



Security Model Description

Lecture 63, v02

A description of an example model developed by MathWorks
and modified for use in an educational setting

Purpose



- This lecture describes a set of Simulink/Stateflow models that describe:
 - A simplified (modified) version of a Home Security System (HSS) model originally developed by the MathWorks
 - This model is hereforth called the As-Is HSS Model
- The description of this model is conducted in two sections
 - A description of the As-Is HSS Simulink (environment) model (Section 1)
 - A description of the As-Is HSS Stateflow (system) model (Section 2)
- Some of the material contained herein to describe the MathWorks model is sourced from various pages on www.mathworks.com
- The copyright applied to this document refers to the arrangement of material both from MathWorks and originally generated by J.G. Artus into a format that is appropriate to covering the subject in a 1- to 2-week educational module

Section 1

A description of the Simulink portion of the Simplified Home Security System (HSS) Model

To learn about the original MathWorks model of the Home Security System (HSS), see
<https://www.mathworks.com/help/stateflow/gs/events.html>

The executable model can be obtained within MATLAB by typing the following into the command prompt:
`openExample('sf_security')`

As-Is Home Security System Model Overview

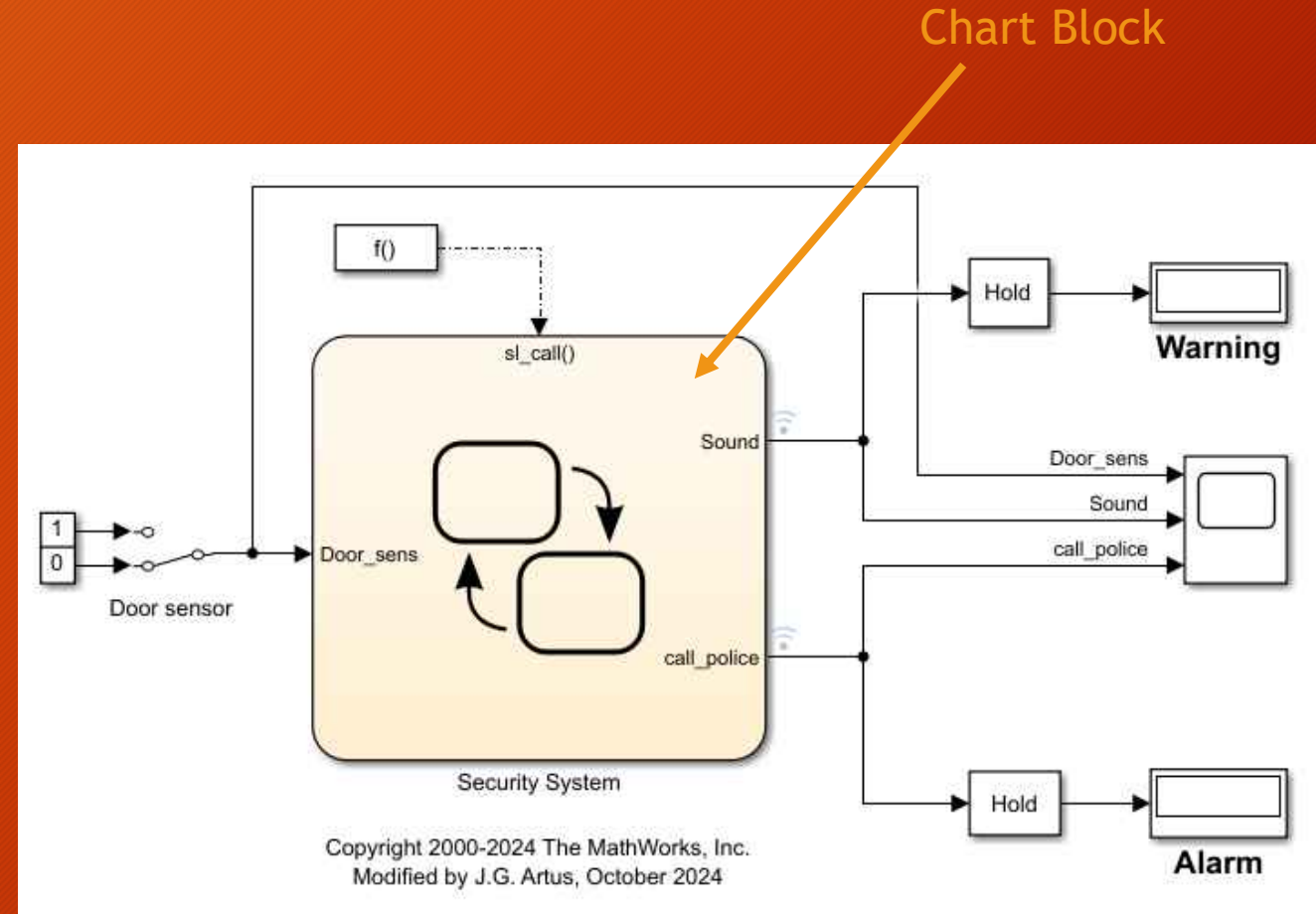


- This model represents a home alarm system that has a single intrusion-detection sensor
 - When the system detects an intrusion, it sounds an audible “Sound”
 - After a period of 60 seconds, a “call_police” signal is issued
- This model shows how to
 - Send Simulink (environment) input events to Stateflow (system) to simulate triggering of a system alarm sensor
 - Broadcast local events within Stateflow to coordinate between parallel states
 - Output Stateflow (system) events to drive external blocks in Simulink (environment)
- The Simulink model represents the environment within which the security system is operating
 - It consists of one anti-intrusion sensor attached to a door of the premises
 - The simulation operator has control over the door sensor to simulate tripping of the sensor by an intruder
- The Stateflow model represents the logic of the security system
