Generator Technologies

Synchronous Machine Modelling Using Simscape

Peenki Rani

MATLAB EXPO 2019 – Silverstone, UK

2nd October 2019

Agenda

- Who We Are
- Product Validation Challenges
- Project Introduction
- Why MATLAB? Why Simscape?
- Approach
- Execution of a System
- Outcome
- Future of Modelling
- How to Model Complex Systems
- Tips
- Conclusion

Who We Are

EST. 1904

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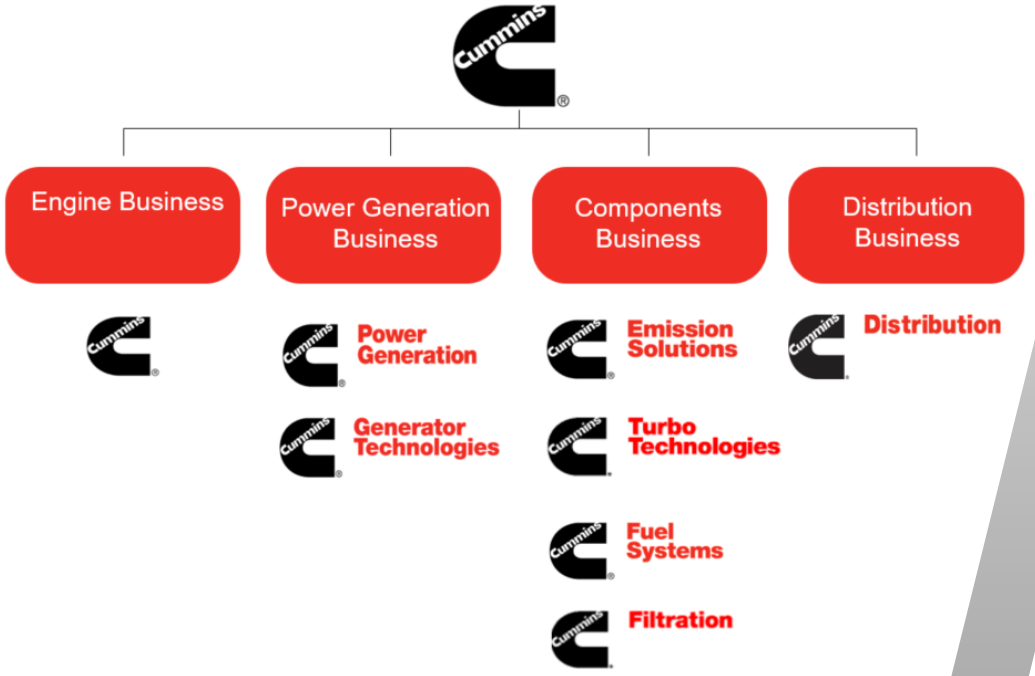
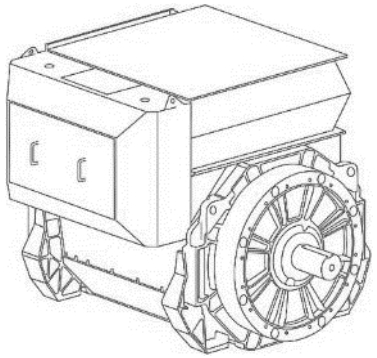
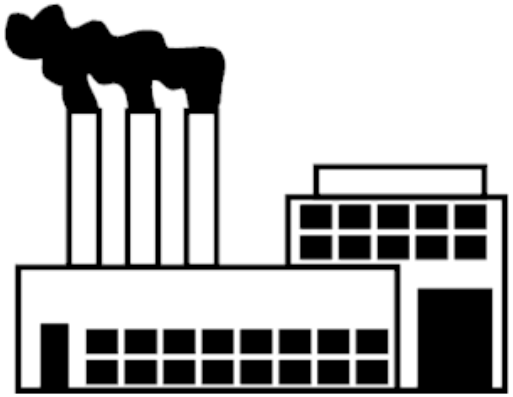




4 – 11,200 kVA



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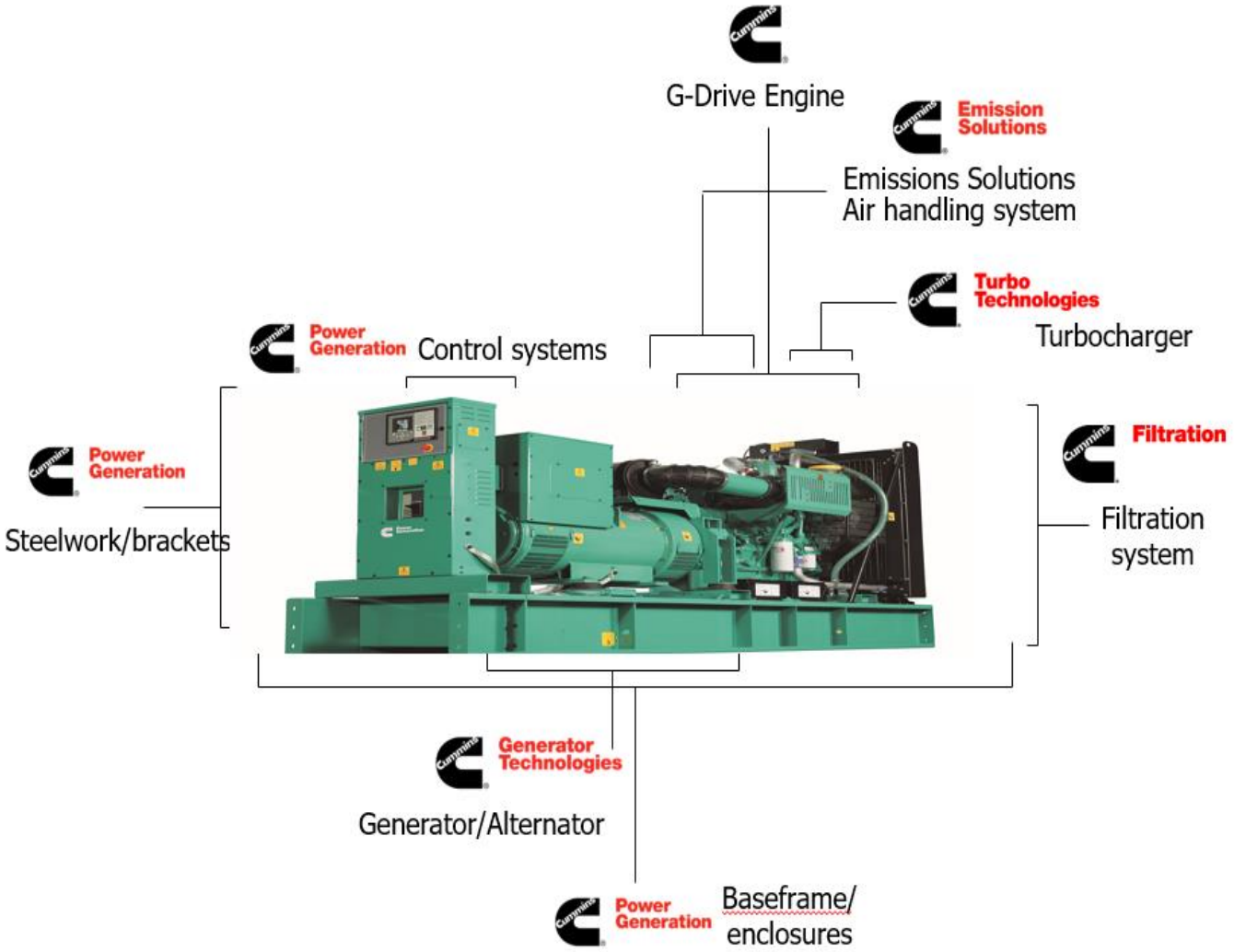

