02 Arduino

Timer

Feladat:

- 1Hz időzítő
- Led villogtatása
- Delay helyett interrupt-tal ☺

Mi a timer?

- Egy olyan „regiszter” ami előre meghatározott időközönként növeli az értékét, az MCU-tól függetlenül.
- Számos működési módja van:
  - Normál: megszakítások generálása megadott időközönként
  - Output Compare: különböző frekvenciájú és szimmetriájú jelek előállítására alkalmas (pl. PWM)

Timer

- ATMEGA2560:
  - 8 bites:
    - Timer 0, Timer 2
  - 16 bites:
    - Timer 1, Timer 3, Timer 4, Timer 5
- A 16 bites timerek több funkcióval rendelkeznek, és a 16 bites felbontásnak köszönhetően pontosabb jelgenerálásra és időzítésre van lehetőség!

Timer

- 8 bit esetén a timer számlálója max. 255-öt vehet fel
- 16 bit esetén a timer számlálója max. 65535 vehet fel.

Timer regiszterek

- TCNTn: Timer/Counter regiszter
- OCRnA/B/C: Output Compare Register (PWM)
- ICRn: Input Capture Register (külső jelhez)
- TCCRnA/B/C : Timer/Counter Control Registers
- TIFRn: Timer Interrupt Flag Register
- TIMSKn: Timer Interrupt Mask Register

Timer

- Timer 1 (16 bites) beállítása, működési mód konfigurálása:
  - TCCRnA (TCCR1A)
  - TCCRnB (TCCR1B) segítségével.
- Az egyes konfiguráló bitek helye timerekként változhat!
- A TCCR1A regiszter az Output Compare működési módok beállítására szolgál, amivel pl. PWM jelet lehet előállítani (mi normál módban használjuk)
- TCCR1B regiszter a Timer-t meghajtó órajel és az Input Capture működési mód beállítására szolgál

TCCR1A – mód beállítása

17.11 Register Description

17.11.1 TCCR1A – Timer/Counter 1 Control Register A

Bit	7	6	5	4	3	2	1	0	
(0x80)	COM1A1	COM1A0	COM1B1	COM1B0	COM1C1	COM1C0	WGM11	WGM10	TCCR1A
Read/Write	R/W	R/W	R/W	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- Bit 7:6 – COMnA1:0: Compare Output Mode for Channel A
- Bit 5:4 – COMnB1:0: Compare Output Mode for Channel B
- Bit 3:2 – COMnC1:0: Compare Output Mode for Channel C
- Bit 1:0 – WGMn1:0: Waveform Generation Mode

Table 17-3. Compare Output Mode, non-PWM

COMnA1 COMnB1 COMnC1	COMnA0 COMnB0 COMnC0	Description
0	0	Normal port operation, OCnA/OCnB/OCnC disconnected
0	1	Toggle OCnA/OCnB/OCnC on compare match
1	0	Clear OCnA/OCnB/OCnC on compare match (set output to low level)
1	1	Set OCnA/OCnB/OCnC on compare match (set output to high level)

TCCR1B

- Beállítandó paraméterek:
  - Clear Timer on Compare (CTC) modes of operation (WGMn2 bit)
  - 1024 precaler (CSn2:0 bit)

17.11.5 TCCR1B – Timer/Counter 1 Control Register B

Bit	7	6	5	4	3	2	1	0	
(0x81)	ICNC1	ICES1	–	WGM13	WGM12	CS12	CS11	CS10	TCCR1B
Read/Write	R/W	R/W	R	R/W	R/W	R/W	R/W	R/W	
Initial Value	0	0	0	0	0	0	0	0	

- **Bit 7 – ICNCn: Input Capture Noise Canceler**

Setting this bit (to one) activates the Input Capture Noise Canceler. When the Noise Canceler is activated, the input from the Input Capture Pin (ICPn) is filtered. The filter function requires four successive equal valued samples of the ICPn pin for changing its output. The input capture is therefore delayed by four Oscillator cycles when the noise canceler is enabled.

- **Bit 6 – ICESn: Input Capture Edge Select**

This bit selects which edge on the Input Capture Pin (ICPn) that is used to trigger a capture event. When the ICESn bit is written to zero, a falling (negative) edge is used as trigger, and when the ICESn bit is written to one, a rising (positive) edge will trigger the capture.