 - It consists of two parallel states: one the door anti-intrusion sensor and one that controls sounding the audio alert and issuing a call to the police
 - In each time step, the parallel states are evaluated in sequence as indicated by the numbers in the top right corners of the states
- Simulink inputs sent to the Stateflow model include
 - For the door sensor, an intrusion detection signal
- Outputs from the Stateflow model include
 - A signal to sound an audible intrusion warning
 - A signal to call the police

As-Is and To-Be are descriptors commonly used in Systems Engineering to represent the original system configuration (As-Is) as it stands today, and the configuration of the system that is anticipated to exist (To-Be) after the planned modifications to the As-Is configuration are completed

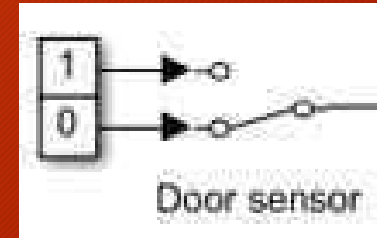
Original HSS Environmental Model (sf_security.slx)

- This model represents a simple Home Security System (HSS)
- Shown here is the Simulink portion of the model that represents the environmental simulation within which the Stateflow system model operates
- The Simulink model includes a “Chart Block” that represents the Stateflow model which is considered to be the model of the “System of Interest”
- The Stateflow model contains the state-based logic that controls the transitions of states within the modeled Security System control unit, based on the Simulink environmental model inputs - it describes the behavioral logic of the system that is the subject of study (the System of Interest or Sol)



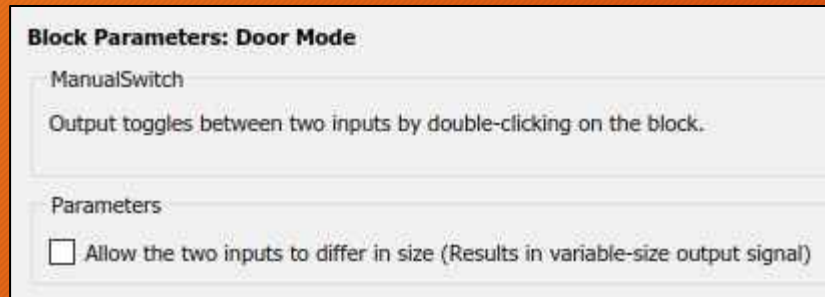
Switch Inputs

- One manual switch is provided in the Simulink model
- This switch represent the current sense of the Door sensor
 - When the switch is set to 0, this indicates that the door sensor has not been tripped (no intrusion is detected)
 - When the switch is set to 1, this indicates that the door sensor has been tripped (intrusion has been detected)
- This switch can be changed by the simulation operator during running of the simulation

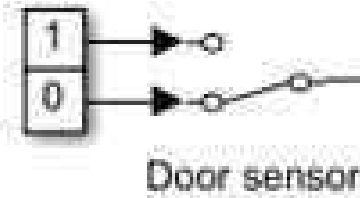


Switch Arrangement

- Switches are simple Simulink Manual Switches that flip between Boolean constants 0 and 1
 - Example Manual Switch for Door Mode



