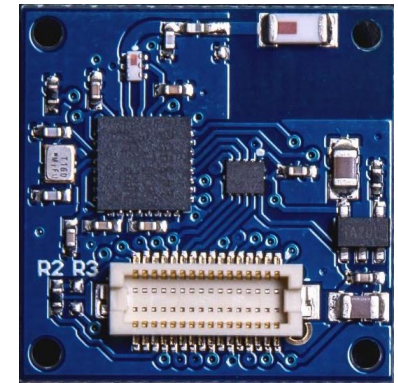
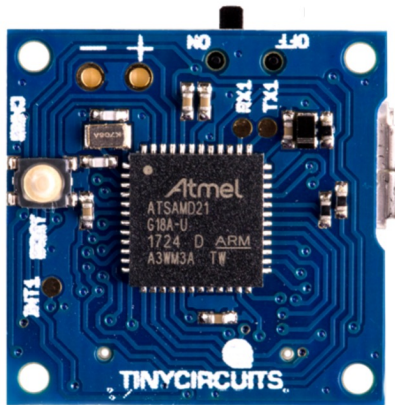


CSE190 Winter 2022

Lecture 17

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



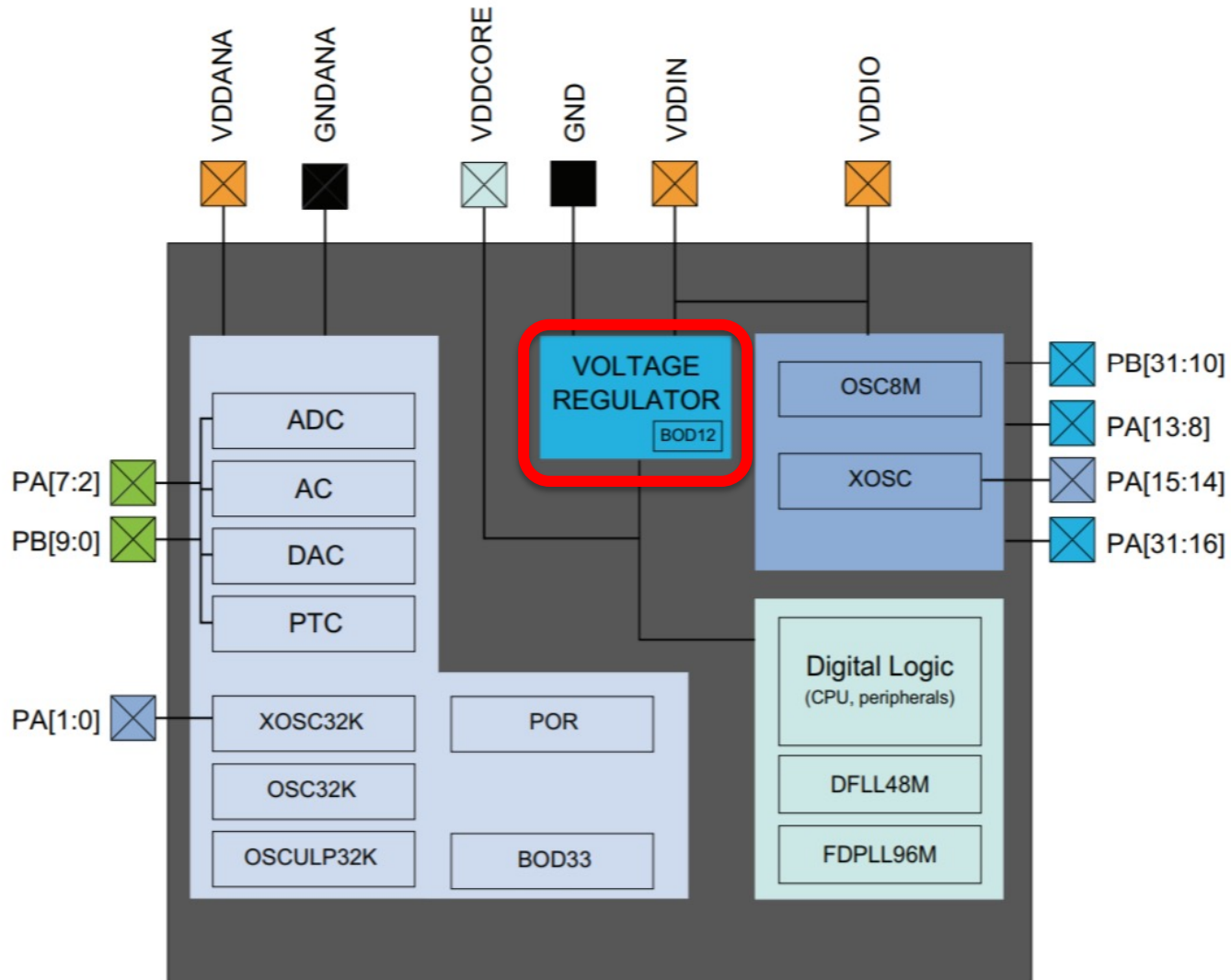
Power dissipation of microcontrollers has two components: dynamic and static

