Summer Camp ‘13

Timers and Interrupts

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Recap

A small computer integrated in a single IC

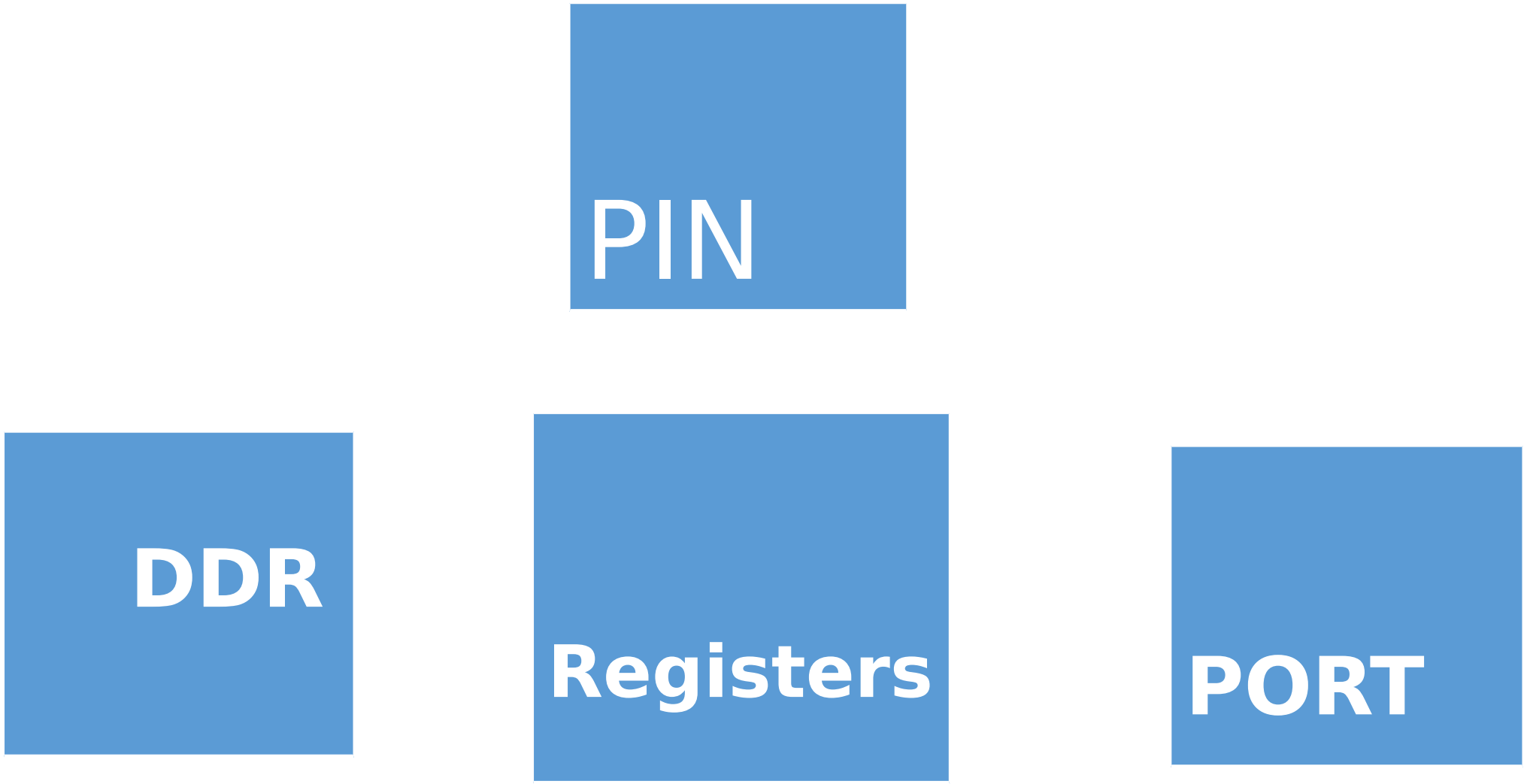
MCU

Has I/O, RAM and Memory

CVAVR

Software used

AVR Studio


PIN
DDR
Registers
PORT

Timers

- 8-bit register.
- Values starts from 0 and goes up to 255. Timer value increases by 1,after each period.

t = 256T	0	0	0	0	0	0	0	0

- When the timer reaches its maximum value, in the next cycle, its value becomes 0 again and the process repeats itself.
- The timer frequency can be factors of the base frequency of the MCU.
- This process is independent of the CPU.

