CP316
Timers and Counters

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Timers and Counters

Timers and Counters

- timers vs. counters

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- timers vs. counters

  A timer counts clock pulses; a counter counts external events

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  size (i.e. number of bits)

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  output pins

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  size (i.e. number of bits)

  output pins

  prescaler

Timers and Counters

- timers vs. counters

  A timer counts clock pulses; a counter counts external events

  size (i.e. number of bits)

  output pins

  prescaler

  start/stop

Timers and Counters

- timers vs. counters

  A timer counts clock pulses; a counter counts external events

  size (i.e. number of bits)

  output pins

  prescaler

  start/stop

  interrupt flag

Definitions

Definitions

- **BOTTOM**

Definitions

- **BOTTOM**

  value from which the timer starts

Definitions

- **BOTTOM**

  value from which the timer starts
- **MAX**

Definitions

- **BOTTOM**

  value from which the timer starts
- **MAX**

  maximum value the timer can reach

Definitions

- **BOTTOM**

  value from which the timer starts
- **MAX**

  maximum value the timer can reach
- **TOP**

Definitions

- **BOTTOM**

  value from which the timer starts
- **MAX**

  maximum value the timer can reach
- **TOP**

  highest value in the timer count sequence

Definitions

- **BOTTOM**

  value from which the timer starts
- **MAX**

  maximum value the timer can reach
- **TOP**

  highest value in the timer count sequence

  depending on *mode*, can be less than or equal to MAX

Pins

Pins

- **Tn**

Pins

- **Tn**

  Timer *n* input

Pins

- **Tn**

  Timer *n* input
- **OCnx**

Pins

- **Tn**

  Timer *n* input
- **OCnx**

  Output compare pin *x* for timer *n*

Pins

- **Tn**

  Timer *n* input
- **OCnx**

  Output compare pin *x* for timer *n*
- **ICPn**

Pins

- **Tn**

  Timer *n* input
- **OCnx**

  Output compare pin *x* for timer *n*
- **ICPn**

  Input capture pin for timer *n*

Flags

Flags

- **TOVn**

Flags

- **TOVn**

  Timer overflow *n*

Flags

- **TOVn**

  Timer overflow *n*
- **OCFnx**

Flags

- **TOVn**

  Timer overflow *n*
- **OCFnx**

  Output compare match *x* for timer *n*

Flags

- **TOVn**

  Timer overflow *n*
- **OCFnx**

  Output compare match *x* for timer *n*
- **ICFn**

Flags

- **TOVn**

  Timer overflow *n*
- **OCFnx**

  Output compare match *x* for timer *n*
- **ICFn**

  Input capture for timer *n*

Timer modes

Timer modes

- **Normal**

Timer modes

- **Normal**

  rolls over at TOP

Timer modes

- **Normal**

  rolls over at TOP
- **CTC** (Clear Timer on Compare Match)

Timer modes

- **Normal**

  rolls over at TOP
- **CTC** (Clear Timer on Compare Match)

  returns to zero when OCRnx (or ICRn) reached

Timer modes

- **Normal**

  rolls over at TOP
- **CTC** (Clear Timer on Compare Match)

  returns to zero when OCRnx (or ICRn) reached
- **Fast PWM**

Timer modes

- **Normal**

  rolls over at TOP
- **CTC** (Clear Timer on Compare Match)

  returns to zero when OCRnx (or ICRn) reached
- **Fast PWM**

  rolls over at TOP

Timer modes

- **Normal**

  rolls over at TOP
- **CTC** (Clear Timer on Compare Match)

  returns to zero when OCRnx (or ICRn) reached
- **Fast PWM**

  rolls over at TOP

  output OCnx set when compare matches TCNTx and OCRnx

Timer modes

- **Normal**

  rolls over at TOP
- **CTC** (Clear Timer on Compare Match)

  returns to zero when OCRnx (or ICRn) reached
- **Fast PWM**

  rolls over at TOP

  output OCnx set when compare matches TCNTx and OCRnx

Timer modes (continued)

Timer modes (continued)

- **Phase correct PWM**

Timer modes (continued)

- **Phase correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

Timer modes (continued)

- **Phase correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output OCnx cleared on upcount, set on downcount when compare matches TCNTx and OCRnx

Timer modes (continued)

- **Phase correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output OCnx cleared on upcount, set on downcount when compare matches TCNTx and OCRnx
- **Phase and frequency correct PWM**

Timer modes (continued)

- **Phase correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output OCnx cleared on upcount, set on downcount when compare matches TCNTx and OCRnx
- **Phase and frequency correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

Timer modes (continued)

- **Phase correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output OCnx cleared on upcount, set on downcount when compare matches TCNTx and OCRnx
- **Phase and frequency correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output set when ????????? compare matches TCNTx and OCRnx ???

Timer modes (continued)

- **Phase correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output OCnx cleared on upcount, set on downcount when compare matches TCNTx and OCRnx
- **Phase and frequency correct PWM**

  counts BOTTOM to TOP then TOP to BOTTOM

  output set when ????????? compare matches TCNTx and OCRnx ???

Timer0

Timer0

counter?

Timer0

counter?

size?

Timer0

counter?

size?

prescaler?

Timer0

counter?

size?

prescaler?

Arduino connections

Timer0 details

Timer0 details

- **BOTTOM**

Timer0 details

- **BOTTOM**

  0x00

Timer0 details

- **BOTTOM**

  0x00
- **MAX**

Timer0 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

Timer0 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

  maximum value the timer can reach

Timer0 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

  maximum value the timer can reach
- **TOP**

Timer0 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

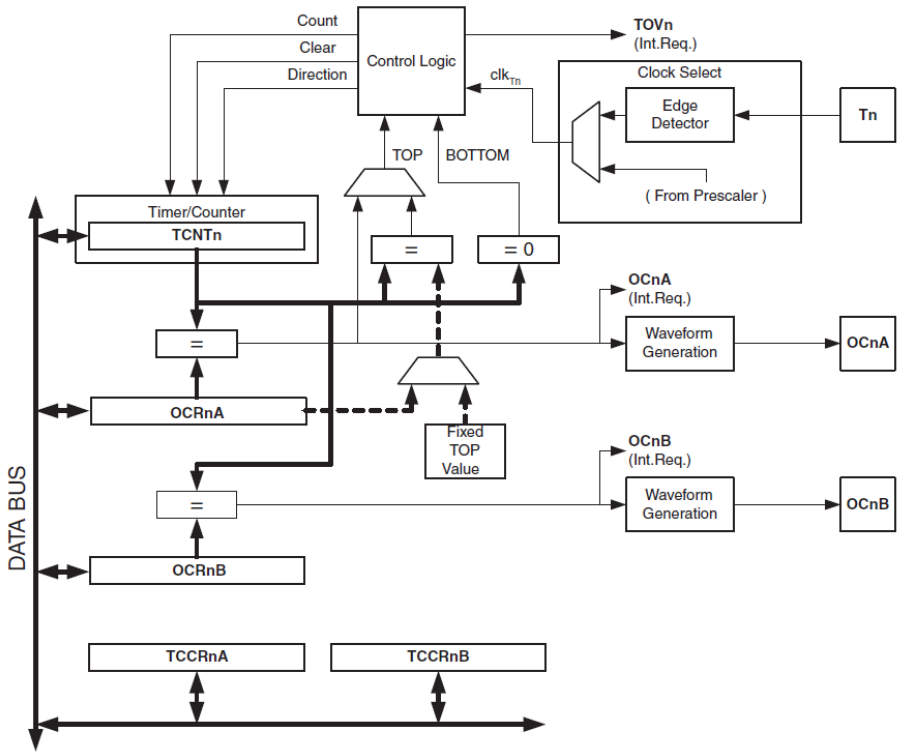
  maximum value the timer can reach
- **TOP**

