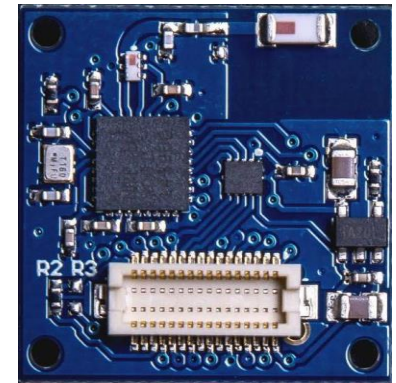
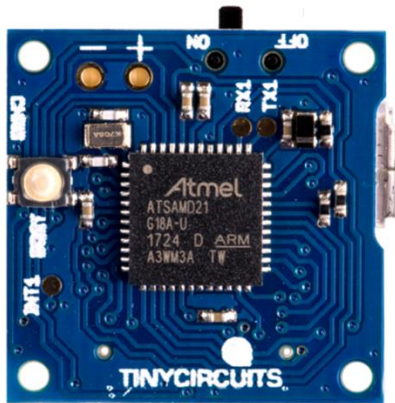


# CSE190 Winter 2025

## Lecture 22

# Power Management



Wireless Embedded Systems

Aaron Schulman

# Power and energy

- Power: the rate of energy being transferred over time
- The unit typically used is “Watt”
  - $1 \text{ Watt} = \frac{1 \text{ Joule}}{1 \text{ Second}}$
- Energy: power dissipated over time
- The unit typically used is “Joule”
  - $1 \text{ Joule} = 1 \text{ Watt} \times 1 \text{ Second}$
- Devices are typically rated in Watts (milliwatts)
- Batteries are typically rated in Joules (milliwatt hours)

# Example: Smartphone battery



# Power dissipation of microcontrollers has two components: dynamic and static

- $P_{total} = P_{dynamic} + P_{static}$
- Dynamic power dissipation
  - Switching load capacitance (majority of power)
  - Short-circuit current (minority of power)
- Static power dissipation
  - Leakage due to imperfections in transistor design
- We only care about static over long intervals

# Dynamic power consumption

- Mostly the power dissipated changing states
  - Running instructions
  - Communicating over a bus
  - **Anything that needs a clock uses dynamic power**
- Related to clock frequency ( $f$ ) and voltage ( $V$ )
- $P_{switching} = CV^2f$ 
  - Run your device at as low voltage as possible
  - Run your CPU or peripheral at as low clock freq as possible
- Many microcontrollers run logic at low voltages to save energy

# Static power consumption

- Common device to worry about is SRAM
  - SRAM leaks power to stay in the same state
- The only way we can stop it is to turn it off
  - But then you lose data in SRAM
- If you want to go idle for a long time, move information into persistent storage.

# How to save dynamic power

## **Clock gating**

**Clock gate:** A circuit that disconnects a clock from a device

- Eliminates all switching activity in that device
  - No dynamic power consumption
  - Minimal recovery time (just ungate the clock)
  - Also effectively makes it useless (as you learned already)
- However, keeps device powered (static power)
  - Retains configuration in registers