Modelado físico de sistemas mecatrónicos complejos: optimización del diseño y su comportamiento

Mikel Armendia- TEKNIKER

Modelado físico de sistemas mecatrónicos complejos: Optimización del diseño y su comportamiento

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Tekniker
MEMBER OF BASQUE RESEARCH & TECHNOLOGY ALLIANCE

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Outline

- Key Takeaways
- TEKNIKER
- Innovation Challenges and Achievements
- Why MathWorks?
- Project Examples
- Concluding remarks

Key Takeaways

- The design of complex mechatronic systems requires the development of simulation models to validate its dynamic behavior and design the most appropriate control strategy.
- MATLAB®/Simulink® and Simscape™ facilitate fast and cost-effective development of these models for different physical domains.
- Productivity can be further improved by using the Simscape™ Electrical™, Fluids™, Multibody™ and Driveline™ libraries.

WHO WE ARE

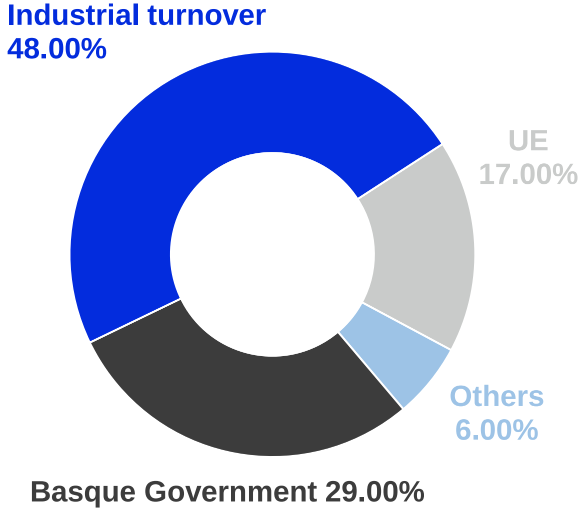
R&D Centre
(not-for-profit Private Foundation) |
Applied research spanning 42 years

Our mission is to deliver growth and wellbeing to society at large via R&D&I and to further the competitiveness of the business fabric in a sustainable manner

Specialised in **Manufacturing**

TEKNIKER IN FIGURES

TOTAL REVENUE TEKNIKER
25.6 M€



PEOPLE TEKNIKER
270

37% Women
63% Men

PhD resources
58 doctors
27 doctoral students

81% university degrees

DATA 2022

TOTAL REVENUES **TEKNIKER + INVESTED COMPANIES**
48.1 M€

PEOPLE **TEKNIKER + INVESTED COMPANIES**
366

CURRENT PORTFOLIO OF SHAREHOLDINGS IN COMPANIES

Atten[2] Deep monitoring solutions
masermic
GMTK MAHER HOLDING
GOIALDE HIGH SPEED
H2GREEM GLOBAL SOLUTIONS
i-TRIBOMAT THE EUROPEAN TRIBOLOGY CENTRE

TOTAL REVENUES INVESTED COMPANIES
22.5 M€

PEOPLE INVESTED COMPANIES
96

TECHNOLOGICAL SOLUTIONS

MECHATRONIC SYSTEMS

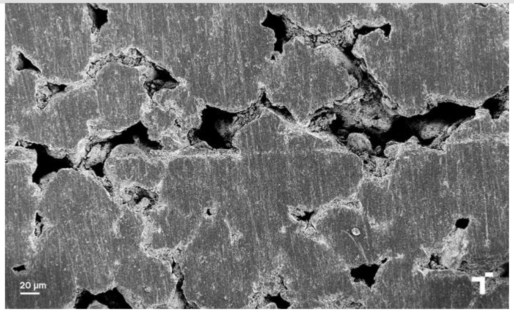
Development of complex mechatronic systems and optimised, accurate, robust and competitive systems.

AUTOMATION AND INDUSTRIAL ROBOTICS

From process or machine design to assemblage and commissioning.

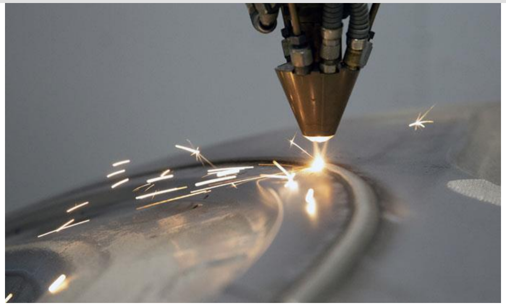
INSPECTION AND MEASURING

Process-integrated solutions. Calibration and characterisation of production resources and components. Development of measuring equipment.



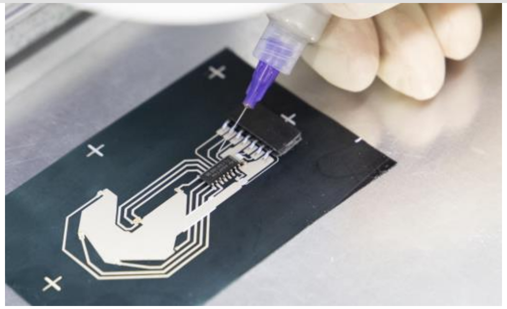
MULTI-FUNCTIONAL SURFACES

Optimisation of material and surface properties (tribologic, superhydrophobic, anti-bacterial, aesthetic, optical, etc…).



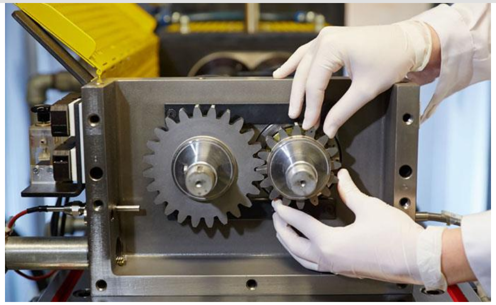
SMART MANUFACTURING

Development of new manufacturing processes. Study and optimisation of production resources, monitoring and digitisation.



SENSOR DEVICES AND IoT

Design and development of devices for the smart industry in line with regulations. Data exploitation and analysis tools.



