

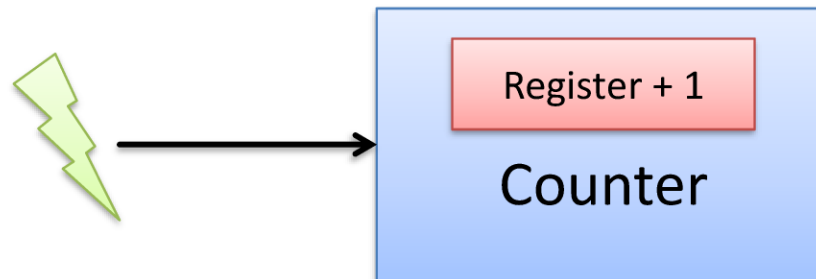
# Timers and Interrupts

Embedded Software

Wolfgang Neff

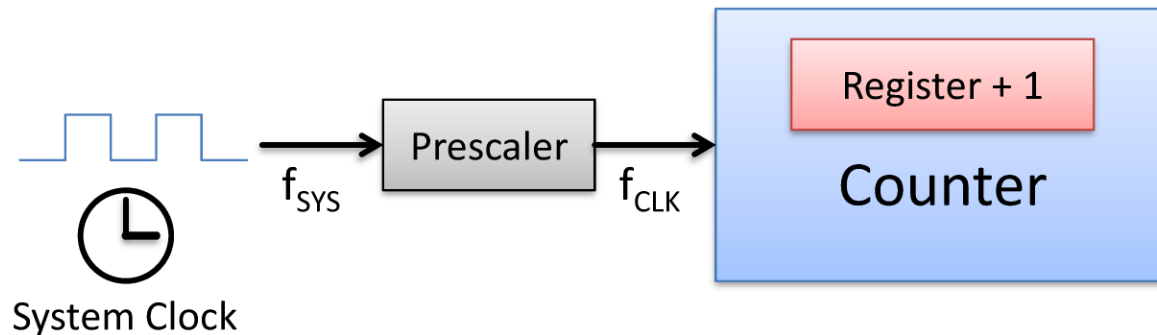
# Counters

- Counters count events
  - Number of events stored in a register
  - Each event increments this register



# Timers (1)

- Timers count clock ticks
  - Primary source is system clock
  - Clock speed is reduced by a prescaler

