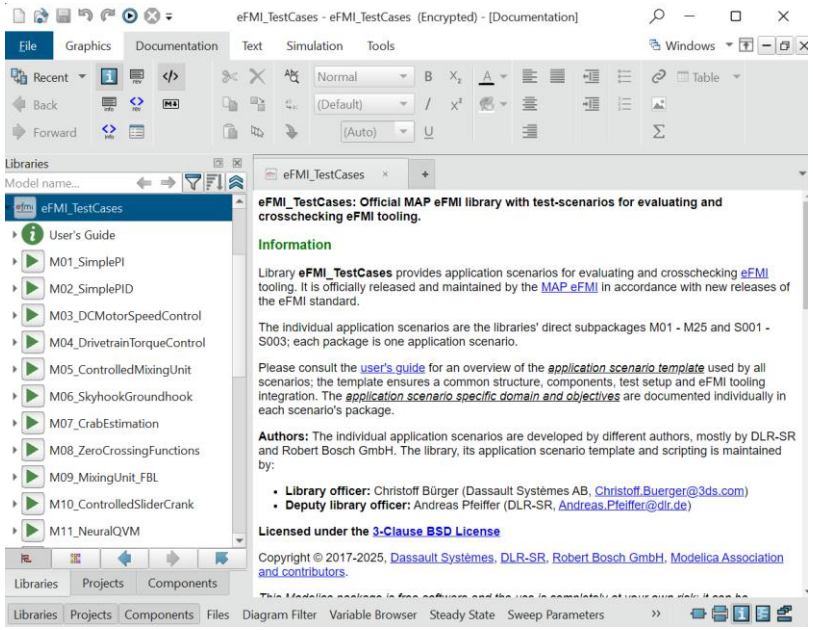
Presenter:
Daeoh Kang

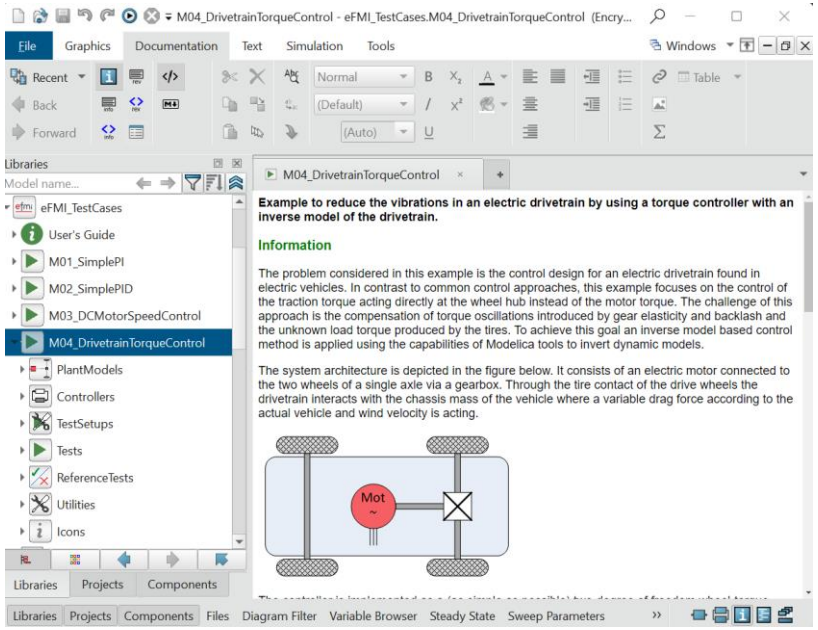
Functional Mock-up Interface for embedded systems

M04: Origin, scenario and objective

As running use-case for the hands-on we use M04 of the `eFMI_TestCases` library

- Open source Modelica library (https://github.com/modelica/efmi-testcases); MAP eFMI published & included in Dymola
- Used by MAP eFMI to conduct official eFMI tooling cross-checks
- Library is ordinary Modelica & tool agnostic
- M04: Developed by DLR & performance assessed by BOSCH





