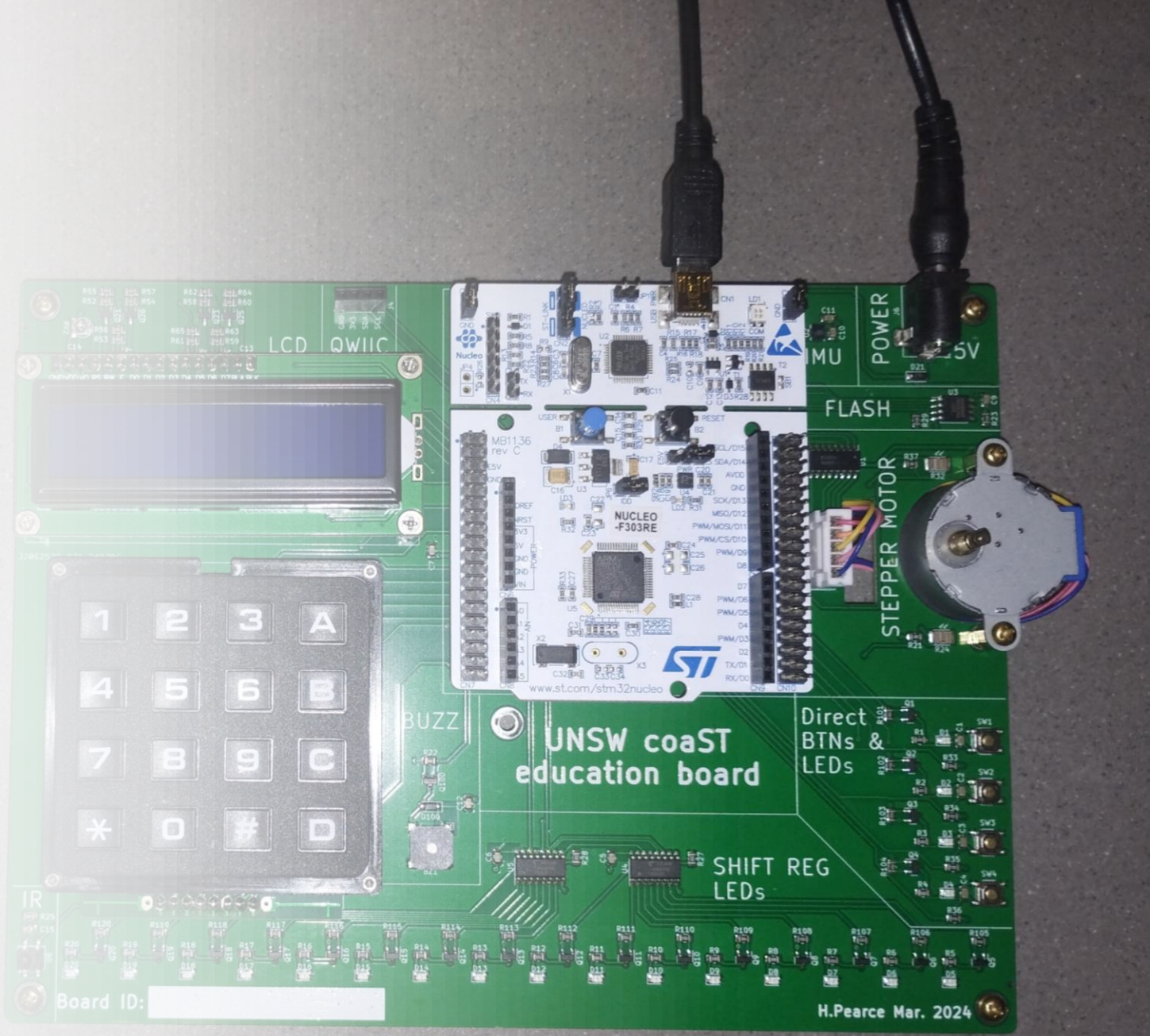
DESN2000 (Computer Engineering) 2025 T2

Timers

Hasindu Gamaarachchi



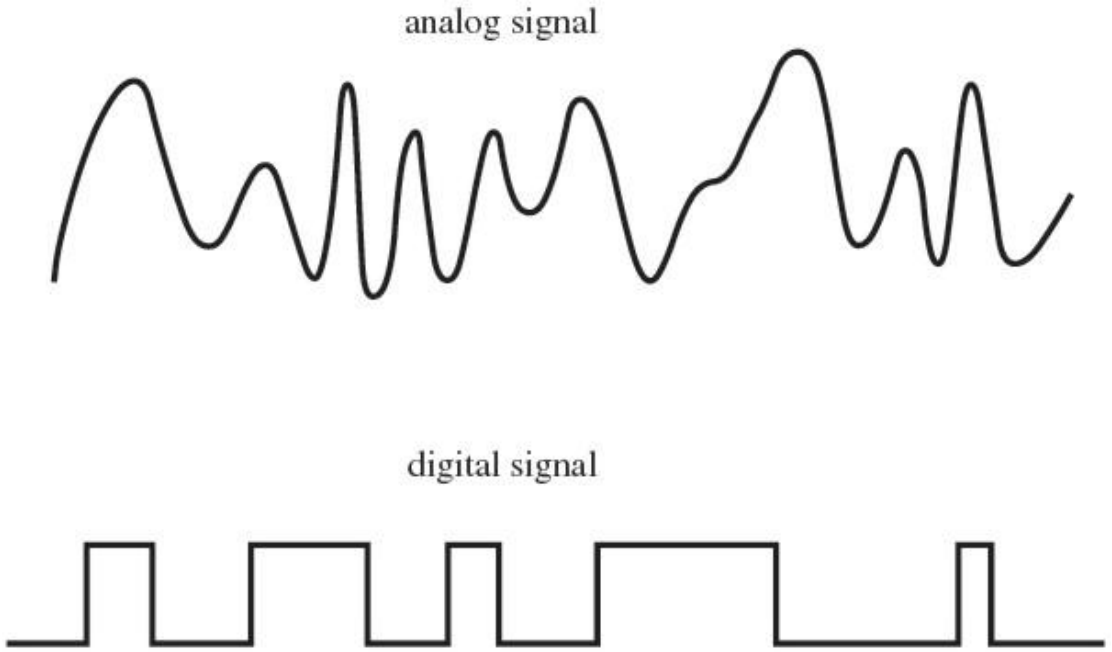
- Theory covered on the whiteboard
- Example coding on STM32 cubeIDE

General Purpose Timers

- Different modes
  - Timer mode (time base generator)
    - Generate a delay
  - Counter mode
    - Count external events (through an external timer input pin)
  - Input capture
    - Measure the duration between two events
  - Output compare
    - Indicates when the timer value matches the compare register value (e.g., assigned on an output pin)
  - PWM - discussed in week 5, Monday lecture
    - Control an analogue variable