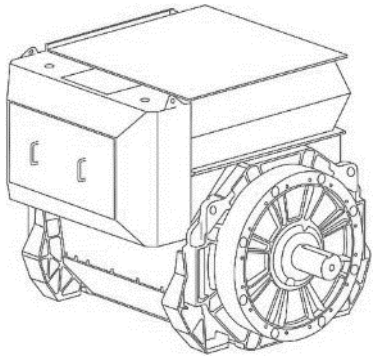

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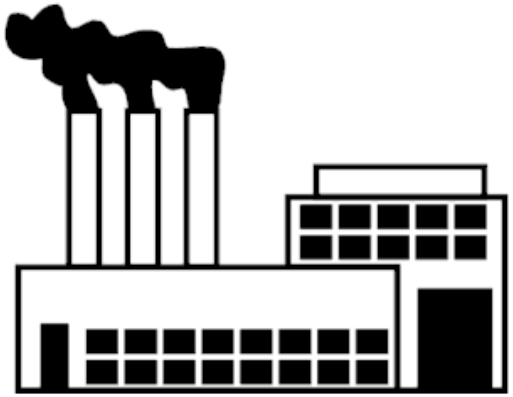

Cummins Generator Technologies

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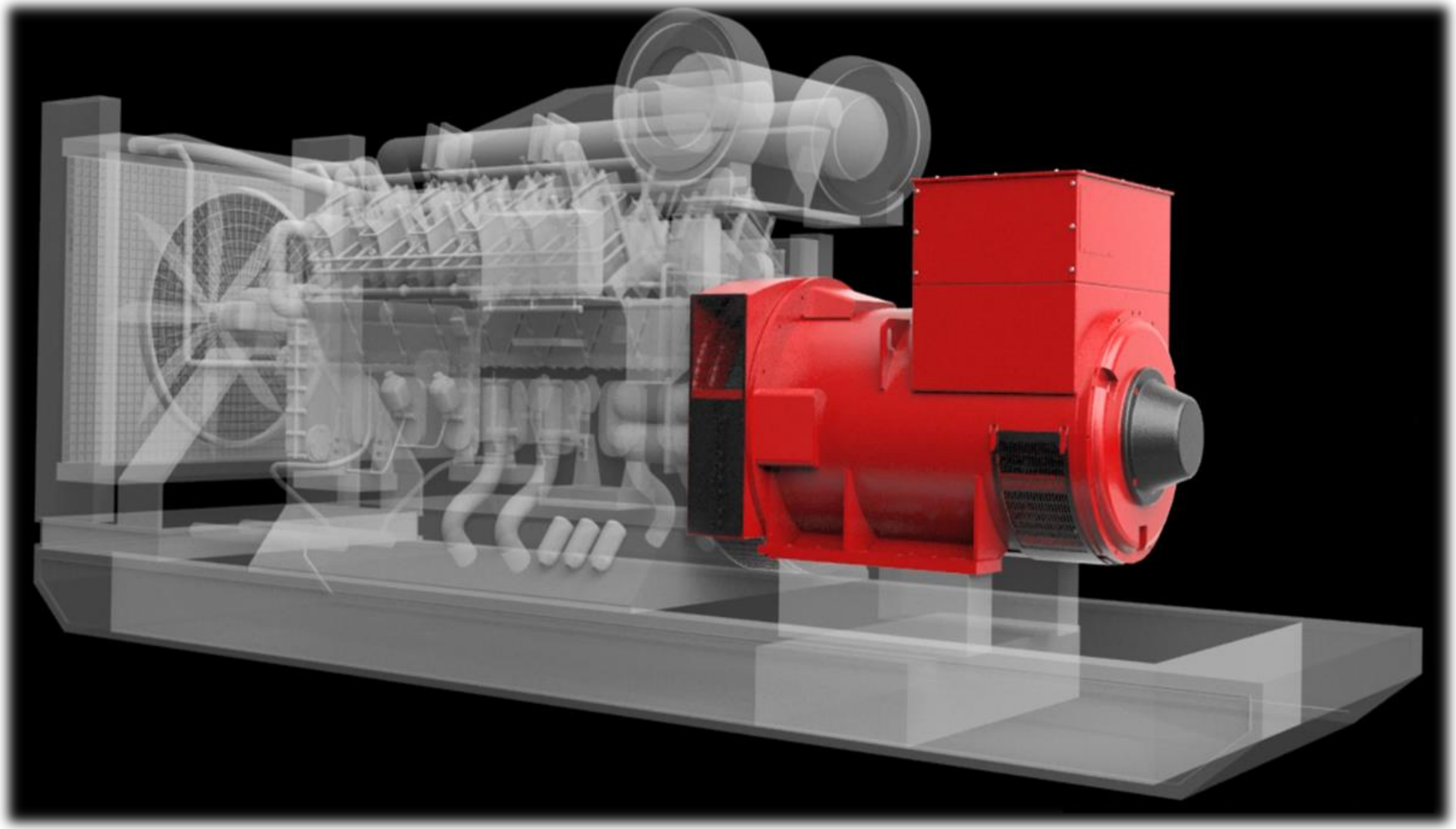


Cummins Generator Technologies

Applications

Prime Power:
Supplying continuous power 24/7 for seven years supporting construction of one of the world's largest natural gas projects

Marine:
Diving support vessel for saturation and air diving support work

Mining:
Alternators required for 58 MW power plant at a remote iron ore mining site

Product Validation Challenges

- Costly and time consuming experimental testing methods
- Remote location testing requirement
- Challenging applications and fault investigation