  MAX or value in OCR0A, depending on *mode*

Timer 0

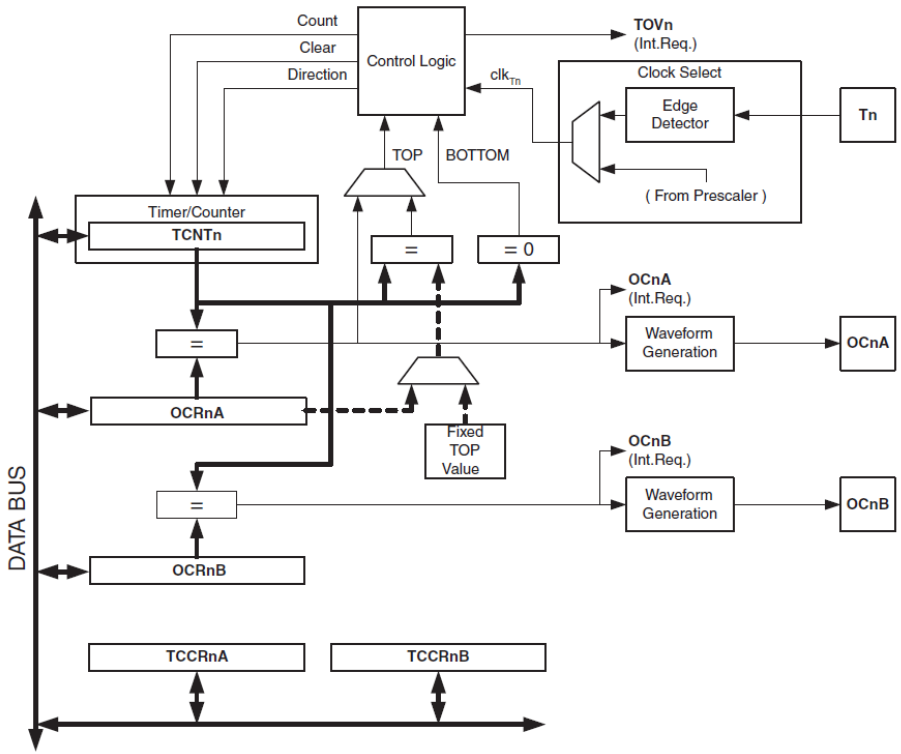
Timer 0

Figure 15-1. 8-bit Timer/Counter Block Diagram



Timer 0

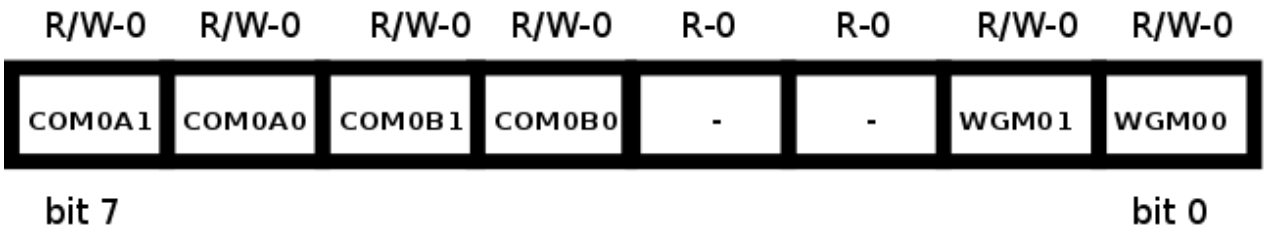
Figure 15-1. 8-bit Timer/Counter Block Diagram



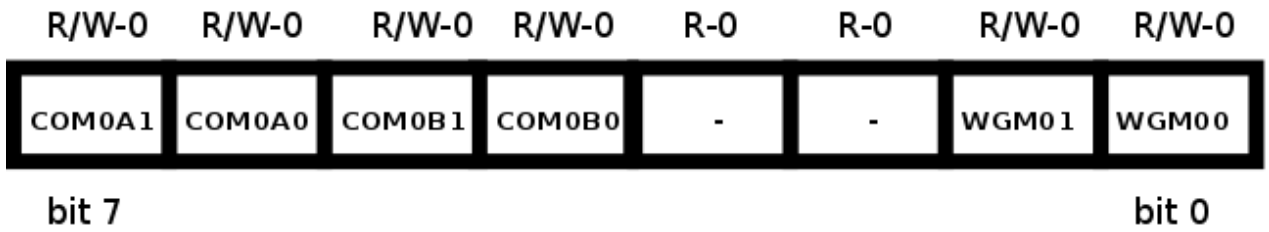
Timer 0

TCCR0A register

TCCR0A register

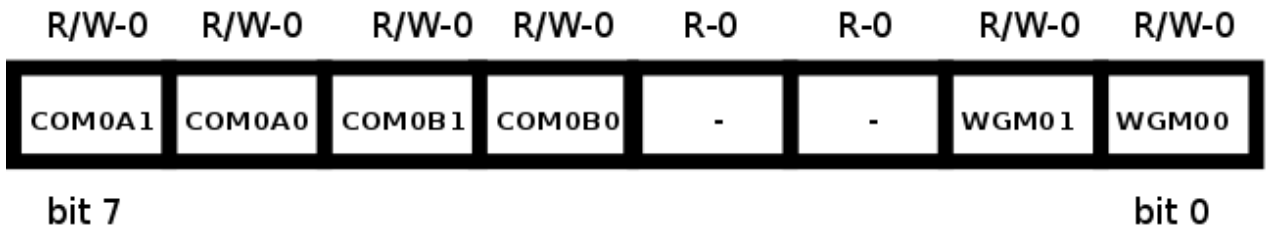


TCCR0A register



Bits in TCCR0A register

TCCR0A register

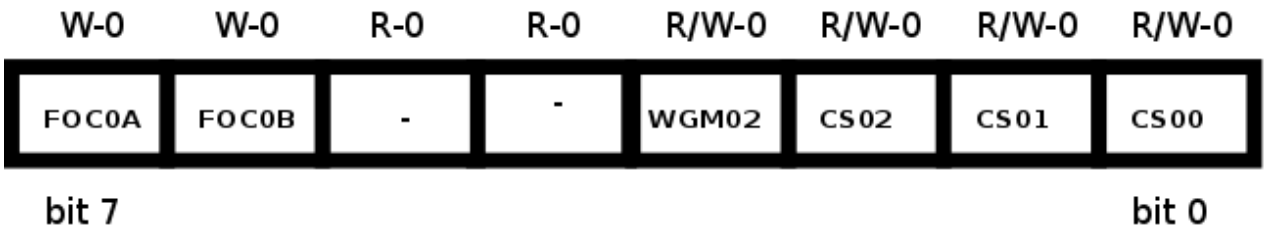


Bits in TCCR0A register

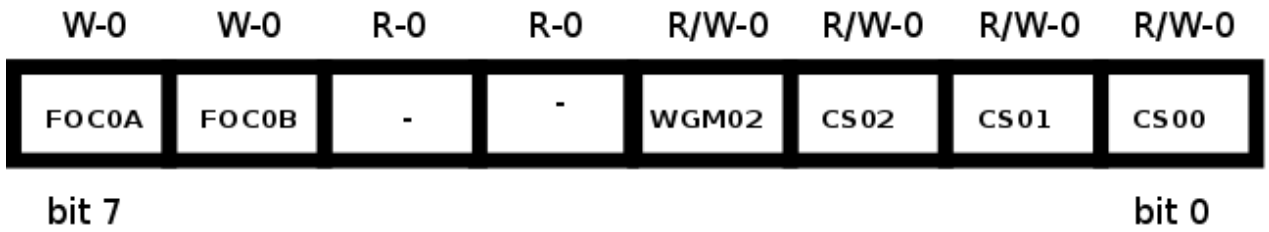
- COM Output compare bits
- WGM Waveform generation mode bits

