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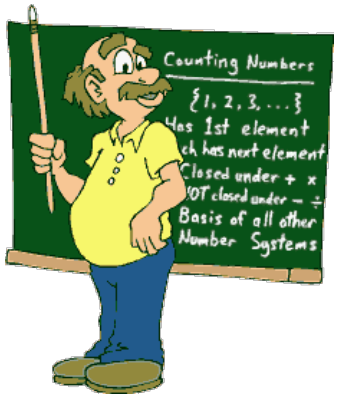
MSYS

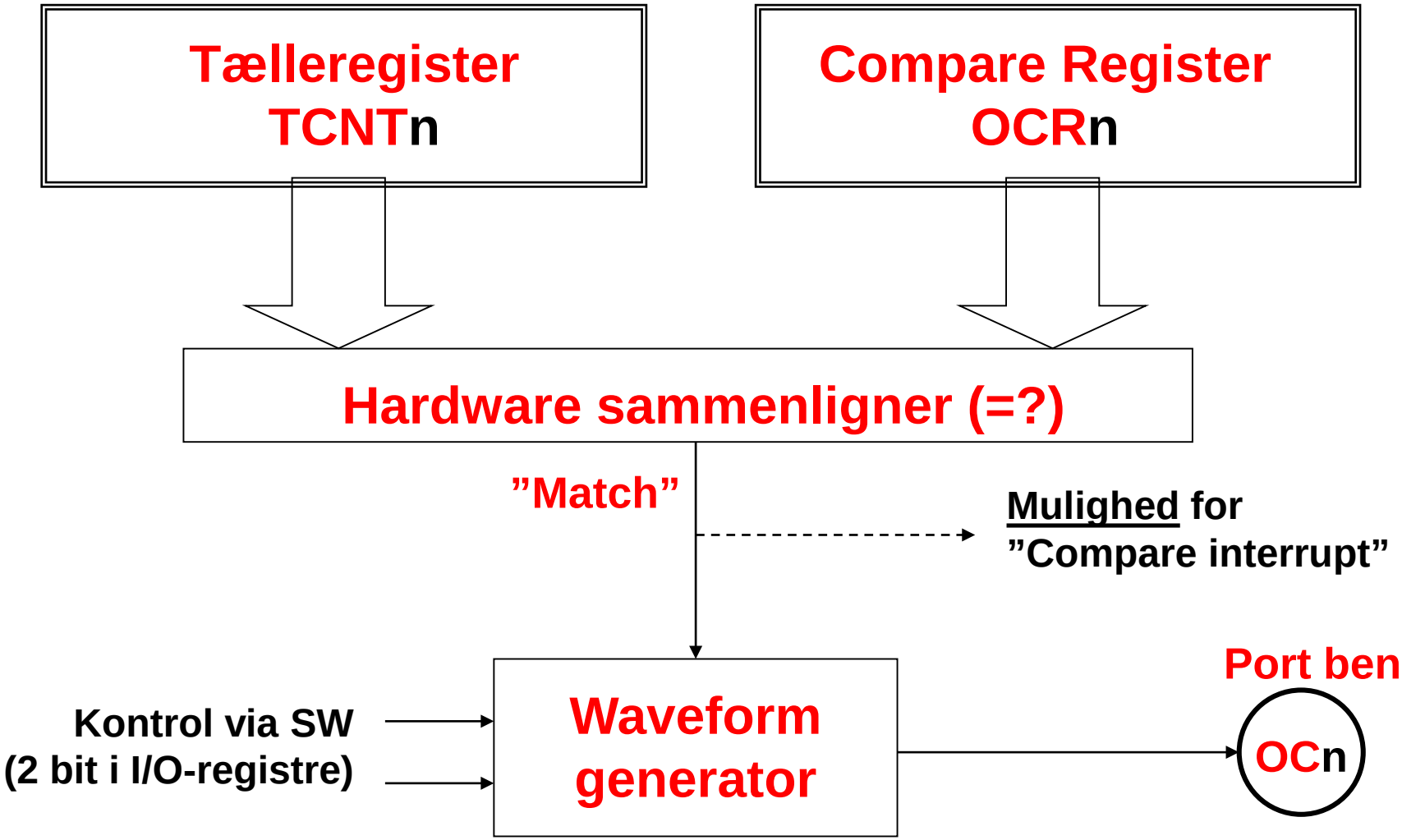
Microcontroller Systems

Lektion 14: Timers i CTC mode



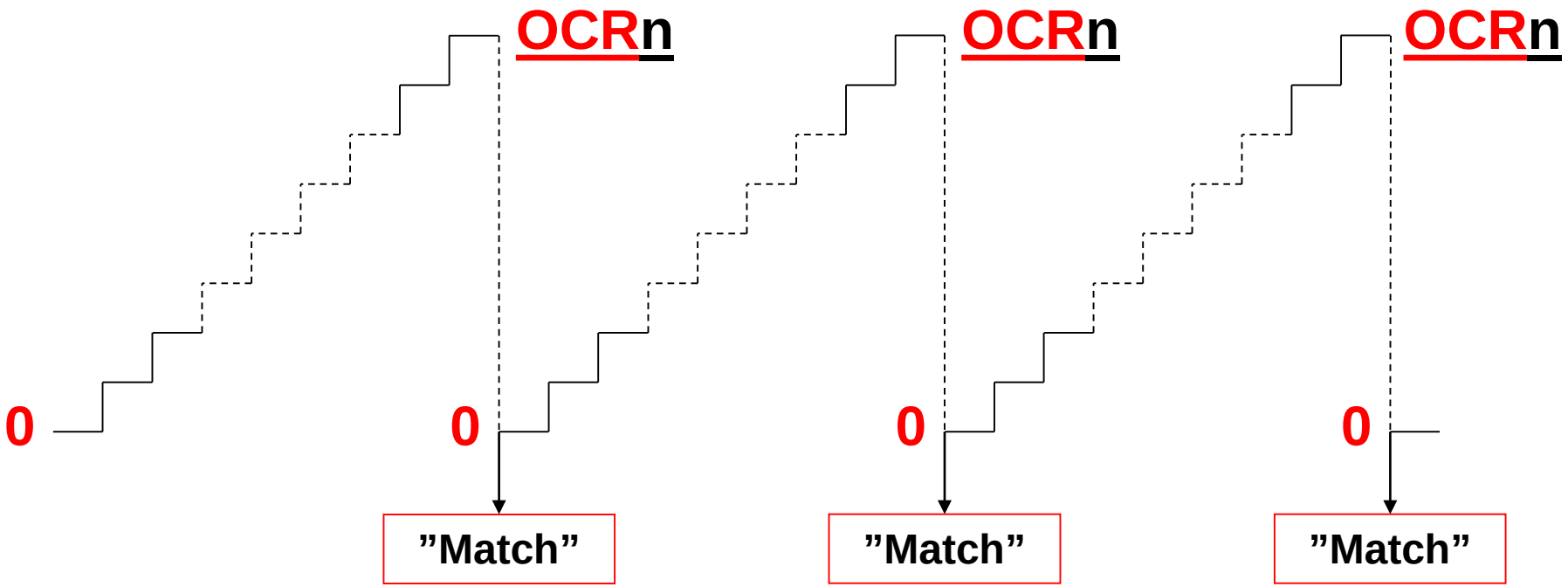
Version: 22-10-2017, Henning Hargaard

Output Compare Unit



Kan sættes til automatisk at toggle port benet ved match!

Timer i ”CTC mode”



Ben frekvens = f_{cpu} / (2 * N * (1 + OCRn))

N er timerens prescaler-værdi

Mega32: 3 timere

- **Timer 0 :**
  8 bit (MAX = 255).
  Normal, **CTC** og PWM modes.

- **Timer 1 :**
  16 bit (MAX = 65535).
  Normal, **CTC**, mange PWM modes.
  (Mulighed for ”Input Capture”)

- **Timer 2 :**
  8 bit (MAX = 255).
  Normal, **CTC** og PWM modes.
  Asynkron mode (Real Time Clock).