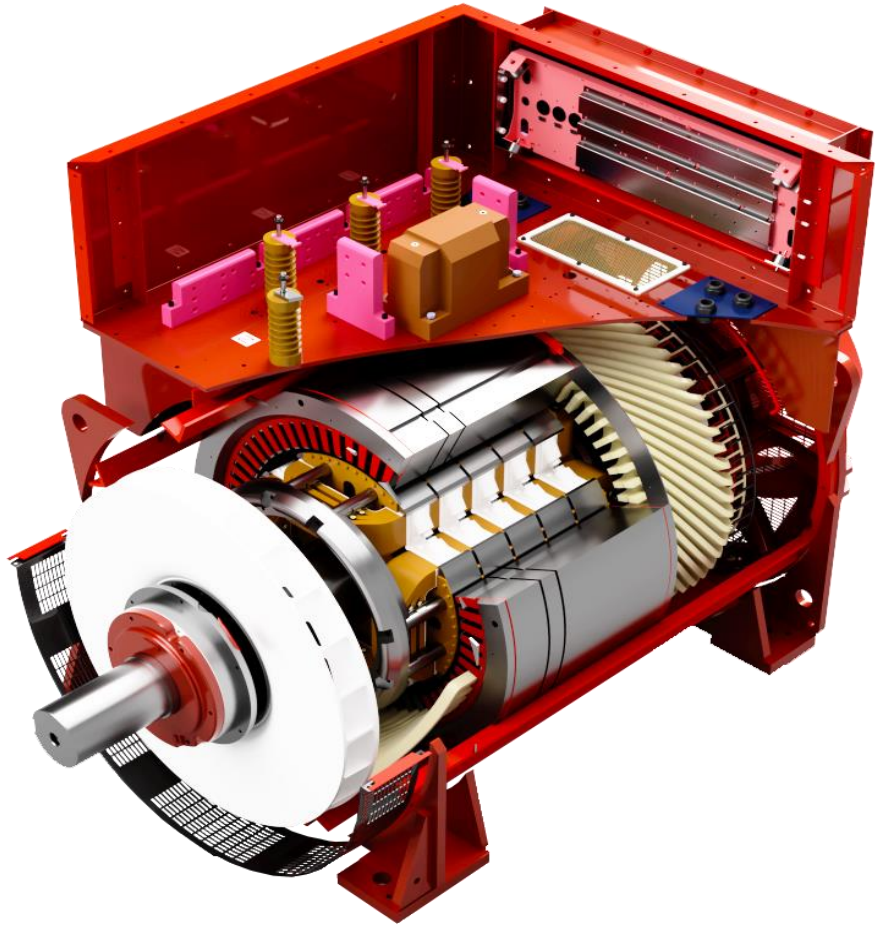
Project Introduction

Challenge:

- Time consuming and expensive
- Remote locations applications

Solution:

- Simscape for plant
- Simulink for the controls
- MATLAB to validate and automate
- Appdesigner to deploy



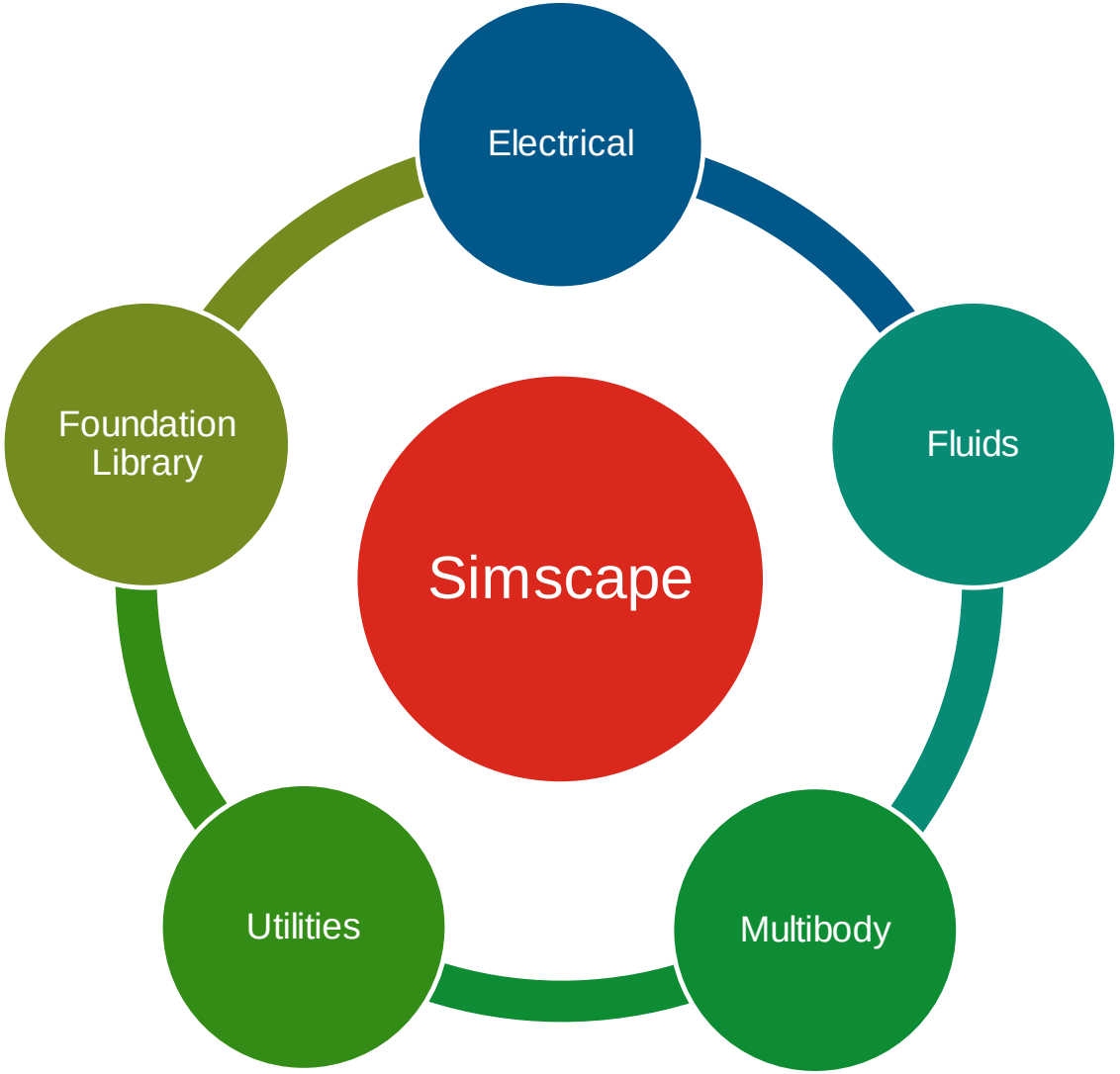
Benefit:

- Reduced commission time
- Application validation
- Fault simulations
- Customer enquiries

Therefore, enhancing simulation capabilities.

