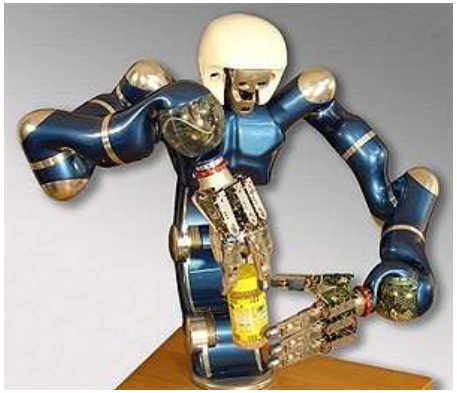
Control System Design for Automated Vehicles

Lecture 9



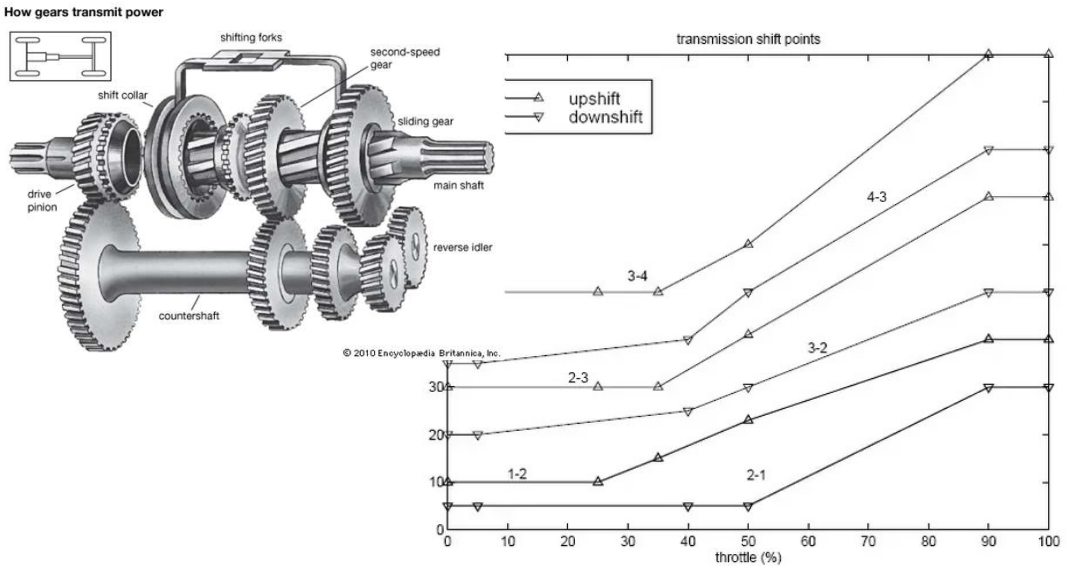
State Flow Toolbox

Reference : Stateflow® User's Guide from Mathworks

Finite State Machine

- What is a finite state machine?
  - Sequential decision logic based on state machines
  - Representation of an event-driven system
  - Transition from one state to another state happens if a certain condition is satisfied.