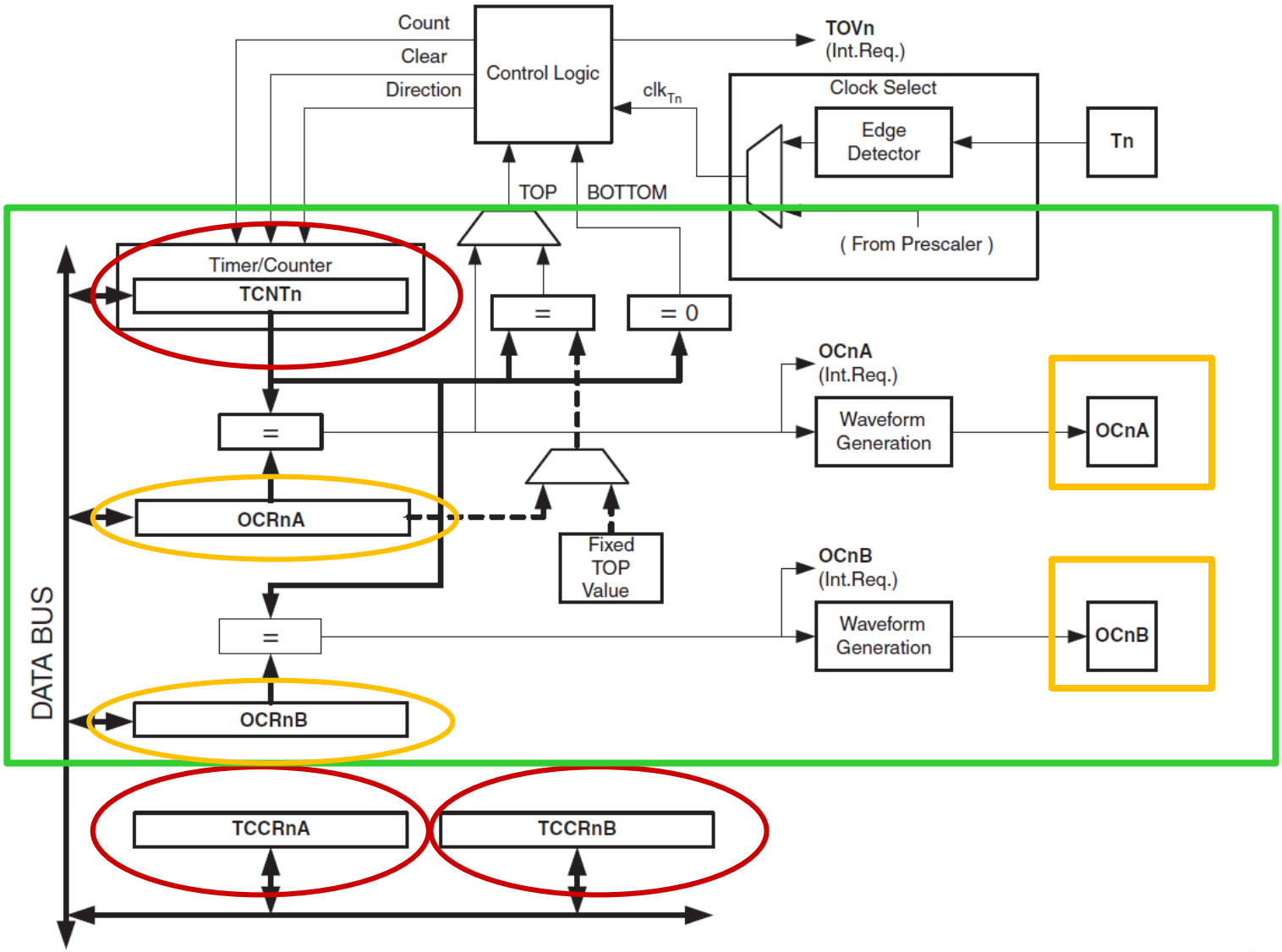
Mega2560: 6 timere

- **Timer 0 :**
  8 bit (MAX = 255).
  Normal, **CTC** og PWM modes.

