HVAC Drive System Analysis

Dennis Steward – Ansoft

David Divins – International Rectifier

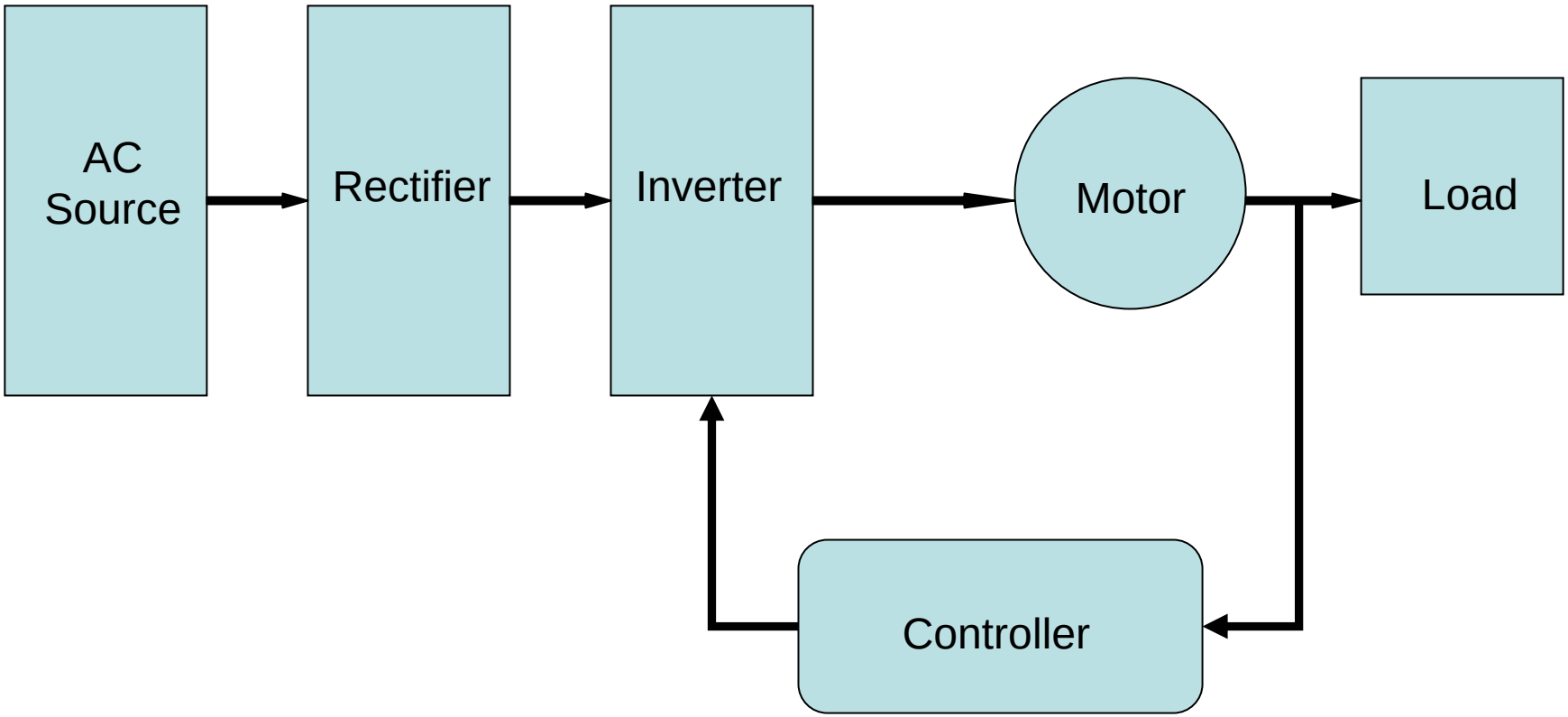
LeadingInsight

Application Workshops for High-Performance Design

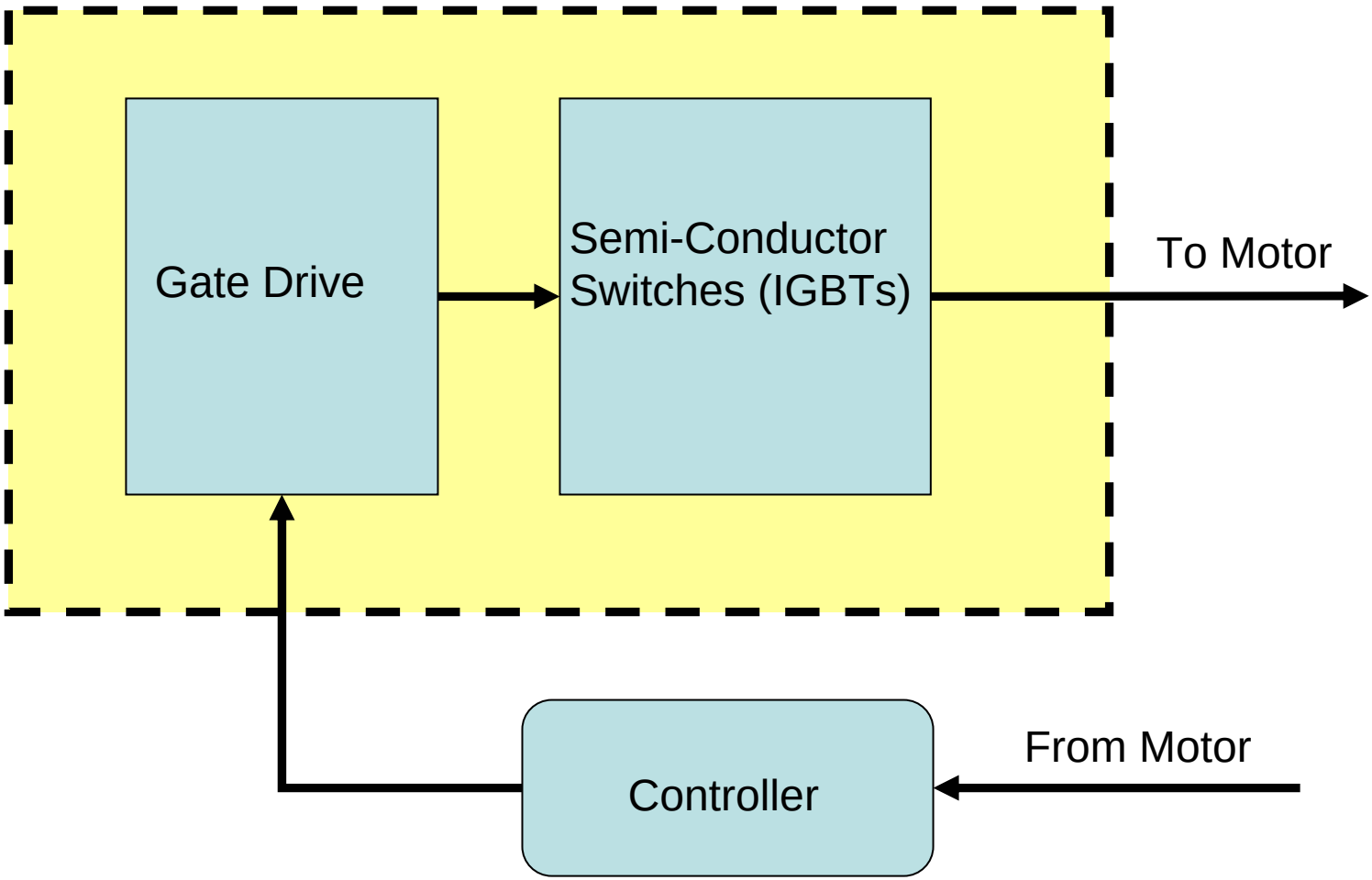
Presentation Goals

- Consider HVAC Drive System
- Discuss relative benefits of Modular Drive IC vs. Discrete Component construction
- Highlight Analysis Capabilities in Simplorer
  - Details of Systems may be Studied
  - Hierarchical Modeling
- Describe Further Analysis Options
  - Dynamic IGBT Parameterization
  - Optimization

Basic Components Of a Drive System



Inverter Components



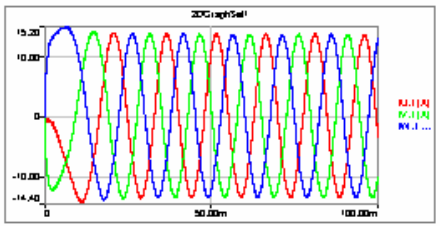
Modular Drive Considerations

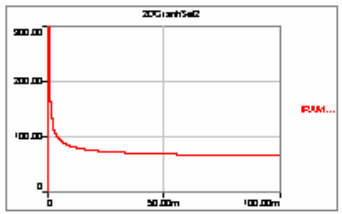
- Fewer Components to Place on PCB
- Smaller Footprint than Discrete Design
- Easier Heatsink Application
- Gate Drive Design Is Fixed
- May Be More Economical than Discrete Design

