Aircraft Power Network

David Meissner, Application Engineer

Key Messages

- Design and Analyze Electrical and Power Systems
- Develop and Implement Logic and Controls
- Perform Verification and Validation

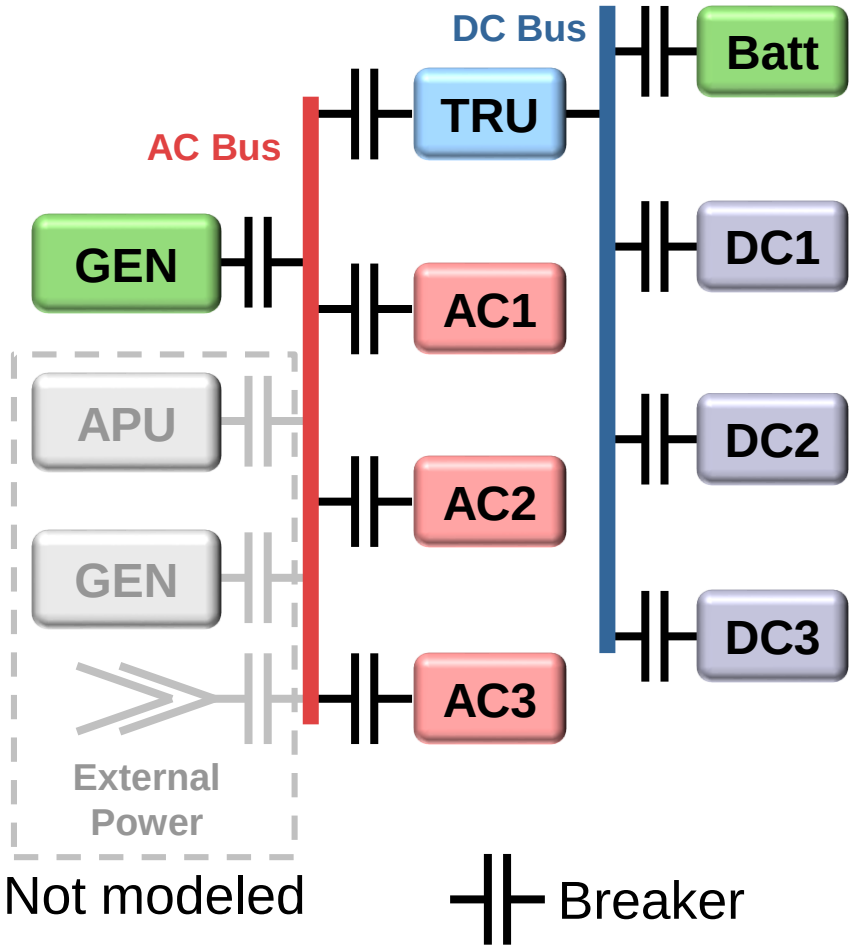
Agenda

- Intro / Overview
- Aircraft Power Network
- Physical Modeling
- Modeling Electrical and Power Systems
- Summary / Additional Resources

Aircraft Power Network

System for Analysis

- Half-aircraft model
  - One generator
  - AC bus with loads
  - TRU (Transformer-Rectifier Unit)
  - DC bus with loads and battery
- Breakers open and close during flight cycle



