Lab6 - Line Following Car

NTHU Logic Design Laboratory (Fall. 2021)

11/30/2021

By Prof. Chun-Yi Lee

Agenda

Introduction

Materials overview

FPGA configuration

Grading

Agenda

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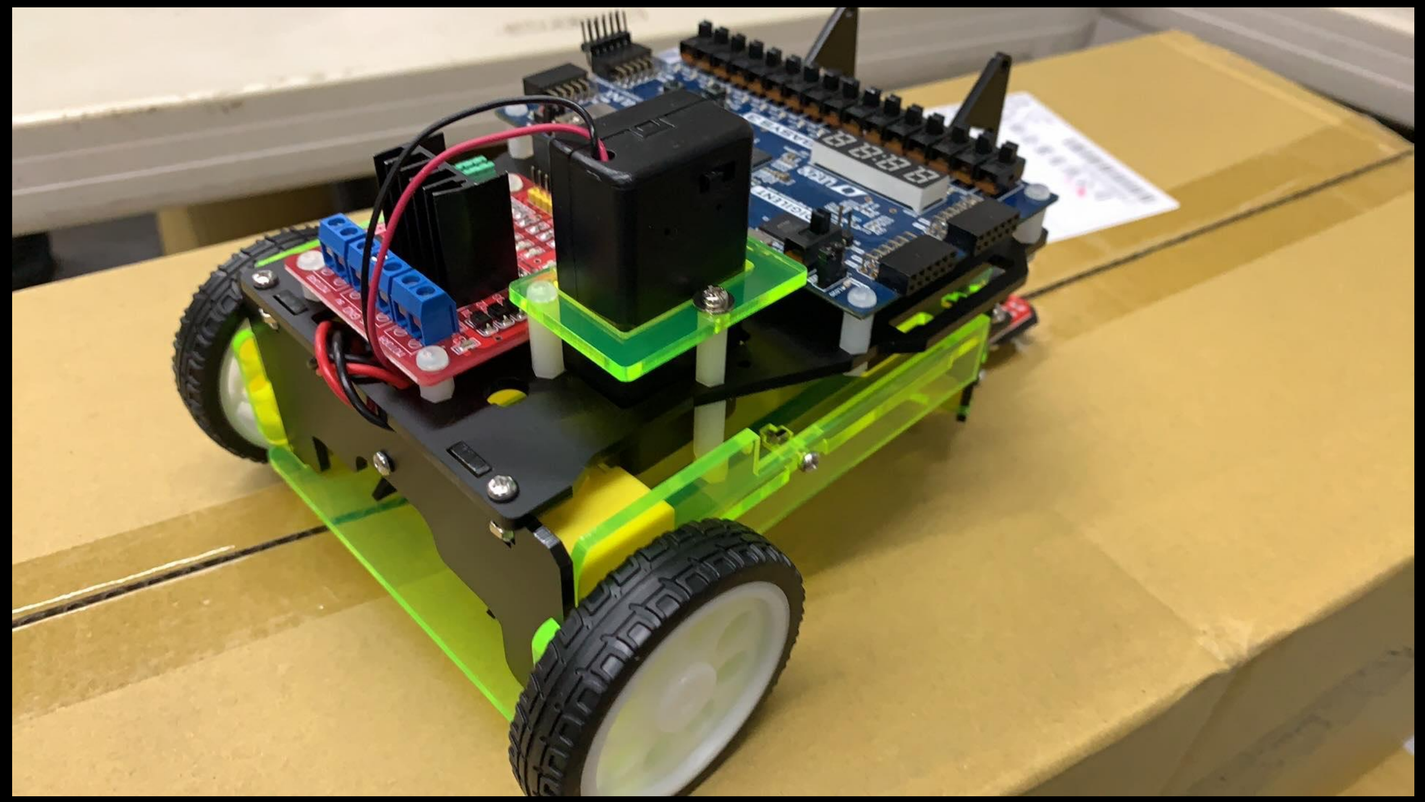
FPGA configuration

Grading

Introduction (1/1)

- One of the advanced question in Lab6 is to implement a line following car.



Agenda

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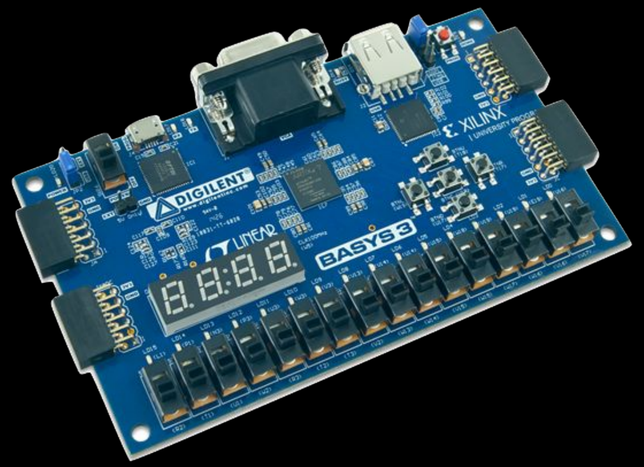
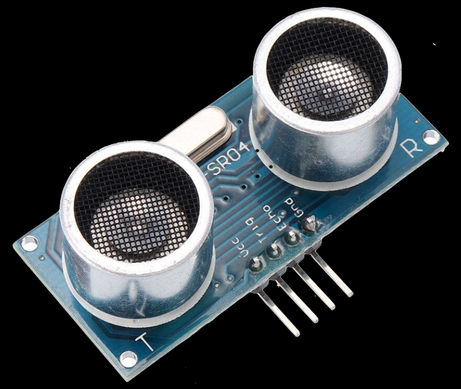
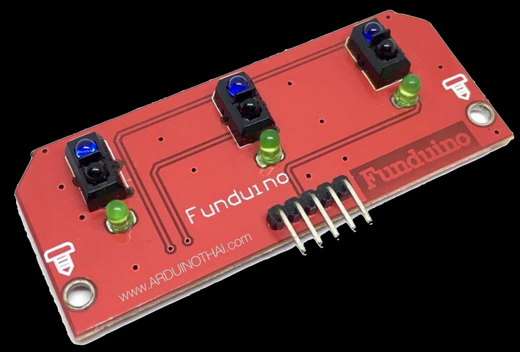
Materials overview (1/17)



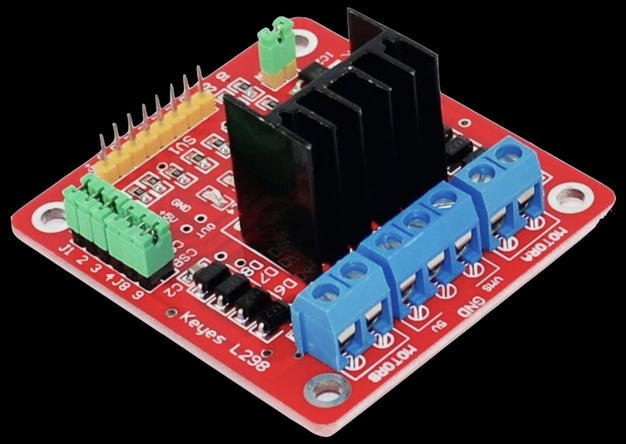
FPGA



HC-SR04



TCRT5000
3-way line tracking IR



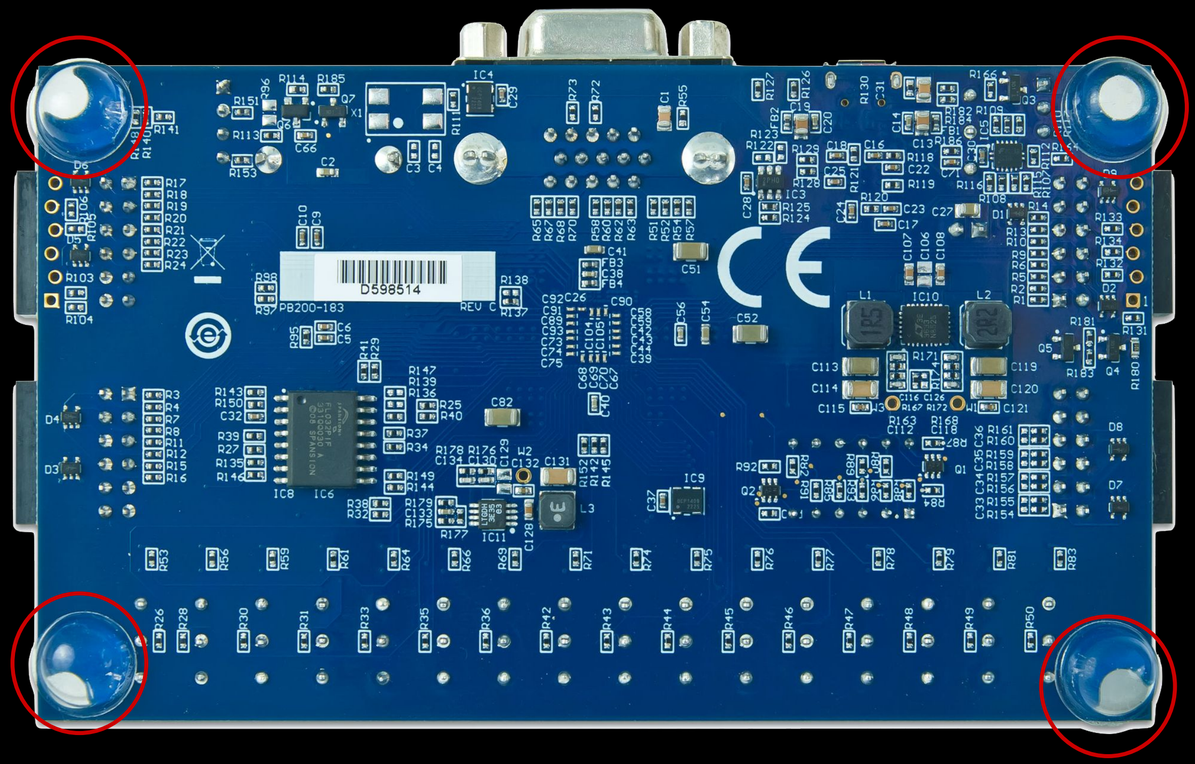
L298N motor driver module

Gear motor

Materials overview (2/17)

FPGA

- Remove the rubber mats at four corners.
- BE CAREFUL ! !
- Don’t lose the mats.
- Screw fpga to the car.