Simple Statistics

- Maximum value of timer is n and clock period is t, then:
  1. Timer period = t
  2. Timer cycle period = $(n+1)\times t$
  3. Frequency of timer (f) = $1/t$
  4. Frequency of timer cycle = $1/(n+1)\times t$

Suppose you need to check for a condition A while running another condition B

```
while(1){
---- -> if (Event A == true)
---- -> // print event A has occurred
----
----
---- -> Event B
---- -> Suppose Event A happens
---- here
}
```

Do you see the problem in this approach??

A better Solution: Interrupt

- Interrupts means causing a break in a continuing process.
- We execute the Event B in a normal while(1) loop.

```
.
while(1){
 ---
 ---
 EVENT B
 ---
 ---
 }
 .
```

- We will consider the occurrence of event A as an interrupt

In

```
.
while(1){
---
---
EVENT B
---
---
}
.
handleA(){
.
---// print event A has occurred
}
```

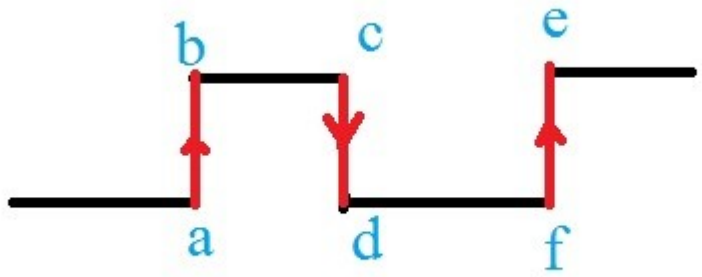
We execute the required code in handler of event A

More on Interrupts

- Interrupts are special events that can “interrupt” the normal flow of a program.
- Whenever an Interrupt is called, the processor stops the normal program, handles the interrupt, and then resumes its normal work.
- There are two types of interrupts:
    1. External
    2. Internal

External Interrupts

- The controller monitors the input at the special pins INT0 and INT1, whenever external interrupt is set on.
- We can configure the program to call an external interrupt whenever any of the following conditions are met.
- Rising Edge
- Falling Edge
- Any change
- Low level



Internal Interrupts

- The internal interrupts are called when different specific conditions are met by the timer value.
- Timers can generate certain interrupts: two, to be precise.
- These are called **OVERFLOW** interrupt and **COMPARE MATCH** interrupt.

Overflow interrupts

- An overflow interrupt is generated when the timer exceeds its maximum value and resets to 0.
- The interrupt may or may not have a handler. In either case, the timer continues to run; remember: timers are independent of the CPU.
- Suppose a timer of maximum value n has a time period t (also called as clock period).
- Then :

  1. Timer cycle frequency = $1/(n+1)\times t$
  2. OVERFLOW interrupt frequency = $1/(n+1)\times t$

- If OVERFLOW interrupt is enabled, then an interrupt is generated in every cycle.

