



# Control System Training

## MODULE 5 – Sequential Boolean Logic

# Copyright Notice

These training materials, including the samples, exercises, and solutions, are copyrighted materials. Any reproduction, or use of any kind without the specific written approval of the author is strictly prohibited.

Permission for extra-curricular use by First FRC teams for FRC related training is granted, provided the original copyright and acknowledgements are retained.

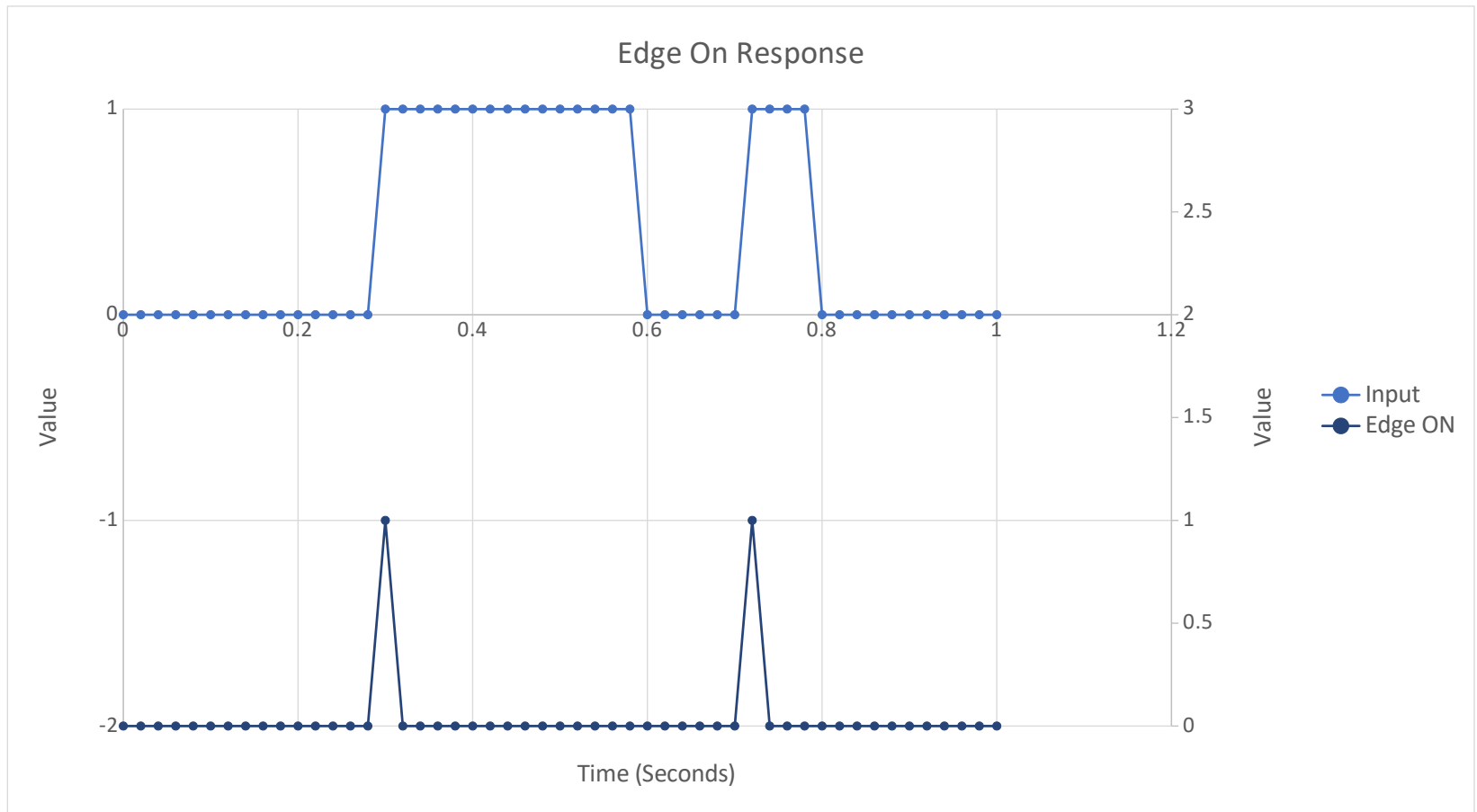
© Jim Simpson, 2018

# Sequential Boolean Logic

## Definitions:

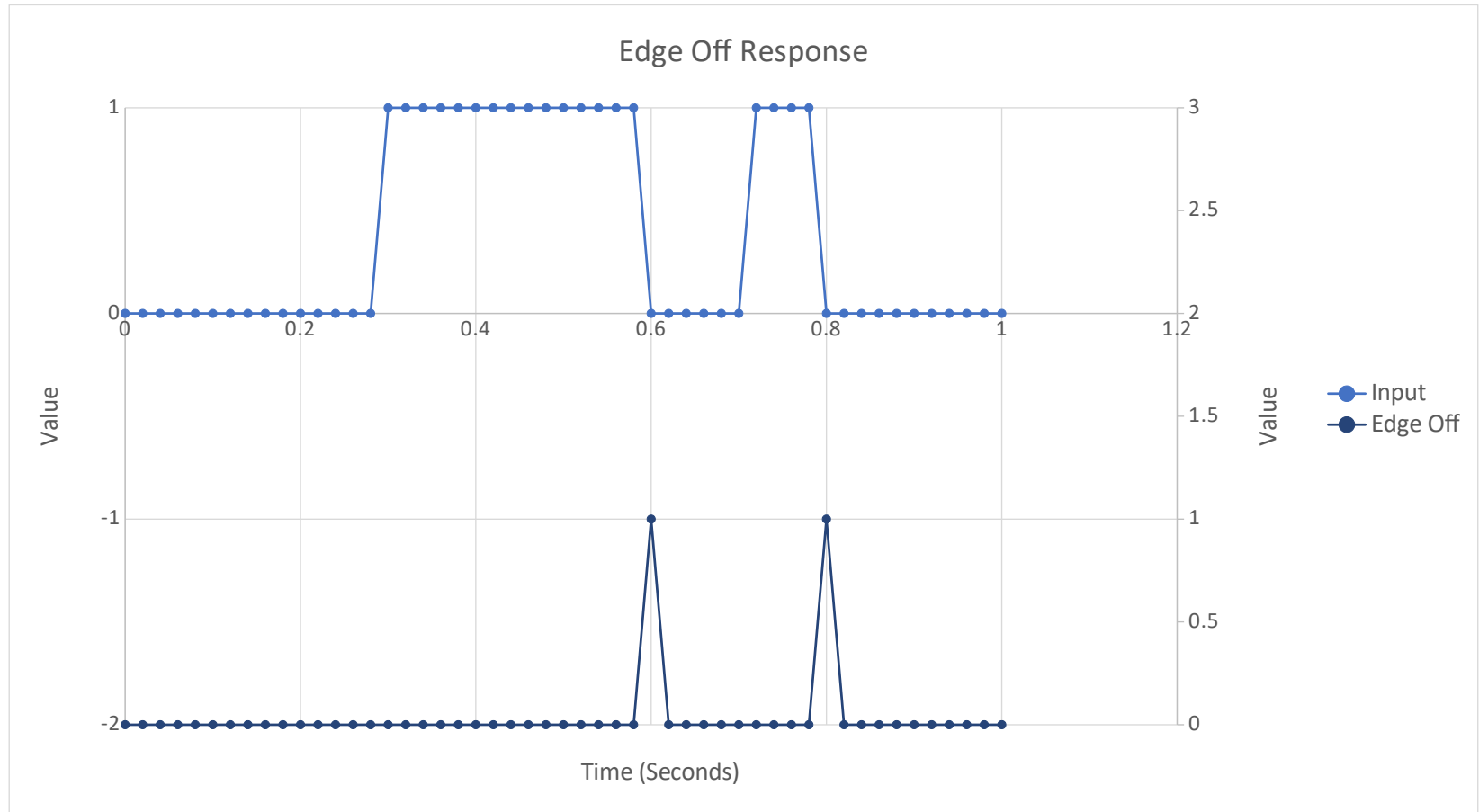
- **Boolean** – Only values are: ZERO / ONE or TRUE/FALSE
- **Sequential Logic** -- Outcome depends on both current values of the inputs and previous values of the inputs and output.

# Edge Triggered – ON



- Only true for a single scan.

