

Robotics and Embedded Systems

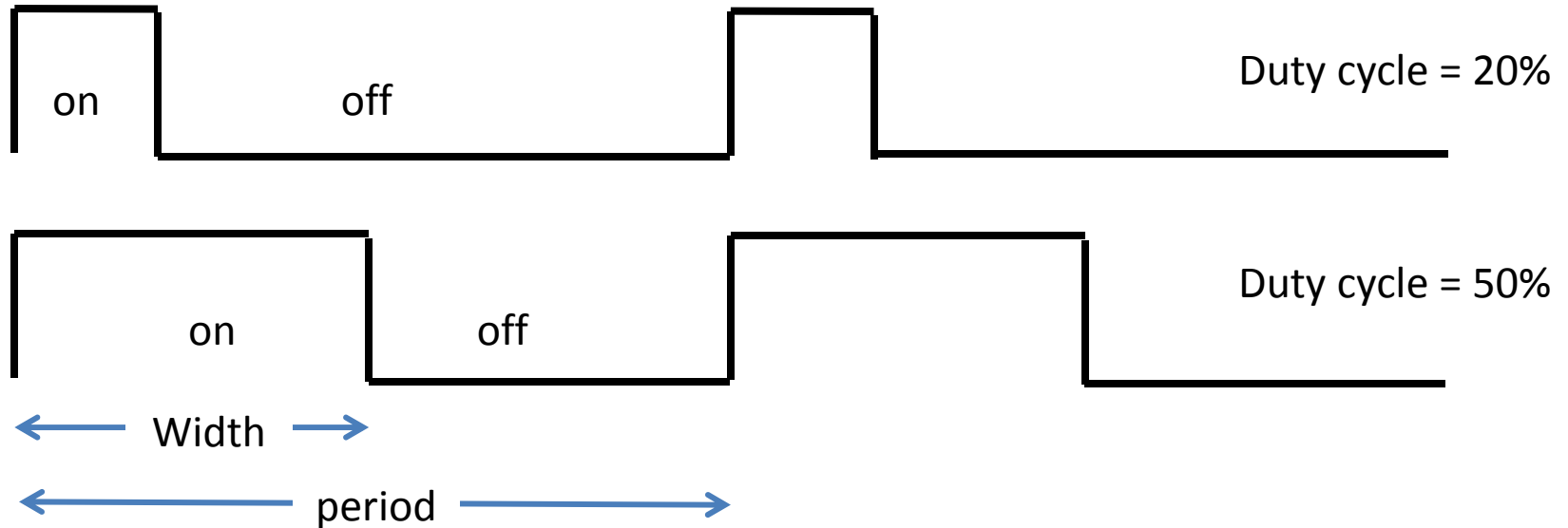


Technische Universität München

# Introduction to Pulse Width Modulation (PWM)



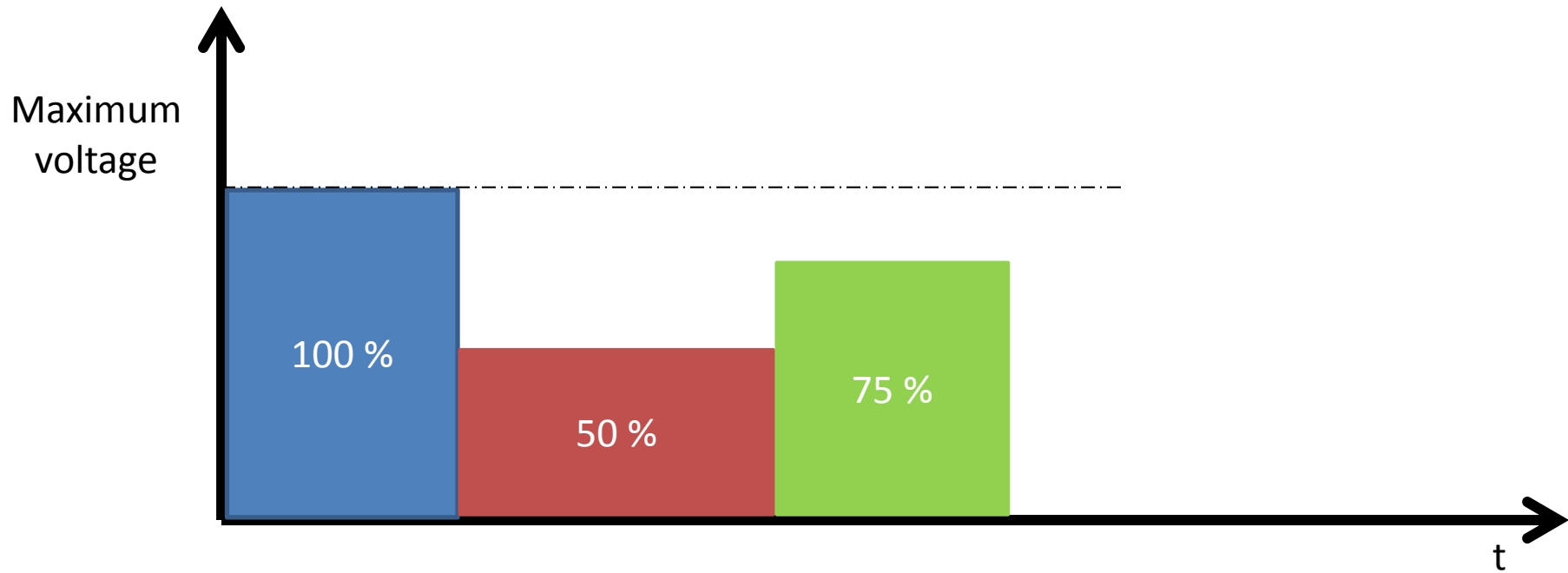
# What is PWM?