Modular Drive System
Top Level Schematic

International Rectifier IRAMS10UP60A Integrated Power Module Simulation

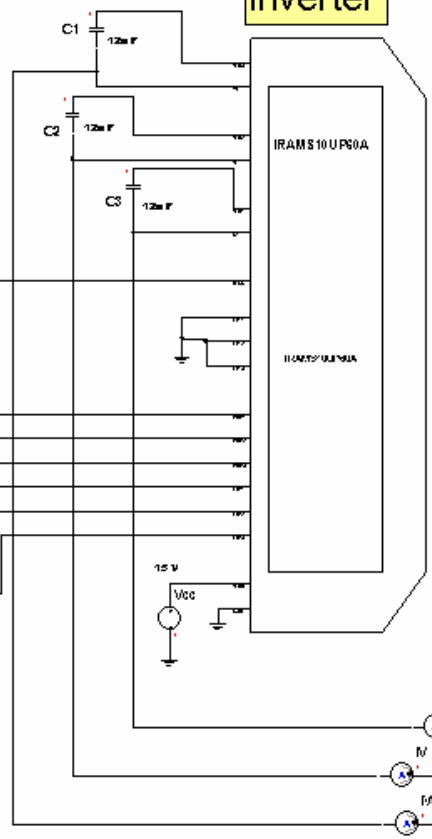
Phase Currents



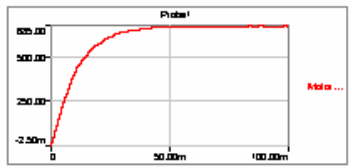


Power Loss

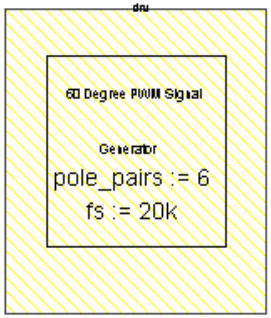
Inverter



Motor Speed

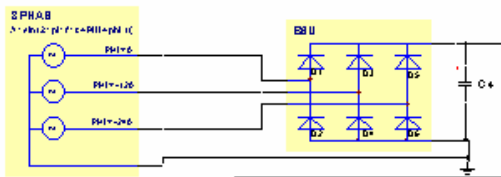


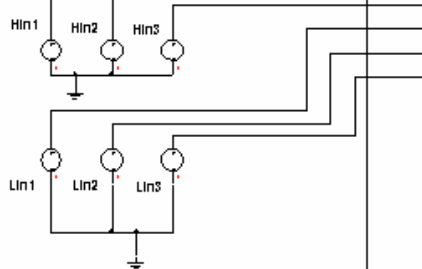