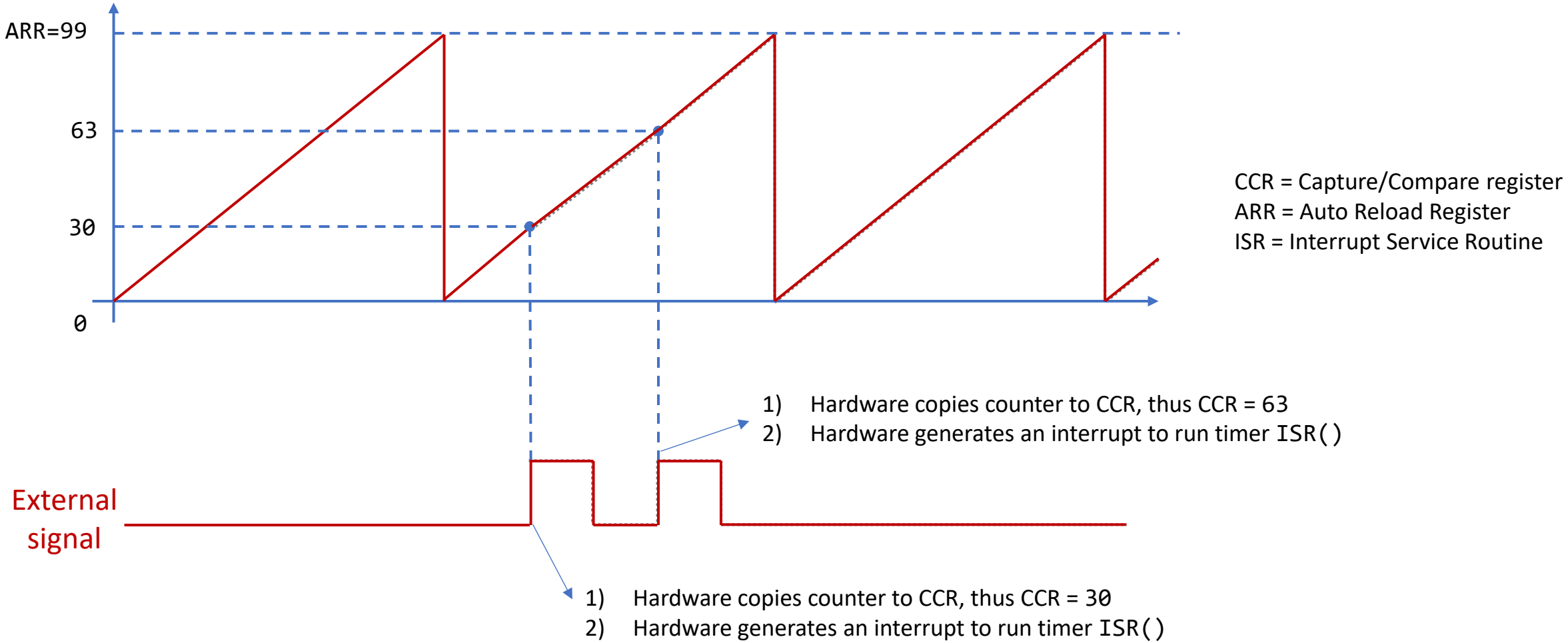
Input Capture Mode

- Capture the timestamp of the occurrence of a rising or a falling edge transition in a digital signal

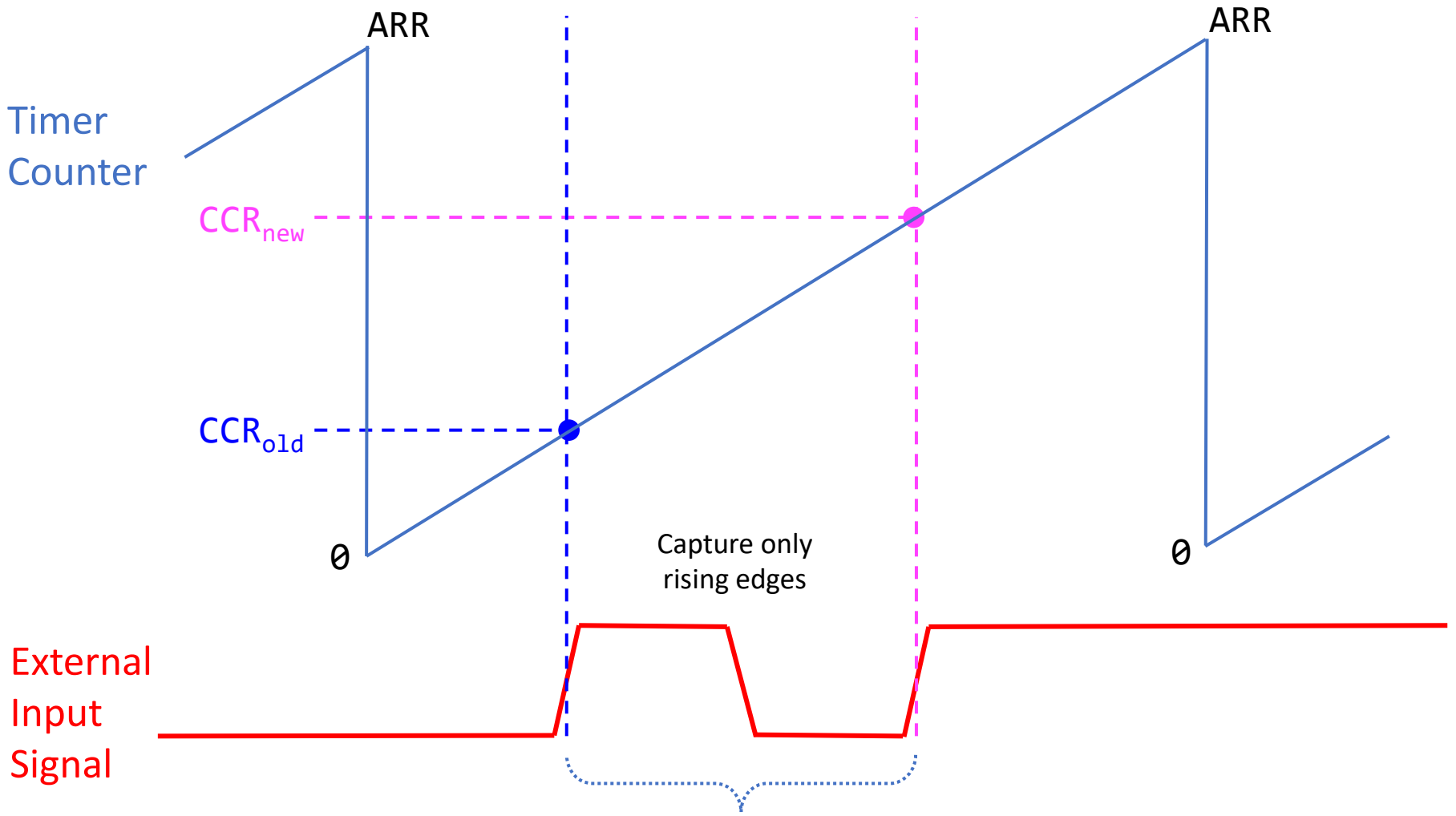


Input Capture

Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



Time span between two events = 63 – 30 = 33 time units



$$Time\ Span = (CCR_{new} - CCR_{old}) \times t_{period}$$

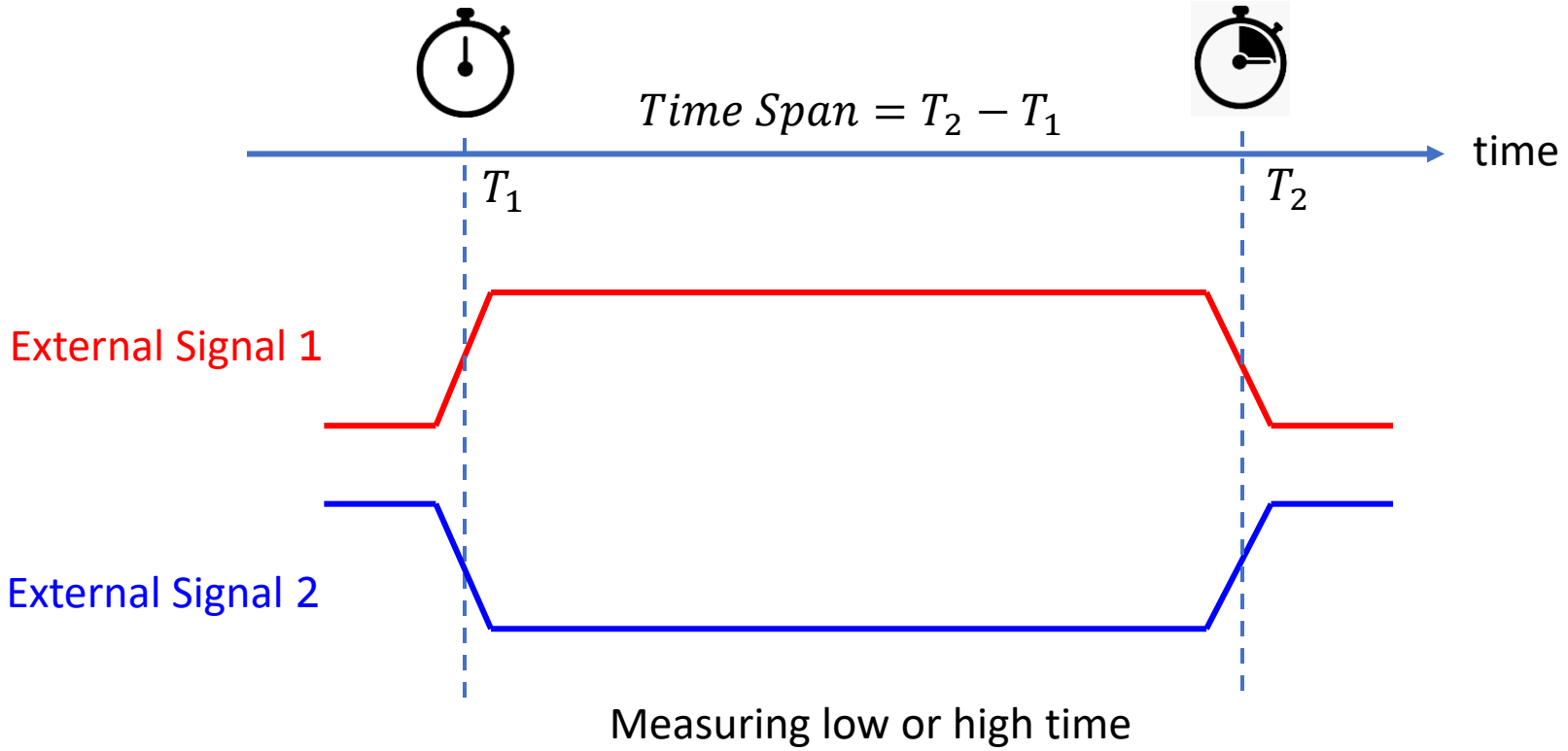
$$t_{period} = \frac{(ARR + 1)(PSC + 1)}{f_{clk}}$$

Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

Input Capture

Figure from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

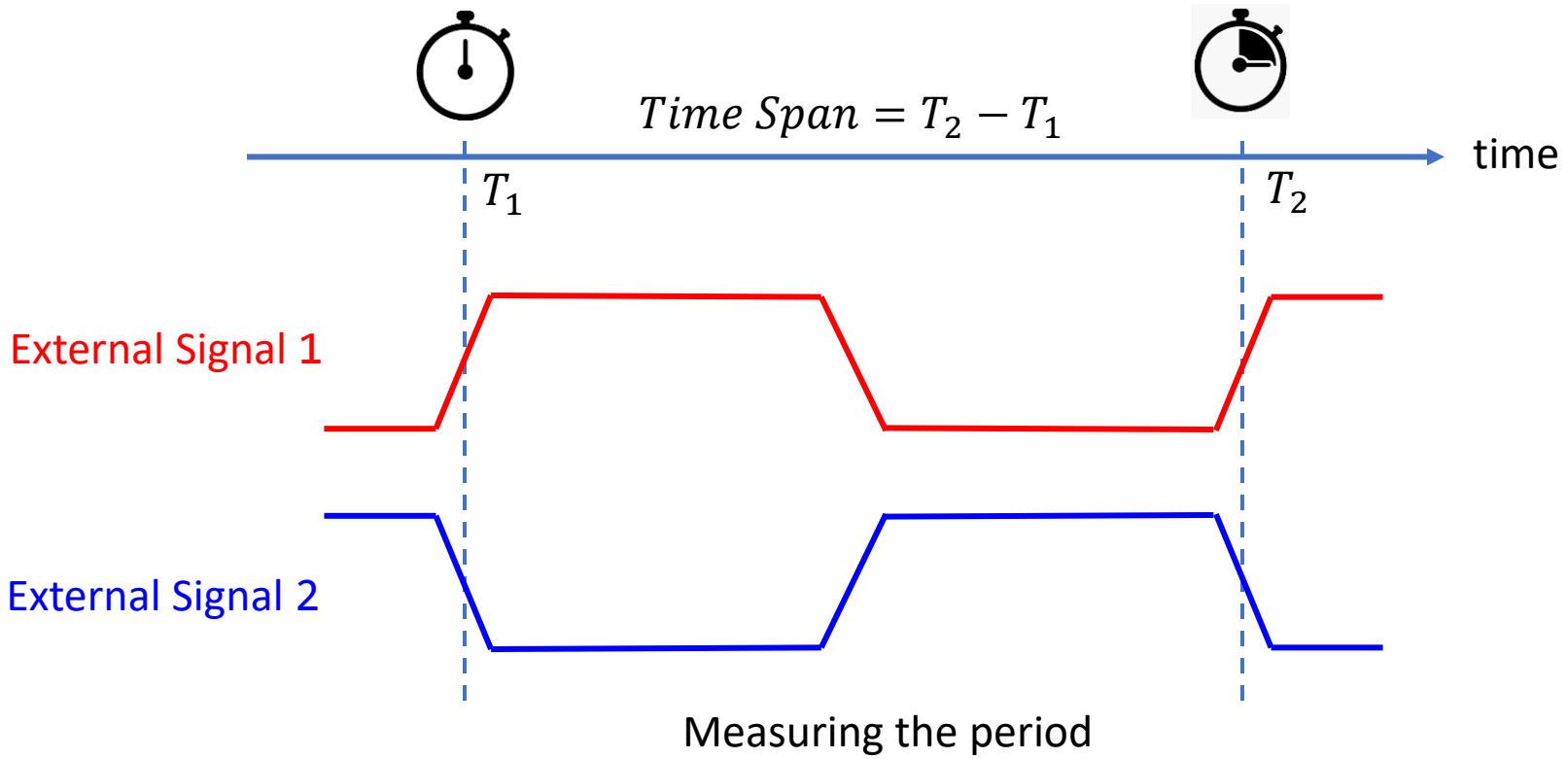
- Record the timestamp of an external event
- Capture both rising and falling edges



Input Capture

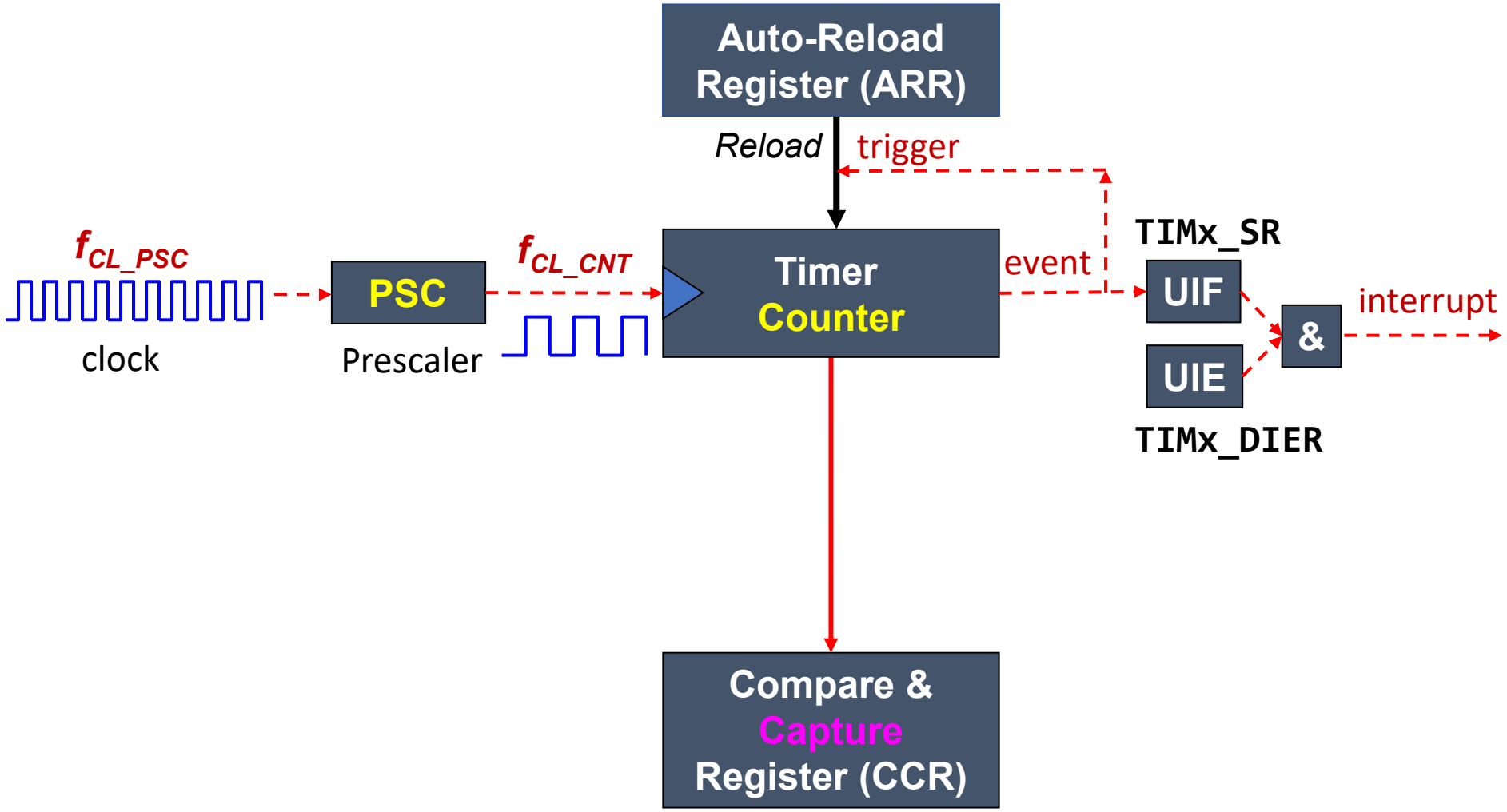
Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

