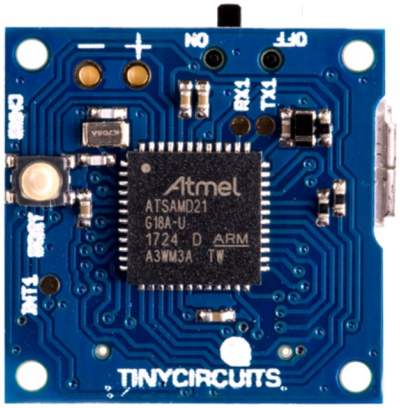
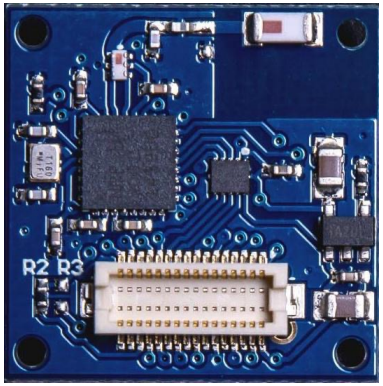
# CSE190 Fall 2023




## Lecture 6

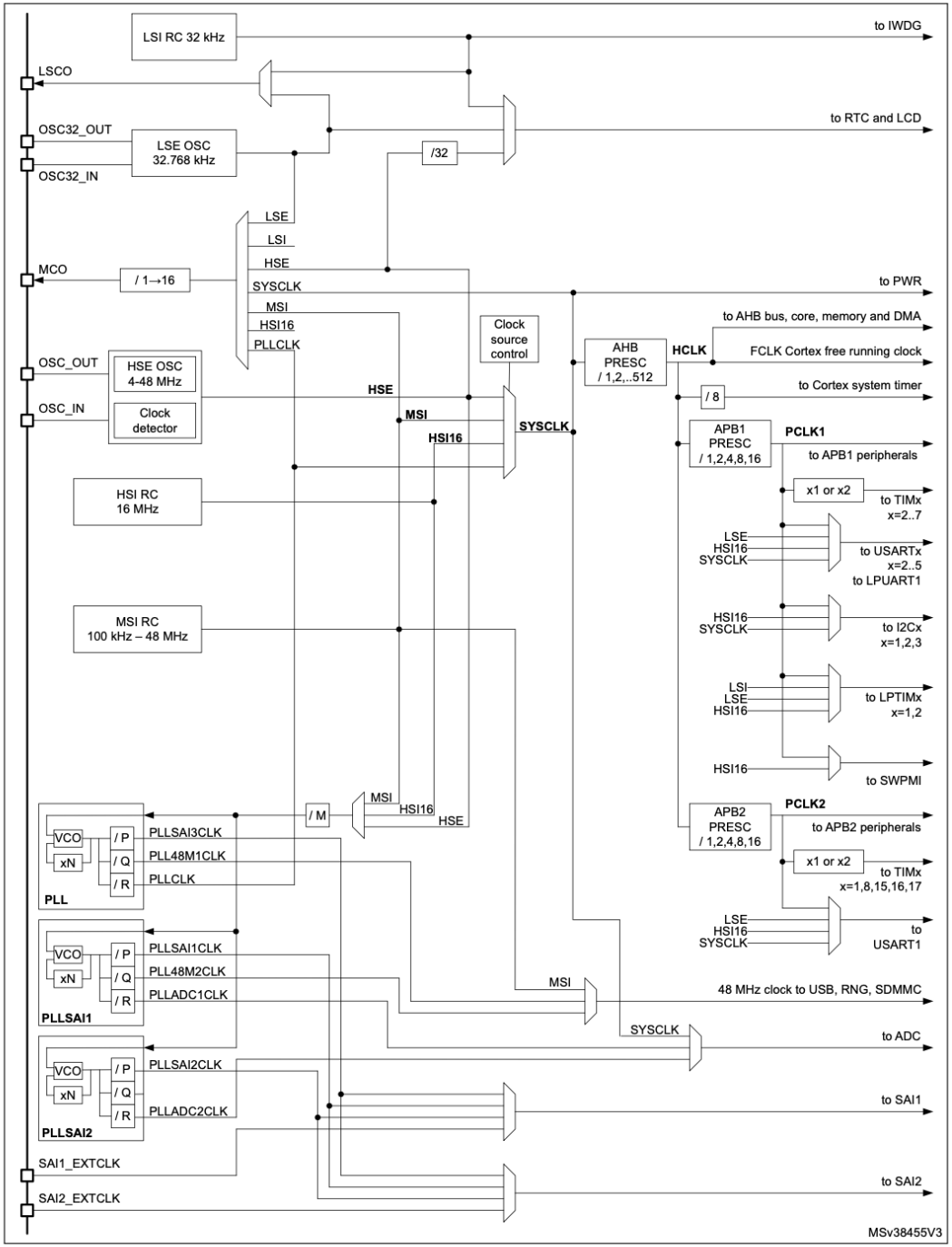
## Time



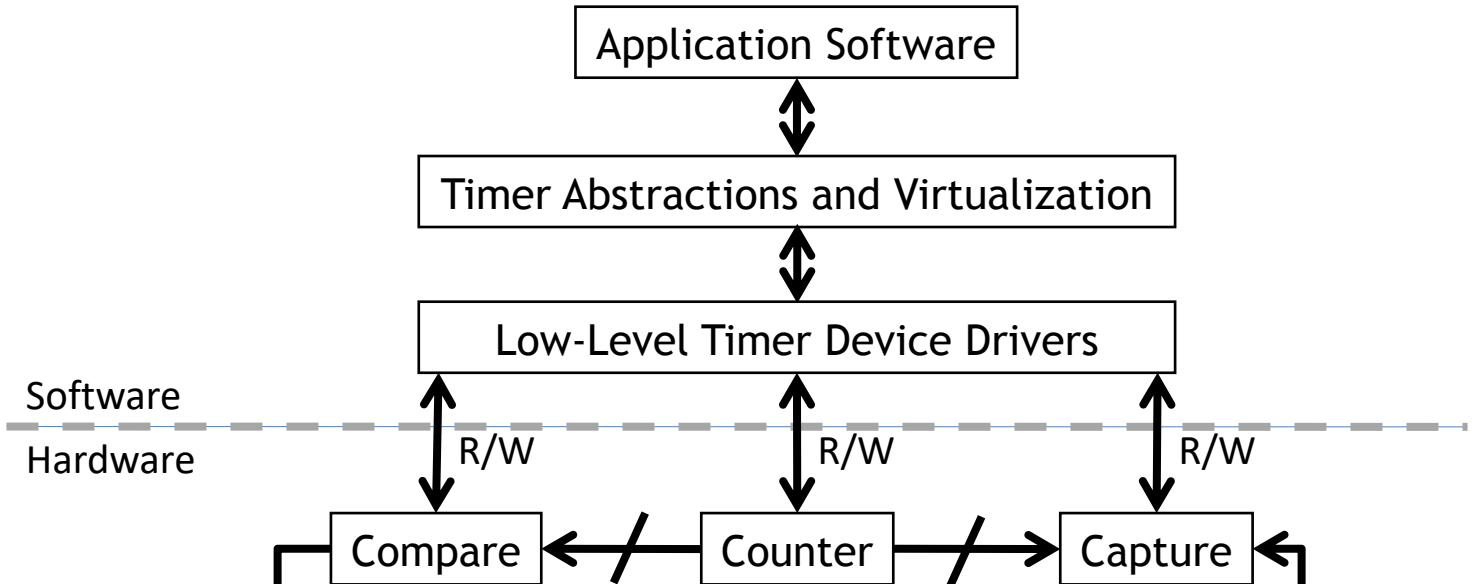

Wireless Embedded Systems

Aaron Schulman

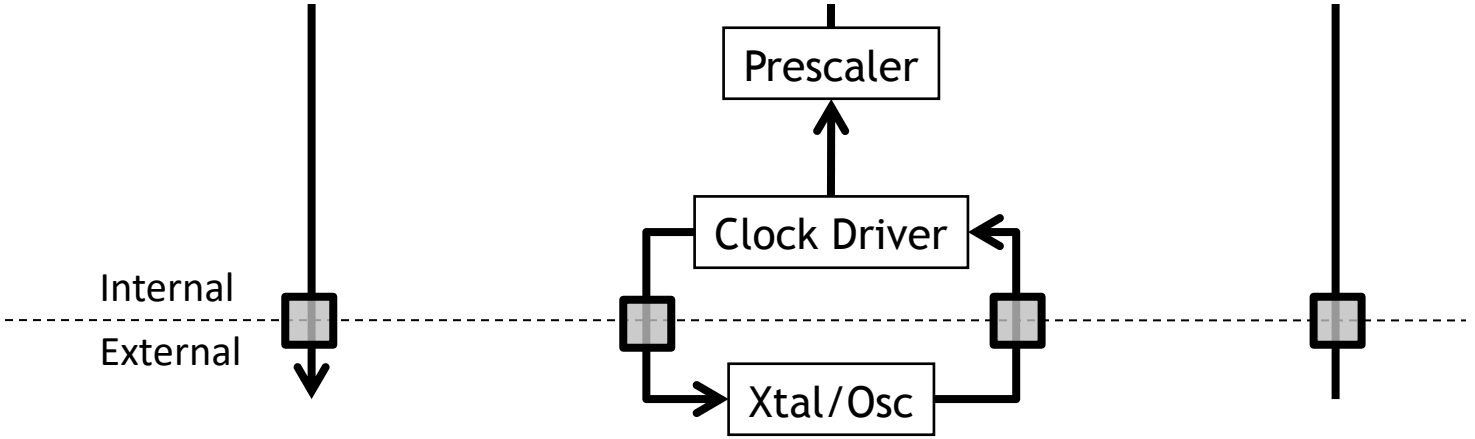
**Figure 15. Clock tree (for STM32L47x/L48x devices)**



# Timer: A peripheral for tracking time




**The purpose of the prescaler is to allow the timer to be clocked at the rate a user desires.**




**Frequency depends on the attached oscillator device**

Figure adapted from Prabal Dutta's EE373 slides

# Timers, why do we need them?

In the first project, what do we need timers for?

- Determining when to change LEDs
  - 20 Hz means change LED bits every 50 milliseconds
  - How to measure 50 ms?
  - Option 1: Use the timer hardware to let you know when 50 ms has passed.
  - Option 2: Count how many processor cycles it would take to equal 50 ms.

# How does the number in the counter register correspond to wall clock time?

Frequency (Hz) = Cycles / Second

**1 / Frequency (Hz) = Seconds / Cycle**

The counter is incremented once per cycle.

**You read 100 from the counter register which is clocked by a 1 MHz oscillator. How much time has passed since the counter was reset?**