When a capture is triggered according to the ICESn setting, the counter value is copied into the Input Capture Register (ICRn). The event will also set the Input Capture Flag (ICFn), and this can be used to cause an Input Capture Interrupt, if this interrupt is enabled.

When the ICRn is used as TOP value (see description of the WGMn3:0 bits located in the TCCRnA and the TCCRnB Register), the ICPn is disconnected and consequently the input capture function is disabled.

- **Bit 5 – Reserved Bit**

This bit is reserved for future use. For ensuring compatibility with future devices, this bit must be written to zero when TCCRnB is written.

- **Bit 4:3 – WGMn3:2: Waveform Generation Mode**

See TCCRnA Register description.

- **Bit 2:0 – CSn2:0: Clock Select**

The three clock select bits select the clock source to be used by the Timer/Counter, see Figure 17-10 and Figure 17-11 on page 152.

Table 17-6. Clock Select Bit Description

CSn2	CSn1	CSn0	Description
0	0	0	No clock source. (Timer/Counter stopped)
0	0	1	$clk_{I/O}$/1 (No prescaling
0	1	0	$clk_{I/O}$/8 (From prescaler)
0	1	1	$clk_{I/O}$/64 (From prescaler)
1	0	1	$clk_{I/O}$/1024 (From prescaler)
1	1	0	External clock source on Tn pin. Clock on falling edge
1	1	1	External clock source on Tn pin. Clock on rising edge

If external pin modes are used for the Timer/Countern, transitions on the Tn pin will clock the counter even if the pin is configured as an output. This feature allows software control of the counting.

Órajel leosztás

Timer/Counter Timing Diagrams

The Timer/Counter is a synchronous design and the timer clock (clk_{Tn}) is therefore shown as a clock enable signal in the following figures. The figures include information on when Interrupt Flags are set, and when the OCRnx Register is updated with the OCRnx buffer value (only for modes utilizing double buffering). Figure 17-10 shows a timing diagram for the setting of OCFnx.

Figure 17-10. Timer/Counter Timing Diagram, Setting of OCFnx, no Prescaling

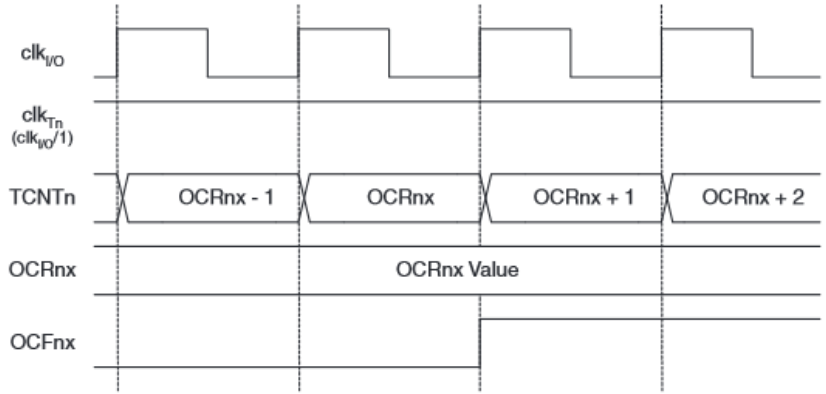
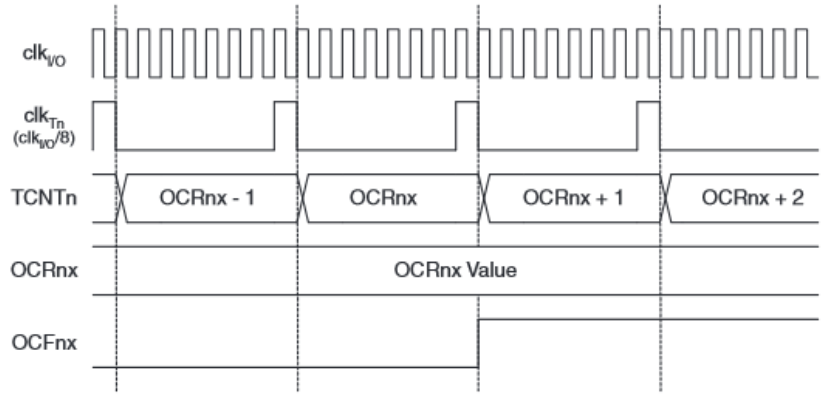


Figure 17-11 shows the same timing data, but with the prescaler enabled.