Materials overview (3/17)

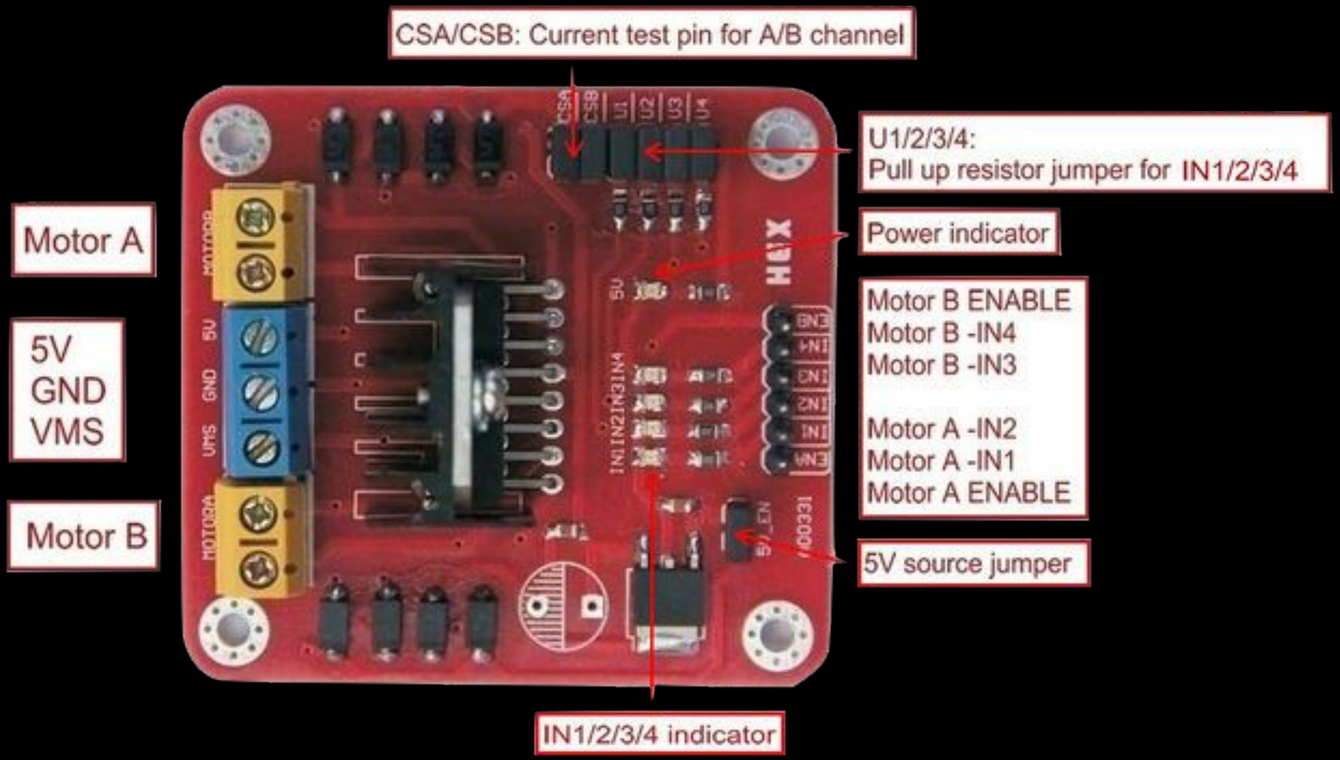
Gear motor + L298N motor driver module

- Why do we need a motor driver module?
  - Motor require high amount of current whereas the controller circuit works on low current signals.
  - We want to control these motors using other controller devices, such as FPGA.
  - Motor drivers acts as an interface between the motors and the control circuits.

Materials overview (4/17)

L298N motor driver module

- Able to control 2 motors.
- VMS for motor.
- 5V pin which can either be an input or output.



Materials overview (5/17)

L298N motor driver module

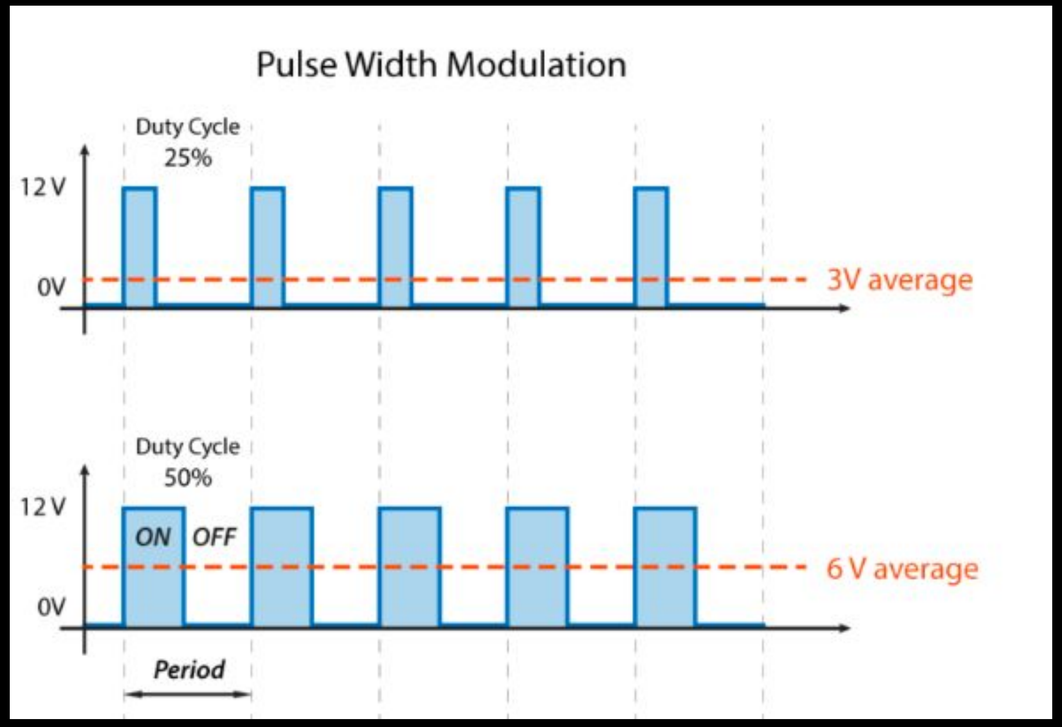
- IN1 and IN2 pins control the spinning direction of the motor A while IN3 and IN4 control motor B.

Input1	Input2	Spinning Direction
Low(0)	Low(0)	Motor OFF
High(1)	Low(0)	Forward
Low(0)	High(1)	Backward
High(1)	High(1)	Motor OFF

Materials overview (6/17)

L298N motor driver module

- ENA and ENB are used to control speed by PWM.
- Run faster with higher duty.



Materials overview (7/17)

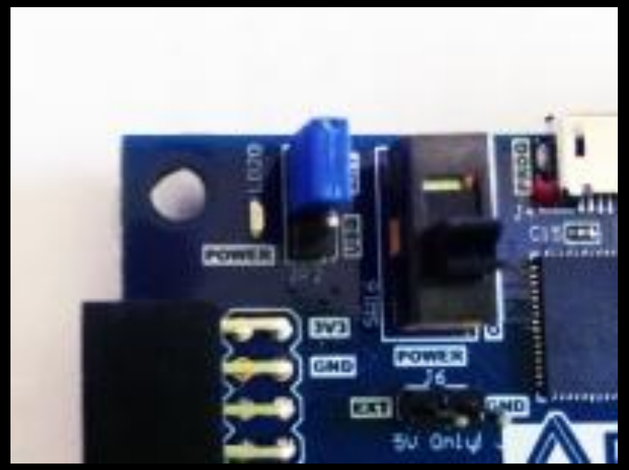
Code for motor (motor.v) :