60 Degree PWM Signal Generator



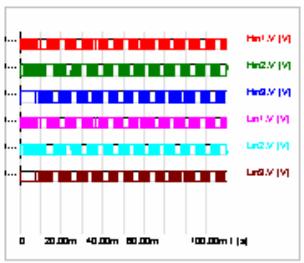
AC Source

Rectifier

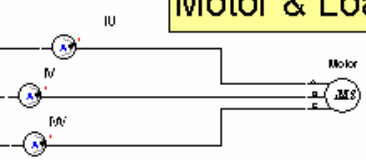




Switching Signals



Motor & Load



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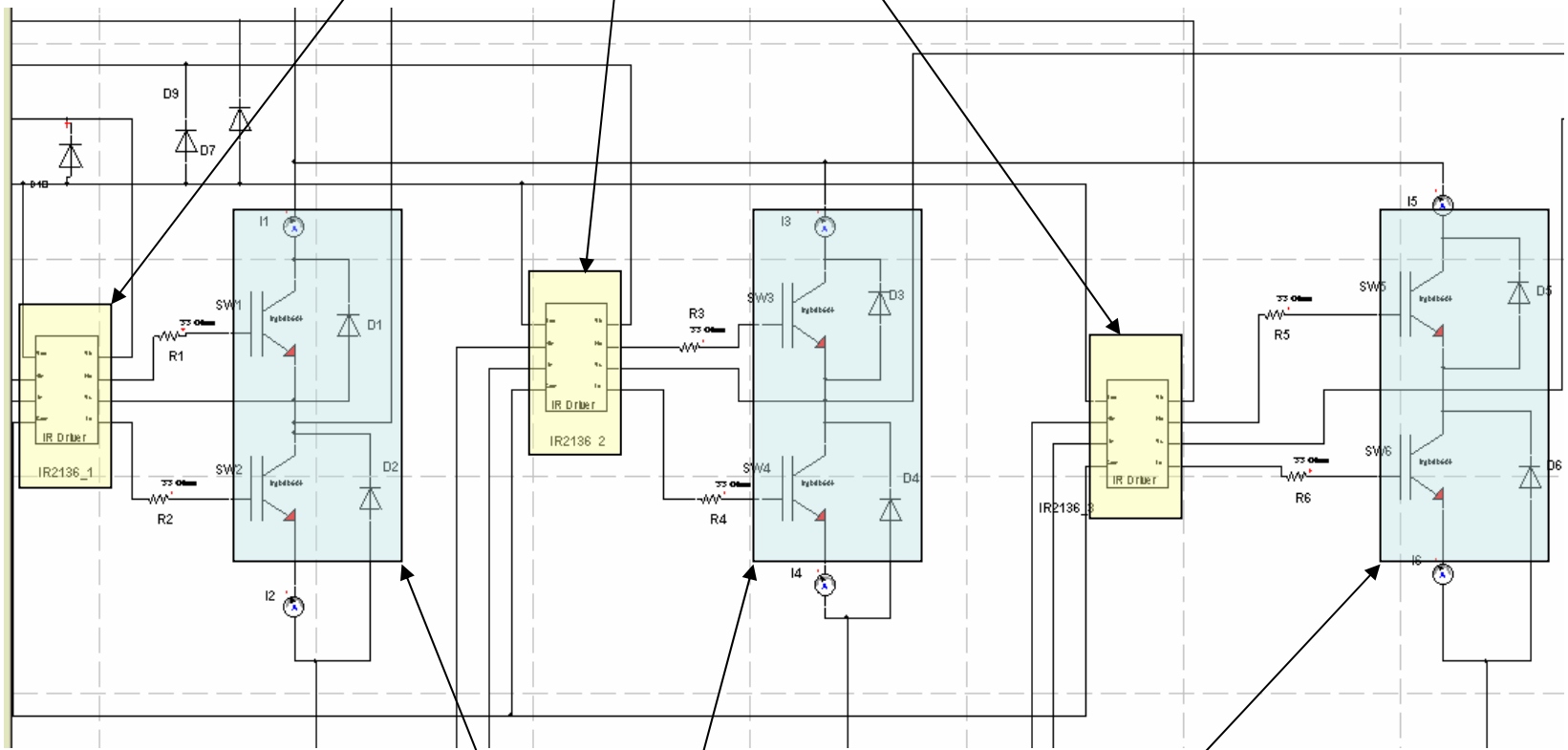
IOR International Rectifier

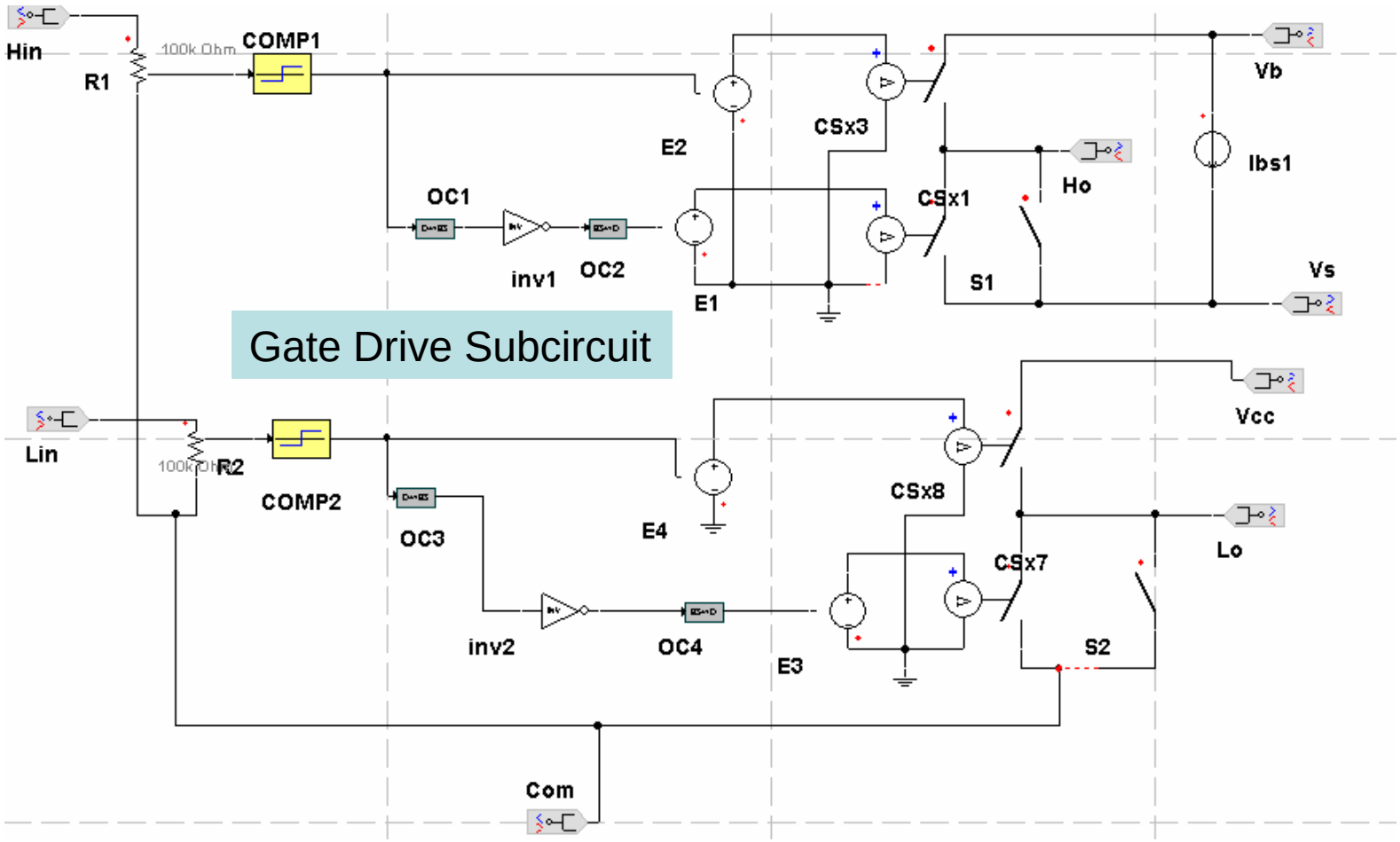
Hierarchical Modeling
First Subsheet Level

