Chapter 6

PROGRAMMING THE TIMERS

Lesson 2

Free Running Timer-Counter Device

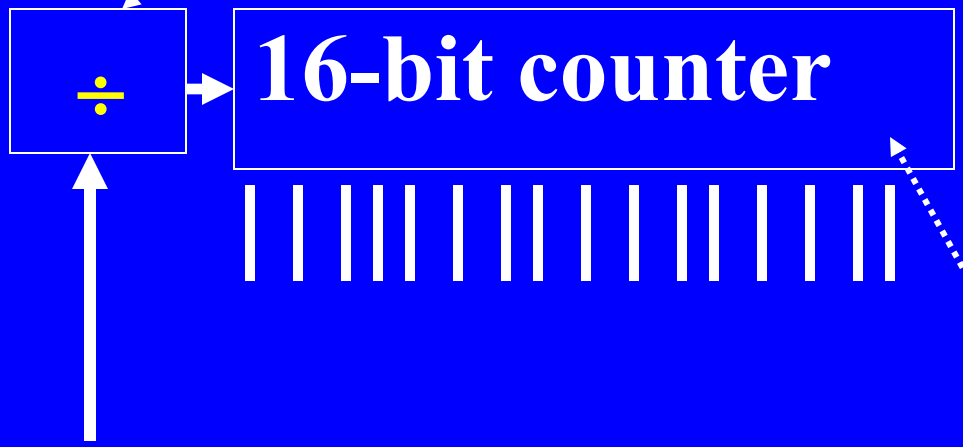
Free running Timer-Counter Overflow Events

Example

- 68HC11 Timer-counter TCNT on overflow after one input from FFFFH and new reading = 0000H at TCNT
- Since TCNT free running, the successive overflows after 10000H internal clock count-inputs
- New TCNT reading after each overflow = 0000H

68HC11 TCNT programmability

Internal clock input rate/prescaling factor programmable



Count Inputs from internal clock

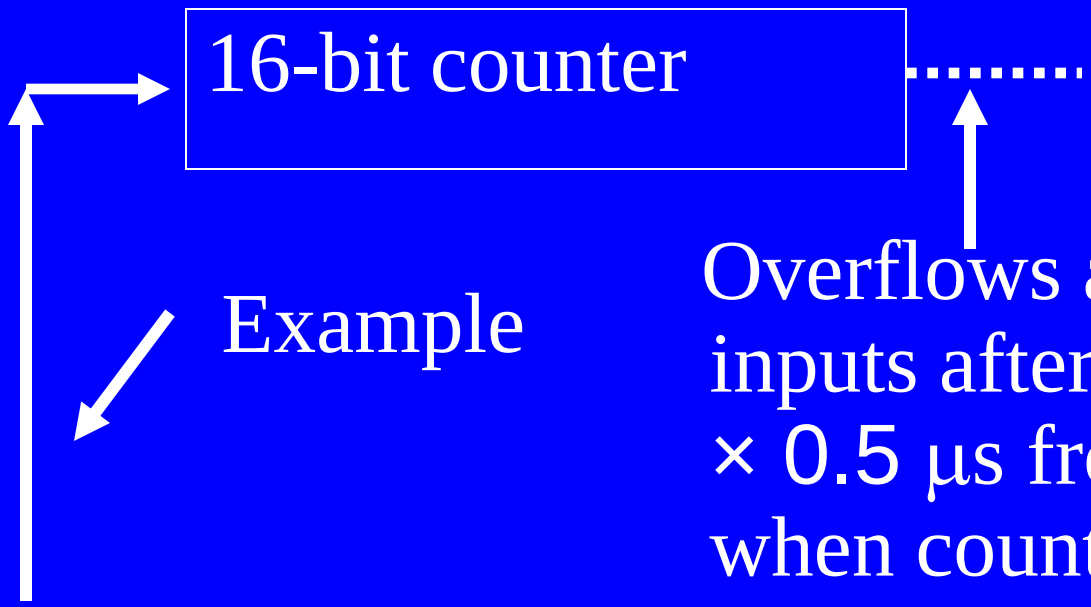
Interrupt service on overflow programmable by mask bit

68HC11 TCNT programmability

Period between successive counts from internal clock extends by pre-scaling factor of 4, 8 or 16 when p = 4 or 8 or 16

An overflow period extends by pre-scaling factor of 4, 8 or 16 when p = 4 or 8 or 16

68HC11 TCNT Overflow example



Timer overflow interrupt if not masked, an ISR executes

Example

Overflows after 2^{16} inputs after each $2^{16} \times p \times 0.5$ μs from instance when count bits all 0s