TCCR0B register

TCCR0B register

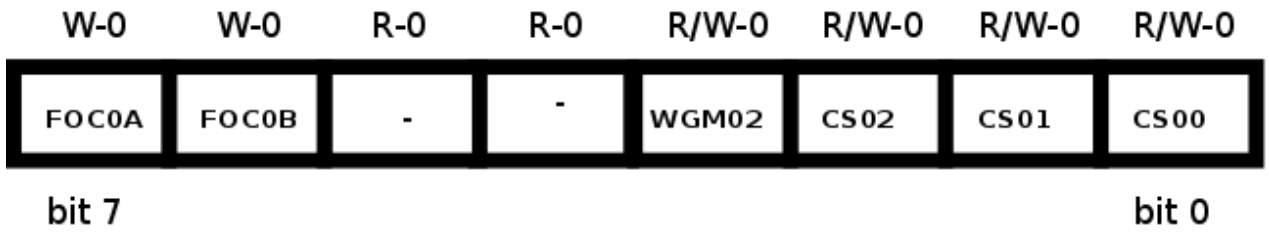


TCCR0B register



Bits in TCCR0B register

TCCR0B register

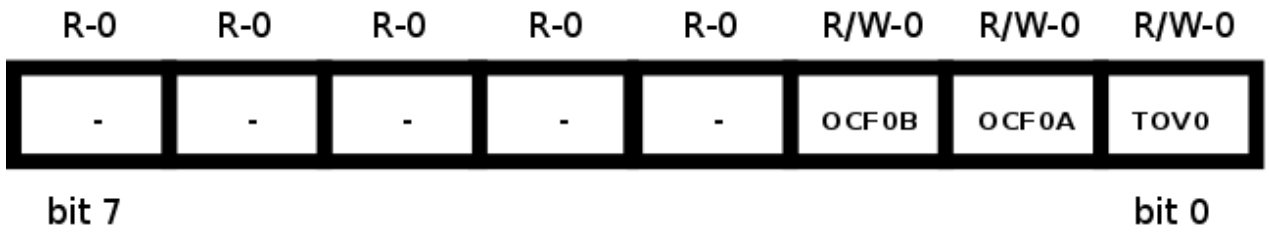


Bits in TCCR0B register

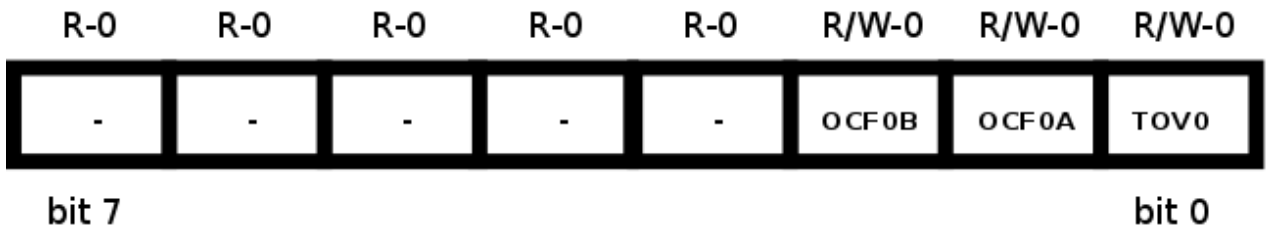
- FOC Force output compare bits
- WGM Waveform generation mode bits
- CS Clock select bits

TIFR0 register

TIFR0 register

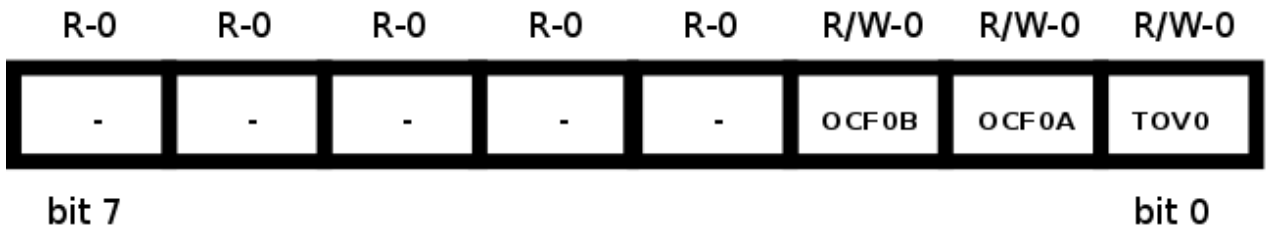


TIFR0 register



Bits in TIFR0 register

TIFR0 register



Bits in TIFR0 register

- OCF Output compare flag bits
- TOV Timer overflow flag bits

Timer1

Timer1

counter?

Timer1

counter?

size?

Timer1

counter?

size?

prescaler?

Timer1

counter?

size?

prescaler?

Arduino connections

Timer1 details

Timer1 details

- **BOTTOM**

Timer1 details

- **BOTTOM**

  0x0000

Timer1 details

- **BOTTOM**

  0x0000
- **MAX**

Timer1 details

- **BOTTOM**

  0x0000
- **MAX**

  0xFFFF

Timer1 details

- **BOTTOM**

  0x0000
- **MAX**

  0xFFFF

  maximum value the timer can reach

Timer1 details

- **BOTTOM**

  0x0000
- **MAX**

  0xFFFF

  maximum value the timer can reach
- **TOP**

Timer1 details

- **BOTTOM**

  0x0000
- **MAX**

  0xFFFF

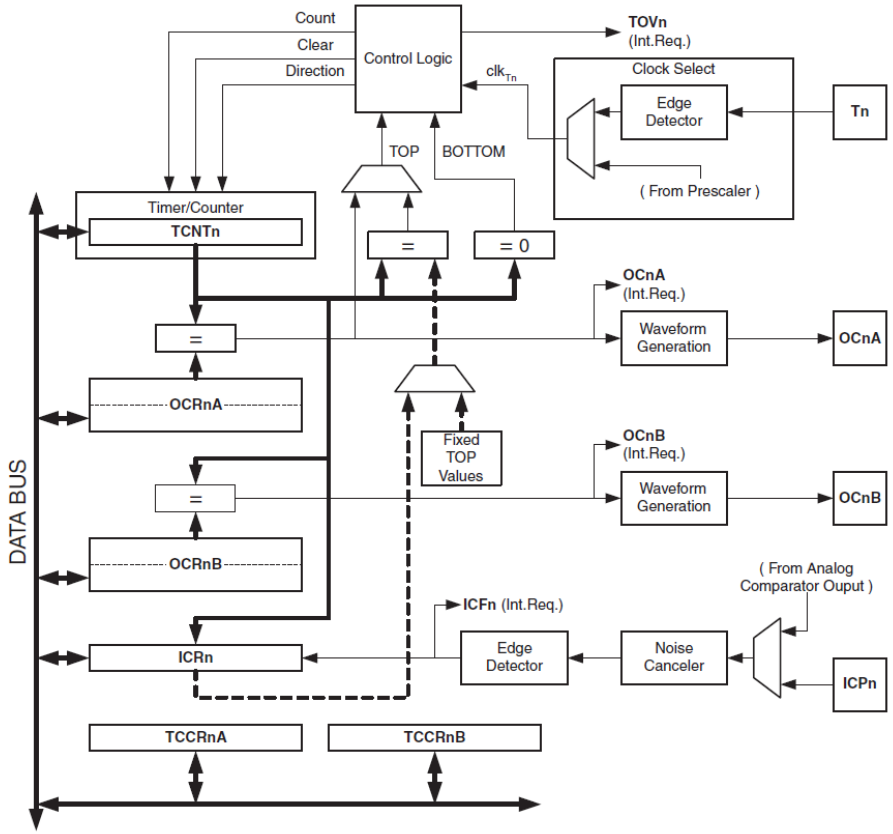
  maximum value the timer can reach
- **TOP**

  0x00FF, 0x01FF,or 0x03FF, or to the value stored in the OCR1A or ICR1, depending on *mode*