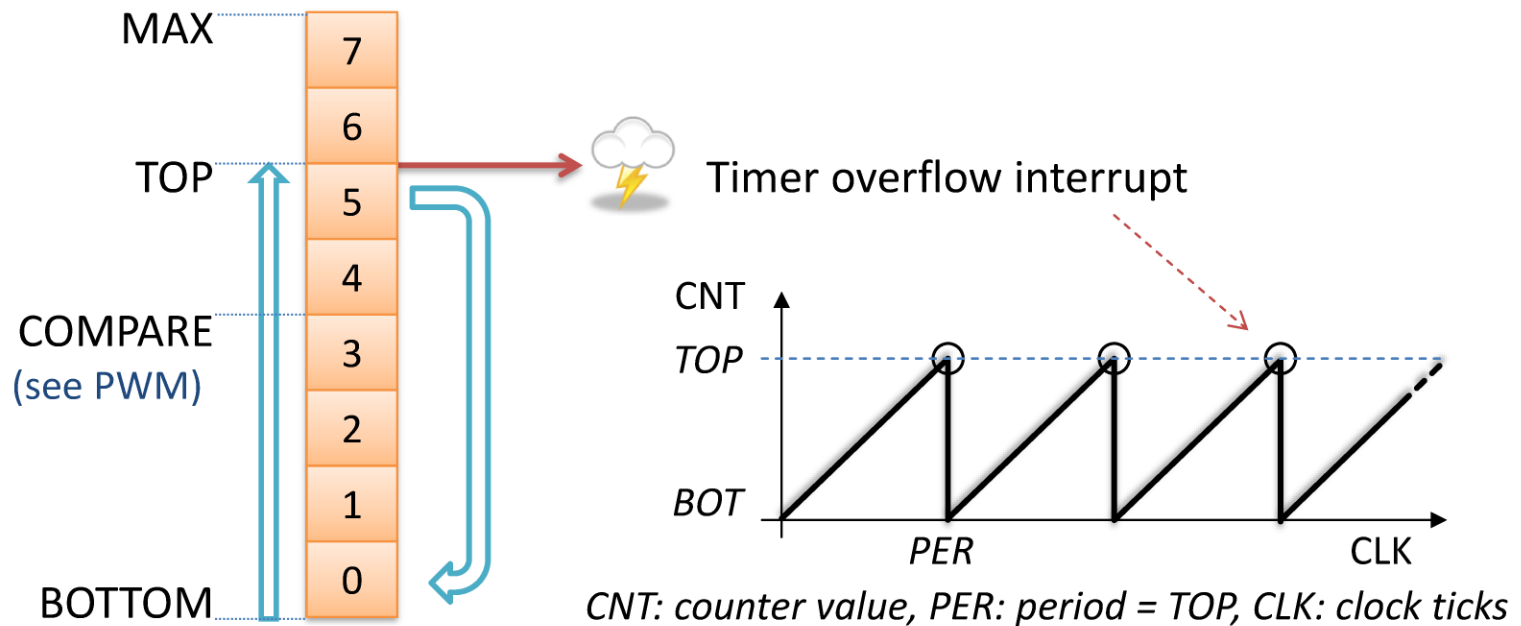


$$f_{CLK} = \frac{f_{SYS}}{n}$$

$f_{SYS}$ : System Frequency  
 $f_{CLK}$ : Clock Frequency  
 $n$ : Prescaler Value

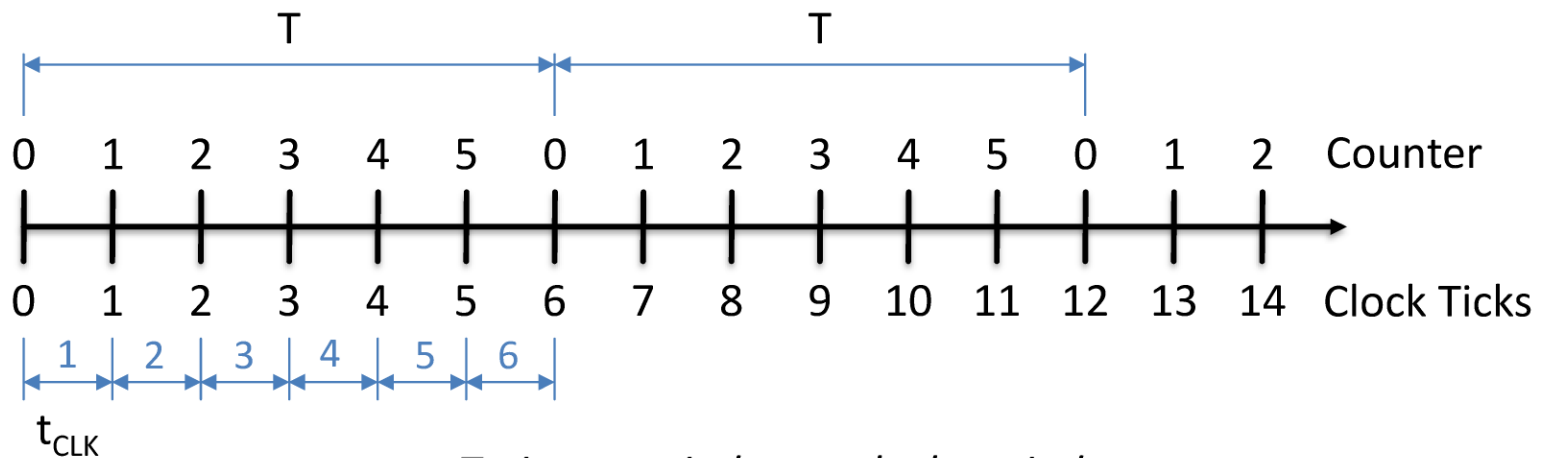
# Timers (2)

