Debouncing signals

Lab 3, ESDM

Objective

Using the Stateflow tool in Simulink to model to implement time-based design requirements which are very often encountered in practice: - debouncing - error timeouts

Theoretical aspects

Debouncing = ignore short transitions in an input signal, ensuring that a boolean condition is valid for sufficient time before taking action.

- One-sided: debounce only the rising or the falling edge
- Two-sided: debounce both the rising and the falling edge

Below is the schematic for debouncing a boolean signal.

Debouncing with hysteresis

Debouncing can be applied to any real signal, by imposing some minimum and maximum **levels** for the signals.

A typical operation is as follows:

- if $input > V_{on}$ for a certain duration T_{on}, turn the output on
- if $input < V_{off}$ for a certain duration T_{off}, turn the output off

When the two levels are different, e.g. $V_{off} < V_{on}$, the system is said to have **hysteresis**.

In this case, when the input value is in the range $V_{off} \leq input \leq V_{on}$, the output can be either on or off, depending on the previous state of the system.

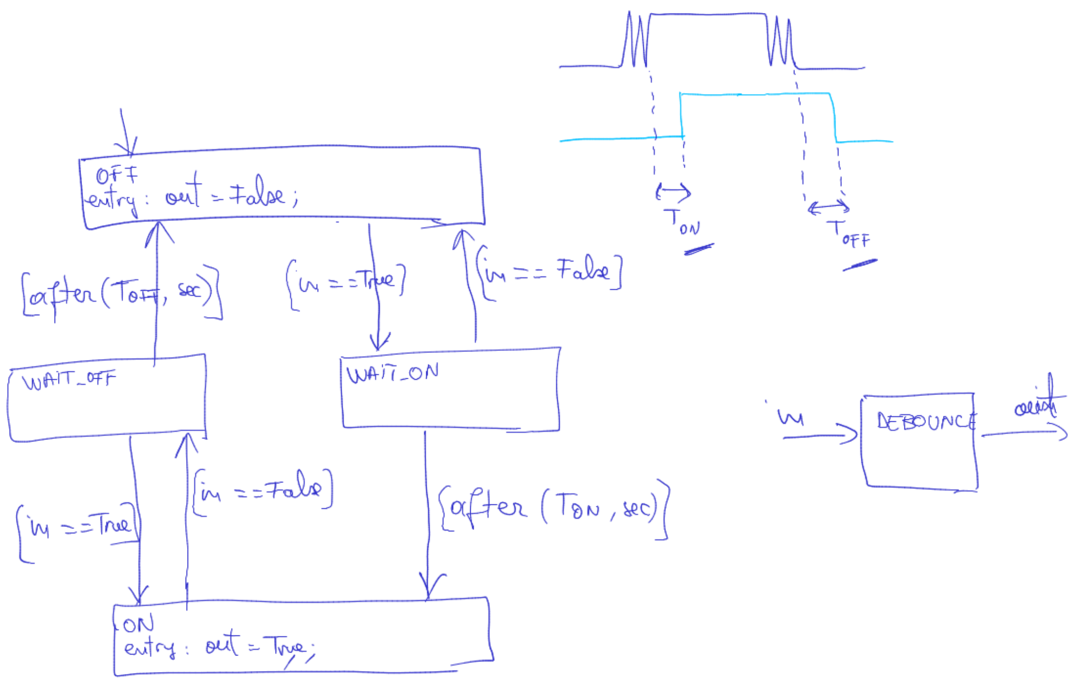


Figure 1: Debouncing schematic

Exercises

1. Design a FSM in Stateflow to implement a User Switch Logic module, according to the following requirements:

    1. **Inputs.** There is one voltage input V_{in} corresponding to the voltage measured after a button, which operates as follows:
        - when button is not pressed, voltage is $V_{in} > 4.5V$
        - when button is pressed, voltage is $V_{in} < 0.5V$
    2. **Outputs.** There are three boolean outputs: `ShortPress`, `LongPress`, `StuckError`
    3. The voltage input shall be debounced as follows:
        - when voltage $V_{in} < 0.5V$ for at least T_{on}, the button shall be considered pressed
        - when voltage $V_{in} > 4.5V$ for at least T_{off}, the button shall be considered de-pressed
        - otherwise the button state will not change
        - the initial state is not-pressed