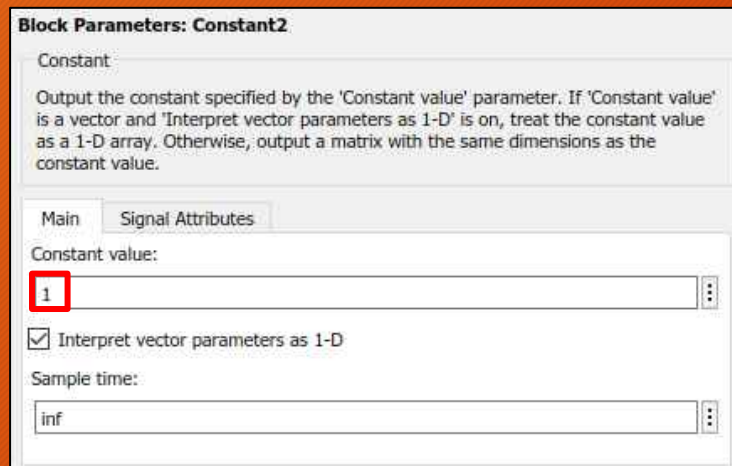
Example Value Input Implementation



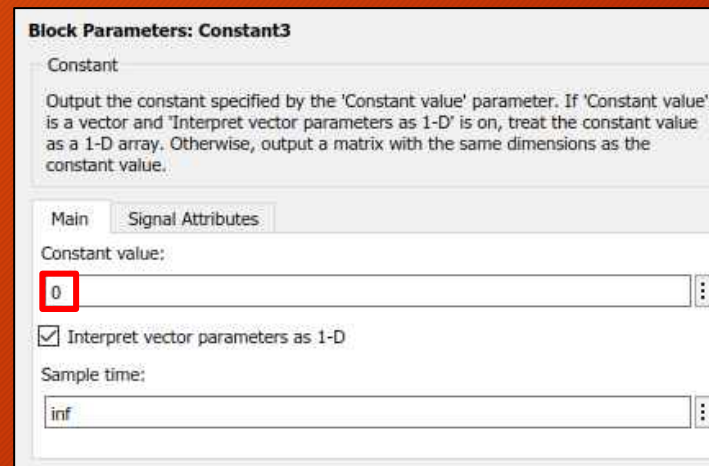
Two Simulink Constant Blocks are used to feed the switch inputs