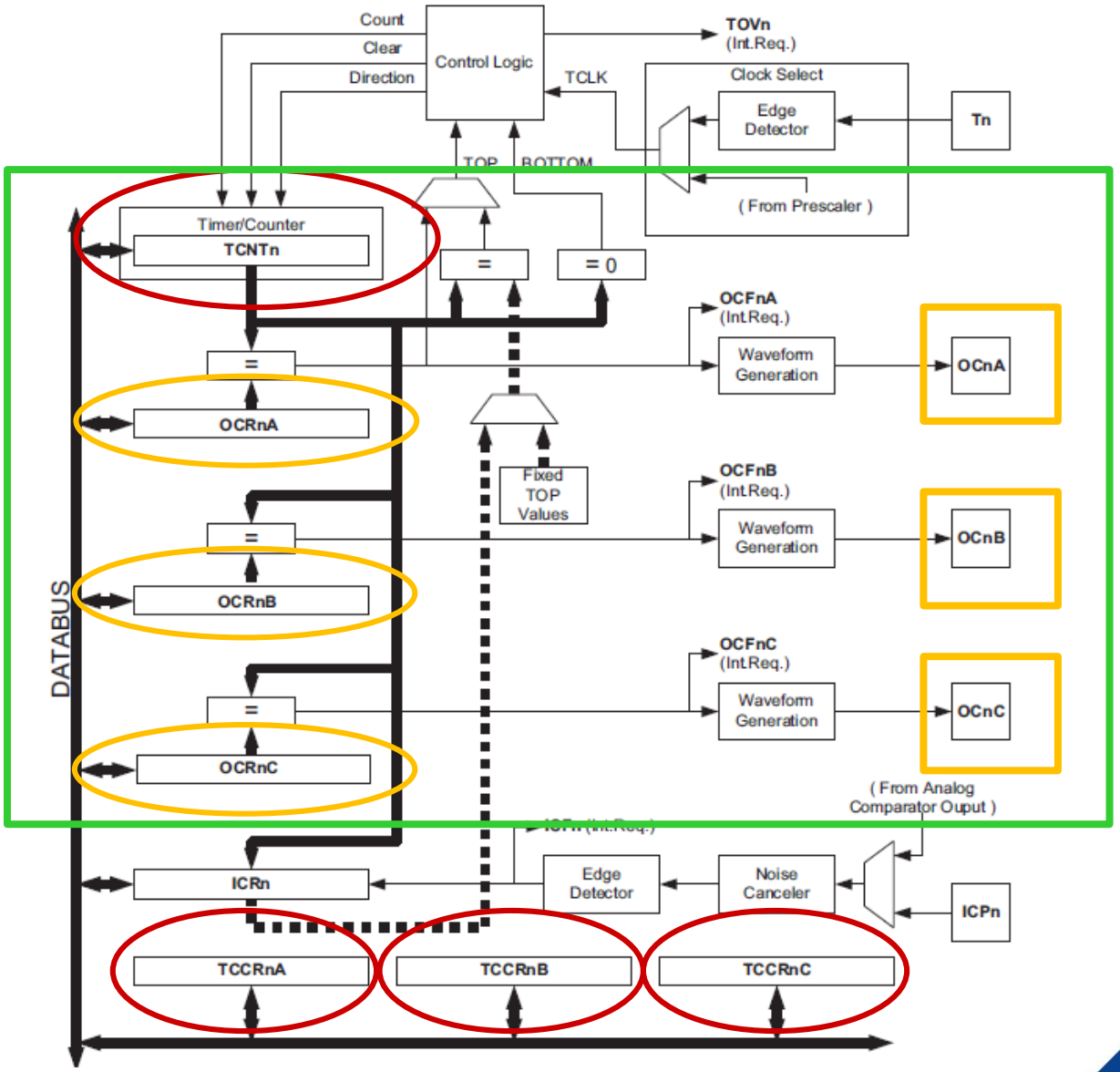
- **Timer 1, Timer 3, Timer 4 og Timer 5 :**
  16 bit (MAX = 65535).
  Normal, **CTC**, mange PWM modes.
  (Mulighed for ”Input Capture”)

- **Timer 2 :**
  8 bit (MAX = 255).
  Normal, **CTC** og PWM modes.
  Asynkron mode (Real Time Clock).

Mega2560: Timer 0 (8 bit)



Mega2560: Timer 1,3,4,5 (16 bit)



