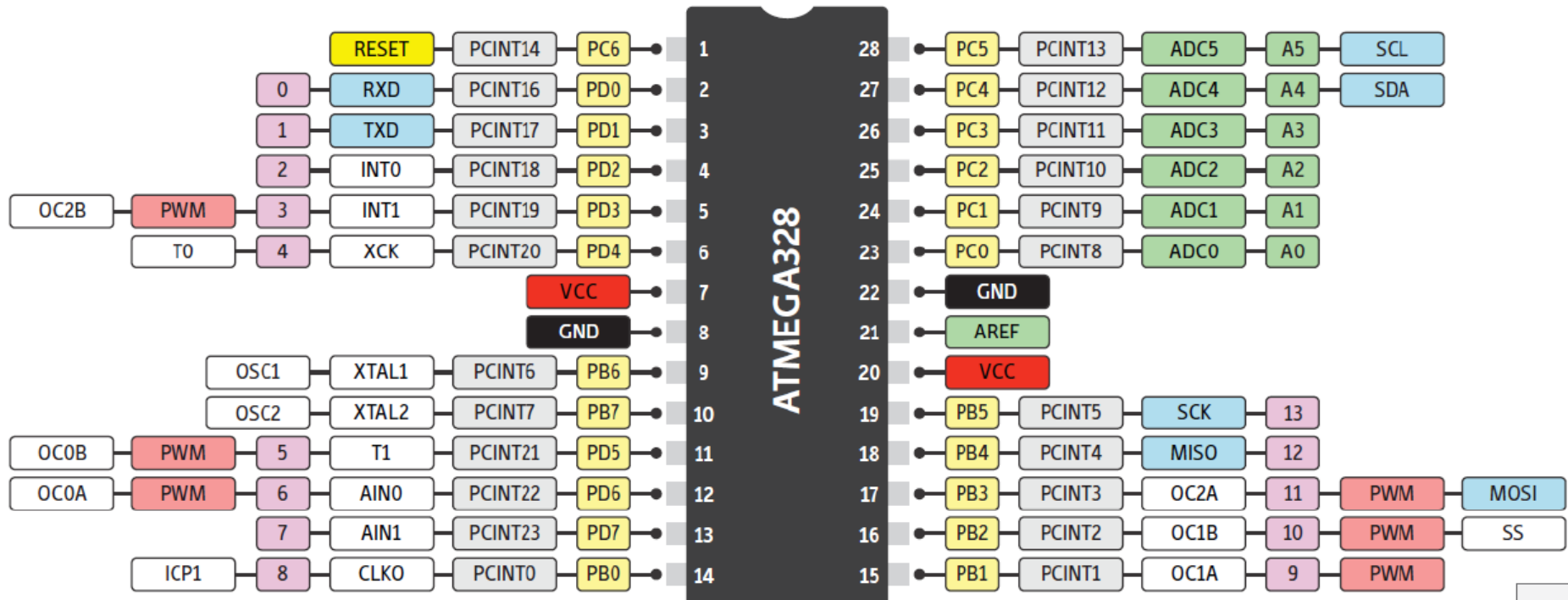


PRIMENA MIKROKONTROLERA

PWM signali

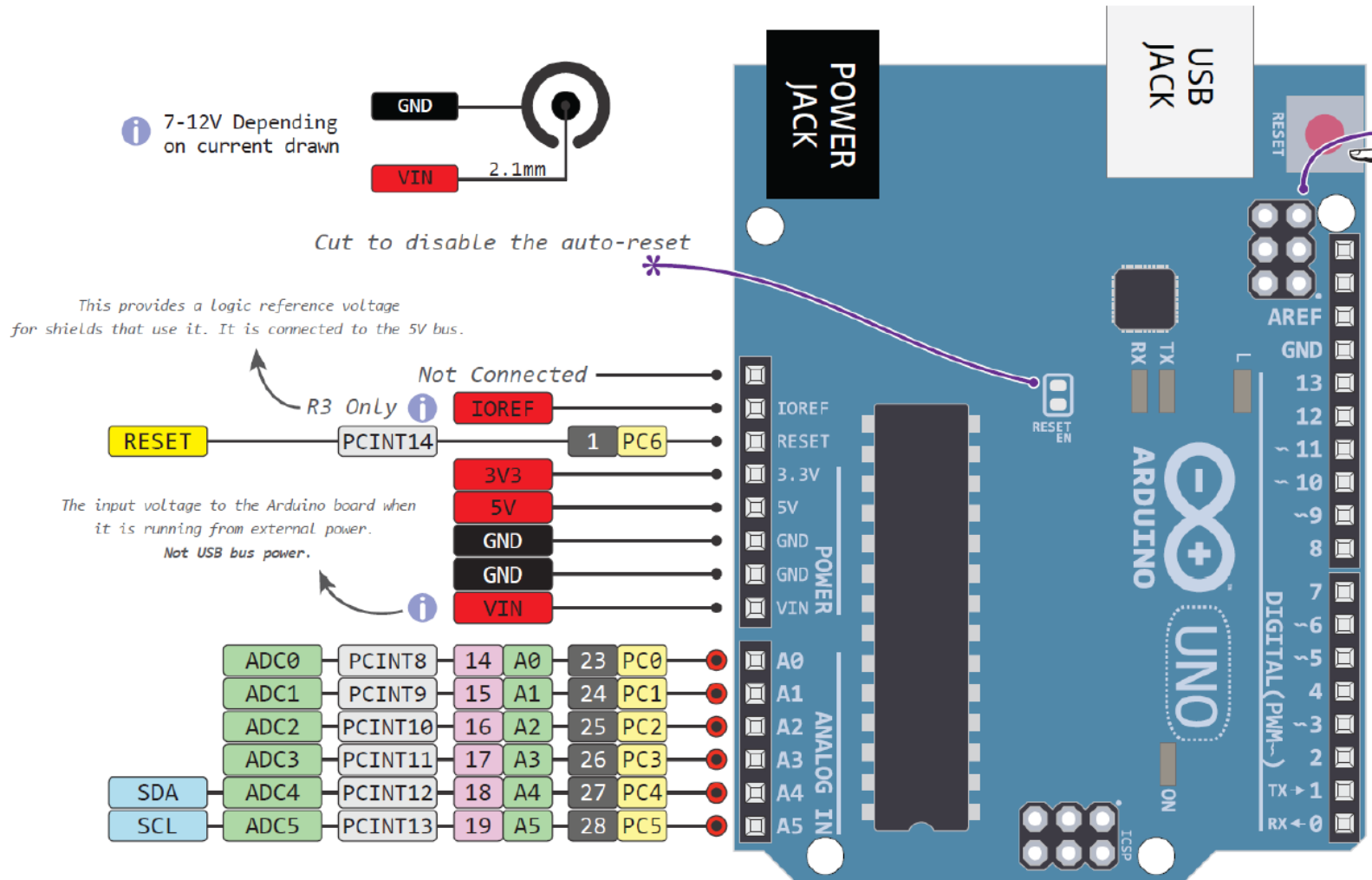
prof. dr Zoran Milivojević
dr Nataša Nešić