- Boolean constants

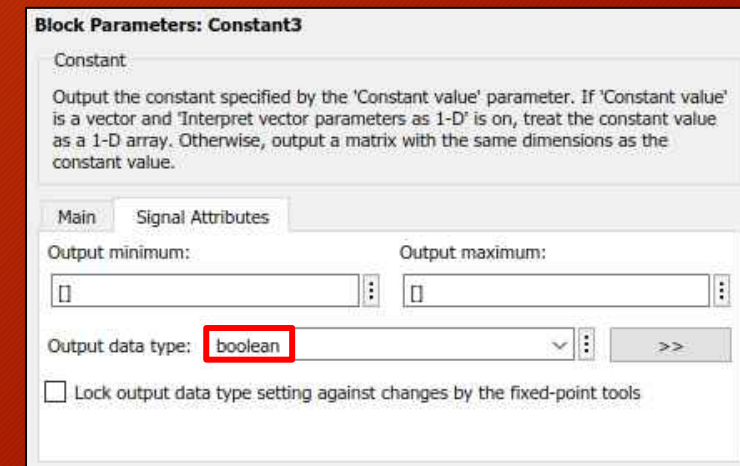
One



Zero

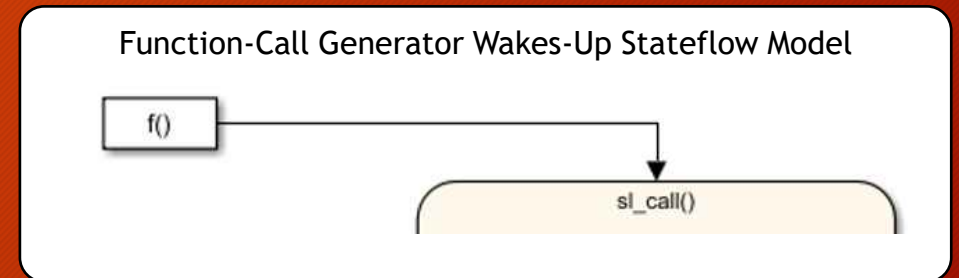
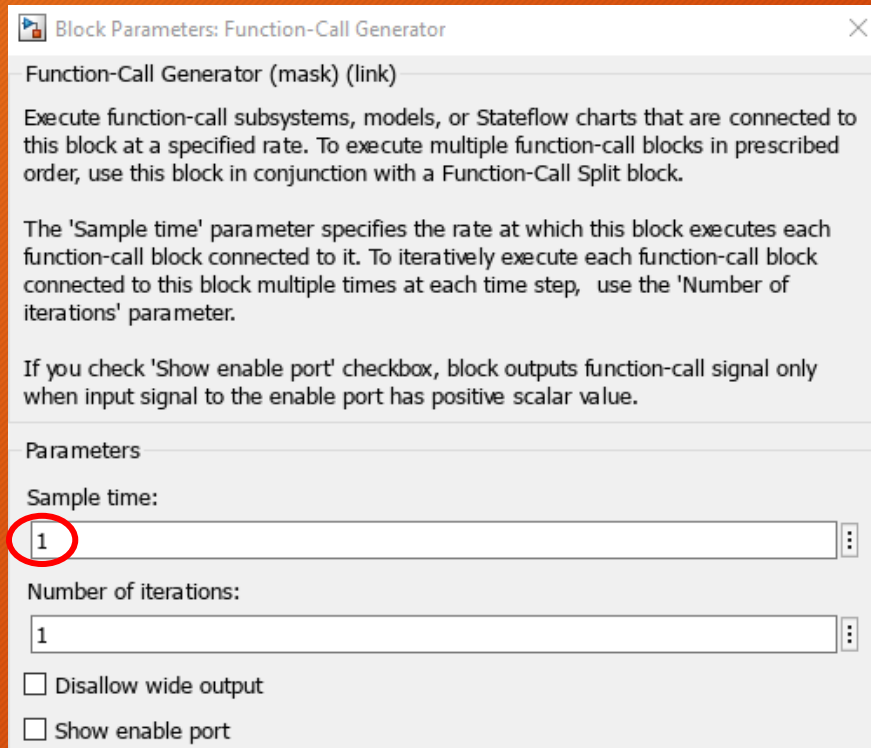


Both Are Boolean



Function-Call Generator

- The Function-Call generator is used to wake up the Stateflow Chart at a selected rate
- The generator for this model operates at a 1 second rate