Aircraft Power Network

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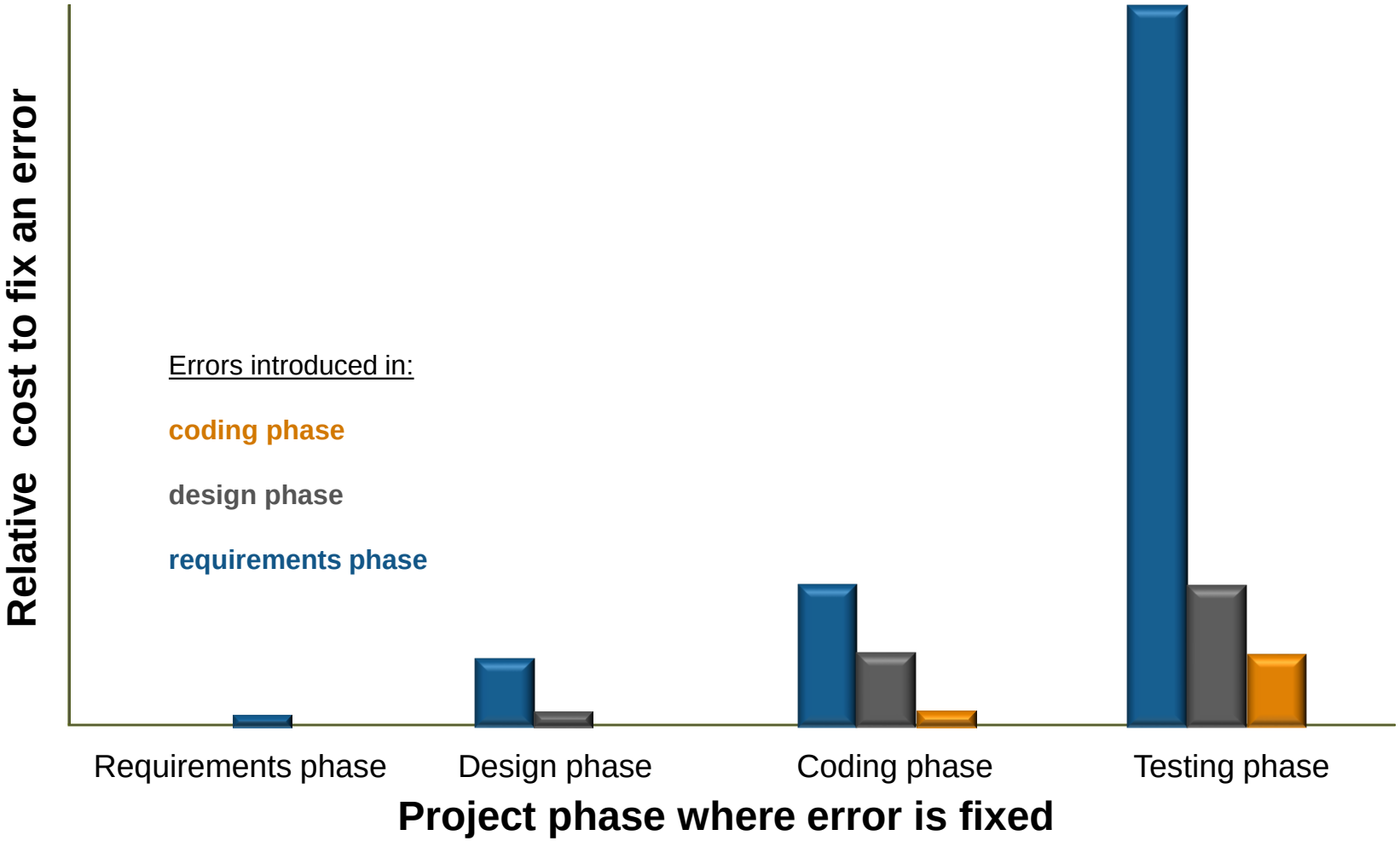
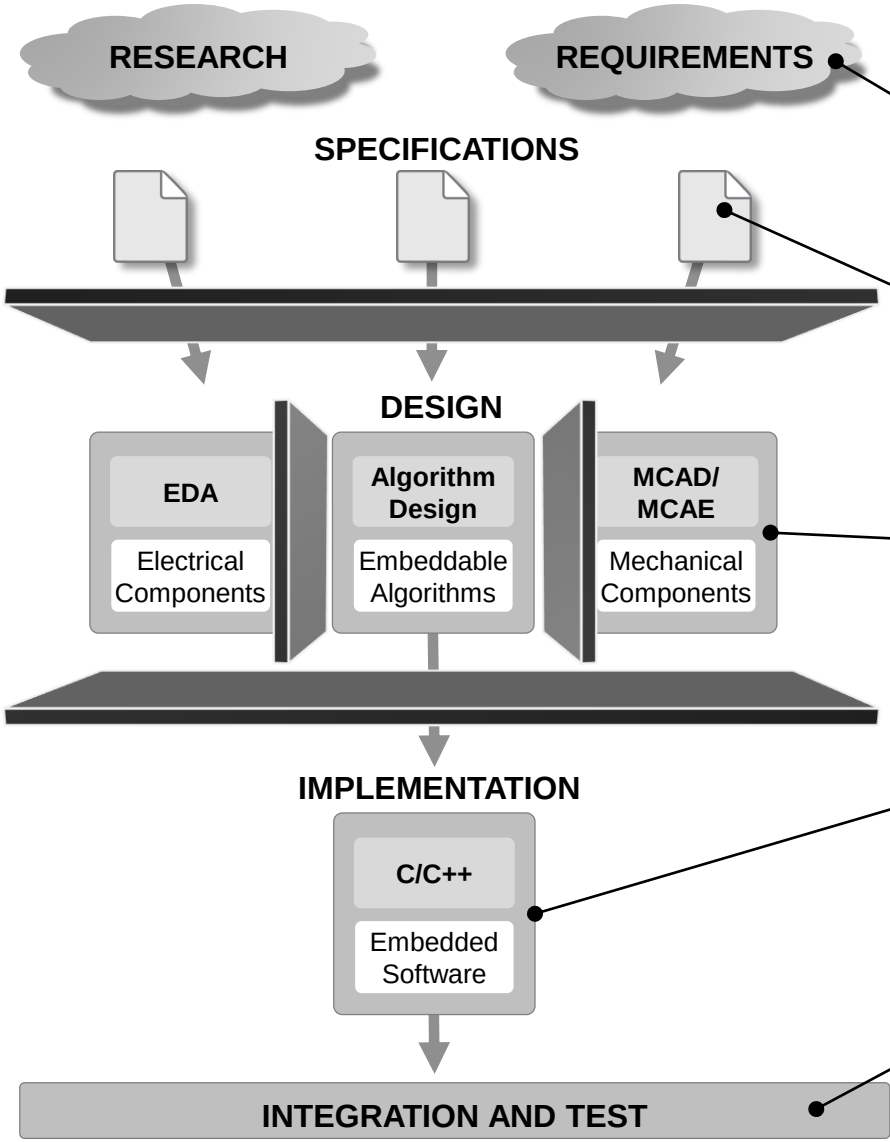
What is the Most Expensive Project Stage to Find Errors In?