- $P_{total} = P_{dynamic} + P_{static}$
- 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

This is why SAM21D always regulates 1.6-3.6V input down to 1.2V



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

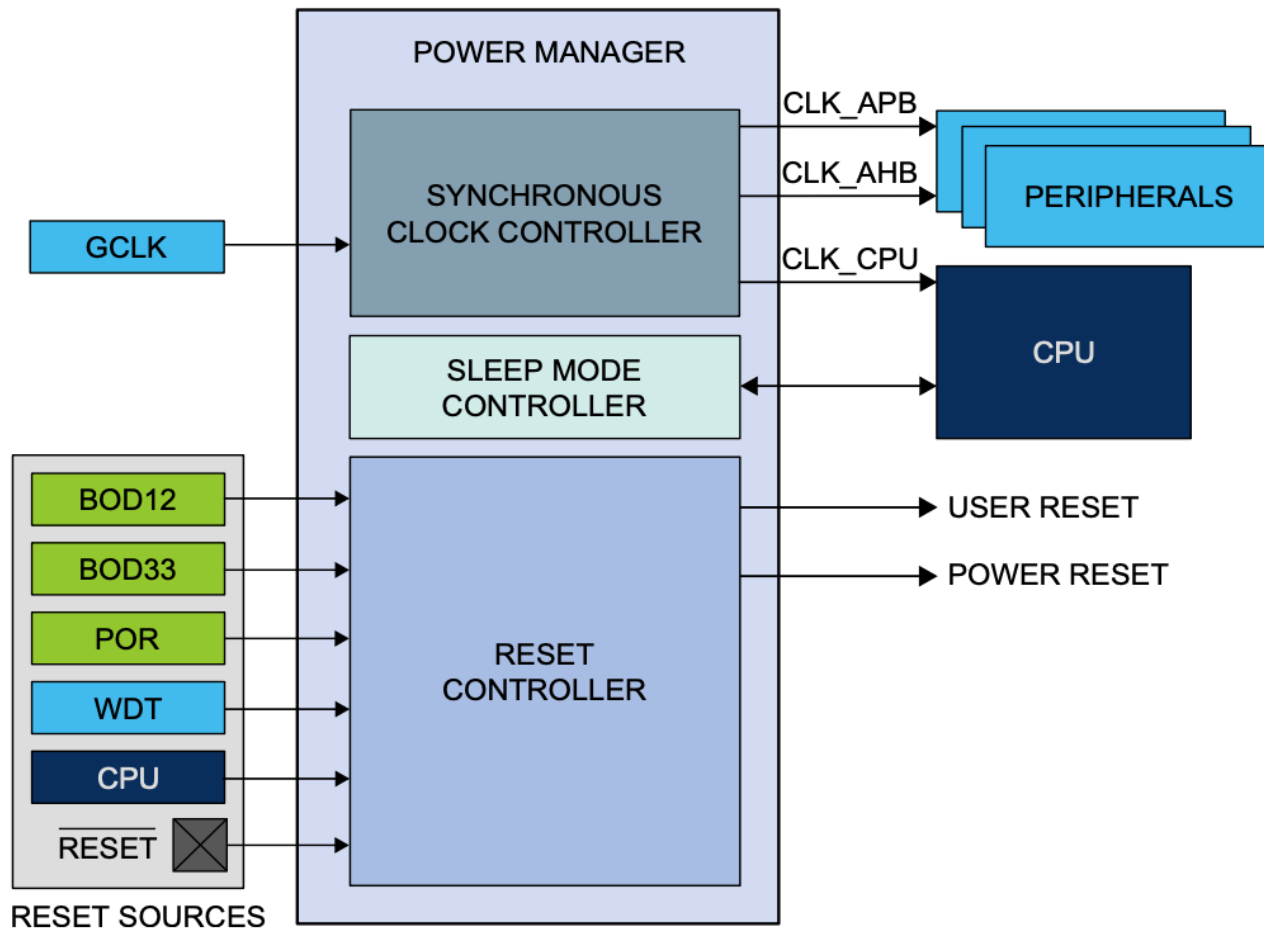
Clock gating

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

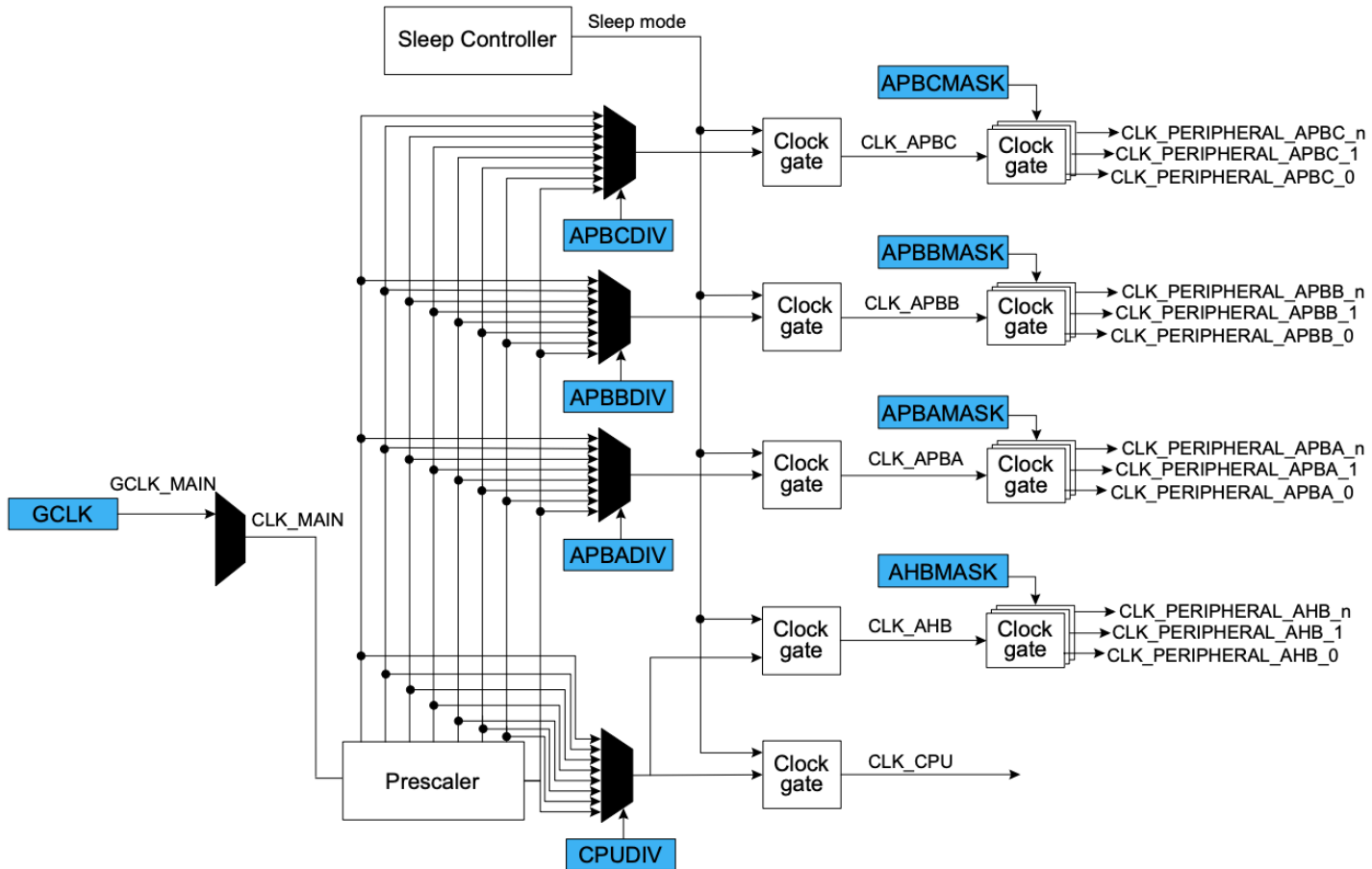
- Eliminates all switching activity in that device
 - No dynamic power consumption
 - Minimal recovery time (just ungate the clock)
 - Also effectively makes it useless (as you learned already)
- However, keeps device powered (static power)
 - Retains configuration in registers

Power management peripheral: Controlling static and dynamic power from software

Figure 15-1. PM Block Diagram



Peripherals: PM lets you disable and enable clocks for peripherals



When should you disable and enable a clock for peripherals?