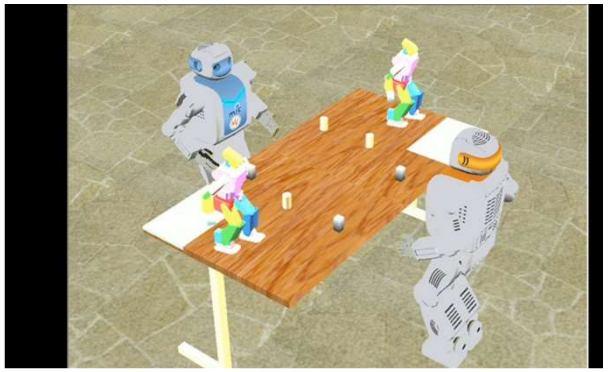
- Bulb : On & Off

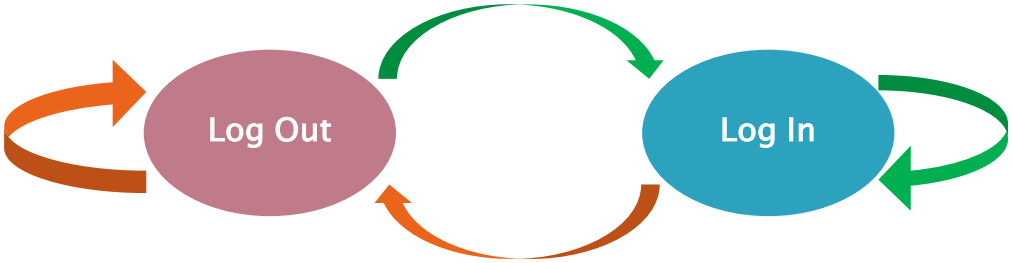


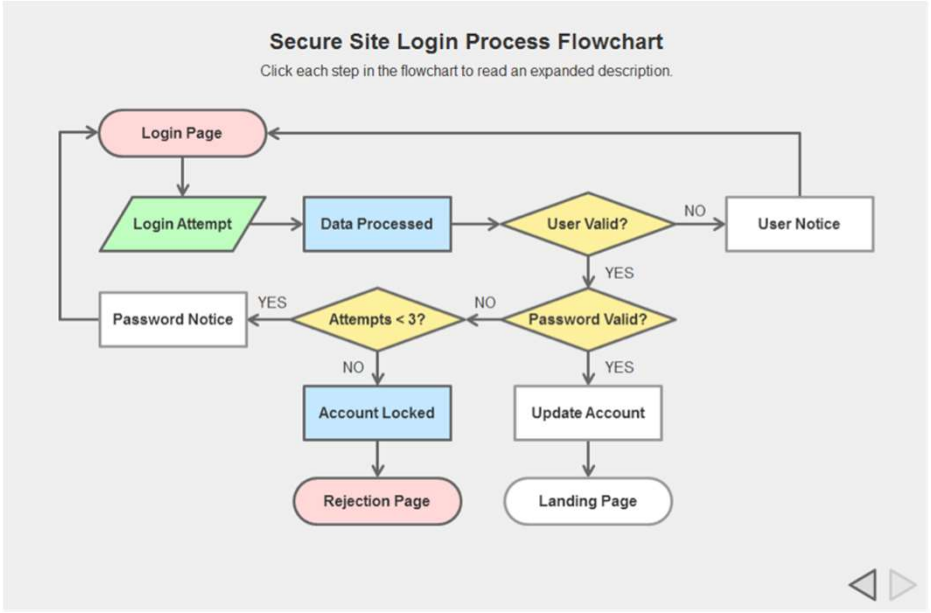
- Transmission Map

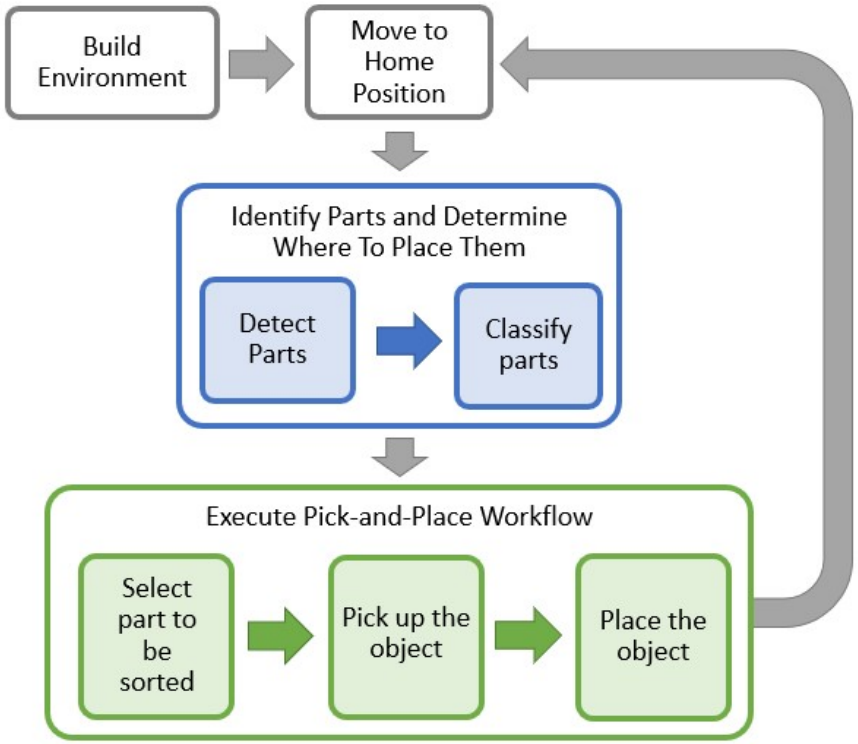
Finite State Machine

- Finite State Machine Applications







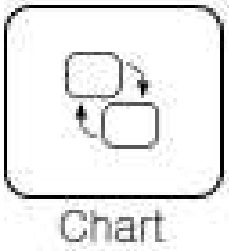


- Secure Login Process
- Robot Workflow description

Example

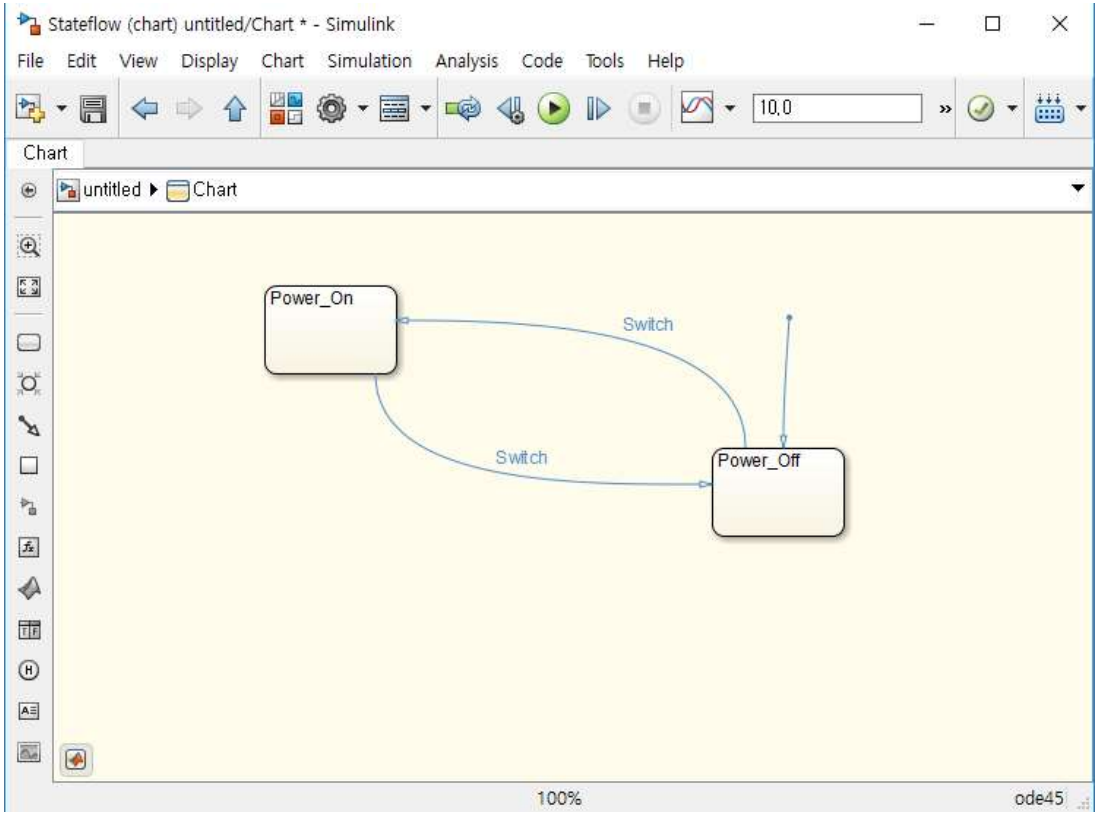
- In the command window, type
  - Open_system('old_sf_car')

What is Stateflow?



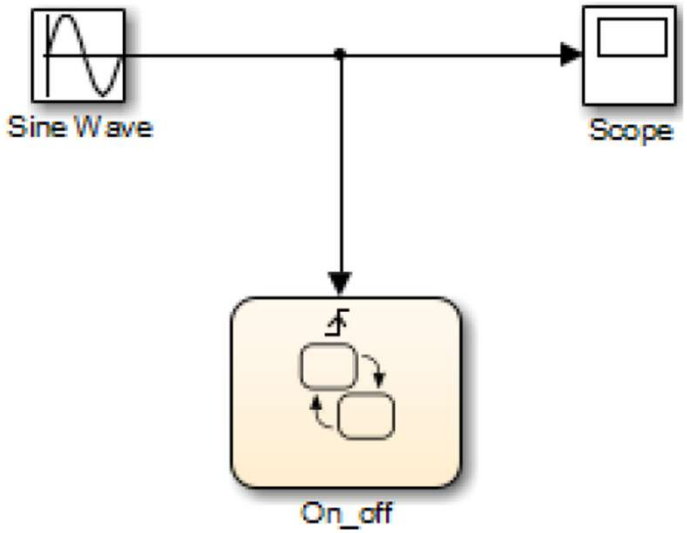
- State flow chart
  - A state machine design tool integrated within Simulink
  - Contains

- A set of "Graphical Objects"
- A set of "Nongraphical Text-based Objects".
- Defined "Relationships between those Objects".



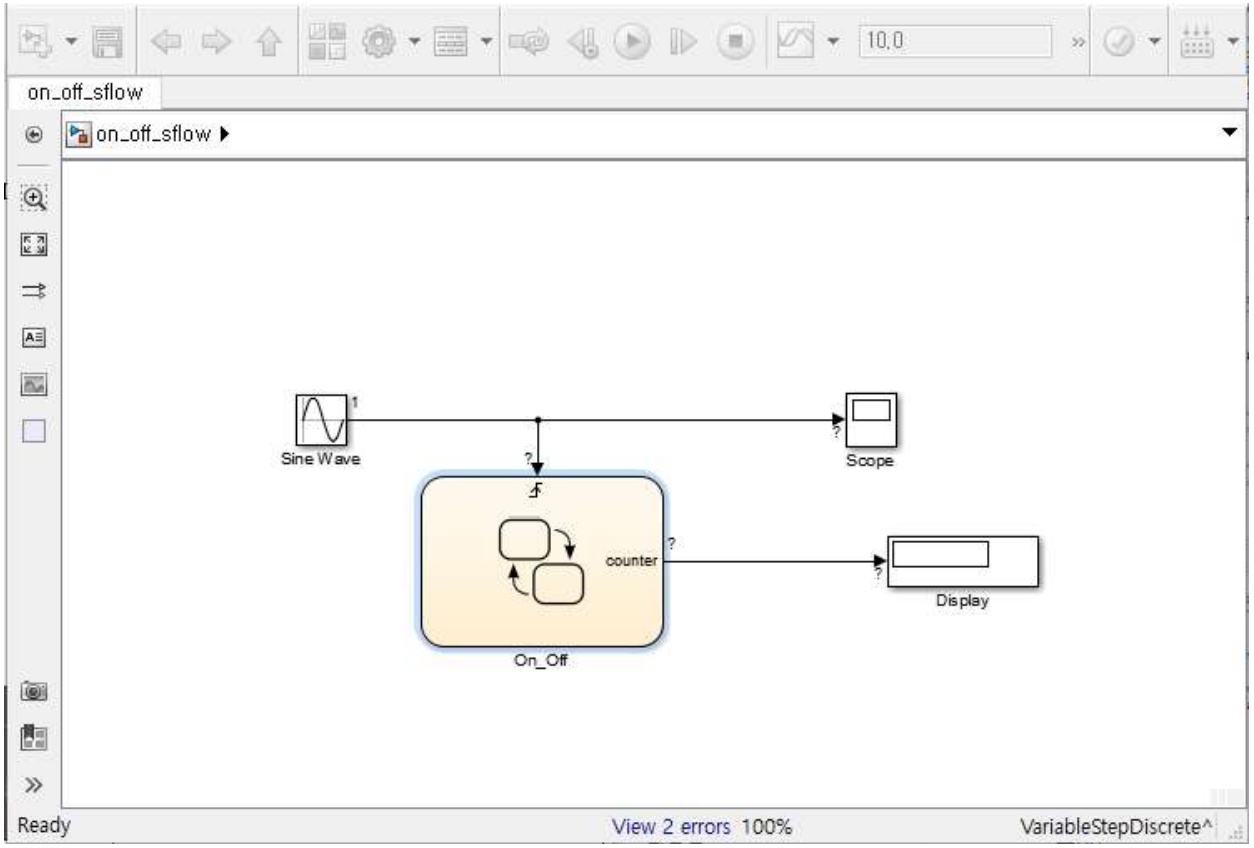
What is Stateflow?