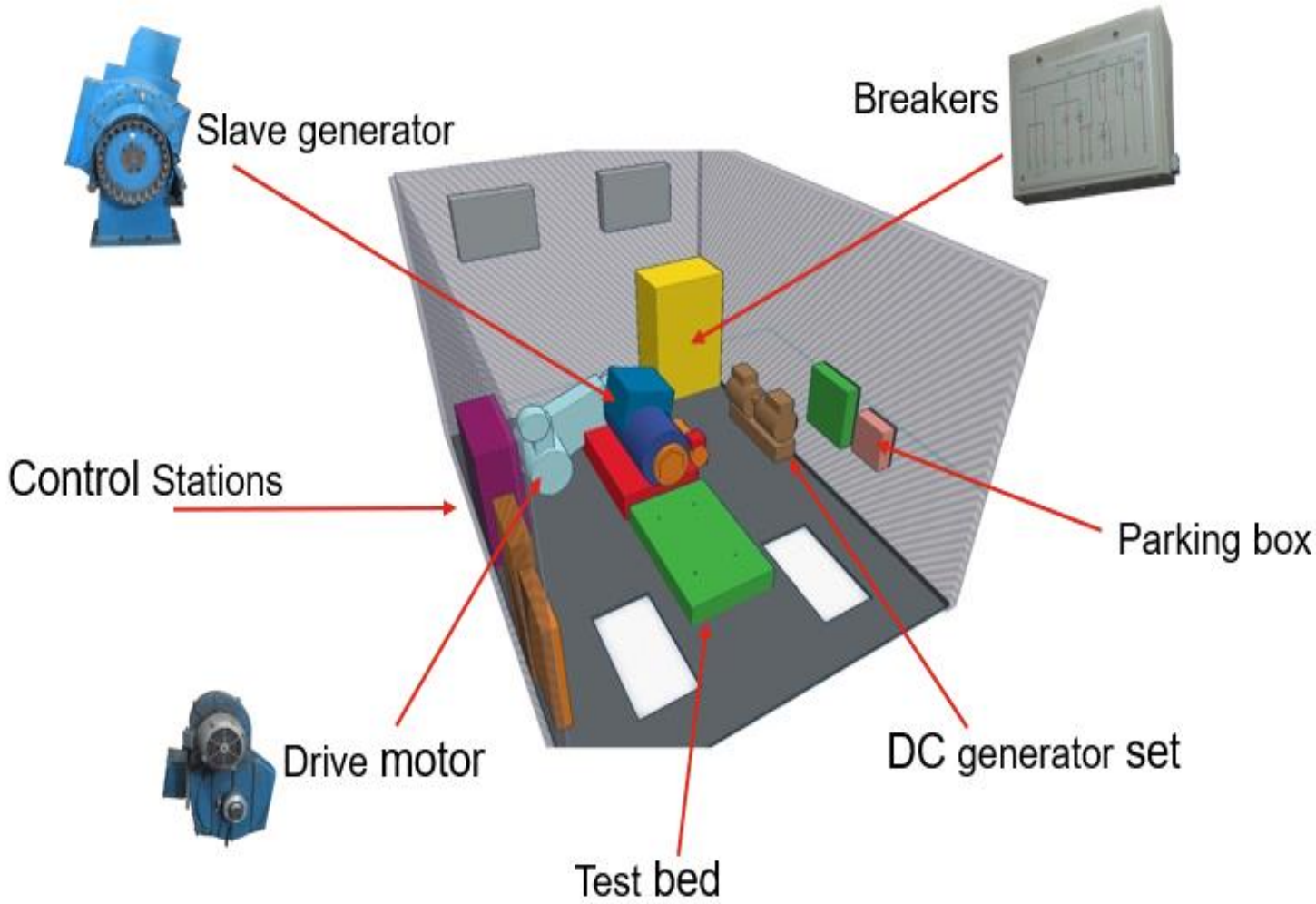
Why MATLAB? Why Simscape?

- Multiple physical domains
- Pre-validated model blocks
- Design optimisation
- Flexible environment
- Cummins adopted software package



Approach

- Learned MATLAB
- Replicate Test
- Define scope
- Design & build
- Validated
- Deploy



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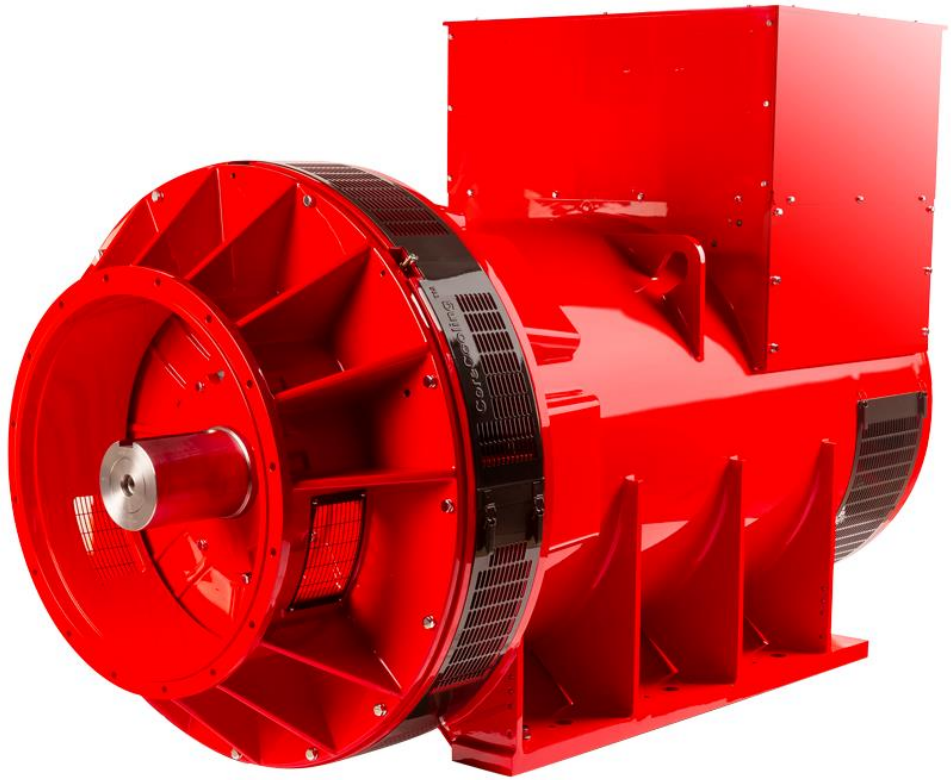

