

# LabVIEW FPGA hands-on part 2

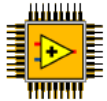


CERN

# Content of LabVIEW FPGA hands-on 2



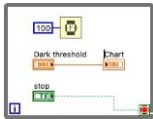
- A few more LabVIEW basics



- Introduction to LabVIEW FPGA



- Overview of NI myRIO



- Exercises

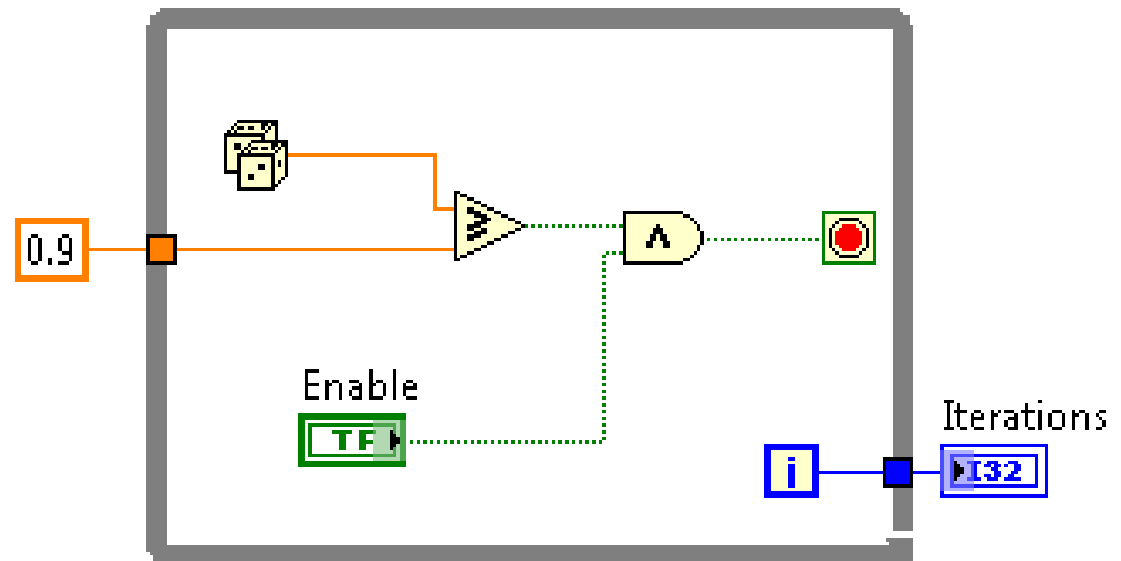


- Resources and Next Steps

## A few more LabVIEW basics

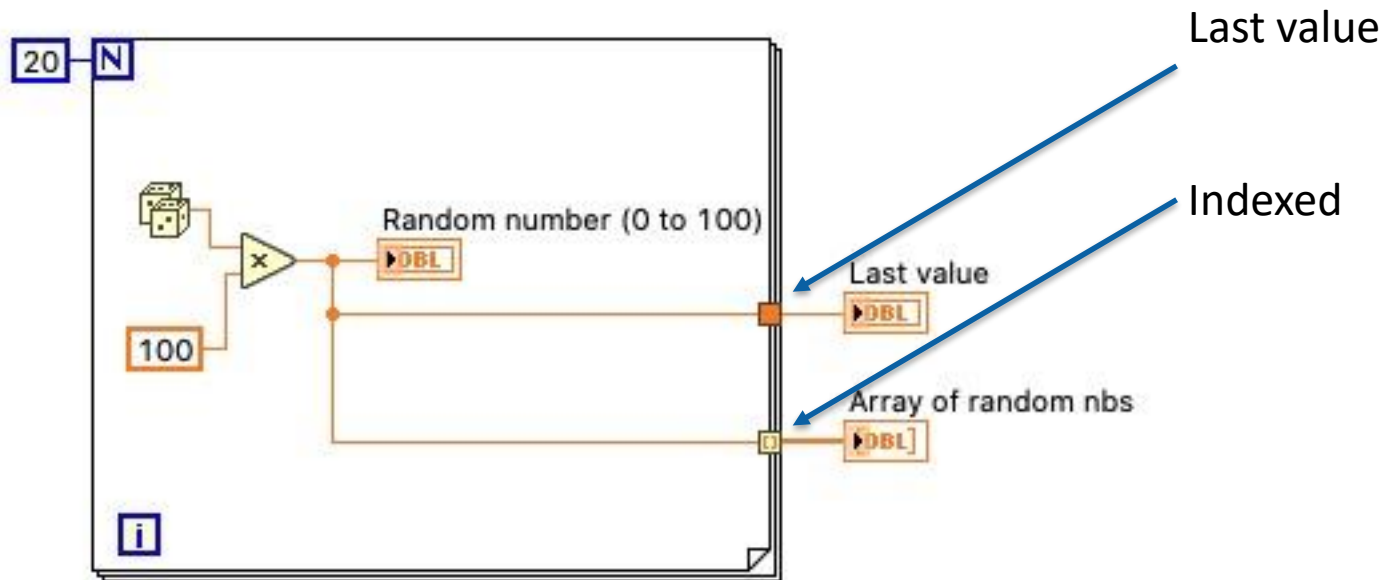
# While loop tunnel

- Tunnels transfer data into and out of structures.
- When a tunnel passes data into a loop, the loop executes only after data arrive at the tunnel (at all tunnels, if there is more than one).
- Data pass out of a loop after the loop terminates.



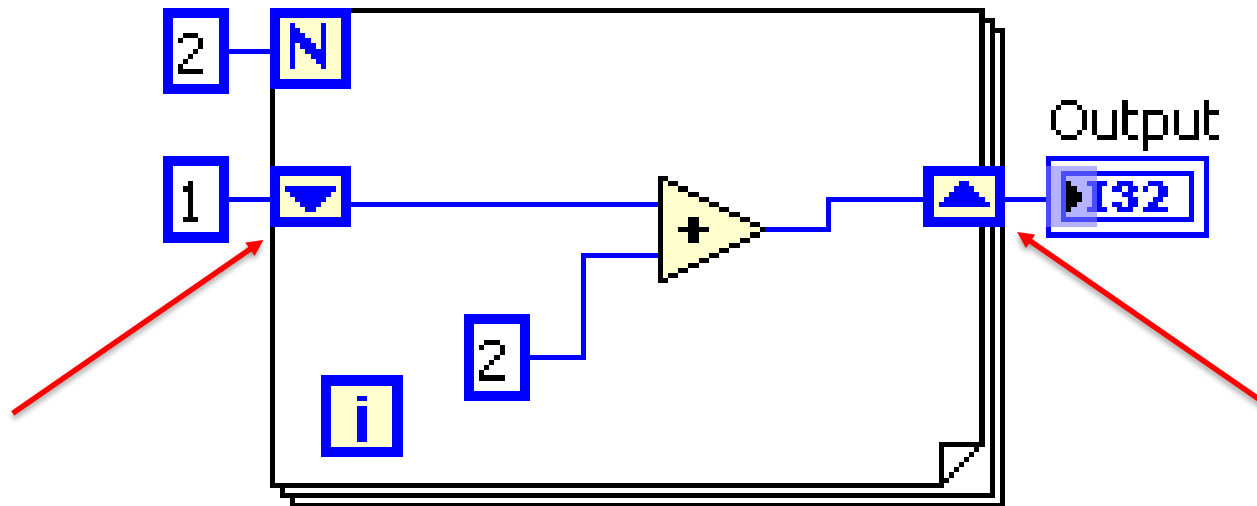
# For loop

- The value in the count terminal (an input terminal) indicates how many times to repeat the subdiagram.



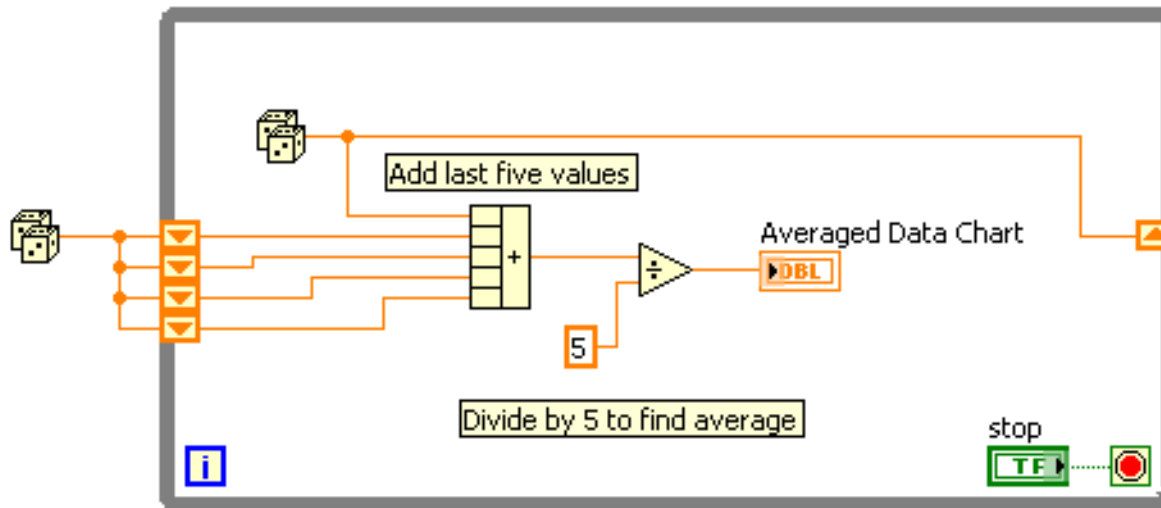
# Shift register

- When programming with loops, you often need to know the values of data from previous iterations of the loop.
- Shift registers transfer values from one loop iteration to the next.