- State flow produces Simulink blocks, fed with Simulink inputs and producing Simulink outputs.
- A Stateflow block can “execute” Simulink blocks as actions.



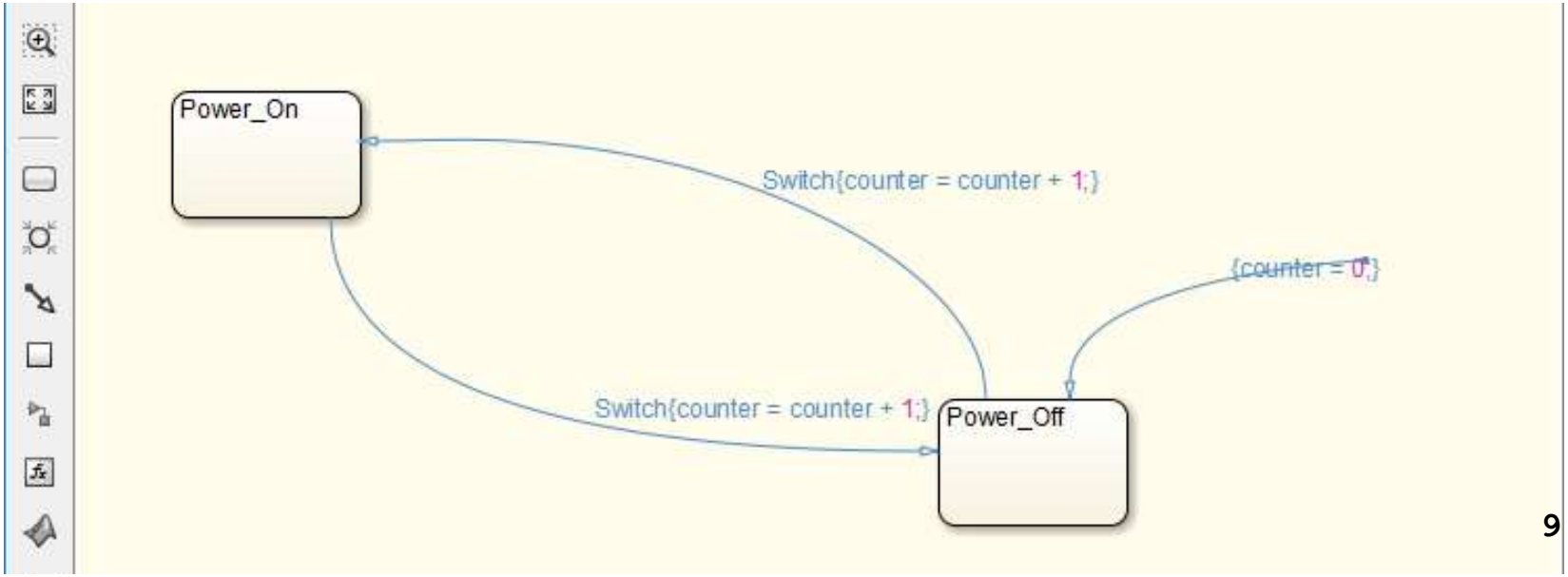
Example

- Power Switch Simulink Model
  - Simulink model of a power switch that toggles on and off at zero crossing of a sine input
  - At each switch, a counter is incremented



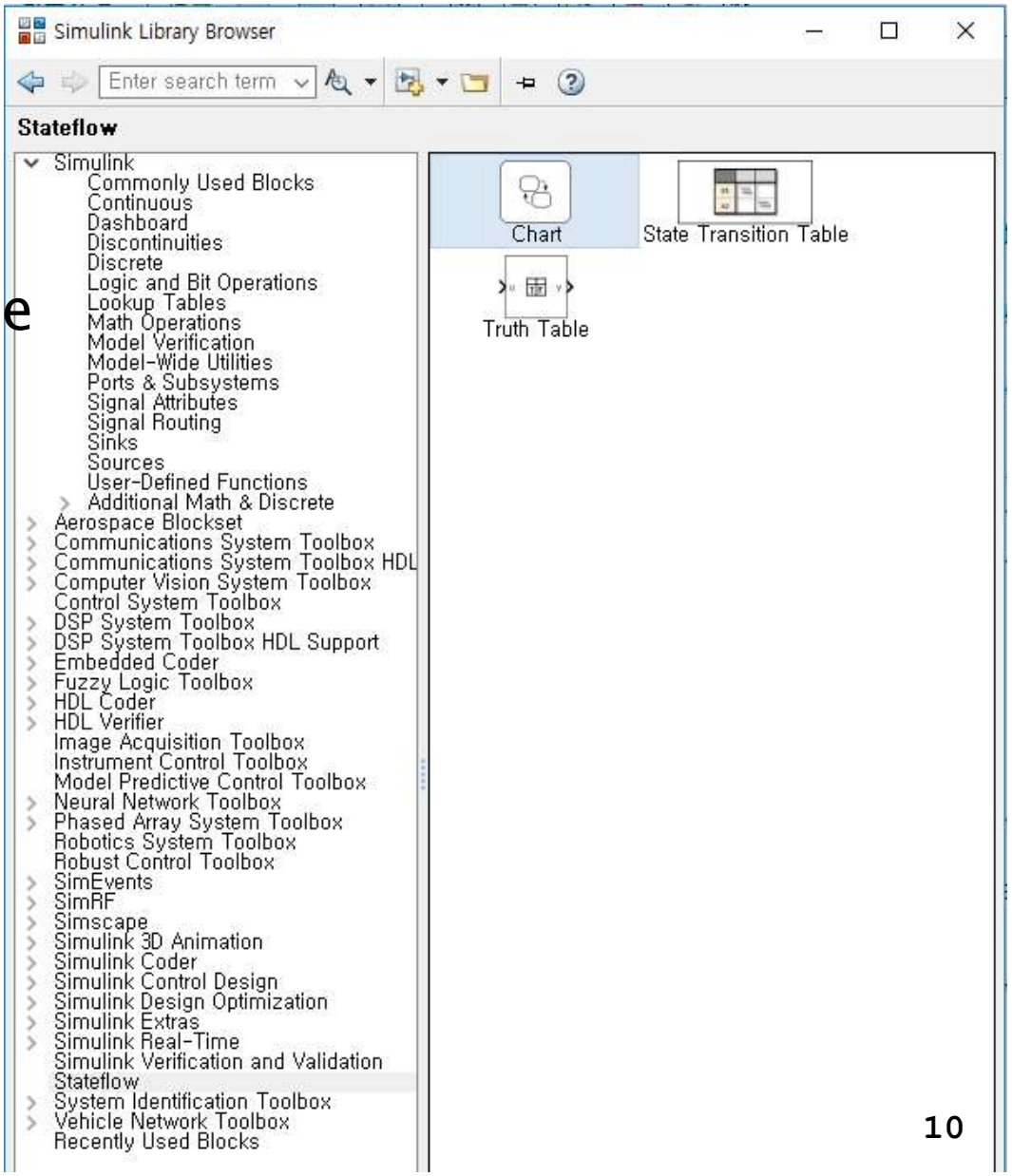
Example

- Inside the state chart
  - Two states of the power switch : on and off
  - Transitions between the states happen whenever the event “Switch” occurs.
  - When a transition occurs, the variable “counter” is incremented
  - By default, the initial state is off