Timer 1

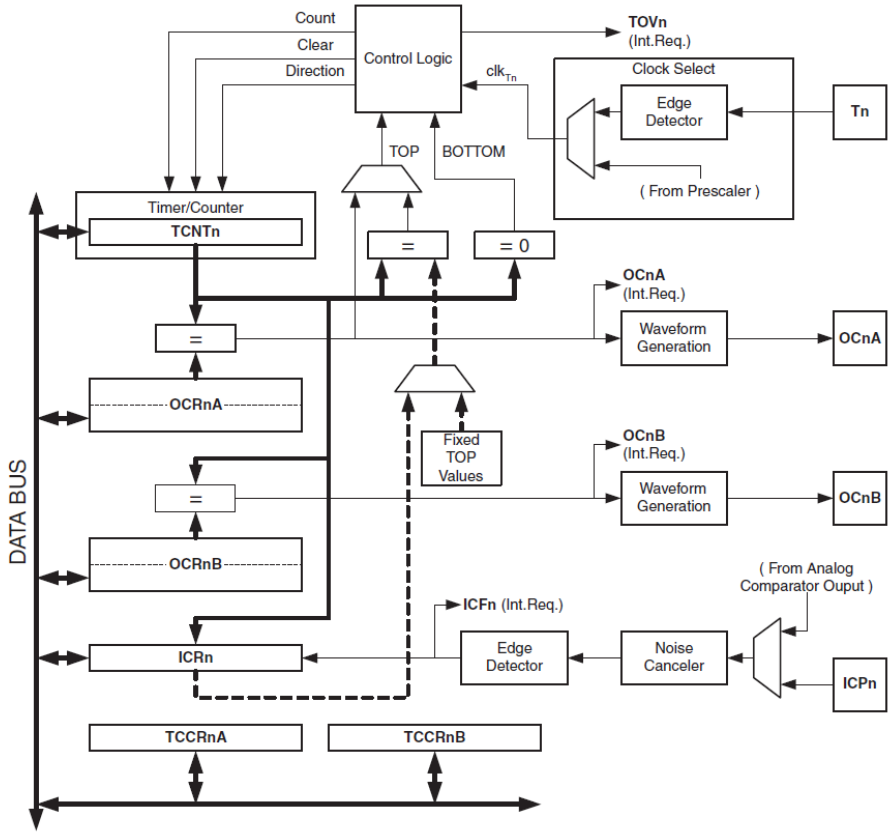
Timer 1

Figure 16-1. 16-bit Timer/Counter Block Diagram[1]



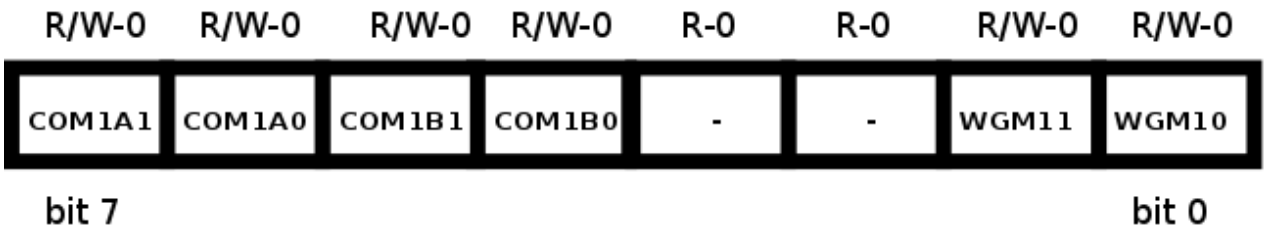
Timer 1

Figure 16-1. 16-bit Timer/Counter Block Diagram[1]

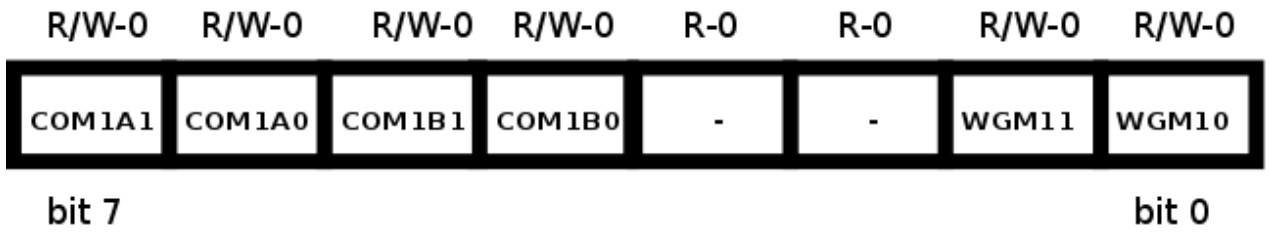


TCCR1A register

TCCR1A register

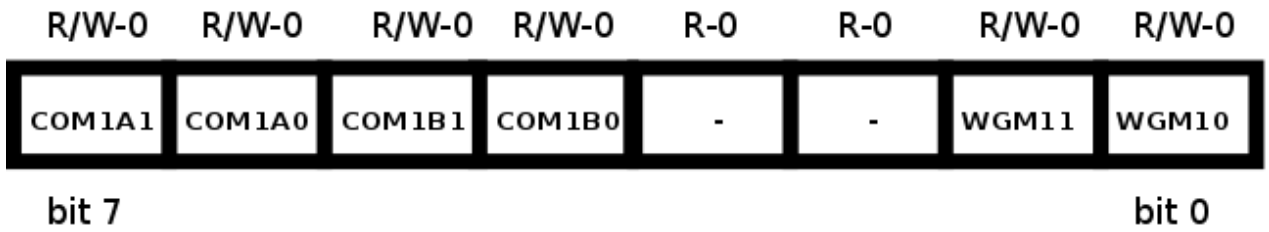


TCCR1A register



Bits in TCCR1A register

TCCR1A register

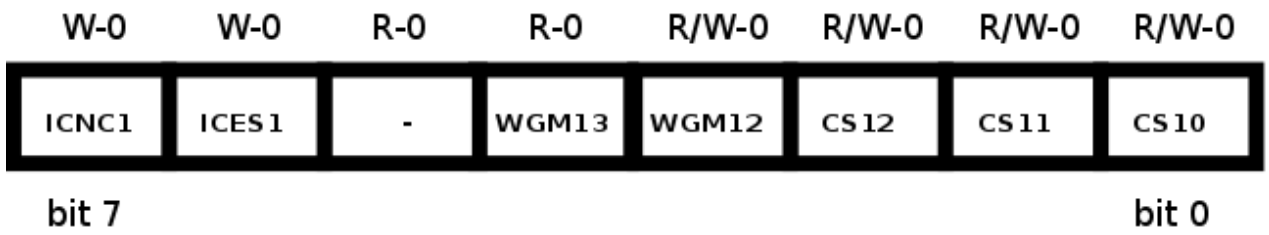


Bits in TCCR1A register

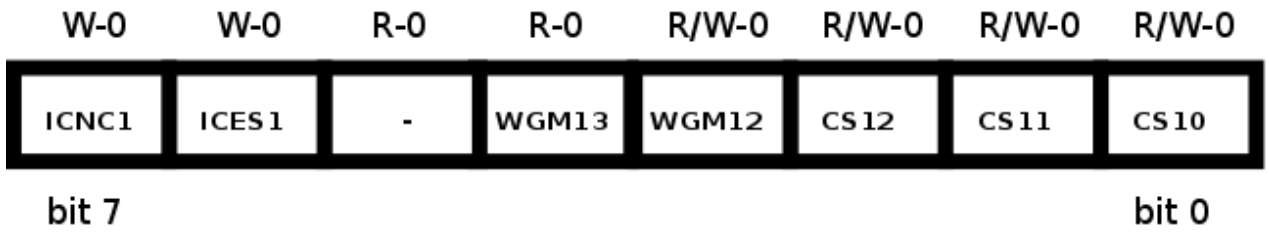
- COM Output compare bits
- WGM Waveform generation mode bits