Three-Phase Gate Driver



IGBTs and Free-Wheeling Diodes (FWDs)
From Converted SPICE Models

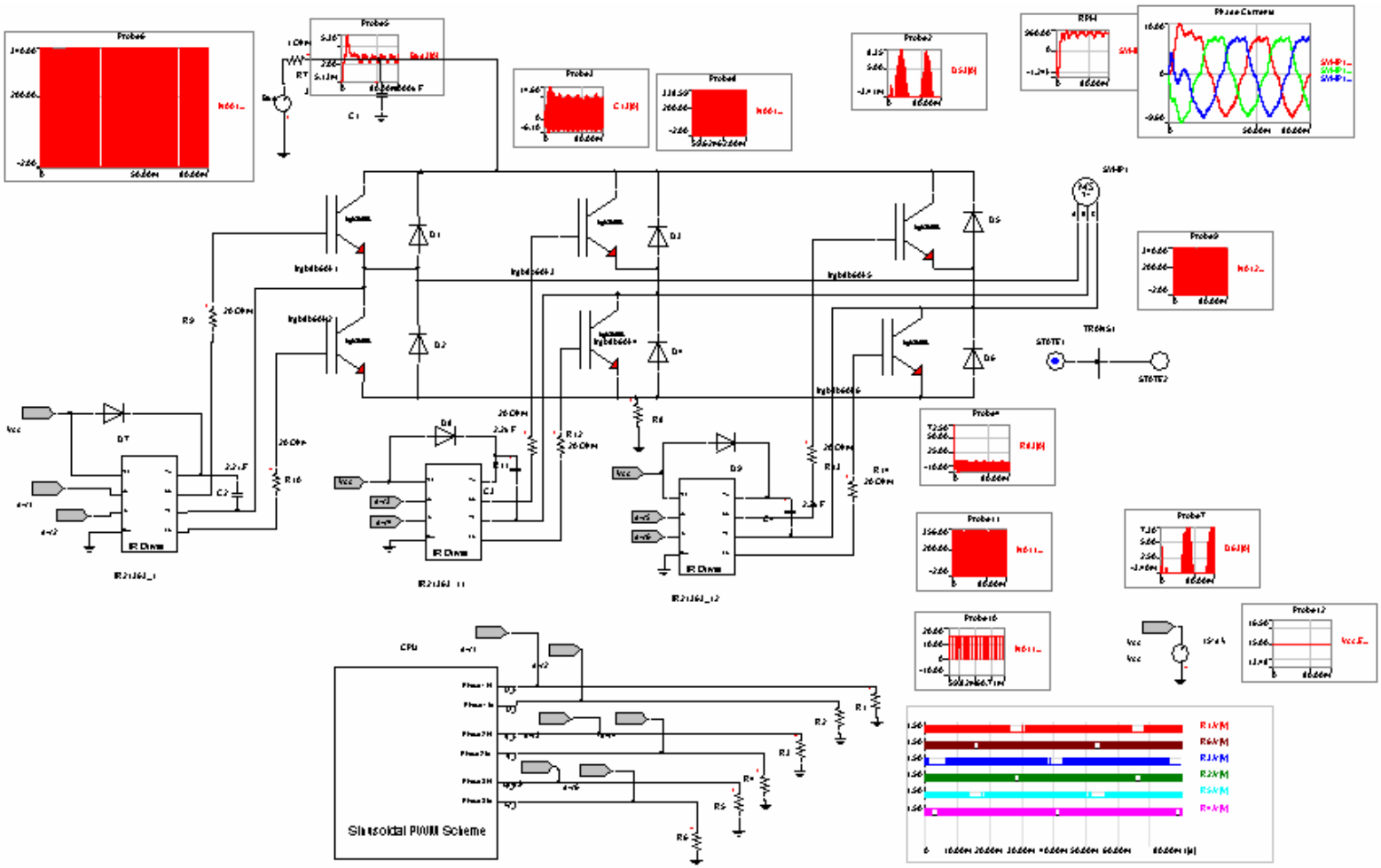
Hierarchical Modeling
Second Subsheet Level



Discrete Drive Considerations

- More Components to Place on PCB
- Larger Footprint than Discrete Design
- More Challenging Heatsink Design
- Full Control Over Gate Drive
- May Be More Economical than Modular Design