# How should we choose the OSC frequency?

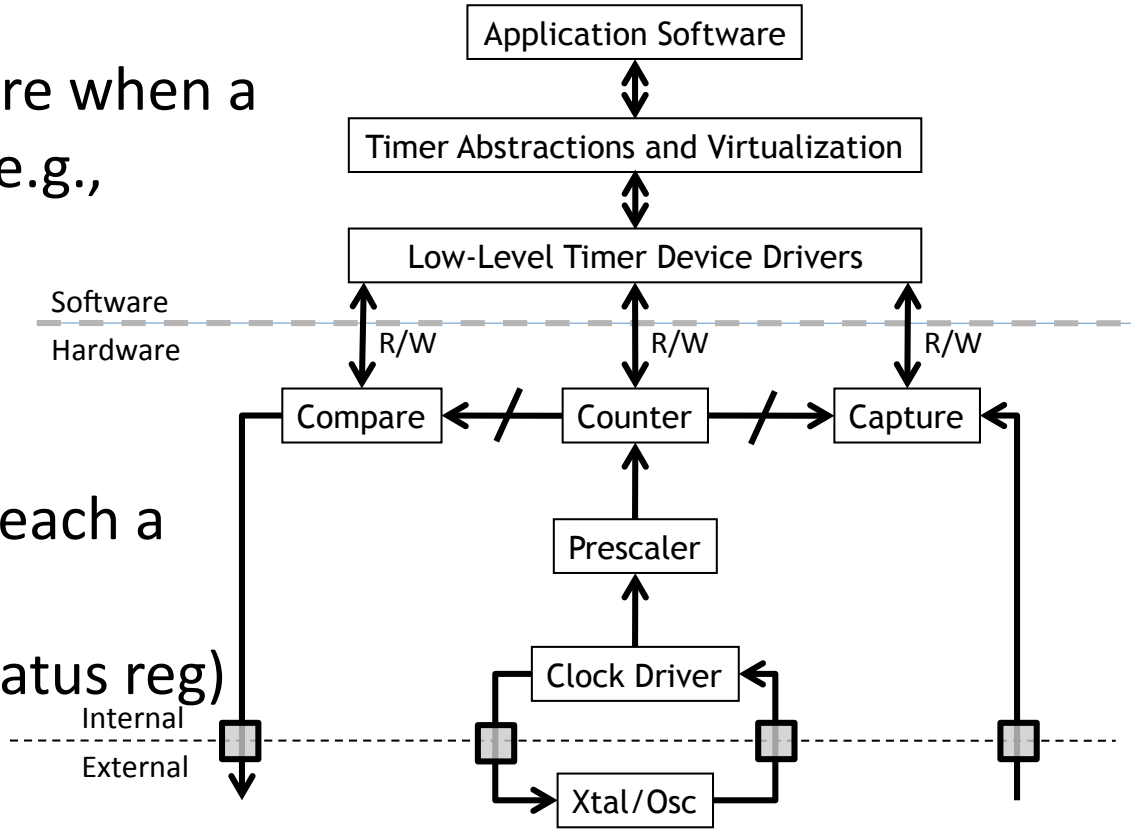
For timers, there will often be a tradeoff between resolution (high resolution requires a high clock rate) and range (high clock rates cause the timer to overflow more quickly).

1MHz OSC: resolution = 1 / 1e6 second = 1us
10MHz OSC: resolution = 1/10e6 second = 0.1us

16-bits timer:
1MHz OSC: max range = 1 / 1e6 * 2^16 = 65.536ms
10MHz OSC: max range = 1/10e6 * 2^16 = 6.5536ms

