CSE190 Fall 2022
Lecture 5
GPIO (cont.) and Time

Wireless Embedded Systems
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Topology of a GPIO pin

Functional Description
Figure 23-2. Overview of the PORT
## GPIO Configurations

### 23.6.3.1 Pin Configurations Summary

Table 23-2. Pin Configurations Summary

<table>
<thead>
<tr>
<th>DIR</th>
<th>INEN</th>
<th>PULLEN</th>
<th>OUT</th>
<th>Configuration</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
<td>X</td>
<td>Reset or analog I/O: all digital disabled</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>0</td>
<td>Pull-down; input disabled</td>
</tr>
<tr>
<td>0</td>
<td>0</td>
<td>1</td>
<td>1</td>
<td>Pull-up; input disabled</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>0</td>
<td>X</td>
<td>Input</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>0</td>
<td>Input with pull-down</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>Input with pull-up</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>X</td>
<td>X</td>
<td>Output; input disabled</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>X</td>
<td>X</td>
<td>Output; input enabled</td>
</tr>
</tbody>
</table>
A fun extra feature: Drive Strength

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Parameter</th>
<th>Conditions</th>
<th>Min.</th>
<th>Typ.</th>
<th>Max.</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>$I_{OL}$</td>
<td>Output low-level current</td>
<td>$V_{DD}=1.62V-3V$, PORT.PINCFG.DRVSTR=0</td>
<td>-</td>
<td>-</td>
<td>1</td>
<td>mA</td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD}=3V-3.63V$, PORT.PINCFG.DRVSTR=0</td>
<td>-</td>
<td>-</td>
<td>2.5</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD}=1.62V-3V$, PORT.PINCFG.DRVSTR=1</td>
<td>-</td>
<td>-</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD}=3V-3.63V$, PORT.PINCFG.DRVSTR=1</td>
<td>-</td>
<td>-</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>$I_{OH}$</td>
<td>Output high-level current</td>
<td>$V_{DD}=1.62V-3V$, PORT.PINCFG.DRVSTR=0</td>
<td>-</td>
<td>-</td>
<td>0.70</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD}=3V-3.63V$, PORT.PINCFG.DRVSTR=0</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD}=1.62V-3V$, PORT.PINCFG.DRVSTR=1</td>
<td>-</td>
<td>-</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>$V_{DD}=3V-3.63V$, PORT.PINCFG.DRVSTR=1</td>
<td>-</td>
<td>-</td>
<td>7</td>
<td></td>
</tr>
</tbody>
</table>
What time is the Apple Watch tracking?

How often | Granularity

Clock (all the time | sec)
Alarm (all the time | sec)
Stopwatch (when open | msec)
Sync (all the time | sec)
UI (when open | msec)
Buzzer (when buzzing | msec)
WiFi (when communicating | usec)
Why do we need timers?

• In general, why do we need timers?
  – What time is it now?
  – How much time has elapsed since I last checked?
  – Let me know when this much time passes.
  – When did this external input occur?
What peripherals do we use to track time?

*(all the time | sec)* - [Alarm, Sync]

*32-bit Real time clock (RTC)* peripheral with interrupts

*(when open/buzzing | msec)* - [Stopwatch, UI, Buzzer]

Processor’s *timer* peripheral with interrupts

*(when communicating | usec)* - [WiFi]

WiFi chip’s internal timer peripheral with interrupts
What peripherals do we use to track time?

*(all the time | sec)* - [Alarm, Sync]

32-bit Real time clock *(RTC)* peripheral with interrupts

The term is used to avoid confusion with ordinary hardware clocks which are only signals that govern digital electronics, and do not count time in human units.

*(when open/buzzing | msec)* - [Stopwatch, UI, Buzzer]

Processor’s *timer* peripheral with interrupts

*(when communicating | usec)* - [WiFi]

WiFi chip’s internal timer peripheral with interrupts
Why do we need timers?

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

• Determining when to change LEDs
  – 20 Hz means change 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.
What is measuring the time?
Oscillators (generally, crystal oscillators)

Video: Crystal oscillators "go to war"