MECHANICAL COMPONENTS AND TRIBOLOGICAL SYSTEMS

Design, manufacture, validation and in-use behaviour. Test benches. Data analytics, diagnosis and monitoring.

INDUSTRIAL MAINTENANCE

Development of equipment and technology to optimise reliability and predictive maintenance.

Innovation Challenges and Achievements

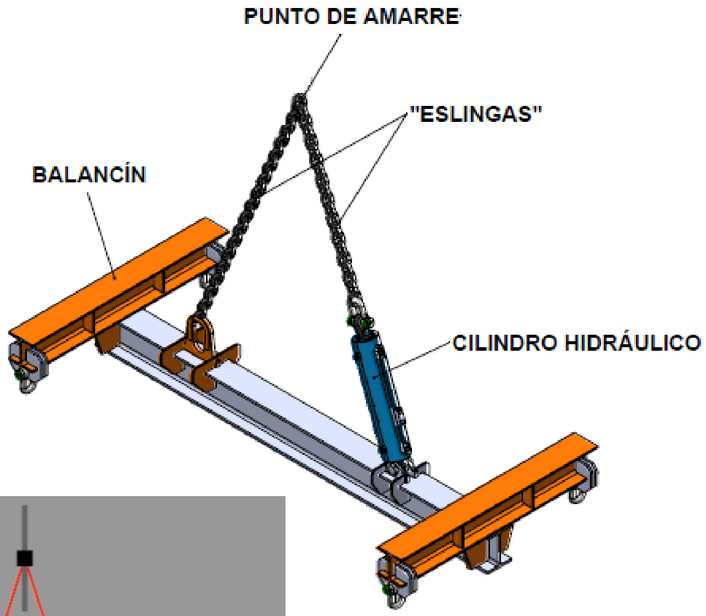
- Challenge: simulation models are usually needed to validate mechatronic designs and/or develop control solutions. However, the development of the simulation model should not impact in the project schedule and cost unless the simulation model is required as a deliverable. Its development is often transparent to the end customer.
- Achievement: TEKNIKER mechatronics modelling framework and library is complemented with Simscape™ based modelling for fast and cost-efficient model development in singular projects

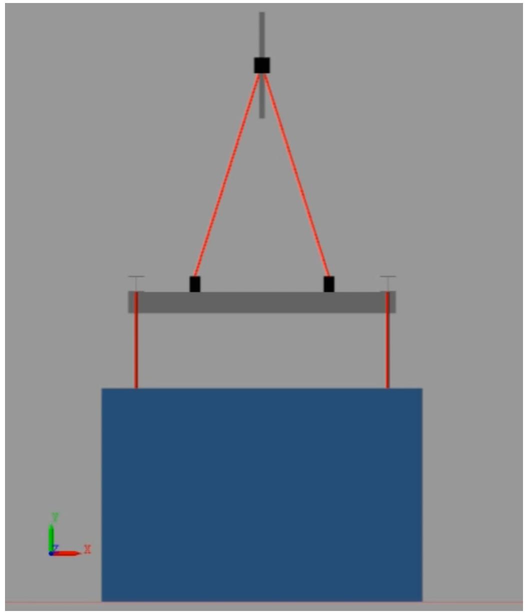
Why MathWorks?

- Main tool used in TEKNIKER for developing simulation models since more than 20 years
- Most demanded model development tool for customers
- Excellent technical support
- Last improvements provide high level modelling blocks, easy code generation, etc.

KIMUA: Automatic leveling system for high load cranes

- System description
  - Specially with big load weight and sizes, hanged loads can get unleveled
  - KIMUA has developed a system to ensure the static leveling of the load
  - This leveling is achieved by adding a hydraulic actuator, which modifies the sling length
  - Load angle is measured by means of an inclinometer and used to feed the leveling control system.