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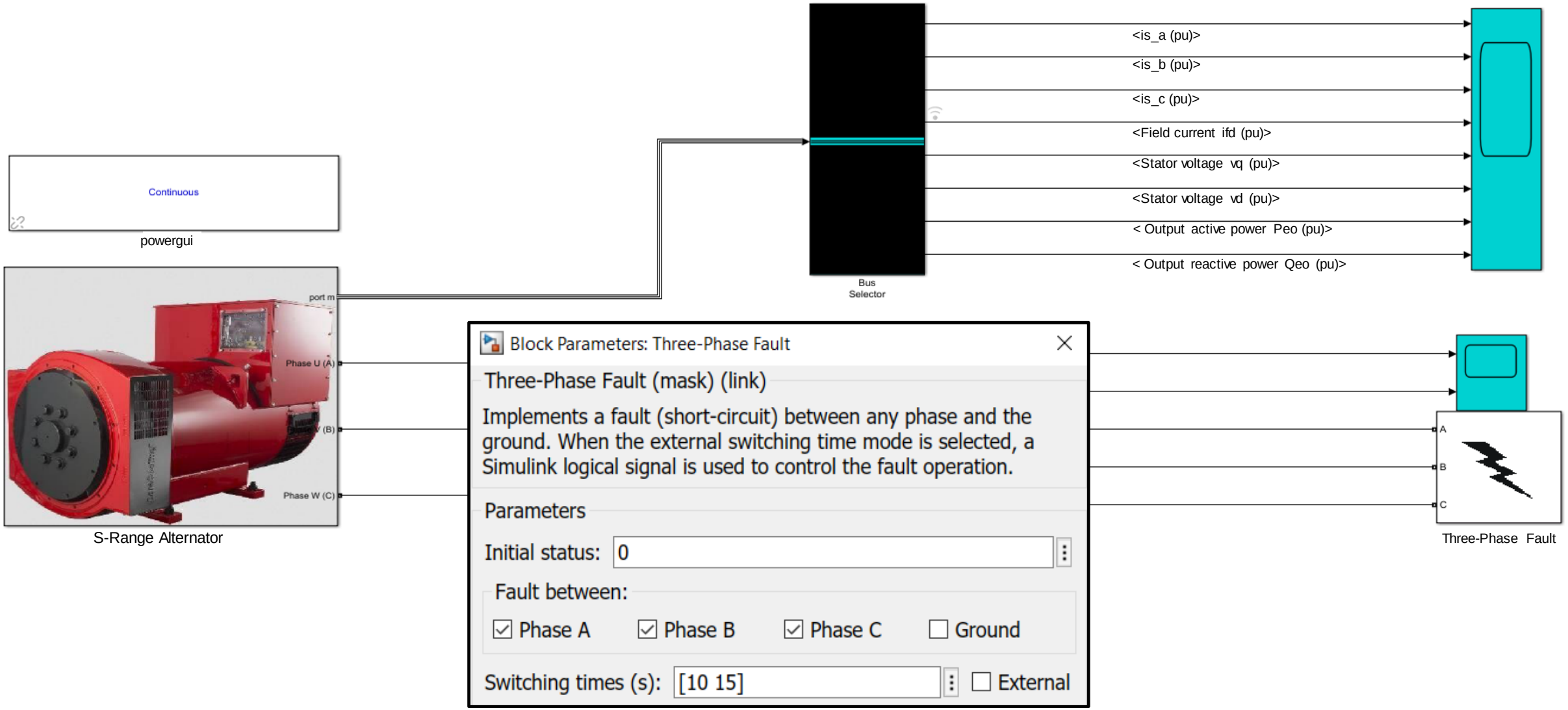
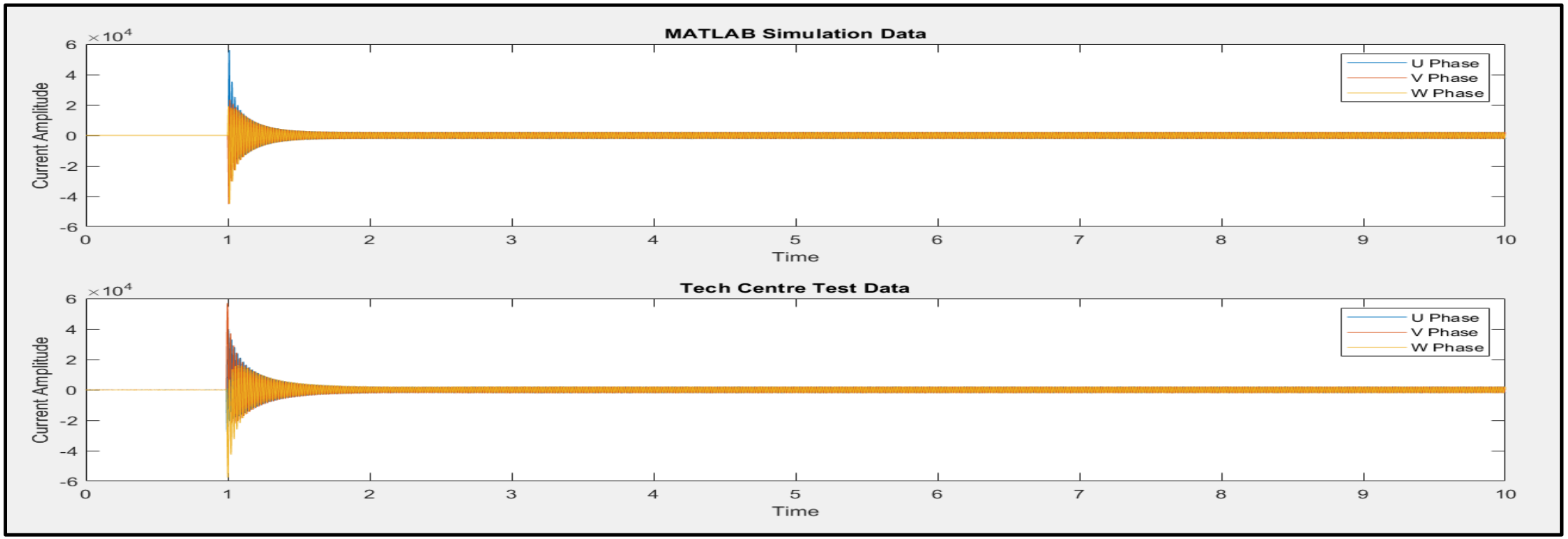
Execution of a System

