
# TIMERS AND INTERRUPTS

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# RECAP


Small computer
Integrated in an single IC
MCU
Has I/O, Ram & Memory

# REGISTERS

**DDR**

- Decides whether pin is INPUT or OUTPUT

**PORT**

- Used to specify the output value

**PIN**

- Used to read the input value

# SOFTWARE NEEDED

# TIMERS

**8-bit register.**

**Values starts from 0 and goes up to 255. Timer value increases by 1,after each period.**

**(The standard issue MCU for Techkriti ‘15 will be Atmega16 which has a 16-bit clock register also. We will cover the theory of timer wrt 8 bit registers for the sake of clarity and ease of representation but all that is subsequently discussed can be applied to 16 bit registers with little or no modification)**

**When the timer reaches its maximum value, in the next cycle, its value becomes 0 again and the process repeats itself.**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| t = 0T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| t = | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| t = 2T | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| t = | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| t = 256T | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

# 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 = $1/(n+1)\times t$

# TIMER MODES

**A timer works in three modes: Normal, CTC and PWM**

**Normal mode: Timer starts at zero, goes to maximum value and then resets itself**

**CTC (Clear Timer on Compare), clearly the timer starts at zero as usual, but instead of resetting after maximum value, it resets after reaching value specified in OCR register**