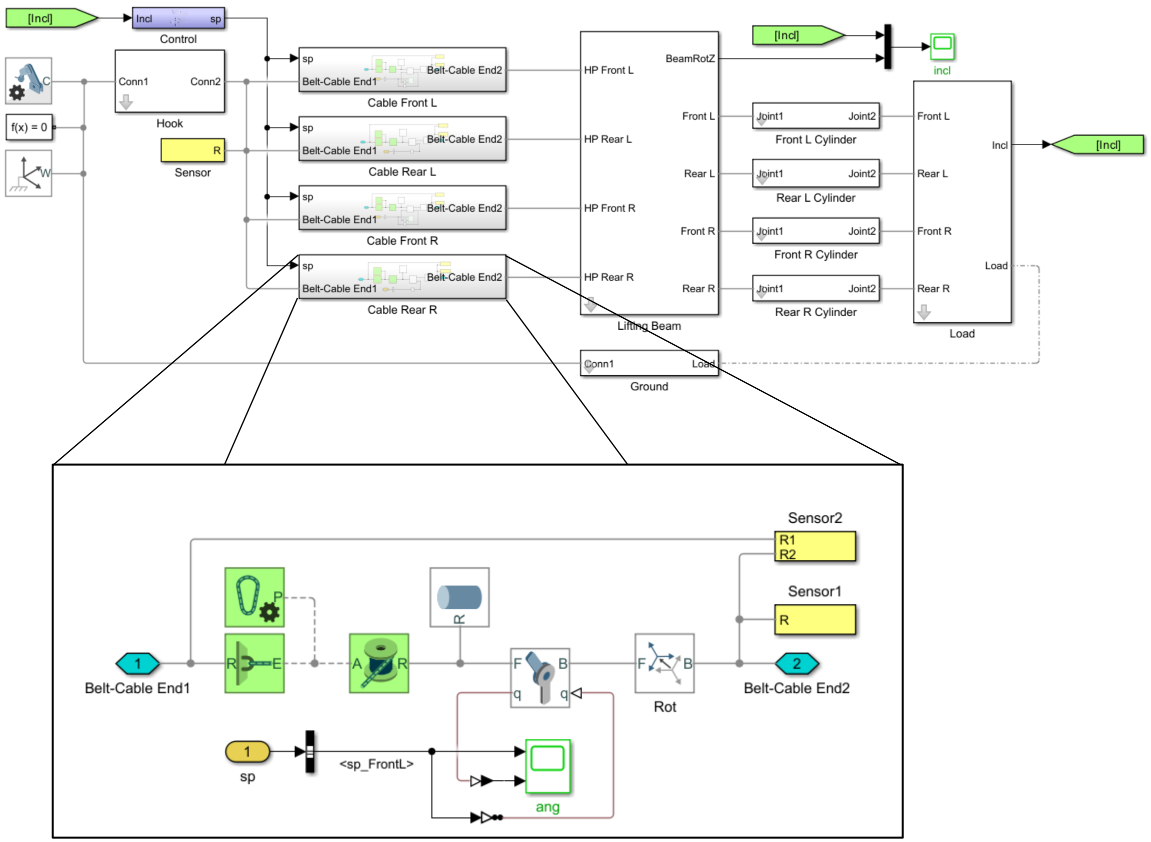




KIMUA.

KIMUA: Automatic leveling system for high load cranes

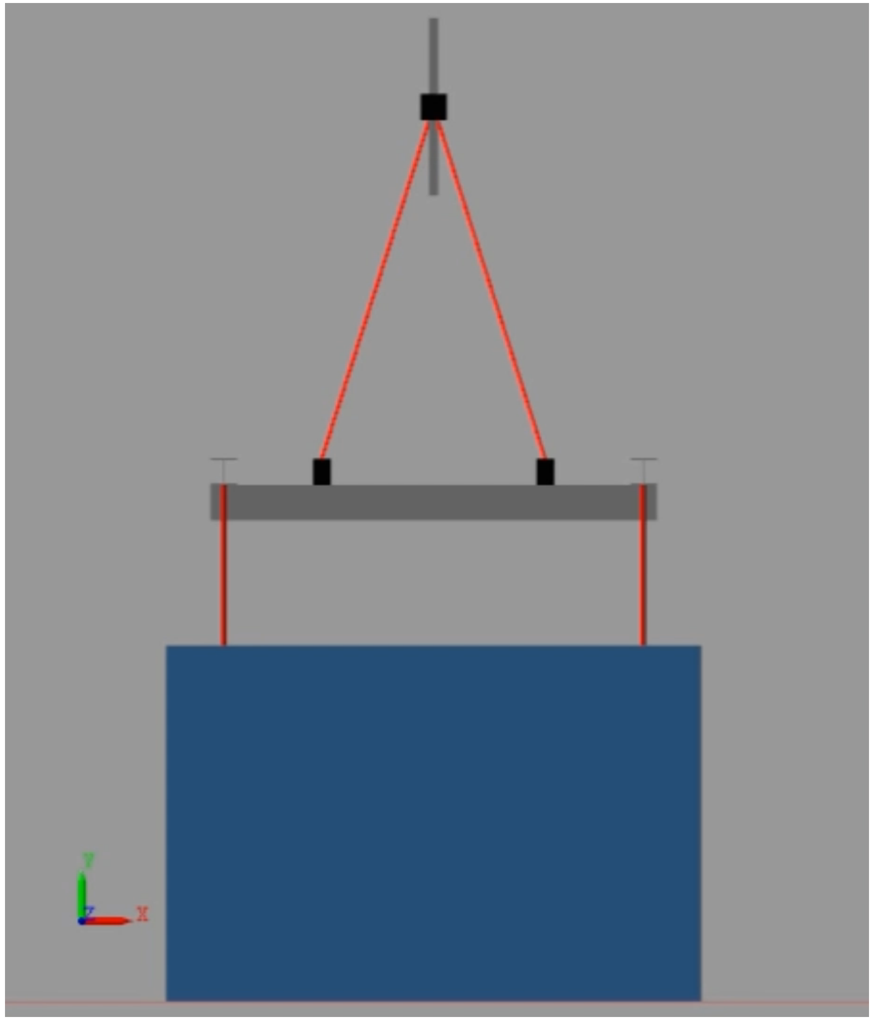
- System model:
  - Mechanical components of the crane. Modelled with Simscape™ Multibody™
  - Dynamics of the hydraulic actuator have been neglected in this case
  - Leveling controller with robustness against oscillations at natural frequency caused by external perturbations acting on the load: wind, etc.