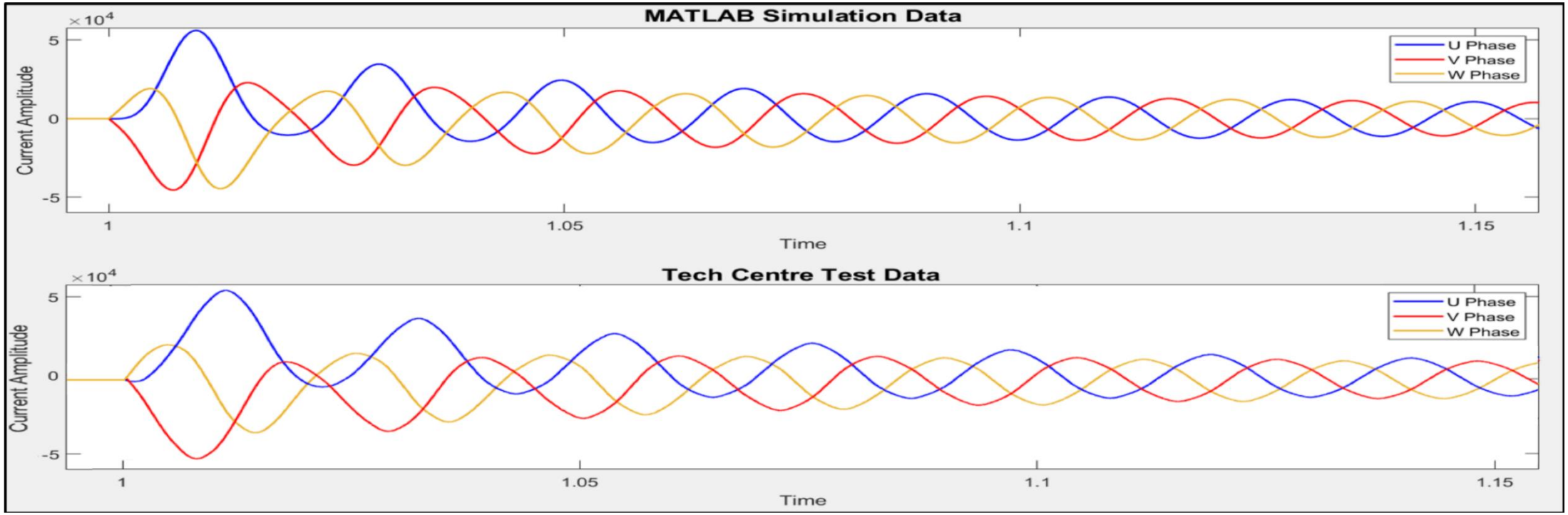


Outcome



Parameters	Test Results	Model Results
Xd direct axis synchronous reactance	2.36	2.3288
X'd direct axis transient reactance	0.16	0.15655
X"d direct axis sub transient reactance	0.13	0.14864
T'd Transient Time Constant	0.164	0.16351
T"d Sub-Transient Time Constant	0.0076	0.010014
Ta armature time constant	0.037	0.030489

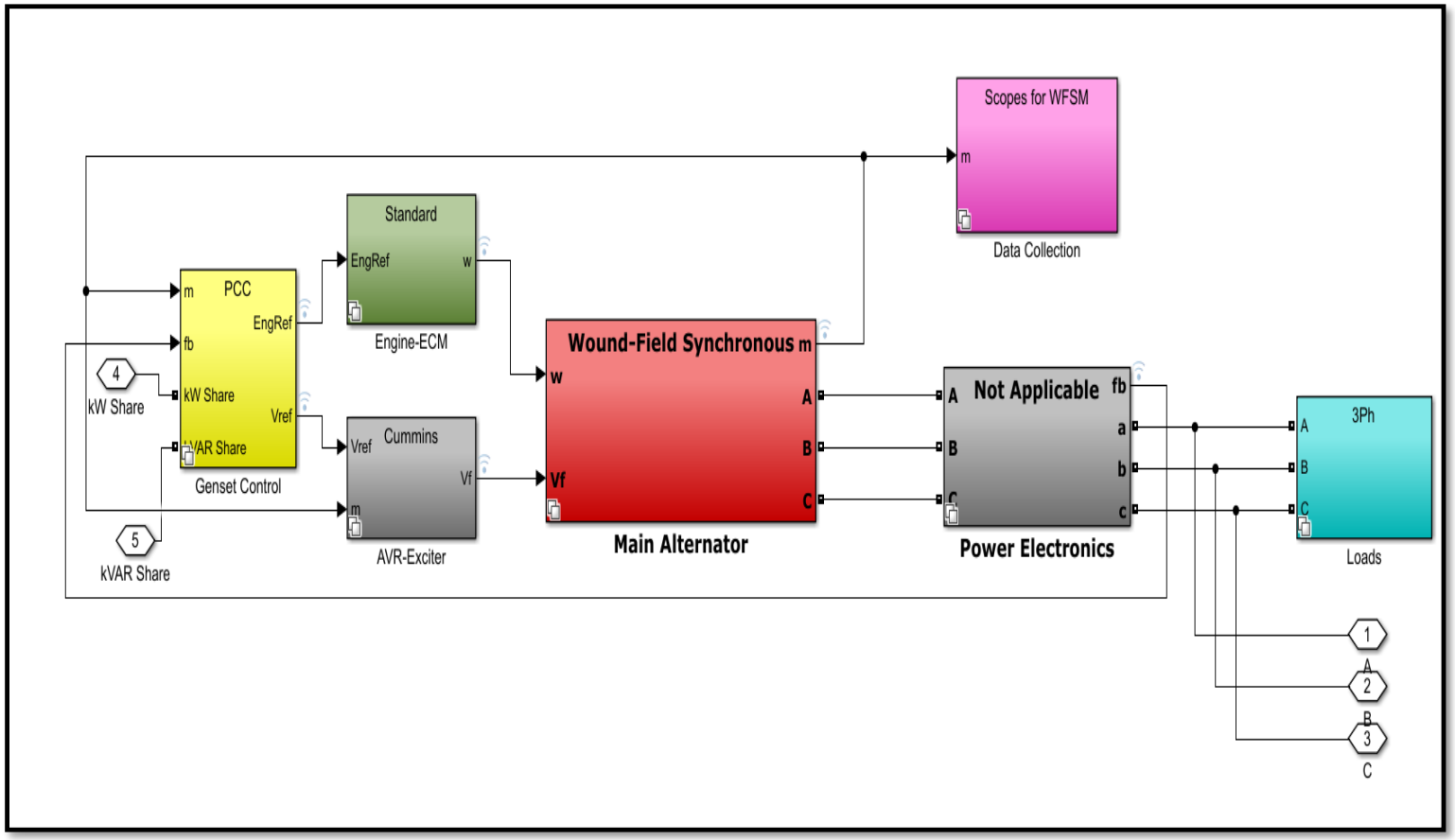
Outcome



Parameters	Test Results	Model Results	Accuracy %
Xd direct axis synchronous reactance	2.36	2.3288	96.88
X'd direct axis transient reactance	0.16	0.15655	99.66
X"d direct axis sub transient reactance	0.13	0.14864	98.14
T'd Transient Time Constant	0.164	0.16351	99.95
T"d Sub-Transient Time Constant	0.0076	0.010014	99.76
Ta armature time constant	0.037	0.030489	99.35

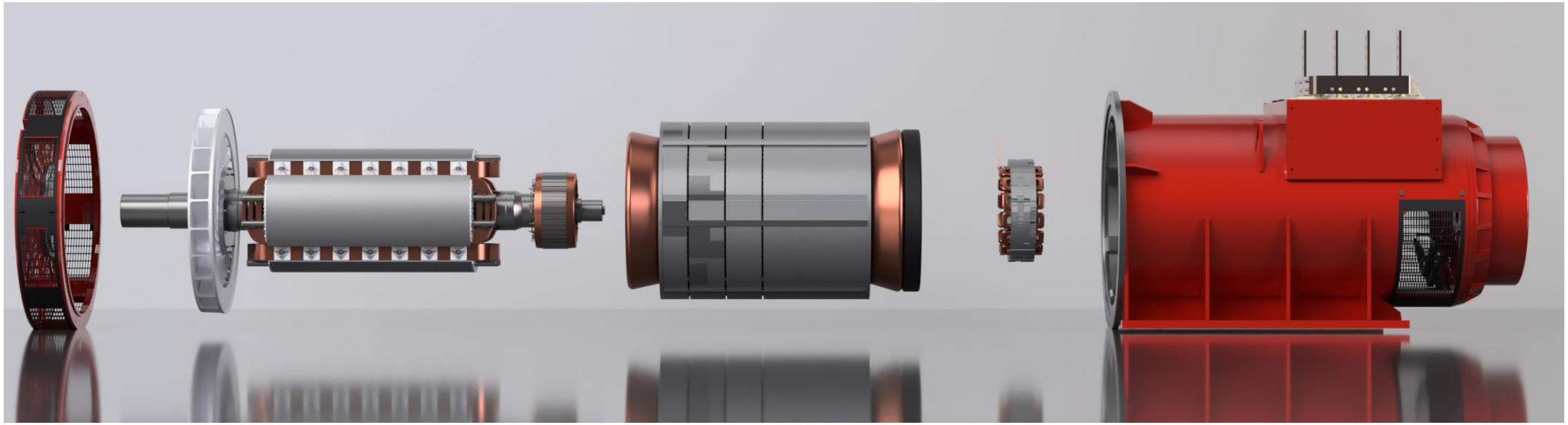
Future of Modelling

- Tool for everyone
- Lays foundation for digital twin
- Implement multi discipline Genset
- Extracting variables from FEA
- Create project library
- Training