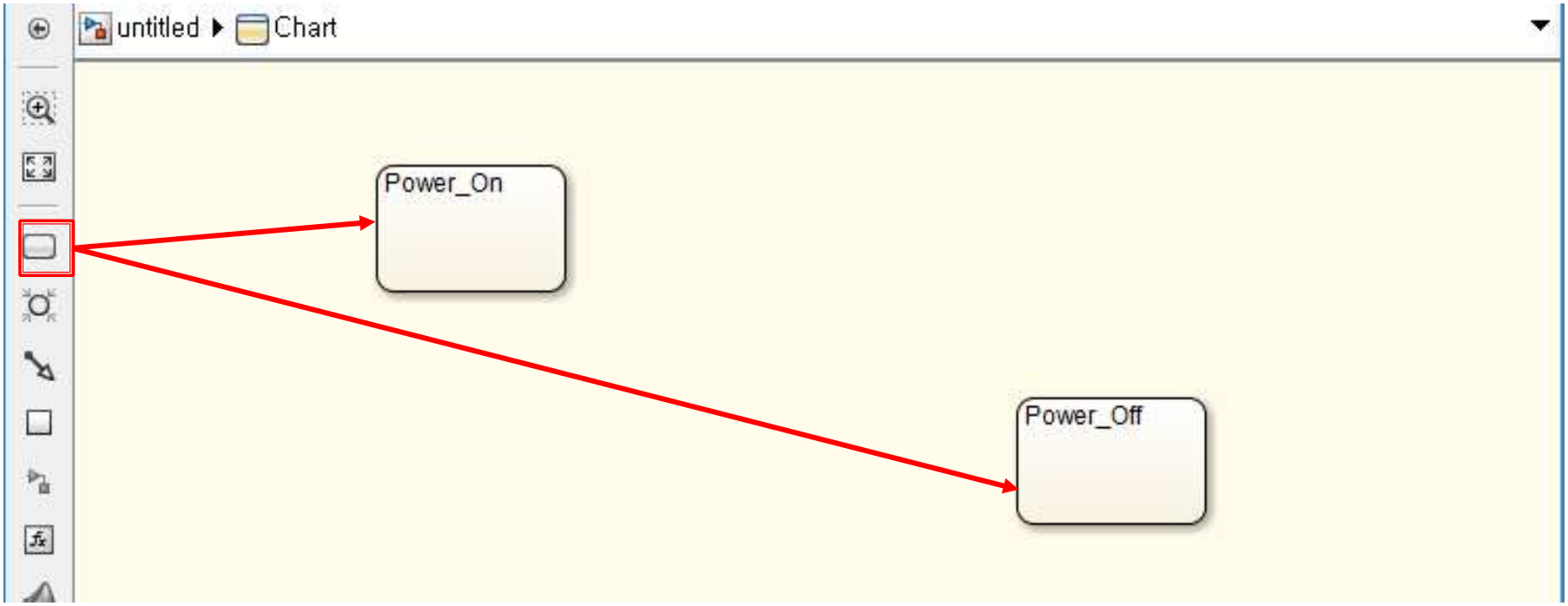
Example

- Add Statechart to Simulink Model
  - Drag StateChart to the Simulink model
  - Change name from “Chart” to “On_Off”



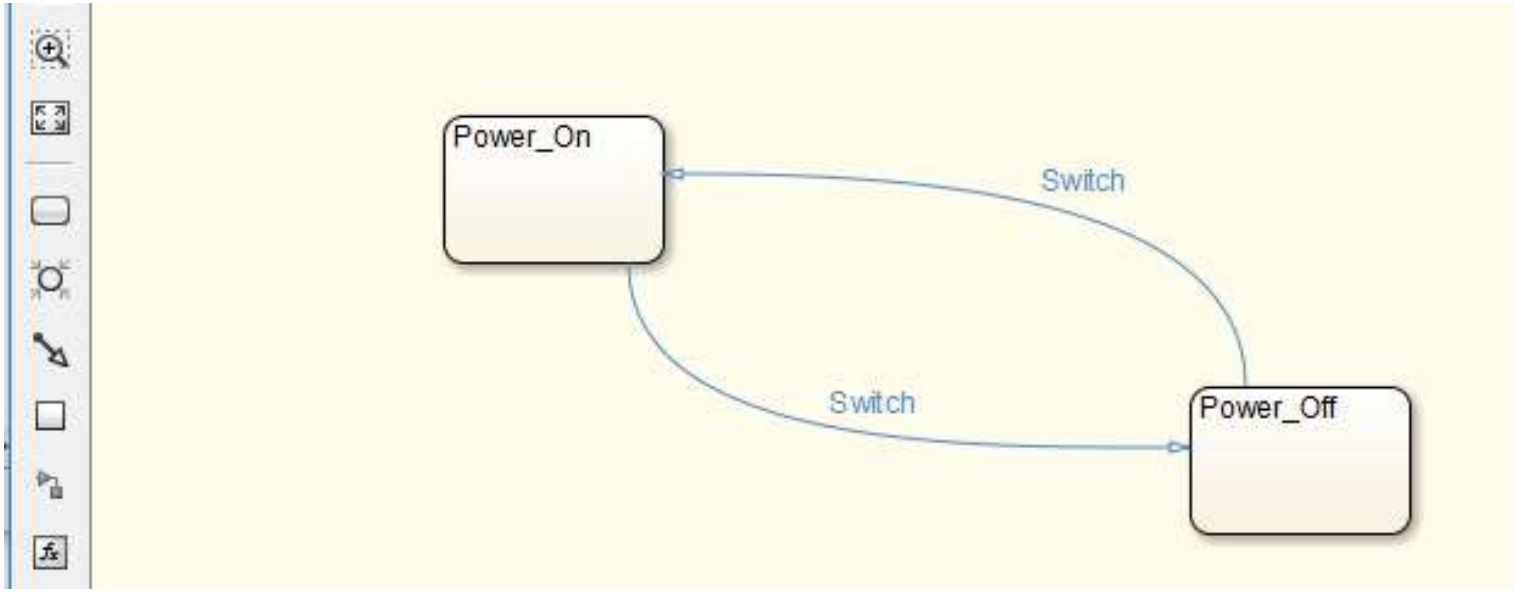
Adding States to a State Chart

- Open Statechart “On_Off” by double-clicking
- Drag two states from the menu at the left.
- Name states “Power_On” and “Power_Off”.



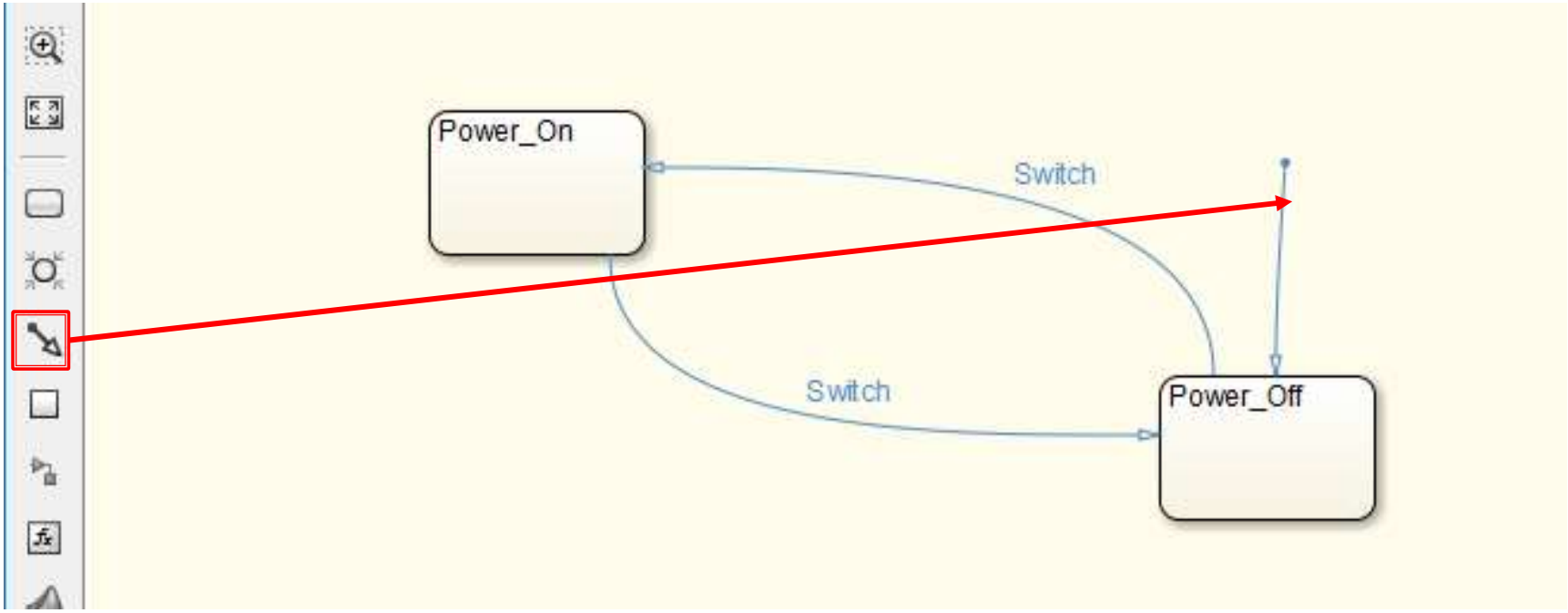
Creating Transitions between States

- Hold the mouse pointer over the border of the states
- Drag the mouse to the terminal state