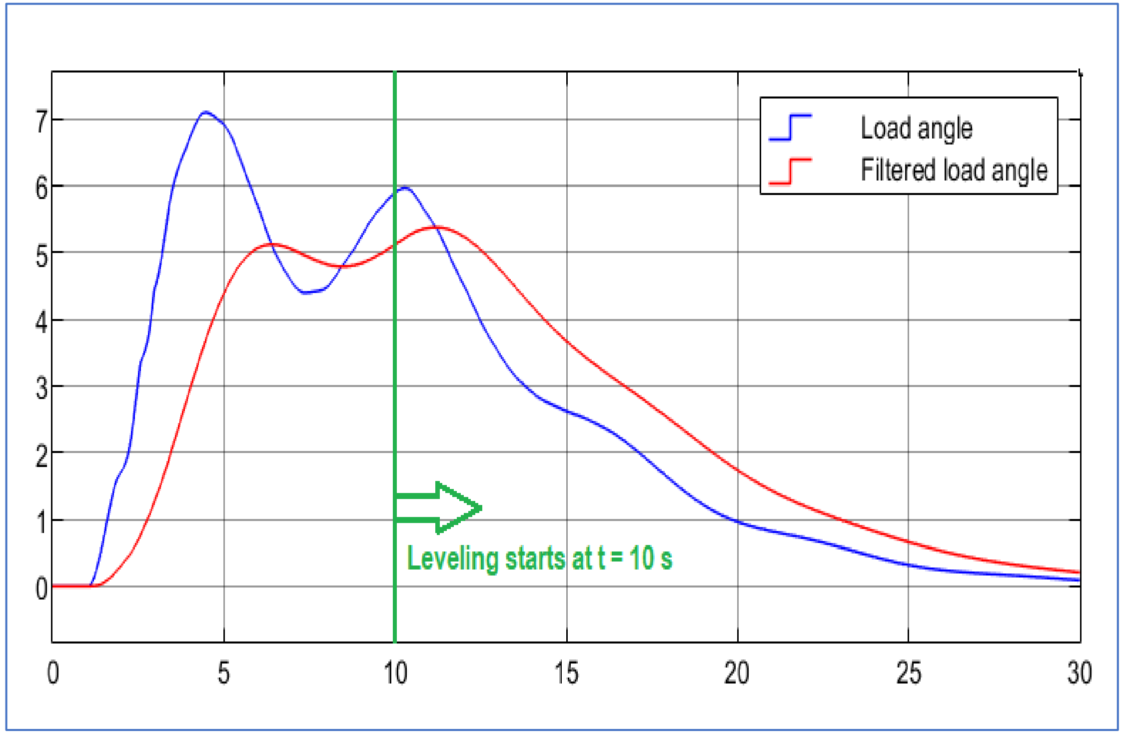


KIMUA.

KIMUA: Automatic leveling system for high load cranes

- Simulation Results





Load Angle Evolution

KIMUA.

KIMUA: Automatic leveling system for high load cranes

- Real System Results

KIMUA.

GH cranes: Anti-sway system for overhead cranes

- System description
  - Overhead cranes present a pendulum type oscillation problem
  - Stable and accurate handling is required in new demanding application
  - TEKNIKER has collaborated with GH cranes in the development of open and closed loop control strategies to minimize oscillations during crane operation
  - The aim of the system is to damp the load oscillations at natural frequency or, alternatively, avoid its excitation
  - Several control algorithms/tools have been evaluated:
    - Notch filters and input shaping
    - Antisway control loop
    - MIMO control: Pole-Placement, Linear Quadratic Regulator (LQR), MIMO control: Model Predictive Control (MPC)
    - State Observers: Kalman Filter, Moving Horizon Estimation

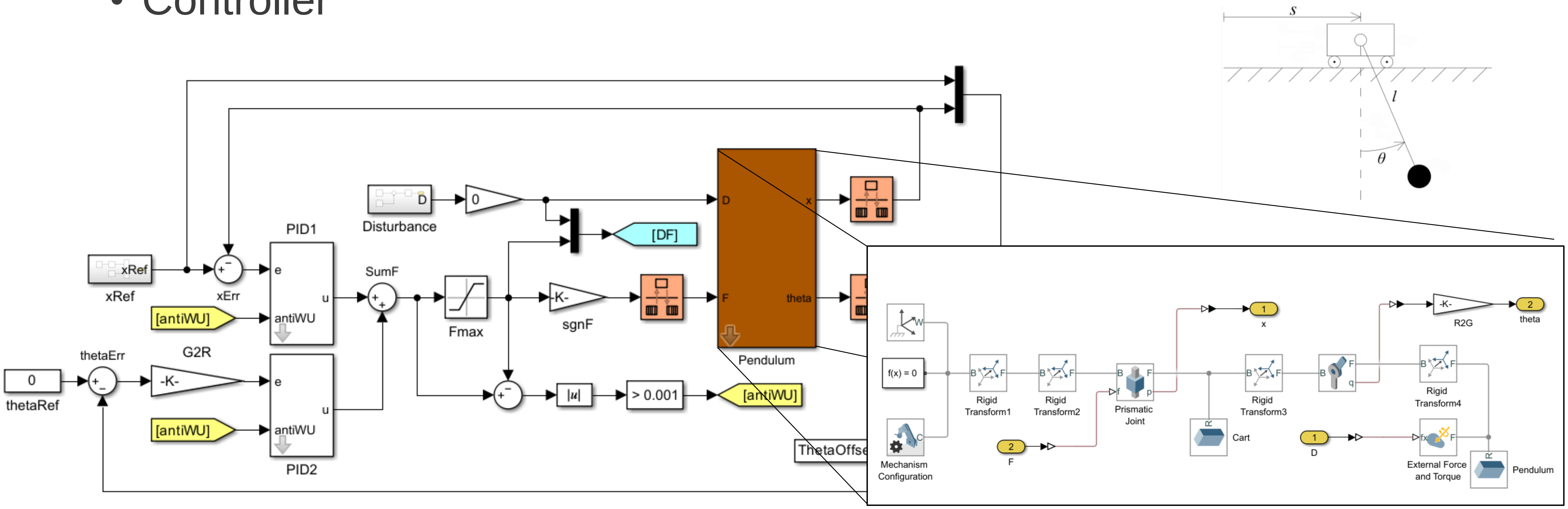
HMK Automation Group Ltd

iMOCO4.E

GH CRANES & COMPONENTS

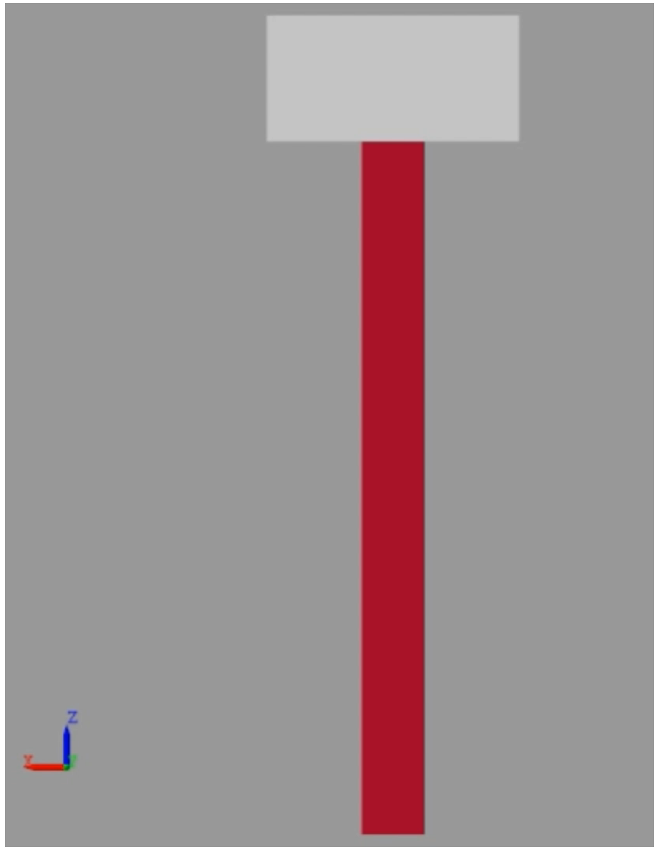
GH cranes: Anti-sway system for overhead cranes