- Operating mode



# Timers (3)

- Operating mode (continued)
  - Example: TOP = 5

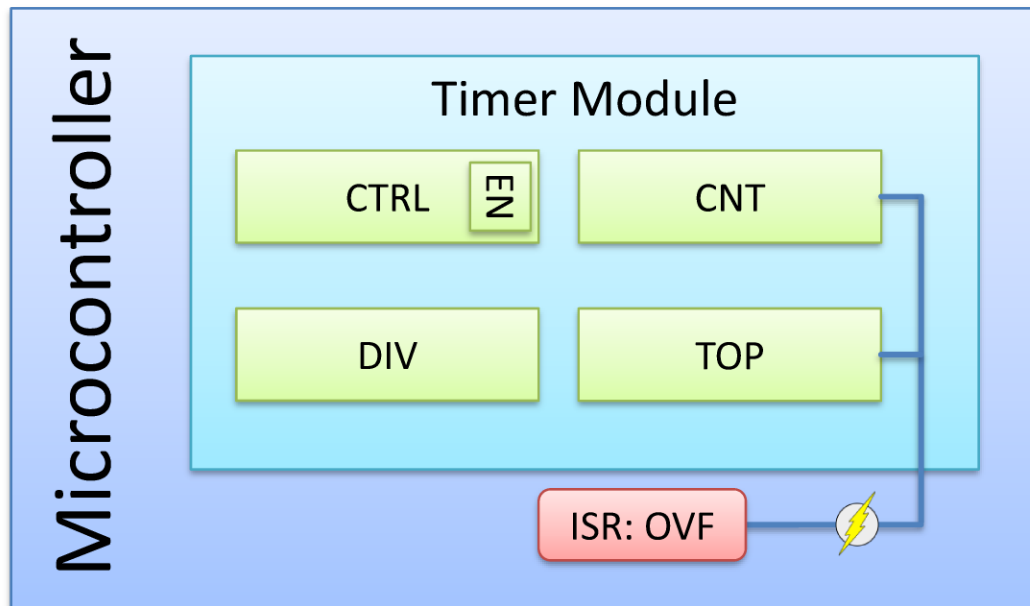


$T$ : timer period,  $t_{CLK}$ : clock period

$$T = (TOP+1) \cdot t_{CLK}$$

# Timers (4)

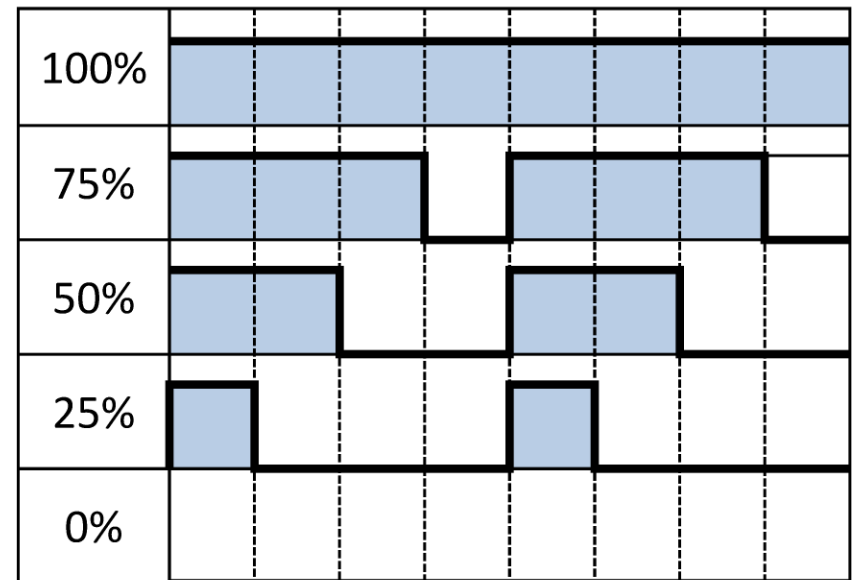
- Timer Module



CTRL: Control Register  
CTRL.EN: Enable Bit  
CNT: Counter Value  
DIV: Clock Divider  
TOP: Top Value  
OVF: Overflow