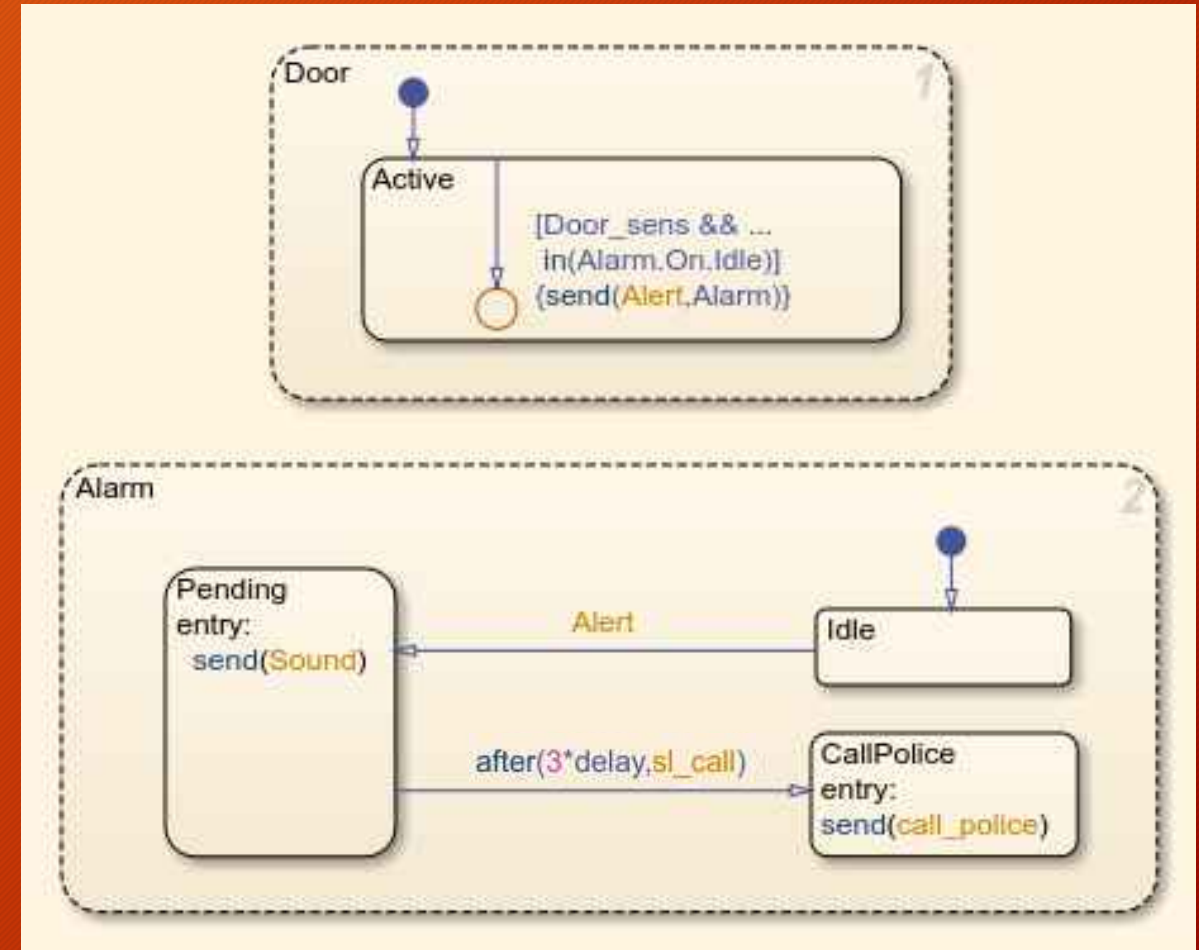


Section 2

A description of the Stateflow portion of the
As-Is Home Security System (HSS) Model

Stateflow Model of Security System State Behavior

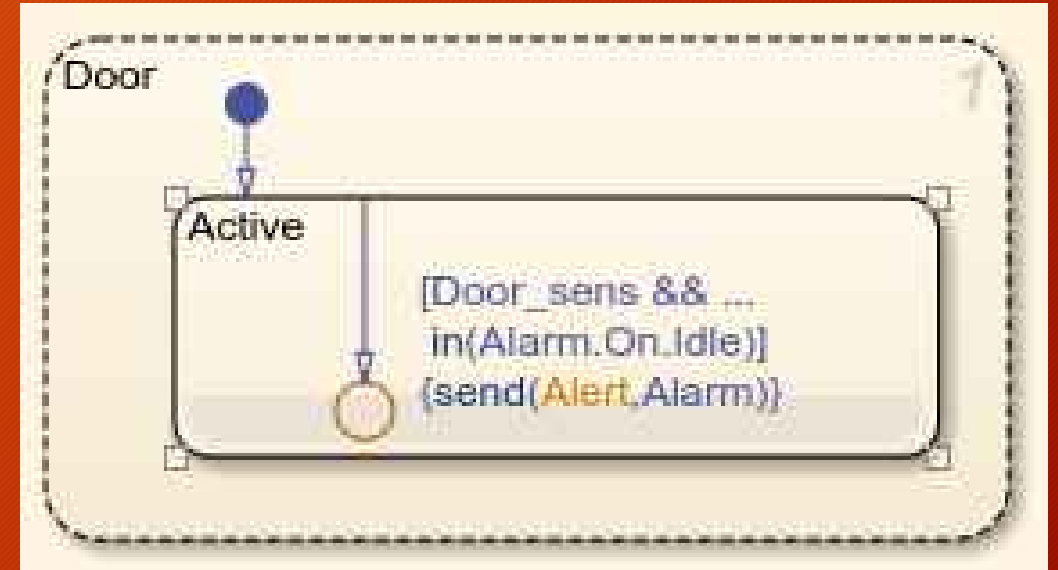
- This model controls the behavior of the system based on the switch setting inputs provided by the Simulink (environment) portion of the model
- The Stateflow model controls how the system reacts to the tripping of the the door sensor
- It also controls the sounding of the audible warning and calling of the police, based on operator responses following tripping of the door sensor



Stateflow simulates state-based behavior, showing how the system transitions from one state to another based on events occurring in and around the system