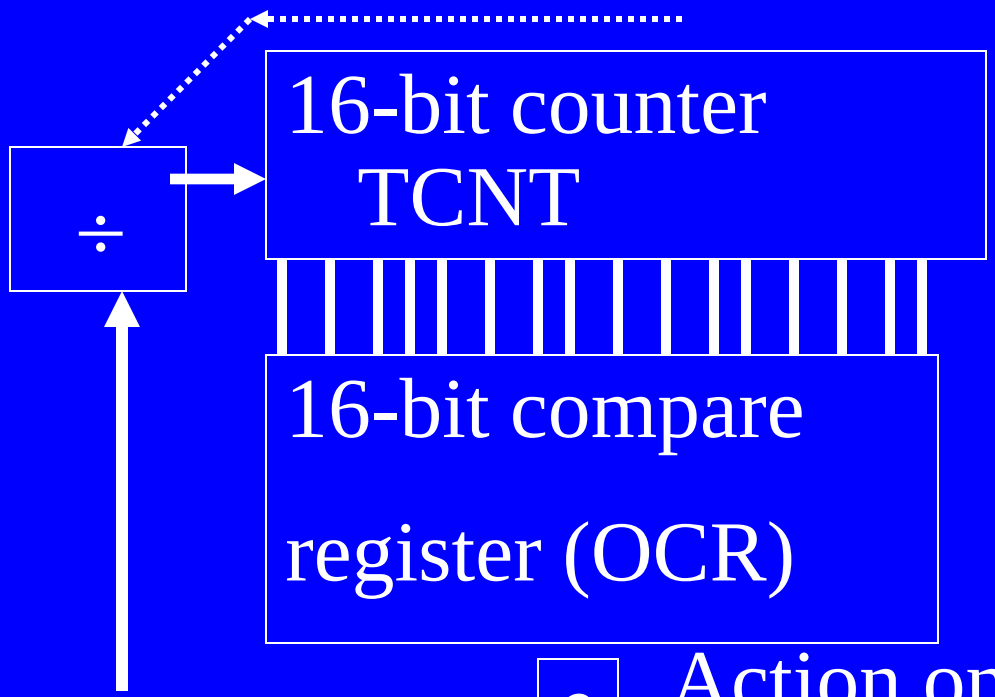
Clock Inputs period = 0.5 μs for 8 MHz XTAL, pre-scaling factor set = p = 1 or 4 or 8 or 16

Exemplary Use

When 68HC11 Timer-counter TCNT repeatedly overflows after $(2^{16} \times p) / 2$ μs, the event(s) or action(s) or instructions on each ISR run can be repeated after every $2^{16} \times p \times 0.5$μs, provided p programmed within 64 clock cycles of start up of 68HC11 MCU

Out-compare(s)