4. When the button is pressed for up to T_{long}, the system shall set the output `ShortPress = TRUE` for duration T_{out}. The output shall be set on the de-pressing of the button.
5. When the button is pressed for longer than T_{long}, the system shall set the output `LongPress = TRUE` for duration T_{out}. The output shall be set as soon as the T_{long} delay has elapsed.
6. When the button is pressed for longer than T_{error}, the system shall set the output `StuckError = TRUE`, and set the other outputs to False. The output shall be set as soon as the T_{error} delay has elapsed. The output is maintained until the button is de-pressed.
7. All the durations shall be customizable by setting them as parameters from the Matlab Workspace. Default values are $T_{on} = 200ms$, $T_{off} = 100ms$, $T_{long} = 3s$, $T_{out} = 20ms$, $T_{error} = 25s$.

2. Test your design: put appropriate inputs and observe the output signals, in different conditions:

   - short / long / error press
   - various debouncing levels
   - etc

Additional / optional / extra:

3. Design a FSM in Stateflow with one input `Voltage` and one output `OvervoltageError` for the following requirements:

   1. The error flag `OvervoltageError` shall be set when input `Voltage` exceeds `CP_MaxVoltage` for at least `CP_DebounceOnTime`
   2. The error flag `OvervoltageError` shall be cleared when input `Voltage` is below `CP_MaxVoltage` for at least `CP_DebounceOffTime`

4. Test your design: put appropriate inputs and observe the output signals.
5. How would you add **hysteresis** to the previous block?
6. Design a FSM in Stateflow with one input `UserCommand` and one output `ActivateHighBeam` for the following requirements:

   1. The High Beam shall be started (`ActivateHighBeam = TRUE`) as soon as the input `UserCommand` becomes TRUE, if they were stopped for a duration of at least `CP_MinimumOffDelay` until the current moment.
   2. The High Beam shall be stopped (`MotorCommand = FALSE`) as soon as the input `UserCommand` is FALSE
   3. When the High Beam is stopped, no activation is allowed for at least `CP_MinimumOffDelay` afterwards.

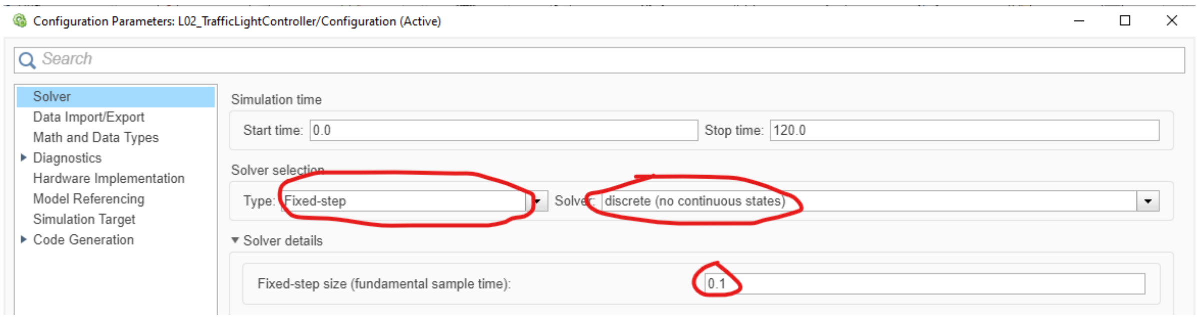
7. Test your design: put appropriate inputs and observe the output signals.
8. Design a FSM in Stateflow with two inputs `MotorOn` and `LatchReached` and one output `LiftgateClosed`, for the following requirements:

    1. The liftgate shall be considered open (`LiftgateClosed = FALSE`) always when `MotorOn = TRUE`.
    2. The liftgate shall be considered closed (`LiftgateClosed = TRUE`) when `MotorOn = FALSE`, if the input `LatchReached` becomes `TRUE` within `CP_MaxLatchDelay` after `MotorOn` has become FALSE.
    3. If the input `LatchReached` becomes `TRUE`, but the motor was not started anytime within `CP_MaxLatchDelay` prior to this moment, it shall be ignored and the liftgate shall be considered open.

9. Test your design: put appropriate inputs and observe the output signals.

General requirements

- Model Settings: Set the Solver type to "Fixed-step", "discrete (no continuous states"), and fixed step size to 0.1 (see Fig.1)


Configuration Parameters: L02_TrafficLightController/Configuration (Active)

Simulation time
Start time: 0.0
Stop time: 120.0

Solver selection
Type: Fixed-step
Solver: discrete (no continuous states)

Solver details
Fixed-step size (fundamental sample time): 0.1

Figure 2: Model Settings

- Use "Simulation Pacing" to have simulation time slightly faster than normal time (see Fig.2)
- Put all inputs and outputs into a Scope block, for visualization and analysis
- Attach a "Push Button" from the Dashboard group as the input button
- You can attach "Lamp" blocks from the Dashboard group to easily see the outputs

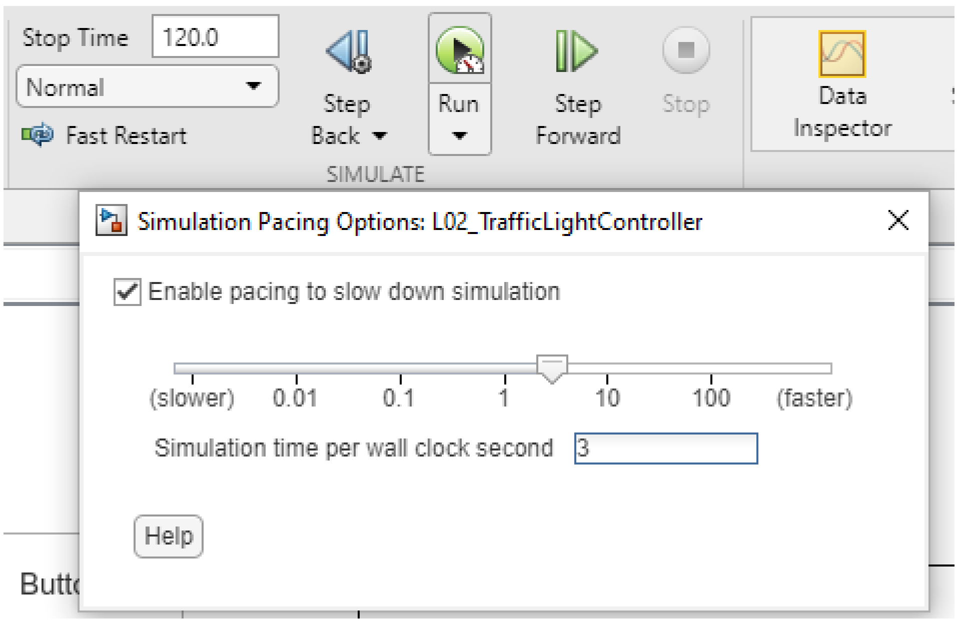

Stop Time
120.0
Normal
Fast Restart
Step Back
Run
Step Forward
Stop
SIMULATE
Data Inspector
Simulation Pacing Options: L02_TrafficLightController
Enable pacing to slow down simulation
(slower)
0.01
0.1
1
10
100
(faster)
Simulation time per wall clock second
3
Help

Figure 3: Simulation time