Introduction to Simulink & Stateflow
Key Message

Simulink and Stateflow provide:

- A powerful environment for modelling real processes...
- and are fully integrated with the MATLAB environment.
- Instrument Control and Data Acquisition enable verification and validation of models
Agenda

- What is Simulink?
  - What is Stateflow?
  - How to connect to outside world?
Why Build Models?

- Verify Designs
- Validate Requirements
- Process Analysis
- Speed up Design
- Performance Optimization
- Speed up Testing
- Training
- …
Dealing with Growing Complexity

Past to Present
Overview of MATLAB®

The leading environment for technical computing

- Interactive development environment
- Technical computing language
- Data analysis and visualization
- Algorithm development
Introduction to Simulink®

- Block-diagram environment
- Model, simulate, and analyze multidomain systems
- Accurately design, implement, and test:
  - Control systems
  - Signal processing systems
  - Communications systems
  - Other dynamic systems
Simulink Product Key Features

- Extensive and expandable libraries of predefined blocks
- Hierarchical, component-based modelling
- Open Application Program Interface (API)
- Hybrid (mixed-signal), multirate and multitasking system simulation
- Full MATLAB® integration
Types of Models

- Continuous-Time
- Discrete-Time / Multi-Rate
- Sampled-Data
- Finite State Machines / Mode Logic
- Discrete Event Systems
- Physical Domains
Products Used in this example

- MATLAB
- Simulink
- Simulink Control Design (only for PID Tuning)
- Simulink Design Optimization (only for PID Tuning)
PID Control of a DC Motor

\[ V = K \cdot \omega + i \cdot R + L \frac{di}{dt} \quad \Rightarrow \quad i = \frac{1}{L} \int (V - K \cdot \omega - i \cdot R) \, dt \]

\[ -T = K \cdot i - b \cdot \omega - J \frac{d\omega}{dt} \quad \Rightarrow \quad \omega = \frac{1}{J} \int (T + K \cdot i - b \cdot \omega) \, dt \]
What Have You Seen?

- Modelling equations in Simulink
- Building a system with hierarchy
- Parameterisation and integration with MATLAB
- Continuous control example
- Design with simulation
Agenda

- What is Simulink?
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What is a finite state machine?

- A representation of a reactive system that contains a finite number of states
- System changes states based on defined conditions
- Examples:
  - Automatic transmission:
    - First, second, third, and fourth gears
  - Actuator in a fault detection, isolation, and recovery system:
    - Active, standby, off, isolated
  - Robot arm
    - Initialization, normal mode, or shutdown
Stateflow Overview

- Extend Simulink with a design environment for developing state machines and flow charts
- Design systems containing control, supervisory, and mode logic
- Describe logic in a natural and understandable form with deterministic execution semantics
How does Stateflow work with Simulink?

Simulink is used to respond to **continuous** changes in dynamic systems.

Stateflow is used to respond to **instantaneous** changes in dynamic systems.

Real-world systems have to respond to both continuous and instantaneous changes.

Use both Simulink and Stateflow so that you can use the right tool for the right job.
Products used in this example

- MATLAB
- Simulink
- Stateflow
Key Features

- Defines functions
  - Procedurally, using Embedded MATLAB™
  - Graphically, using flow diagrams
  - In tabular form, with truth tables
- Provides language elements, hierarchy, and parallelism
- Animates Stateflow® charts
- Incorporates custom and legacy C code
- Performs static and run-time checks
Working with Stateflow
Create Stateflow charts

- Drag and drop states, junctions, and functions from a graphical palette into the drawing window.

- Create transitions and flow by connecting states and junctions together.

- Reduce a complex chart to a set of simpler, hierarchically organized diagrams using subcharts.
Working with Stateflow
Execute Stateflow charts

After modeling your logic in Stateflow, you can simulate and view its behaviour live to test and validate your design by:

- Highlighting the active states and the transition paths taken
- Viewing states and data with the displays and scopes provided in Simulink
- Building your own custom displays using MATLAB visualization tools
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Connect to the “Real World”

- Instrument Control Toolbox
- Data Acquisition Toolbox
Instrument Control Toolbox

Control and communicate with scientific instruments

- Integrate instruments into MATLAB applications and Simulink® models
- Interactive tool for detecting and controlling instruments
- Automatic code generation for faster and easier implementation
- Support for IVI, VXI plug & play, and MATLAB instrument drivers
- Support for common communication protocols
**Instrument Control Toolbox:**

Supported Instrument Manufacturers, Standards, and Protocols

- Agilent
- Anritsu
- LeCroy
- Rohde & Schwarz
- Tektronix
- Others

- Standards such as IVI, VXIplug&play, LXI
- Protocols such as GPIB, VISA, TCP/IP, UDP

- Serial devices – Any device with a RS-232, RS-422, or RS-485 interface (EEGs, mass spectrometers, etc.)

For a full support listing, visit:  www.mathworks.com/products/instrument
Instrument Control Toolbox: Instrument Drivers

- Industry-standard instrument drivers
  - Interchangeable Virtual Instrument (IVI™) drivers
  - VXIplug&play™ drivers

- Several hundred supported instruments
  - Drivers available through the instrument vendor

- Instrument drivers do not require knowledge of low-level commands

```plaintext
fwrite(obj, 'TRIG:MAI:EDGE:SLO RIS');
set(obj, 'TriggerSlope', 'Rising');
```
Instrument Control Toolbox: Instrument Drivers

- Automatically create MATLAB instrument driver for vendor’s driver
- Customize MATLAB driver to extend or enhance vendor’s driver
- Create custom MATLAB driver for any instrument
- MATLAB instrument drivers available at: www.mathworks.com/products/instrument/drivers
Benefits of using MATLAB with Instrument Control Toolbox

1. Use MATLAB as your single software environment for data acquisition, data analysis, and application development
   – Saves time transferring data
   – Only maintain one software tool (product upgrades, training, maintenance costs, etc.)

2. MATLAB and Instrument Control Toolbox are hardware neutral
   – You are not tied to one hardware manufacturer
   – Mix hardware from multiple manufacturers today
   – Easily switch hardware tomorrow

3. MATLAB is widely used
   – Over 1,000,000 users
   – Technical personnel available with MATLAB experience
Using Instrument Control Toolbox with Simulink

- Control and acquire data from instruments and serial devices such as RS-232 directly into Simulink

- Also supports communication with remote applications using TCP/IP and UDP
Data Acquisition Toolbox
Acquire and output data from data acquisition boards

- Immediately analyze live or acquired data in MATLAB and Simulink
- Configure hardware without leaving MATLAB
- Incorporate custom analysis into PC-based digital oscilloscope
- Ability to do “one-shot” or continuous acquisition
- Support multiple data acquisition devices and vendors
Data Acquisition Toolbox: Supported Hardware

- Agilent (Acqiris)
- ADLINK
- Advantech
- CONTEC
- Data Translation
- g.tec
- IOTech
- Keithley
- Measurement Computing (MCC)
- National Instruments
- Ono Sokki
- United Electronic Industries
- VXI Technology

- Any PC compatible sound card
- Parallel Port

For a full support listing, visit: www.mathworks.com/products/daq
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Using Data Acquisition Toolbox with Simulink

- Acquire live or measured data directly into Simulink® models from data acquisition devices
- Directly evaluate your Simulink algorithms against real-world data
Conclusion

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