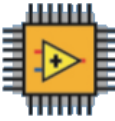
# Shift register, multiple values

- Stacked shift registers remember values from multiple previous iterations and carry those values to the next iterations.
- Right-click the left shift register and select **Add Element** from the shortcut menu to stack a shift register.



# Introduction to LabVIEW FPGA

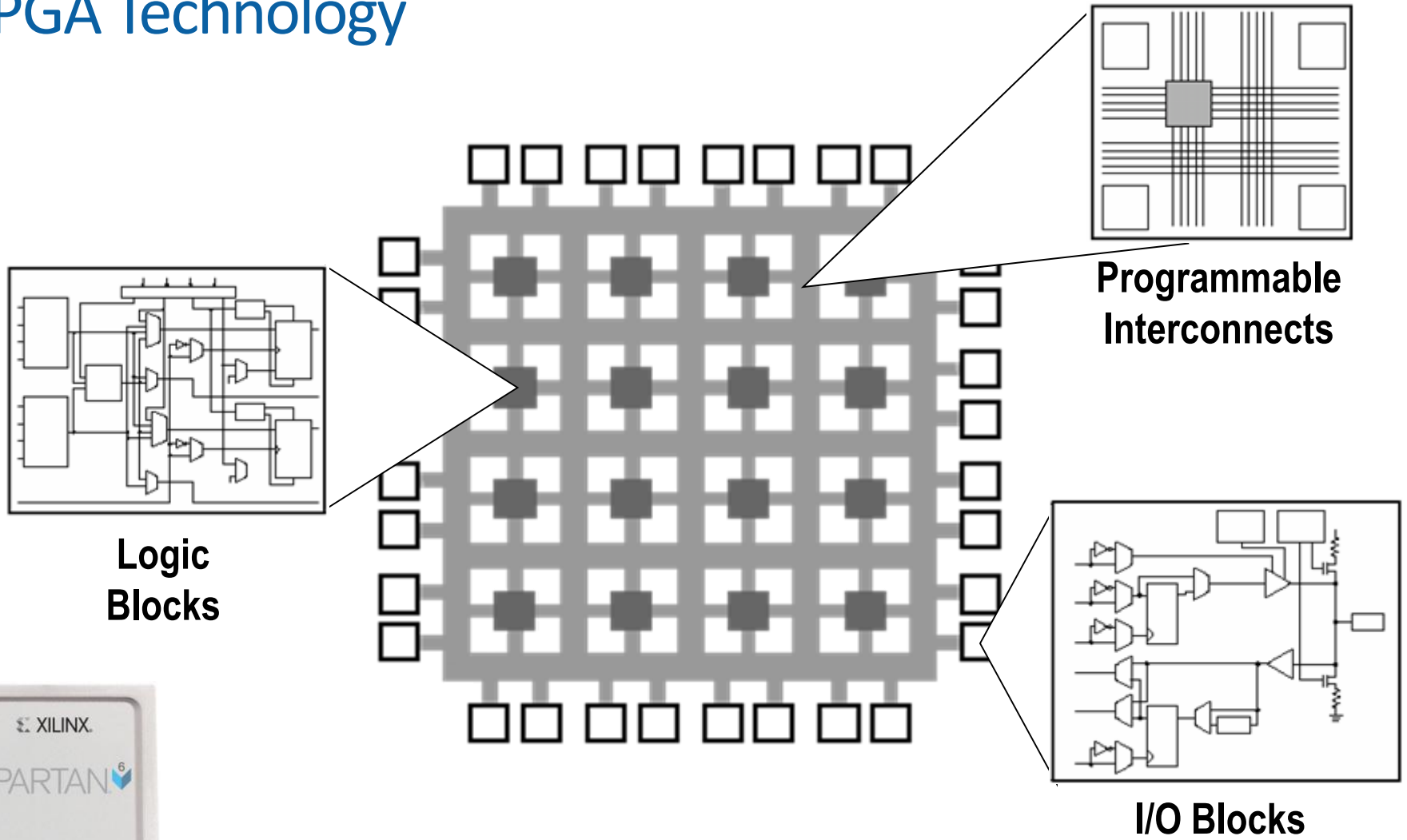




# Why Are FPGAs Useful?

- **True Parallelism**  
Provides parallel tasks and pipelining
- **High Reliability**  
Designs become a custom circuit
- **High Determinism**  
Runs algorithms at deterministic rates down to 25 ns  
(faster in many cases)
- **Reconfigurable**  
Create new and alter existing tasks easily

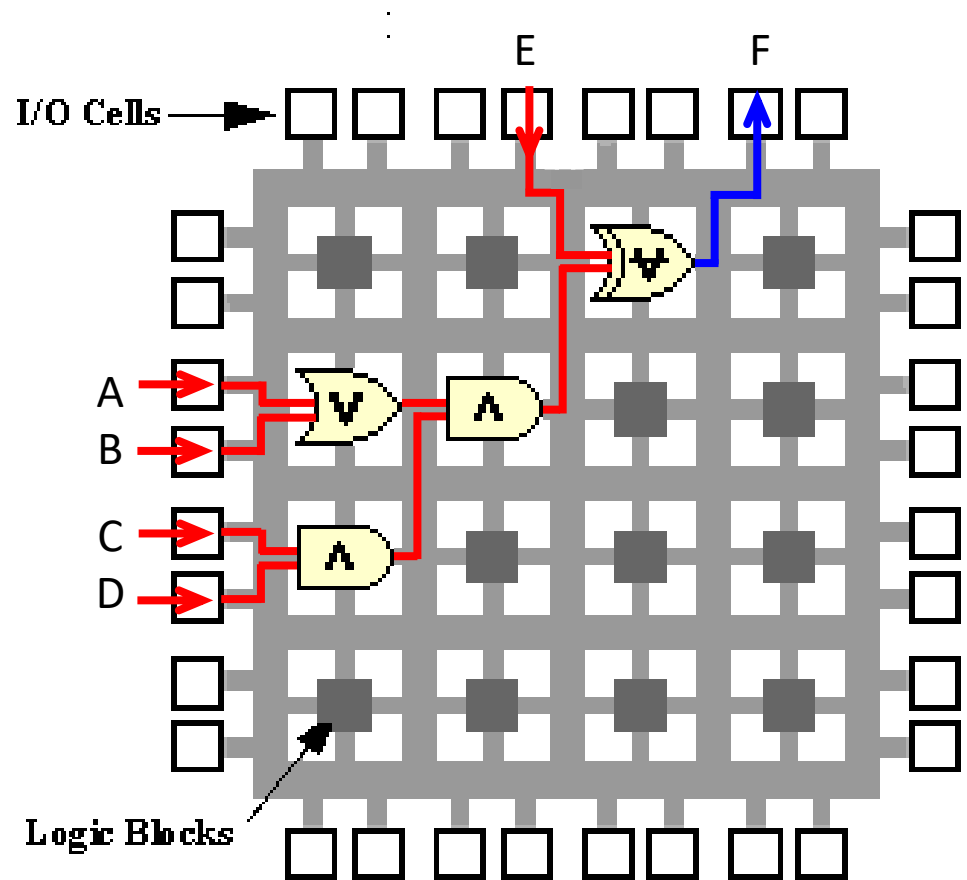
# FPGA Technology



# FPGAs are Dataflow Systems

Implementing Logic  
on FPGA:

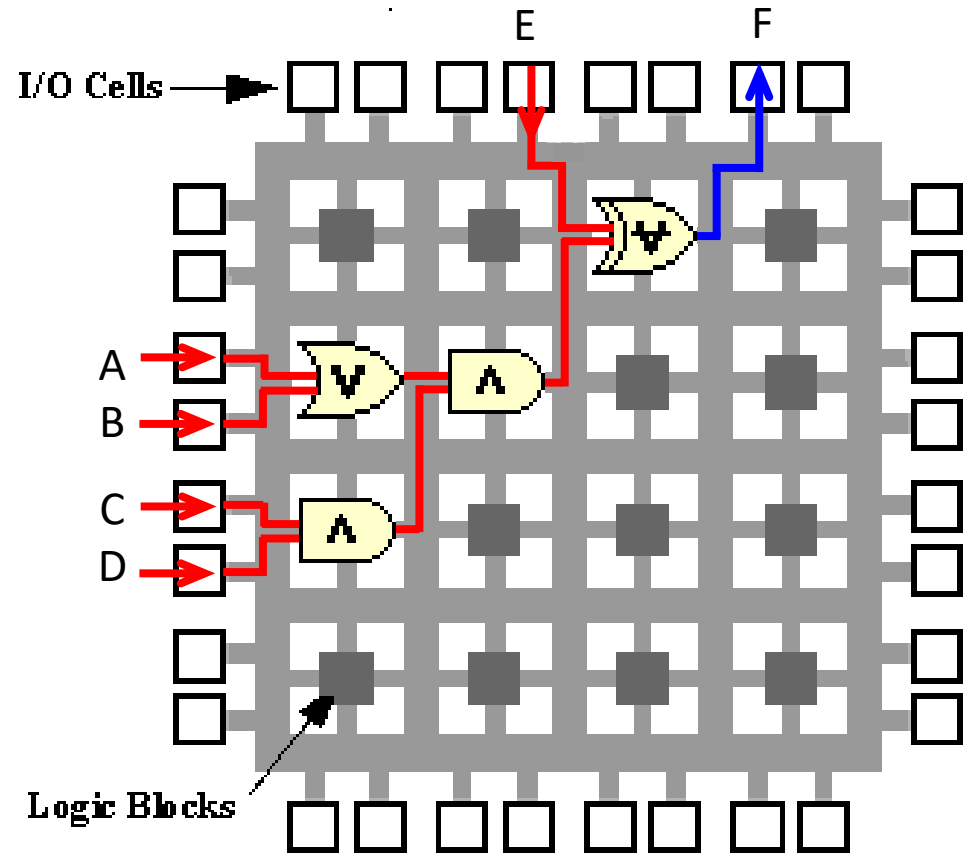
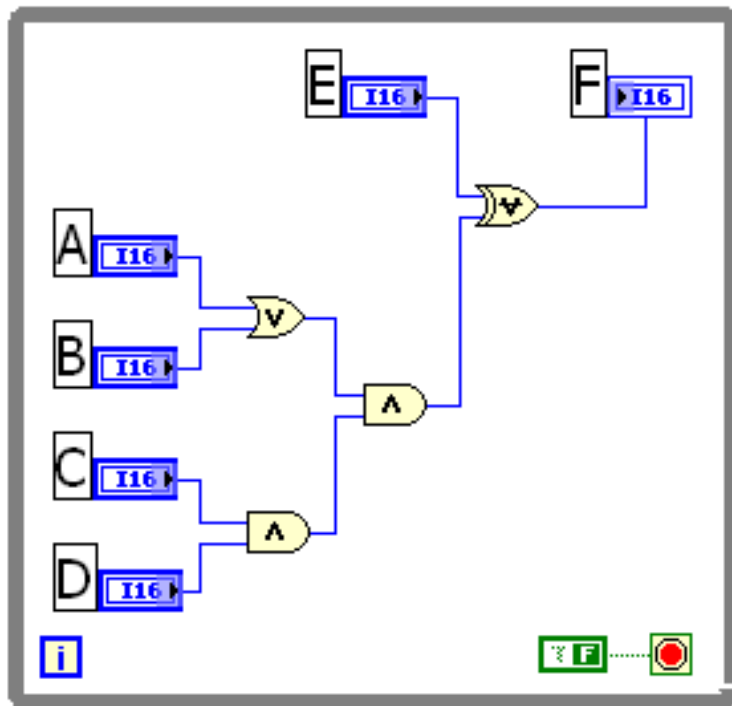
$$F = \{(A+B)CD\} \oplus E$$