- Capture only rising edges or only falling edges



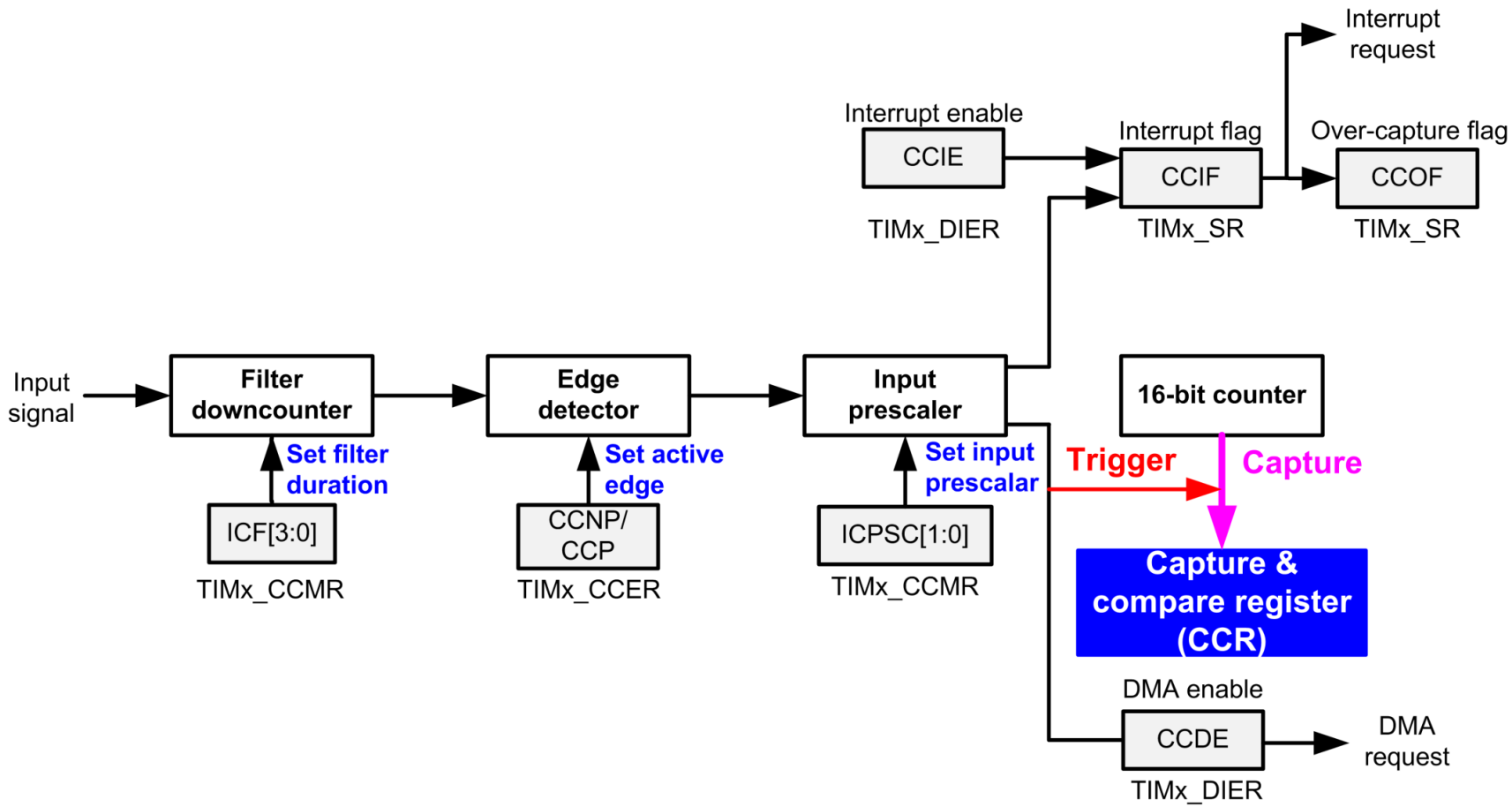
Timer: Input Capture

Figure from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



Input Capture Diagram

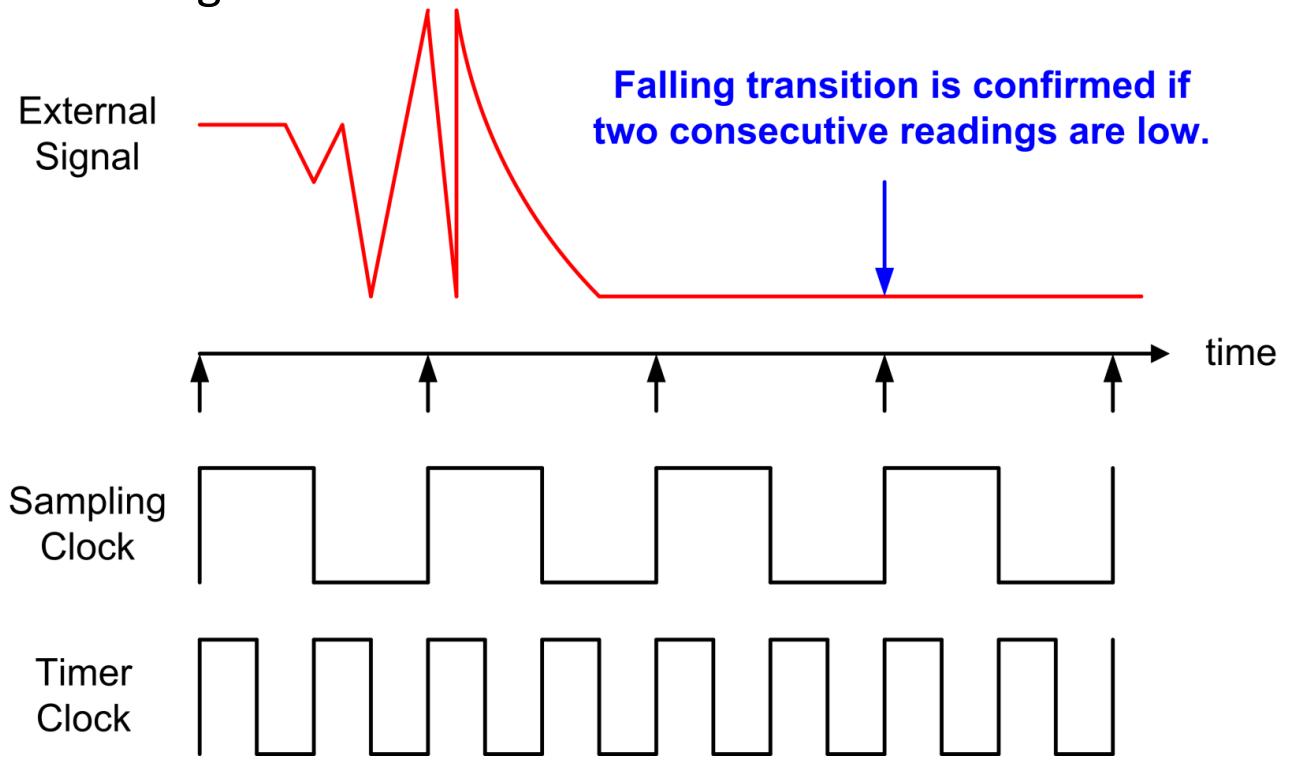
Figure from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