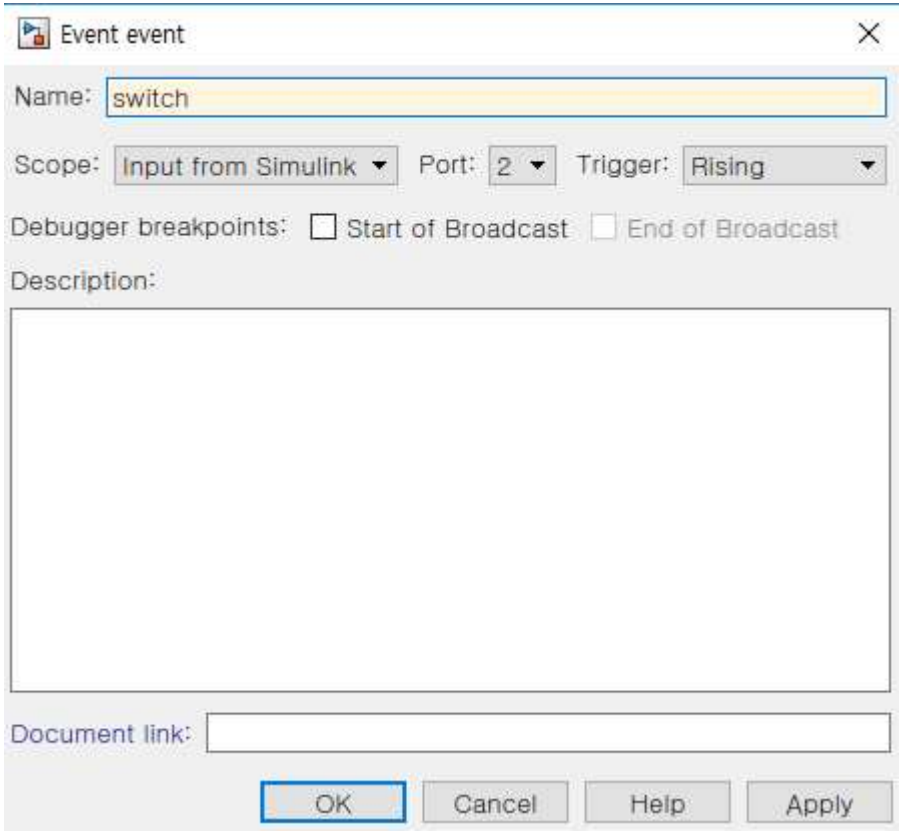
Add Default Transition

- Specify the initial state by adding a default transition



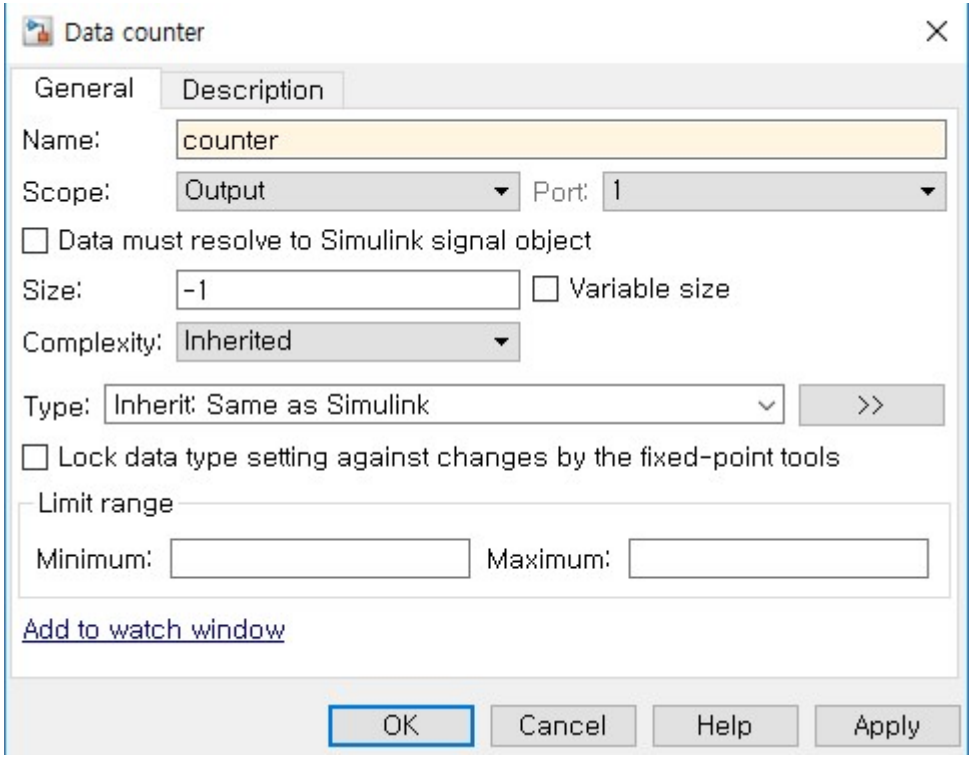
The Model Explorer

- Add an “Event” that is “Input from Simulink” by right click on the StateChart. (Name it “Switch”).



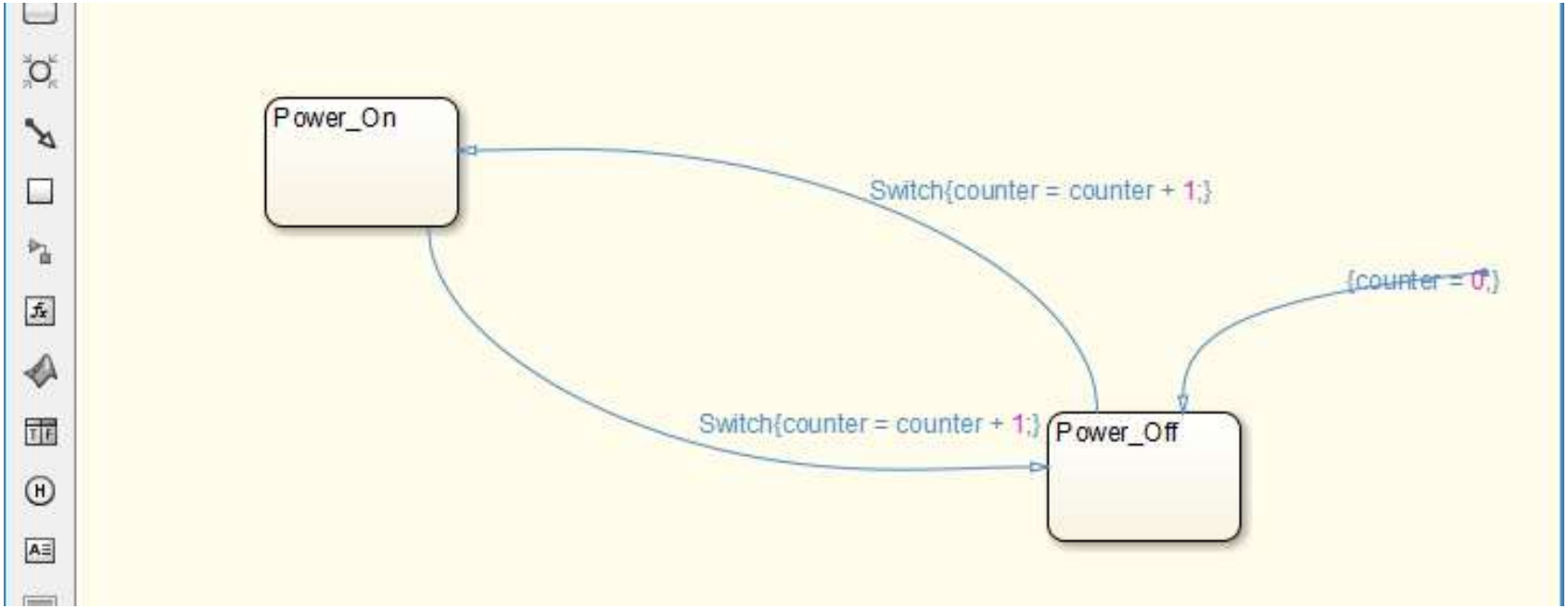
Counting Transitions

- Add “Data” that is “Output to Simulink” by right clock on the StateChart
- A window will open allowing you to name the data (Name it “counter”).