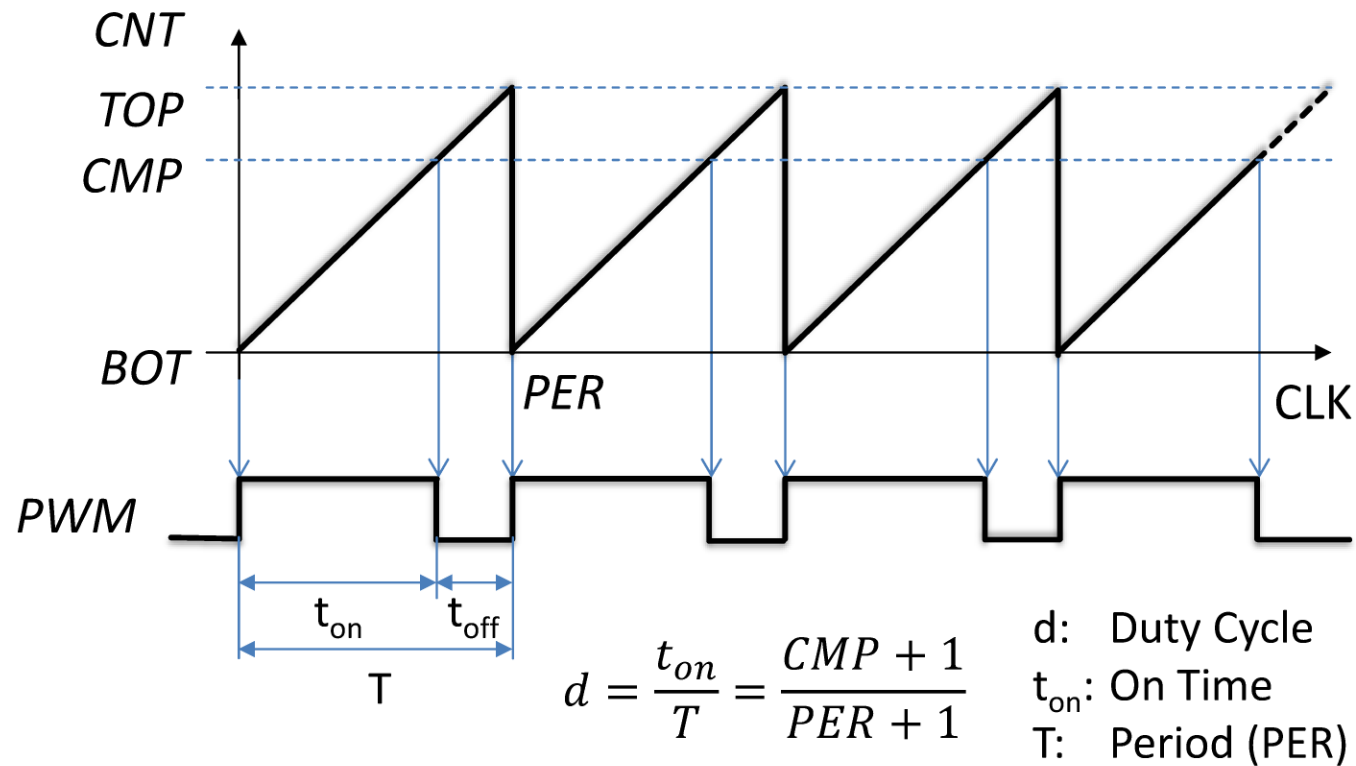
# PWM (1)

- Pulse-Width Modulation
  - Digital pins are either high or low
  - Time enables intermediate values
  - Inertia for averaging necessary
  - Alternative: Digital Analog Converter