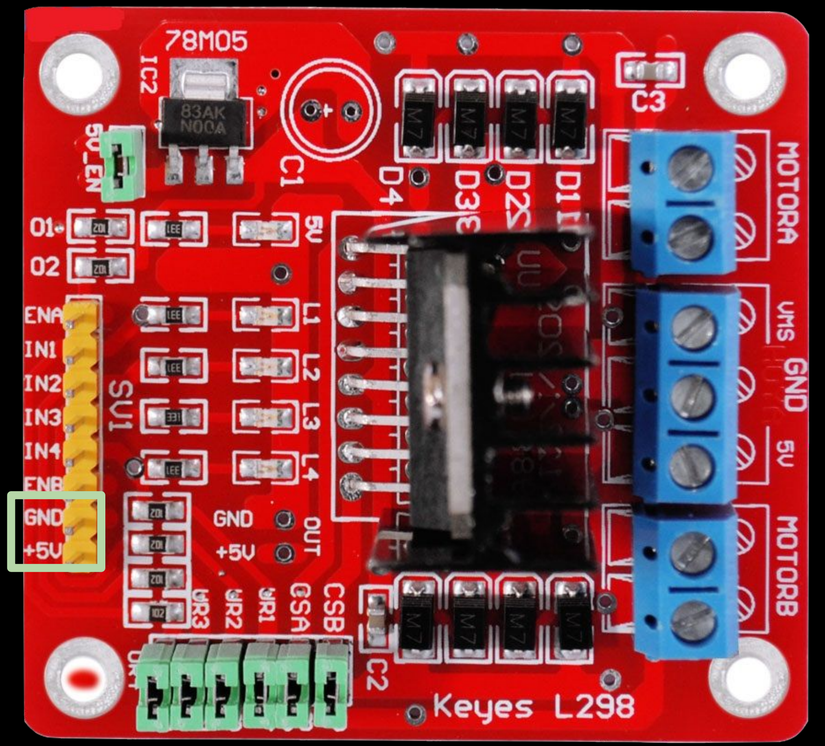
```
module motor(
    input clk,
    input rst,
    output  [1:0]pwm
);

    reg [9:0]next_left_motor, next_right_motor;
    reg [9:0]left_motor, right_motor;
    wire left_pwm, right_pwm;

    motor_pwm m0(clk, rst, left_motor, left_pwm);
    motor_pwm m1(clk, rst, right_motor, right_pwm);

    always@(posedge clk)begin
        if(rst)begin
            left_motor <= 10'd0;
            right_motor <= 10'd0;
        end else begin
            left_motor <= next_left_motor;
            right_motor <= next_right_motor;
        end
    end
```

Materials overview (8/17)

L298N motor driver module

- Supply power for FPGA.
- Connect pin GND, +5v with external power header.
- Set jumper JP2 to "EXT".





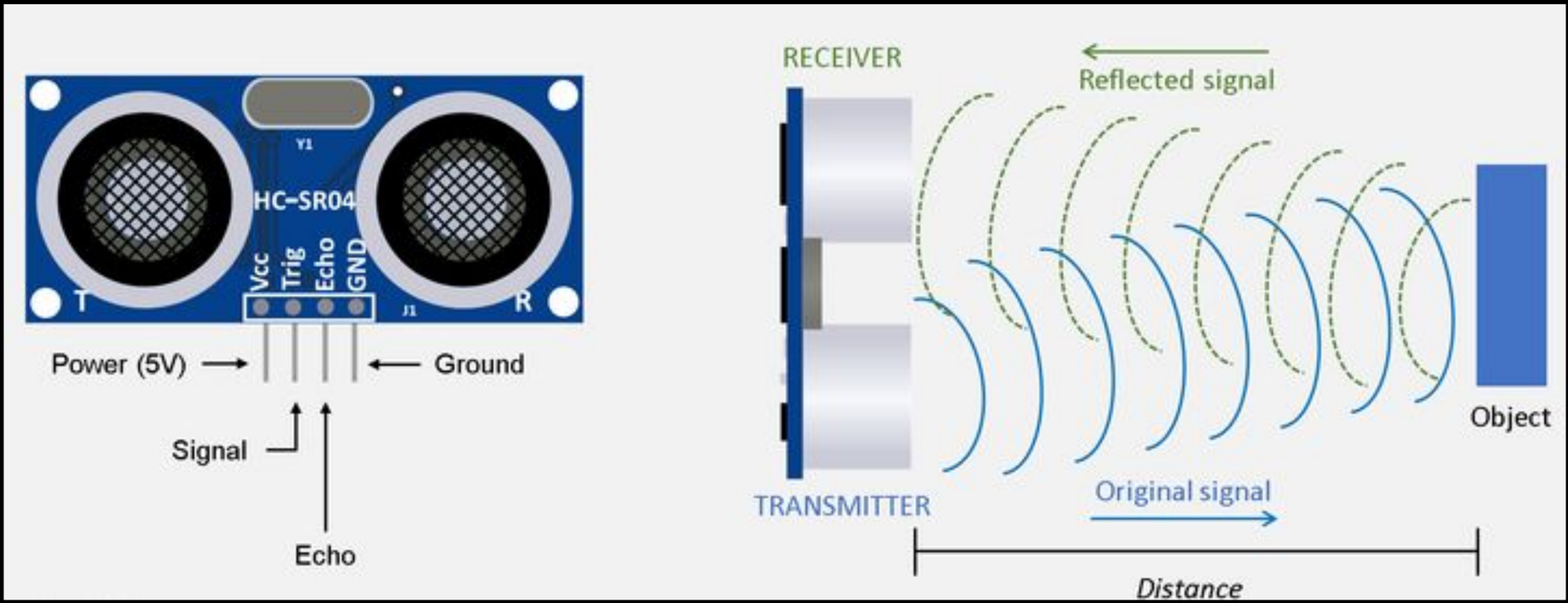
Materials overview (9/17)

Ultrasonic sensor: HC-SR04

Parameter	Value
Main Parts	Transmitter & Receiver
Technology Used	Non-Contact Technology
Operating Voltage	5 V
Operating Frequency	4 MHz
Detection Range	2cm to 400cm
Measuring Angle	30°
Resolution	3mm
Operating Current	<15mA
Sensor Dimensions	45mm x 20mm x 15mm

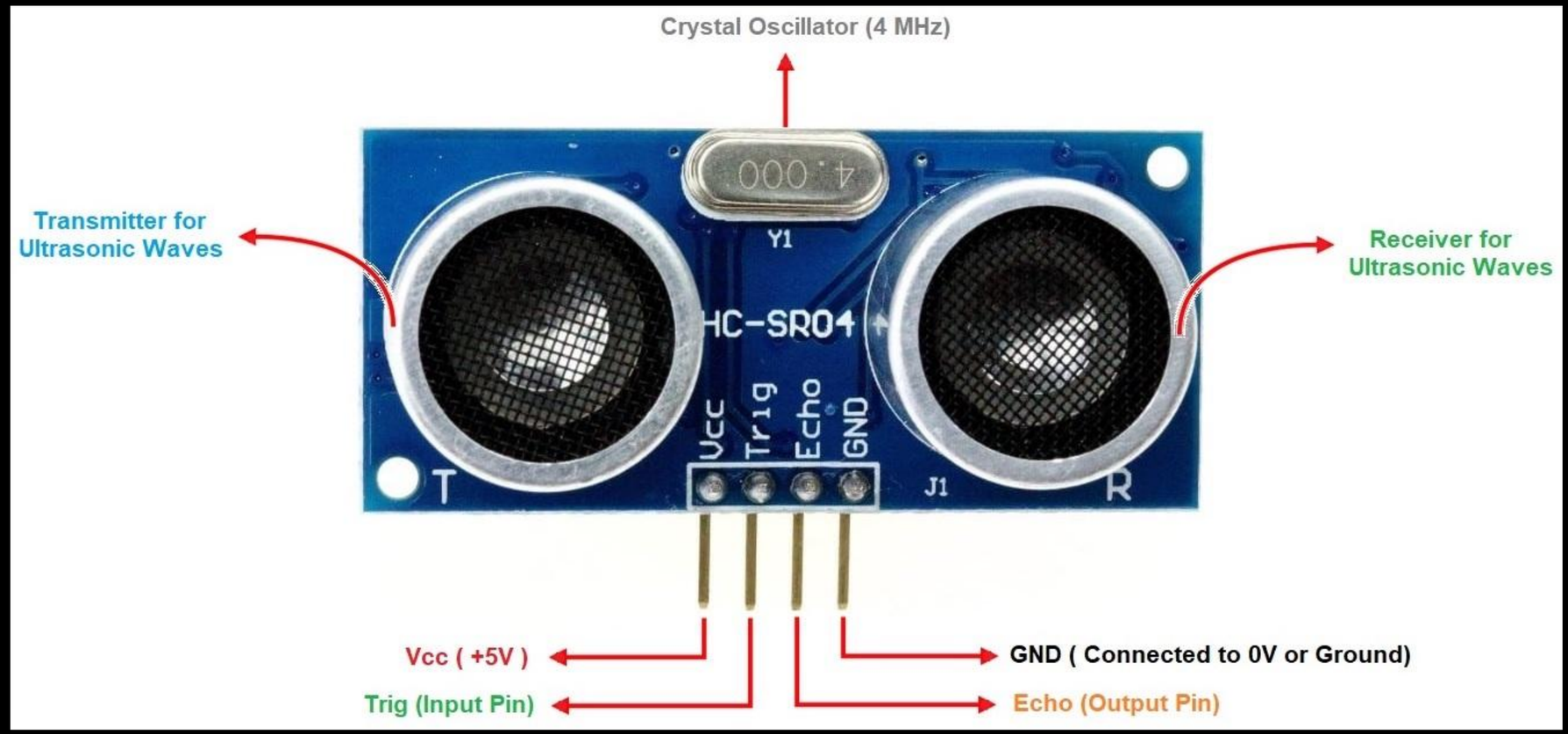
Materials overview (10/17)

HC-SR04



Materials overview (11/17)