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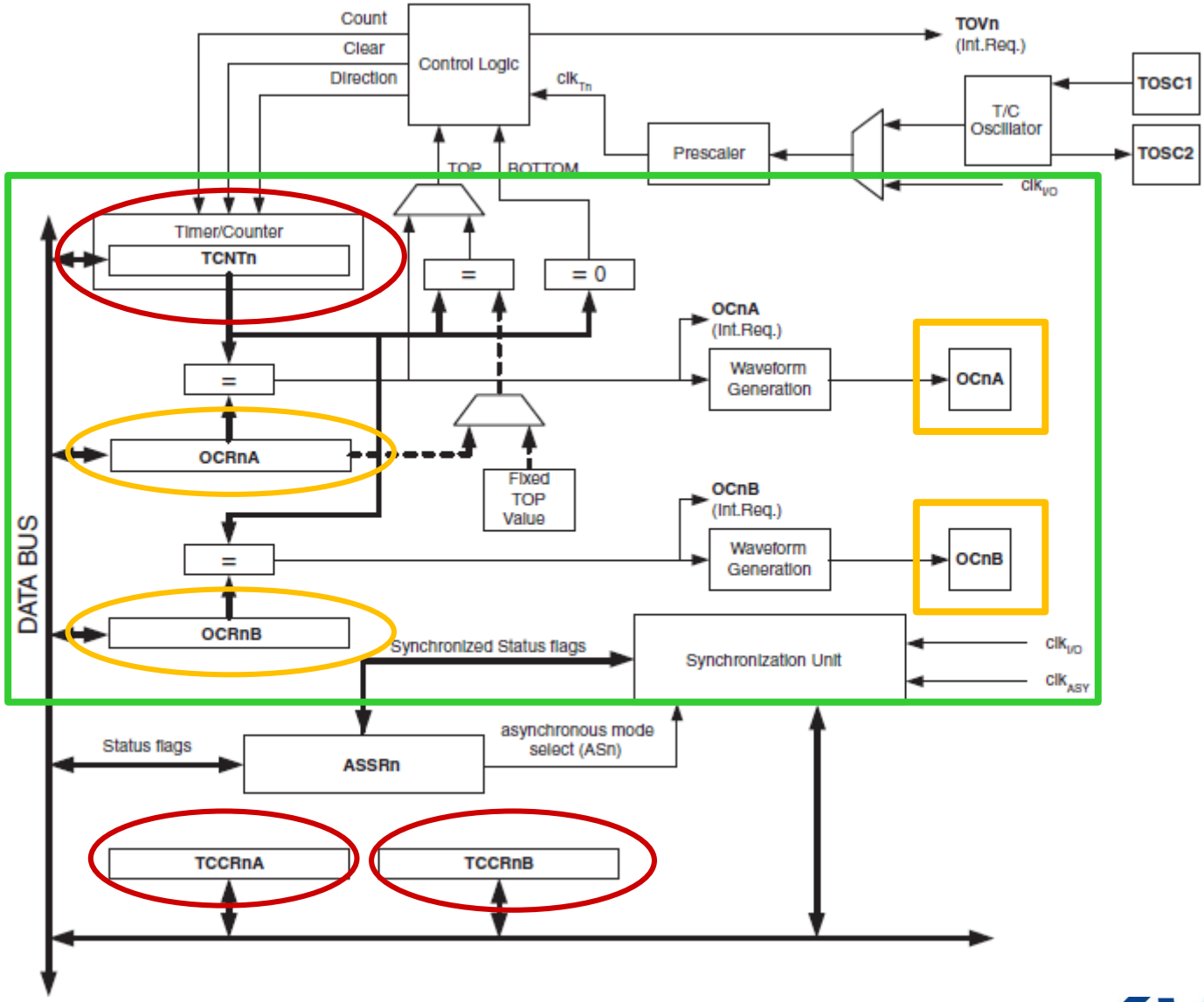
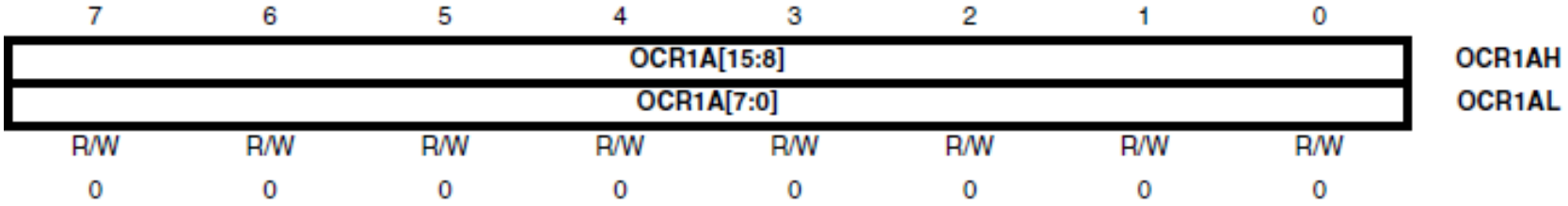
Mega2560: Timer 2 (8 bit)



Output Compare Registre (16 bit)



AVR GCC C:

```
#include <avr/io.h>

// Herefter er 16-bit adgang muligt:
OCR1A = 12345;
```

Valg af CTC Mode

- CTC mode vælges normalt under opstart (initiering).

- Hvilke registre, der skal skrives til, afhænger af, om vi bruger Mega32 eller Mega2560.
  Desuden afhænger det af, hvilken timer, der drejer sig om.

Mega2560: Timer 0. CTC mode.