TCCR1B register

TCCR1B register

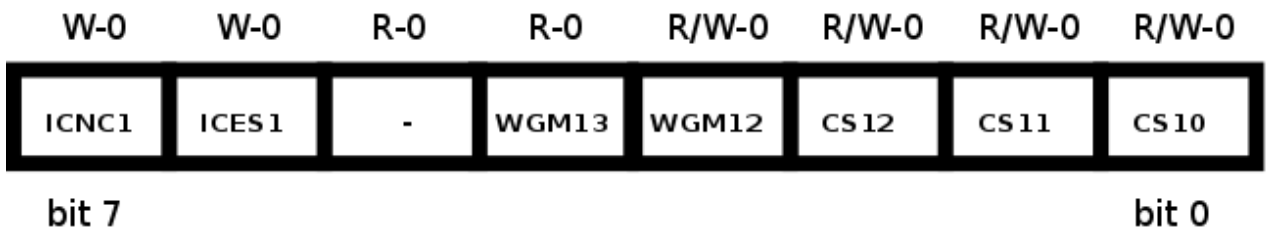


TCCR1B register



Bits in TCCR1B register

TCCR1B register

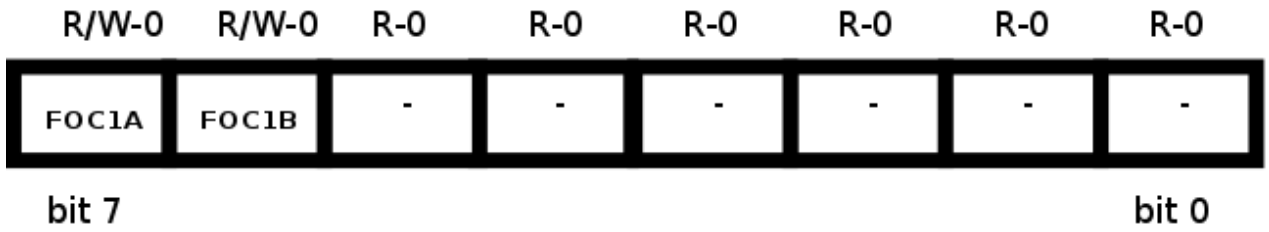


Bits in TCCR1B register

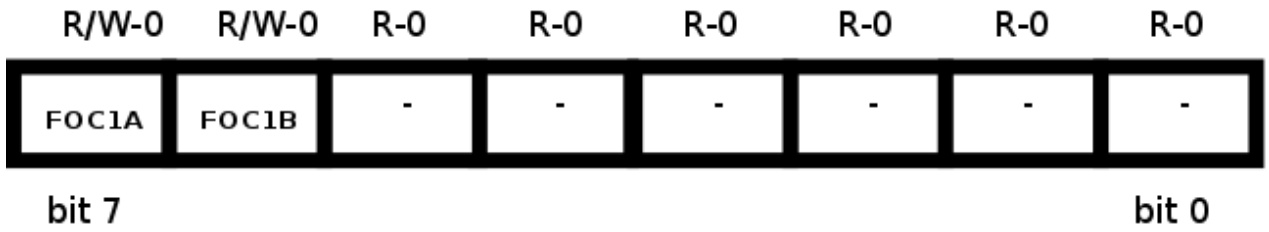
- ICNC Input capture noise canceler bit
- ICES Input capture edge select bit
- WGM Waveform generation mode bits
- CS Clock select bits

TCCR1C register

TCCR1C register

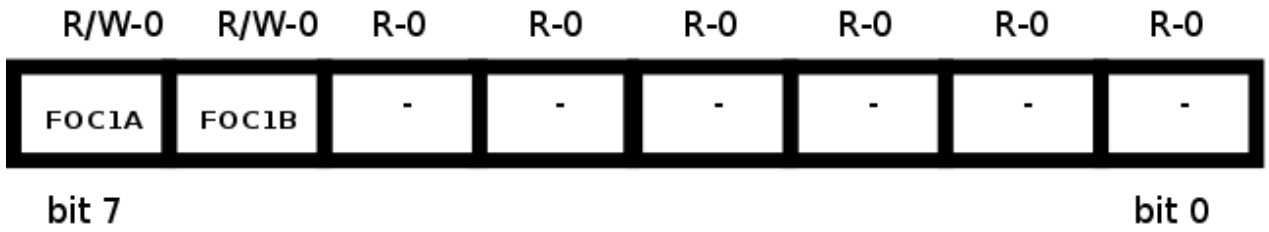


TCCR1C register



Bits in TCCR1C register

TCCR1C register

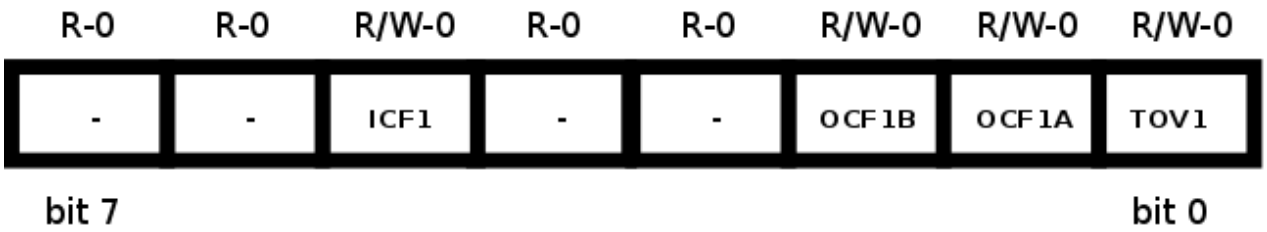


Bits in TCCR1C register

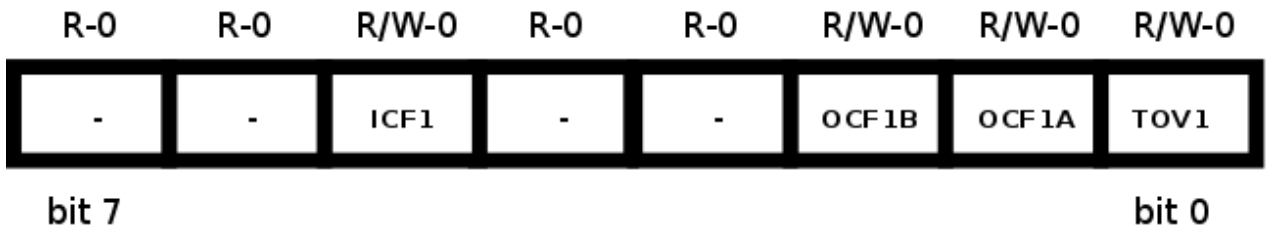
FOC Force output compare bits

TIFR1 register

TIFR1 register

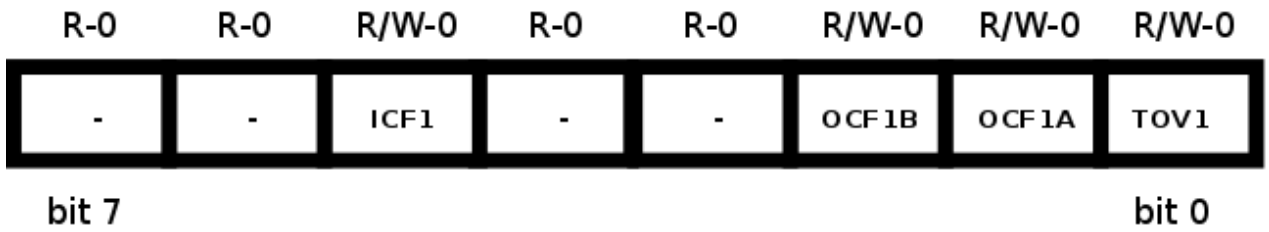


TIFR1 register



Bits in TIFR1 register

TIFR1 register



Bits in TIFR1 register

- ICF Input capture flag bit
- OCF Output compare flag bits
- TOV Timer overflow flag bits

Timer2

Timer2

counter?

Timer2

counter?

size?

Timer2

counter?

size?

prescaler?

Timer2

counter?

size?

prescaler?

Arduino connections

Timer2 details

Timer2 details

- **BOTTOM**

Timer2 details

- **BOTTOM**

  0x00

Timer2 details

- **BOTTOM**

  0x00
- **MAX**

Timer2 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

Timer2 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

  maximum value the timer can reach

Timer2 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

  maximum value the timer can reach
- **TOP**

Timer2 details

- **BOTTOM**

  0x00
- **MAX**

  0xFF

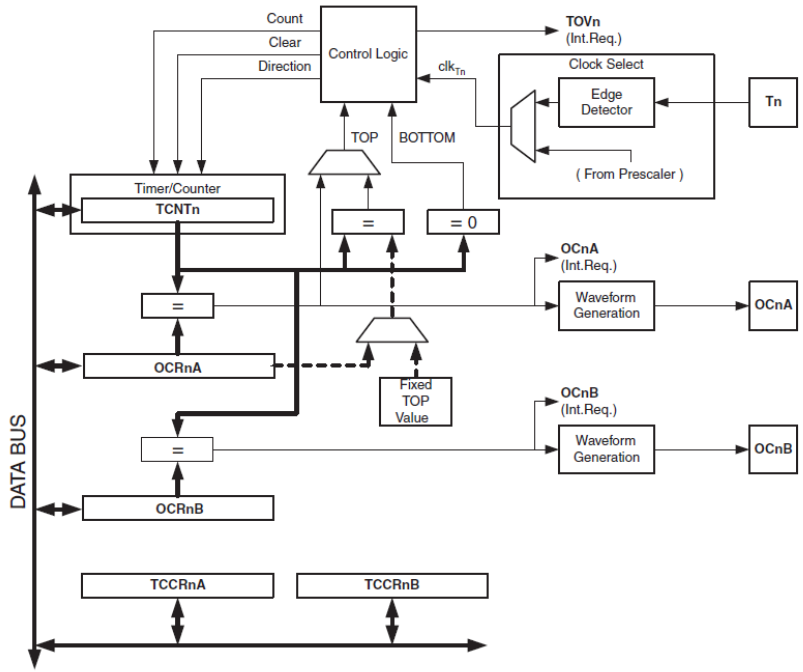
  maximum value the timer can reach
- **TOP**

