

# Bond Graph Modeling, Pt. 2 and a Brief Introduction to Simulink

Joshua Langsfeld

COMP 517

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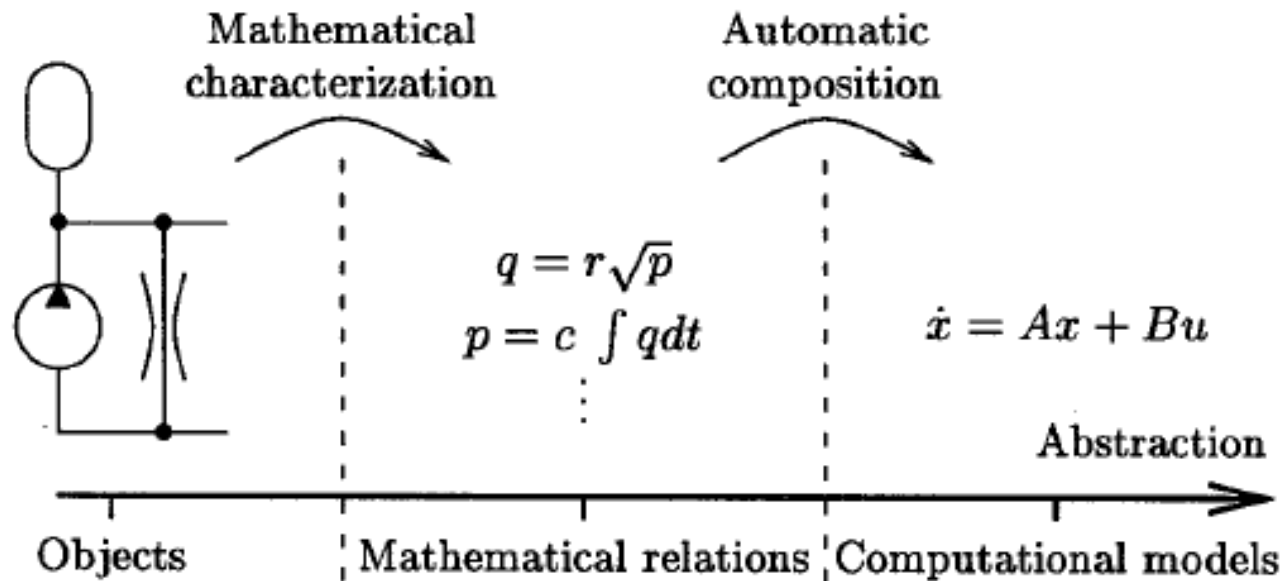
# Switched Bond Graphs as Front-End to Formal Verification of Hybrid Systems