- Depending on the requirement the width of the pulse is modulated (adjusted).
- Duty cycle =  $t_{\text{on}} / (t_{\text{on}} + t_{\text{off}})$ .



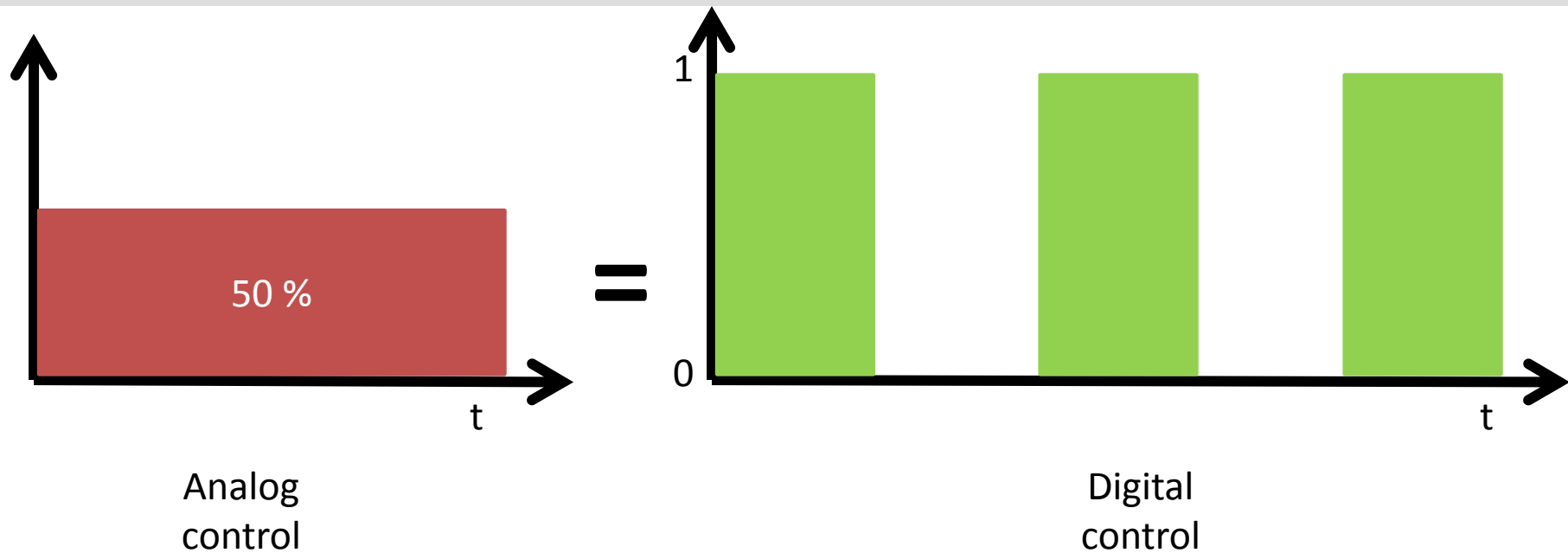
# Why PWM?



- Analog voltage control:
  - Voltage can be changed to control the motor speed
  - Can NIOS change voltage ?



# Why PWM?



- Digital voltage control:
  - Can only control '1' and '0'
  - X% of maximum analog voltage = X% of duty cycle





# PWM Control Example

- Disco gate:
  - 100 % open gate = 10 persons per second
  - 50% open gate = 5 persons per second
- Analog control:
  - Open 50 % gate
  - Total how many people can go in 10 seconds?
- Digital control:
  - Open 100 % gate on every odd second (1,3,5,7,9, ..)
  - Total how many people can go in 10 seconds?