  MAX or the value stored in the OCR2A, depending on *mode*

Timer 2

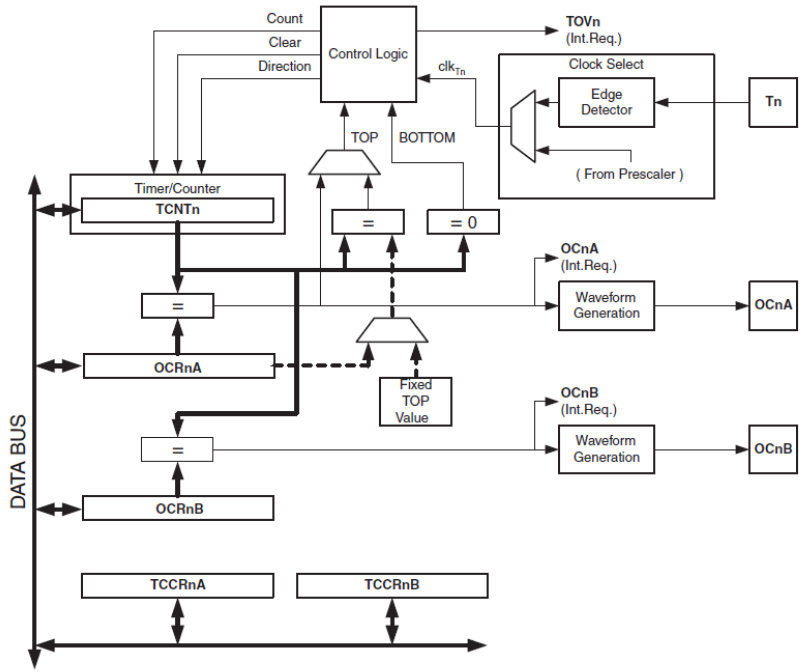
Timer 2

Figure 18-1. 8-bit Timer/Counter Block Diagram



Timer 2

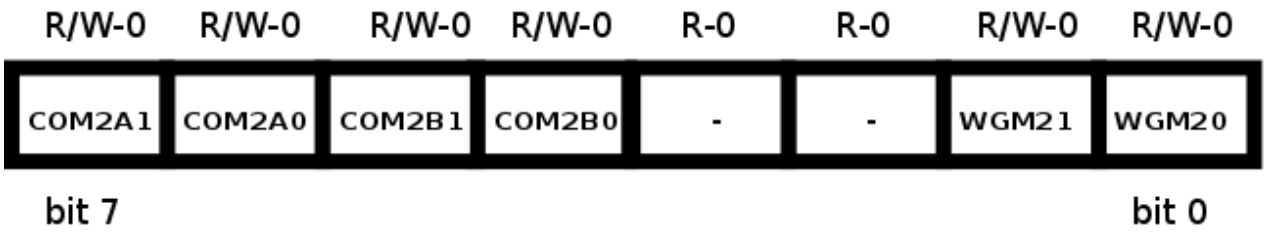
Figure 18-1. 8-bit Timer/Counter Block Diagram



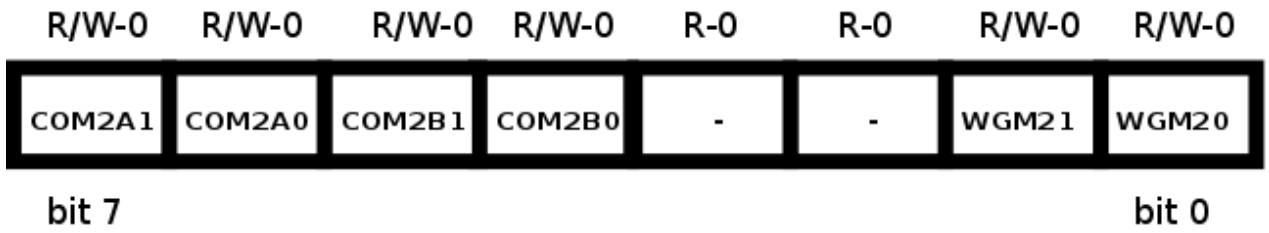
Timer 2

TCCR2A register

TCCR2A register

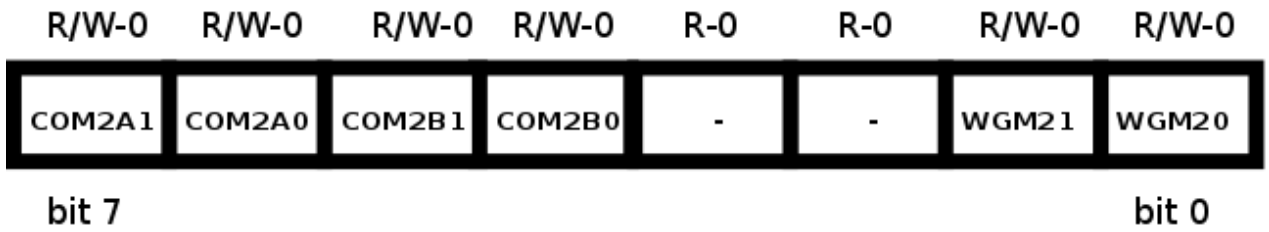


TCCR2A register



Bits in TCCR2A register

TCCR2A register

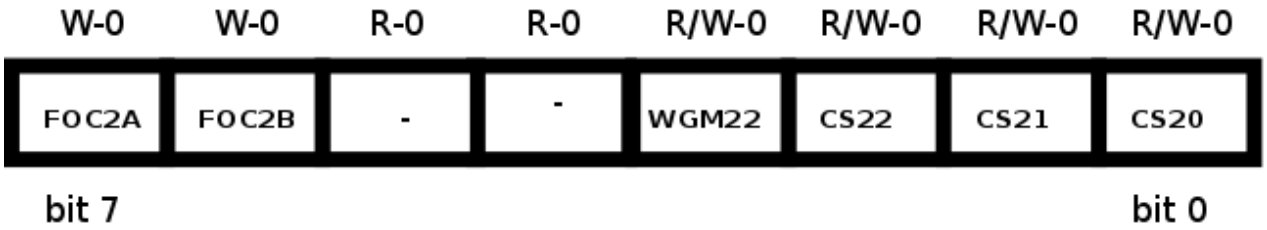


Bits in TCCR2A register

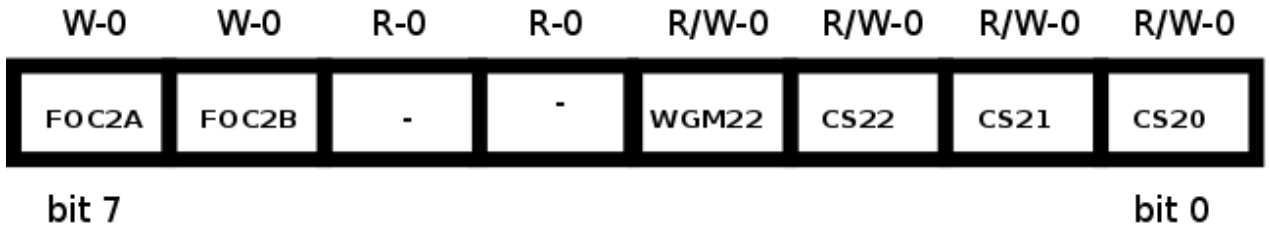
- COM Output compare bits
- WGM Waveform generation mode bits