# How does a firmware developer use the capture register?

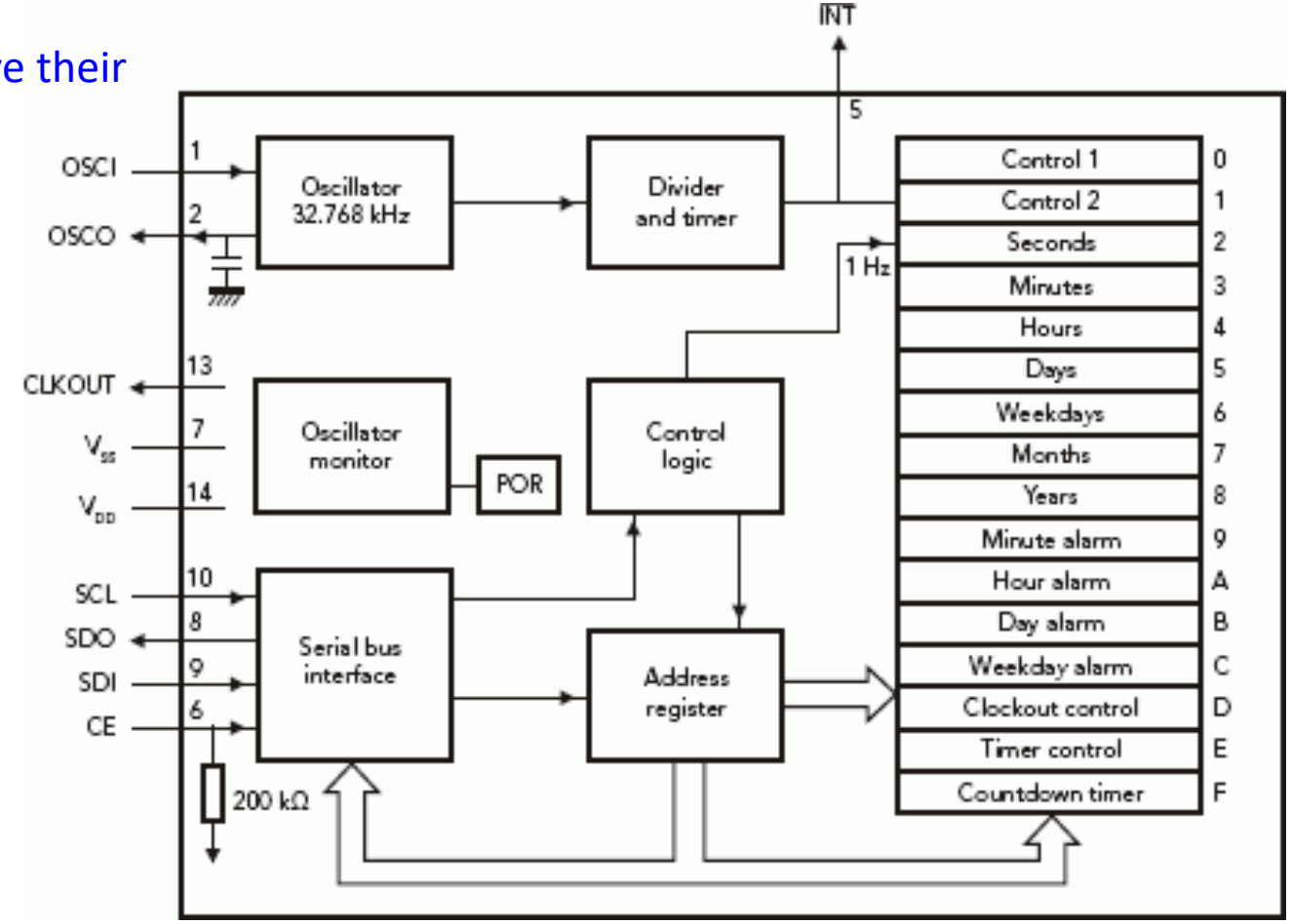
1. Stop the timer
2. Setup the timer to capture when a particular event occurs (e.g., change of GPIO pin)
3. Reset the counter
4. Start the timer
5. Wait for the counter to reach a capture event
   (via interrupt or check status reg)



# A timer for keeping track of wall-clock time
# Real Time Clock (RTC)

Note: RTCs have their own oscillator.

Why is it 32,768 kHz?




The reason the 32,768 Hz resonator has become so common is due to a compromise between the large physical size of low frequency crystals and the large current drain of high frequency crystals.

Figure adapted from Prabal Dutta's EE373 slides

# Interrupts

How peripherals notify the CPU that an event has occurred.

Example: GPIO detected that a button was just pressed.

# Interrupts

*Definition*

- An event external to the currently executing process that causes a change in the normal flow of software execution; usually generated by hardware peripherals, but can also be generated by the CPU.
- Key point is that interrupts are asynchronous w.r.t. current software procedure
- Typically indicate that some device needs service immediately

# Why interrupts?

- MCUs have many external peripherals
  - Keyboard, mouse, screen, disk drives, scanner, printer, sound card, camera, etc.
- These devices occasionally need the CPU to act
  - But we can't predict when
- We want to keep the CPU busy (or idle for power) between these events
  - Need a way for CPU to find out when a particular peripheral needs attention

# Possible Solution: Polling

- CPU periodically checks each device to see if it needs service
  - "Polling is like picking up your phone every few seconds to see if you have a call. …"

# Possible Solution: Polling

- CPU periodically checks each device to see if it needs service
  - "Polling is like picking up your phone every few seconds to see if you have a call. …"
  - Cons: takes CPU time even when no requests pending
  - Pros: can be efficient if events arrive rapidly