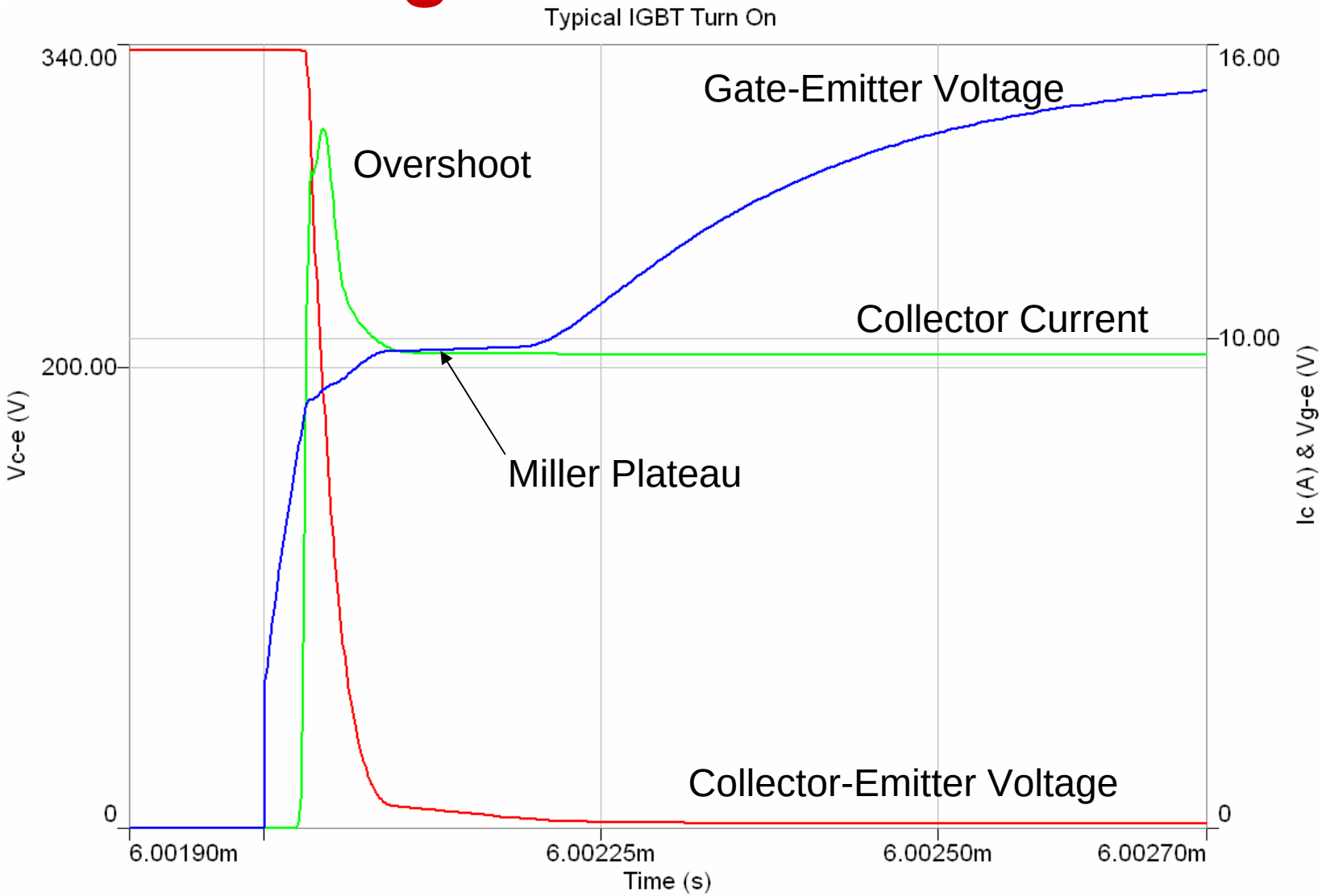
Discrete Drive System



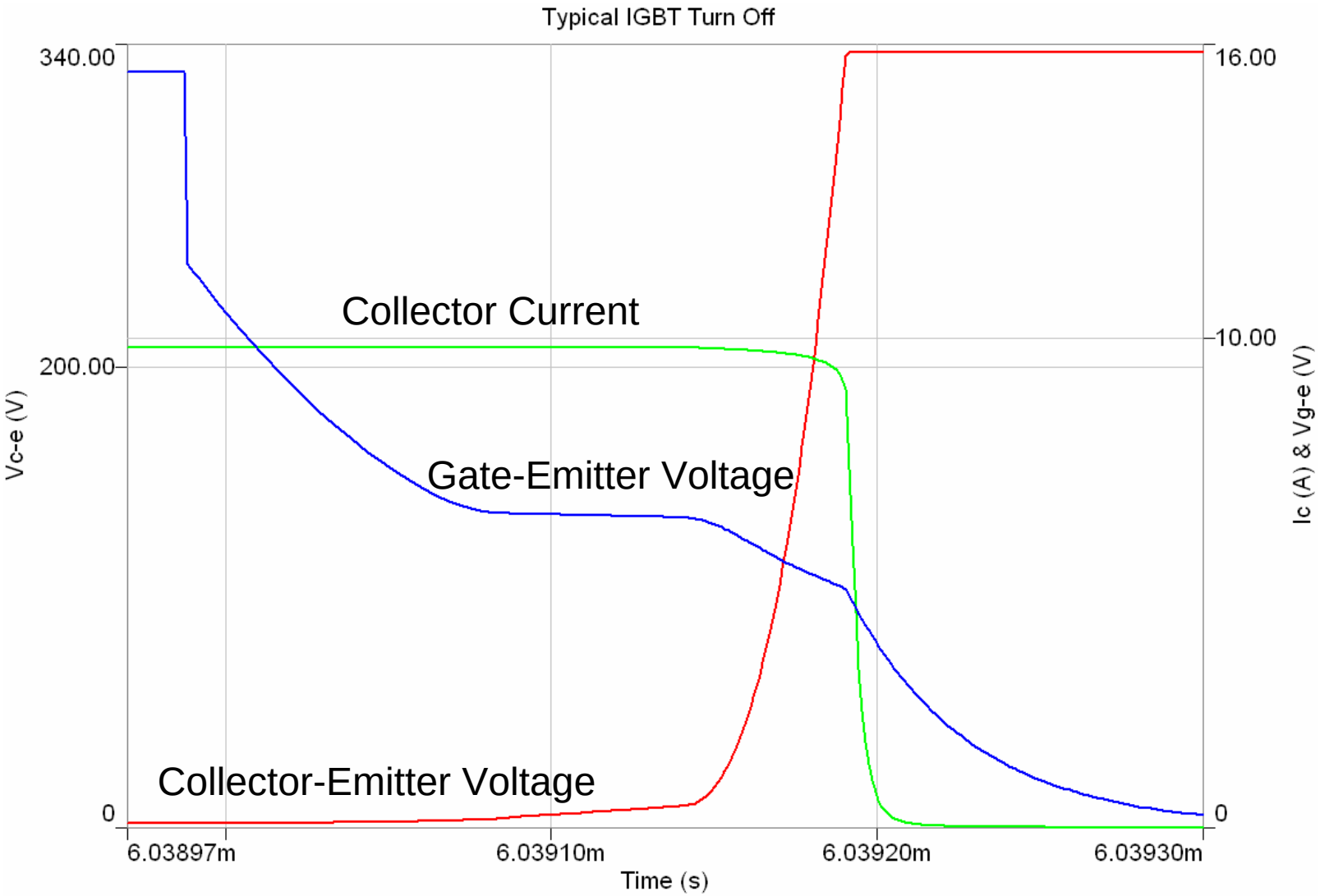
Why Simulate ?