# Edge Triggered - OFF



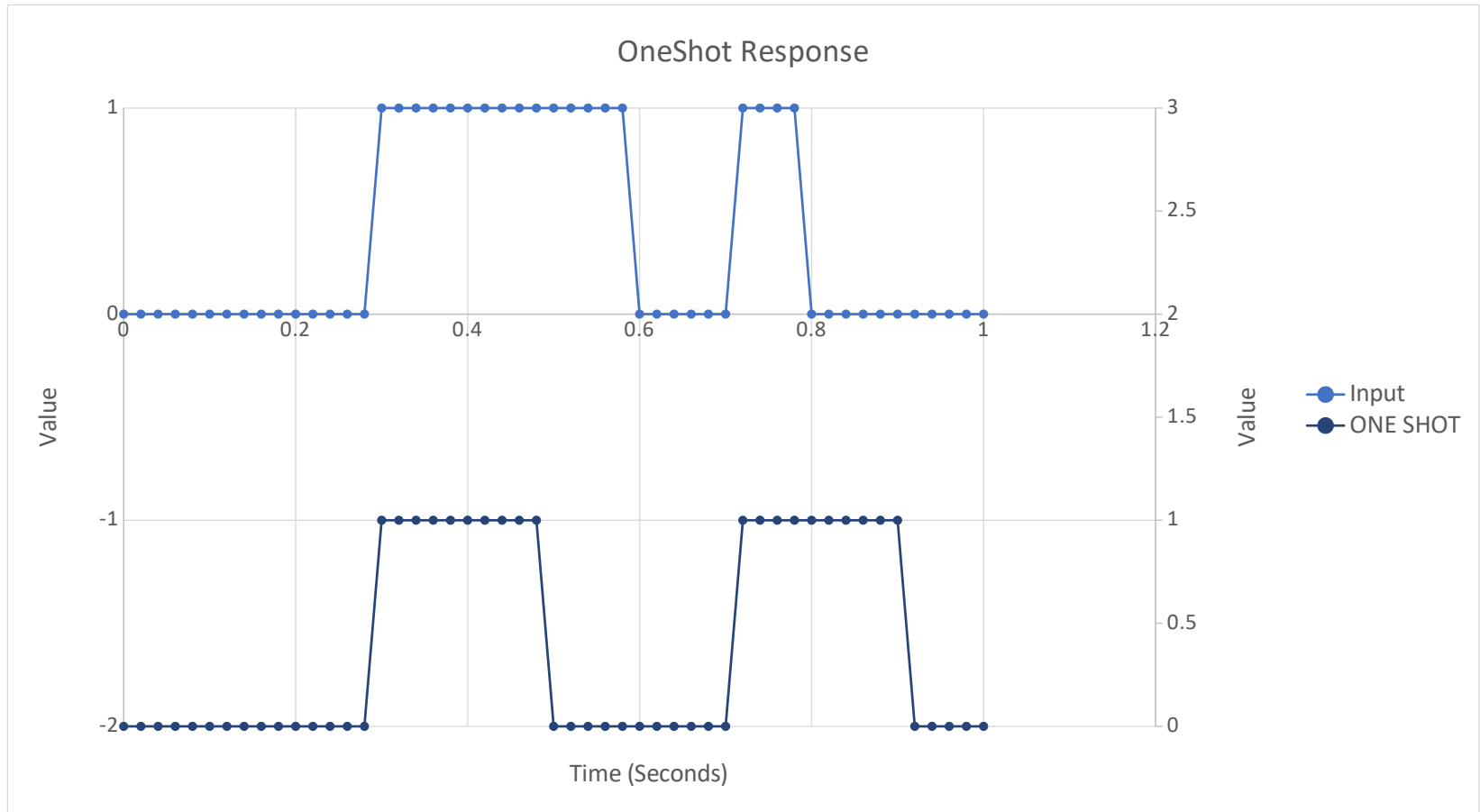
- Only true for a single scan

# Edge Triggered - CHANGE



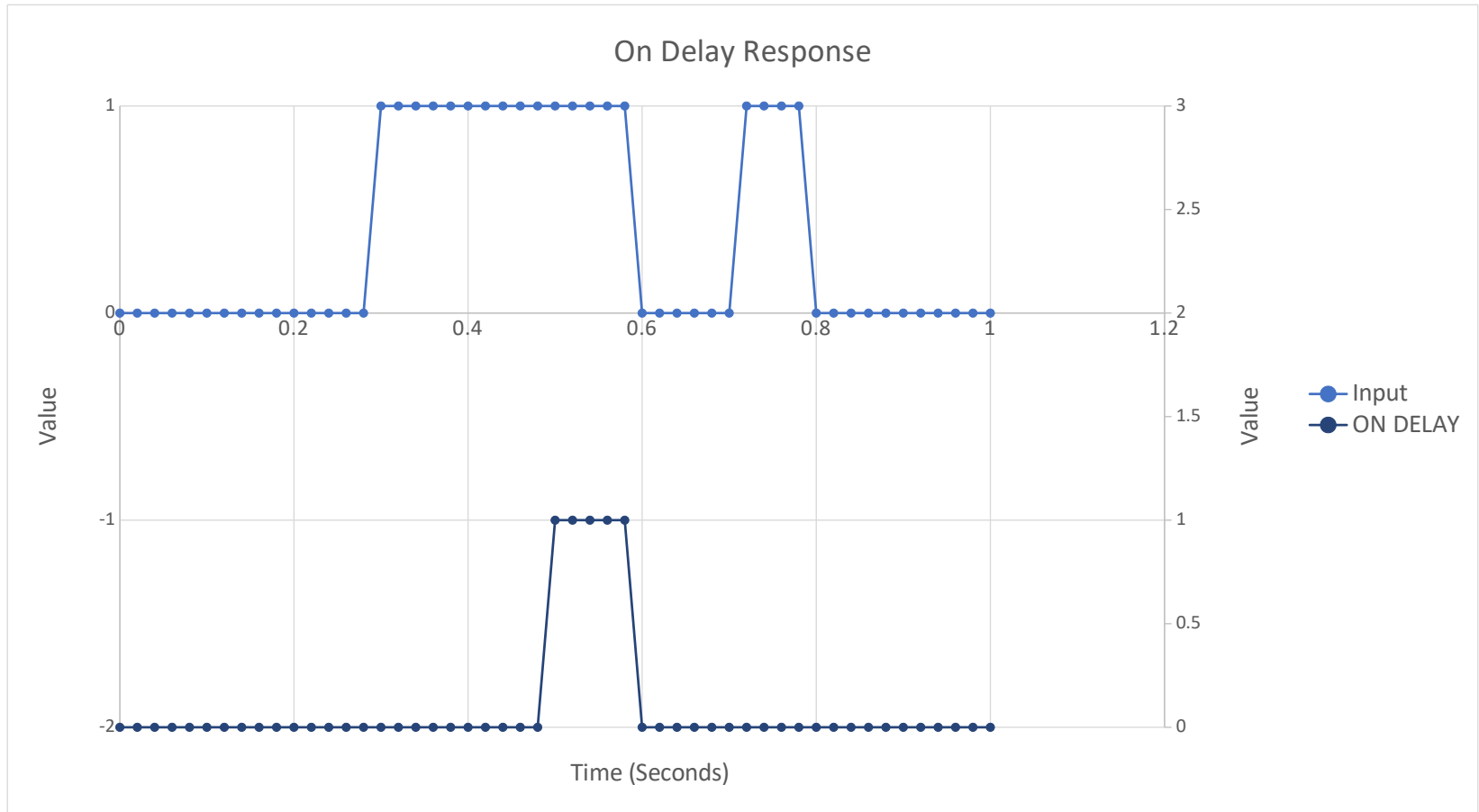
- Only true for a single scan

# One Shot



- Oneshot time is 0.200 seconds

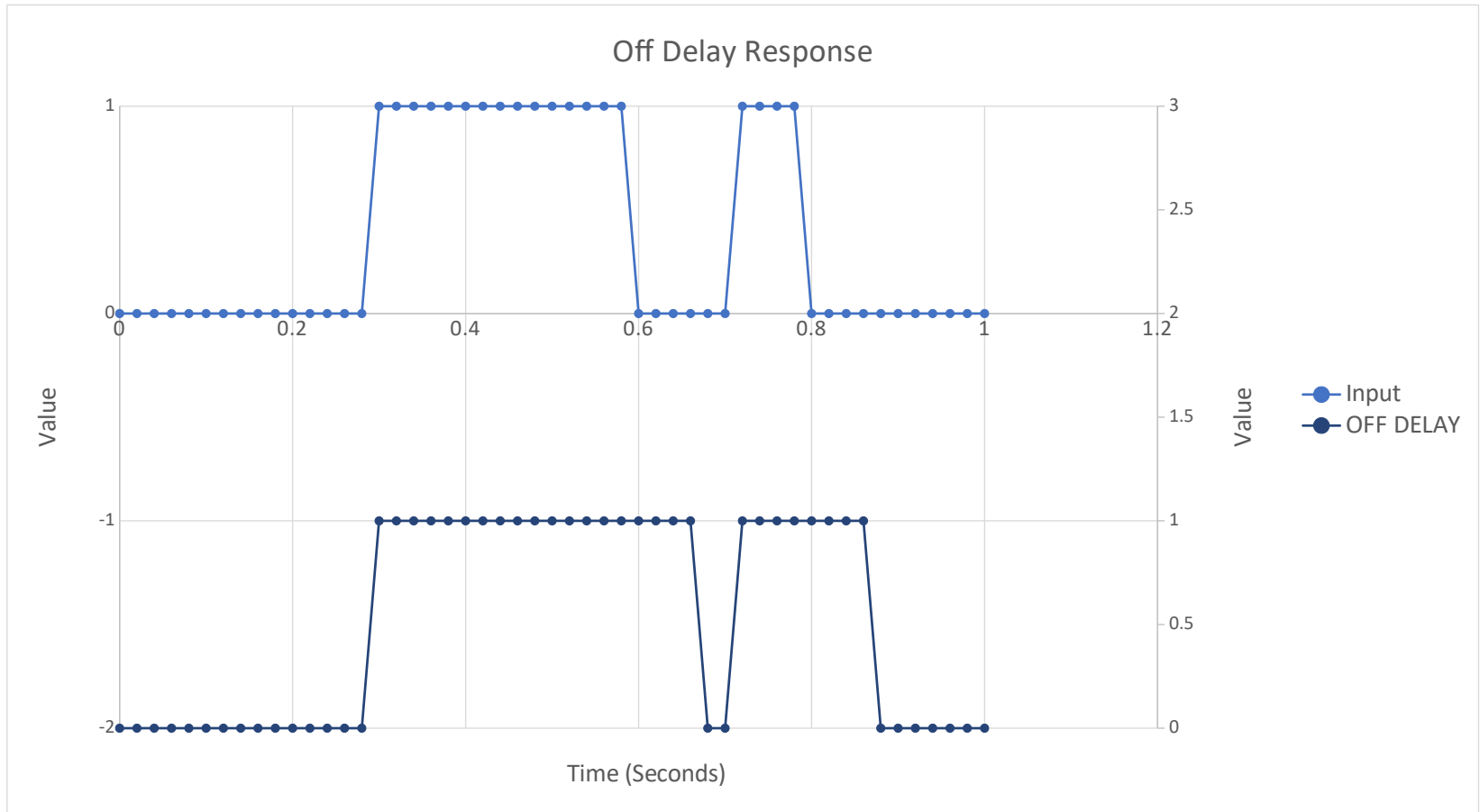
# On Delay



- **Delay is 0.200 Seconds**
- **If input goes false before delay expires, output is never true.**



# Off Delay

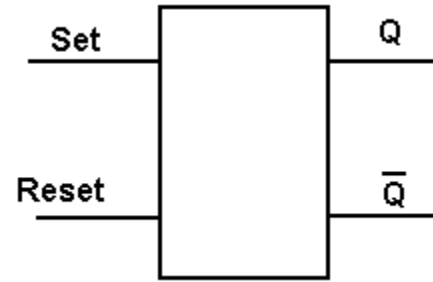


- Off delay time is 0.080 seconds.

# Set / Reset Flip Flop

Set / Reset Flip Flop

Input			Output
Set	Reset	Override	
1	0	N/A	1
0	1	N/A	0
0	0	N/A	Prev Output
1	1	Set	1
1	1	Reset	0



- Can think of this as “Boolean memory”. This is the building block of all computers.
- If both are true at the same time, one overrides the other. This is usually selectable.