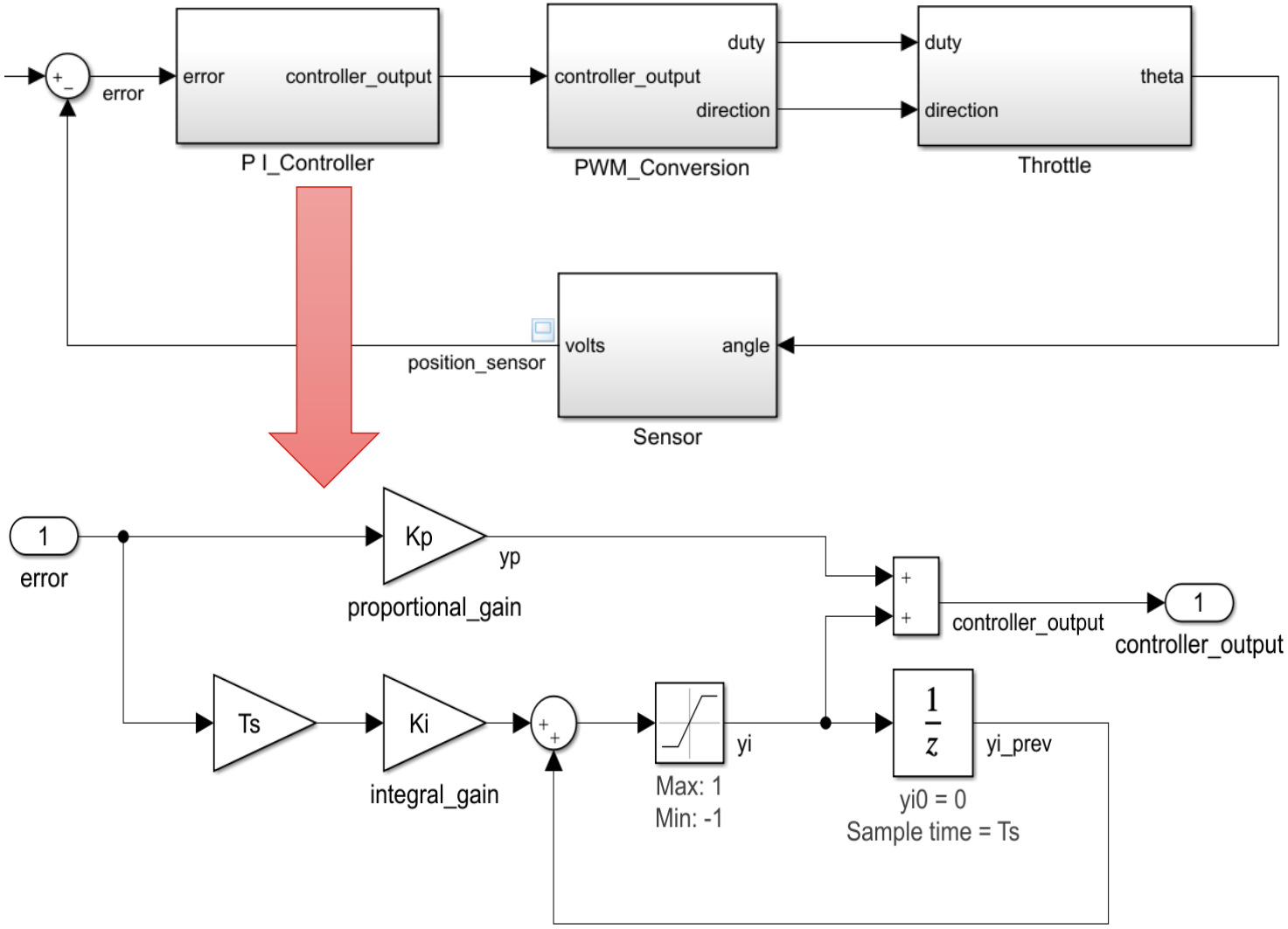
How Not to Model Complex Systems

- Model the full system
- Build subsystems individually
- Finally, connect the subsystems to complete the model
- Run
- Oops…. What went wrong?