TCCR2B register

TCCR2B register

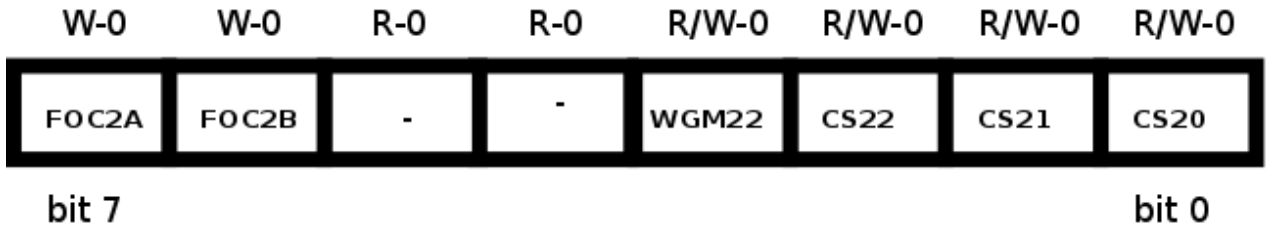


TCCR2B register



Bits in TCCR2B register

TCCR2B register

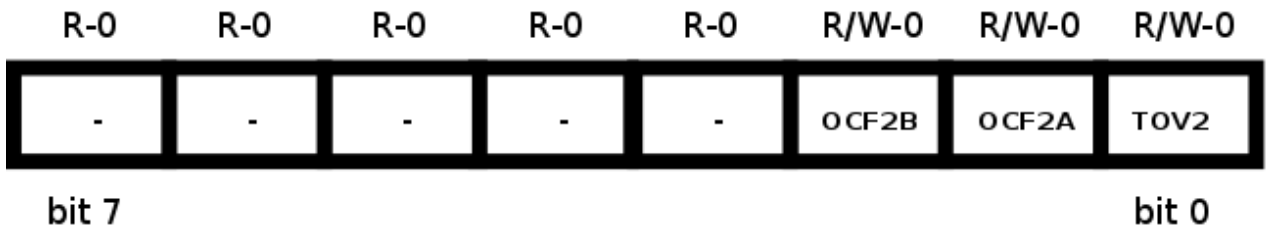


Bits in TCCR2B register

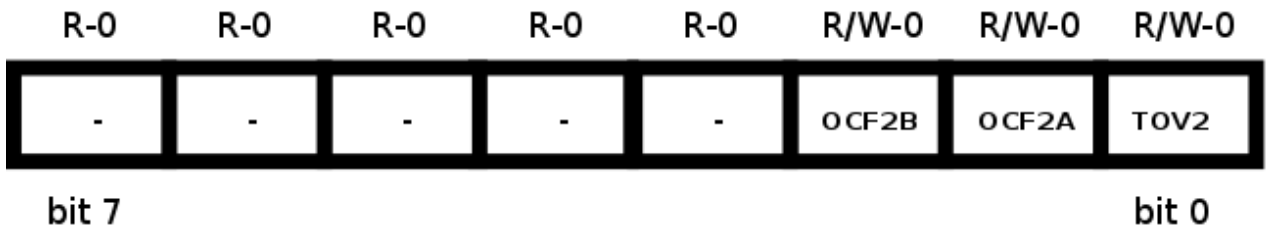
- FOC Force output compare bits
- WGM Waveform generation mode bits
- CS Clock select bits

TIFR2 register

TIFR2 register

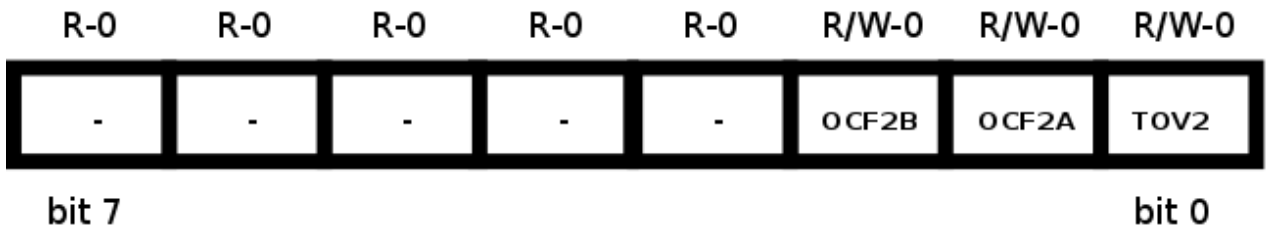


TIFR2 register



Bits in TIFR2 register

TIFR2 register



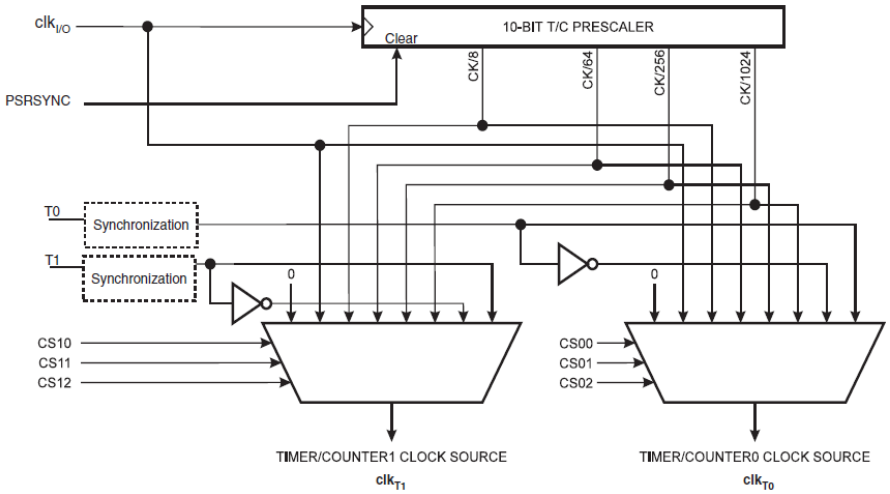
Bits in TIFR2 register

- OCF Output compare flag bits
- TOV Timer overflow flag bits

Timer 0-1 prescaler

Timer 0-1 prescaler

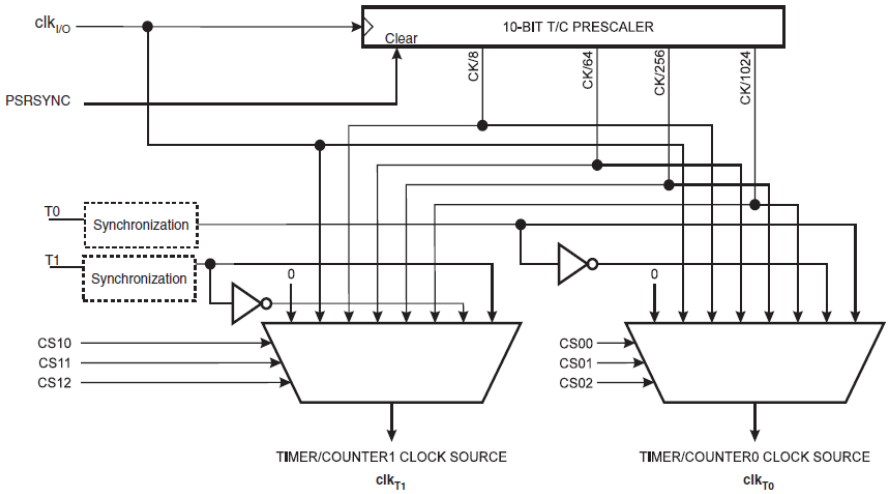
Figure 17-2. Prescaler for Timer/Counter0 and Timer/Counter1[1]



Note: 1. The synchronization logic on the input pins (T1/T0) is shown in Figure 17-1.

Timer 0-1 prescaler

Figure 17-2. Prescaler for Timer/Counter0 and Timer/Counter1[1]



Note: 1. The synchronization logic on the input pins (T1/T0) is shown in Figure 17-1.