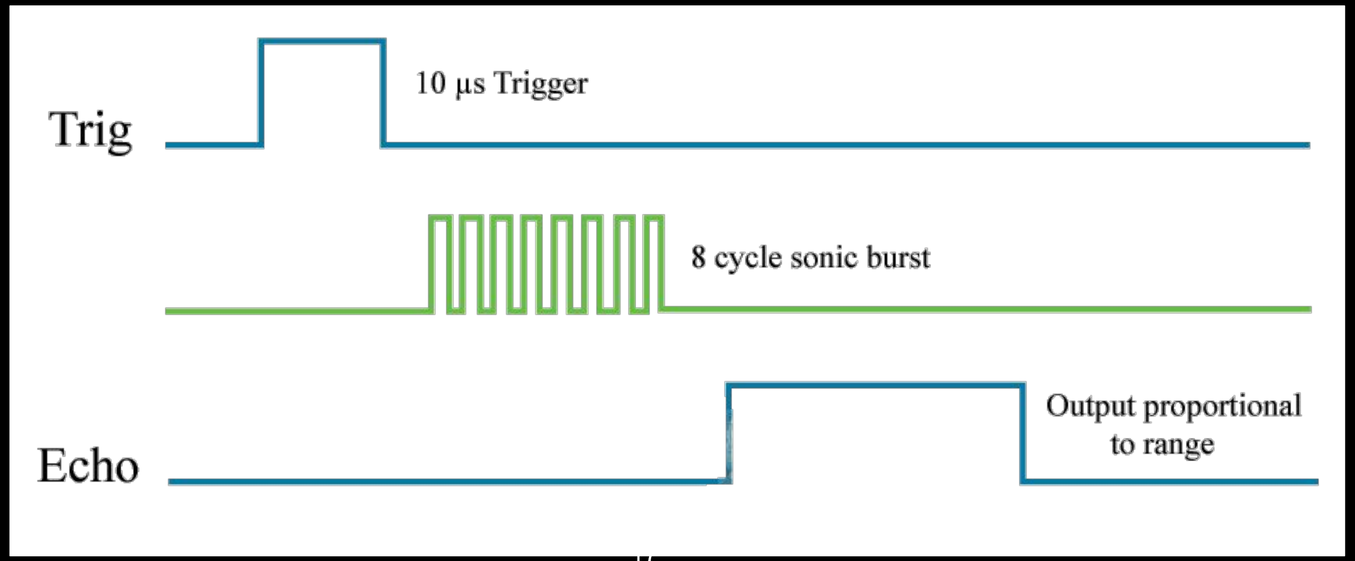
HC-SR04 Pinout



Materials overview (12/17)

HC-SR04

- To generate the ultrasound, set the Trig on a High State for 10 µs.
- Transmitter will send out 8 cycle sonic burst, and be received by Receiver.
- The Echo pin will output the time in microseconds the sound wave traveled.
- S = t * v / 2



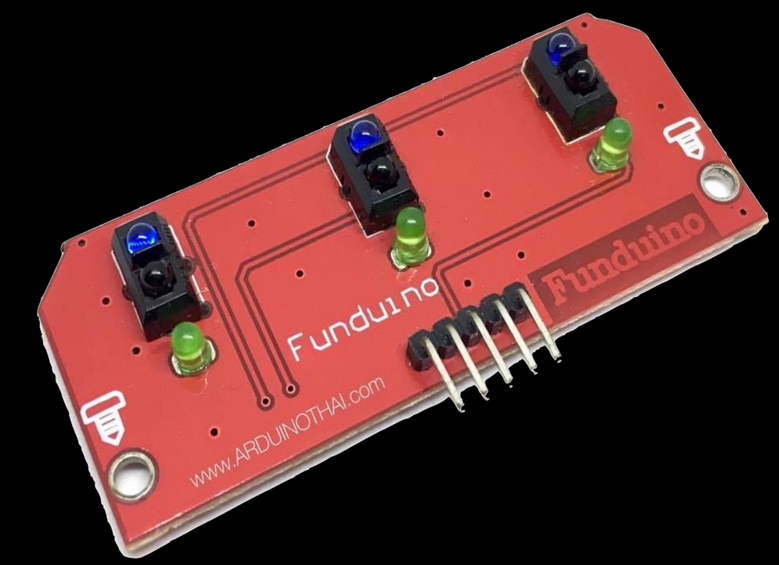
Materials overview (13/17)

Code for HC-SR04 (sonic.v) :

```
module sonic_top(clk, rst, Echo, Trig, stop);
    input clk, rst, Echo;
    output Trig, stop;

    wire[19:0] dis;
    wire[19:0] d;
    wire clk1M;
    wire clk_2_17;

    div clk1(clk ,clk1M);
    TrigSignal u1(.clk(clk), .rst(rst), .trig(Trig));
    PosCounter u2(.clk(clk1M), .rst(rst), .echo(Echo), .distance_count(dis));
```

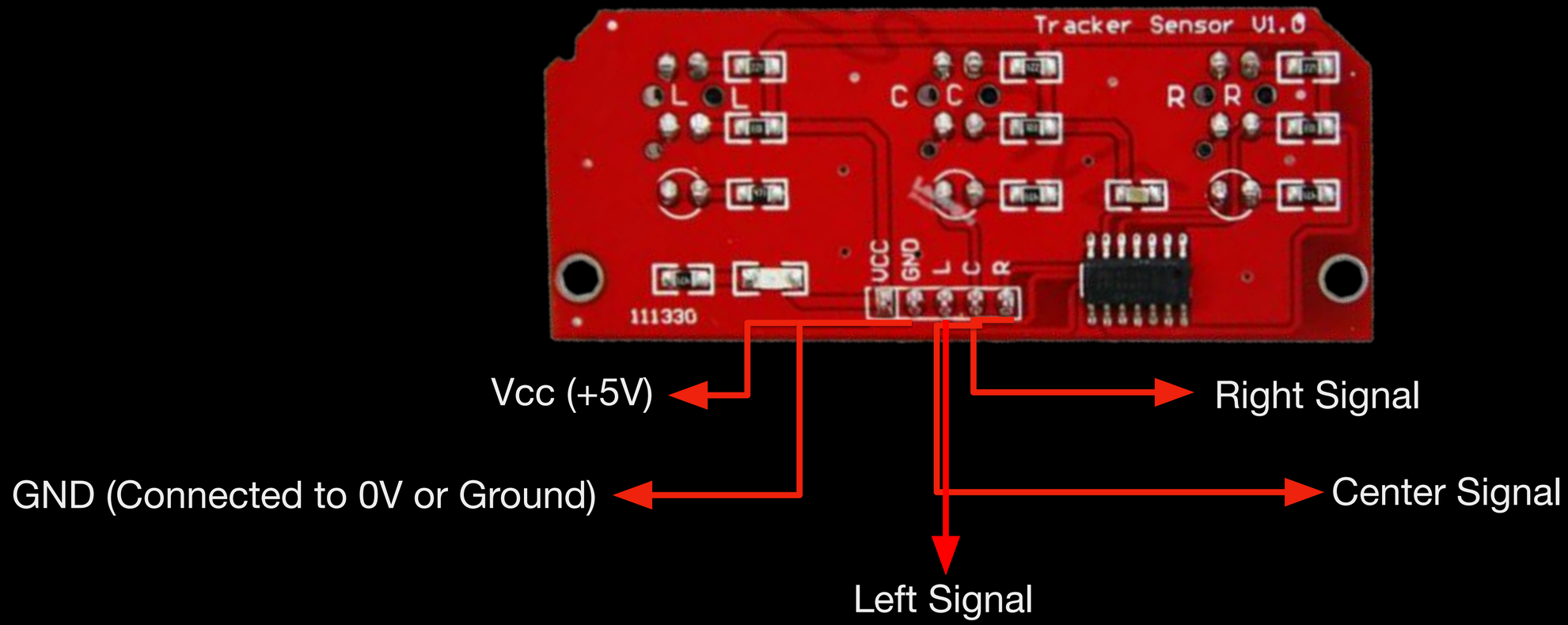
Materials overview (14/17)

3-Way Line Tracking IR : TCRT5000



- Include 3 TCRT5000 - IR Proximity Sensor
- Operating Voltage : 5V
- Output low black line, a white line output high

Materials overview (15/17)



Materials overview (16/17)

Document link

FEATURES

- Package type: leaded
- Detector type: phototransistor
- Dimensions (L x W x H in mm): 10.2 x 5.8 x 7
- Peak operating distance: 2.5 mm
- Operating range within > 20 % relative collector current: 0.2 mm to 15 mm
- Typical output current under test: I_C = 1 mA
- Daylight blocking filter
- Emitter wavelength: 950 nm
- Lead (Pb)-free soldering released
- Compliant to RoHS directive 2002/95/EC and in accordance to WEEE 2002/96/EC

Pb-free

e2

RoHS COMPLIANT

Materials overview (17/17)

Code for Line Tracking IR (tracker_sensor.v) :

```
module tracker_sensor(clk, reset, left_signal, right_signal, mid_signal, state);
    input clk;
    input reset;
    input left_signal, right_signal, mid_signal;
```