7	6	5	4	3	2	1	0	
COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00	TCCR0A
R/W	R/W	R/W	R/W	R	R	R/W	R/W	
0	0	0	0	0	0	0	0	

7	6	5	4	3	2	1	0	
FOC0A	FOC0B	–	–	WGM02	CS02	CS01	CS00	TCCR0B
W	W	R	R	R/W	R/W	R/W	R/W	
0	0	0	0	0	0	0	0	

Mode	WGM2	WGM1	WGM0	Timer/Counter Mode of Operation	TOP	Update of OCRx at	TOV Flag Set on[1][2]
0	0	0	0	Normal	0xFF	Immediate	MAX
1	0	0	1	PWM, Phase Correct	0xFF	TOP	BOTTOM
2	0	1	0	CTC	OCRA	Immediate	MAX
3	0	1	1	Fast PWM	0xFF	TOP	MAX

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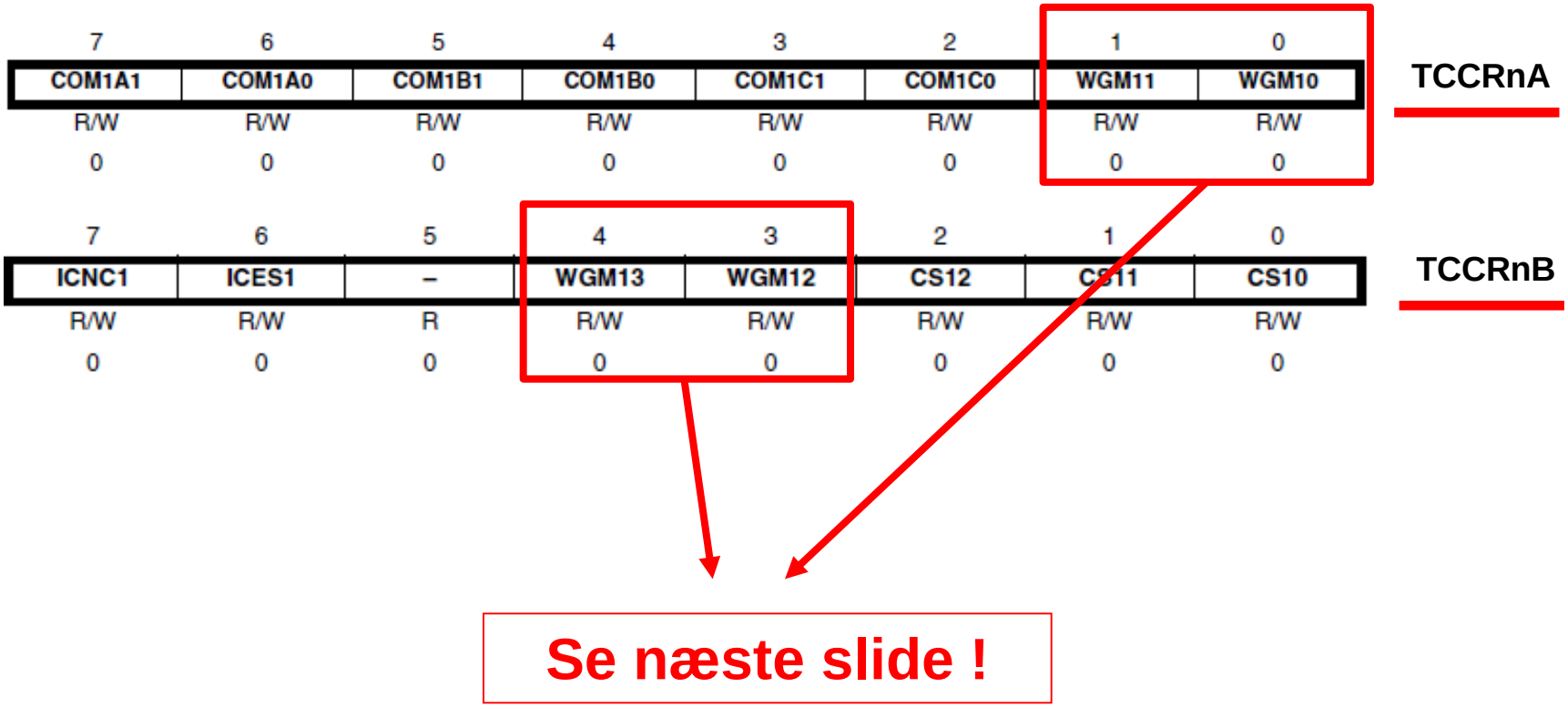
Mega2560: Timer 1,3,4,5. CTC mode.