Source: Return on Investment for Independent Verification & Validation, NASA, 2004.

Traditional Development Process



Requirement Documents
- Difficult to analyze
- Difficult to manage as they change

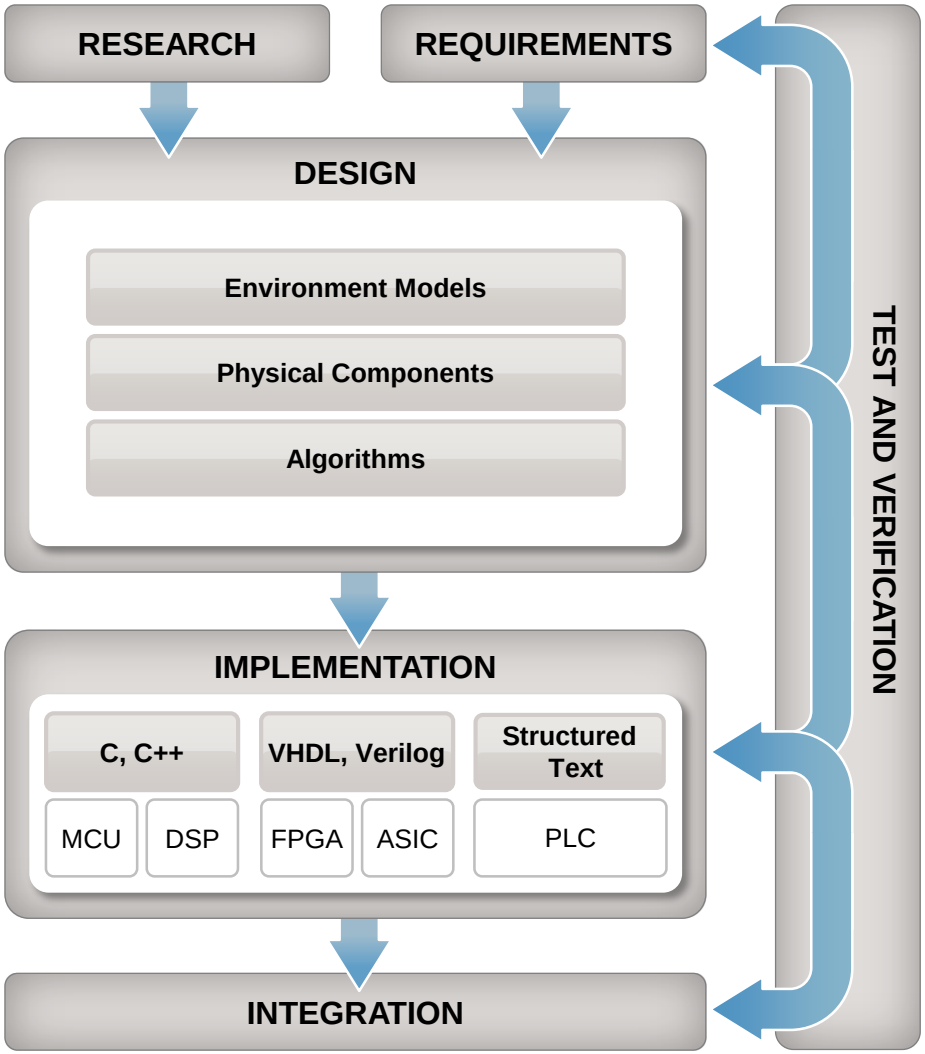
Paper Specifications
- Easy to misinterpret
- Difficult to integrate with design