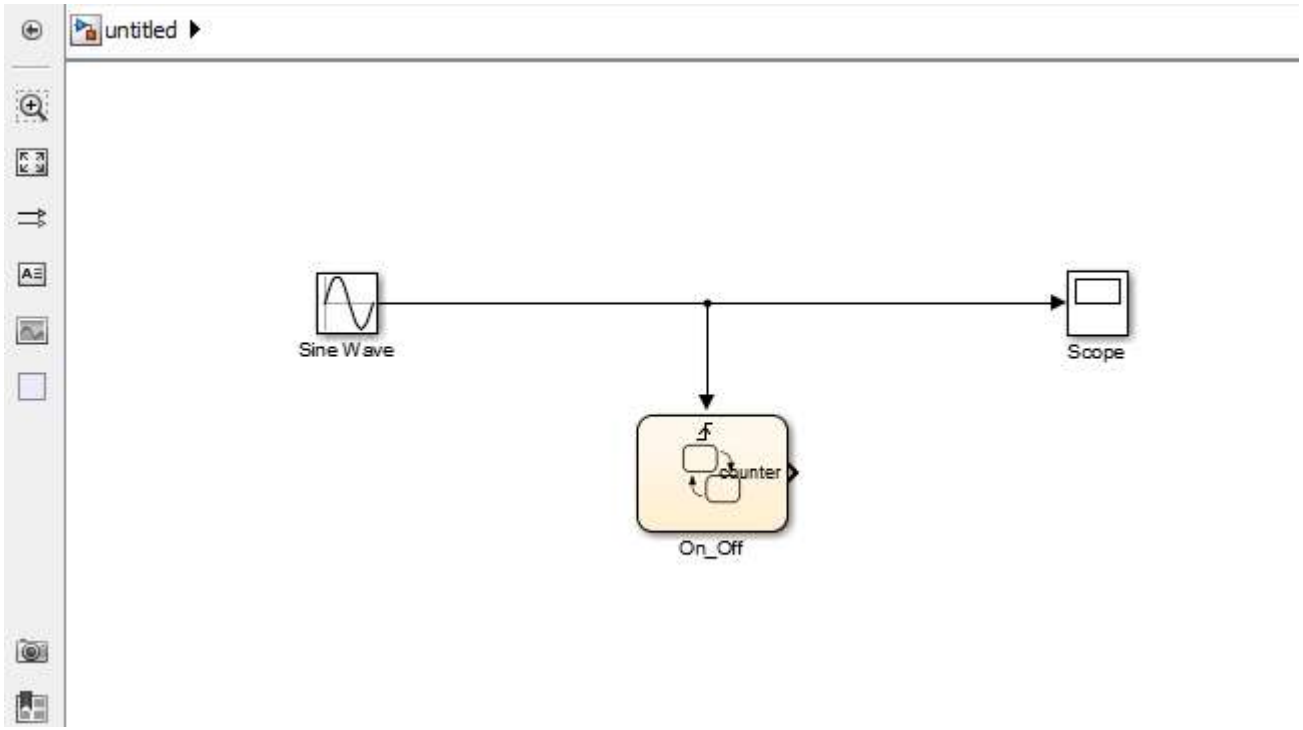
Increment the Counter

- Increment the counter every time the event “Switch” occurs by placing
  - “{counter = counter + 1}” next to Switch.
- Set initial value to the counter by adding
  - “{counter = 0}” on the default transition arrow.



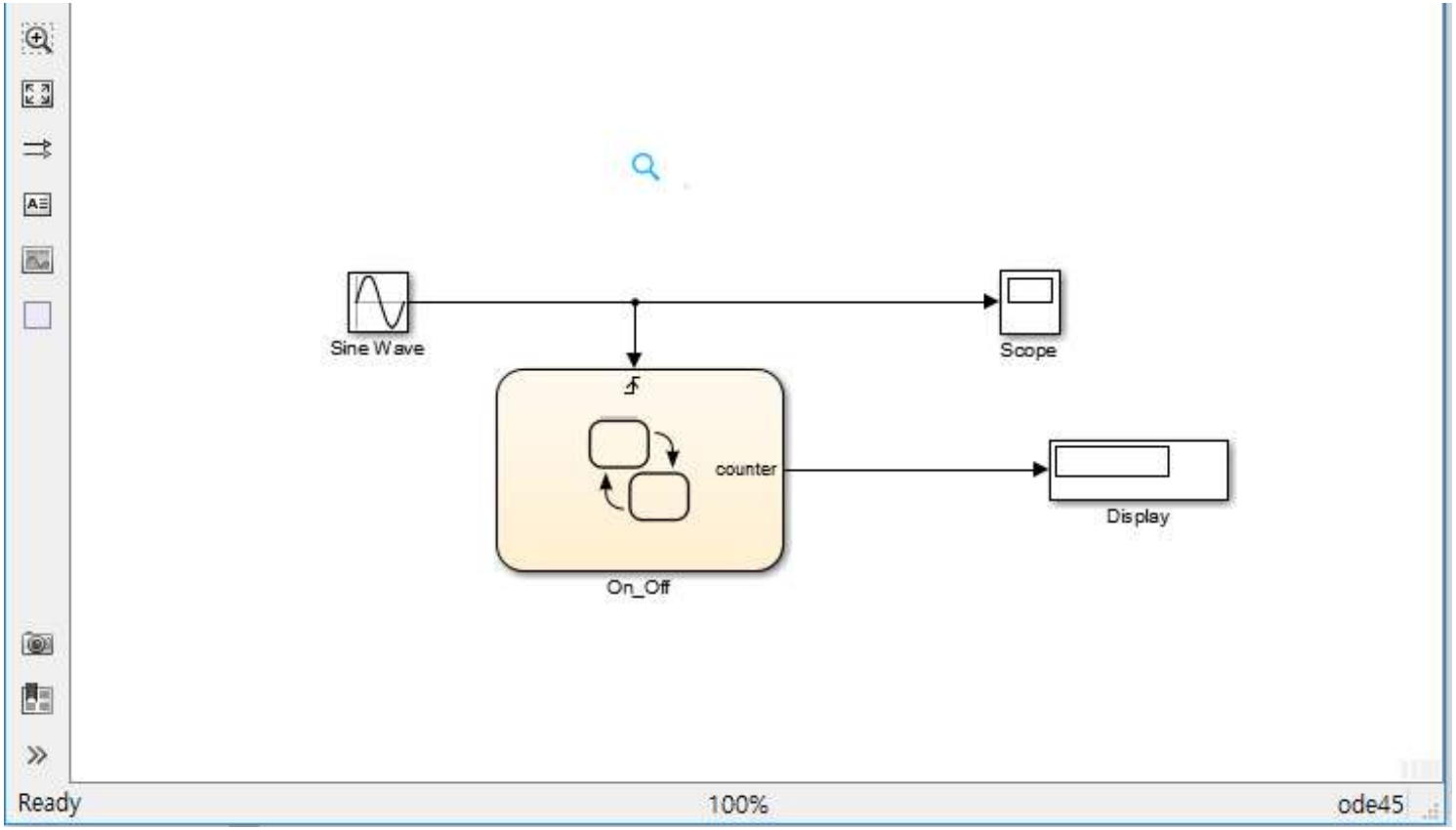
Adding the Sine Input

- Return to the top-level Simulink diagram
- The Statechart “On-off” now has an arrow entering it.
- Add a sine wave input and add a scope to the output data