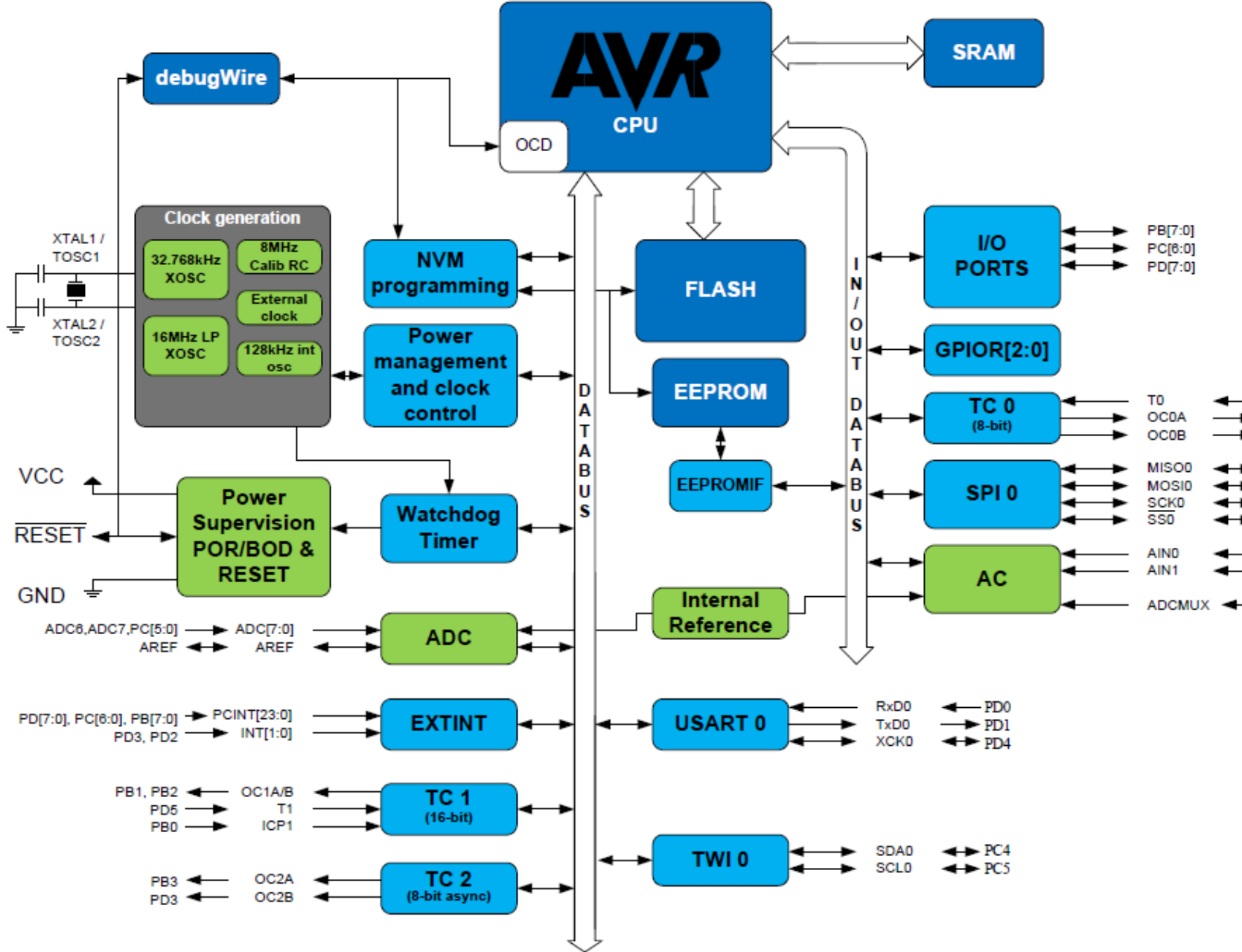
Mikrokontroler ATmega328P



Slika 1. PINOUT dijagram mikrokontrolera ATmega328P.

Arduino UNO





Generisanje PWM signala

- Generisanje PWM pomoću TC0
- Upravljanje pomoću registra TCCR0A, TCCR0B, OCRA i OCRB
- Generisani PWM signali su na pinu PD5 i PD6 mikrokontrolera ATmega328
- Odgovarajući pinovi na mikrokontrolerskom sistemu Arduino UNO su pin5 i pin6.