Physical Prototypes
- Incomplete and expensive
- Prevents rapid iteration
- No system-level testing

Manual Coding
- Time consuming
- Introduces defects and variance
- Difficult to reuse

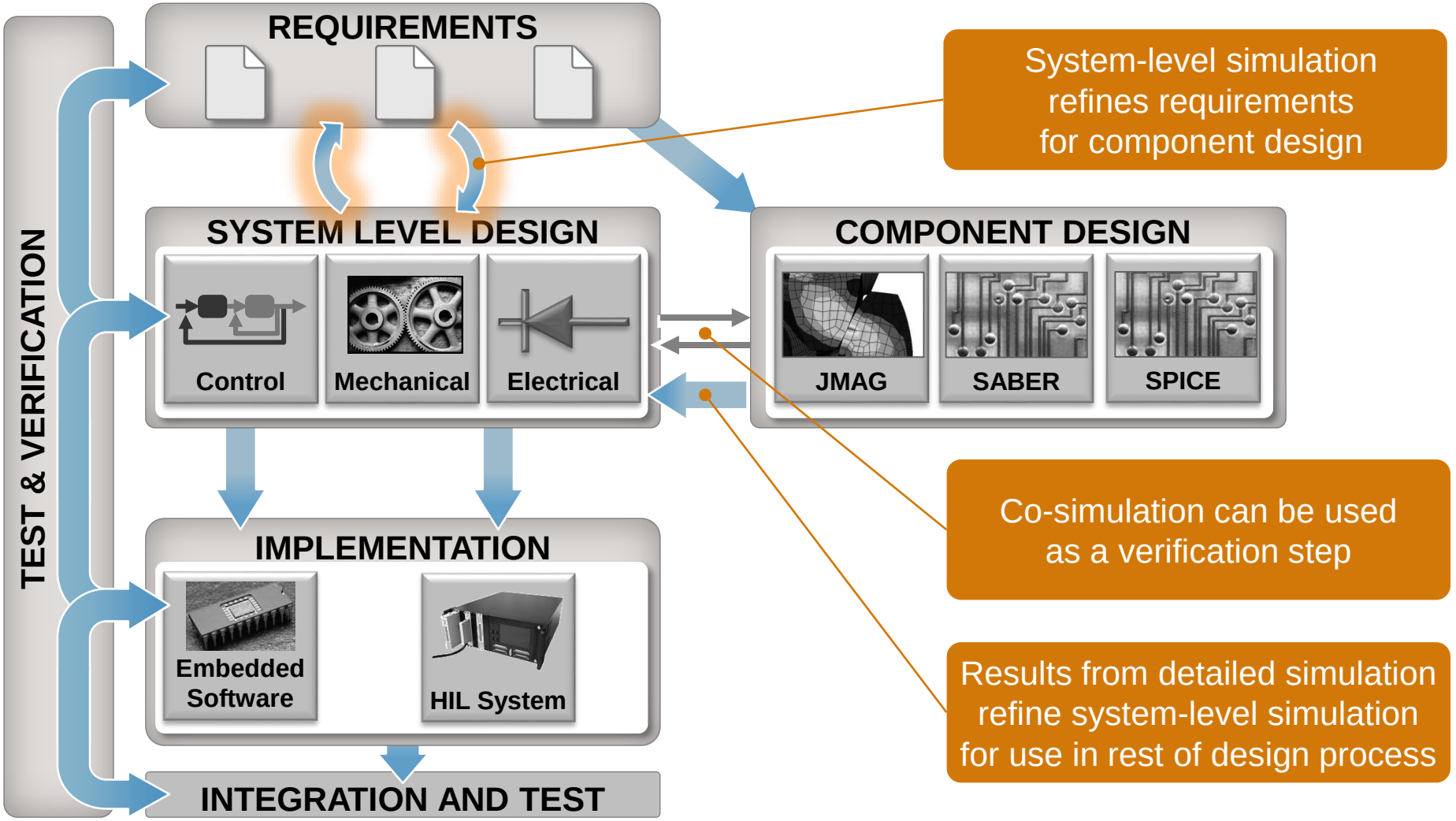
Traditional Testing
- Design and integration issues found late
- Difficult to feed insights back into design process
- Traceability