68HC11 TCNT Example



1 Load y1 for initiating an action when y1 = counts x

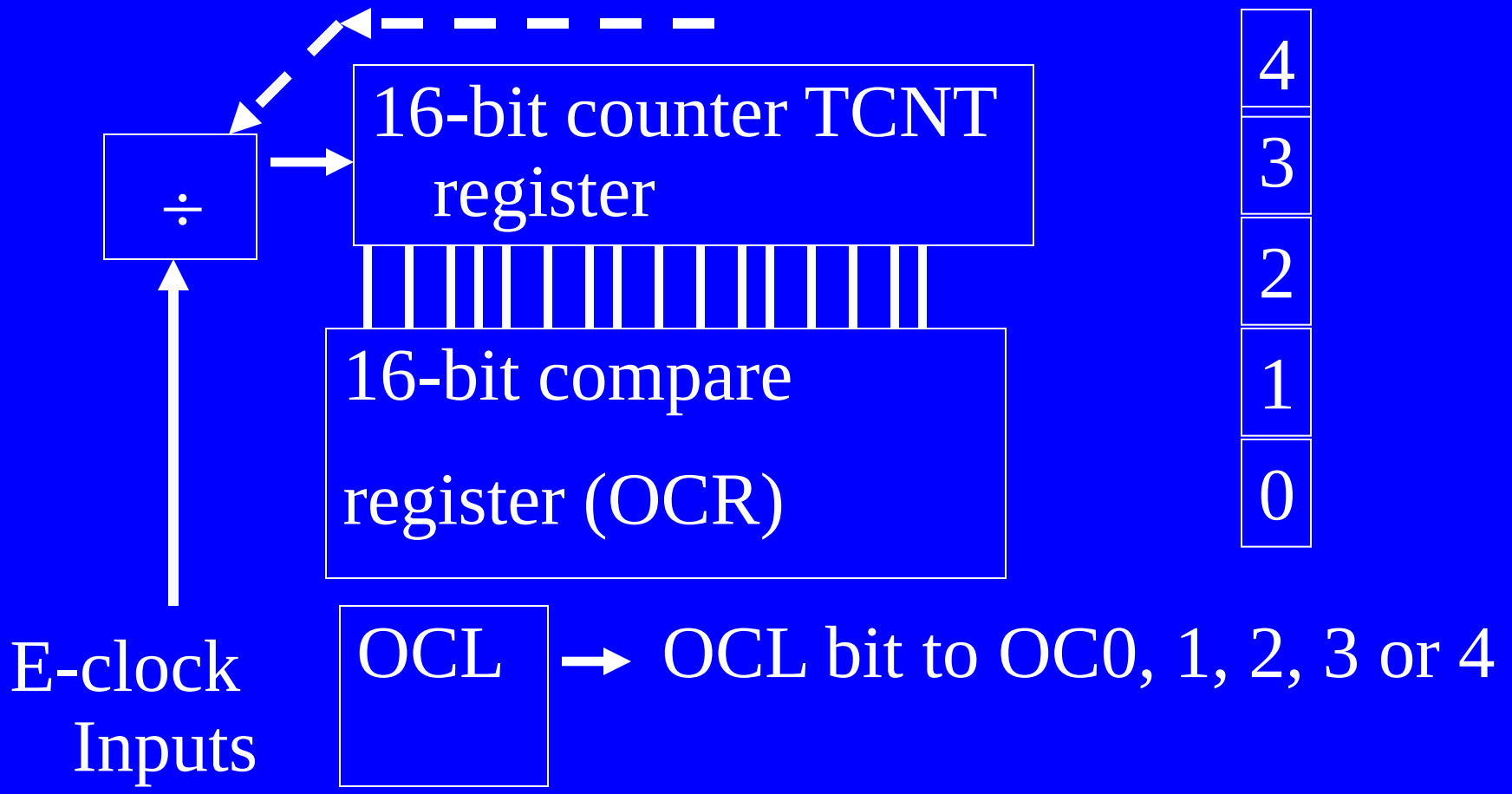
2 Action on y1 = x

out-compare interrupt ISR runs

3 Action on y1 = x

output = 0 or 1 or toggle as programmed

68HC11 TCNT Registers



Preset time interval ON-OFF of a unit

1. load OCR = with y. Preset time instance = y × p × 0.5 μs.

2. On OC interrupt, Reset OC flag, Read TCNT counts = x, set output level to switch ON the unit and load OCR = with y1= (x + y),

unmask OC interrupt.

3. On OC interrupt, reset output level to switch Off the unit, reset OC flag and mask next OC interrupt.

Preset long time interval ON-OFF of a unit

1. Let *k* is required preset number of overflows and y is the count inputs to be made for an overflow at the beginning. Calculate *y* and *k* for given *p* and *t from required* preset time interval *t using formula* $T = (k \times 2^{16} + y) \times p \times 0.5\ \mu$

2. On OC interrupt, Read TCNT counts = x,

Set output level to switch ON the unit and load **(OCR)** = x + y

Preset long time interval ON-OFF of a unit

3. On TCNT overflow 1^{st} to $(k-1)^{th}$ interrupt, reset OV flag, unmask next OV interrupt, keep masked OC interrupt.

4. On k^{th} overflow interrupt after $(k-1)^{th}$ overflows, reset OV flag, mask next OV interrupt, unmask OC interrupt

5. On OC interrupt, reset output level to switch Off the unit,reset OC flag and mask next OC interrupt.

Exemplary Applications

1. Moving robot arm for a defined period.
2. Output change for a pre-fixed interval
3. Current output for a fixed interval
4. A microwave oven ON for a fixed interval

Force outputs on Out-compare(s)