# PWM (2)

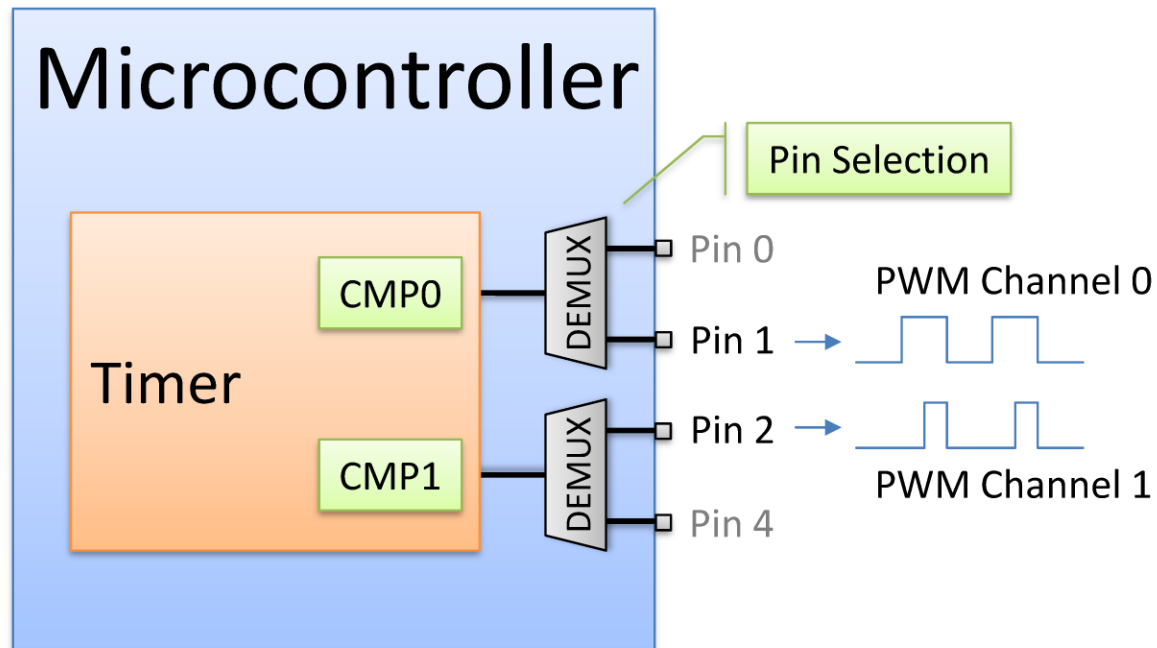
- Generation





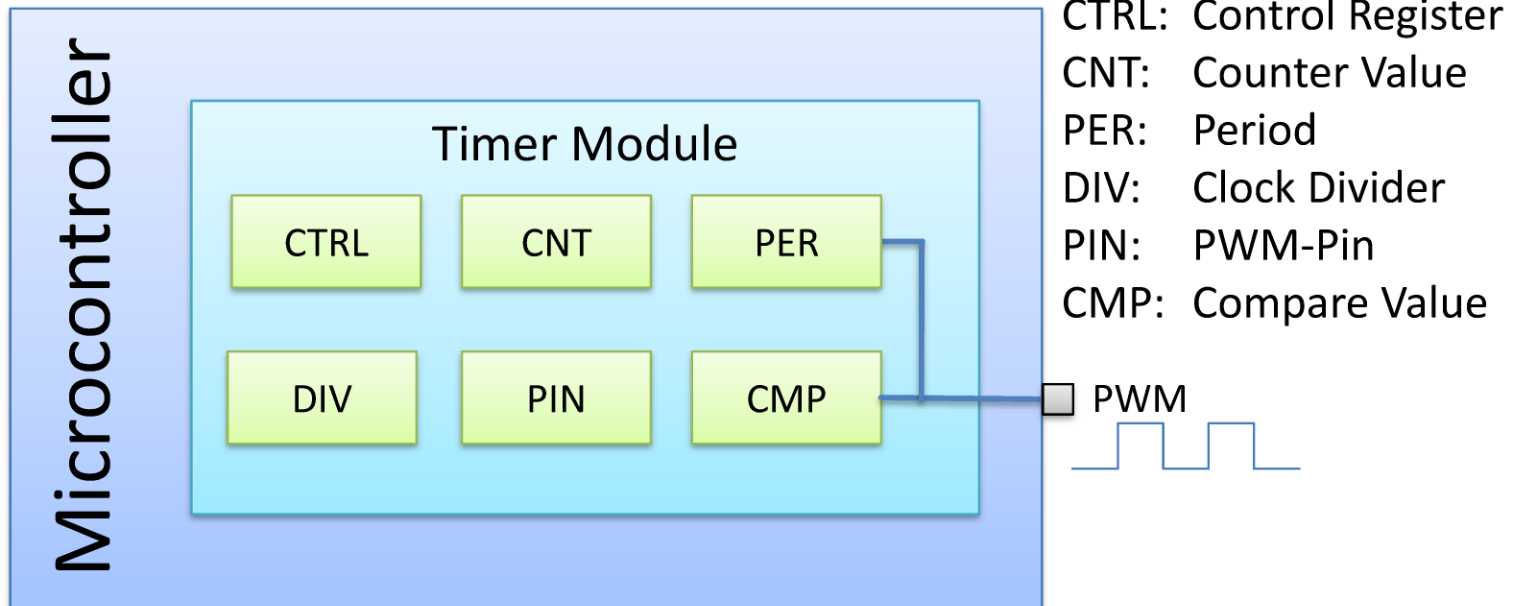
# PWM (3)