- Cheaper than Building and Testing
- Faster Than Building and Testing
- Quickly Gain Insight into System
  - Power Dissipation
  - Thermal Considerations
  - PWM Strategy Comparison
  - Load Modeling
  - EMI / EMC Issues
- Entire System may be validated

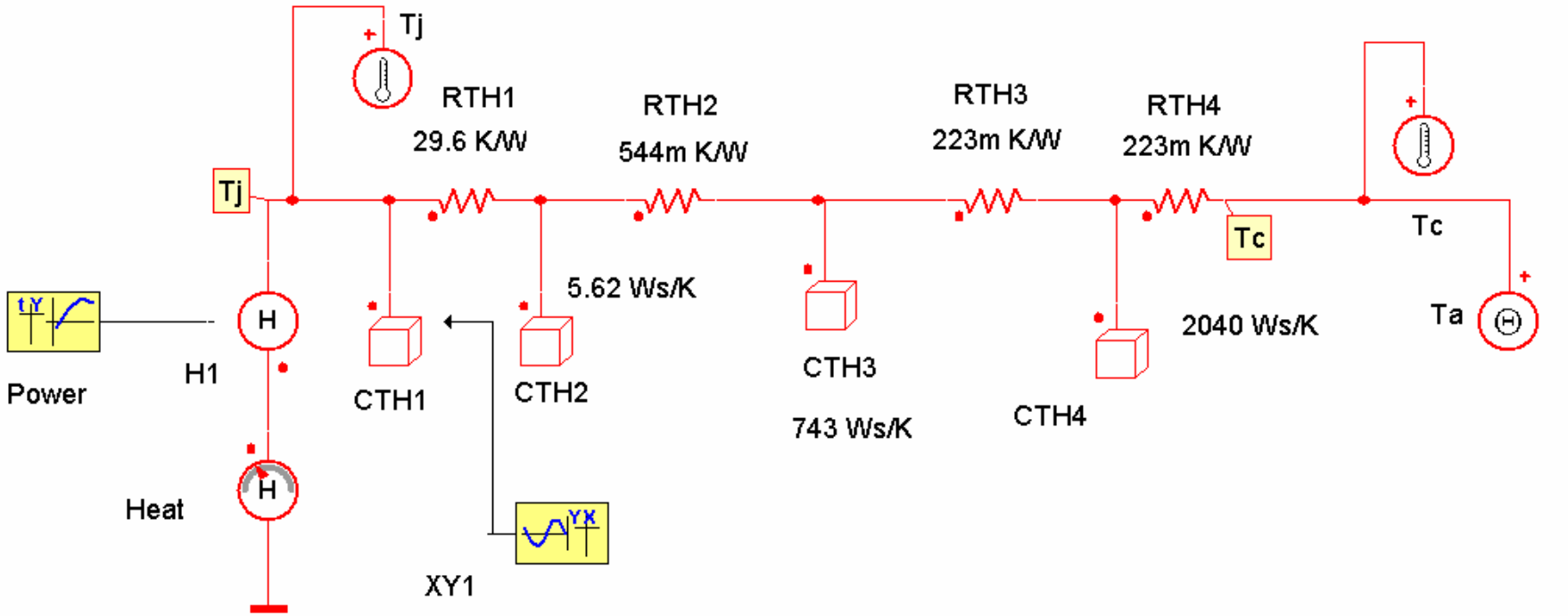
Switching Behavior – Turn On



Switching Behavior – Turn Off



Typical Thermal Equivalent Network



PWM Strategies

- Sinusoidal
  - Easiest scheme to understand and implement
  - Maximum phase voltage is 50% of the bus
  - Phase current is sinusoidal
  - Motor Line to Neutral is 50% of the bus voltage
- 60 Degree PWM
  - Reduces Switching losses
  - Motor Line to Neutral includes all of the triple harmonics (3^{rd}, 9^{th}, 15^{th}, 21^{st}, 27^{th}, etc…)
  - Provides 57.8% bus utilization
  - Phase current is sinusoidal