# Usage of PWM

- Motor Control
- Intensity of LED



# How to generate PWM signal ?

## ■ Software method

### ○ Using counter

- Count to 100 in a loop
- Set the output value to 1 in the beginning of the loop
- Set the output value to 0 as soon as the counter reaches the value of required duty cycle.
- Continue the process

### ○ Using interrupt

- Home work
- Think about the concept





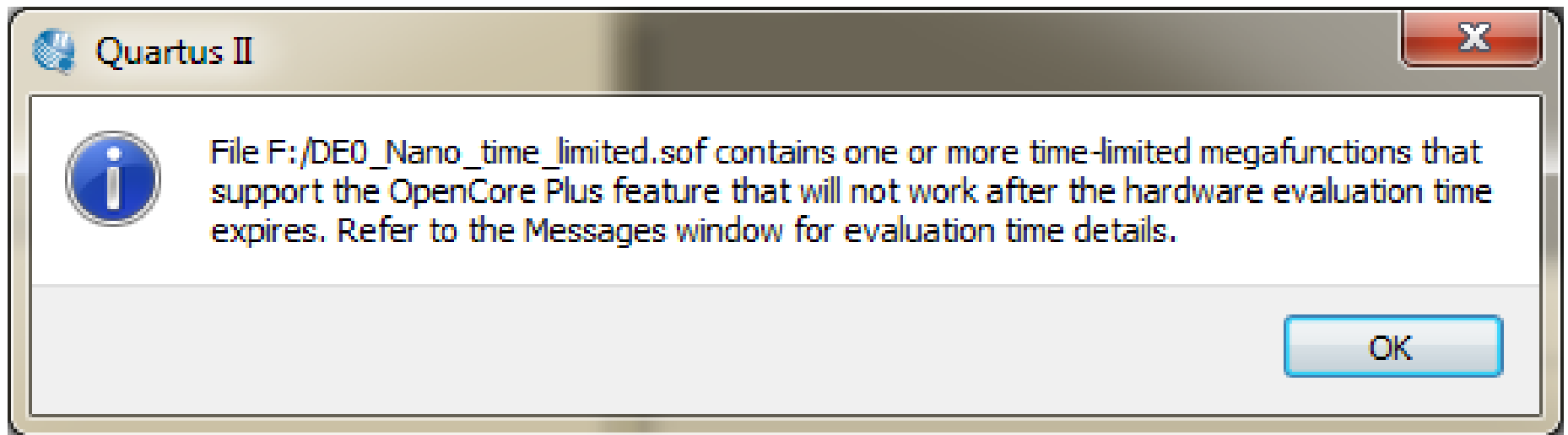
## Your tasks

- Create projects in a usual way using provided SOF and SOPCINFO file.
- Type the code in your application project.
- Change duty cycle variable and observe the effect LED, and test it on the car.



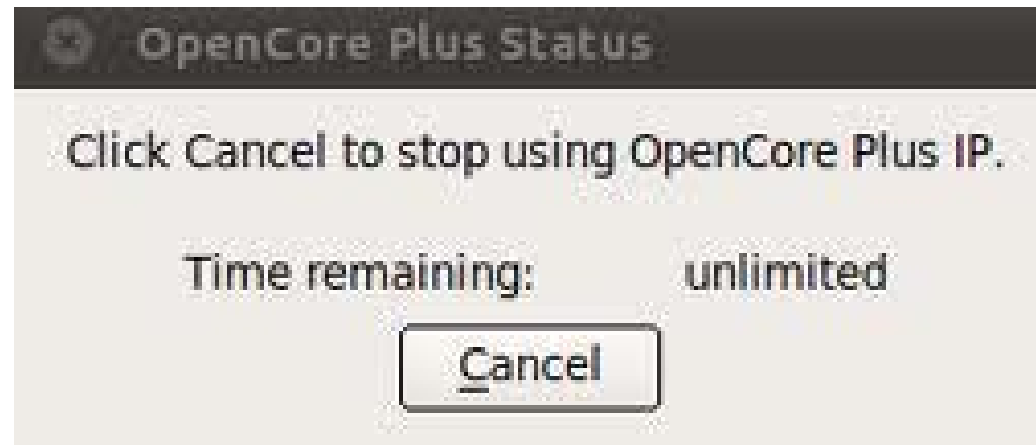


# Licenses



- You will get such message when you open the SOF file
  - Click OK

# Licenses



- After programming the FPGA, you will get this warning
  - **DO NOT click cancel**