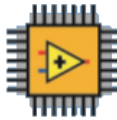


# FPGAs are Dataflow Systems

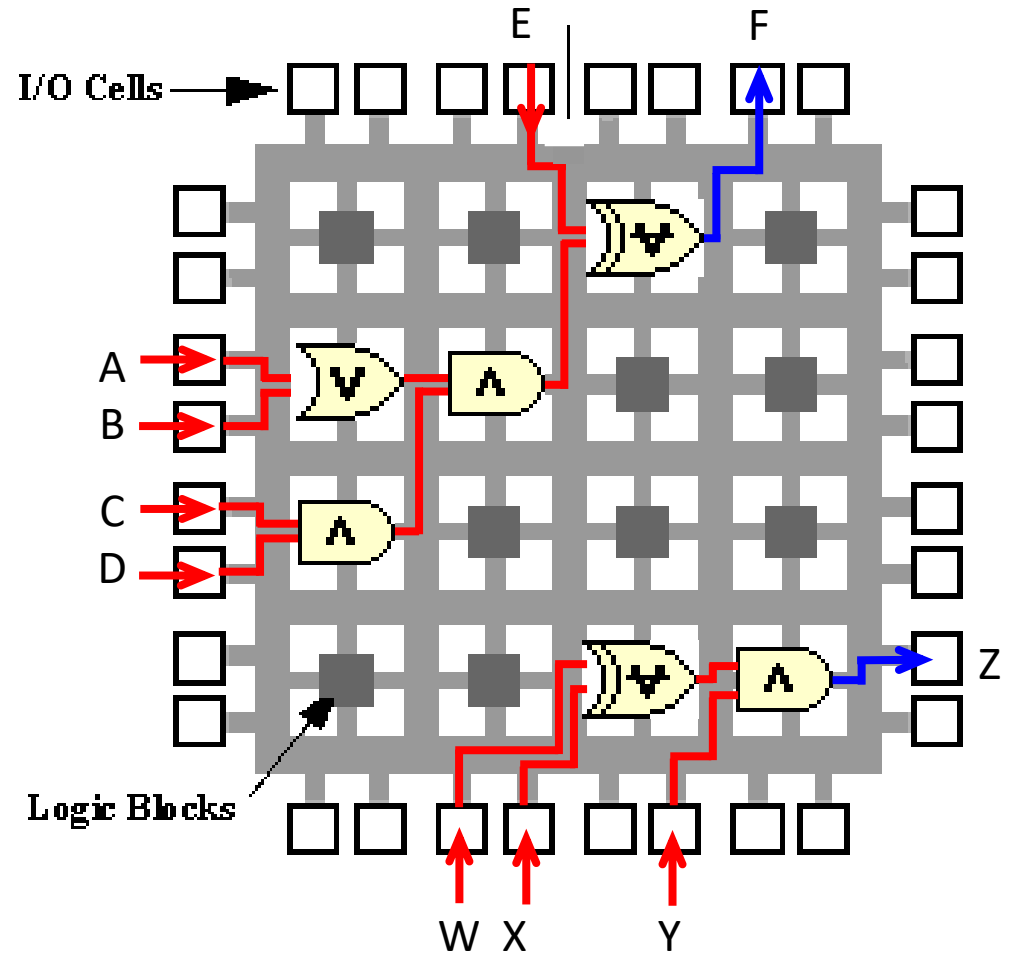
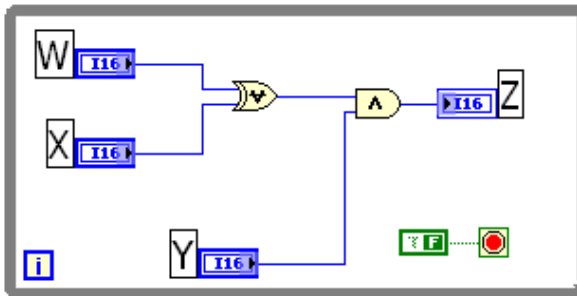
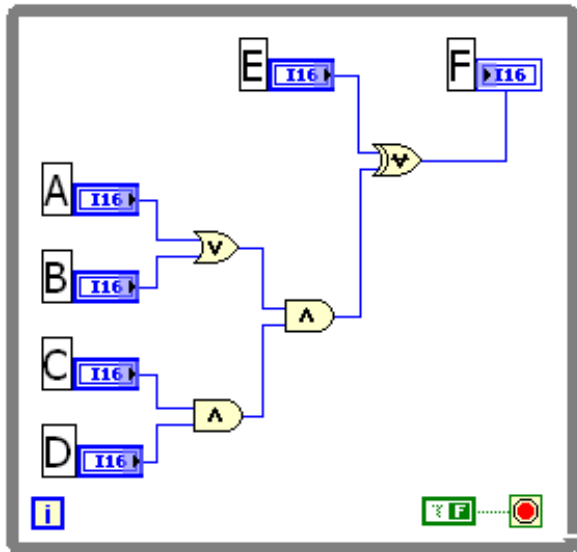
Implementing Logic on FPGA:  $F = \{(A+B)CD\} \oplus E$