- **TCCR**nA = TCCR1A, TCCR3A, TCCR4A eller TCCR5A.
- **TCCR**nB = TCCR1B, TCCR3B, TCCR4B eller TCCR5B.

Mega2560: Timer 1,3,4,5. CTC mode.

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

OBS: I denne mode styres TOP (og dermed frekvensen) af 16 bit registeret ICR1 !

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Mega2560: Timer 2. CTC mode.

7	6	5	4	3	2	1	0	
COM2A1	COM2A0	COM2B1	COM2B0	–	–	WGM21	WGM20	TCCR2A
R/W	R/W	R/W	R/W	R	R	R/W	R/W	
0	0	0	0	0	0	0	0	

7	6	5	4	3	2	1	0	
FOC2A	FOC2B	–	–	WGM22	CS22	CS21	CS20	TCCR2B
W	W	R	R	R/W	R/W	R/W	R/W	
0	0	0	0	0	0	0	0	

Mode	WGM2	WGM1	WGM0	Timer/Counter Mode of Operation	TOP	Update of OCRx at	TOV Flag Set on(1)(2)
0	0	0	0	Normal	0xFF	Immediate	MAX
1	0	0	1	PWM, Phase Correct	0xFF	TOP	BOTTOM
2	0	1	0	CTC	OCRA	Immediate	MAX
3	0	1	1	Fast PWM	0xFF	BOTTOM	MAX

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Valg af clock

- De næste slides er de samme som fra ”Normal mode”.
- Gentaget for overskuelighedens skyld.

Mega2560: Timer 0. Valg af clock

7	6	5	4	3	2	1	0	
FOC0A	FOC0B	–	–	WGM02	CS02	CS01	CS00	TCCR0B
W	W	R	R	R/W	R/W	R/W	R/W	
0	0	0	0	0	0	0	0	

CS02	CS01	CS00	Description
0	0	0	No clock source (Timer/Counter stopped)
0	0	1	$clk_{I/O}$/(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

Mega2560: Timer 1,3,4,5. Valg af clock

7	6	5	4	3	2	1	0	
ICNC1	ICES1	–	WGM13	WGM12	CSn2	CSn1	CSn0	TCCRnB
R/W	R/W	R	R/W	R/W	R/W	R/W	R/W	
0	0	0	0	0	0	0	0	

- **TCCRnB = TCCR1B, TCCR3B, TCCR4B eller TCCR5B.**

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	0	$clk_{I/O}$/256 (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

Mega2560: Timer 2, Valg af clock

7	6	5	4	3	2	1	0	
FOC2A	FOC2B	–	–	WGM22	CS22	CS21	CS20	TCCR2B
W	W	R	R	R/W	R/W	R/W	R/W	
0	0	0	0	0	0	0	0	

CS22	CS21	CS20	Description
0	0	0	No clock source (Timer/Counter stopped)
0	0	1	clk_{T2S}/(No prescaling)
0	1	0	clk_{T2S}/8 (From prescaler)
0	1	1	clk_{T2S}/32 (From prescaler)
1	0	0	clk_{T2S}/64 (From prescaler)
1	0	1	clk_{T2S}/128 (From prescaler)
1	1	0	clk_{T2S}/256 (From prescaler)
1	1	1	clk_{T2S}/1024 (From prescaler)

NYT: Pin styring i CTC Mode

- OC – benene styres af waveform-generatoren i CTC mode.
- Normalt vil vi vælge ”Toggle pin on compare match”.
- Se de næste slides for detaljer.