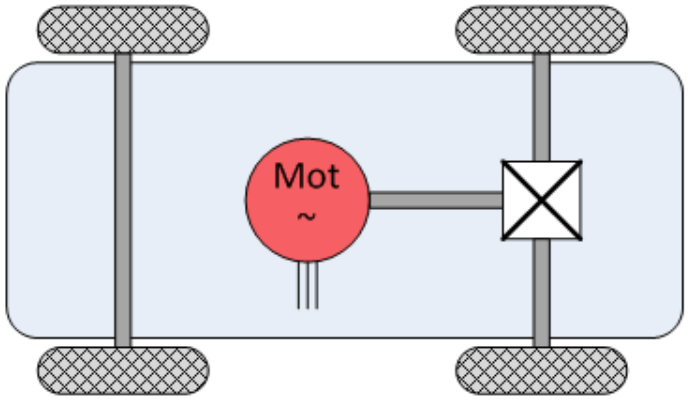
Functional Mock-up Interface for embedded systems

M04: Origin, scenario and objective

M04: Electric vehicle drivetrain torque controller to reduce drivetrain vibrations

- **Objective:** control of traction torque acting directly at the wheel hub (instead of motor torque, as common approach)
  - Control input: desired torque at wheel mounting
  - Sensor input: relative velocity between motor side & wheel speed (as common in anti-lock braking systems (ABS))
- **Challenge:** compensate torque oscillations due to gear elasticity & backlash; unknown load torque produced by tires
- **Solution:** use of inverse model of elastic drivetrain (virtual sensor) to feed simple PI controller
  - Inverse model (feed-forward controller): approximated, simple plant model ⇒ easy to model
  - PI controller (feed-back controller): model from stock/MSL ⇒ easy to parameterize (thanks to “correction” by virtual sensor input)

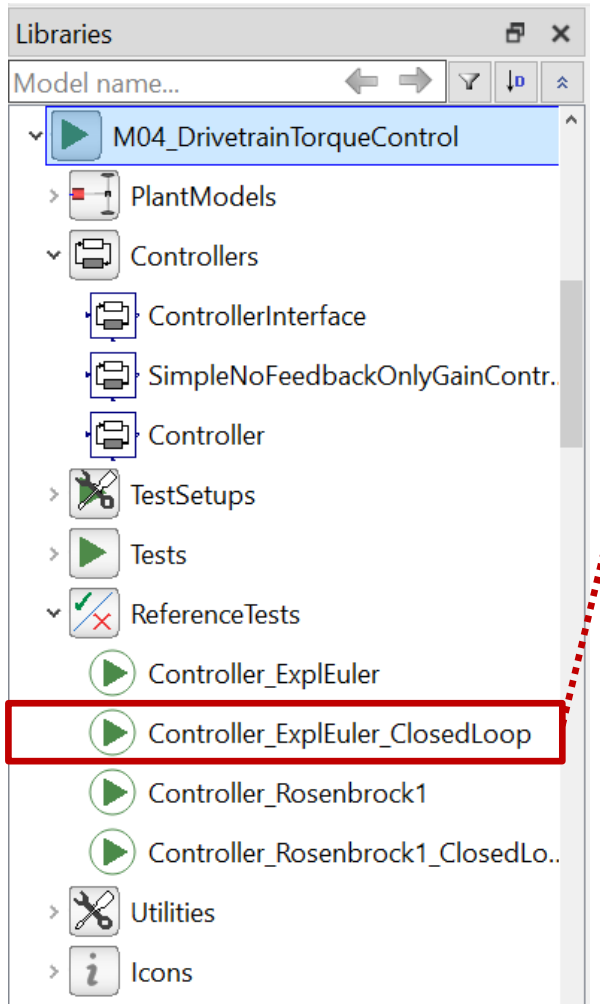
⇒ Combination of both controllers: robust performance, even if modeling errors & sensor noise exist