LabVIEW FPGA Code



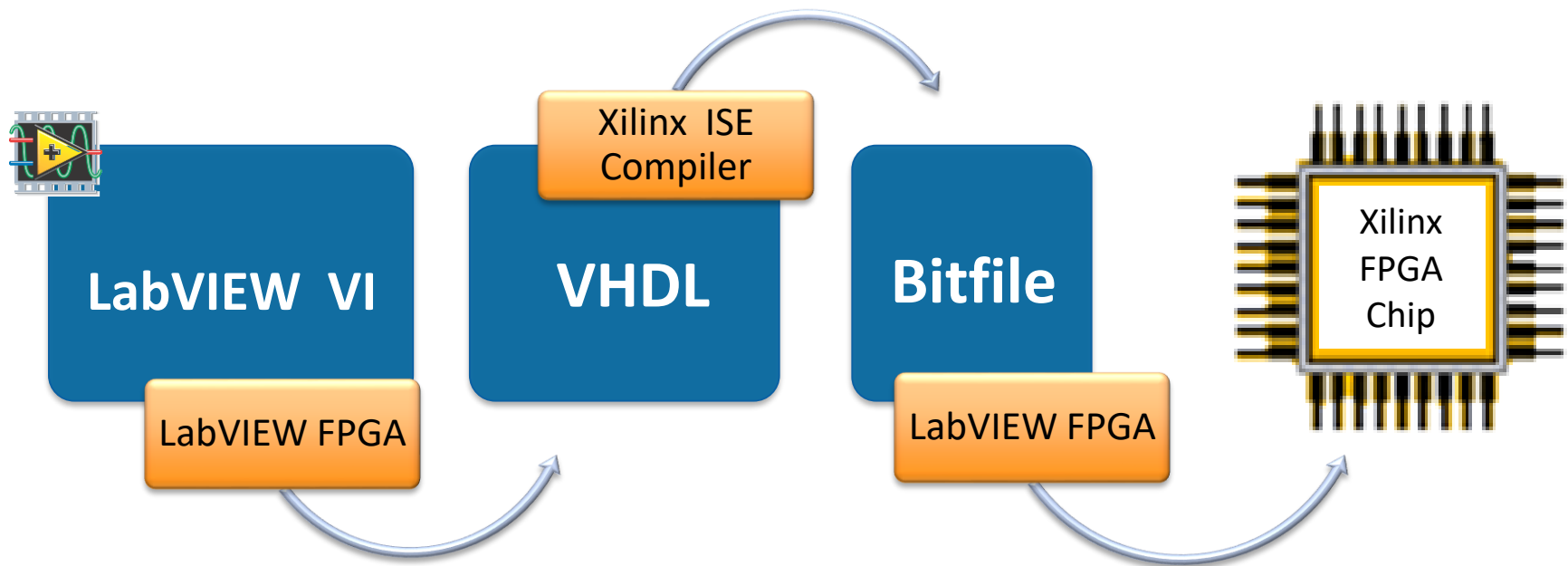


# FPGAs are Parallel Dataflow Systems

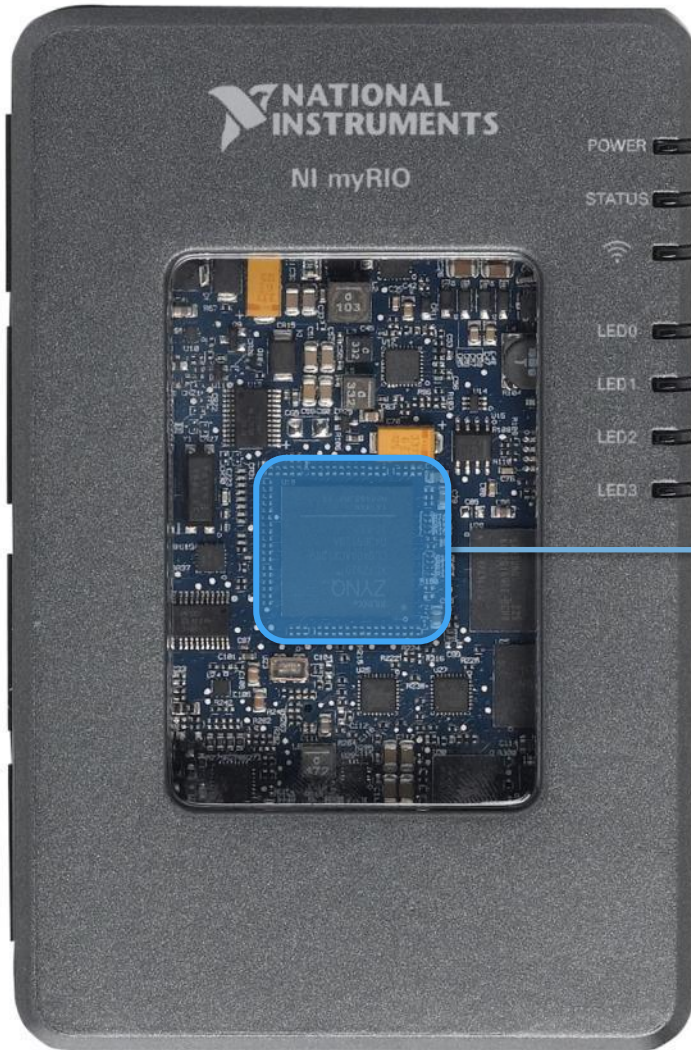




# LabVIEW FPGA: How does it work?



# NI myRIO Product Overview: Front View

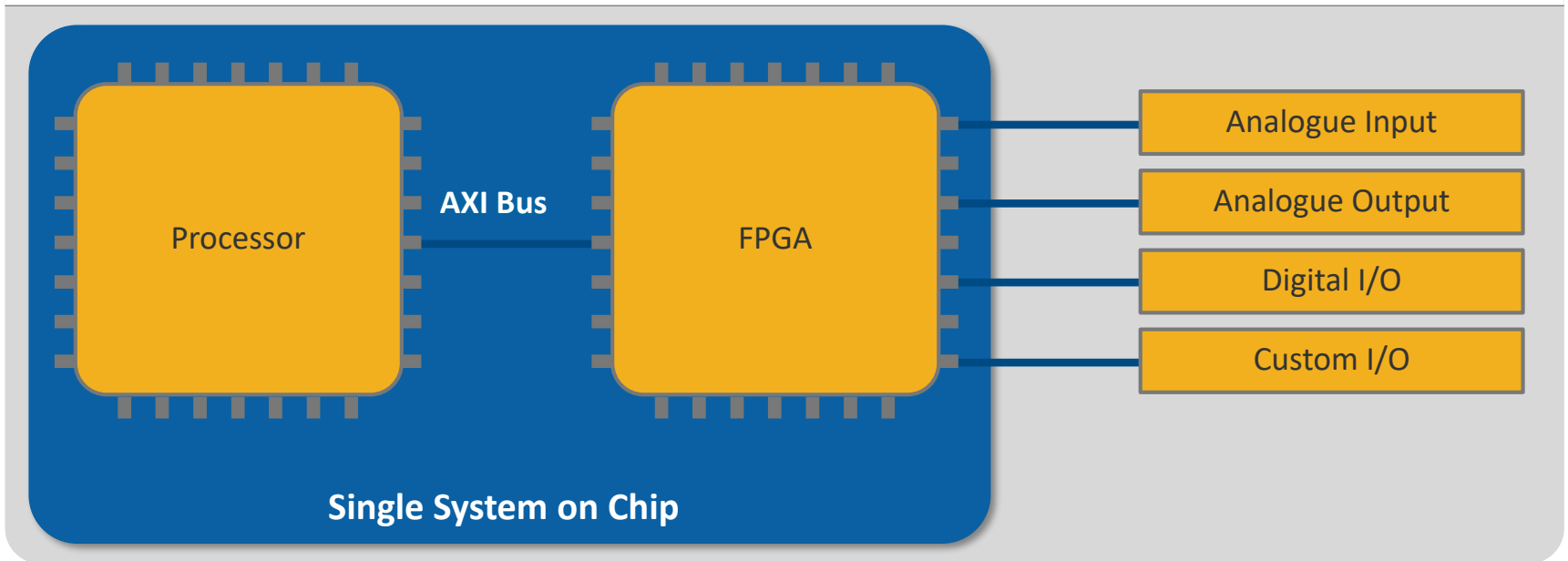


XILINX Zynq SoC



# What is Zynq?

## ZYNQ™ Traditional Implementation



# Why Zynq Matters in Education



- Smaller Size, Lower Power
- 667 MHz Dual-Core ARM Cortex-A9 Processor
- Artix-7 FPGA, 28k logic cells
- 16 DMA Channels
- 92 Billion calculations per second

# Why Zynq Really Matters in Education



## Leading Industry Grade Technology

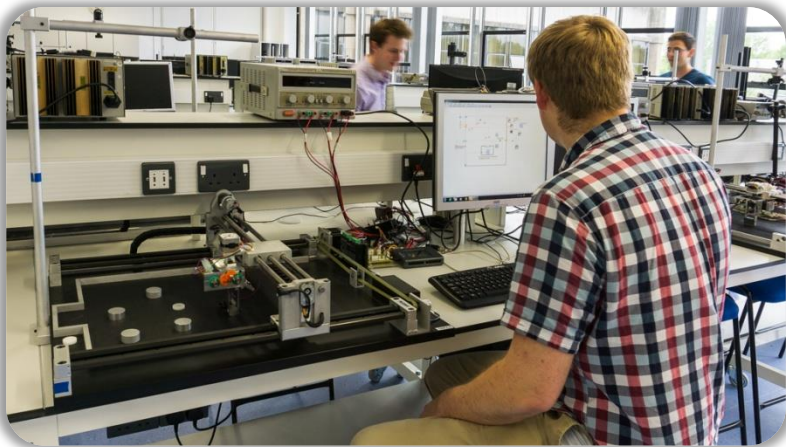


The same technology is used in the modular I/O Compact RIO systems

# Robotic Table Football

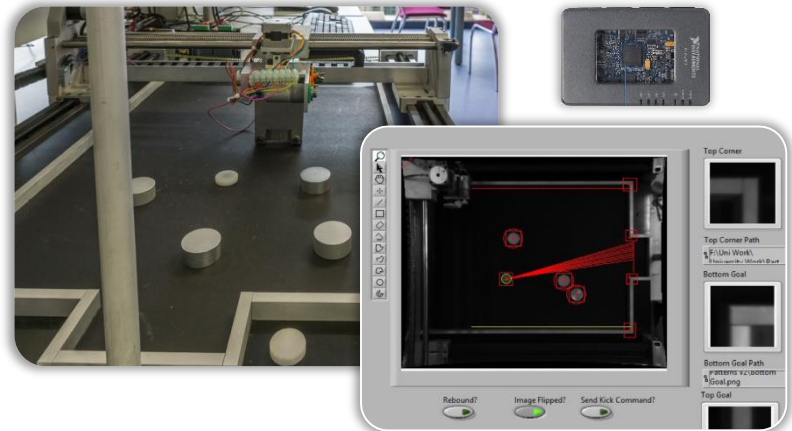
## Revolutionising Mechatronics Education

### The Challenge



Students struggled to realise their innovations using textual programming, due to unintuitive syntax and complex hardware integration. Following many research successes, Loughborough wanted to incorporate LabVIEW into their refined Mechatronic module

### The Solution



Using **LabVIEW** and **myRIO** to develop the Robotic Table Football challenge. This practical approach to teaching *mechatronic systems integration* resulted in a marked increase in student engagement, improved grades and the best system implementations to date.

### The Challenge



Developing an embedded system which operates under low pressure and temperature conditions - **space**. The system must carry out various experiments, including the study of solar radiation and atmospheric pollution

### The Solution



Using **myRIO** to control all on-board sensors and experimental equipment in a high altitude balloon, from the launch to the landing with real time monitoring and post processing.