PWM Strategies

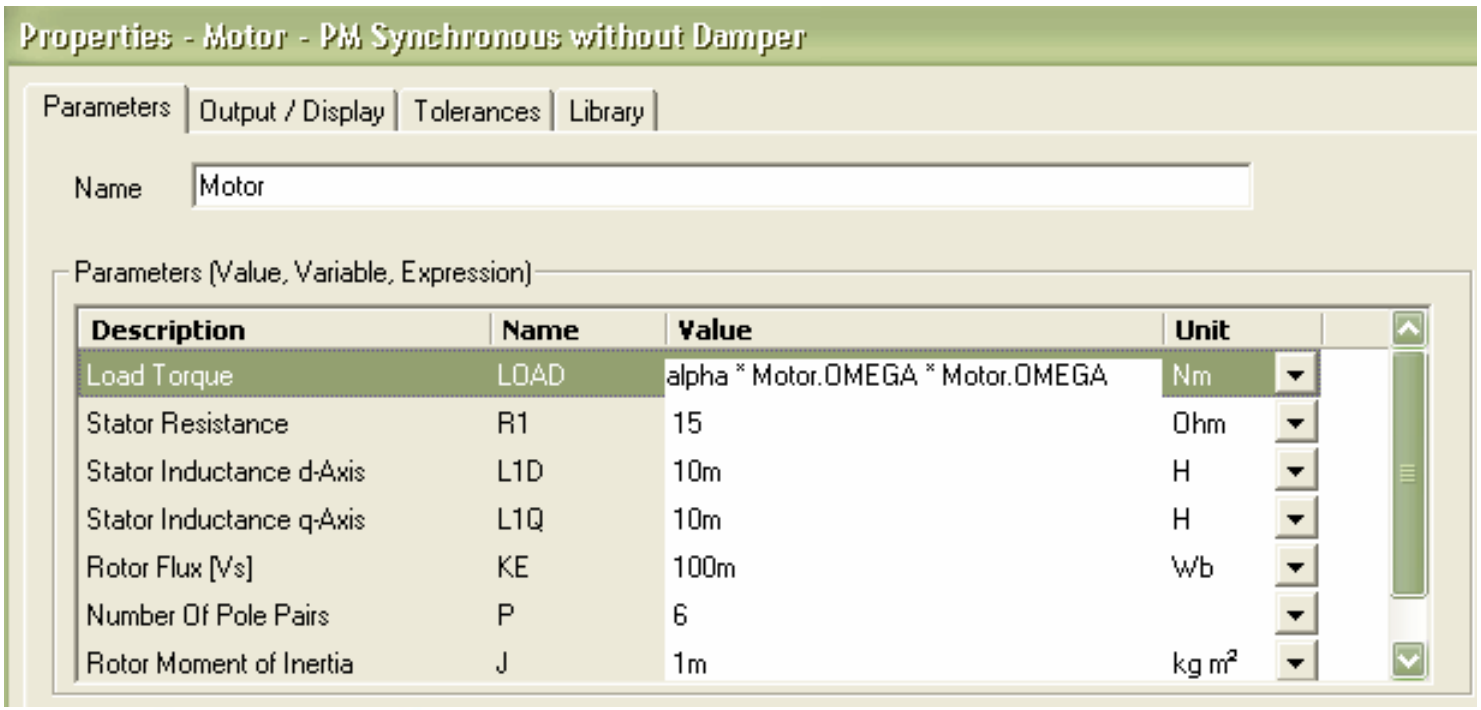
- Space Vector Modulation
  - Utilizes 58.7% of the bus voltage
  - Believed to have better harmonic performance
  - Better aligned with digital techniques
  - Multiple variations
  - Phase Current is Sinusoidal
- 6 Step
  - Low switching loss
  - Estimated to have higher than 57.8% bus utilization
  - Phase current is trapezoidal
  - Tends to cause torque ripple in the motor

PWM Comparison
60 Degree vs. Sinusoidal

- Compare Power Dissipation
  - 60 Degree PWM vs. Sinusoidal PWM
  - Average Losses Lower For Sinusoidal Drive
  - 40.0W vs. 45.5W
- BUT!
  - 60 Deg Drive Delivers 19% more power to Motor for the same DC bus Voltage due to increased Bus Utilization

Motor Load (Fan)

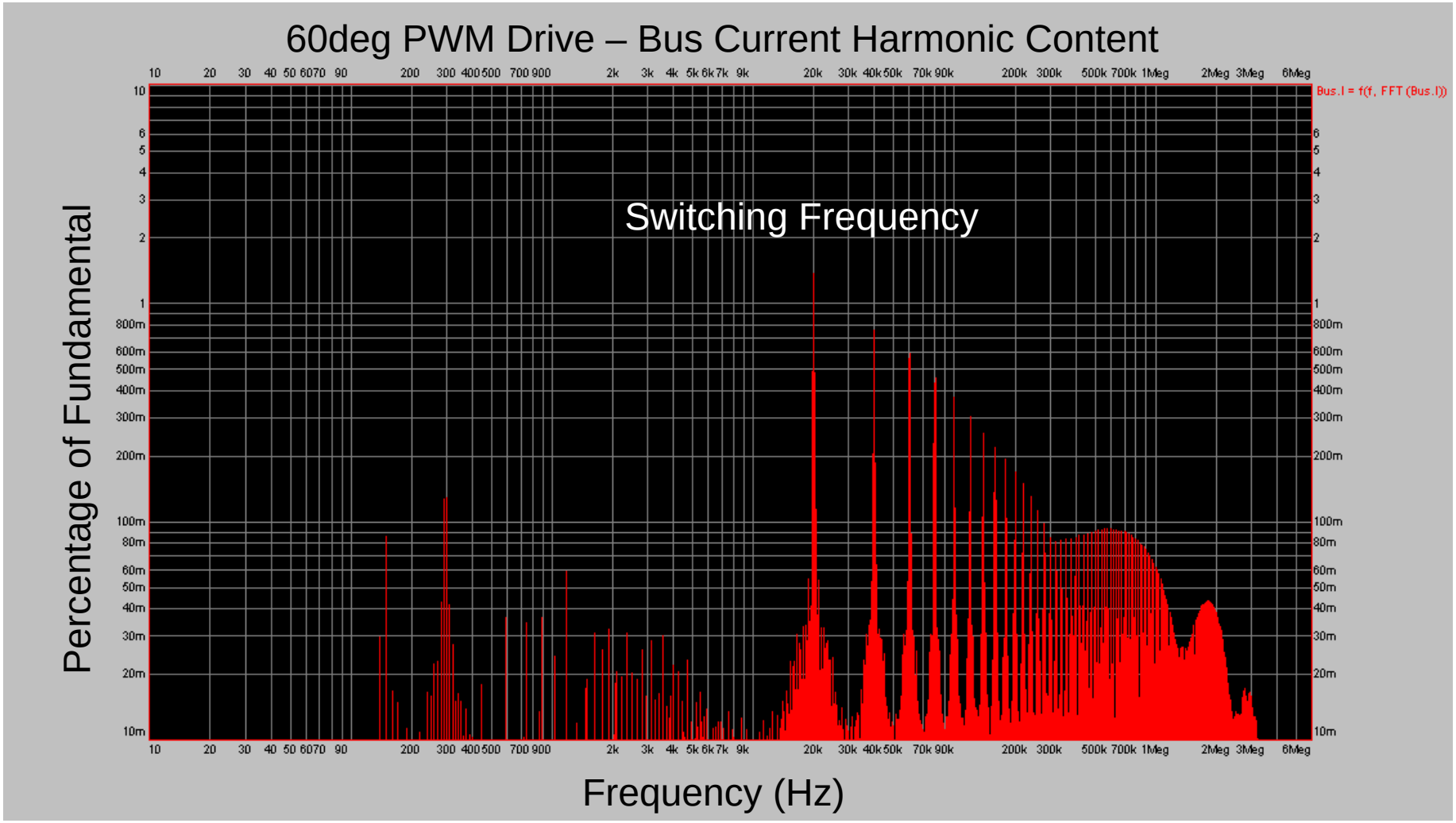
- Fan Load Increases as the Square of the Motor Speed
- Easily Implemented in Motor Model