Stromberg, Jan Erik  
Nadjm-Tehrani, Simin  
Top, Jan

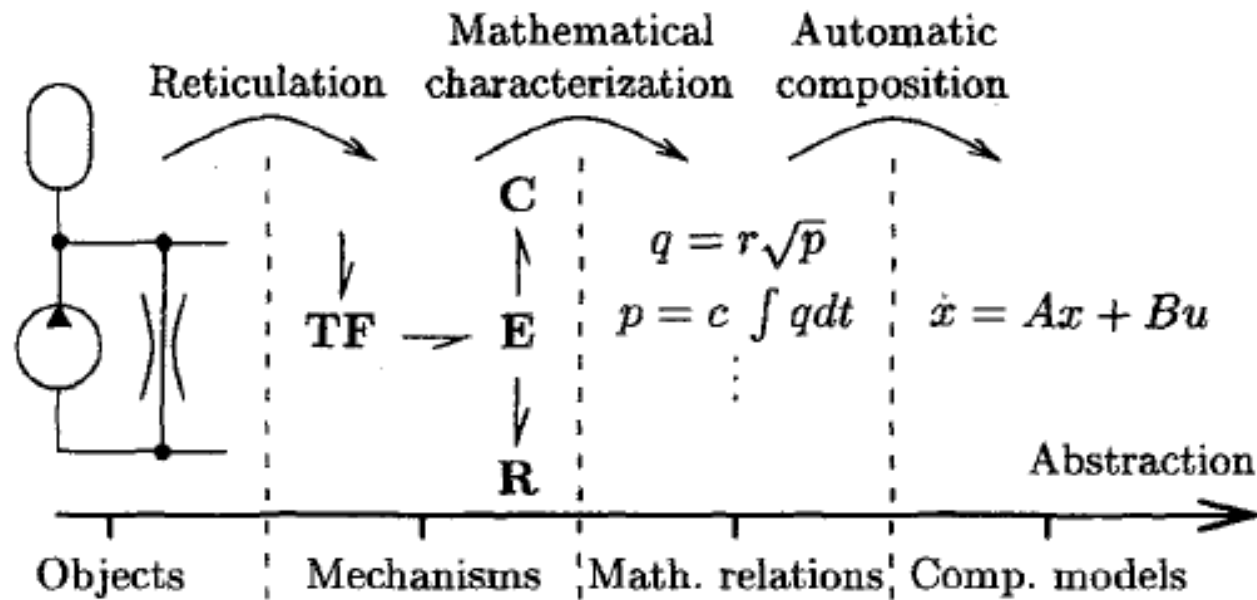
# Modeling Procedure

- Phase 1: Reticulation
  - Determination of Physical Effects
  - Non-computational aspect
- Phase 2: Constitution
  - Creates formal mathematical model
  - Can be done w/o extra system knowledge