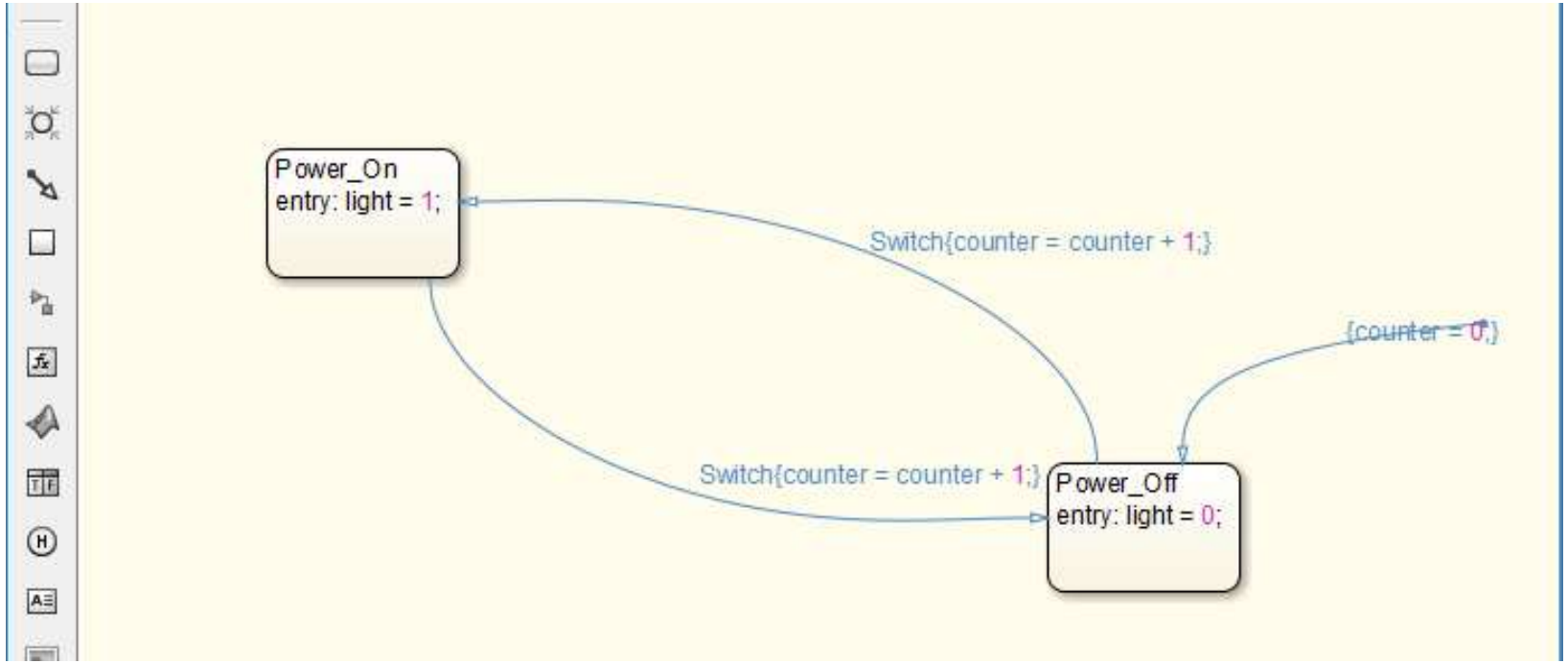
Counting the Transitions

- Add a display block from the Sink Library



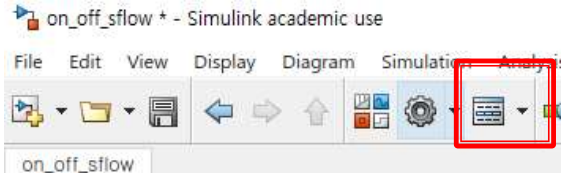
Toggle a Bit

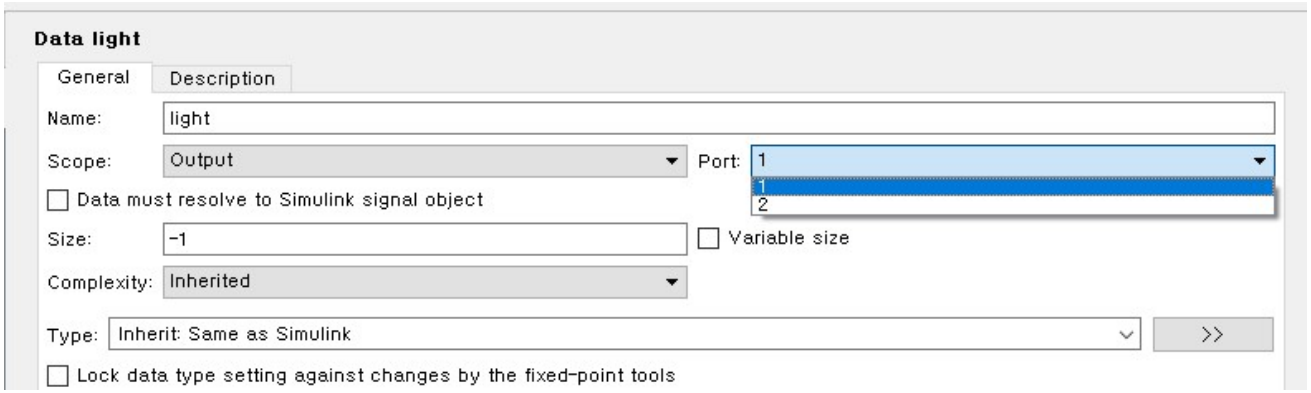
- Add a new data output “light” : initial value 0.
- Set “light = 0;” in the Power_off state
- Set “light = 1;” in the Power_on state

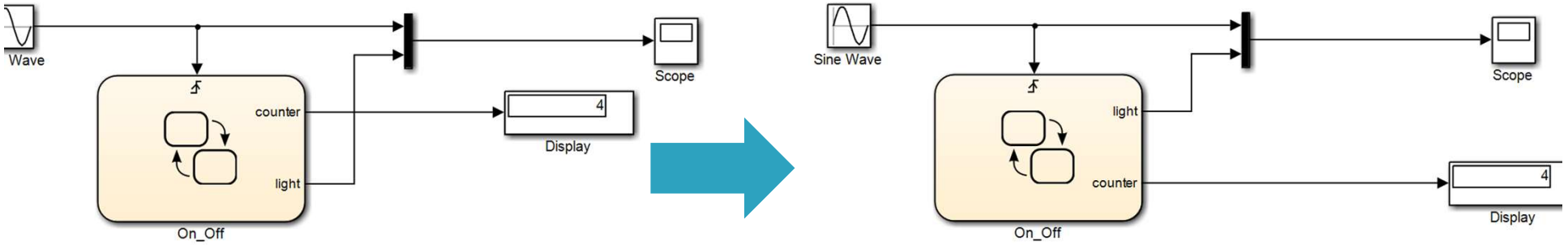


Change Port Values

- The output “light” is assigned port 2 by default
- Open “Model Explorer” by clicking button below.
- To make model more readable, change port value for “light” from 2 to 1.