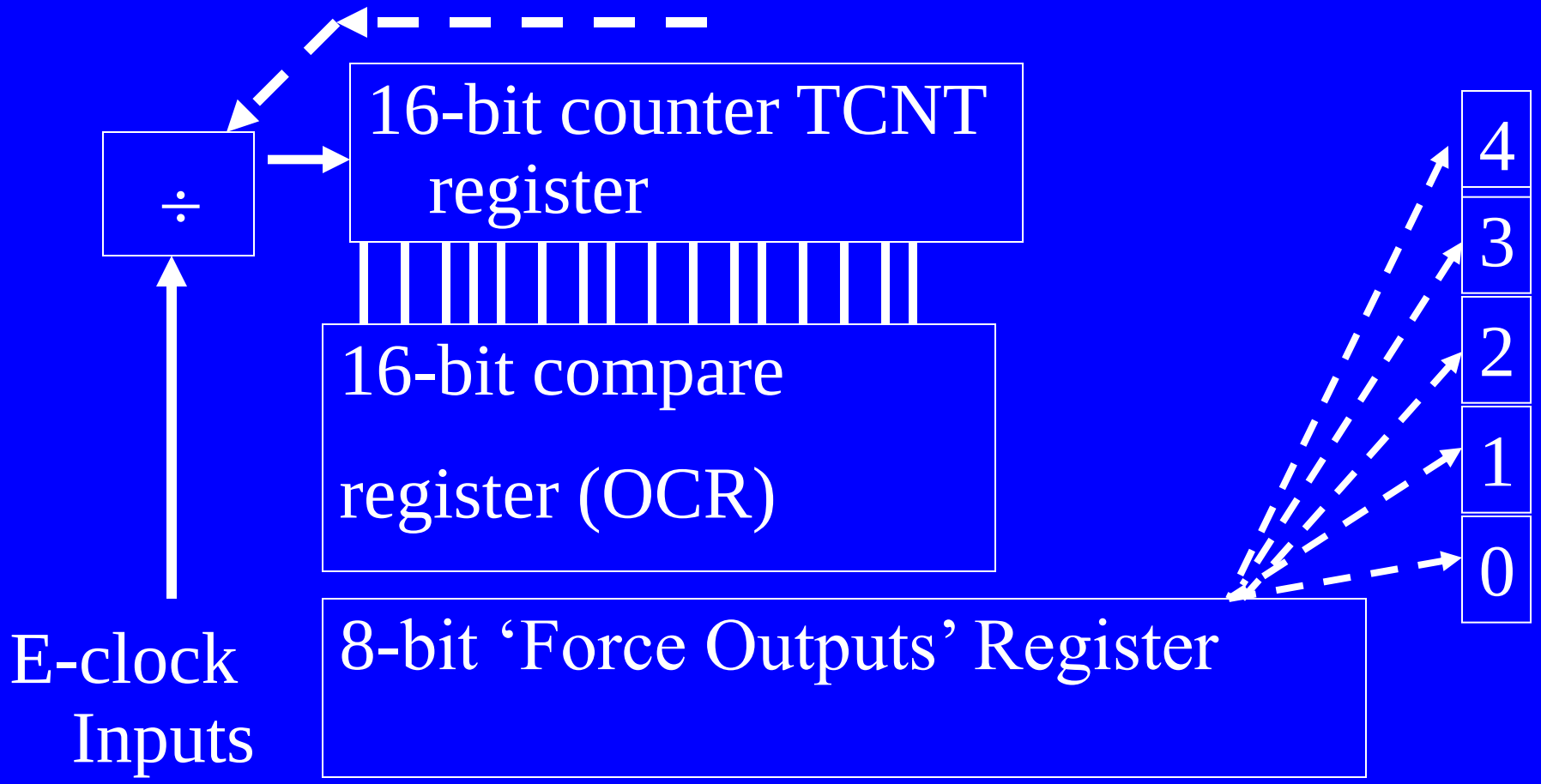
Preset time interval reset- set of the units

Let preset time interval = y × p × 0.5 μs.