TC0

- Veza TC0 sa spoljnim okruženjem je preko pinova
 - PD4 (ulazni pin za impulse koji se vode u brojač)
 - PD5, PD6 (izlazni pinovi, PWM signali)

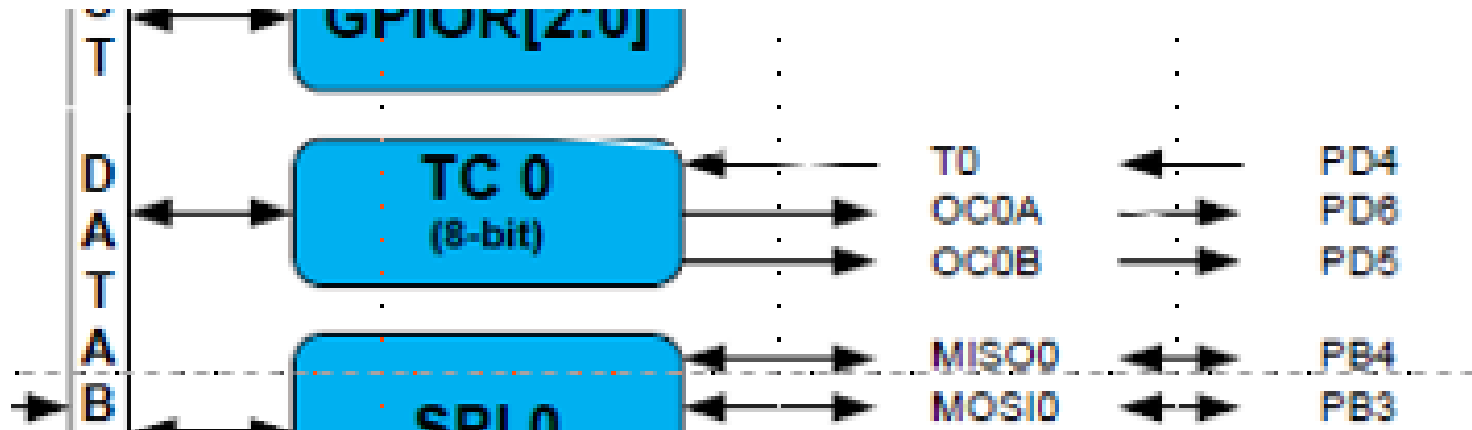
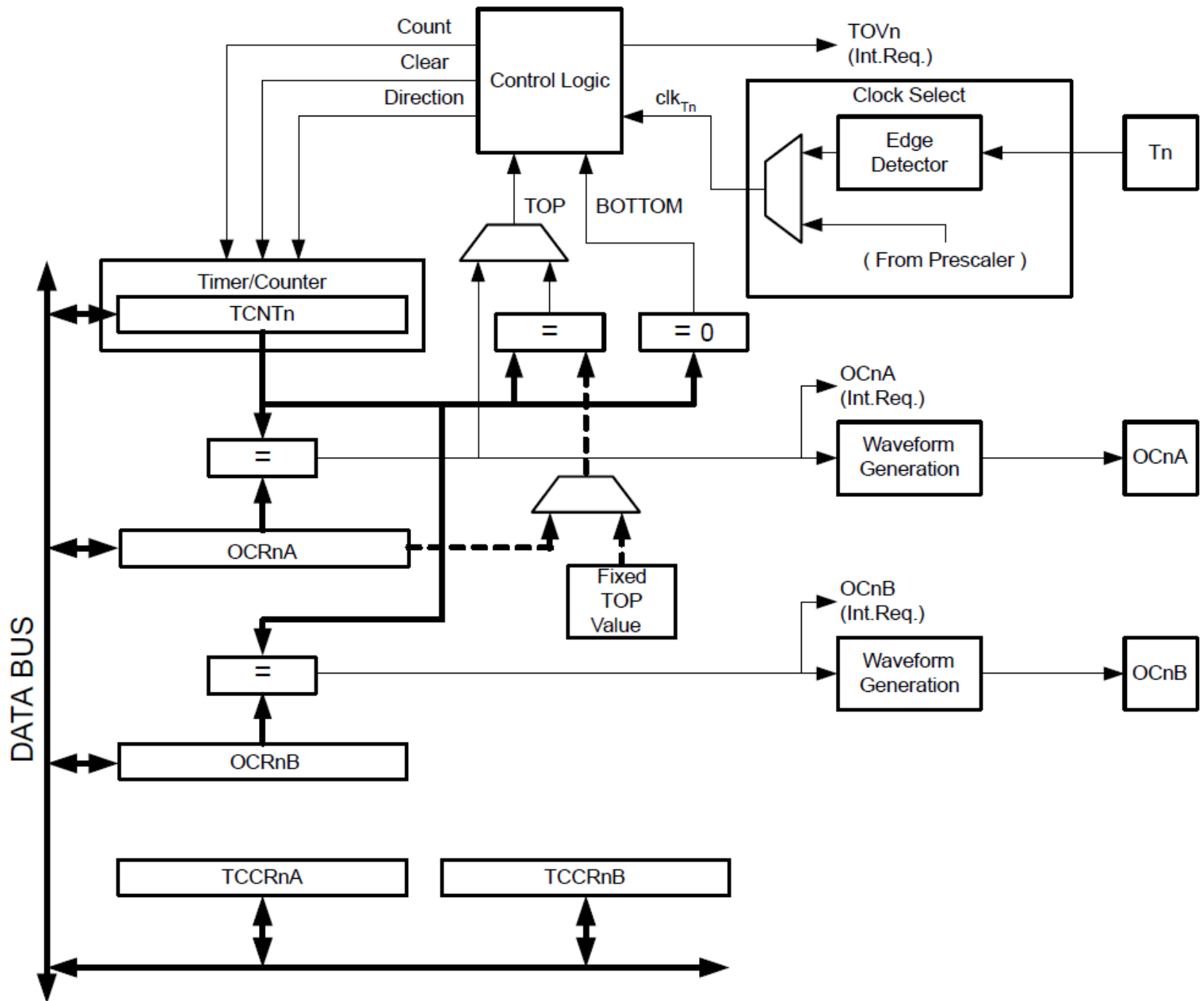