Mega2560: Timer 0. Pin styring A + B

7	6	5	4	3	2	1	0	
COM0A1	COM0A0	COM0B1	COM0B0	–	–	WGM01	WGM00	TCCR0A
R/W	R/W	R/W	R/W	R	R	R/W	R/W	
0	0	0	0	0	0	0	0	

Table 16-2. Compare Output Mode, non-PWM Mode

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

Table 16-3. Compare Output Mode, non-PWM Mode

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

Mega2560: Timer 0. OC pins

OC0A = PB, ben 7

OC0B = PG, ben 5

Mega2560: Timer 1,3,4,5. Pin styring A+B+C

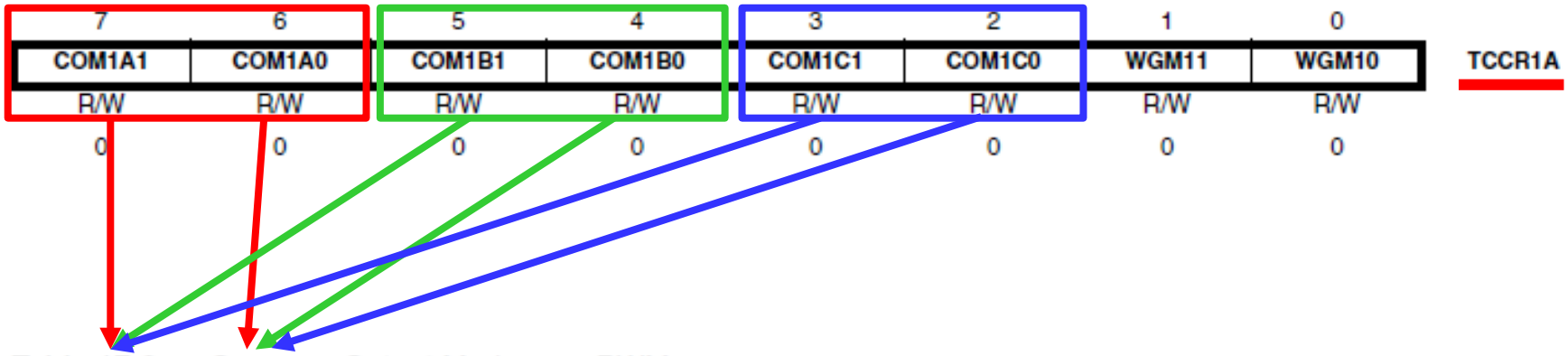

Table 17-3. Compare Output Mode, non-PWM

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)

Rød = A-systemet.

Grøn = B-systemet.

Blå = C-systemet.

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Mega2560: Timer 1,3,4,5. OC pins

Timer 1
OC1A = PB, ben 5
OC1B = PB, ben 6
OC1C = PB, ben 7

Timer 3
OC3A = PE, ben 3
OC3B = PE, ben 4
OC3C = PE, ben 5

Timer 4
OC4A = PH, ben 3
OC4B = PH, ben 4
OC4C = PH, ben 5

Timer 5
OC5A = PL, ben 3
OC5B = PL, ben 4
OC5C = PL, ben 5

Mega2560: Timer 2, Pin styring A + B

7	6	5	4	3	2	1	0	
COM2A1	COM2A0	COM2B1	COM2B0	–	–	WGM21	WGM20	TCCR2A
R/W	R/W	R/W	R/W	R	R	R/W	R/W	
0	0	0	0	0	0	0	0	

Table 20-2. Compare Output Mode, non-PWM Mode

COM2A1	COM2A0	Description
0	0	Normal port operation, OC2A disconnected
0	1	Toggle OC2A on Compare Match
1	0	Clear OC2A on Compare Match
1	1	Set OC2A on Compare Match

Table 20-5. Compare Output Mode, non-PWM Mode

COM2B1	COM2B0	Description
0	0	Normal port operation, OC2B disconnected
0	1	Toggle OC2B on Compare Match
1	0	Clear OC2B on Compare Match
1	1	Set OC2B on Compare Match

Mega2560: Timer 2. OC pins

OC2A = PB, ben 4

OC2B = PH, ben 6

Test (”socrative.com”: Room = MSYS)

- En Mega2560's clockfrekvens er **3,6864 MHz**.
  Timer 0 er initieret til CTC mode, og der er valgt "Toggle OC0 on compare match".
  Timer 0's clock prescaler er sat til**1024**.
  Hvilken frekvens vil kunne måles på benet OC0A, når register **OCR0A = 199** ?

- A: 18 Hz.
- B: 199 Hz.
- C: 1024 Hz.
- D: 9 Hz.

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Test (”socrative.com”: Room = MSYS)

- Mega2560's Timer 1 er i CTC mode (mode 4), og CPU clock-frekvensen er **4 MHz**.
  Timer 1's clock prescaler = **8**.
  Hvilken værdi skal skrives til register OCR1A, for at man kan generere et firkantsignal på benet OC1A på **1000 Hz** ?

- A: OCR1A = 1000;
- B: OCR1A = 4000000;
- C: OCR1A = 249;
- D: OCR1A = 999;

Slut på lektion 14