Agenda

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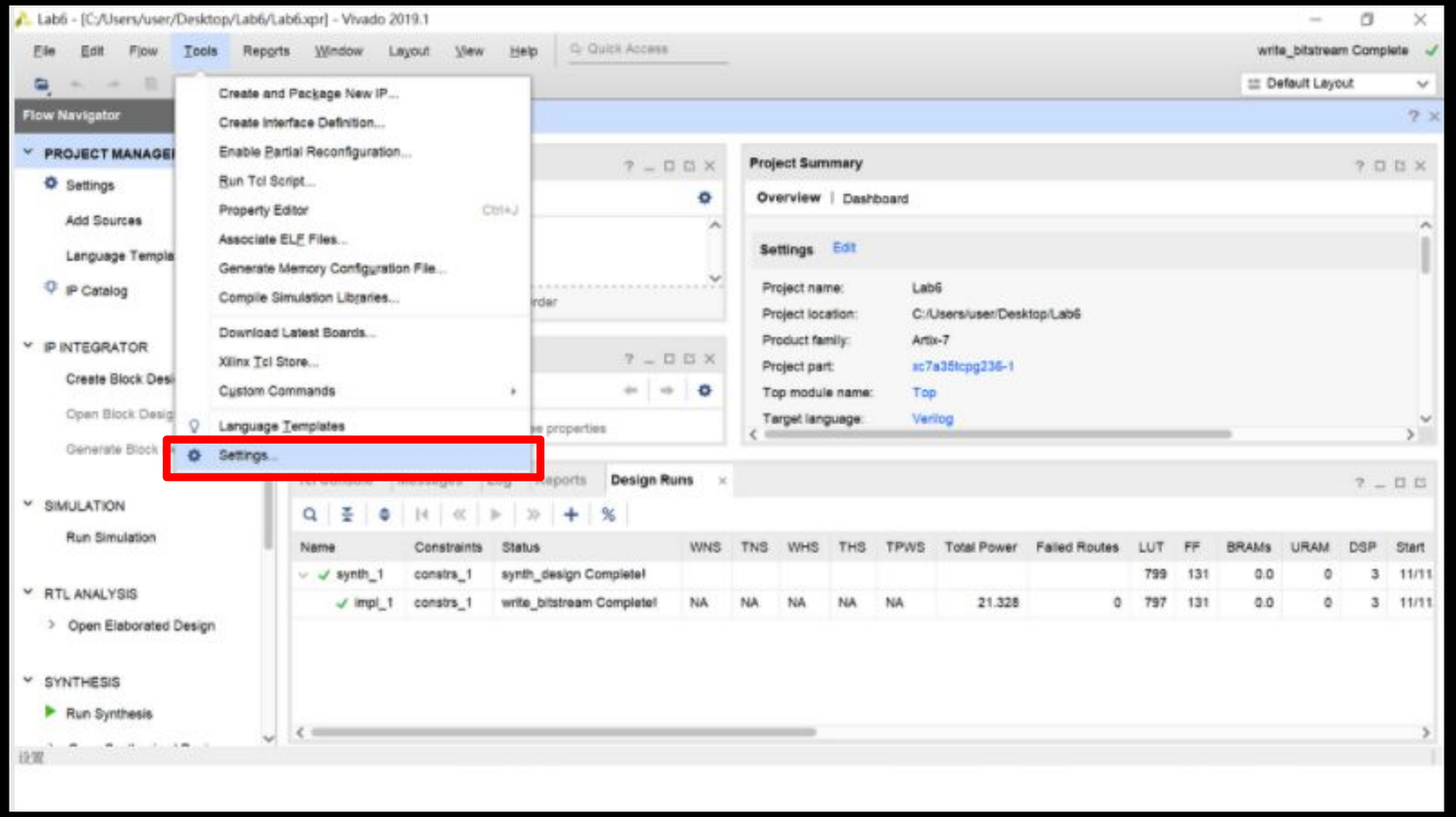
FPGA configuration (1/8)

- Bitstream Configuration
- Flash Memory Setting

FPGA configuration (2/8)

Bitstream Configuration

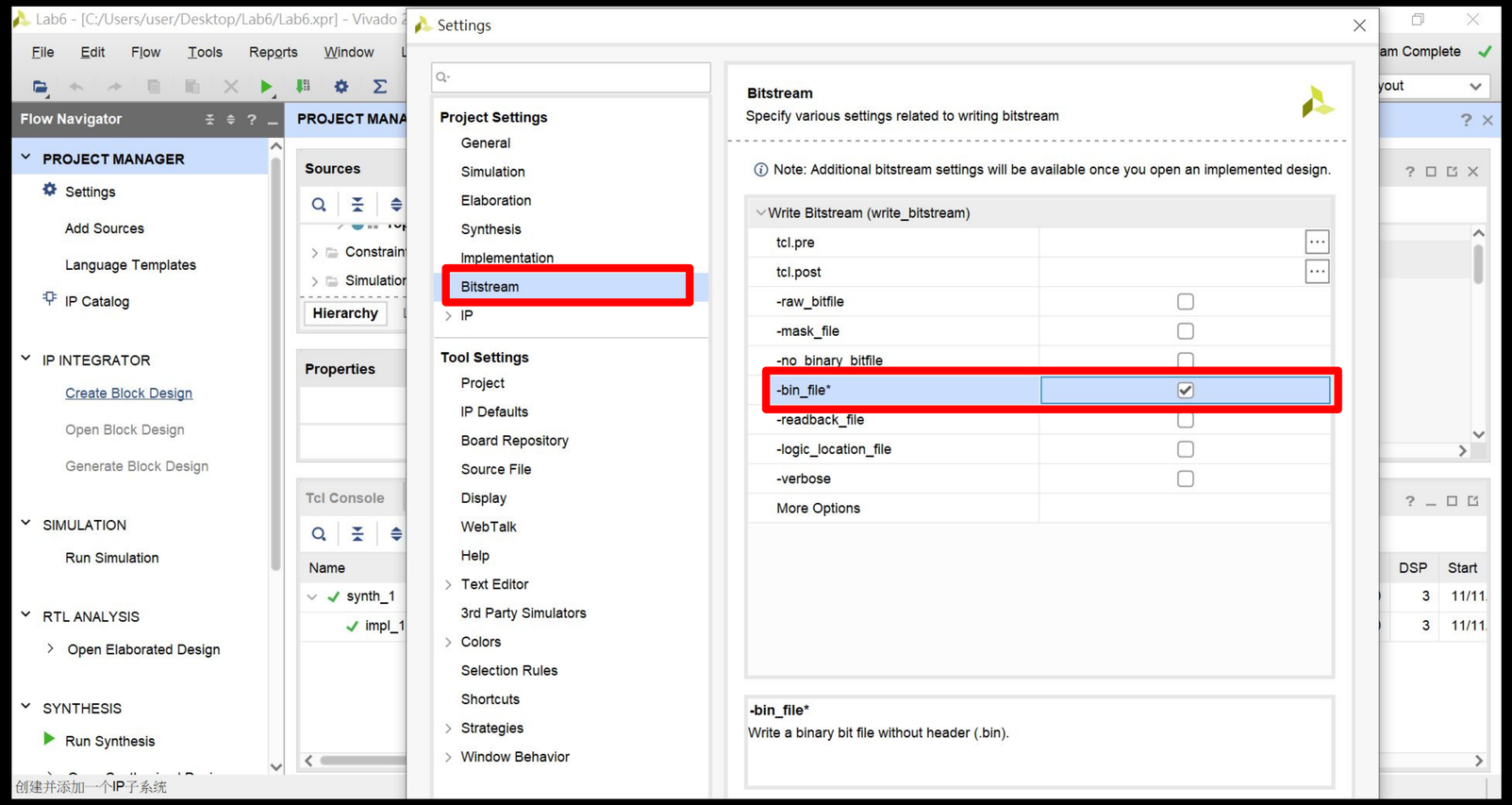
- Tools -> Settings



FPGA configuration (3/8)