Model-Based Design



Model-Based Design

System and Component Level Design



Requirements Traceability

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- Overview of Aircraft Power Network Model
- Model Based Design
- Requirements Traceability
- Transformer Rectifier Unit
- Logic and Controls
- SimElectronics vs SimPowerSystems

Transformer Rectifier Unit

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Logic and Controls

- Synchronizing Breaker
- Voltage Regulator

Agenda

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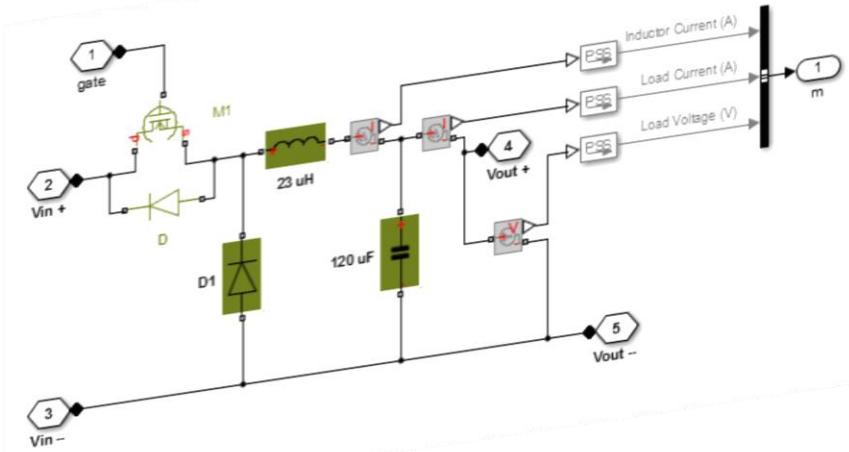
- SimElectronics vs SimPowerSystems

SimElectronics or SimPowerSystems?

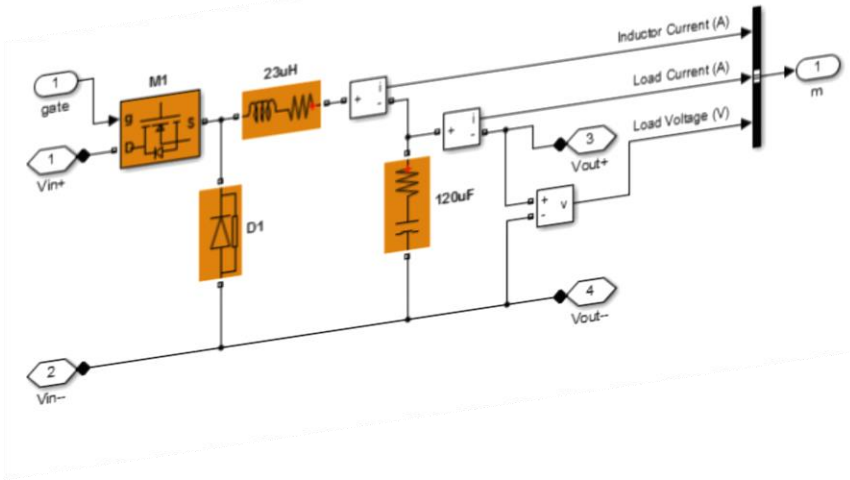


SimElectronics

Simultaneous nonlinear equations solution
SPICE level switching device models
Include switching losses
Include parasitic current effects
Include temperature effects
Higher fidelity simulation

SimPowerSystems

Piecewise linear systems solution
Multiphase bridges and pulse generators
Detailed and average voltage models
Transient and harmonic analysis
Faster simulation

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SimElectronics or SimPowerSystems?