# Designing Sequential Logic 1/4

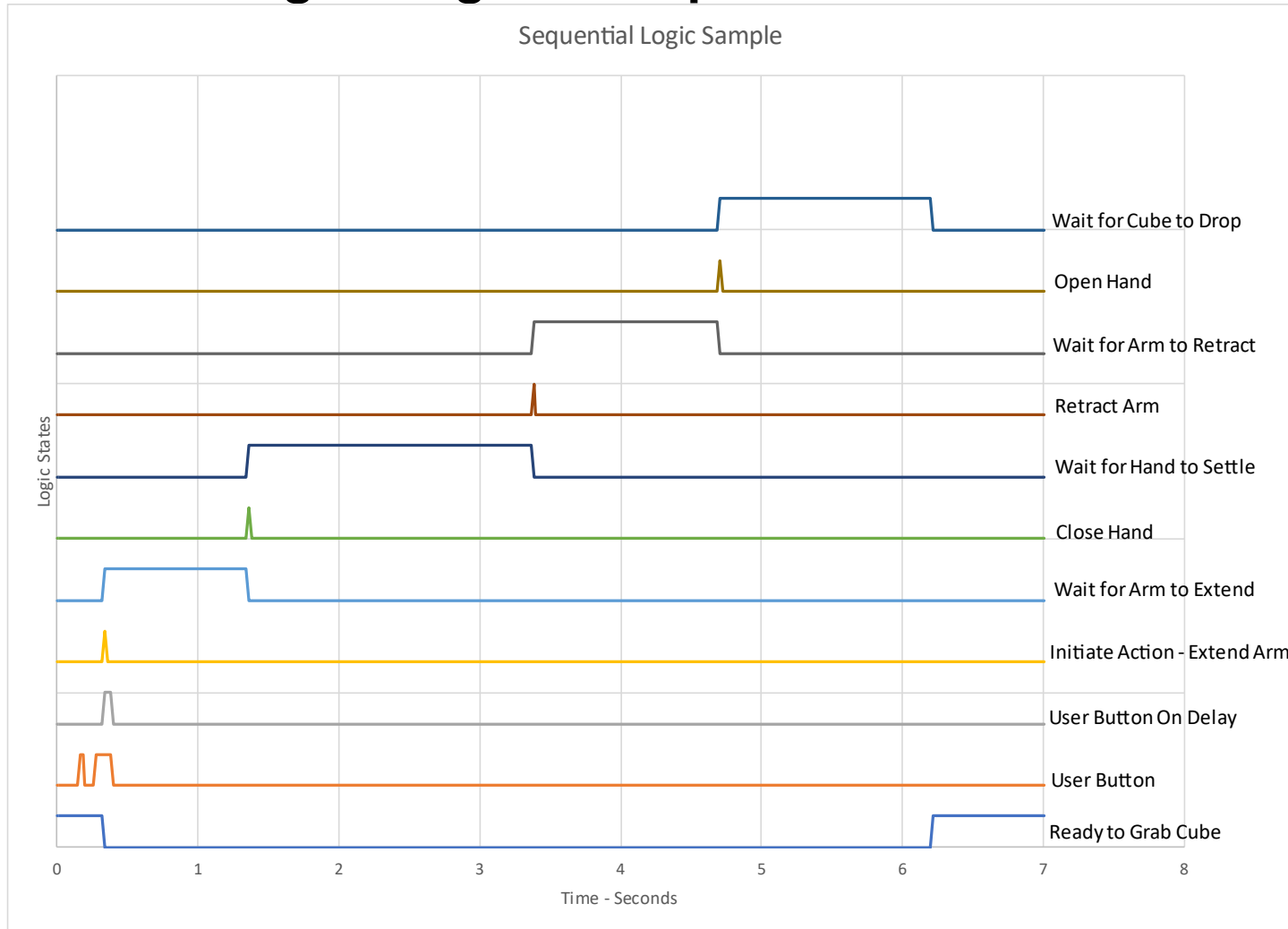
## ■ Sample Problem – Cube Capture

- Control system uses a 20 msec loop time
- System is ready when “hand” is opened and “arm” is retracted
- Users pushes button to initiate “cube capture”. Auto repeat of cube capture is not allowed.
- Ensure user pushed button for 60 msec
- Close “arm” extension solenoid. Wait 1 second for arm to extend.
- Close “hand” solenoid. Wait 2.0 seconds for “hand” to settle.
- Open “arm” extension solenoid. Wait 1.3 seconds for arm to retract.
- Open “hand” solenoid to release potential cube into bin. Wait 1.5 seconds for cube to drop before allowing next “capture” action.

## ■ Enhancement – Add a cancel button

# Designing Sequential Logic 2/4

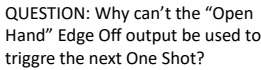
## ■ Draw the Logic Diagram Graph



# Designing Sequential Logic 3/4

- **Start with inputs**
- **Determine relationships**
  - What inputs does an output relate to
- **Draw Logic Diagram**
- **Add intermediate Logic to Graph**
- **Repeat last two steps if needed to refine logic**