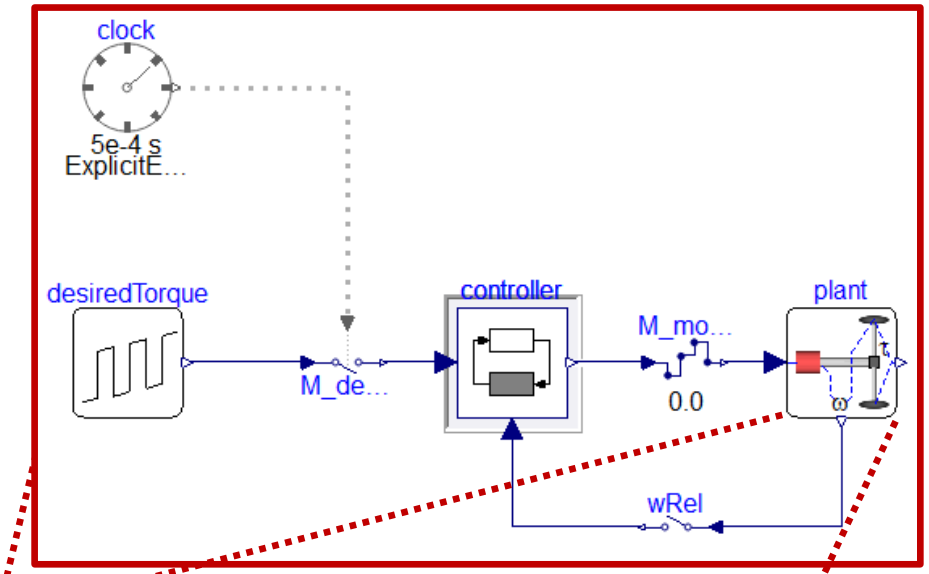


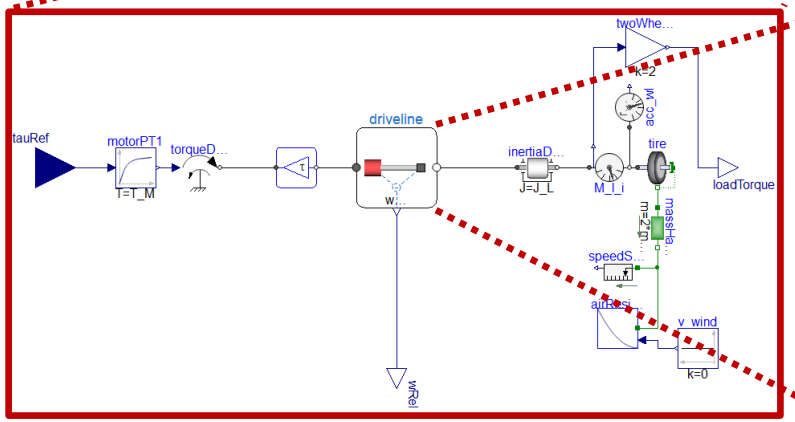
⇒ Production code (eFMU) = virtual drivetrain sensor + PI controller

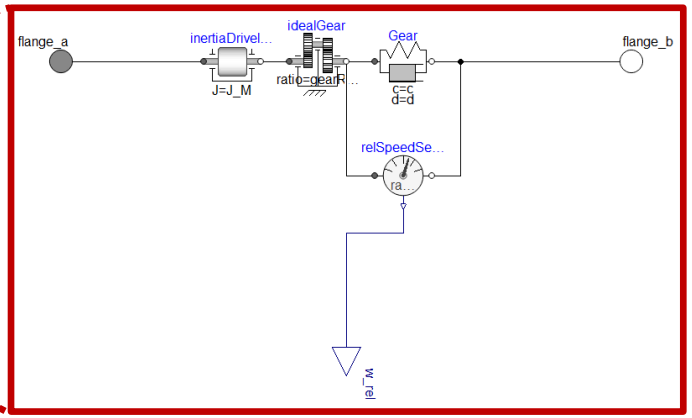
efmi Functional Mock-up Interface for embedded systems