Bitstream Configuration

- Bitstream -> bin_file
- Apply -> OK

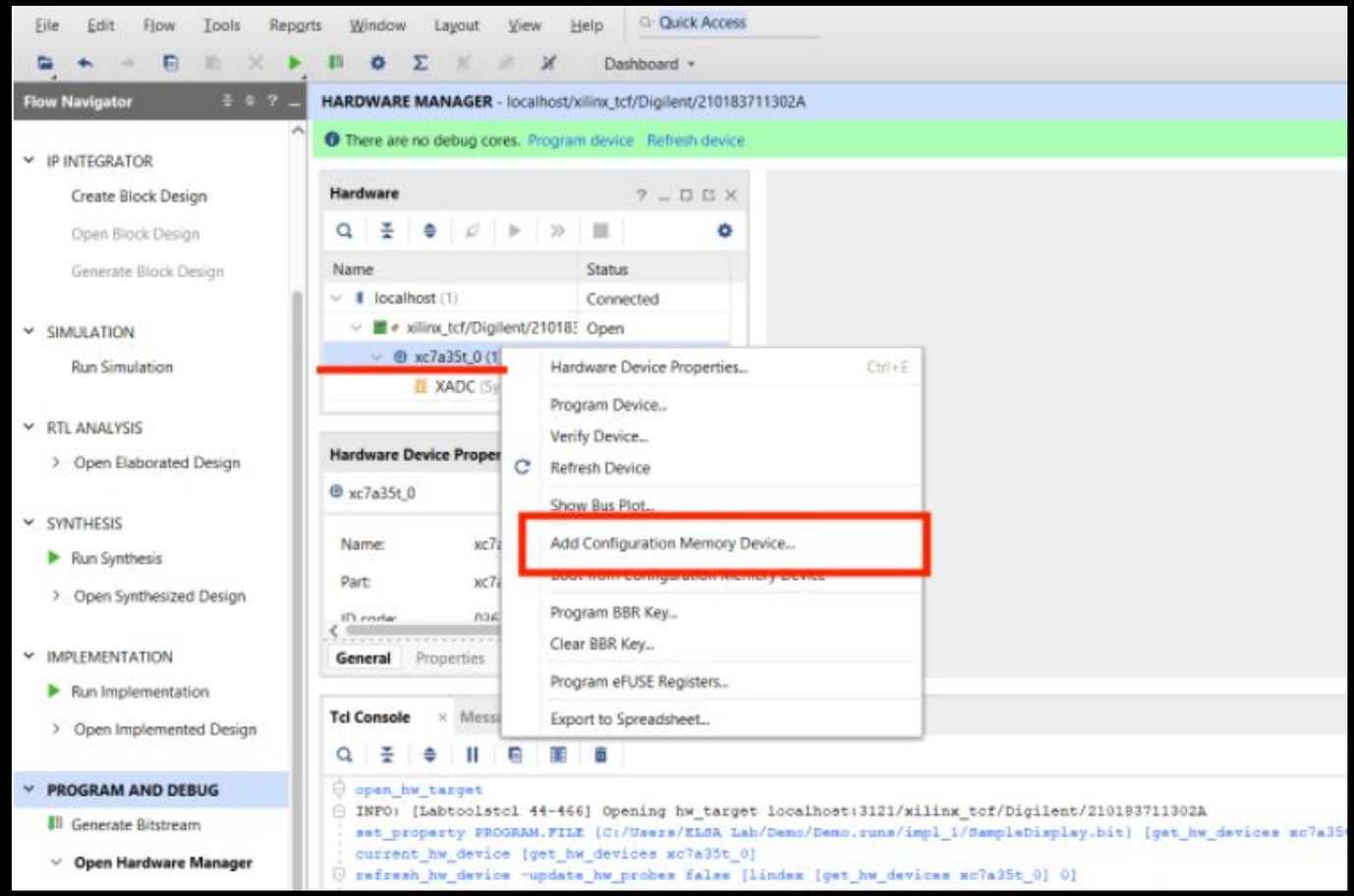


FPGA configuration (4/8)

Flash Memory Setting

- Hardware Manager ->
  Add Configuration Memory Device

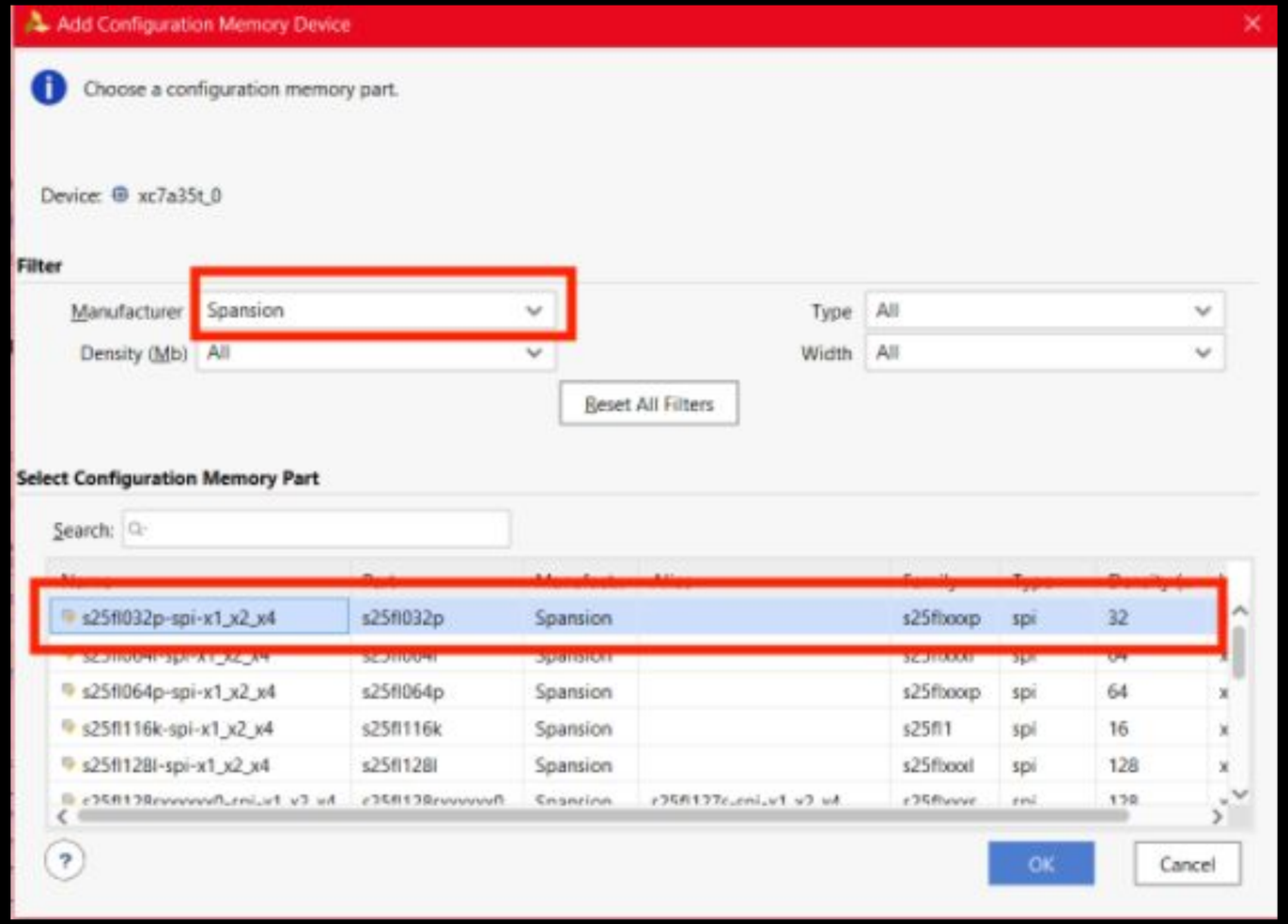
- If you have previous configuration memory, you need to delete it first



FPGA configuration (5/8)

Flash Memory Setting

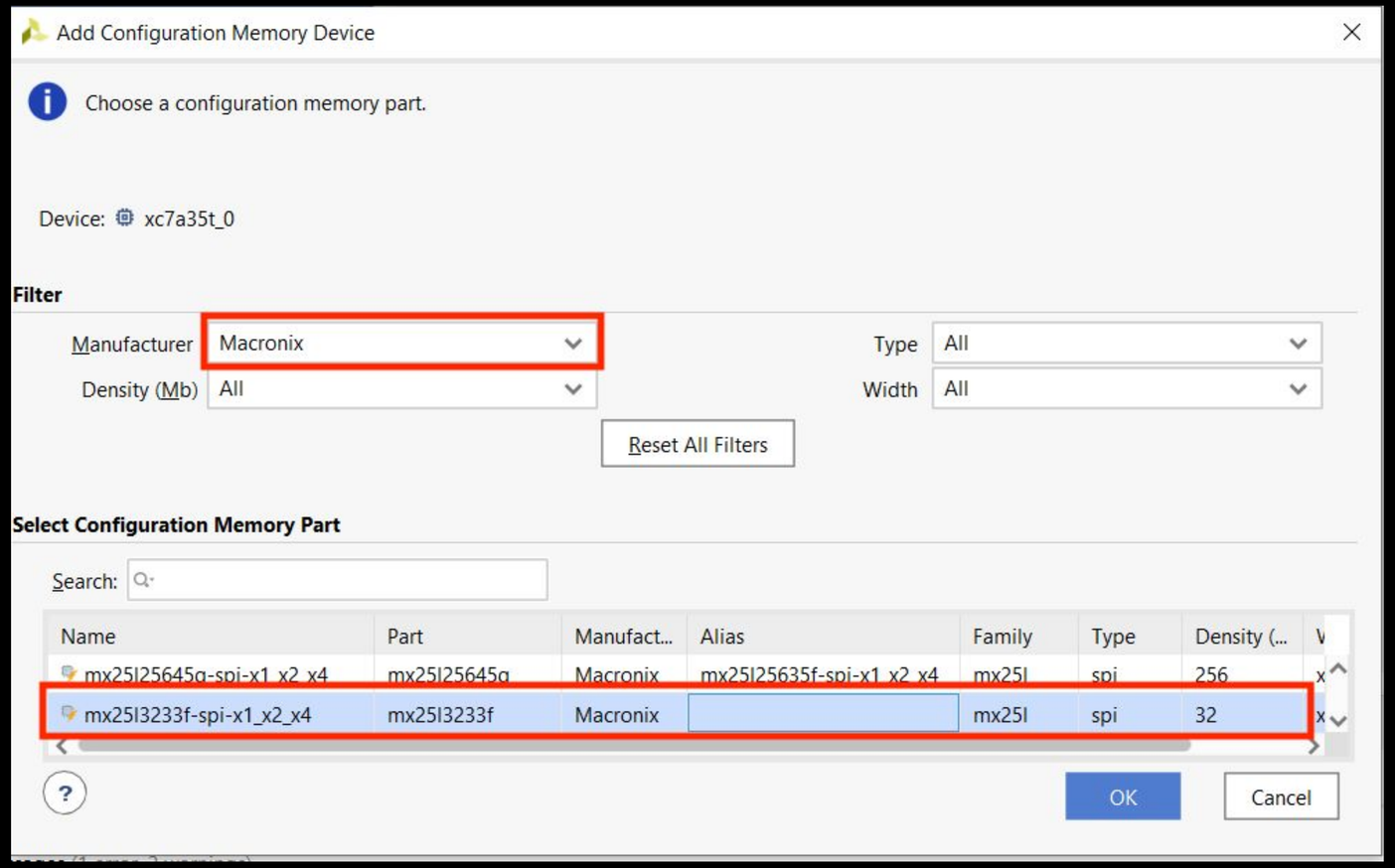
- [Filter] -> [manufactureer] -> [Spansion]
- [Configuration Memory Part] -> [s25fl032p]