SimElectronics

SimElectronics › Semiconductor Devices

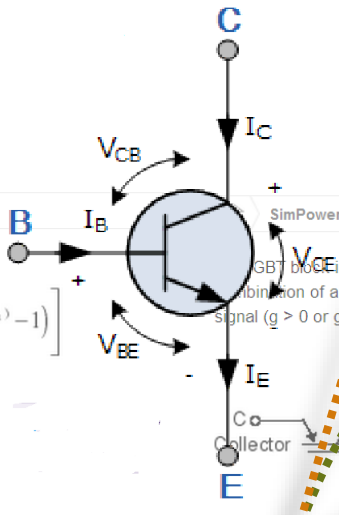
The collector and base currents are [1]:

$$I_C = -IS\left[\left(e^{-qV_{BE}/(kT_{m1})} - e^{-qV_{BC}/(kT_{m1})}\right)\left(1+\frac{V_{BC}}{V_A}\right) - \frac{1}{\beta_R}\left(e^{-qV_{BC}/(kT_{m1})}-1\right)\right]$$

$$I_B = -IS\left[\frac{1}{\beta_F}\left(e^{-qV_{BE}/(kT_{m1})}-1\right) + \frac{1}{\beta_R}\left(e^{-qV_{BC}/(kT_{m1})}-1\right)\right]$$

Where:

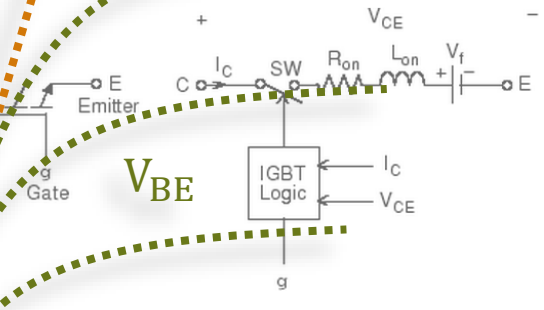
- I_B and I_C are base and collector currents, defined as positive into the device.
- IS is the saturation current.
- V_{BE} is the base-emitter voltage and V_{BC} is the base-collector voltage.
- β_F is the ideal maximum current gain BF
- β_R is the ideal maximum current gain BR
- V_A is the forward Early voltage VAF
- q is the elementary charge on an electron (1.602176e-19 Coulombs).
- k is the Boltzmann constant (1.3806503e-23 J/K).
- T_{m1} is the transistor temperature, as defined by the **Measurement temperature** parameter value.



SimPowerSystems

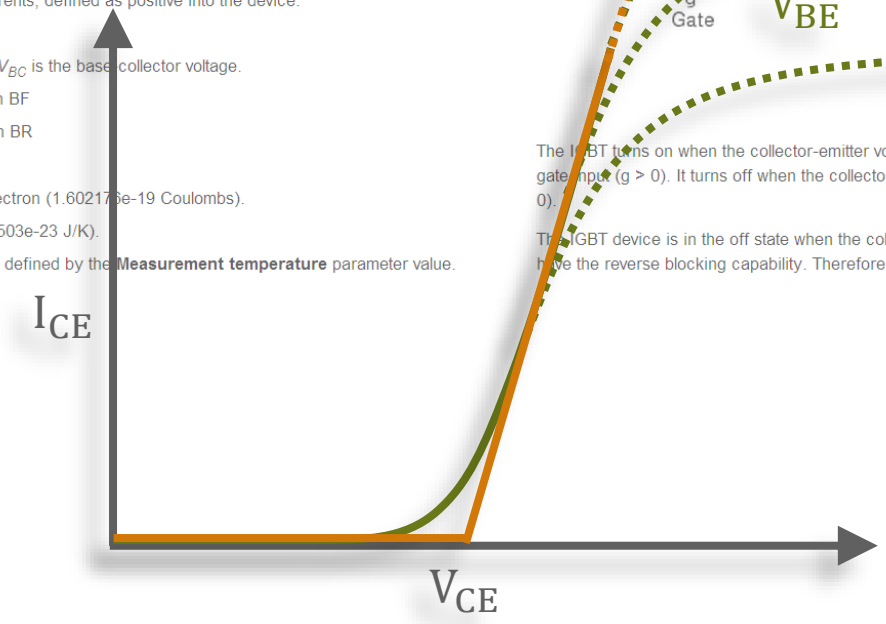
SimPowerSystems › Specialized Technology › Power Electronics

IGBT block implements a semiconductor device controllable by the gate signal. The IGBT is simulated as a series combination of a resistor Ron, inductor Lon and a DC voltage source Vf in series with a switch controlled by a logical signal (g > 0 or g = 0)



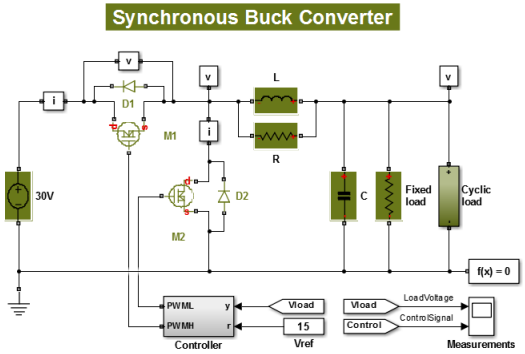
The IGBT turns on when the collector-emitter voltage is positive and greater than Vf and a positive signal is applied at the gate input (g > 0). It turns off when the collector-emitter voltage is positive and a 0 signal is applied at the gate input (g = 0).