Door Behavior

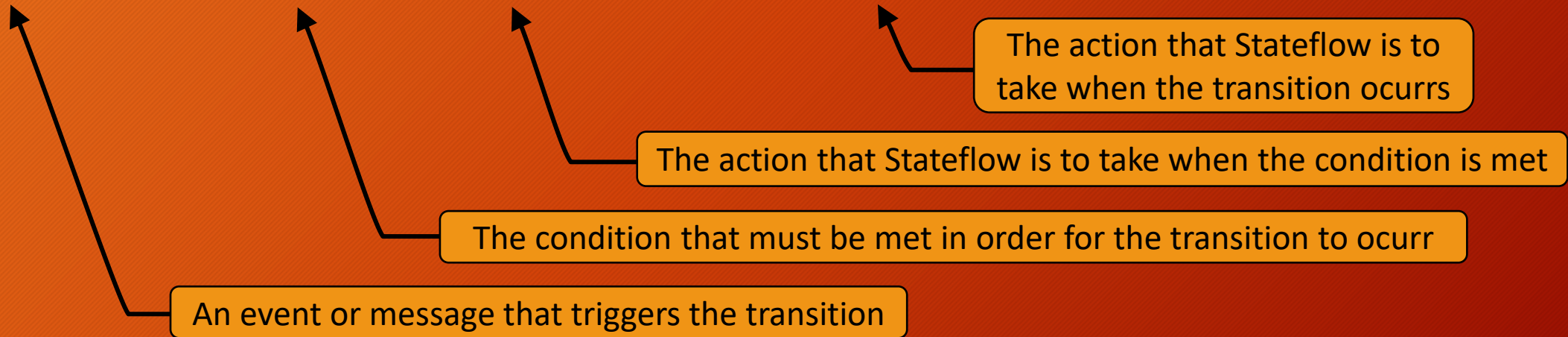
- Door has one substate: Active
- The event “Door_sens” (=1 input from Simulink) simulates the door sensor being tripped (by an open door)
- This event is triggered via the manual switch “Door sensor” in Simulink
- When the event “Door_sens” occurs, it sends an “Alert” signal to the Alarm state (see slide for Alarm state)
 - The door sensor interprets a single positive trigger signal as an intrusion and issues an immediate alert



Interpreting the Transition Label

- Transitions in Stateflow use a particular format, and understanding that format and using it correctly is critical to getting a Stateflow model to execute correctly
- The Transition Label in Stateflow is broken into parts using the following format

event_or_message[condition]{condition_action}/transition_action



- Specifying an event or message is optional
- The ? character is the default transition label
- You can specify multiple events using the OR logical operator (|)
- The absence of an event or message indicates that the transition takes place immediately on the occurrence of any event

What are Events?



- An event is a Stateflow object that can trigger actions in a Stateflow or Simulink model
- Explicit events (defined by user) can have one of these types:
 - Input Event - Event that is broadcast to a Stateflow chart from outside the chart
 - Local Event - Event that can occur anywhere in a Stateflow chart but is visible only from within the parent object and its descendants
 - Local events are supported only in Stateflow charts in Simulink models
 - Output Event - Event that occurs in a Stateflow chart but is broadcast to a Simulink block
 - Output events are supported only in Stateflow charts in Simulink models
- Events do not have values like variables do - sending and receiving an event simply means something has happened in the scenario (that can trigger something else to happen)

Use of Events in the Original HSS Model

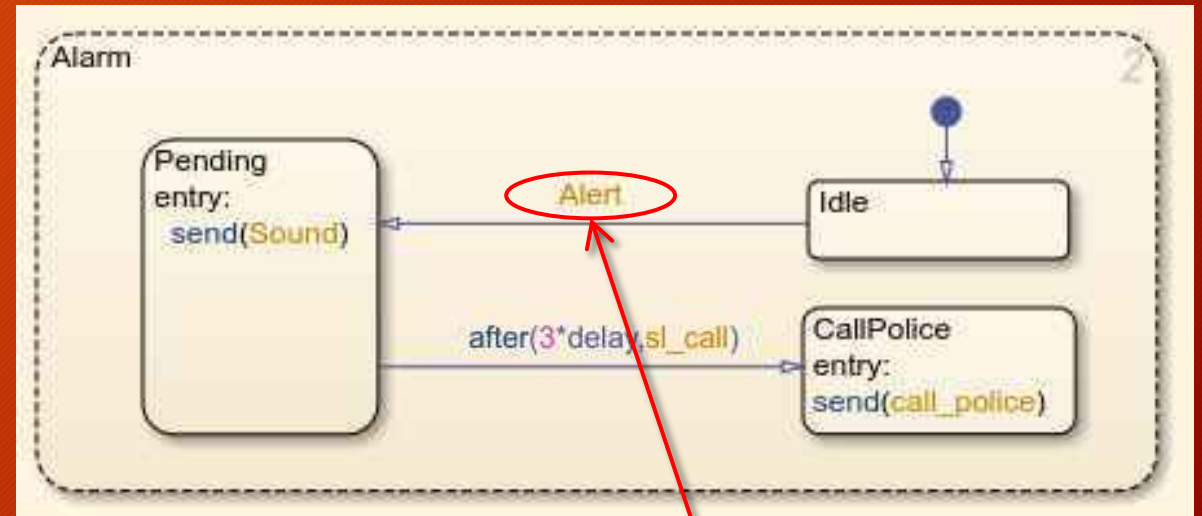
- In state Door.Active, the transition

```
[Door_sens && in(Alarm.On.Idle)] {send(Alert,Alarm);}
```