Figure 19-1. 8-bit Timer/Counter Block Diagram



TCCR0A

Name: TCCR0A

Offset: 0x44

Reset: 0x00

Property: When addressing as I/O Register: address offset is 0x24

Bit	7	6	5	4	3	2	1	0
	COM0A1	COM0A0	COM0B1	COM0B0			WGM01	WGM00
Access	R/W	R/W	R/W	R/W			R/W	R/W
Reset	0	0	0	0			0	0

Table 19-3. Compare Output Mode, non-PWM

COM0A1	COM0A0	Description
0	0	Normal port operation, OC0A disconnected.
0	1	Toggle OC0A on Compare Match.
1	0	Clear OC0A on Compare Match.
1	1	Set OC0A on Compare Match .

TCCR0A

Table 19-4. Compare Output Mode, Fast PWM⁽¹⁾

COM0A1	COM0A0	Description
0	0	Normal port operation, OC0A disconnected.
0	1	WGM02 = 0: Normal Port Operation, OC0A Disconnected WGM02 = 1: Toggle OC0A on Compare Match
1	0	Clear OC0A on Compare Match, set OC0A at BOTTOM (non-inverting mode)
1	1	Set OC0A on Compare Match, clear OC0A at BOTTOM (inverting mode)

Table 19-6. Compare Output Mode, non-PWM

COM0B1	COM0B0	Description
0	0	Normal port operation, OC0B disconnected.
0	1	Toggle OC0B on Compare Match.
1	0	Clear OC0B on Compare Match.
1	1	Set OC0B on Compare Match.

TCCR0A

Table 19-9. Waveform Generation Mode Bit Description

Mode	WGM02	WGM01	WGM00	Timer/Counter Mode of Operation	TOP	Update of OCR0x at
0	0	0	0	Normal	0xFF	Immediate
1	0	0	1	PWM, Phase Correct	0xFF	TOP
2	0	1	0	CTC	OCRA	Immediate
3	0	1	1	Fast PWM	0xFF	BOTTOM
4	1	0	0	Reserved	-	-
5	1	0	1	PWM, Phase Correct	OCRA	TOP
6	1	1	0	Reserved	-	-
7	1	1	1	Fast PWM	OCRA	BOTTOM

TCCR0B

Name: TCCR0B

Offset: 0x45

Reset: 0x00

Property: When addressing as I/O Register: address offset is 0x25

Bit	7	6	5	4	3	2	1	0
	FOC0A	FOC0B			WGM02	CS0[2:0]		
Access	R/W	R/W			R/W	R/W	R/W	R/W
Reset	0	0			0	0	0	0

Table 19-10. Clock Select Bit Description

CA02	CA01	CS00	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	0	clk _{I/O} /256 (From prescaler)
1	0	1	clk _{I/O} /1024 (From prescaler)
1	1	0	External clock source on T0 pin. Clock on falling edge.
1	1	1	External clock source on T0 pin. Clock on rising edge.

Proracun

- Frekvencija oscilatora je $f_{osc} = 16 \text{ MHz}$
- Perioda je $T_{osc} = 1/f_{osc} = 0.0625 \mu\text{s}$
- Frekvencija signala za brojanje, nakon deljenja u preskaleru
- $f_{clk} = f_{osc}/N_{presk}$
- Perioda signala za brojanje
- $T_{clk} = 1/f_{clk}$
- Perioda PWM signala
- $T_{pwm} = 256 * T_{clk}$
- Frekvencija PWM signala
- $f_{pwm} = 1/T_{pwm}$

Proracun

- Sadržaj registra za komparaciju
- **$N_OCR0A = \text{fix}(255/100 * k_oc0a)$**
- **$N_OCR0B = \text{fix}(255/100 * k_oc0b)$**

- Trajanje impulse na OC0A
- **$T_oca = N_OCR0A * T_clk$**

- Trajanje impulse na OC0B
- **$T_ocb = N_OCR0B * T_clk$**

Zadatak

- Generisati PWM signal pomocu brojaca TC0 sa faktorima ispunje
 - $k_{oc0a}=30\%$ (signal na OC0A) i
 - $k_{oc0b}=65\%$ (signal na OC0B)
- deljenje preskalerom
 - $N_{presk} = 1, 8, 64, 256, 1024.$
- Odrediti period i frekvenciju PWM signala
- Odrediti trajanje impulse za definisane faktore ispunje