The IGBT device is in the off state when the collector-emitter voltage is negative. Note that many commercial IGBTs do not have the reverse blocking capability. Therefore, they are usually used with an antiparallel diode.

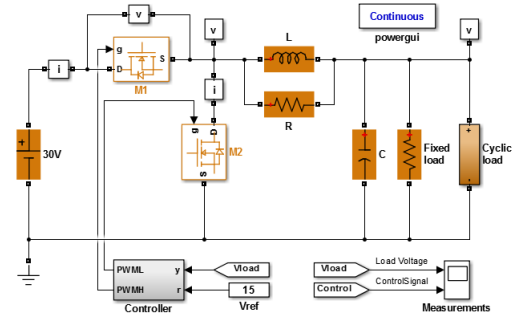


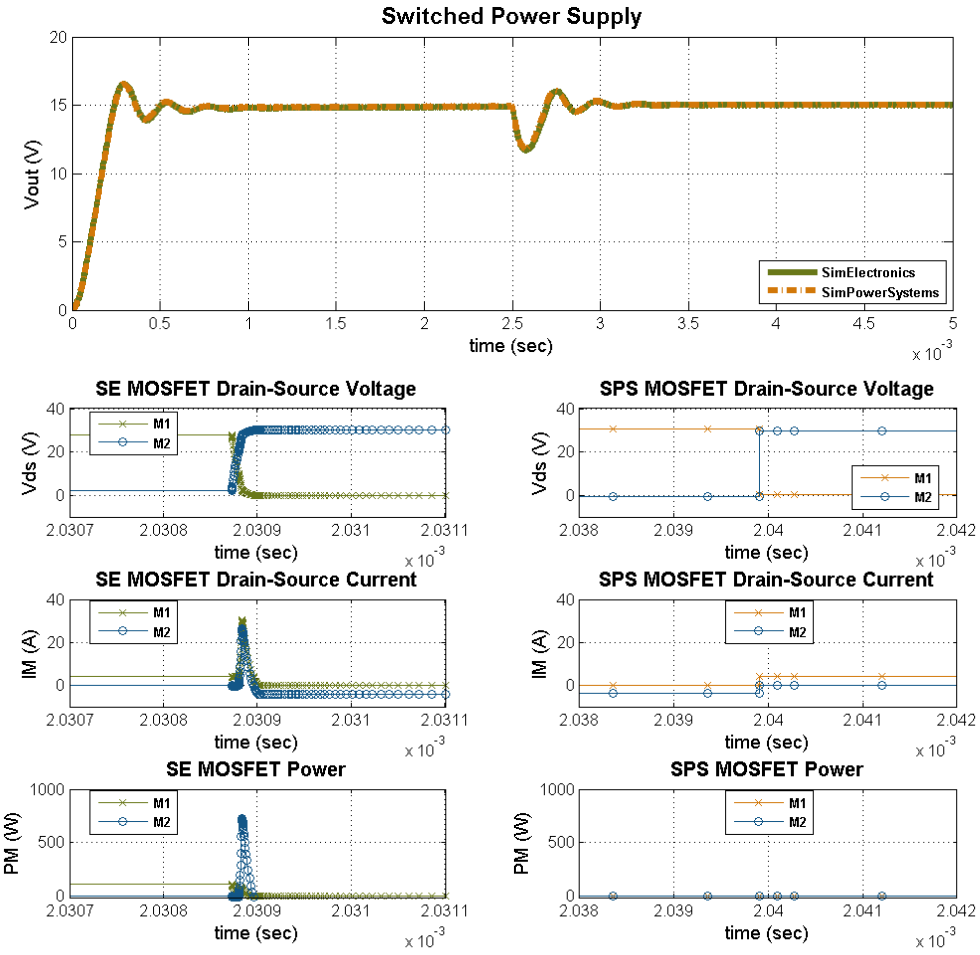
SimElectronics or SimPowerSystems?