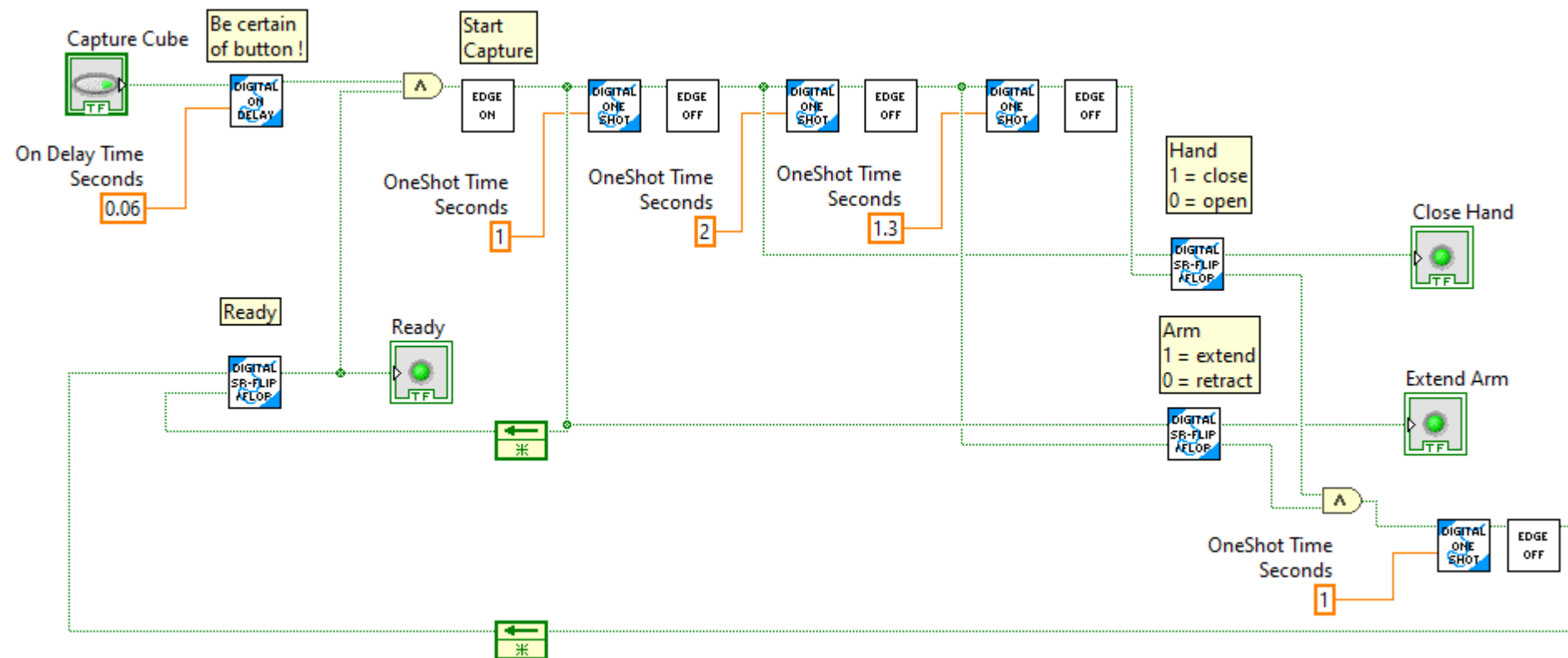
## ■ Final Logic Diagram



NOTE: The inputs to the FLIP/FLOPs can also be used to perform the solenoid output commands.

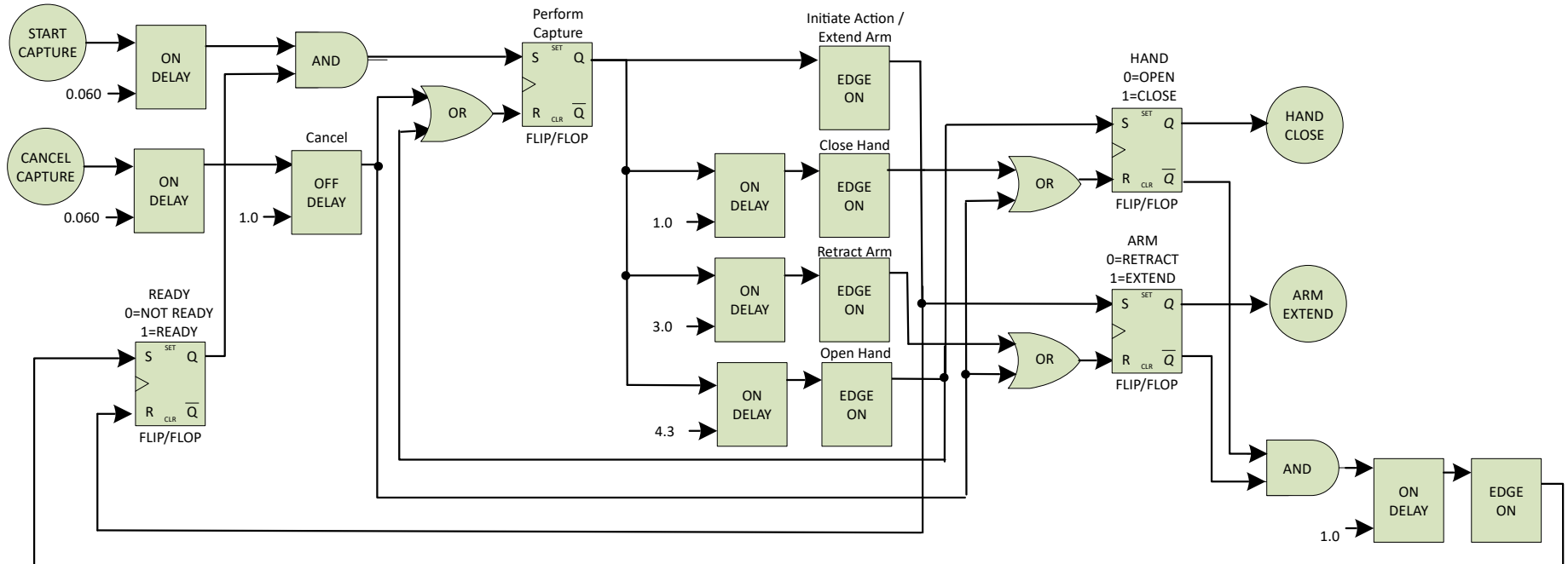
# Designing Sequential Logic 4/4 - LabVIEW