Program

```
void setup ()
{
  pinMode (5, OUTPUT);
  pinMode (6, OUTPUT);
  TCCR0A=0;           //resetovanje registra TCCR0A
  TCCR0B=0;           //resetovanje registra TCCR0B
  TCCR0A=0b10100011; // fast pwm mode
  TCCR0B=0b00000001; // prescaler 1
  OCR0A=76;           //sirina impulsa na pinu 6
  OCR0B=165;          // sirina impulsa na pinu 5
}

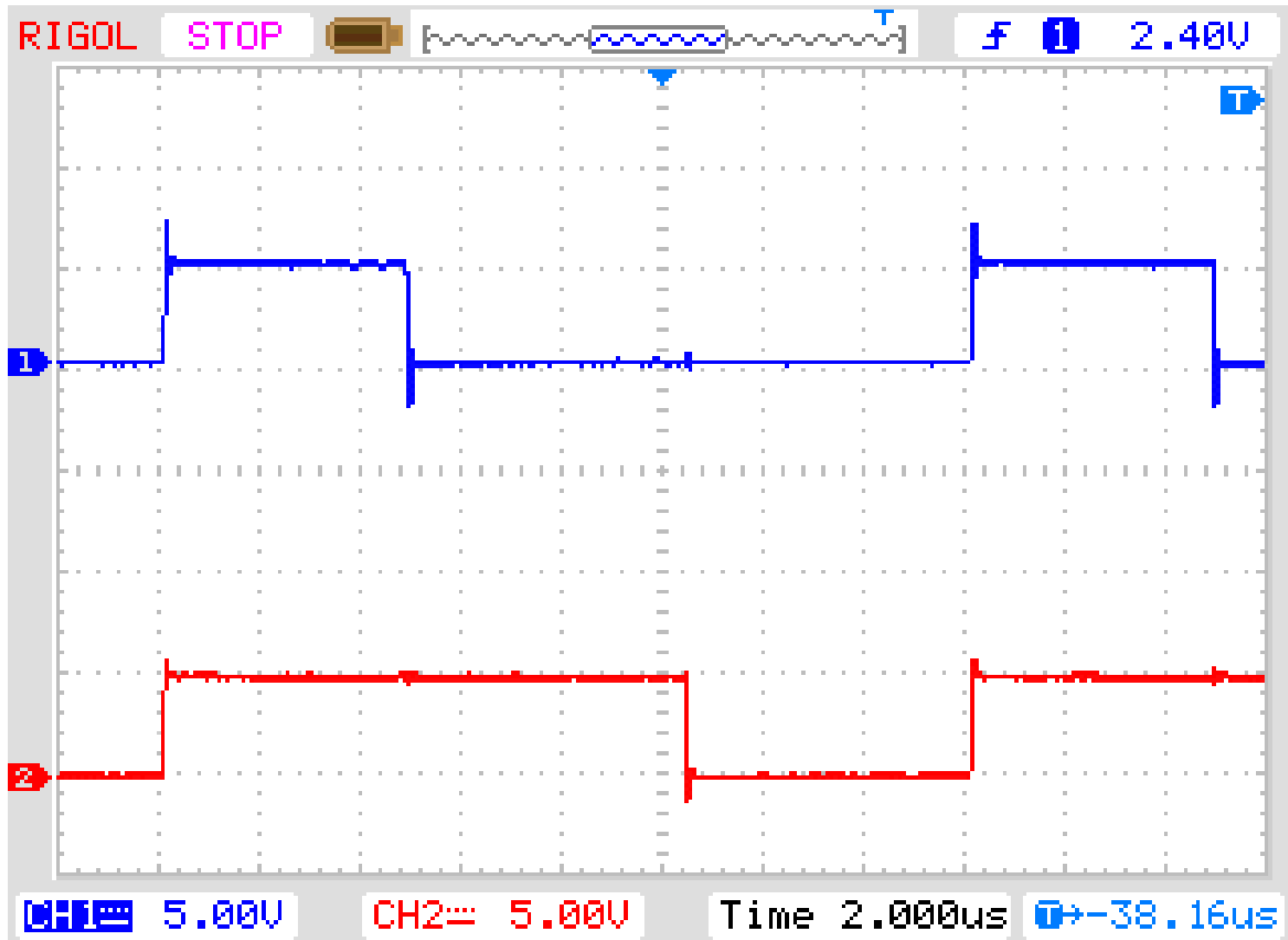
void loop ()
{
  //
}
```

Primer $N_presk = 1$

- $k_oc0a=30\%$ (signal na OC0A) i
- $k_oc0b=65\%$ (signal na OC0B)

- $f_osc = 16000000$ Hz, $T_osc = 0.06250$ μ s
- $f_clk = 16000000$ Hz, $T_clk = 0.0625$ μ s
- $T_pwm = 16$ μ s, $f_pwm = 62500$ Hz
- $N_OCR0A = 76$, $N_OCR0B = 165$
- $T_oca = 4.75$ μ s, $T_ocb = 10.31$ μ s