M04: Plant model & test scenario





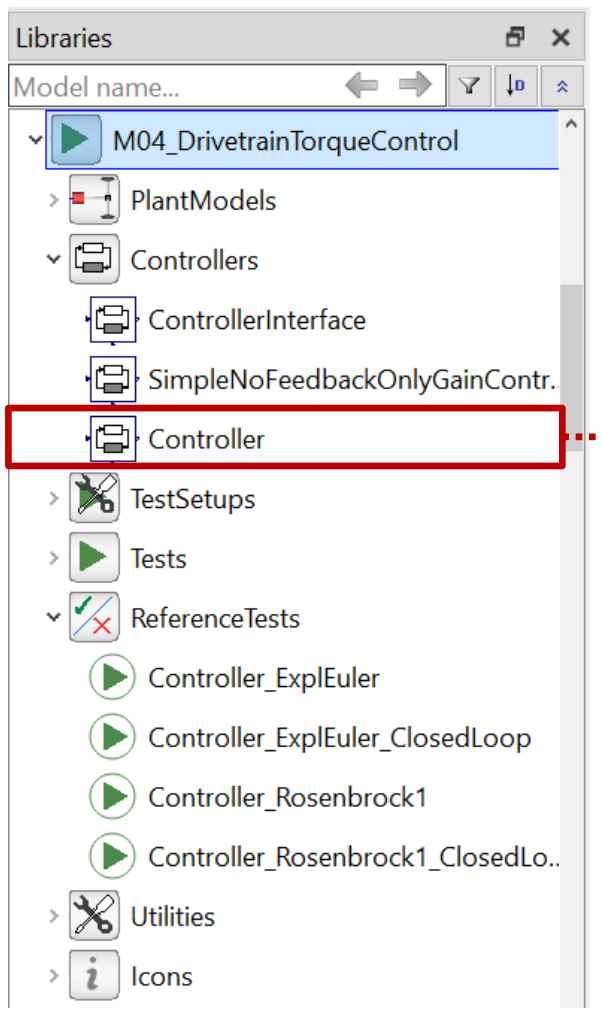


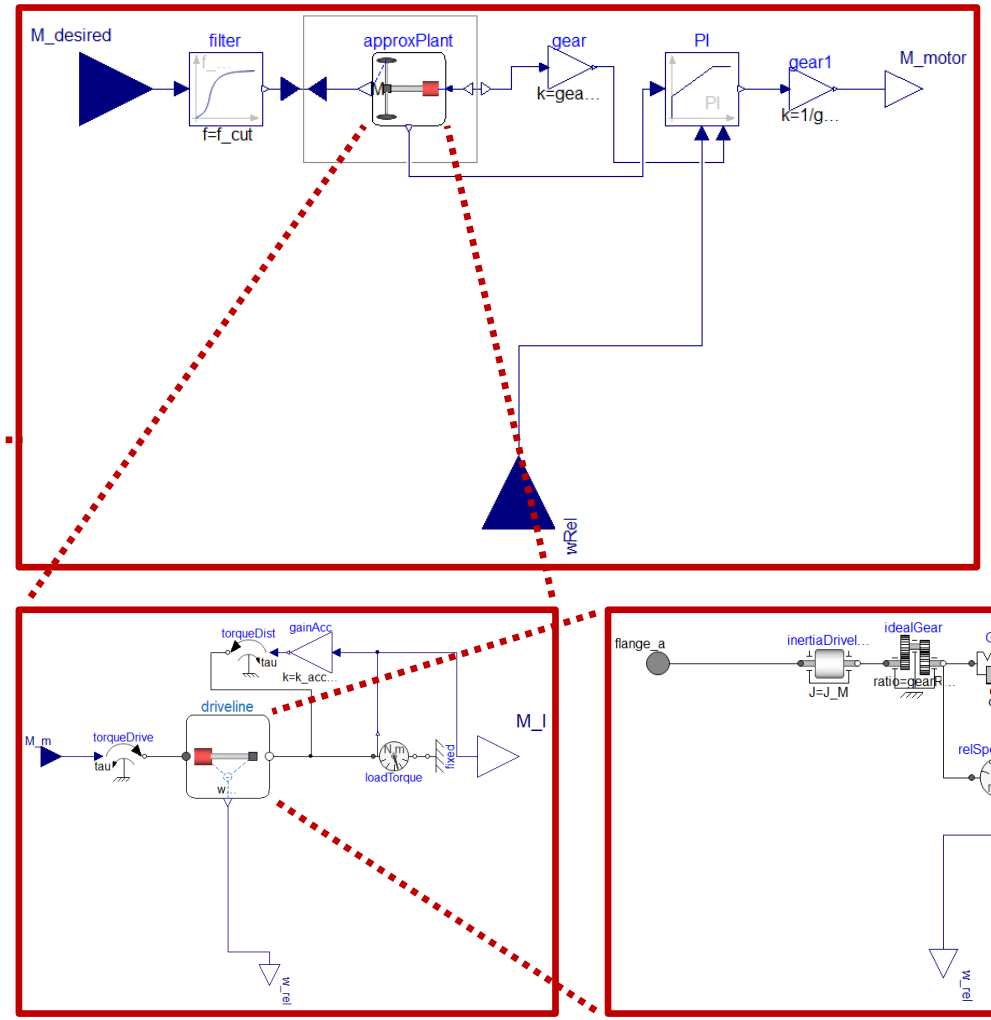


Closed loop with sampled controller and simple plant model just for eFMU testing.

Plant model not realistic industrial detail, but such is also not required to test correctness of eFMI *tooling*.

M04: Controller





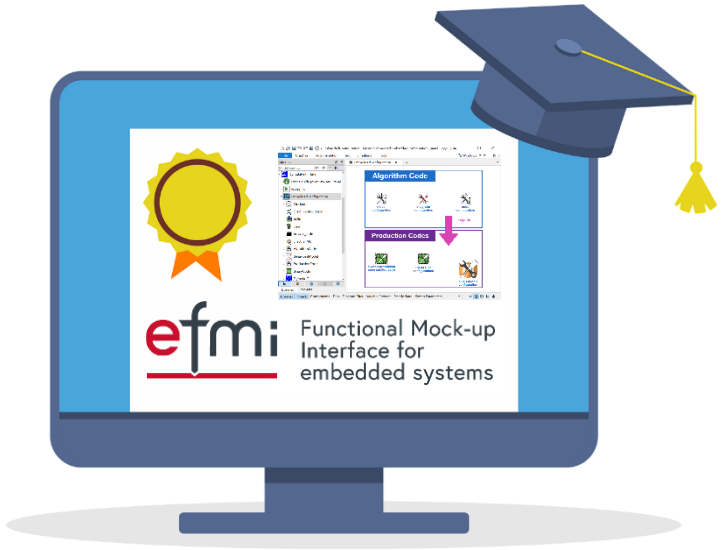
Approximated, i.e., reduced inverse model.

But with acausal physics (e.g., rotational flange connectors).

M04: A simple, but good eFMI introductory example

M04 is a good demonstrator to motivate eFMI:

- Simple ⇒ comprehensible generated manifests, GALEC & production codes (can be fully understood and related back to original model by humans)
- Not just imperative control, but also leverage on acausal physics (advantage of virtual sensor improving PI controller performance obvious)
- Scratches the need for *reduced* plant models as inverse model (general challange to address real-time requirements)
- Easy to foresee advantage for realistic industrial demonstrators (high-level graphical modeling scales development-wise, acausal physics ease to model the right thing)