## ■ Sample LabVIEW logic



# Designing Sequential Logic 4/4 - LabVIEW

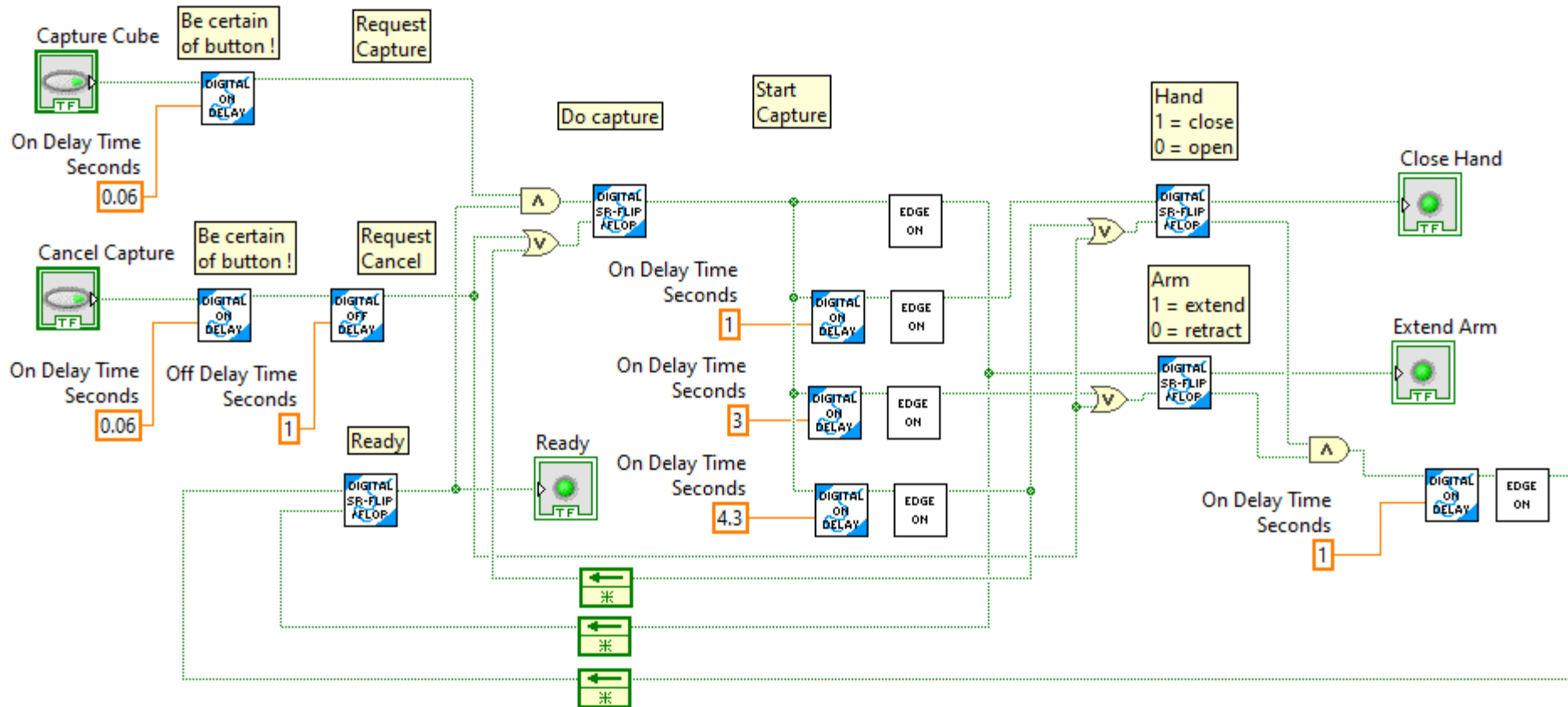
## ■ Alternate logic diagram – With Cancel





# Designing Sequential Logic 4/4 - LabVIEW

## ■ Alternate sample LabVIEW logic – With Cancel



# Exercise 5.1 – Shoot Flying Disc

- User pushes a button to shoot frisbee.
- Ensure user meant to push button. Button must be pressed for three cycles before initiating action. (Cycle time is 0.020 seconds).
- Can only shoot a frisbee if we have one. A limit switch indicates this. Also battery voltage must be  $> 11.5$  volts. Can only shoot one frisbee at a time.
- Motors take 3 seconds to spin up to speed.
- Engage solenoid for 2 second to push frisbee into shooting wheel.
- Allow 2 more seconds for shooting to occur.
- After shooting is done, stop motor. (For now, don't allow continuous shooting.)
- Allow user to press a Cancel button. The cancel button must be pressed for at least 3 cycles before becoming active. After the Cancel, force a 5 second reset before allowing a new shot.
- It takes 5 seconds after shooting for a new frisbee to be in place ready to shoot.
- Design shooting logic. Also provide “ready to shoot” digital for dashboard display. Use ONLY the algorithms discussed in this module, and perhaps module 4.

# Robot Programming 02

## ■ Complete Robot Programming Training 02

# Exercise 5.2 – Shoot Flying Disc Robot Code

- **Implement Exercise 5.1 in robot code.**