FPGA configuration (5/8) - new board

Flash Memory Setting

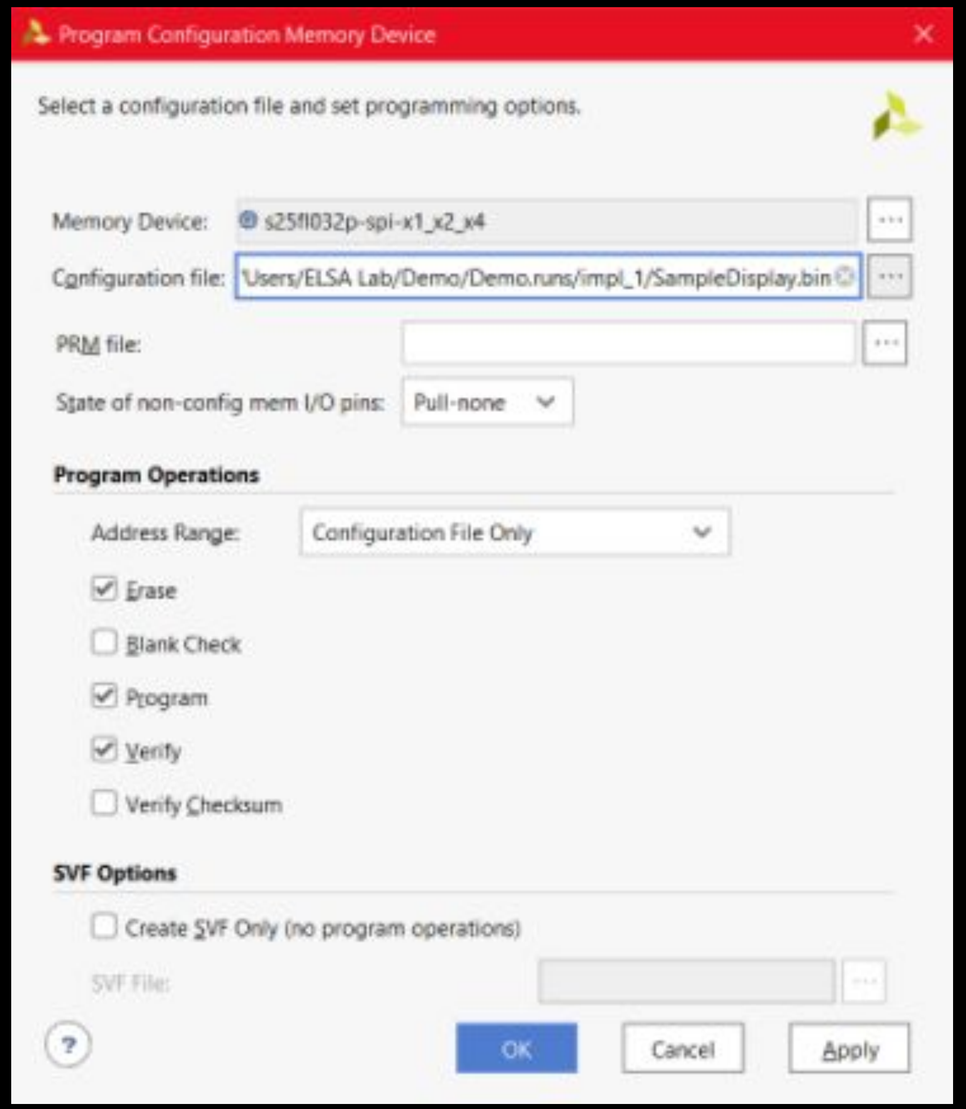
- [Filter] -> [manufactureer] -> [Macronic]
- [Configuration Memory Part] -> [mx25l3233f]



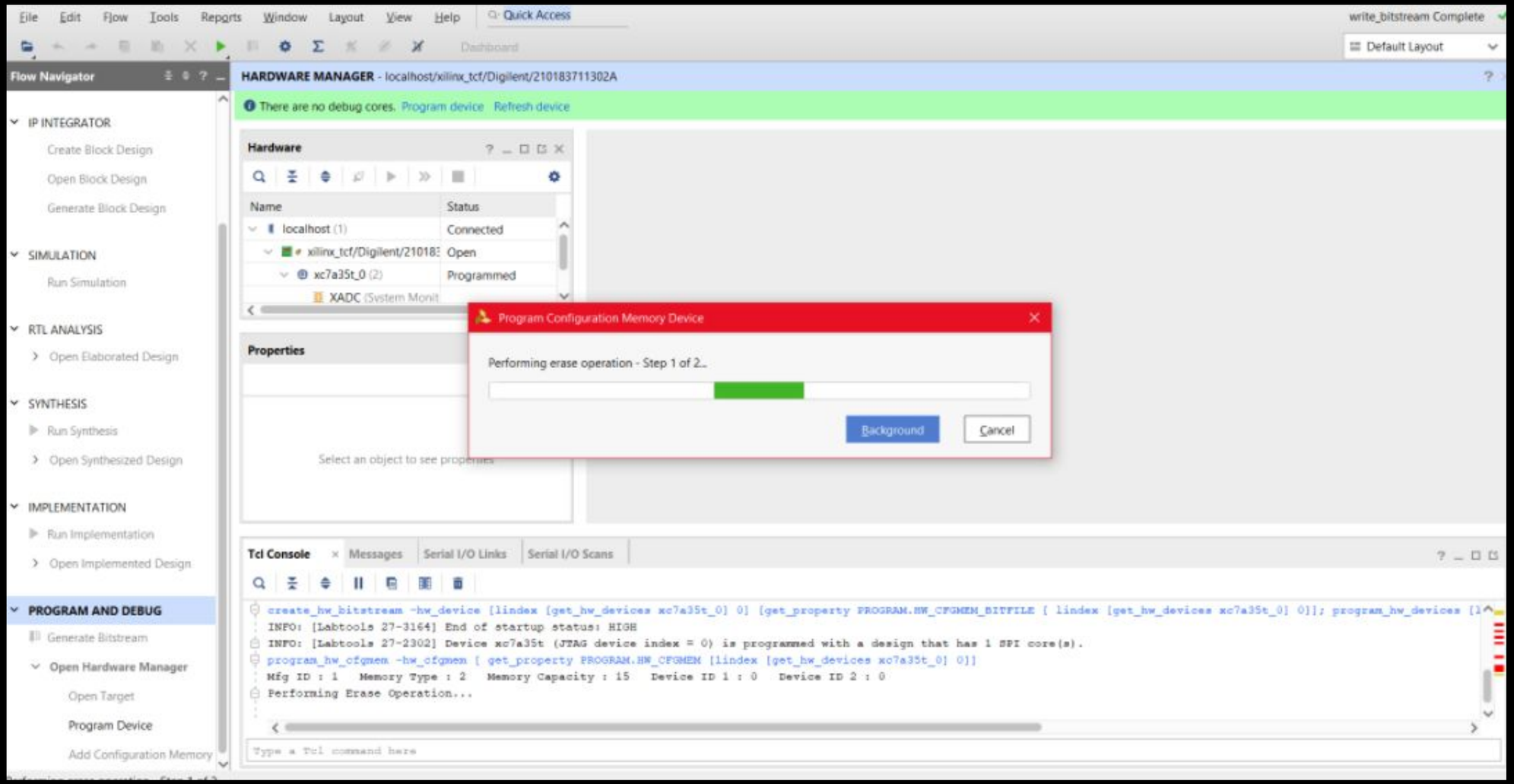
FPGA configuration (6/8)

Flash Memory Setting

- Select configuration file : Project_Name.runs/impl_1/**.bin
- Not .bit nor .mcs
- Apply -> OK



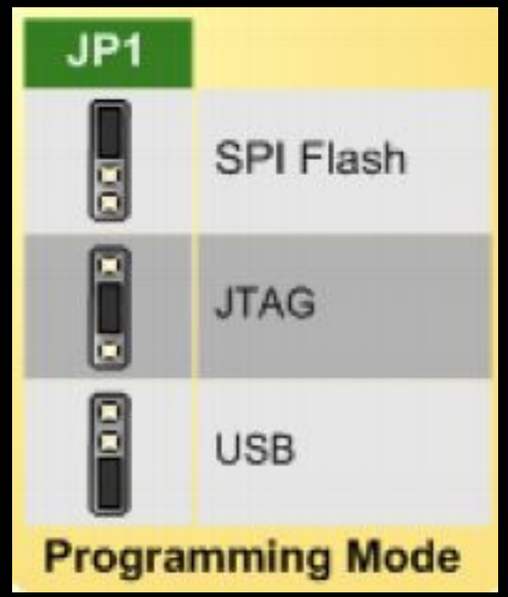
FPGA configuration (7/8)

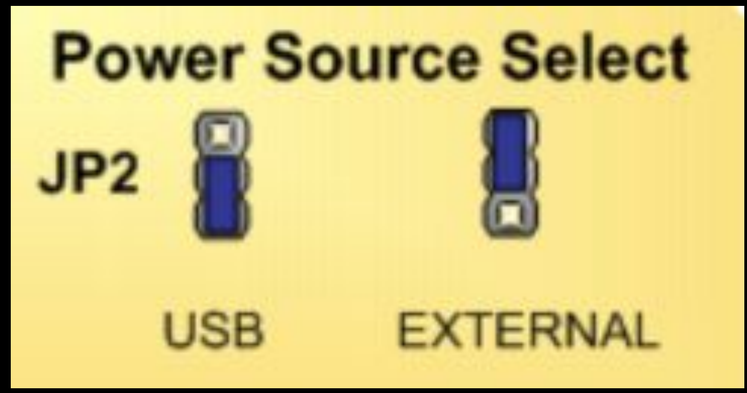


FPGA configuration (8/8)