Primer N_presk = 1

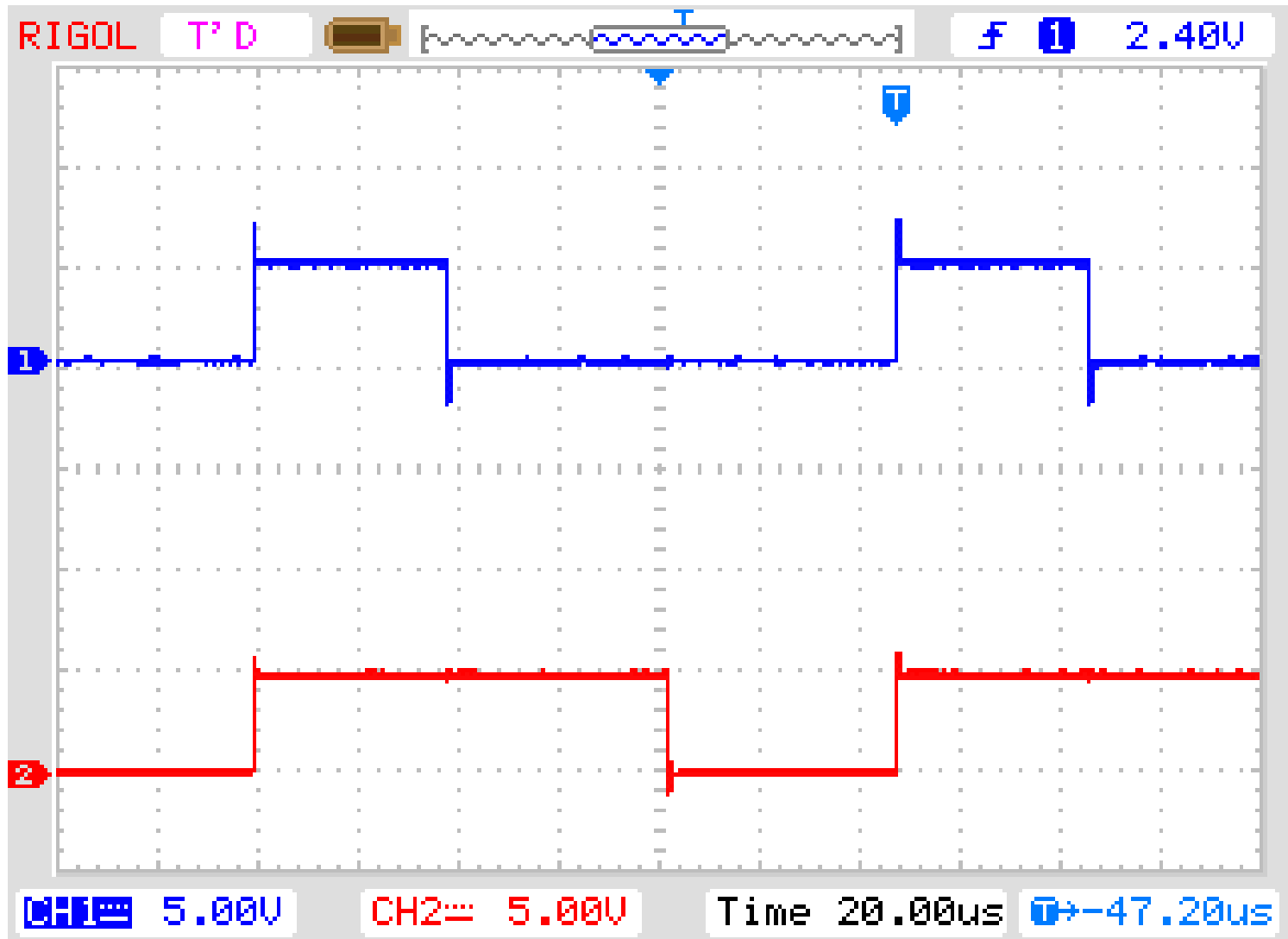


Primer $N_{presk} = 8$

- $k_{oc0a} = 30\%$ (signal na OC0A) i
- $k_{oc0b} = 65\%$ (signal na OC0B)

- $f_{osc} = 16000000$ Hz, $T_{osc} = 0.06250$ μ s
- $f_{clk} = 2000000$ Hz, $T_{clk} = 0.5$ μ s
- $T_{pwm} = 128$ μ s, $f_{pwm} = 7.8125$ kHz
- $N_{OCR0A} = 76$, $N_{OCR0B} = 165$
- $T_{oca} = 30.4$ μ s, $T_{ocb} = 66$ μ s