# Student Design Contest Winner 2014

## Sepios, the Omnidirectional Cuttlefish Robot

### The Challenge



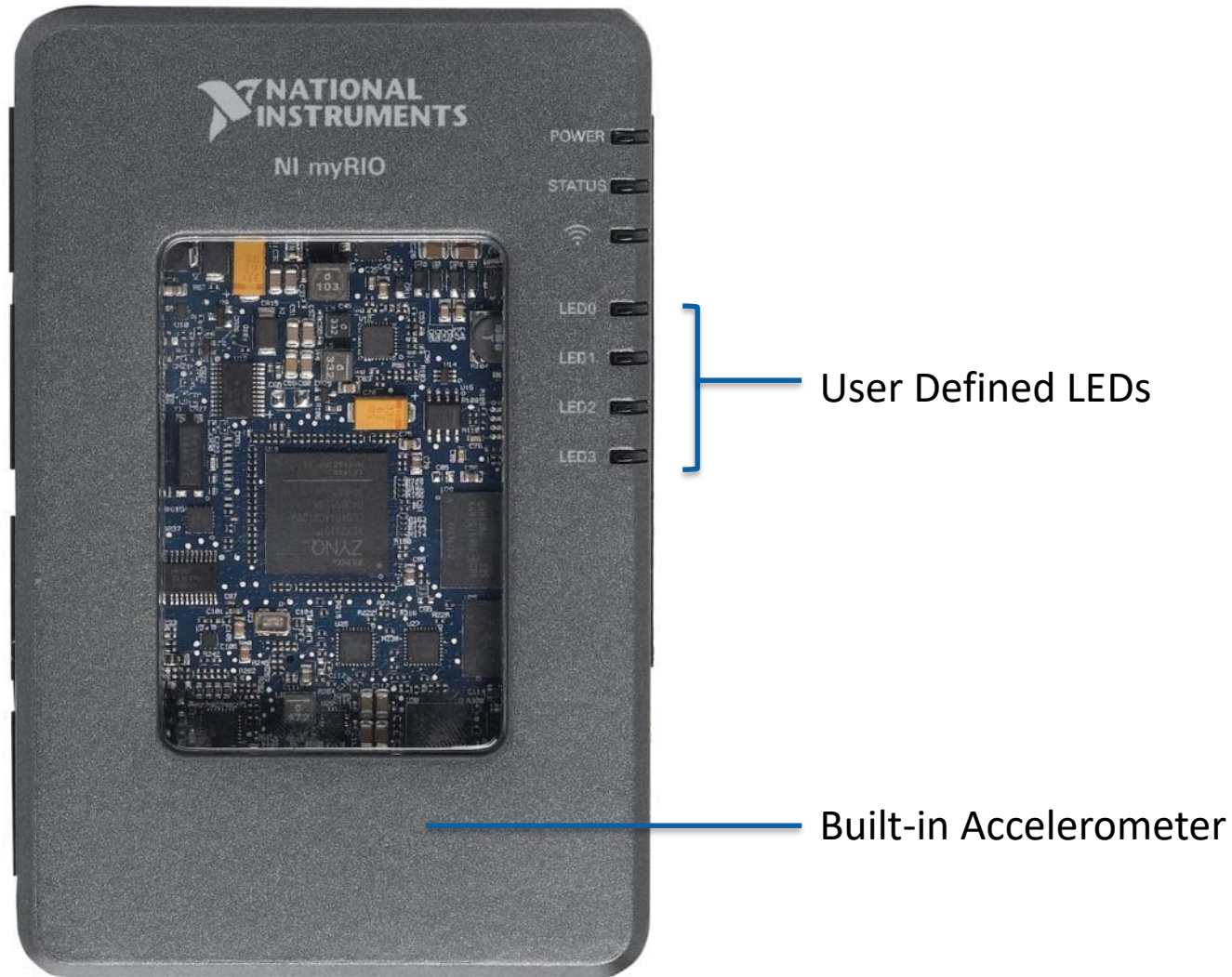
Creating a nautical robot driven by cuttlefish inspired fins to study this unique propulsion mechanism and its advantages

### The Solution

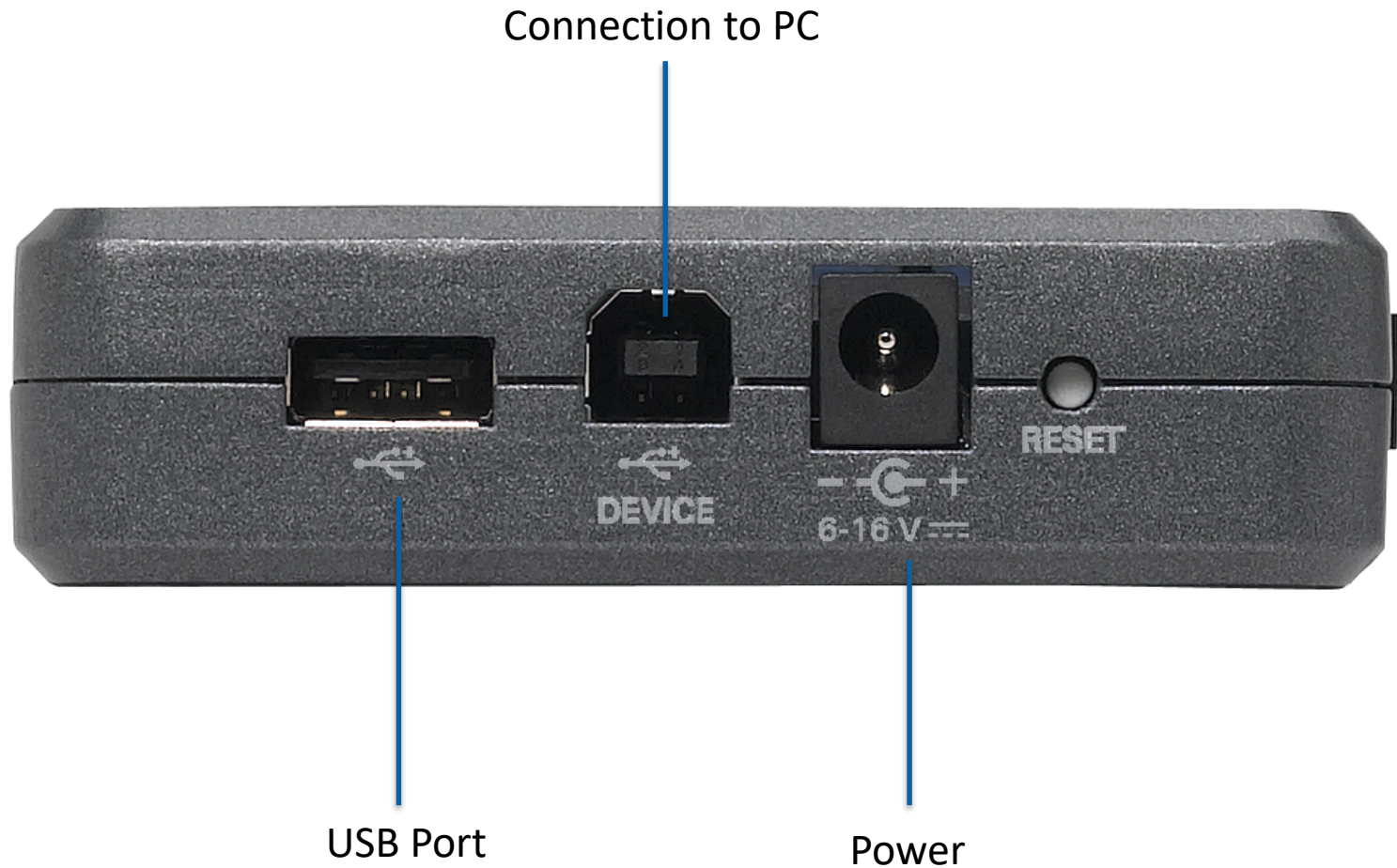


A four-finned robot, each fin equipped with nine servo motors to generate waves of various shapes and perform any conceivable manoeuvre. All this is coordinated by a single NI myRIO at the heart of the drone.