- uses the “send” function to transmit the event Alert to state Alarm
- This only happens IF the system is currently in the state Alarm.Idle where the Alert event has meaning
- Inside state Alarm, the transition from substate Idle to substate Pending is triggered on reception of the Alert event



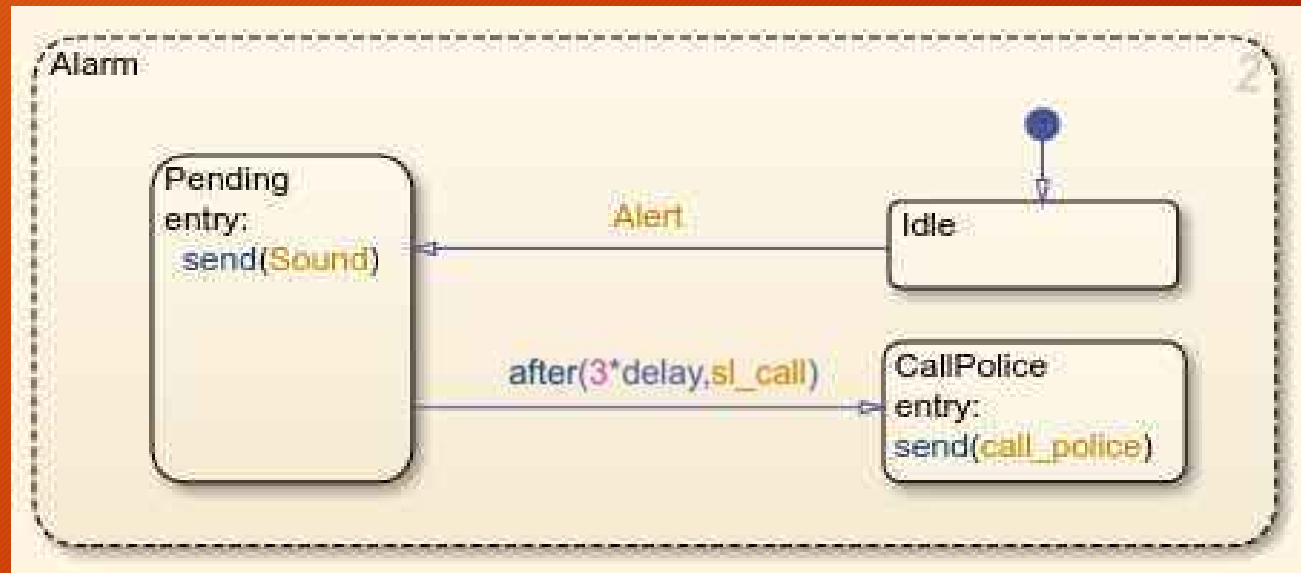
Transmit “Alert”



Respond to “Alert”

Alarm Behavior

- The Alarm state has three substates: Idle, Pending, and CallPolice
- The system will transition from Idle to the Pending state when an Alert event occurs
 - The Alert event is sent (using “send(Alert,Alarm)”) to the Idle substate of the Alarm parent state (using “in(Alarm.On.Idle)”) by state Door
- After 4 seconds in the Pending state, the system transitions to the CallPolice state in which the event “call_police” is broadcast