Primer N_presk = 8

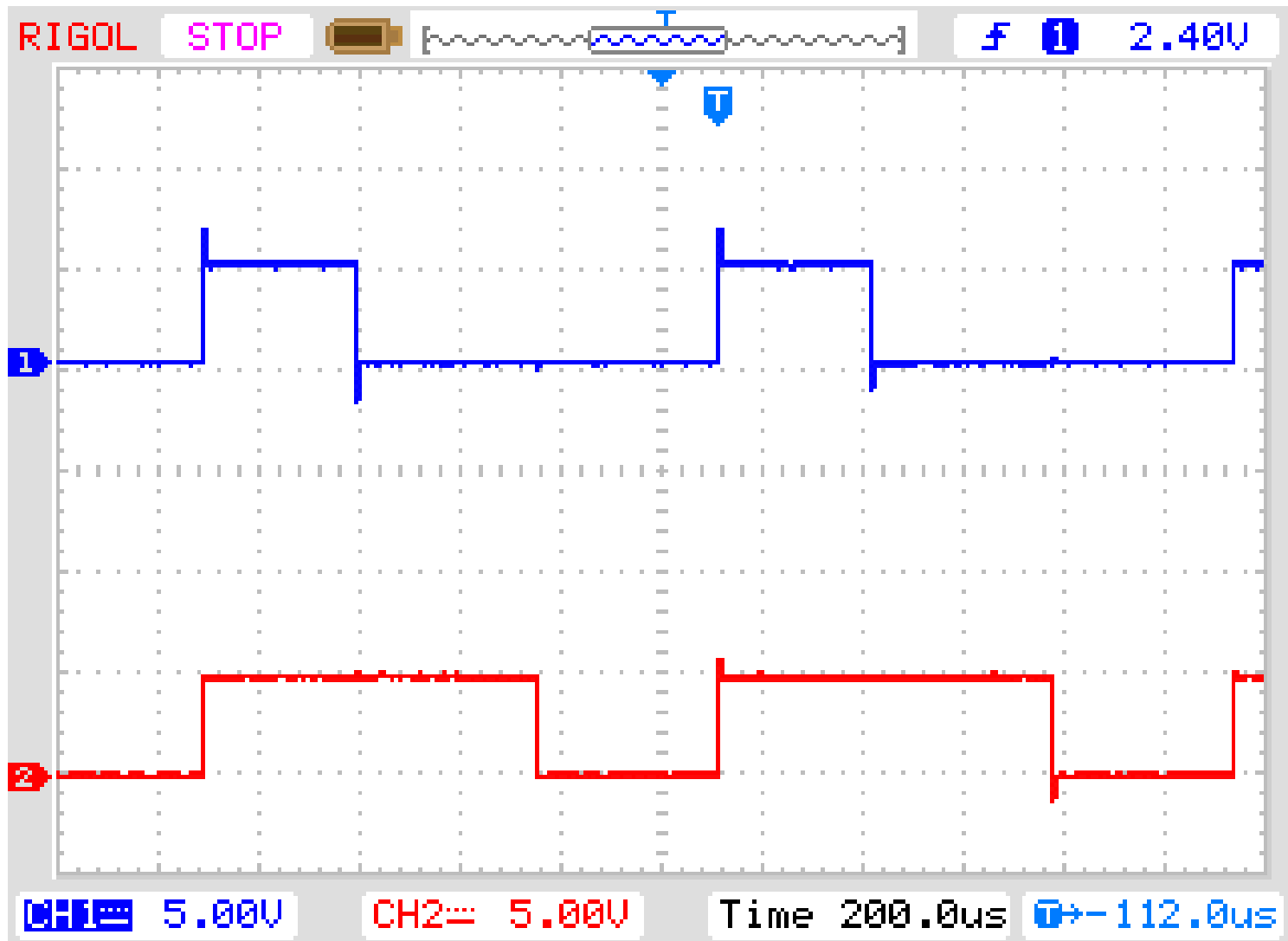


Primer $N_{presk} = 64$

- $k_{oc0a} = 30\%$ (signal na OC0A) i
- $k_{oc0b} = 65\%$ (signal na OC0B)

- $f_{osc} = 16000000$ Hz, $T_{osc} = 0.06250$ μ s
- $f_{clk} = 250000$ Hz, $T_{clk} = 4$ μ s
- $T_{pwm} = 1$ ms, $f_{pwm} = 976.5625$ Hz
- $N_{OCR0A} = 76$, $N_{OCR0B} = 165$
- $T_{oca} = 0.3$ ms, $T_{ocb} = 0.66$ ms

Primer $N_{presk} = 64$

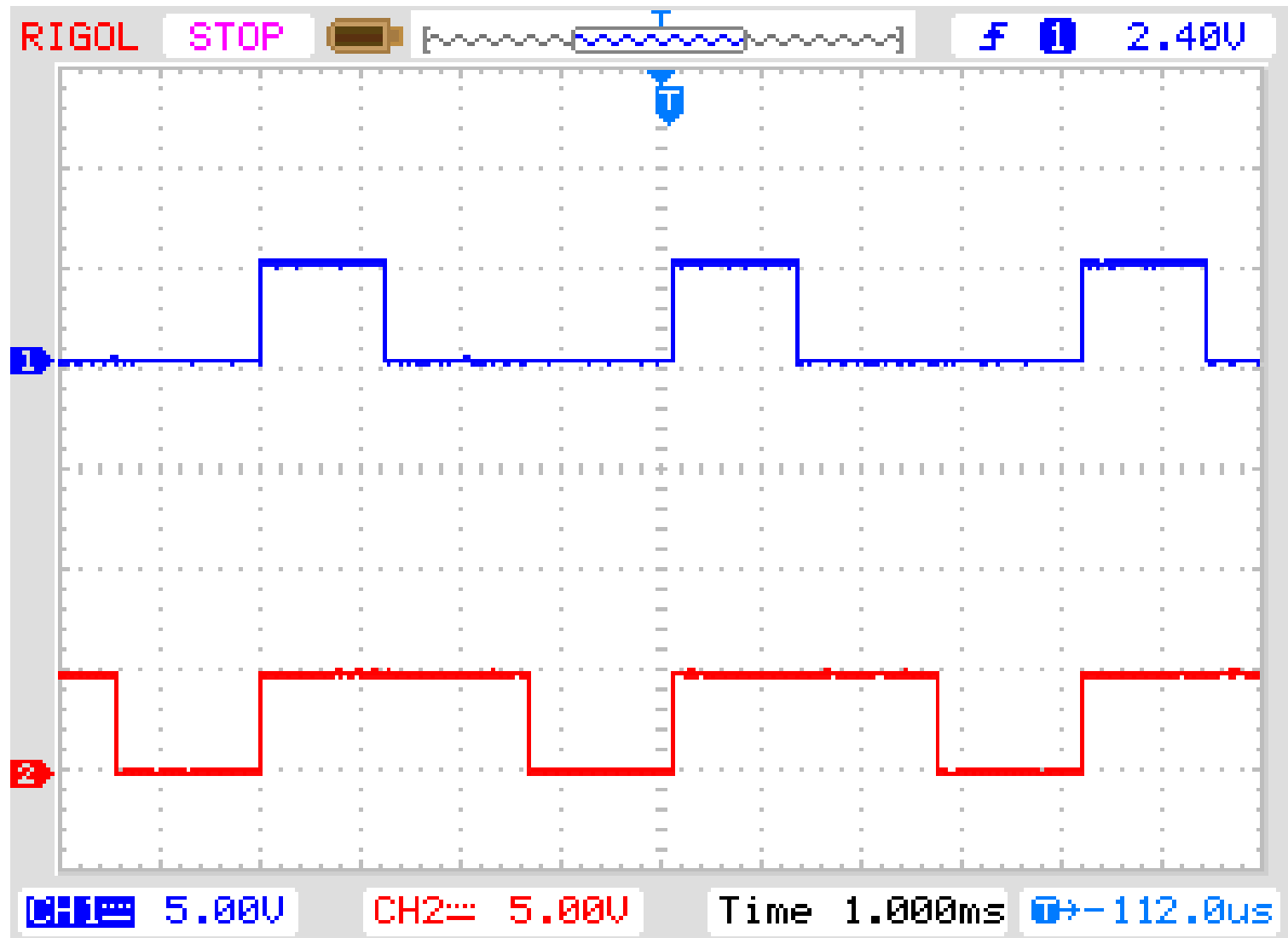


Primer $N_{presk} = 256$

- $k_{oc0a} = 30\%$ (signal na OC0A) i
- $k_{oc0b} = 65\%$ (signal na OC0B)
- $N_{presk} = 1$