Compare Match Interrupt

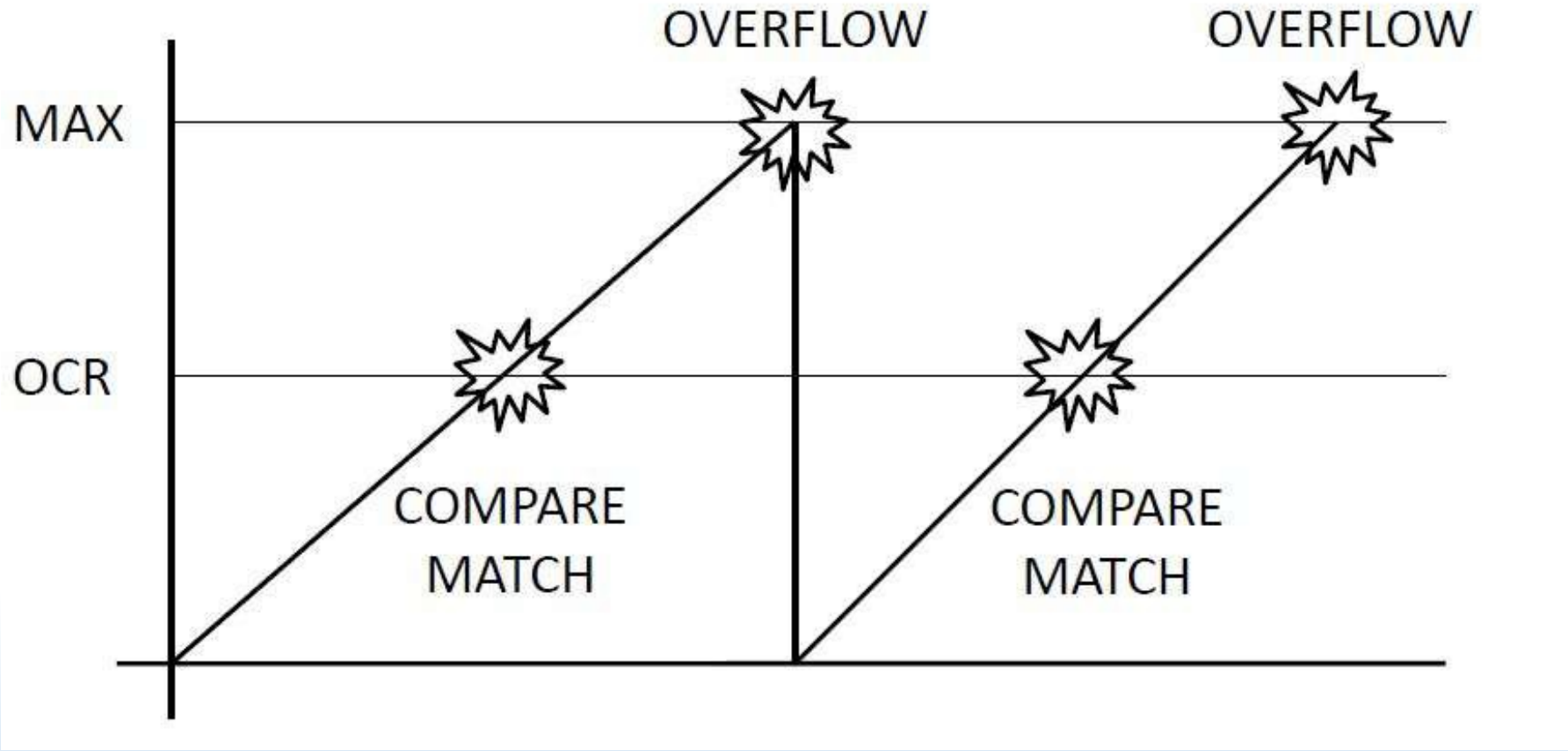
- A compare match interrupt is called when the value of the timer equals a specific value, set by the user.
- This value is set by setting the value of OCR register.
- Before incrementing, the value of the timer is compared to OCR. If the two are equal, a COMPARE MATCH interrupt is generated.
- Suppose a timer of maximum value n has a time period t (also called as clock period).

  Then :

  1. Timer cycle frequency = $1/(n+1)\times t$
  2. COMPARE MATCH interrupt frequency = $1/(n+1)\times t$

- If COMPARE MATCH interrupt is enabled, then an interrupt is generated in every cycle.

Interrupts: Overflow and Compare Match



Timer modes

- A timer works in three modes: Normal, CTC and PWM.
- All three modes differ in the response of the controller to the interrupts generated.

Normal Mode

- Standard mode: Timer starts at 0, goes to maximum value and then resets itself.

- OVERFLOW and COMPARE MATCH interrupts generated as normal.

CTC Mode

- Known as Clear Timer on Compare.
- As evident by the name, the timer starts at 0 as usual, but instead of resetting after maximum value, it resets after reaching value specified in OCR register.
- Compare match interrupt if enabled will be generated but not overflow interrupt (Why?)