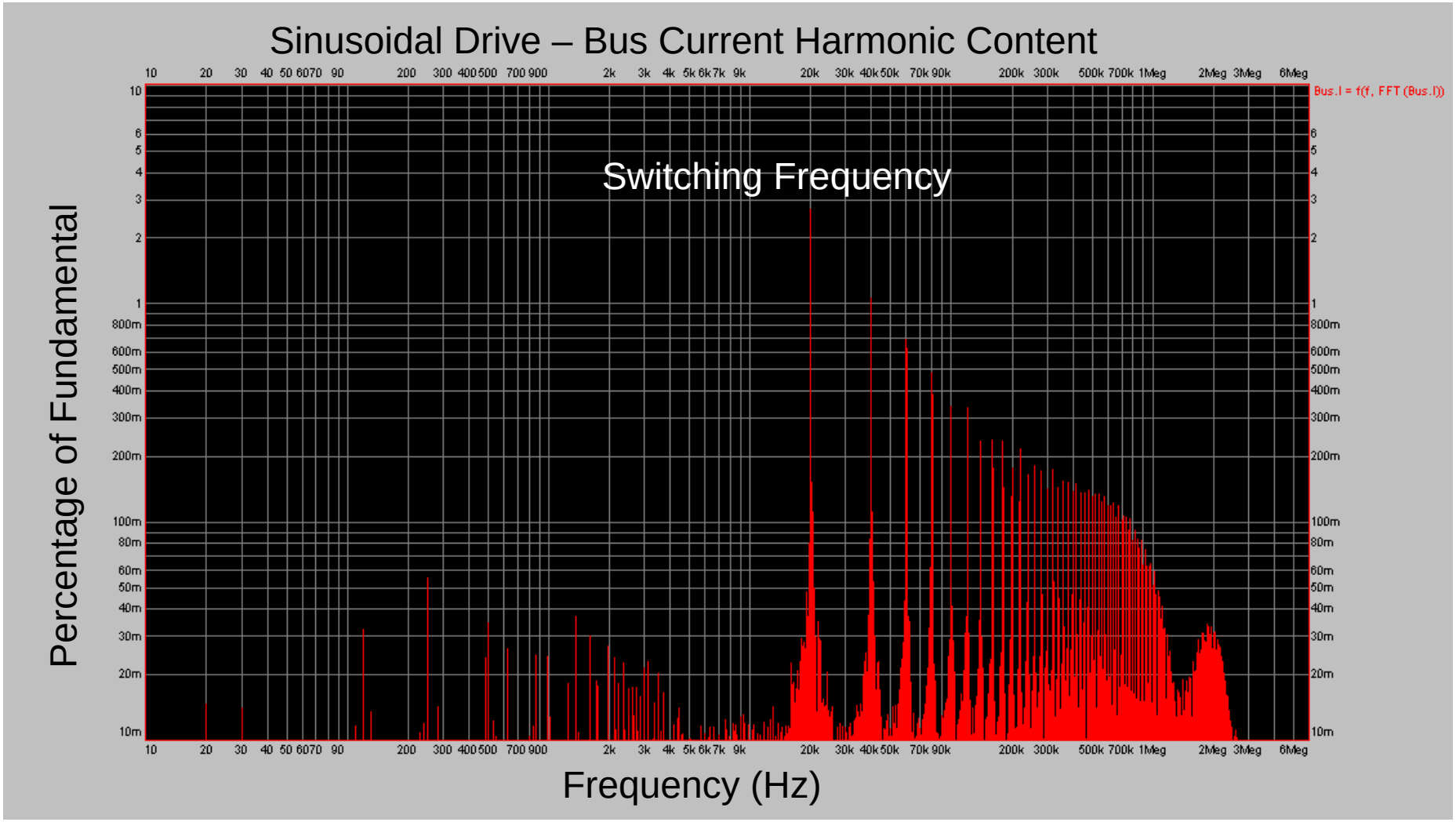
EMI / EMC Analysis

- Using Simplorer's FFT Tools, relative comparisons of Harmonic Content may be made.
- Conducted EMI is more easily analyzed
- Radiated EMI could be analyzed with HFSS
- Sinusoidal Drive Creates more Low Frequency Harmonics than 60deg Drive

EMI / EMC Analysis



EMI / EMC Analysis



Further Analysis

- Use Dynamic IGBT Models created with the Parameterization Wizard
- Use RMxprt Model for Motor
- Use ePhysics to analyze Thermal System

Conclusions

- Simplorer can be used to accurately predict Power Dissipation
- Simulation Provides Insight into EMI Issues and Thermal effects
- Different Switching Strategies May be Studied Easily
- Complete System Is Represented