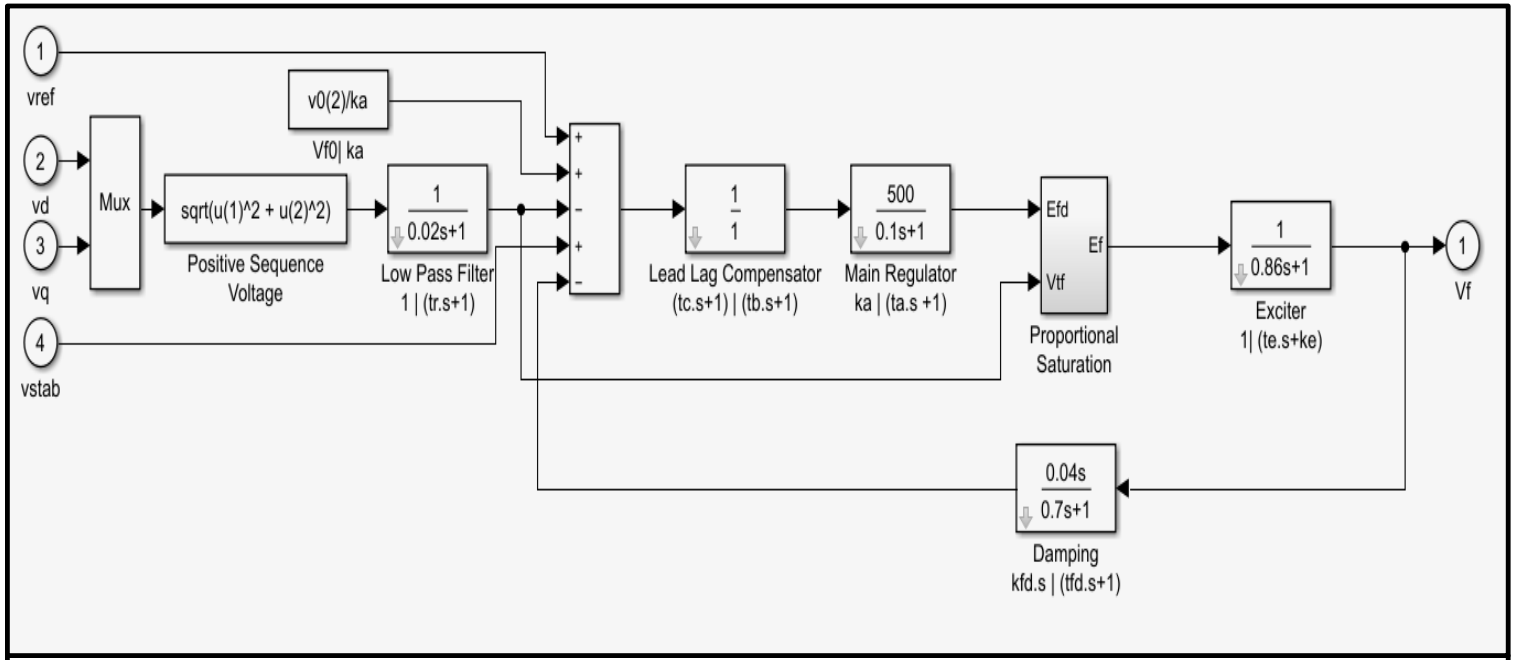
How to Model Complex Systems

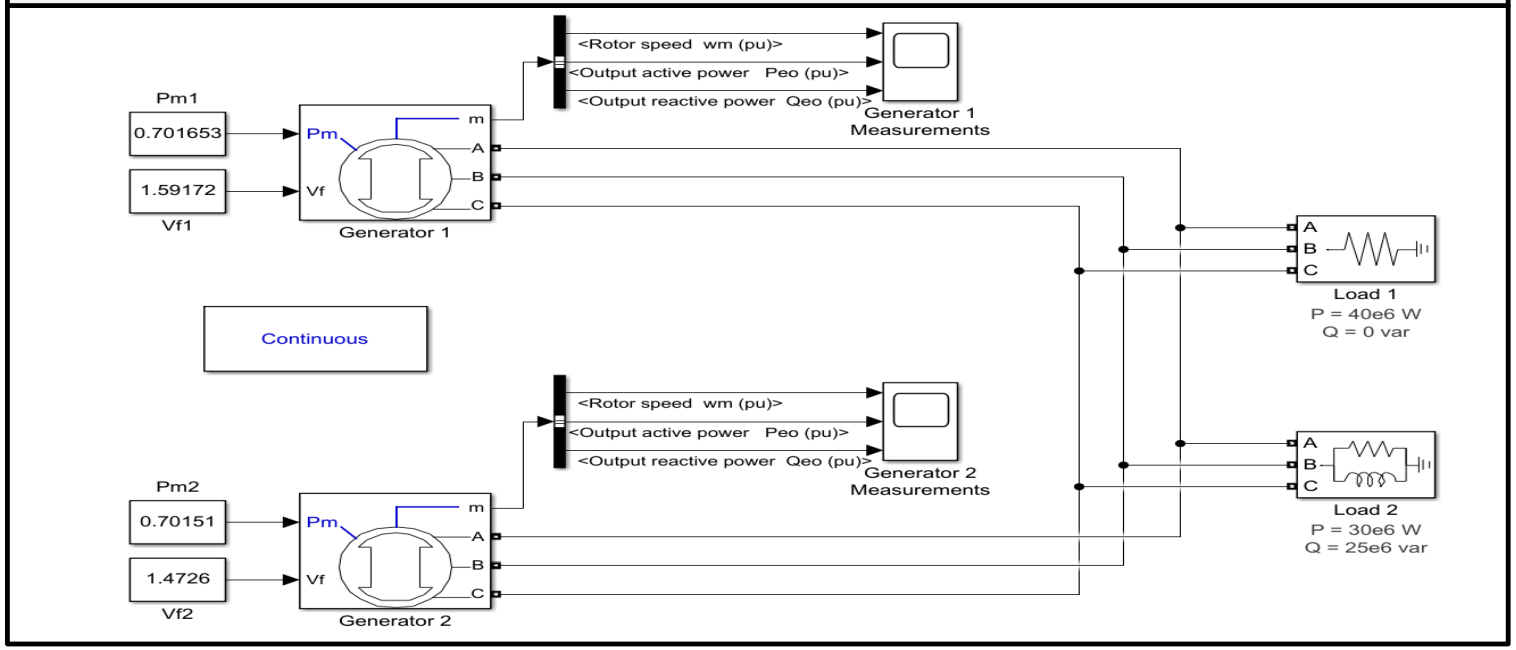
- Understand science behind your system
  - Inputs and outputs
  - Expected performance of system
  - Physical boundaries of model
- Breakdown your system
- Understand its safety features
- Customise the model



Subsystems

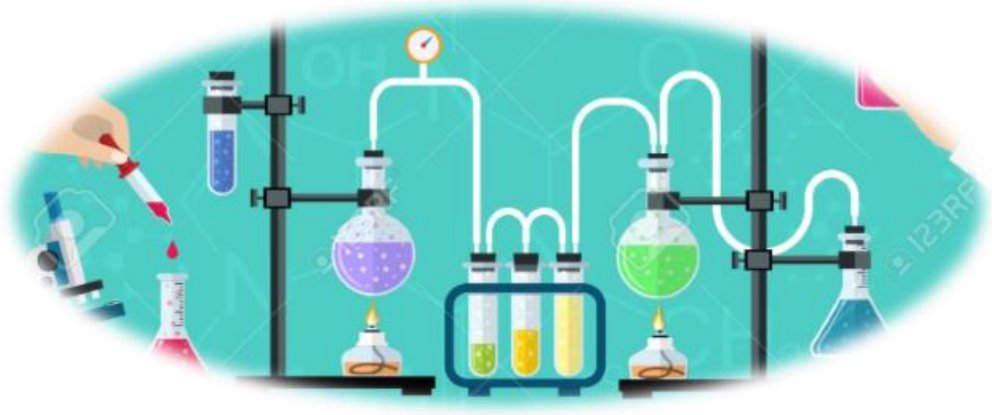
- Identify correct result for a subsystems
- Don’t re-invent the wheel
- Define the inputs and outputs
- Consider how to set the initial states
- Testing for physical boundaries
- Test the subsystem





Testing Subsystems

- Understand expected result
- Test the subsystem using real and validated test data
- Input incorrect variables
- Select suitable solver
  - Start with variable-step
  - Consider if appropriate to move to fixed-step
- Update on live document
  - Keep track of model updates
  - Easy for others to take on use of the model and understand the modeling process



ode45	• For linear electrical models
ode15s	• For nonlinear electrical numerically stiff models • Simulation inefficiently
ode23tb	• For nonlinear electrical models • Improves Simulation performance

Summary of Model-Based Design Process

- Connect all the subsystems
- Have you checked:
  - Physical boundaries
  - Initial conditions - Machine initialisation and load flow analysis
- Do not ignore any warnings or error
- Save the initialising states

Conclusion

- Science behind your system
- Difficult problem to solve
- Modelling and Simulation benefits on projects
- Commissioning time reduced
- Saved cost

Thank You

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