# NI myRIO Product Overview: Front View



# Top View

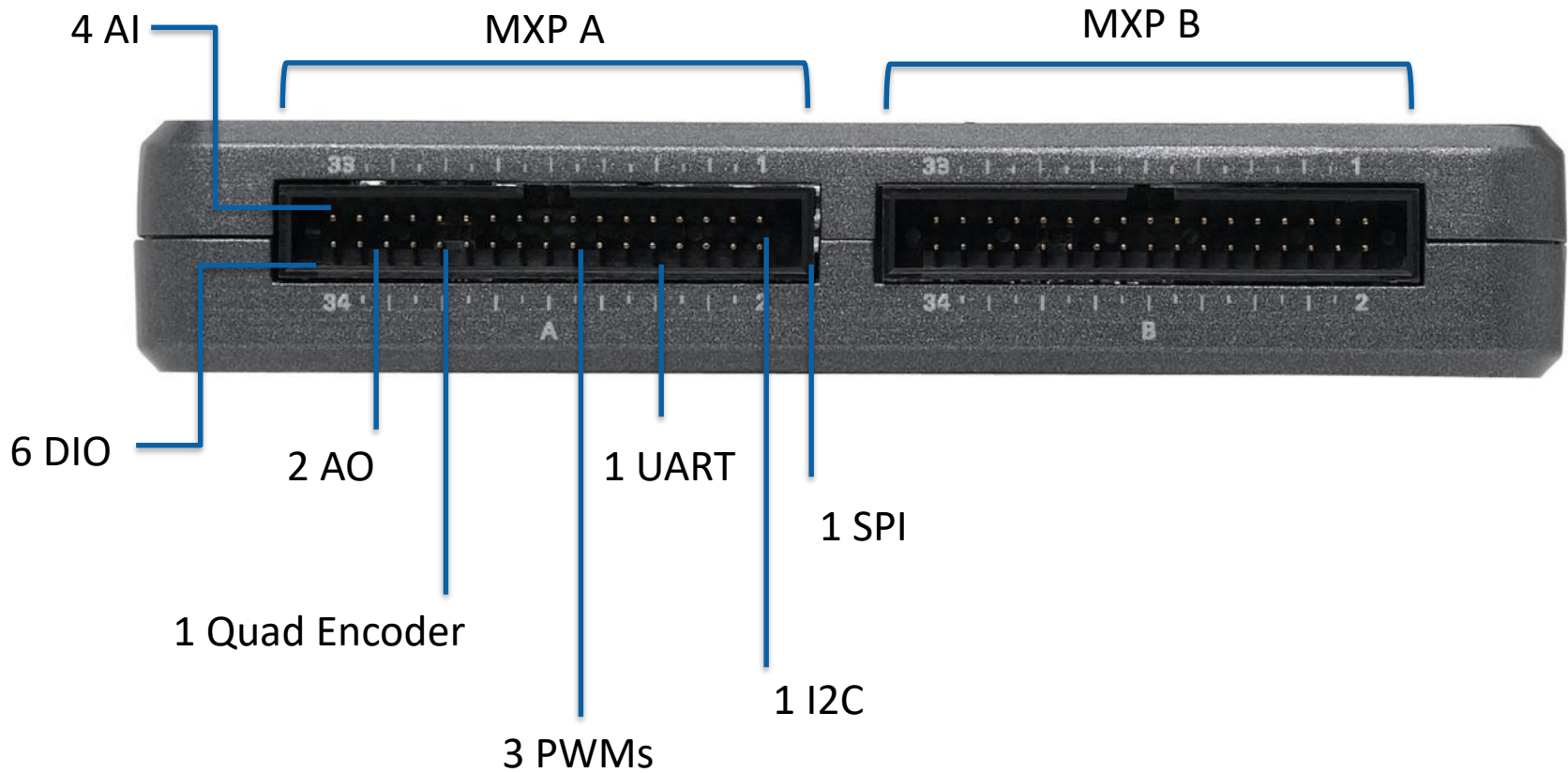




# NI myRIO Expansion Port (MXP)



Identical Connectors



# NI miniSystems Port (MSP)

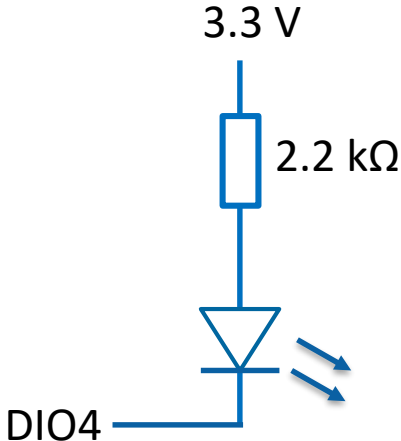
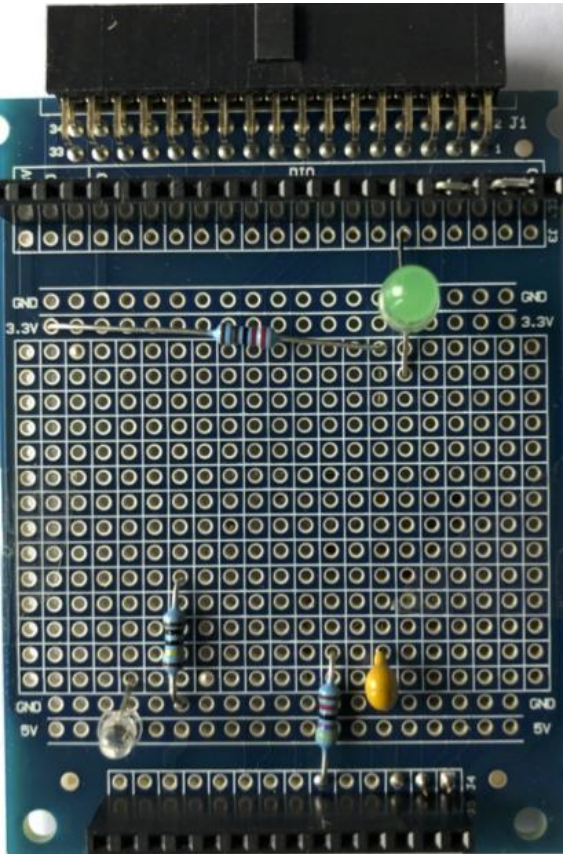


Audio in/out

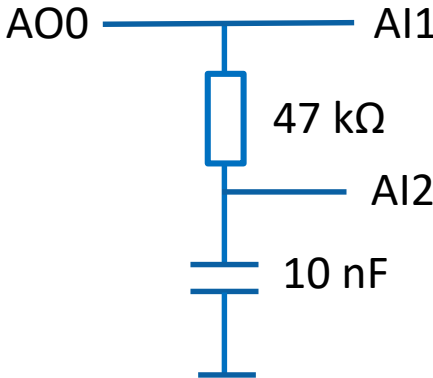
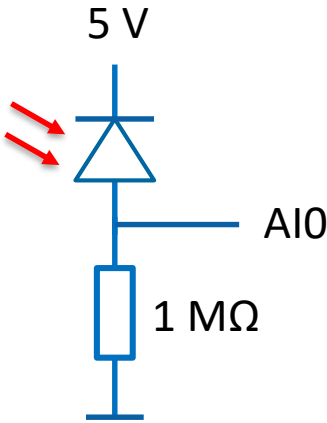
more analog and digital I/O

myRIO exercise board

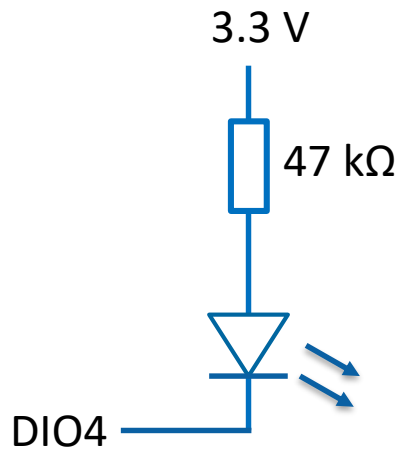
# Exercise board



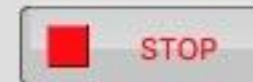
DIO0 ——— DIO1  
DIO2 ——— DIO3



# Exercise 1 Blinking LED

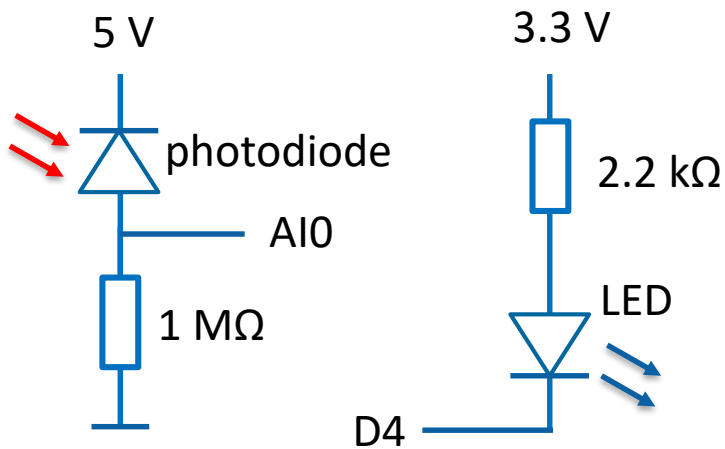


Make the LED blink with a controllable speed from 1 to 40 Hz



Question:  
At what frequency you don't see the blinking anymore?

# Exercise 2 Switch on when it's dark



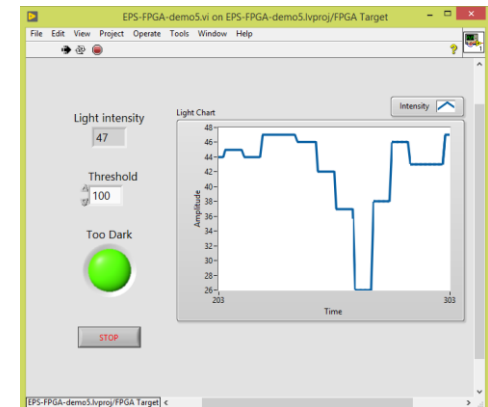
Switch on the LED when the photodiode signal is below the threshold 100 (arbitrary units)

- Plot the photodiode signal in a chart
- The threshold value should be set using a control
- Remember the LED is on when D4 is False

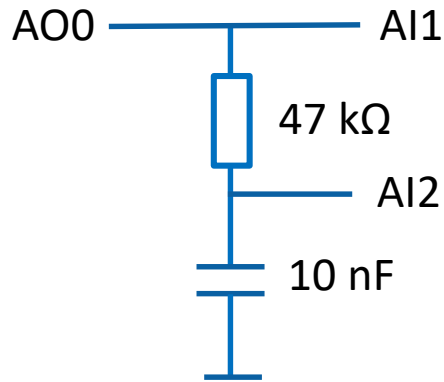
To test, block the light to the photodiode or increase light using your mobile phone

Question:

- What would happen when the photodiode would pick up the LED light?



# Exercise 3 Acquire transient

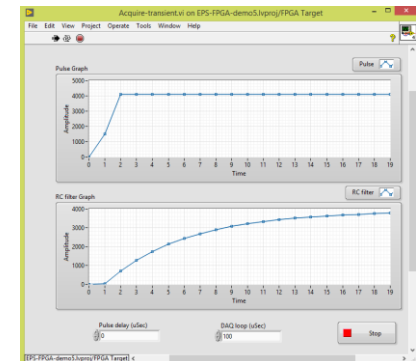


Generate a step function from 0 – 5 V (int. value 4095)  
Acquire step function signal and response of RC circuit

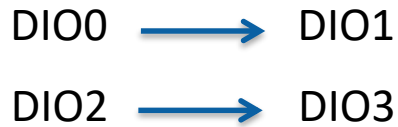
- Once per second
- Generate output voltage from 0 to 5 V (and reverse)
- Acquire both AI1 and AI2 signals using 20 points
- Show both in a graph
- RC value is 470  $\mu$ s
- Set DAQ loop time (with a control) to 100  $\mu$ s

Questions:

- Is the step function (AI1) really a step?
- What do you see when changing the DAQ loop time (both AI1 and 2)?