CTC mode statistics

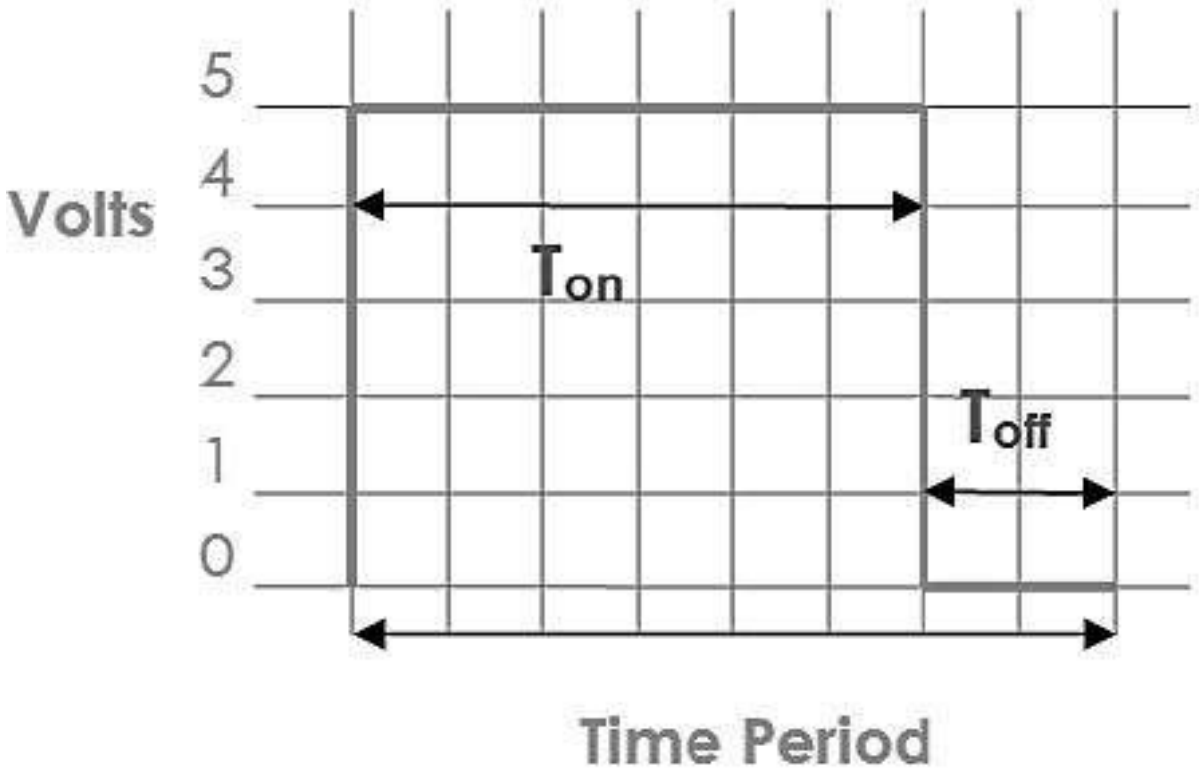
- If clock time period is t:
  1. Timer cycle time period = $(OCR+1)\times t$
  2. Frequency = $1/(OCR+1)\times t$

- With the use of CTC Mode we can theoretically generate any frequency up to 8 MHz.

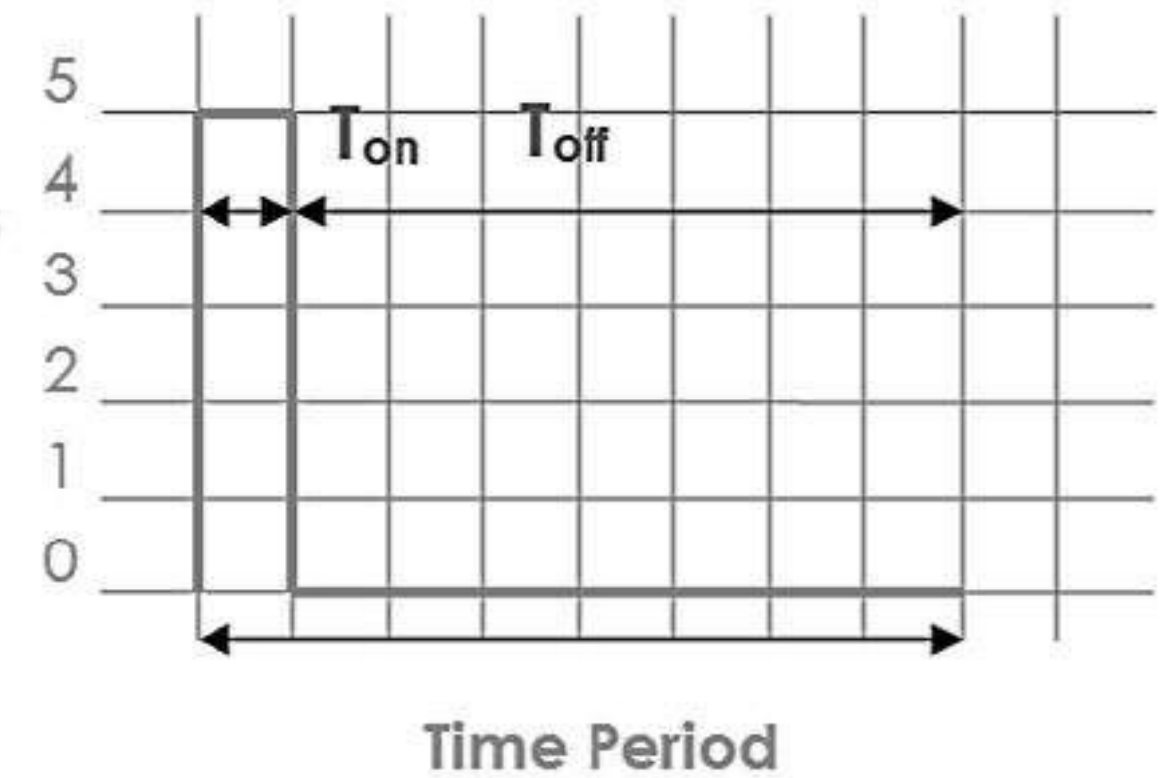
- Example : 1 Hz generation.