- System model:
  - Mechanical components of the crane with Simscape™ Multibody™
  - Dynamics of the electromechanical actuator
  - Controller



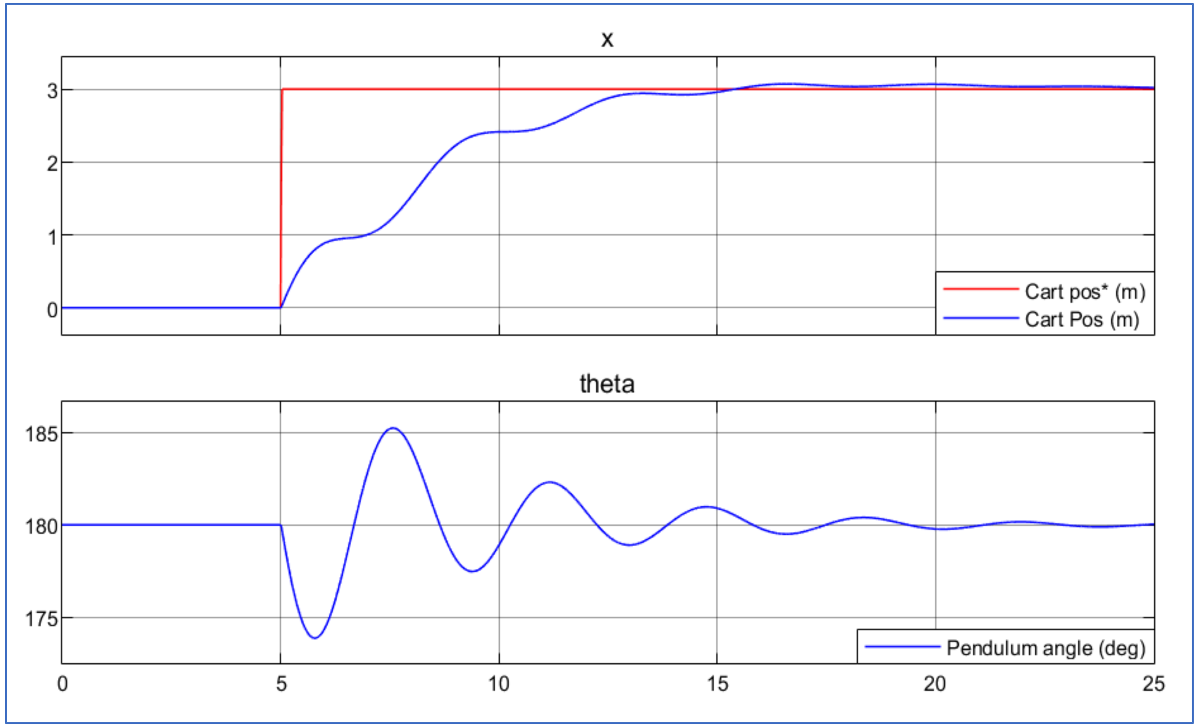
GH cranes: Anti-sway system for overhead cranes

- Simulation Results:



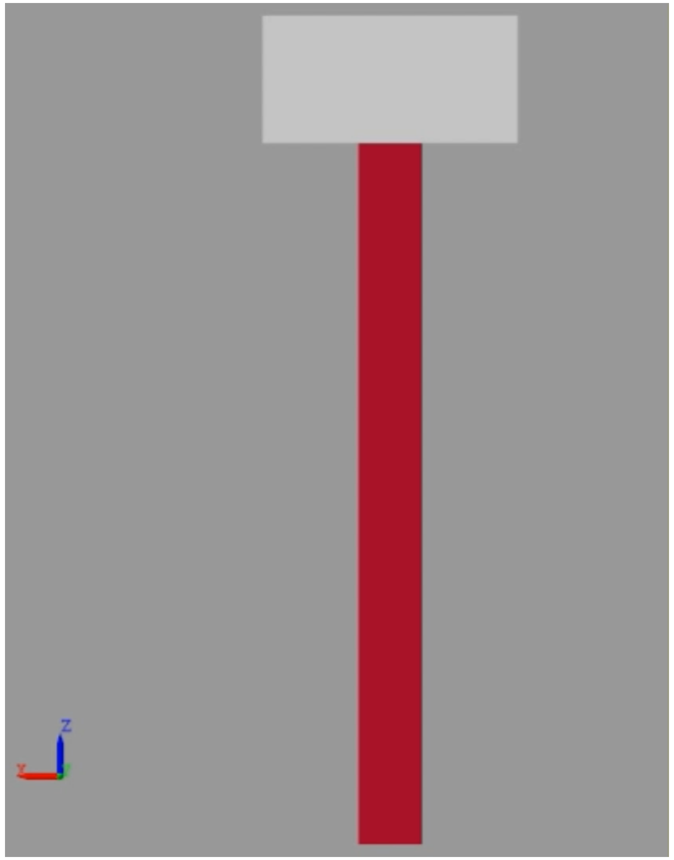
No vibration damping

Single PID control loop for cart position



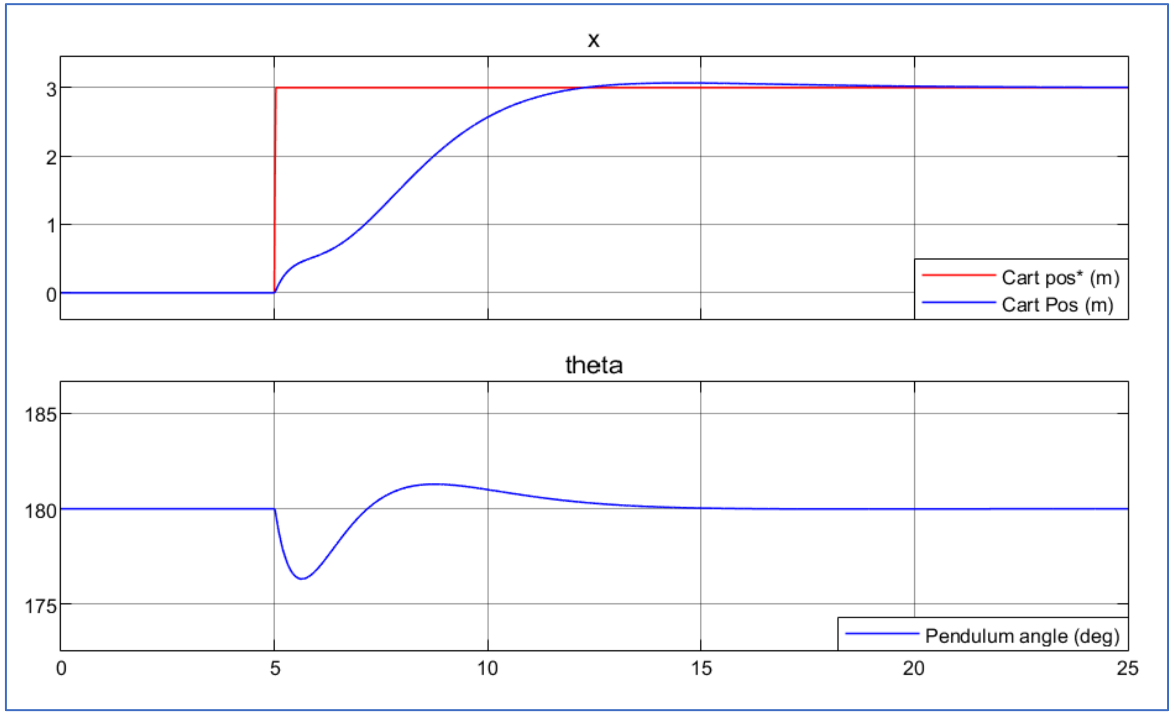
GH cranes: Anti-sway system for overhead cranes

- Simulation Results:



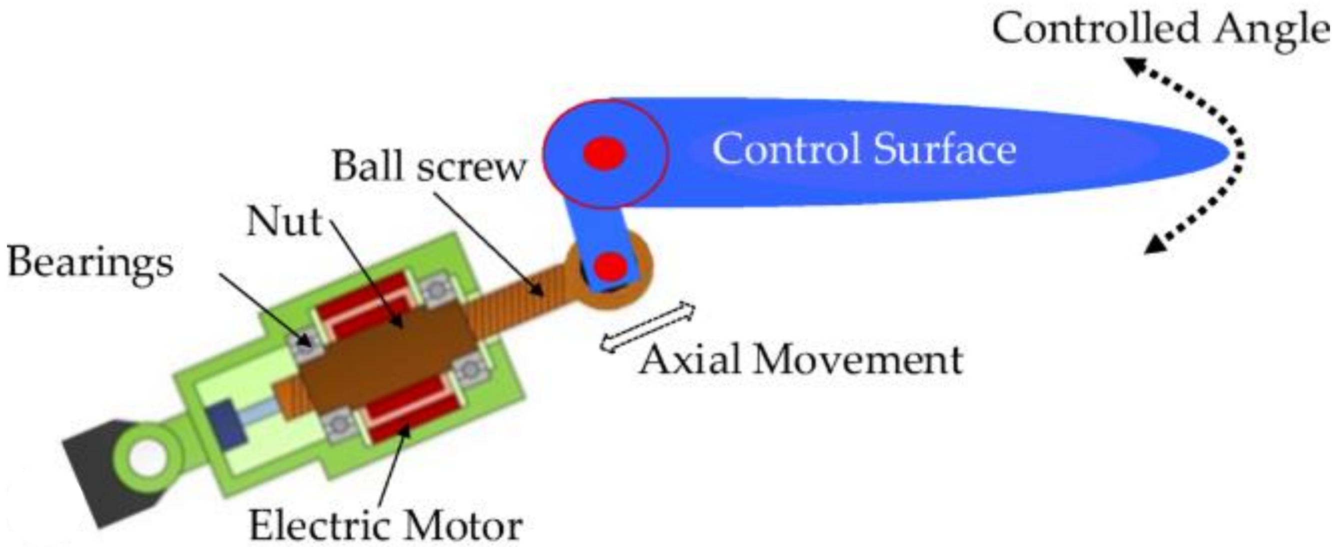
Vibration damping

Additional load inclination rate control loop added to standard cart position controller



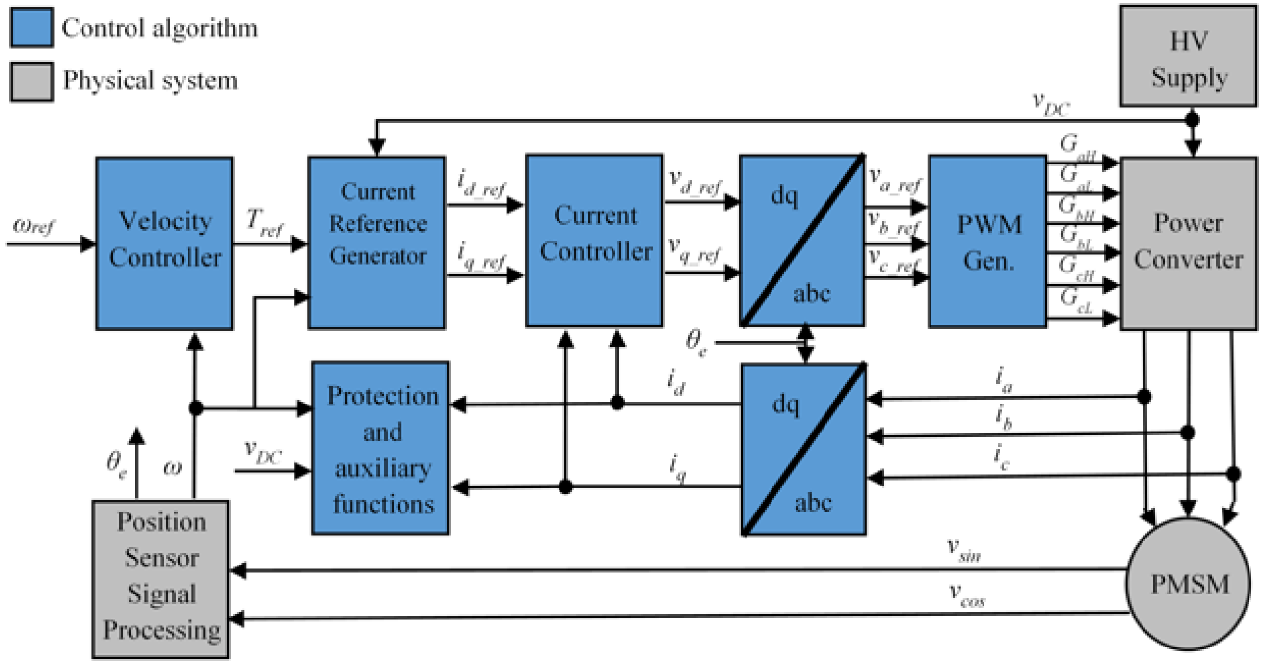
CESA/AKKODIS: Health Monitoring System for aeronautic EMA