Figure 17-11. Timer/Counter Timing Diagram, Setting of OCFnx, with Prescaler ($f_{clk\_I/O}/8$)



WGMm: Clear Timer on Compare (CTC) modes of operation

Table 17-2. Waveform Generation Mode Bit Description[(1)]

Mode	WGMn3	WGMn2 (CTCn)	WGMn1 (PWMn1)	WGMn0 (PWMn0)	Timer/Counter Mode of Operation	TOP	Update of OCRnx at	TOVn Flag Set on
0	0	0	0	0	Normal	0xFFFF	Immediate	MAX
1	0	0	0	1	PWM, Phase Correct, 8-bit	0x00FF	TOP	BOTTOM
2	0	0	1	0	PWM, Phase Correct, 9-bit	0x01FF	TOP	BOTTOM
3	0	0	1	1	PWM, Phase Correct, 10-bit	0x03FF	TOP	BOTTOM
4	0	1	0	0	CTC	OCRnA	Immediate	MAX
5	0	1	0	1	Fast PWM, 8-bit	0x00FF	BOTTOM	TOP
6	0	1	1	0	Fast PWM, 9-bit	0x01FF	BOTTOM	TOP
7	0	1	1	1	Fast PWM, 10-bit	0x03FF	BOTTOM	TOP
8	1	0	0	0	PWM, Phase and Frequency Correct	ICRn	BOTTOM	BOTTOM
9	1	0	0	1	PWM,Phase and Frequency Correct	OCRnA	BOTTOM	BOTTOM
10	1	0	1	0	PWM, Phase Correct	ICRn	TOP	BOTTOM
11	1	0	1	1	PWM, Phase Correct	OCRnA	TOP	BOTTOM
12	1	1	0	0	CTC	ICRn	Immediate	MAX
13	1	1	0	1	(Reserved)	–	–	–
14	1	1	1	0	Fast PWM	ICRn	BOTTOM	TOP
15	1	1	1	1	Fast PWM	OCRnA	BOTTOM	TOP

```
void setup() {
    Serial.begin(115200);
    pinMode(13, OUTPUT);
    noInterrupts();

    //TCCRnA/B/C Timer/Counter
      Control Register
    TCCR1A = 0;
    TCCR1B = 0;

    //TCNTn Timer/Counter
    TCNT1 = 0;
```

TCCR1B

```
//WGMn3:0 Waveform Generation mode
TCCR1B |= (1 << WGM12);

//CS10:2 -> 1024 prescaler

TCCR1B |= (1 << CS12) | (1 << CS10);
```

```
OCRnx érték =
       [ 16 000 000Hz / (prescaler * kívánt_frekvencia) ] - 1
       (-1: 0-tól számol)

//OCRnA/B/C Output Compare Register
OCR1A = 15624;       // = 16 000 000 / (1*1024) - 1
                     // OCRnx < 65536 16bites regiszter esetén
```

DATASHEET:

//The 16-bit comparator continuously compares TCNTn with the Output Compare Register (OCRnx). If TCNT equals OCRnx the comparator signals a match. A match will set the Output Compare Flag (OCFnx) at the next timer clock cycle. If enabled (OCIEnx = 1), the Output Compare Flag generates an Output Compare interrupt. The OCFnx Flag is automatically cleared when the interrupt is executed.

Megszakítás engedélyezése, globális megszakítások engedélyezése

```
// enable timer compare interrupt
TIMSK1 |= (1 << OCIE1A);
(OCIEnx: Output Compare Interrupt Enable 1A)

interrupts();

} //setup ends
```

Megszakítás kiszolgálása (loop() után)

```
ISR(TIMER1_COMPA_vect){
//Ha TCNT1 (Timer/Counter1) eléri
OCR1A értéket


digitalWrite(13,1-digitalRead(13));
//digitalWrite() digitalRead() ☹
}
```

loop (~main)

```
void loop() {
// put your main code here, to run repeatedly:
delay(1000);
myFun();
}

void myFun(void){
Serial.print(".");
}
```