Input Filtering

Figure from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

- Digital filter for debouncing and noise removal
  - N consecutive

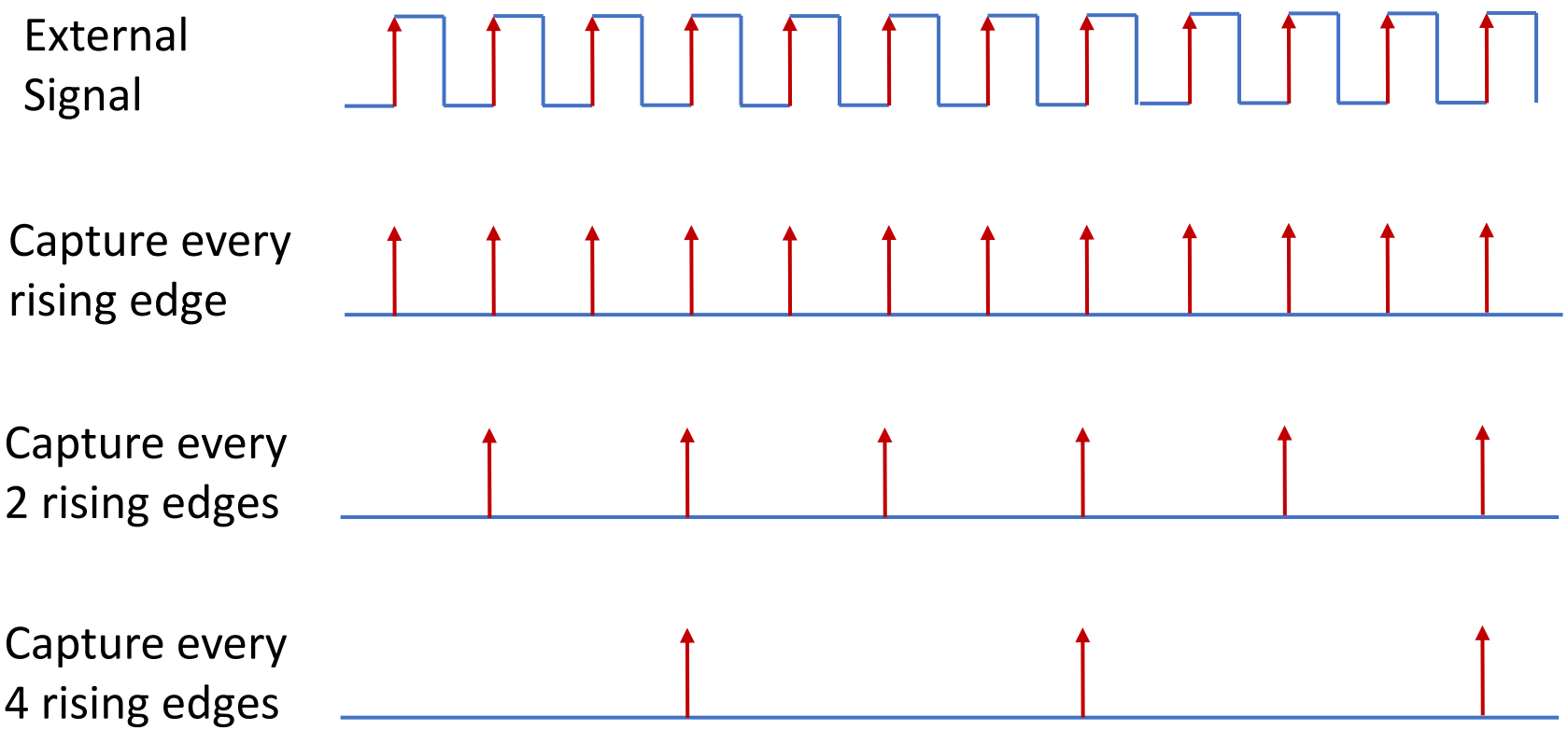


Filter acceptance = 2

Input Prescaler

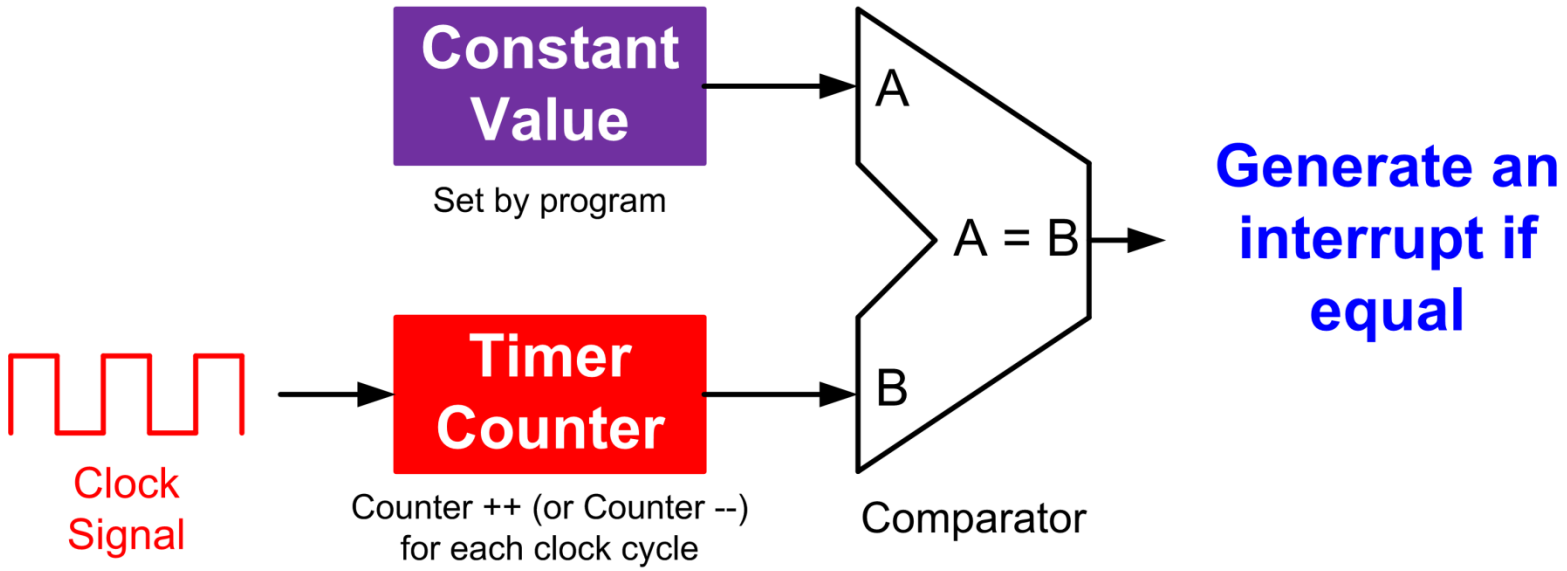
Figure from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

- Assume capture only rising edge



Output Compare

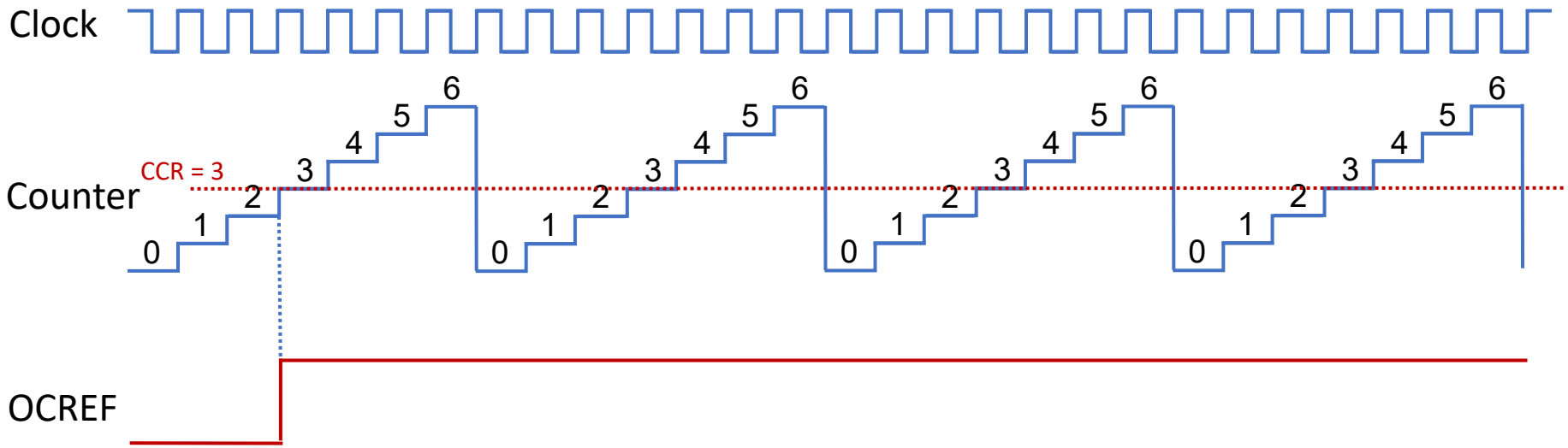
Slide from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



Output Compare (Active Mode)

Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

Upcounting mode, ARR = 6, CCR = 3



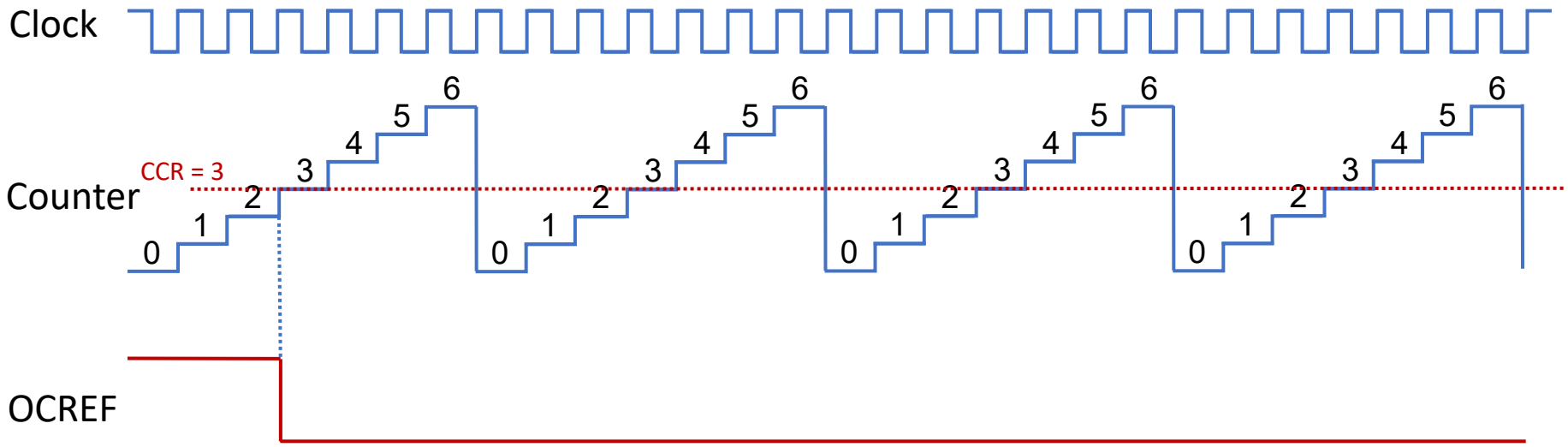
Active Mode

Timer Output (OCREF) = High if counter == CCR

Output Compare (Inactive Mode)

Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

Upcounting mode, ARR = 6, CCR = 3



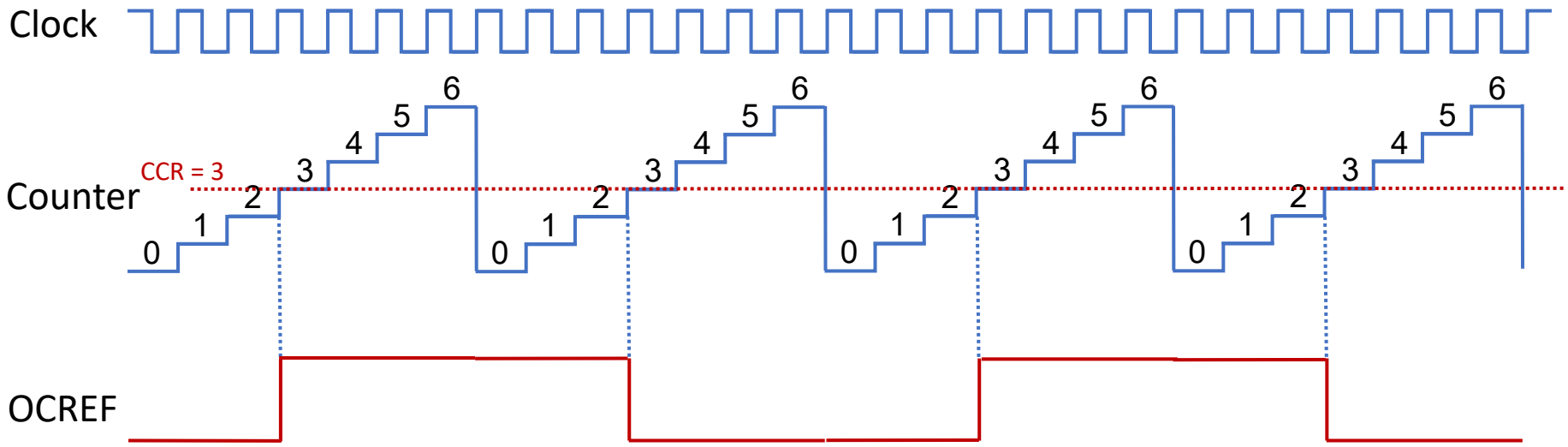
Inactive Mode

Timer Output (OCREF) = Low if counter == CCR

Output Compare (Toggle Mode)

Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

Upcounting mode, ARR = 6, CCR = 3

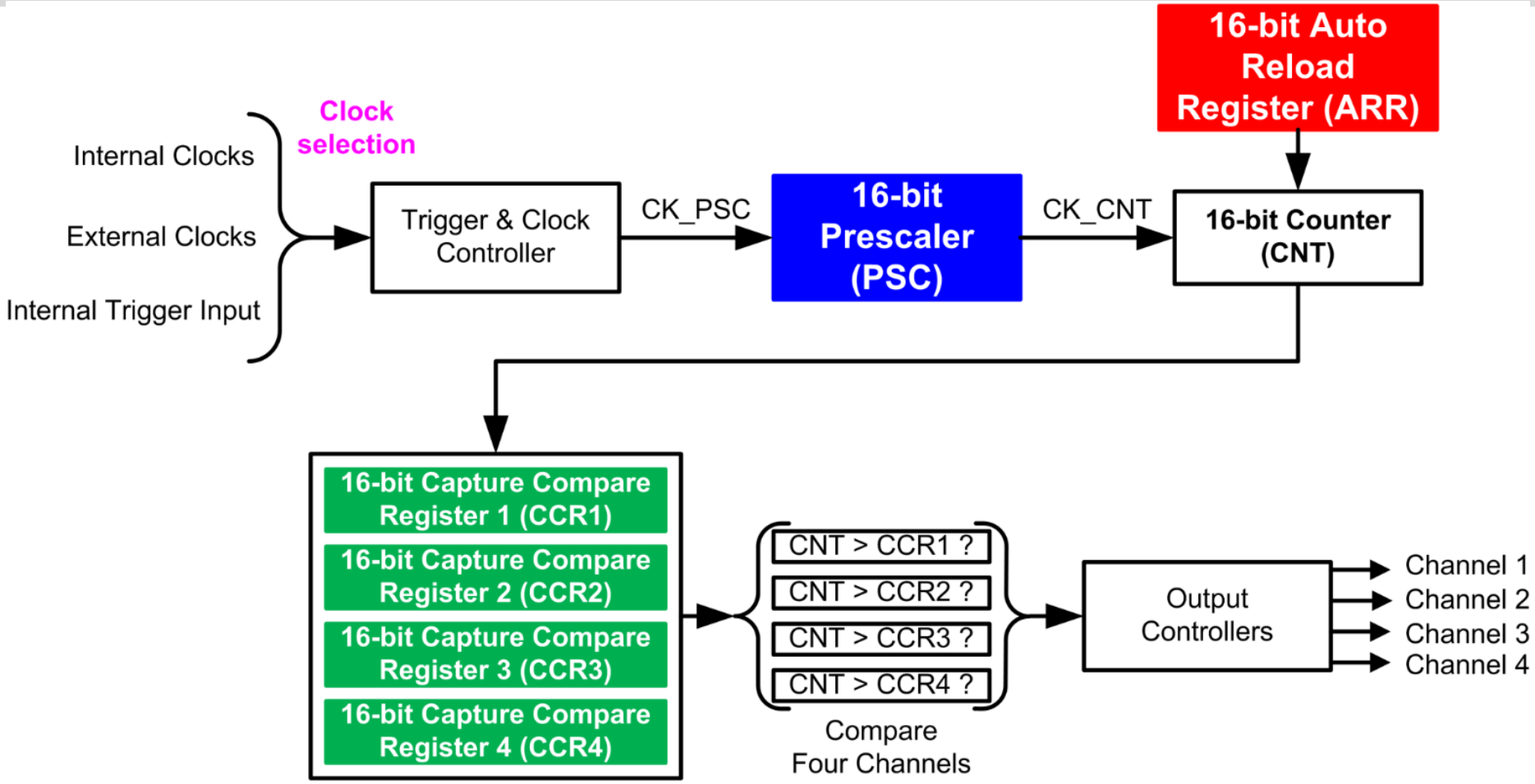


Toggle Mode

Timer Output (OCREF) = Toggle if counter == CCR

Multi-Channel Outputs

Figure adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



STM32 Timers

22.2 TIM6/TIM7 main features

Basic timer (TIM6/TIM7) features include:

- 16-bit auto-reload upcounter
- 16-bit programmable prescaler used to divide (also “on the fly”) the counter clock frequency by any factor between 1 and 65535
- Synchronization circuit to trigger the DAC
- Interrupt/DMA generation on the update event: counter overflow