Make sure your

- JP1 is on FLASH mode
- JP2 is on EXTERNAL





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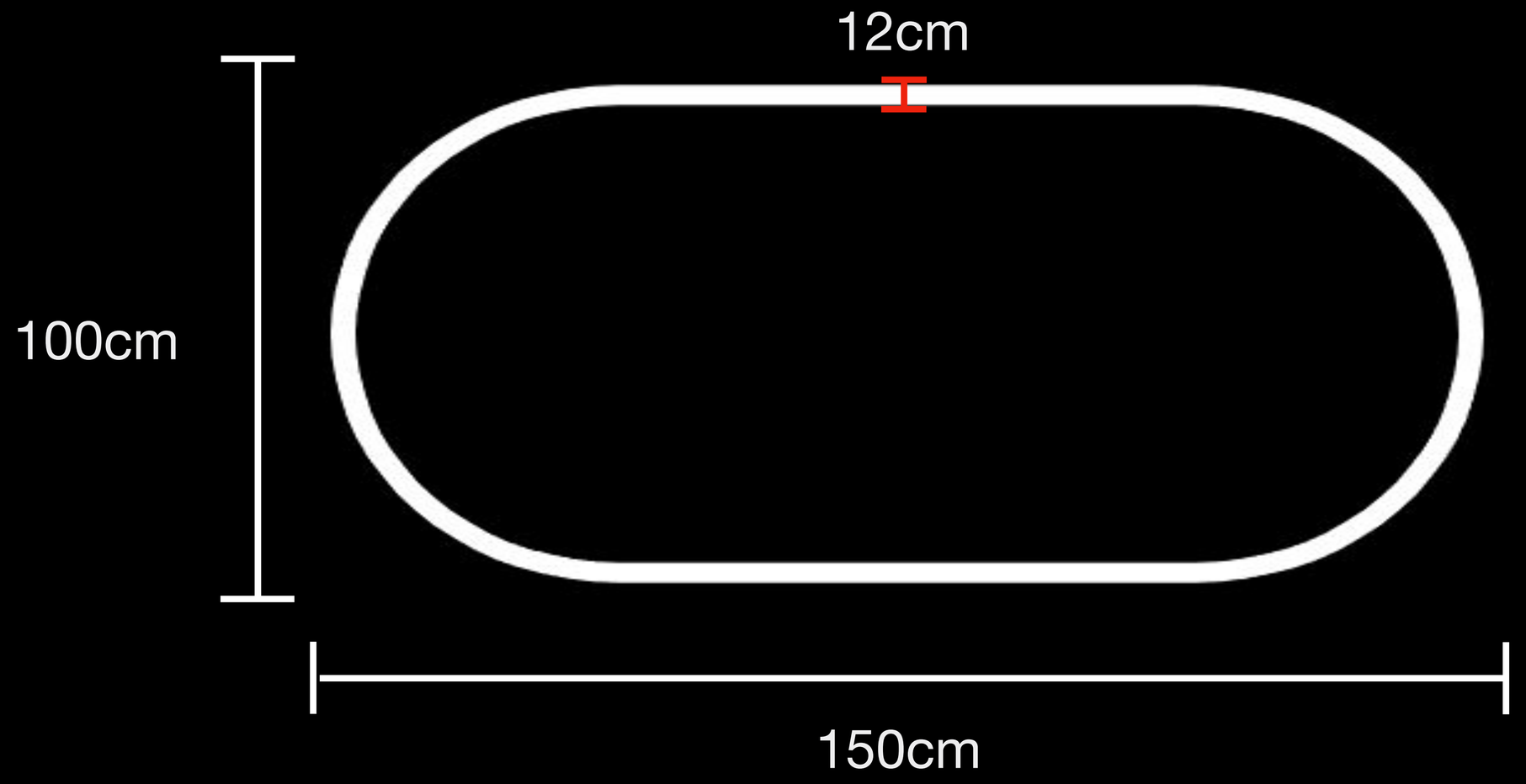
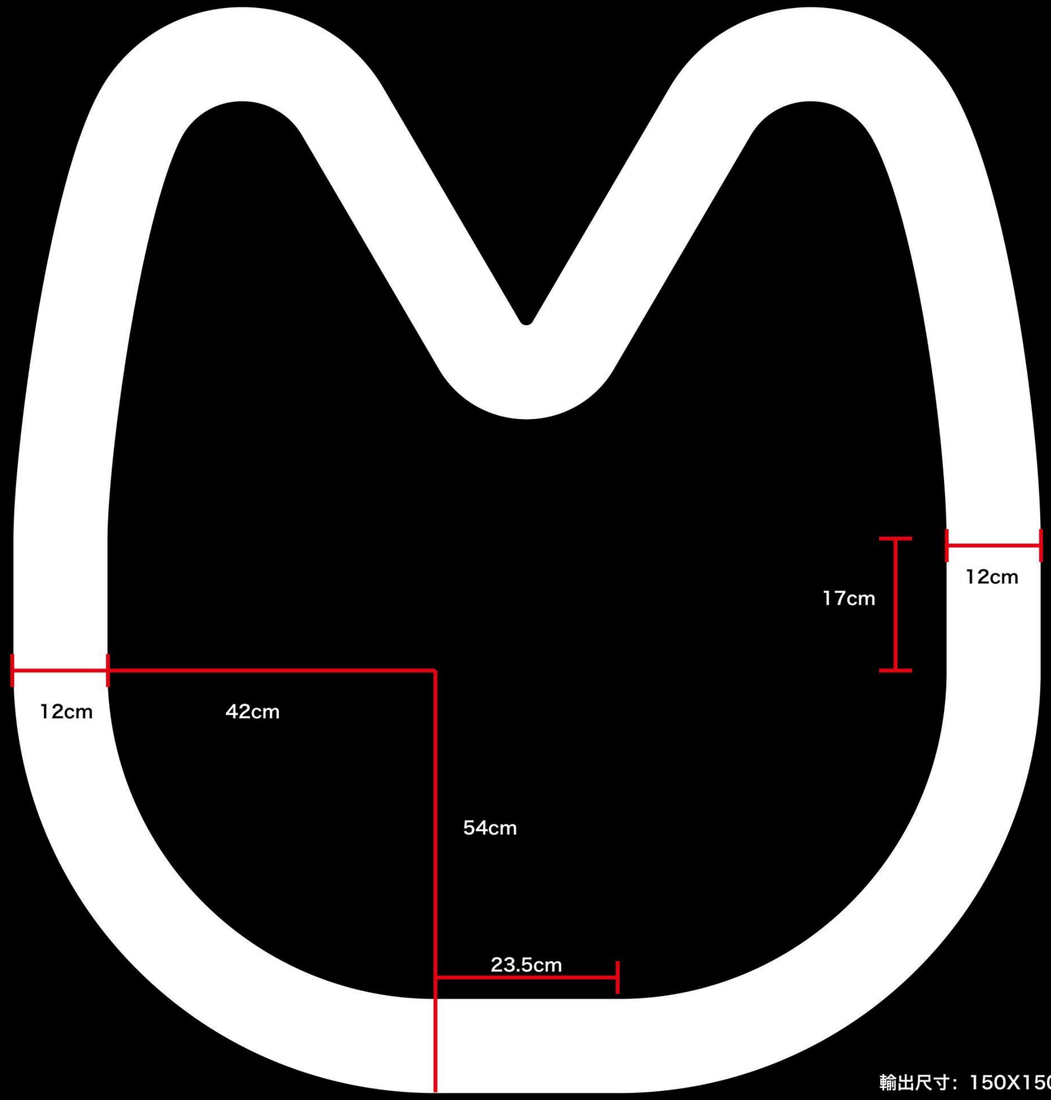
Grading (1/4)

- Use sonic sensor to detect the distance.
  If distance < 40cm, you need to stop the car.
- Make sure your car can turn right and left successfully.
- We will have two basic tracks, and one bonus track.

Grading (2/4)



Grading (3/4)

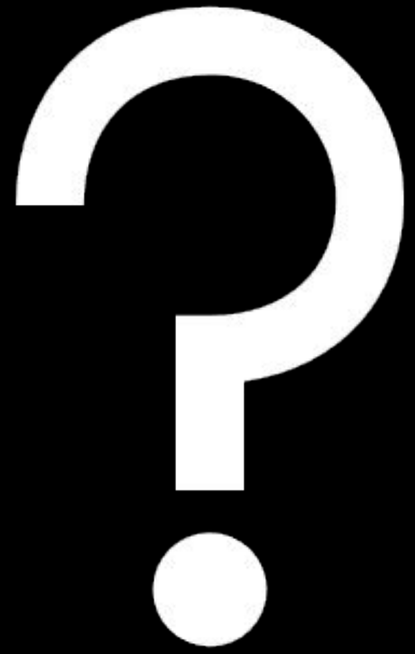


輸出尺寸：150X150cm

Grading (4/4)

Bonus track

- Be careful on a sharp turn.
- You don’t need to handle Square Corner.
- You don’t need to reverse your car.
- You don’t need to handle overlap track.
- Bonus track will first test its correctness, and then test its speed.



Q&A