**PWM(Pulse Width Modulation) can be used to obtain analog values at the pins**

# 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**

# INTE

```
.
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.**

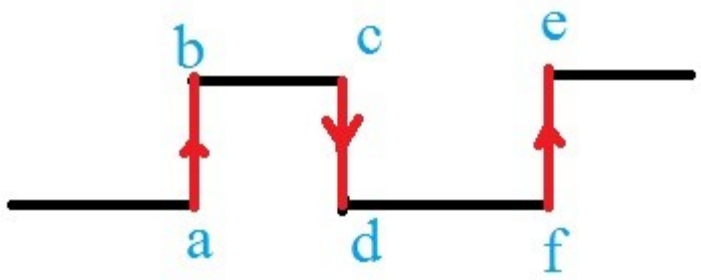
**We can configure the program to call an external interrupt whenever any of the following conditions are met.**

**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.**

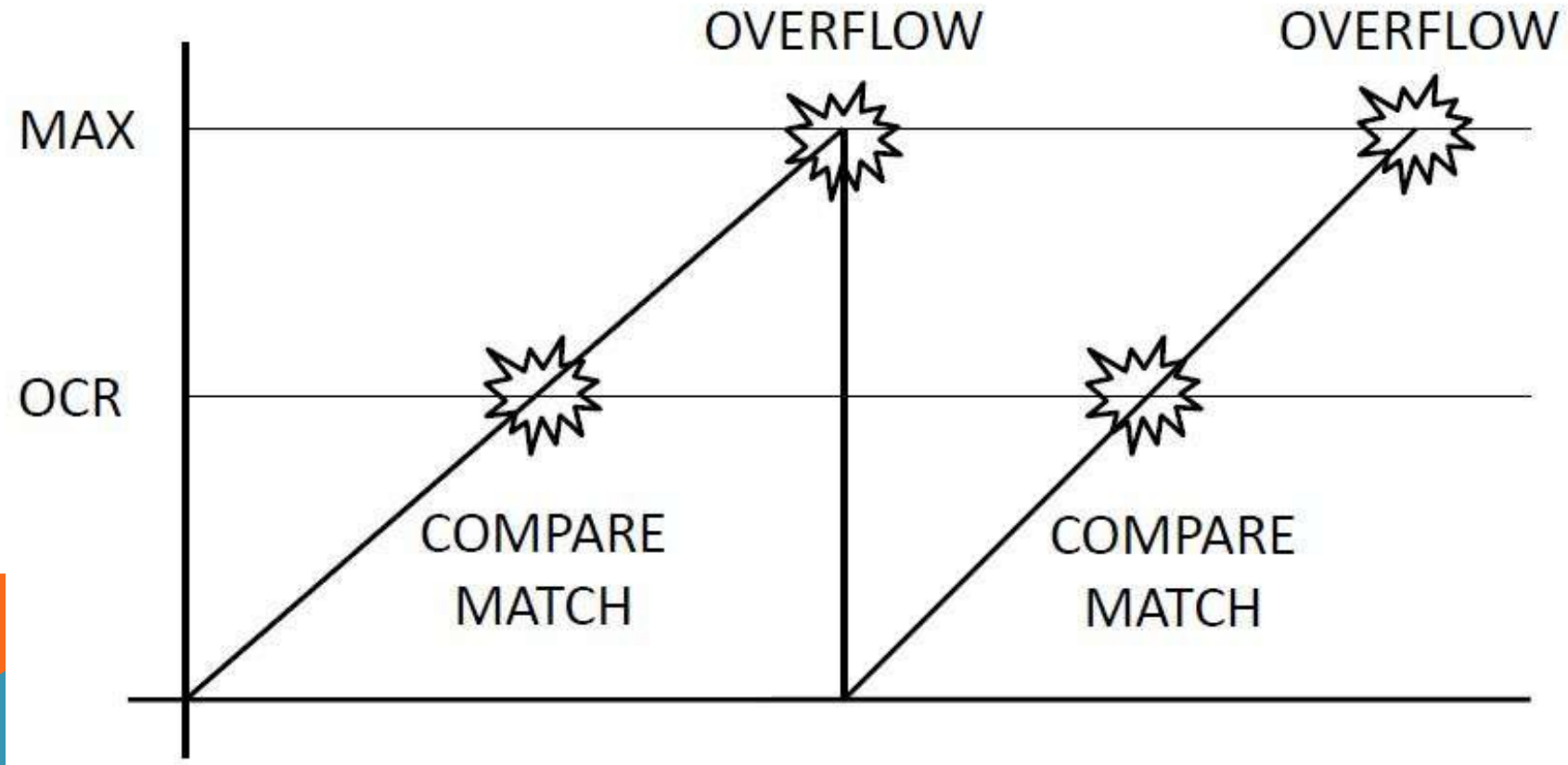
**Suppose a timer of maximum value n has a time period t (also called as clock period).**

**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



# TIMERS AND INTERRUPTS

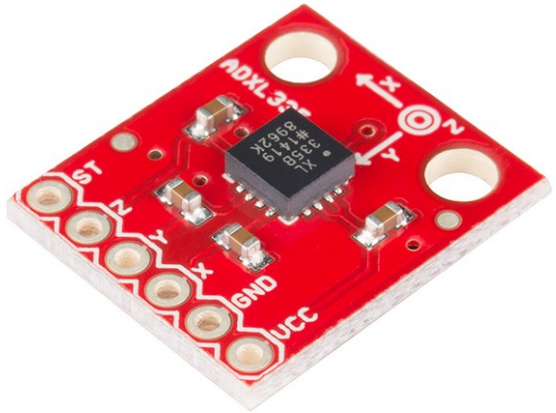
**All three timer modes differ in the response of the controller to the interrupts generated**

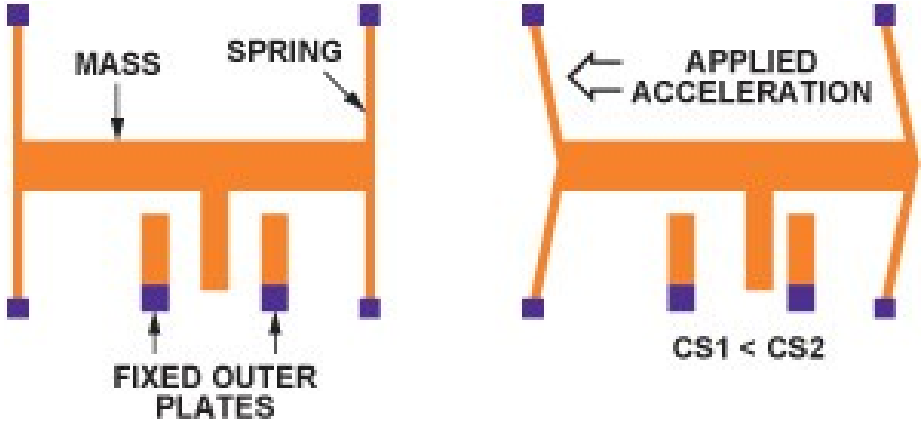
**OVERFLOW and COMPARE MATCH interrupts generated as normal in NORMAL timer mode**

**Compare match interrupt if enabled will be generated but not overflow interrupt (Why?)**

# ACCELEROMETER

**For Electromania this year, the standard issue board will be one based on an Analog 3-Axis MEMS Accelerometer**




**Poll values using Analog Input pins and scale appropriately to acquire the acceleration due to gravity on each axis and hence orientation**

**Refer to the datasheet for scaling information**

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