Figure 247. Basic timer block diagram

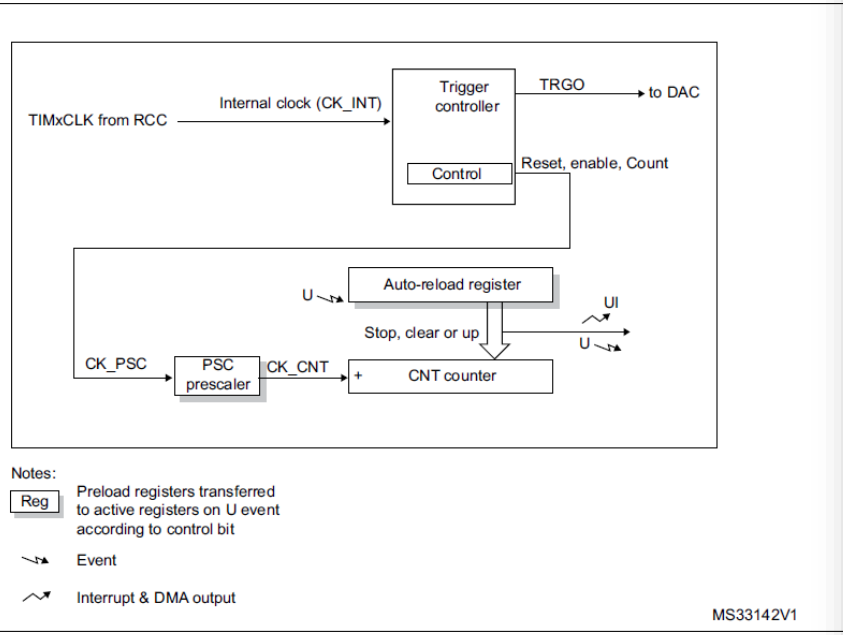
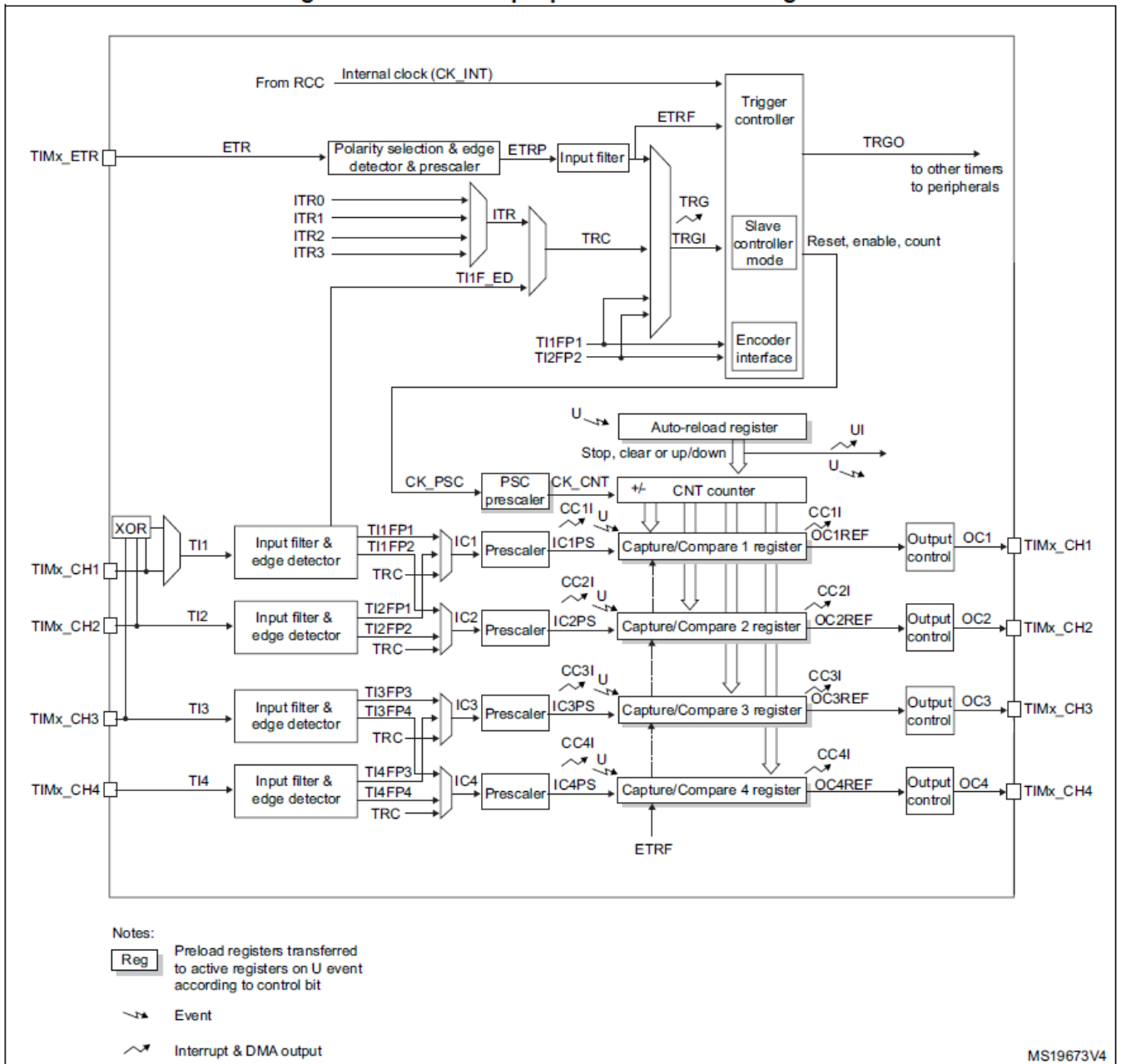


Figure 197. General-purpose timer block diagram



Real-time Clock

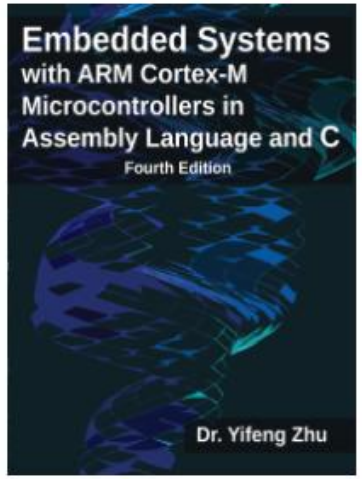
- RTC is a digital clock that provides calendar time and date.
- The RTC on STM32F303 supports:
  - Calendar with subsecond, seconds, minutes, hours (12 or 24 format), weekday, date, month, year, in BCD (binary-coded decimal) format
  - Two programmable alarms with wake-up from Stop and Standby mode capability.

https://wiki.st.com/stm32mcu/wiki/Getting_started_with_RTC

Learning Resources

"Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C (Fourth Edition)" – Yifeng Zhu

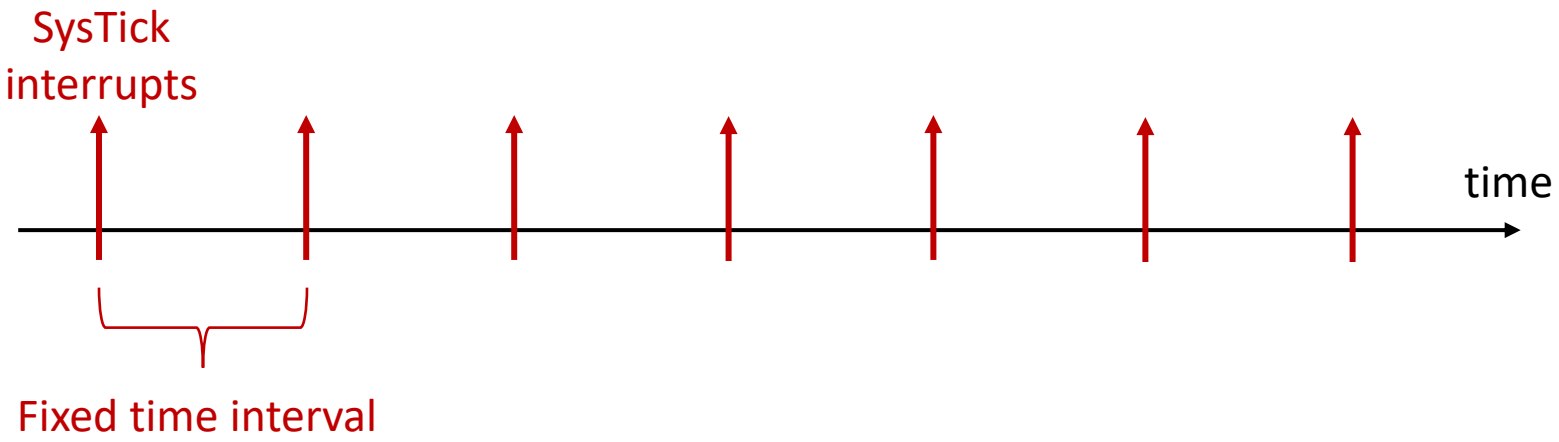
- General purpose timers - chapter 16

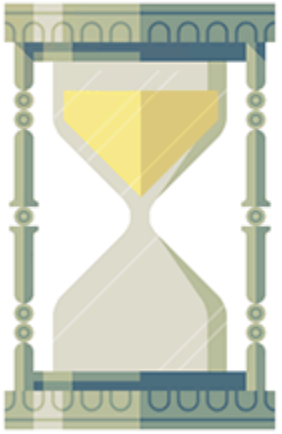


System Timer (SysTick)