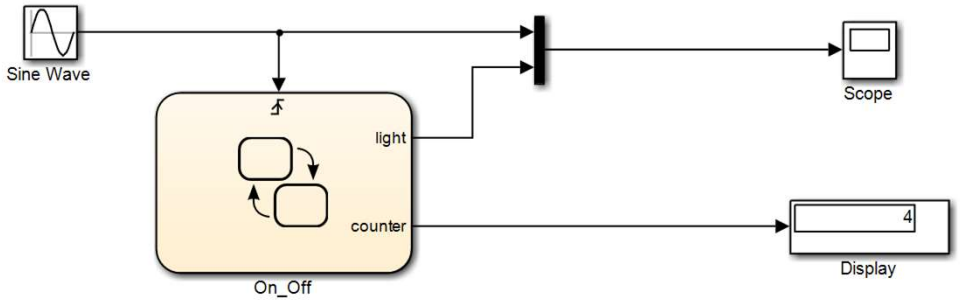


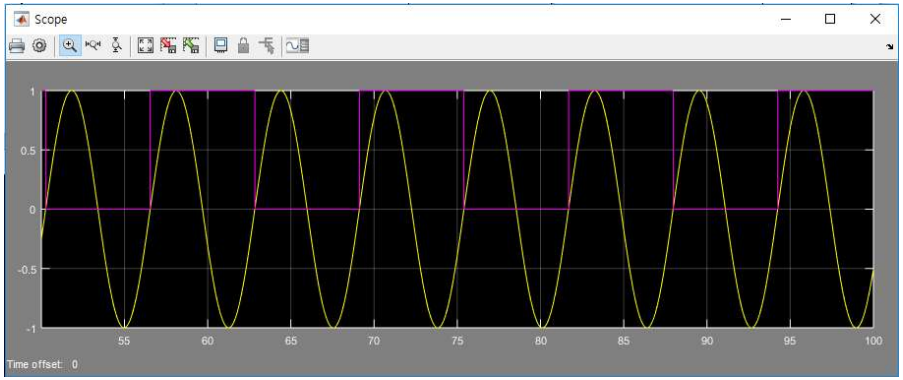




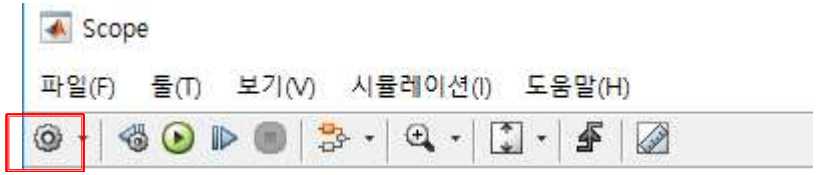
Running the Simulation

- Connect the output “light” to the scope using a “Mux” block.
- Set the simulation time to 100 and run simulation.
- Running the simulation shows a square wave that toggles between 0 and 1.





※ 스코프 블록에 전체 시간이 나오지 않으면 아래 옵션을 변경



Stateflow Chart Objects

- Graphical Objects

Type of Graphical Object	Toolbar Icon
State	
Transition	Not applicable
History junction	
Default transition	
Connective junction	
Truth table function	
Graphical function	
MATLAB® function	
Box	
Simulink based state	

Stateflow Chart Objects

- Nongraphical Objects
  - Data Objects
  - Event Objects
  - Message Objects

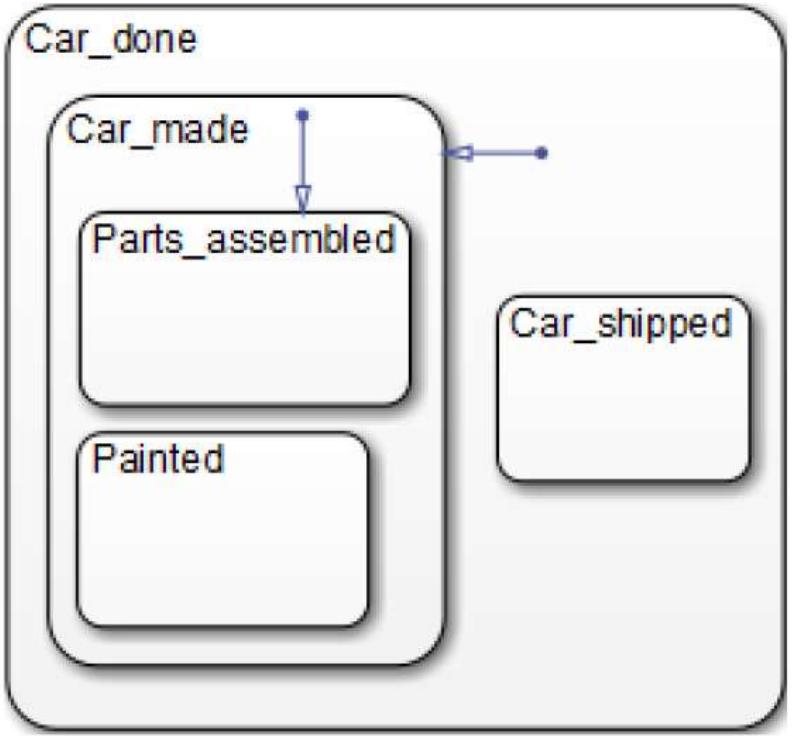
States

- What is a State?
  - Operating Mode of a Reactive System
  - Can be either active or inactive.
  - Activity or inactivity can change depending on events and conditions.

- State Hierarchy
  - Multi-level of subcomponents can be represented using State Hierarchy.

State Hierarchy Example

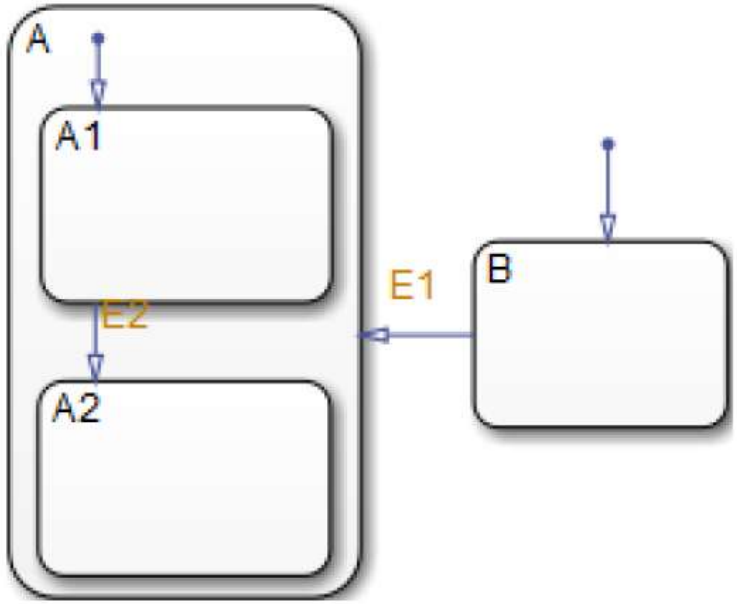
- Car_done is the parent state of the Car_made and Car_shipped states.
- Parts_assembled and Painted are children of the Car_made state.



State Decomposition

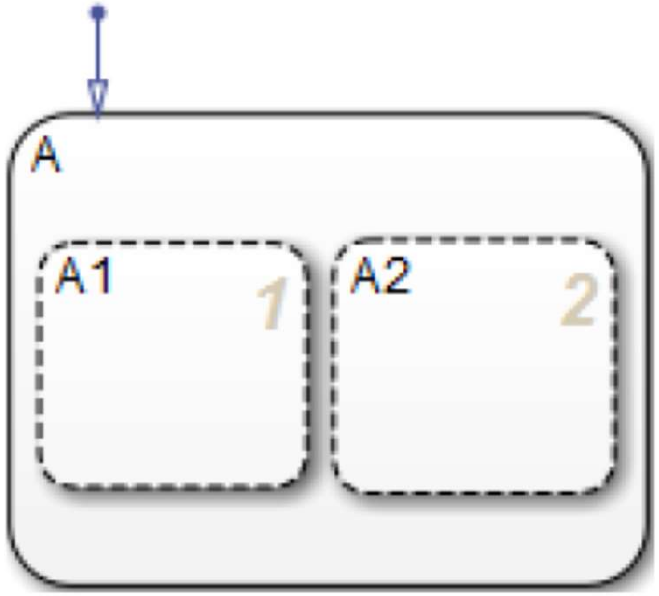
- State decomposition can be exclusive (OR) or parallel (AND).

- Exclusive (OR) State Decomposition
  - Either A or B can be active.
  - If state A is active, either A1 or A2 can be active at a given time.



State Decomposition

- Parallel (AND) State Decomposition
  - Substate with dashed borders indicate parallel (AND) decomposition.
  - When a state has parallel (AND) decomposition, all substates are active at the same time.
  - In the following example, when state A is active, A1 and A2 are both active.



State Decomposition

- Example
  - Decomposition can be selected by right click on the parent state, and select “decomposition” to choose option.