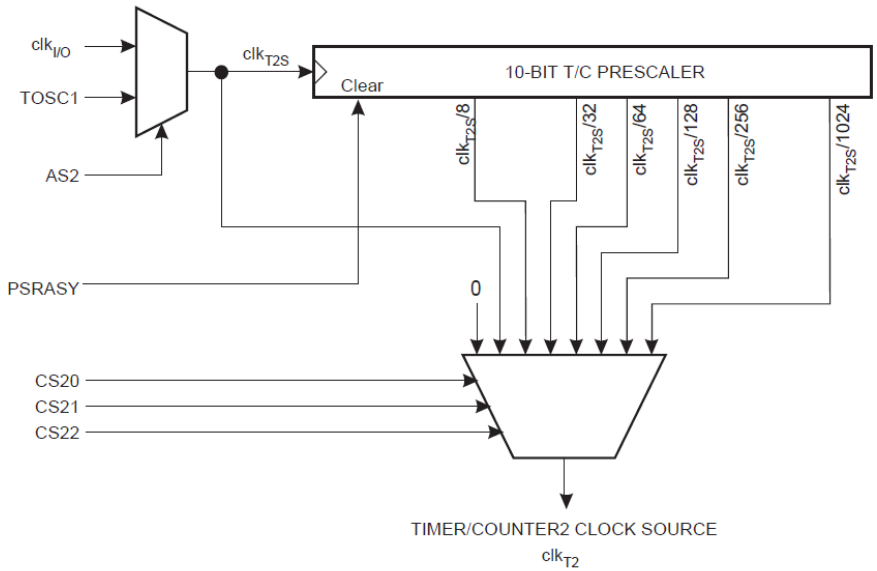
Timer 0-1 prescaler

Timer 2 prescaler

Timer 2 prescaler

18.10 Timer/Counter Prescaler

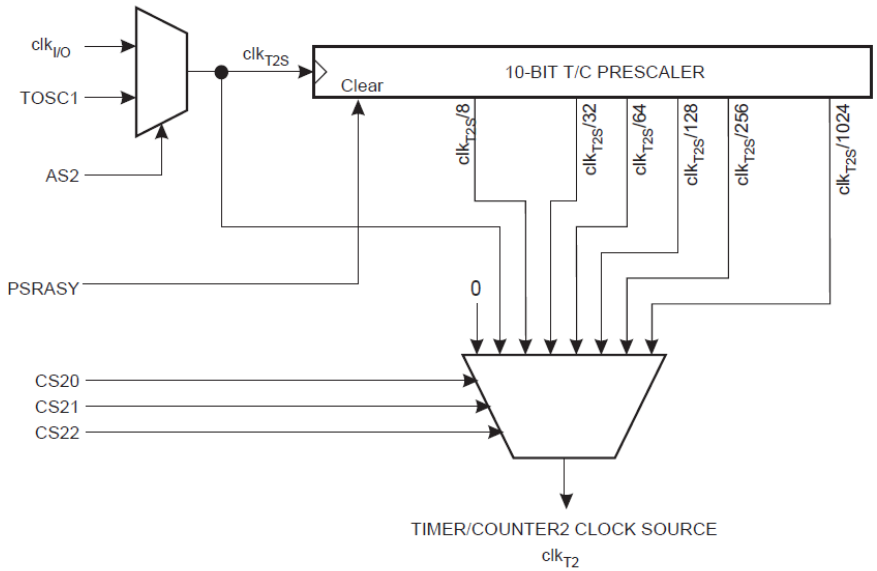
Figure 18-12. Prescaler for Timer/Counter2



Timer 2 prescaler

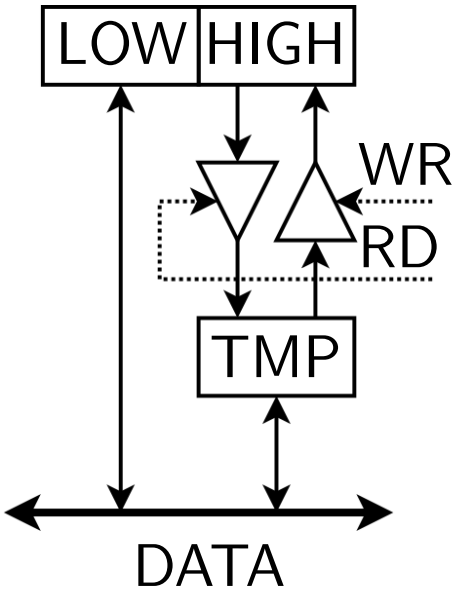
18.10 Timer/Counter Prescaler

Figure 18-12. Prescaler for Timer/Counter2



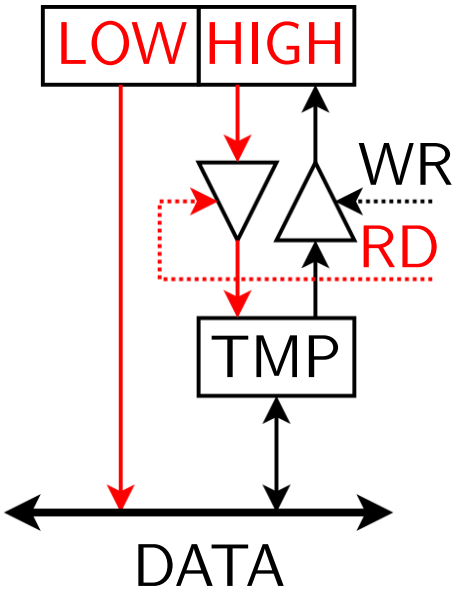
Timer 2 prescaler

16 bit register access



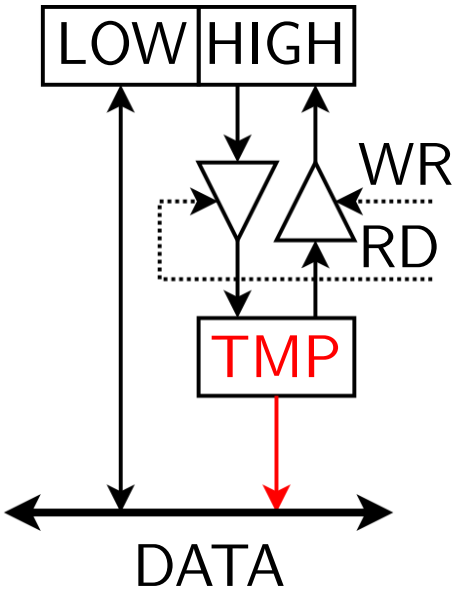
16 bit register access

16 bit register access



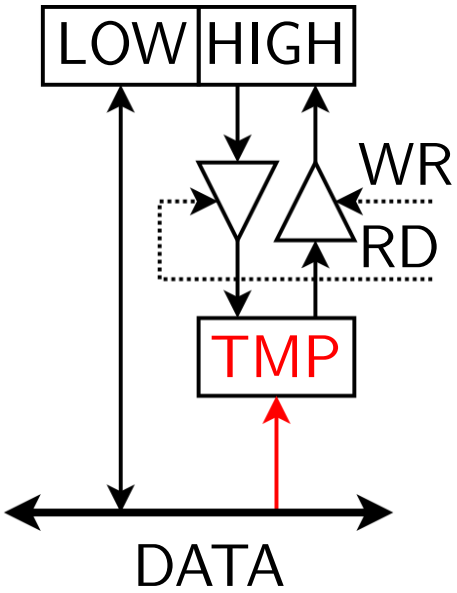
Reading LOW byte latches HIGH byte

16 bit register access



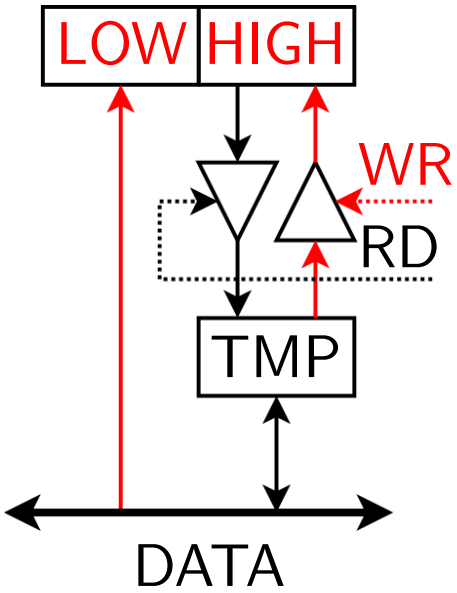
Reading HIGH byte gets value from latch

16 bit register access



Writing HIGH byte places value in latch

16 bit register access



Writing LOW byte transfers value from latch