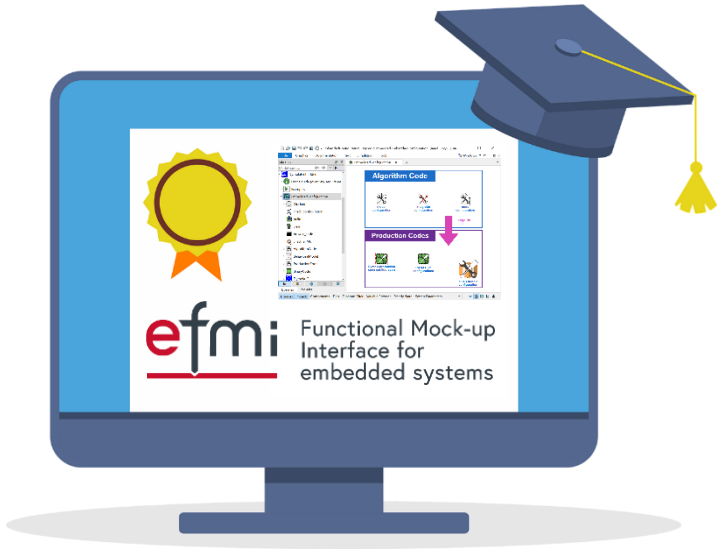


M04: Good introductory example, but we can more…

M04 is a good demonstrator to motivate eFMI.

But we can much more:

- We have eFMI applications with 20 000 and more equations yielding 12 MB GALEC code optimized to 290 kB target binaries, mixed system of equations, wild mix of imperative control in block diagram style & physics etc, but they are NDA protected!
  - E.g., EMPHYSIS demonstrator: full drivetrain as virtual sensor (Volvo Cars)
- In Part 4 of the tutorial we will have a short look into more advanced examples
  - Public available M11: neural quarter car vehicle model for vertical dynamics, adding unknown non-linearities of suspension spring and damper via neural networks
  - Battery management system (BMS) simulating battery temperature to limit power-requests using a realistic battery model from the commerical Dassault Systèmes Battery library



efmi Functional Mock-up Interface for embedded systems

eFMI® tutorial – Agenda

Part 1: eFMI® motivation and overview (40 min)

Part 2: Running use-case introduction (10 min)

Part 3: Hands-on in Dymola and Software Production Engineering (25 min)

Coffee break (30 min)

Part 3: Hands-on in Dymola and Software Production Engineering (30 min)

Part 4: Advanced demonstrators (20 min)

Part 5 (industry case-study): eFMI based thermal management system (TMS) development for fuel cell electric vehicles (FCEV) (20 min)

Part 6: Outlook and conclusion (5 min)

Tutorial leader:
Christoff Bürger

Presenter:
Daeoh Kang

Functional Mock-up Interface for embedded systems

License for

https://pixabay.com/illustrations/education-online-school-elearning-5307517/

I create these images with love and like to share them with you. My passion is to provide vintage designs to honor those artists that created something great and timeless. You are most welcome to use it for commercial projects, no need to ask for permission. I only ask that you not resell my images AS IS or claim them as your own creation. As always, a BIG thank you for the coffee donations I received, every dollar is a blessing for my family.

Education Online School royalty-free stock illustration. Free for use & download.

Content License Summary

Welcome to Pixabay! Pixabay is a vibrant community of authors, artists and creators sharing royalty-free images, video, audio and other media. We refer to this collectively as "**Content**". By accessing and using Content, or by contributing Content, you agree to comply with our Content License.

At Pixabay, we like to keep things as simple as possible. For this reason, we have created this short summary of our Content License which is available in full here. Please keep in mind that only the full Content License is legally binding.

What are you allowed to do with Content?

- Subject to the Prohibited Uses (see below), the Content License allows users to:
- Use Content for free
- Use Content without having to attribute the author (although giving credit is always appreciated by our community!)
- Modify or adapt Content into new works

What are you not allowed to do with Content?

We refer to these as Prohibited Uses which include:

- You cannot sell or distribute Content (either in digital or physical form) on a Standalone basis. Standalone means where no creative effort has been applied to the Content and it remains in substantially the same form as it exists on our website.
- If Content contains any recognisable trademarks, logos or brands, you cannot use that Content for commercial purposes in relation to goods and services. In particular, you cannot print that Content on merchandise or other physical products for sale.
- You cannot use Content in any immoral or illegal way, especially Content which features recognisable people.
- You cannot use Content in a misleading or deceptive way.
- Please be aware that certain Content may be subject to additional intellectual property rights (such as copyrights, trademarks, design rights), moral rights, proprietary rights, property rights, privacy rights or similar. It is your responsibility to check whether you require the consent of a third party or a license to use Content.