- Architecture



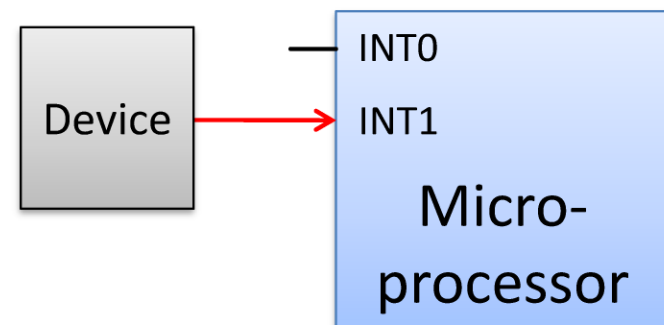
# PWM (4)

- PWM Module



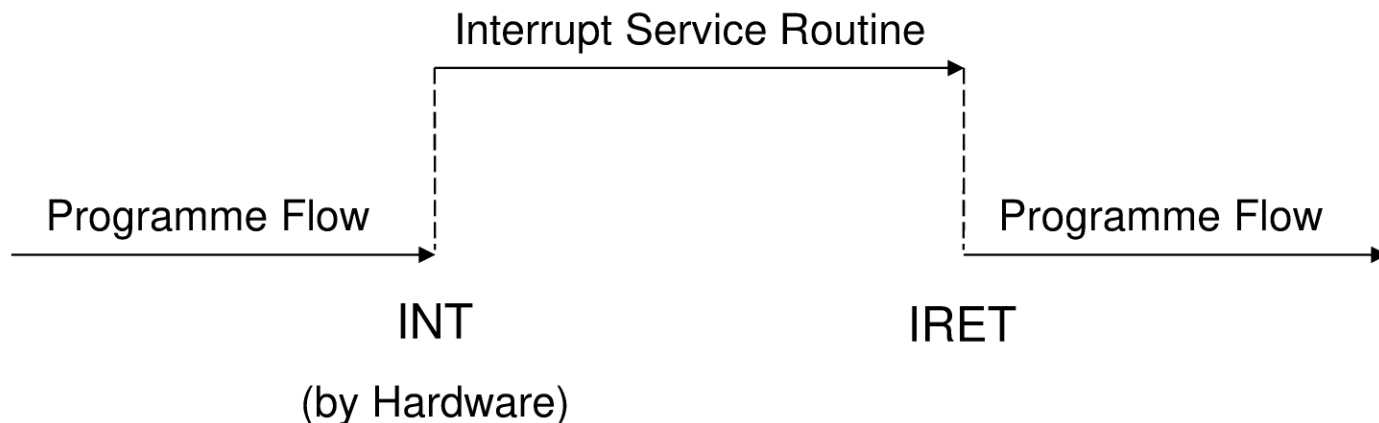
# Interrupts (1)

- Generated by hardware
- Indicated by an interrupt line
- Occur unpredictably
- Tell that something happened
- Examples
  - Port interrupt
  - Timer interrupt
  - Data ready interrupt



# Interrupts (2)

- Interrupt Processing
  - Execution of code is interrupted
  - Interrupt service routine (ISR) is executed
  - Execution of original code is resumed.



# Interrupts (3)

- Interrupt Controller

- Handles Interrupts

- Queueing
      - Which one is served first?
    - Nesting
      - Based on priority levels
      - Which interrupt interrupts other interrupts?
    - Forwarding
      - Notifies the CPU of an interrupt request (IRQ)