PWM mode

- Known as Pulse Width Modulation
- Simple method of obtaining analog output of any value between 0 and 5V.
- Suppose we need 3V for our device at a specified pin. We supply 5V on it for (3/5)* 100 % = 60% of the time period and 0V for the remaining time period.
- The average voltage at the pin for a time period becomes 3V
- If this step is repeated very fast (T is very small), then the output behaves as a analog signal of 3V.


Volts
5
4
3
2
1
0
Ton
Toff
Time Period

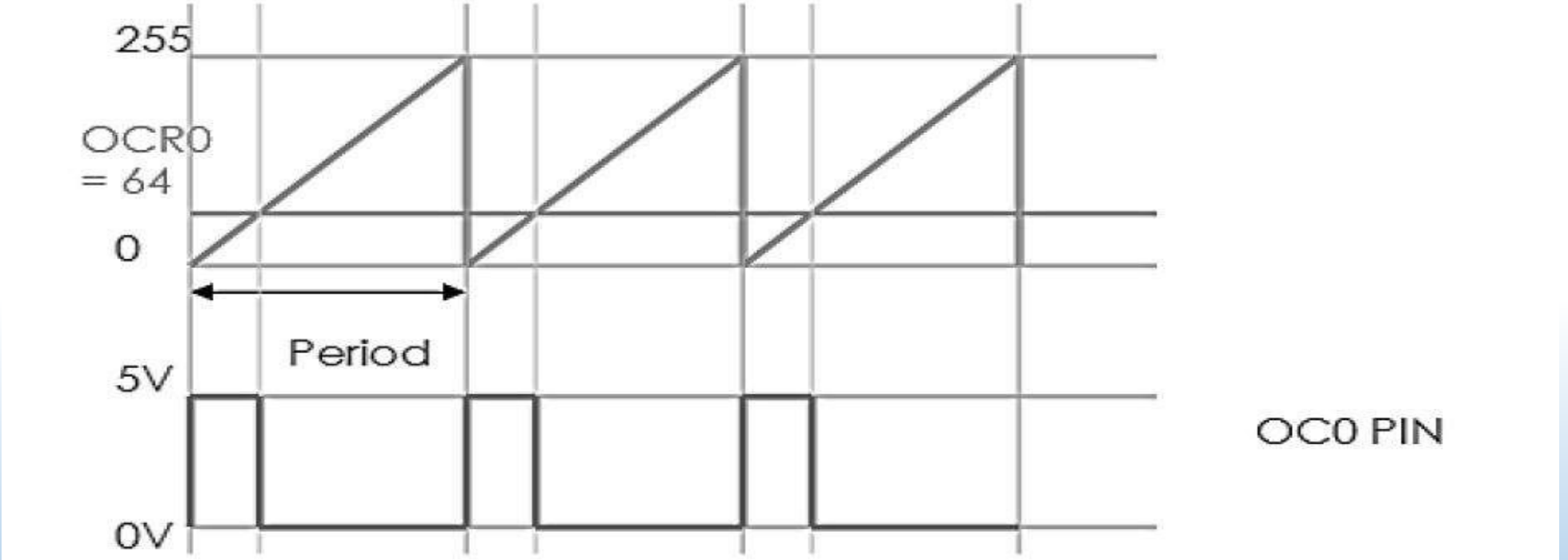
3.75 V


Volts
5
4
3
2
1
0
Ton
Toff
Time Period

0.625 V

PWM mode

- This “analog” value is obtained using timers.
- A specific pin is set as output. When the timer reaches 0, the voltage of the pin is set to 5V.
- When the timer reaches the value specified by OCR, on the next clock, the pin voltage is set to 0 until the timer res



PWM mode Statistics

- If clock time period is t and maximum timer value is n:

  1.Timer cycle time period $=(n+1)\times t$

  2.Frequency $=1/(n+1)\times t$

  3.Duty cycle $=[(OCR+1)/(n+1)]\times 100\%$

  4.Output voltage $=[(OCR+1)/(n+1)]\times 5V$

- COMPARE MATCH interrupt and OVERFLOW interrupt both will work properly.


SO ... DO YOU HAVE ANY QUESTIONS FOR ME?