Slide adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C

- Generate SysTick interrupts at a fixed time interval

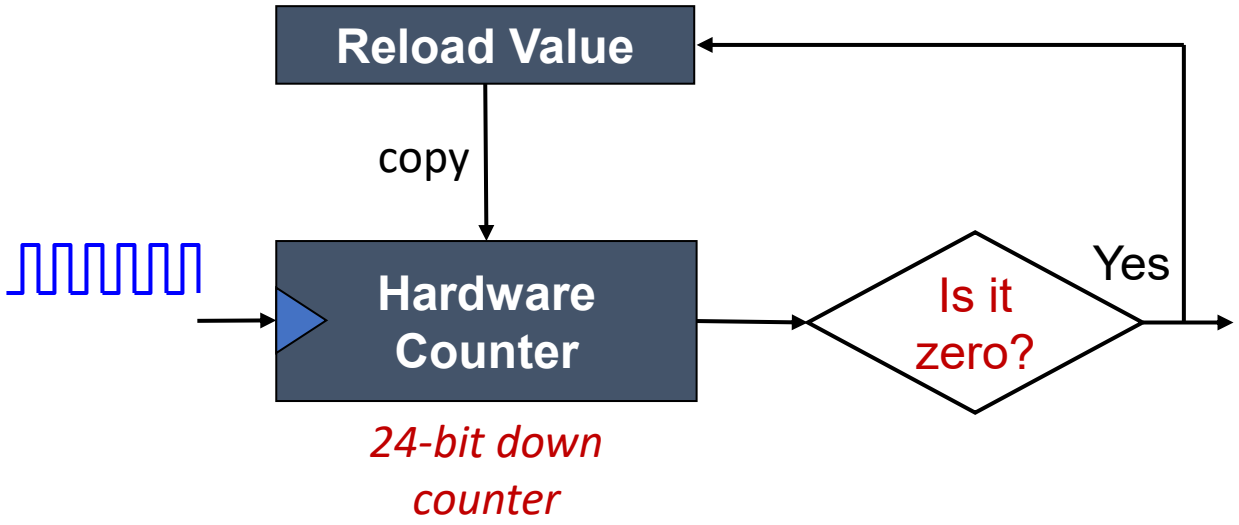




- Example Usages:
  - Measuring time elapsed, such as time delay function
  - Executing tasks periodically, such as periodic polling, and OS CPU scheduling

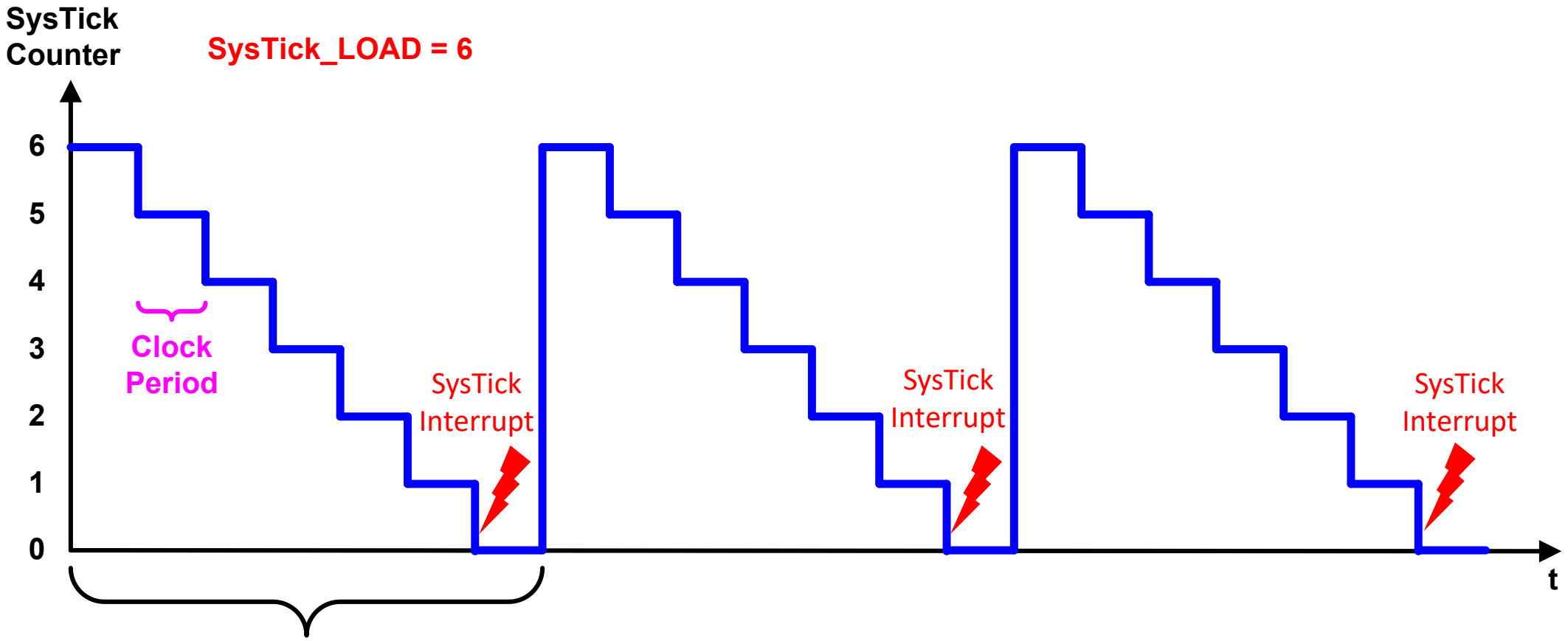
Diagram of System Timer (SysTick)

Slide adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



System Timer

Slide adapted from: Yifeng Zhu, Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C



SysTick Interrupt Time Period = (SysTick_LOAD + 1) × Clock Period = 7 × Clock Period

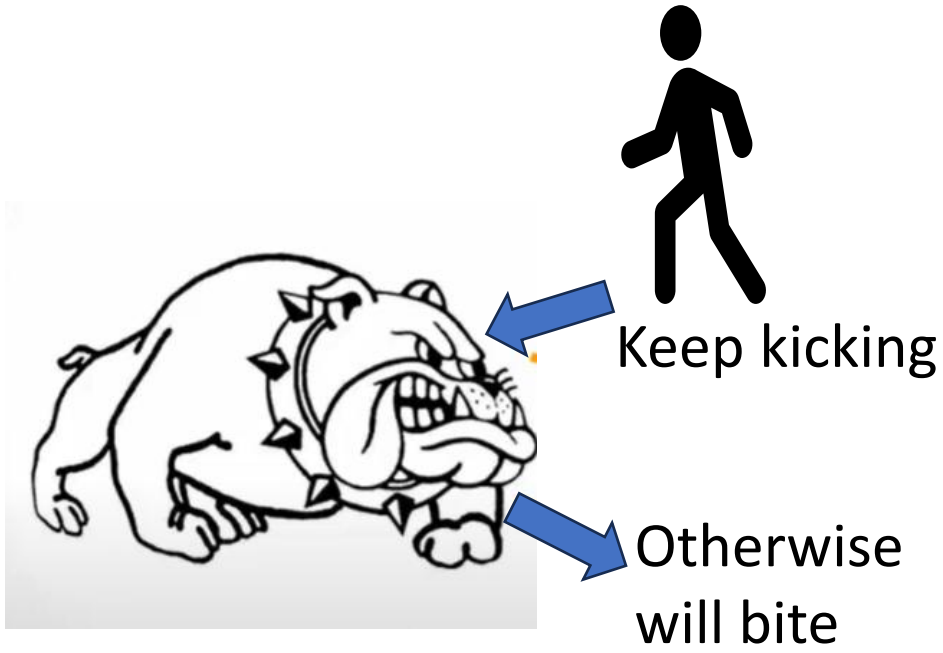
Learning Resources

"Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C (Fourth Edition)" – Yifeng Zhu

- Interrupts: System Timer - chapter 11

Watchdog Timer

- a timer that monitors microcontroller programs to see if they are out of control or have stopped operating
- Keep refreshing the watchdog timer's counter
- If not refreshed before timeout, the processor will reset



https://wiki.st.com/stm32mcu/wiki/Getting_started_with_WDG