SimElectronics



SimPowerSystems



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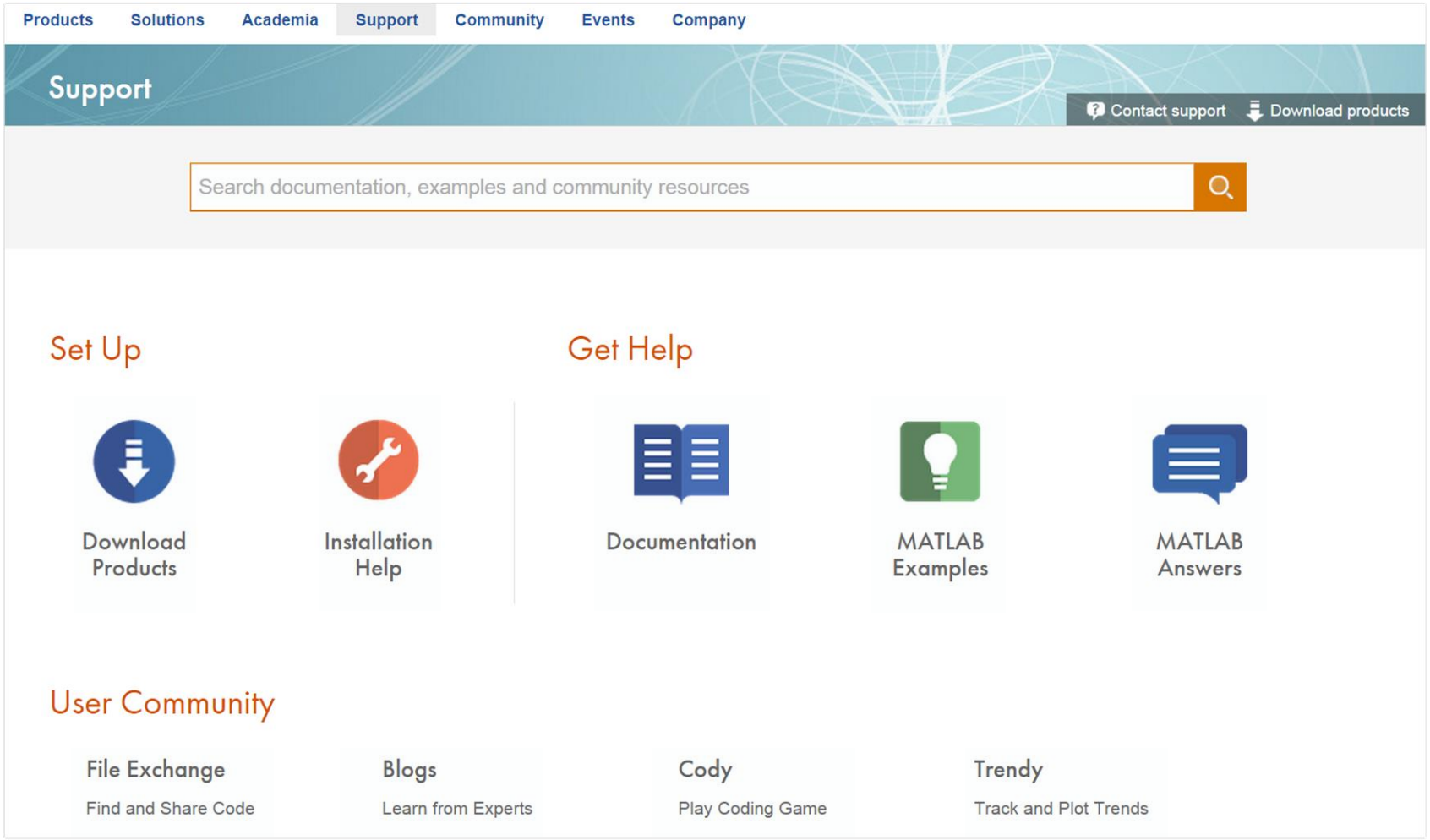
Summary

- Design and Analyze Electrical and Power Systems
- Develop and Implement Logic and Controls
- Perform Verification and Validation

Additional Resources

- Videos and Webinars
  - Aircraft Power Network (4:58)
  - Automatic Report Generation for Aircraft Power Network (2:30)
  - Running Parallel Simulations of Aircraft Flight Cycles (5:00)
  - Aircraft Power Network Development with MBD (46:41)
- Example: Aircraft Power Network on MATLAB Central
- Documentation: (SimElectronics) (SimPowerSystems)
- Tutorials: Build and Simulate a Simple Circuit
- Training: Physical Modeling: Electrical Power Systems
- Consulting: Proven Solutions from MathWorks Consulting

Support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