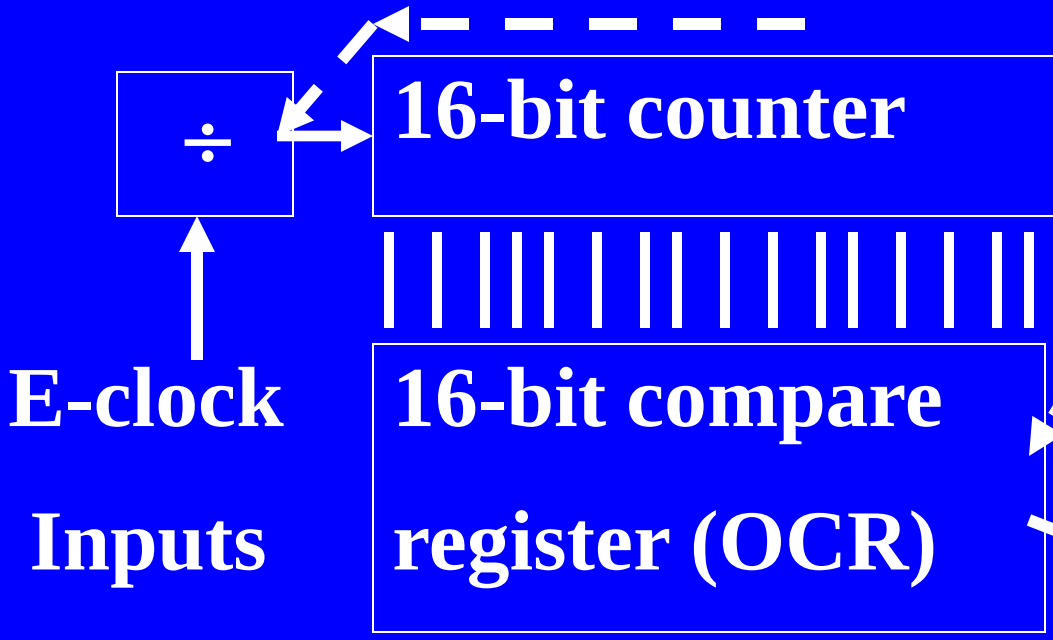
Reset OC flag, Read TCNT counts = x,
set output level to switch ON the unit and load **OCR** = with y1= (x + y),
unmask OC interrupt.

On OC interrupt, as per Force outputs register bits, set-reset output levels to switch on-Off the port connected units, reset OC flag and mask next OC interrupt.

68HC11 TCNT Registers



68HC11 TCNT Example



1 Load y1 for initiating an action when y1 = counts x

2 Action 1 on y1 = x: on ports pins as per present and force register bits

3 Action 2 on y1 = x: Out-compare interrupt and ISR runs

In-capture(s)

68HC11 TCNT Registers

Input Pin for capturing count values x

IC

Capture enable bits Register

Capture interrupt enable bits Register

E-clock Inputs

Finding a time interval between two events

Set input edge as desired, enable capture, reset IC flag, unmask IC interrupt, reset TOV flag and unmask OV interrupts,

Read x1 and x2 from TCNT register on IC interrupts for first and second events and find (x2− x1). On first event, set number of overflows k= 0.

Finding a time interval between two events contd.

No overflow case, interval = (x2 − x1).p.T, where T-input clock interval.

On overflow interrupt, increment k and reset flag and unmask next OV interrupt. If k >0, after second event mask OV and IC interrupts

The interval = $(x2 + 2^{16} \times k - x1).p.T$

Exemplary Applications

Finding period of a pulse at a port pin

Finding input frequency

Find time taken for an input event change

Find time taken for a weight-lifter to lift

Find time taken for a motor or rotating spindle in 1 or more revolutions

Simultaneous use of input capture (device 2) and out compare (device 1)

Output after certain interval from an input

1. Find capture time x0, from TCNT on the input on. [device 1 IC capture]

2. When device 1 interrupts, the OCR (device 2) is loaded x0 + y, where y.p.T is preset interval.

3. When OC interrupt occurs, an output occurs after y.p.T.

Simultaneous use of overflow(device 3) interrupt, input capture (device 2) interrupt for output using out compare (device 1)

1. When x0 read, the OCR (device 2) is loaded x0 + y

2. When device 3 interrupts, the k is decremented, if k > 0, OC (device 2) interrupt is kept masked and if k = 0,then then OC is unmasked and OV is masked.

3. On OC interrupt, the output occurs on TCNT reaching y after ($2^{16} * k$ + y).p.T.

PWM using Out-compare

Pulse width modulation by use of out compare (device 1)

Pulse width modulation

• Output remains 0 till TCNT reaches counts = x

2. Output = 1 till TCNT reaches x + y on each successive run of TCNT from 0000H to FFFFH.

3. y is set in OCR as per analog output needed on integrating PWM output at the OC pin.

Step1- Load OCR with x, unmask OC interrupt

Step 2 - On OC interrupt, send output = 1 at PWM output, load OCR with x+ y, reset OC flag, unmask OC interrupt again

Step 3 - When OC interrupt occurs,the output 0 at PWM output,which is again 0 after y.p.T.

$\times y/(2^{16})$

Summary

We learnt

Free running timer-counter devices -

- Overflow periods programmable by pre-scaling factor
- Out-compare register, out-compare enable, output (0,1, toggle) and OC interrupt mask programmable

We learnt

- In-capture, capture enable and capture edge, and IC interrupt mask programmable
- PWM output can be generated by two OC interrupts, one for output 0 and other for output 1

We learnt

Overflow interrupt(s) of timer-counter device -

- Initiate an action
- Initiate an action after pre-fixed number of overflows