- $f_{osc} = 16000000$ Hz, $T_{osc} = 0.06250$ μ s
- $f_{clk} = 62500$ Hz, $T_{clk} = 16$ μ s
- $T_{pwm} = 4.1$ ms, $f_{pwm} = 244.14$ Hz
- $N_{OCR0A} = 76$, $N_{OCR0B} = 165$
- $T_{oca} = 1.2$ ms, $T_{ocb} = 2.6$ ms

Primer $N_presk = 256$

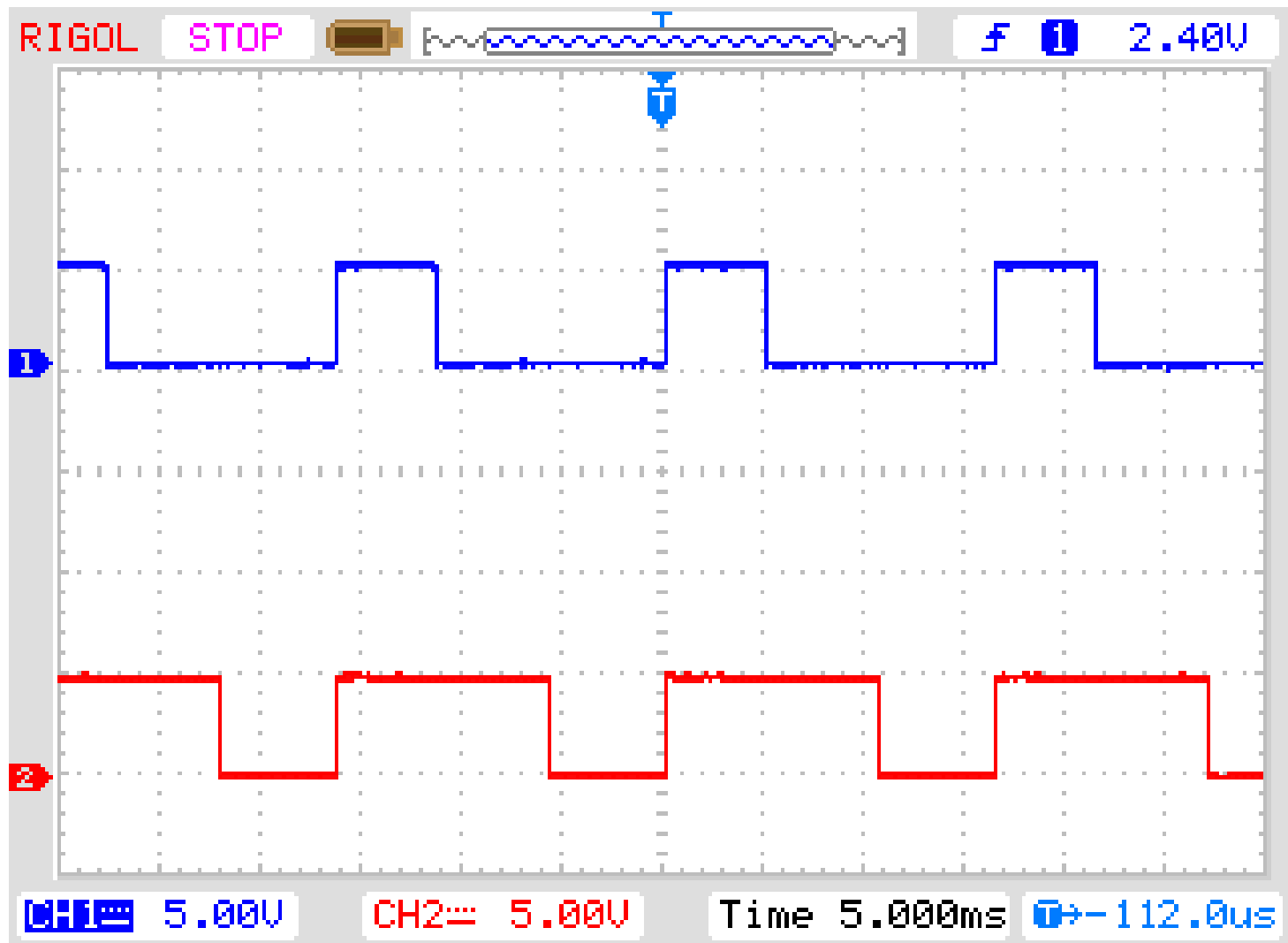


Primer $N_{presk} = 1024$

- $k_{oc0a} = 30\%$ (signal na OC0A) i
- $k_{oc0b} = 65\%$ (signal na OC0B)

- $f_{osc} = 16000000$ Hz, $T_{osc} = 0.06250$ μ s
- $f_{clk} = 15625$ Hz, $T_{clk} = 64$ μ s
- $T_{pwm} = 16.4$ ms, $f_{pwm} = 61.03$ Hz
- $N_{OCR0A} = 76$, $N_{OCR0B} = 165$
- $T_{oca} = 4.9$ ms, $T_{ocb} = 10.6$ ms

Primer $N_{presk} = 1024$



• **HVALA NA PAŽNJI**