# Exercise 4 Pulse delay

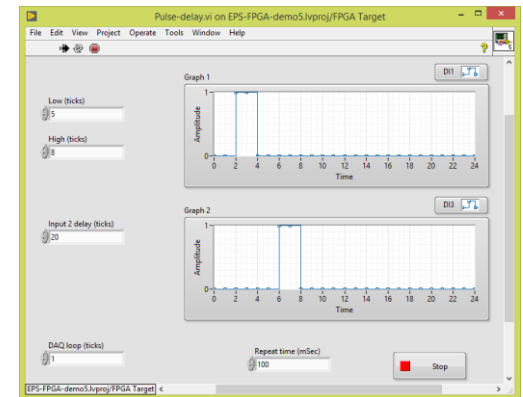


Generate short pulse on D0 and D2 (low – high – low)  
Make a separate control for low D0 and D2 (using ticks)  
Acquire 20 points on D1 and D3 with 1 tick loop delay  
Repeat at 100 ms (10 Hz)

- Control for low time of pulse (4 ticks)
- Control for high time of pulse (8 ticks)
- Control for DAQ loop (1 tick)
- Graph D1
- Graph D3

Questions:

- What do you see when changing the high and low values?
- Can you explain?



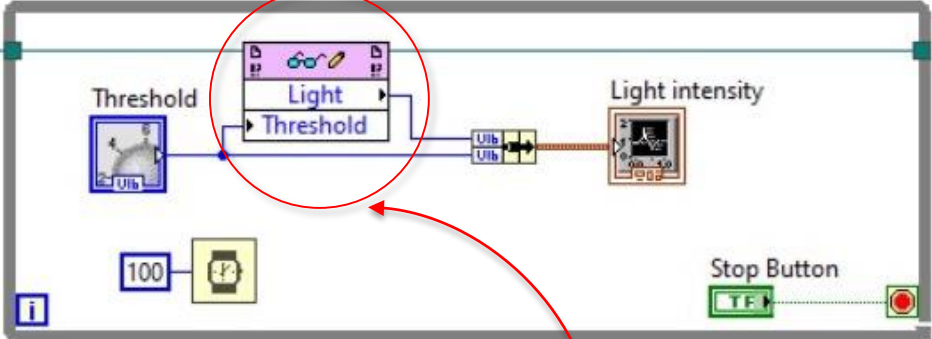
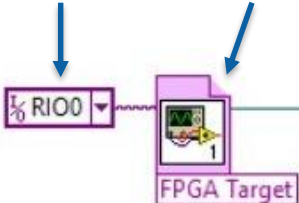


# FPGA to ARM communication

Which myRIO?

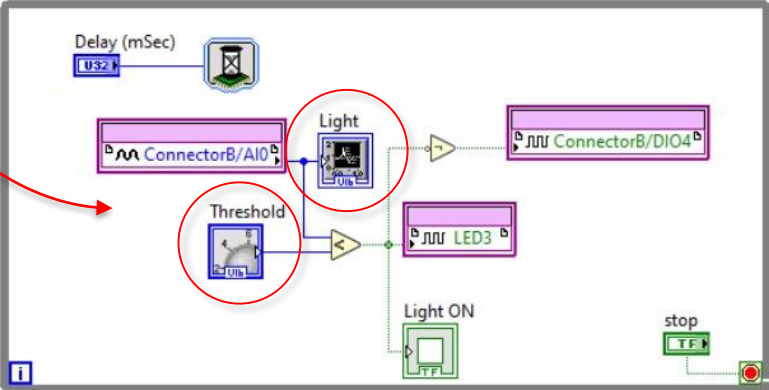
Which VI?

Which data?



ARM

FPGA



# Resources and Next Steps

# NI myRIO Kits | [ni.com/myrio](http://ni.com/myrio)



## Starter

- LEDs & switches
- 7-segment display
- Potentiometer
- Thermistor
- Photo resistor
- Hall effect
- Microphone/Speaker
- Battery holder
- DC motor



## Mechatronics

- DC gear motors/encoders
- H-bridge driver
- Accelerometer
- Triple-axis gyro
- Infrared proximity sensor
- Ambient light sensor
- Ultrasonic range finder
- Compass
- Hobby servo motors



## Embedded

- RFID reader kit
- Numeric keypad
- LED matrix
- Digital potentiometer
- Character LCD
- Digital temp sensor
- EEPROM

# From small to big

1. myRIO



2. sbRIO



3. cRIO



4. PXIe R-series boards



5. PXIe FlexRIO boards



# Learn More About Programming NI myRIO

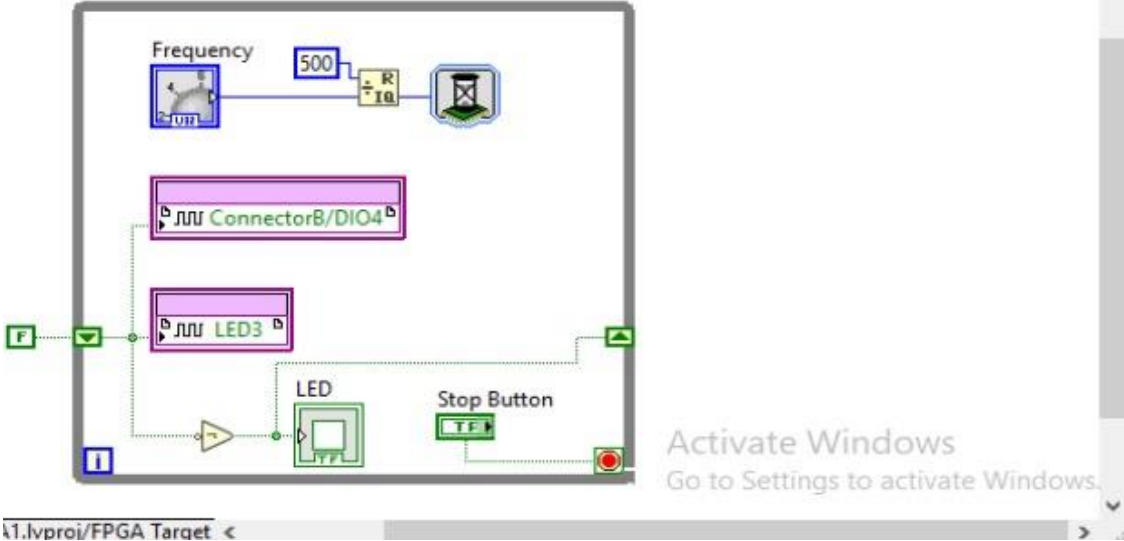
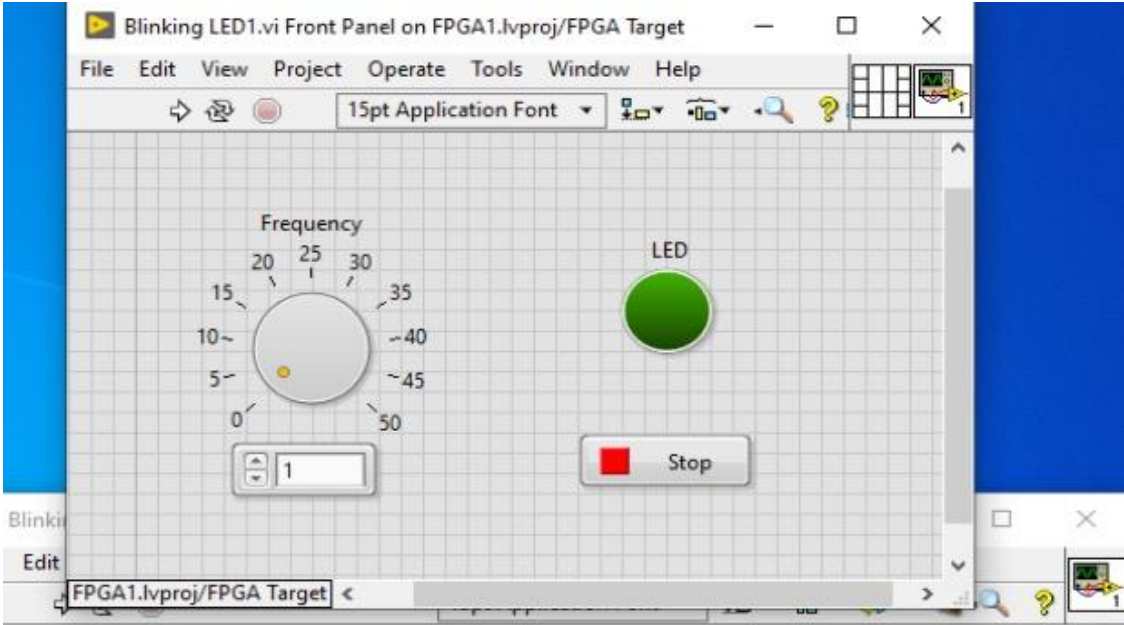


ni.com/learn-myRIO  
ni.com/community/myrio

Thank you !!!