# Classical Modeling



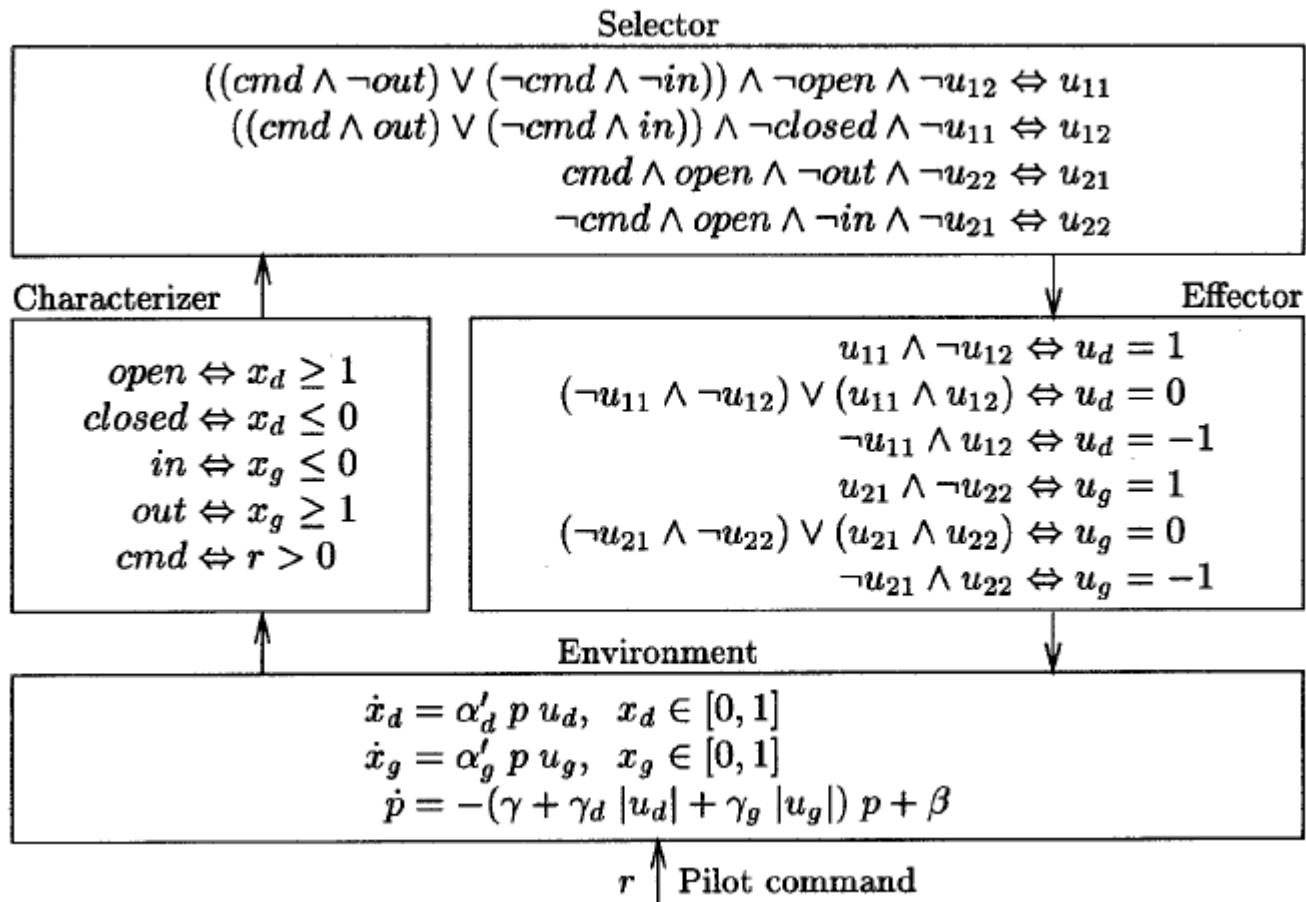
# Modeling with Bond Graphs



# Switched Bond Graphs

- Allow for modeling of mode-switching systems
- Each mode defines a set of DAE (Differential and Algebraic Equations)
- Uses switch element, **Sw**
- Formal definitions referenced in PhD theses

# Switched Landing Gear Model



# Simulink

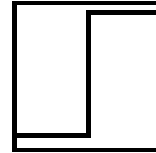
- MATLAB extension for modeling dynamic systems
- Graphical block diagram interface
- Strengths:
  - Control Theory Application
  - Digital Signal Processing

# Domains

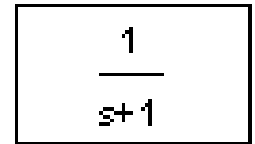
- Linear and Nonlinear Systems
- Continuous and Discrete Time
- Time and Frequency Domain Analysis

# Block Elements

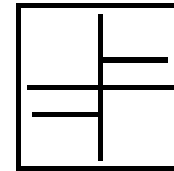
- Sources and Sinks



- Continuous and Discrete Operators



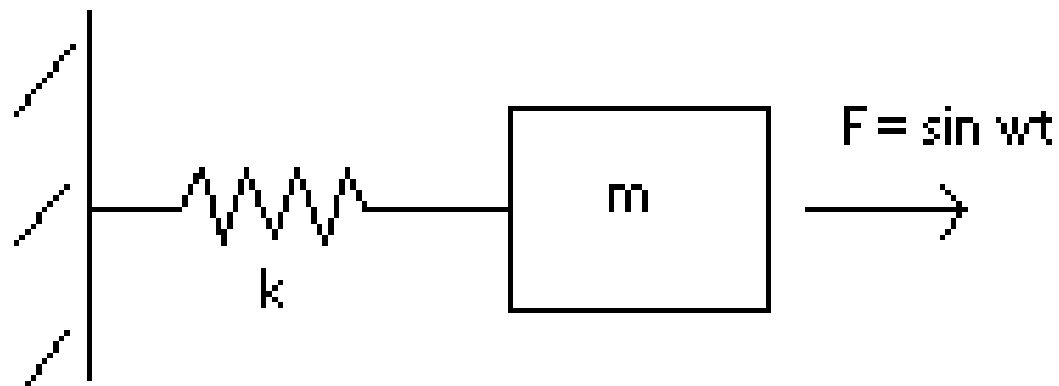
- Standard Math Functions



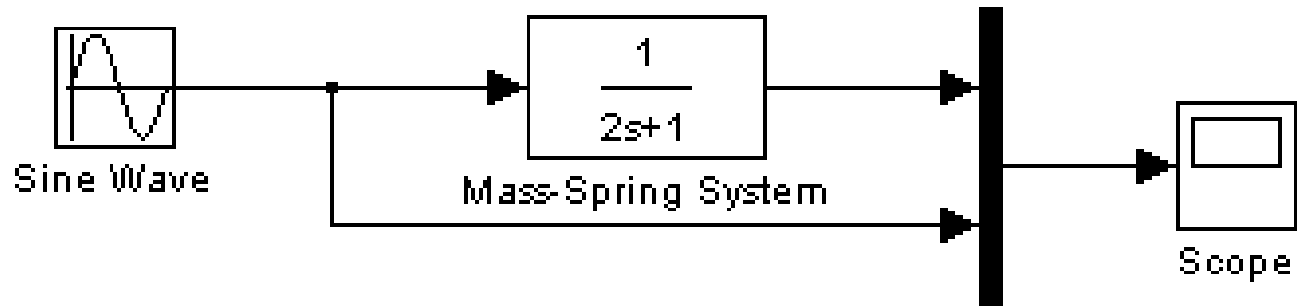
- User Defined Functions

# A Simple Example

- Harmonic Forced Vibration of a Mass-Spring System



# Simulink Model



# Results