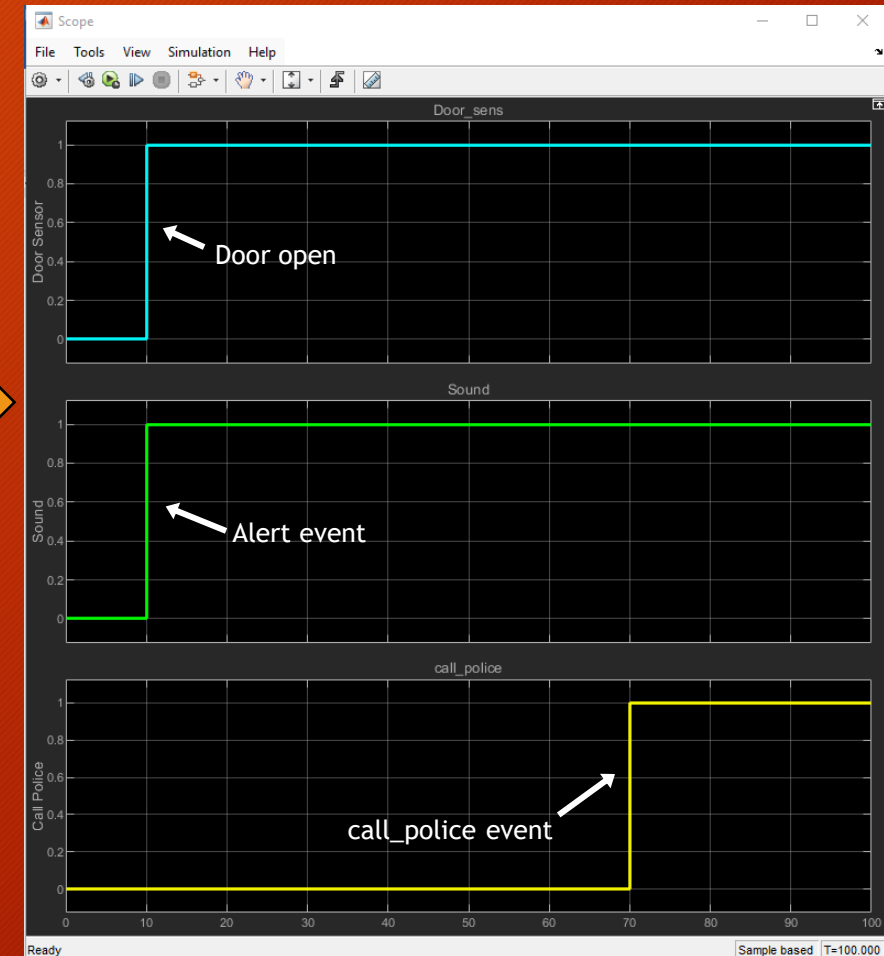
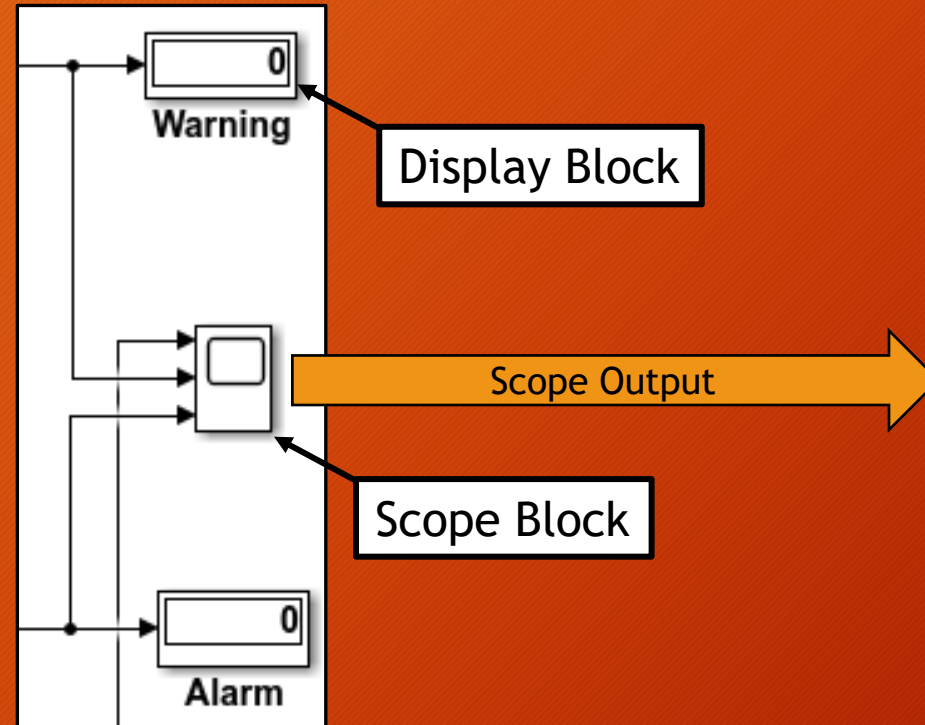
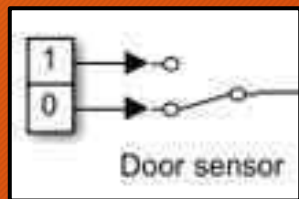
Monitoring System Behavior Using the Scope Block in Simulink

- The Scope Block is used to display signals over time
- The Display Block simply displays the current value that exists on a signal channel

Procedure

1. Run the sim

2. Flip the switch



Section 3

References

References



- The MathWorks. (2022), *Synchronize Parallel States by Broadcasting Events*
 - <https://www.mathworks.com/help/stateflow/gs/events.html>