- System description
  - CESA is developing electromechanical actuation (EMA) systems to be employed in future aircrafts
  - CESA and AKKODIS are collaborating in the development of a Health Monitoring System for EMAs
  - To train the model, a model of a position-controlled EMA with PMSM and a ball screw has been developed by TEKNIKER



CESA/AKKODIS: Health Monitoring System for aeronautic EMA

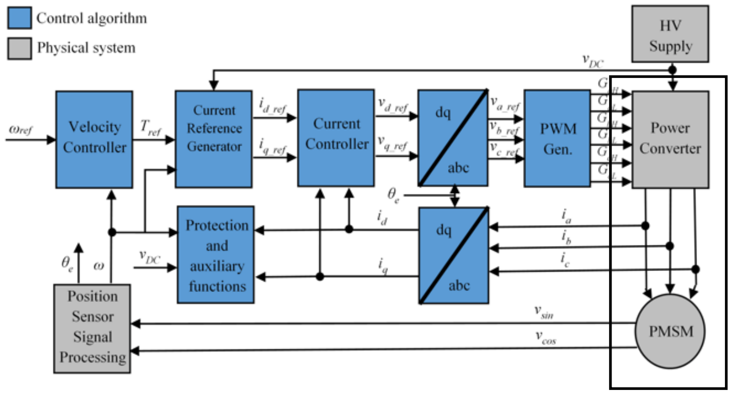
- System model
  - Plant
    - The electrical, including power electronics, and mechanical components must be modelled in detail for considering different faulty conditions

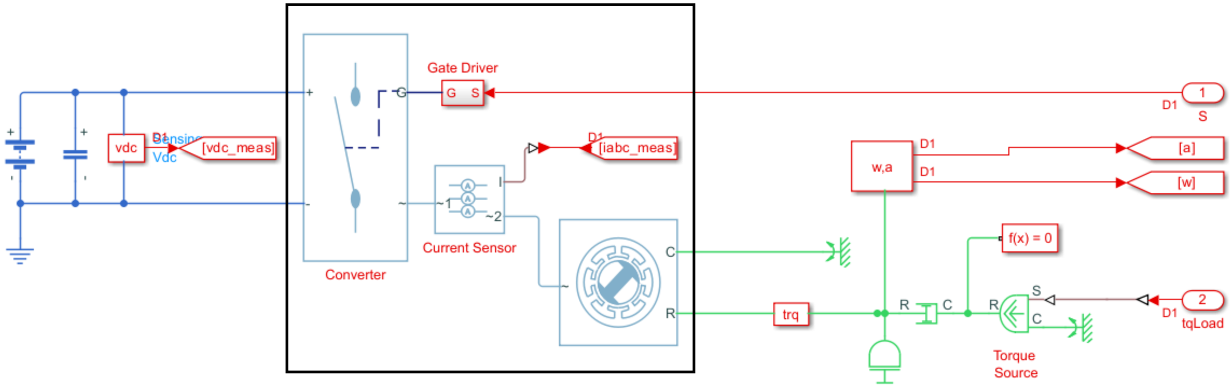


MathWorks®

CESA/AKKODIS: Health Monitoring System for aeronautic EMA

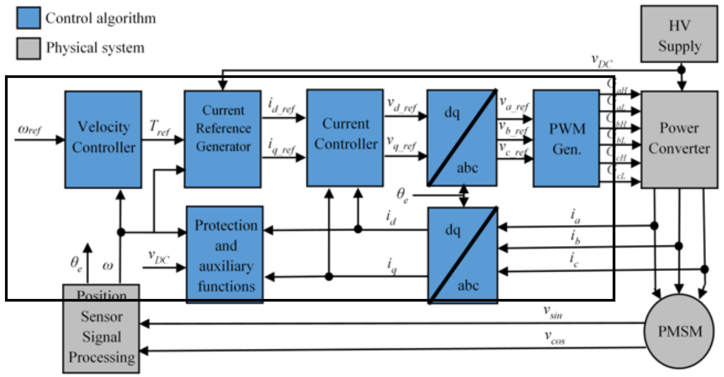
- System model
  - Plant
    - Simscape™ Electrical™ is used for modelling the power electronics and the PMSM
      - Only two blocks needed, compared to several blocks needed in the traditional approach
    - Very simple modelling of the mechanical part, using Simscape™