# Solutions

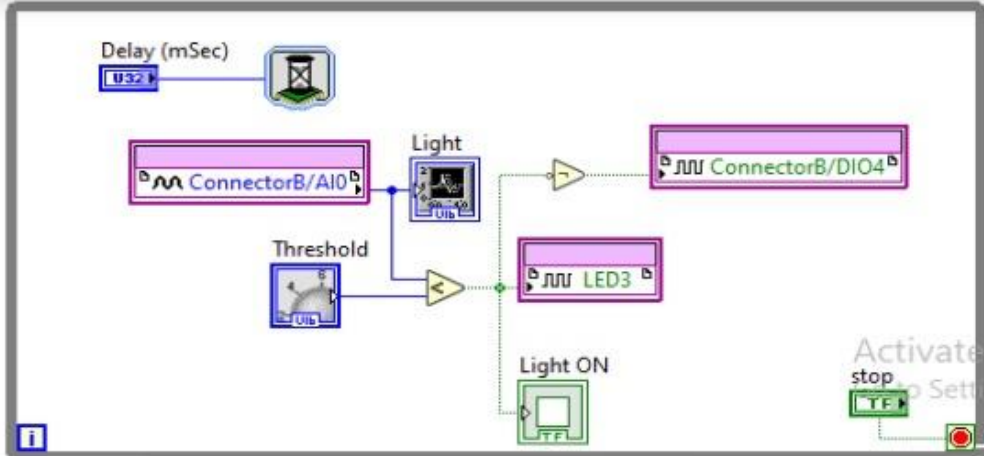
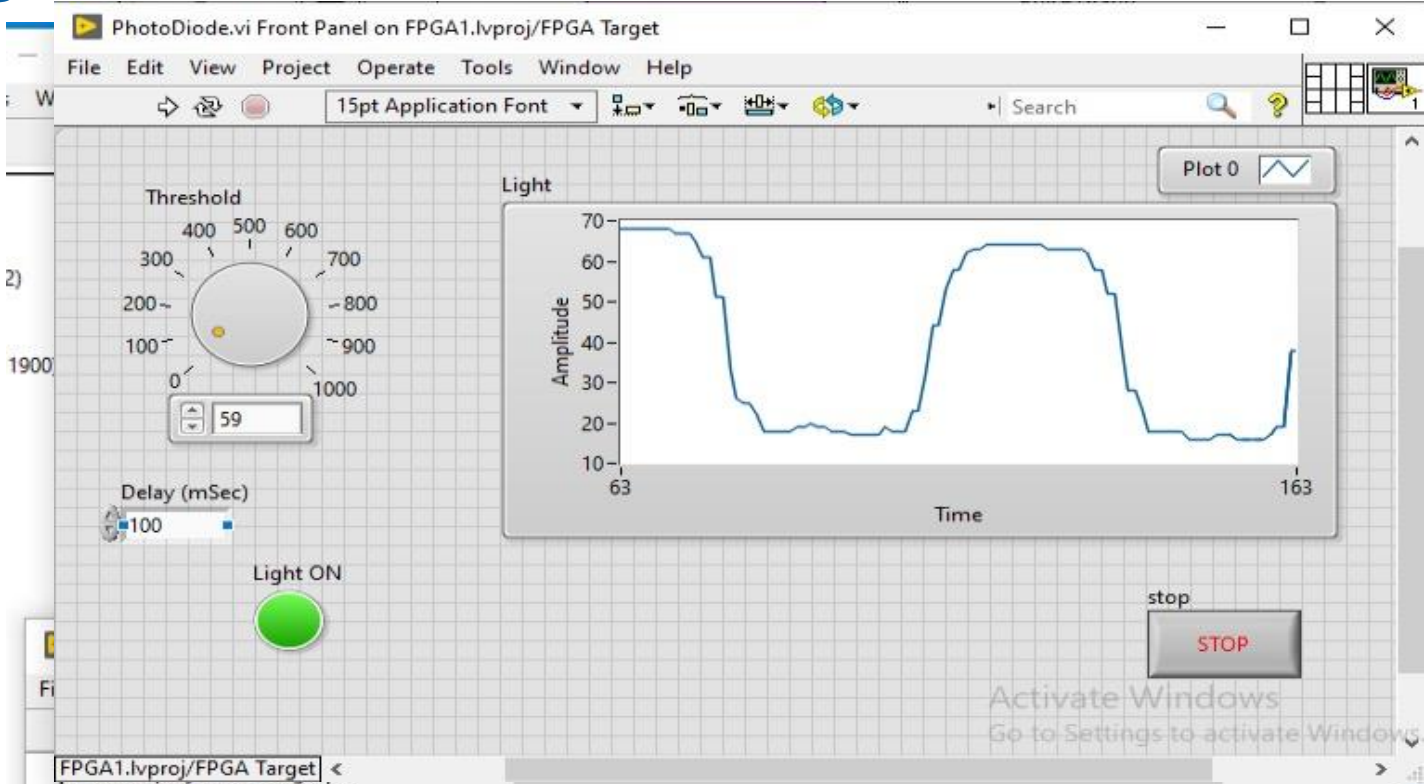
# Diagram: Blinking LED



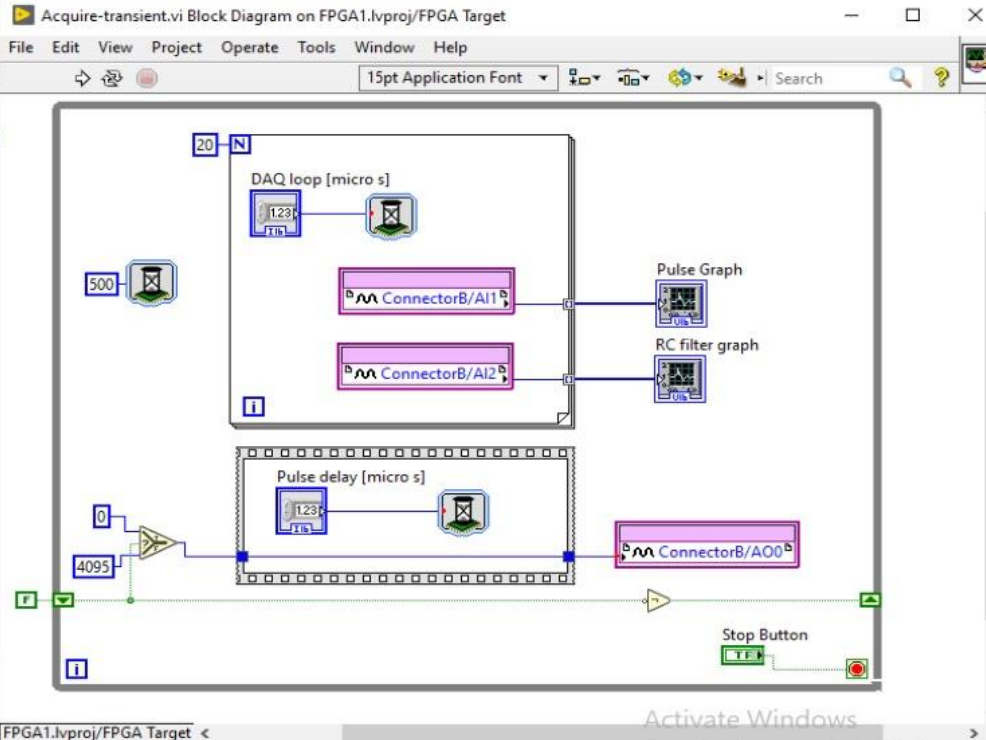
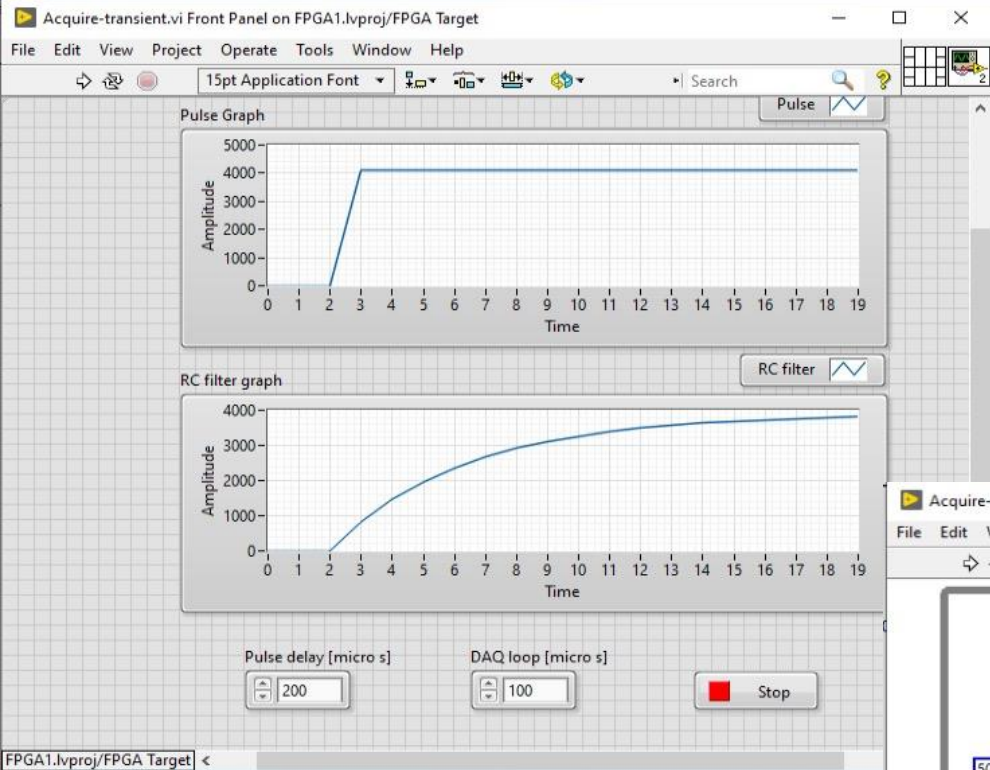
Activate Windows  
Go to Settings to activate Windows.



# Diagram: Photodiode



# Diagram: Acquire transient



# Diagram: Pulse delay (front panel)



# Diagram: Pulse delay (diagram)