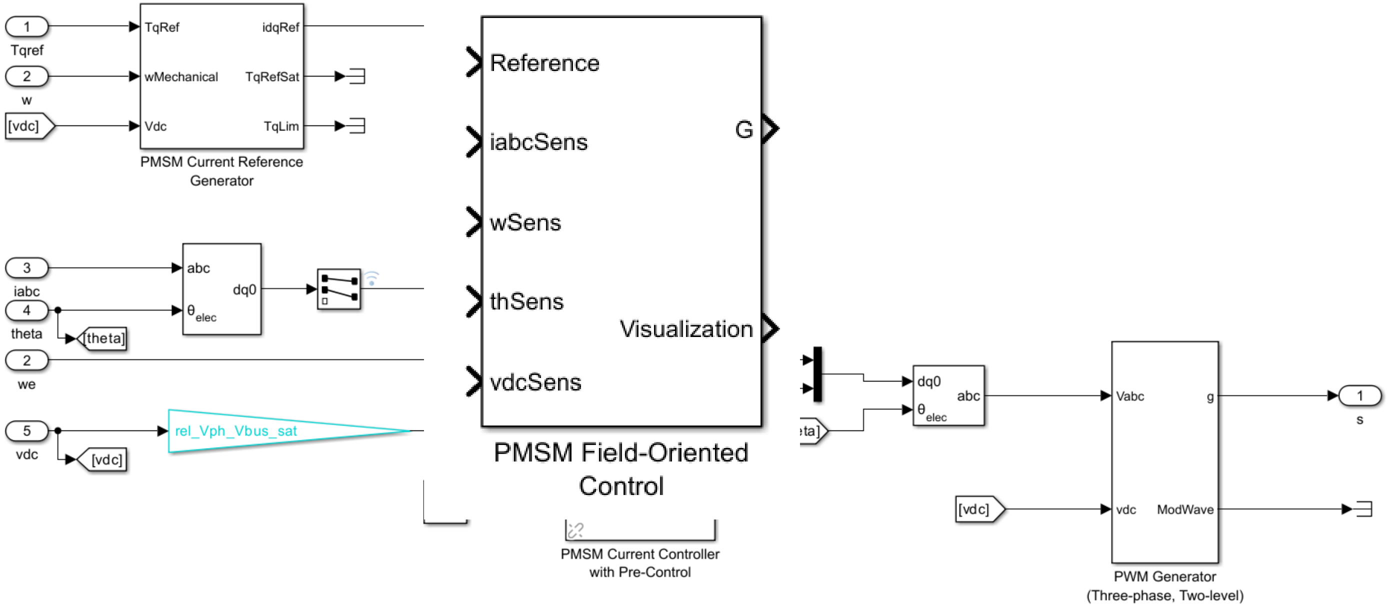




CESA/AKKODIS: Health Monitoring System for aeronautic EMA

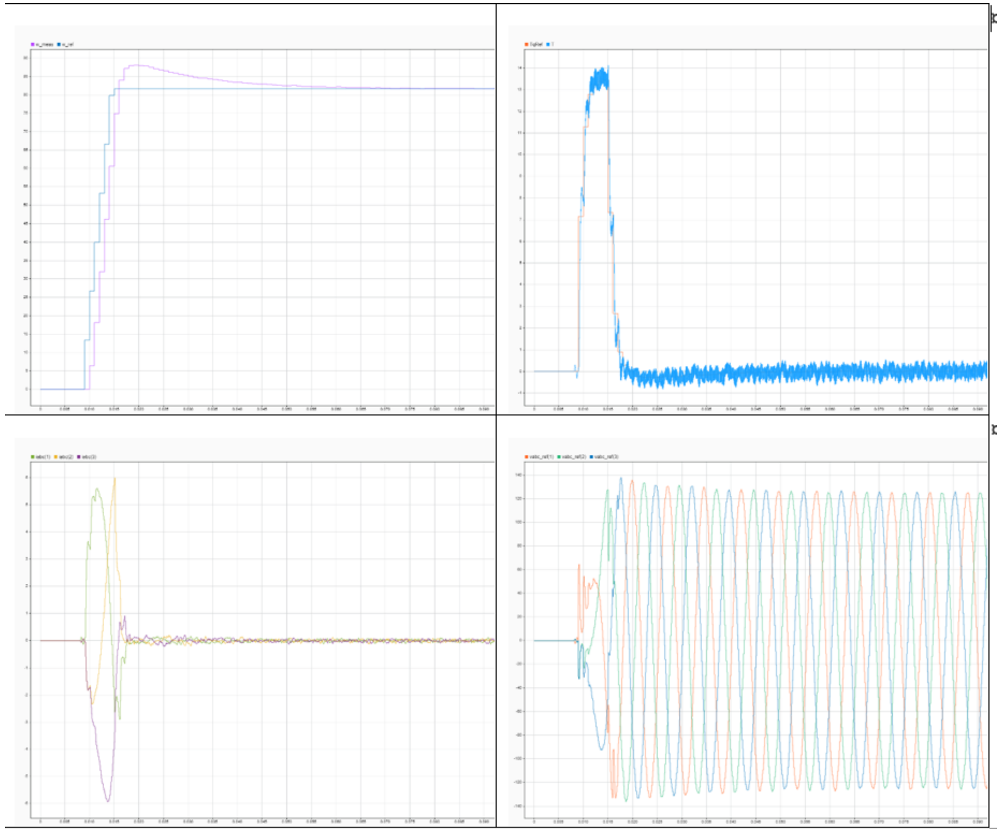
- System model
  - Controller
    - Simscape™ Electrical™ provides a control block with all functionalities needed
    - Alternatively, blocks with the corresponding submodules are also available, allowing flexibility in the controller design





CESA/AKKODIS: Health Monitoring System for aeronautic EMA

- Results:
  - Mechanical (torque, speed, etc.) and electrical (voltages, currents, etc.) signals are perfectly generated by the model for training the HMS
  - Currently working in error modelling



CONCLUDING REMARKS

- Simscape™ allows fast and cost-efficient simulation model development.
- Simscape™ Multibody™ allows a fast modelling of simple multibody mechanisms, like cranes. Moreover, the correct system modelling and behavior can be visually evaluated by means of the associated animation tools, avoiding many potential errors.
- Simscape™ Electrical™ allows an easy modelling of the electrical actuators and their most common control algorithms. Development time of this kind of systems can be reduced to 10% of the original time when using this tool.

QUESTIONS

#GrowthMakers

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