

Week 9 - Power Management

If a circuit draws 1 Amp current from a battery rated 1 Ah, the battery will last max 1 hour.

$$\text{MaximumTime} = \text{BatteryCapacity}(mAh) / \text{CurrentDraw}(mA)$$

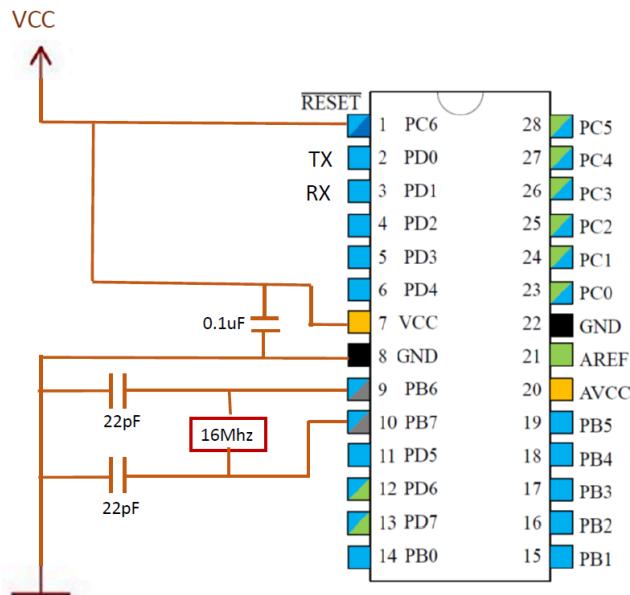
Reducing Power Consumption

- **Hardware:**
 - Use efficient voltage regulators
 - Lower operating voltage, cpu clock speed
 - Take ATmega328p out of Arduino (use standalone)



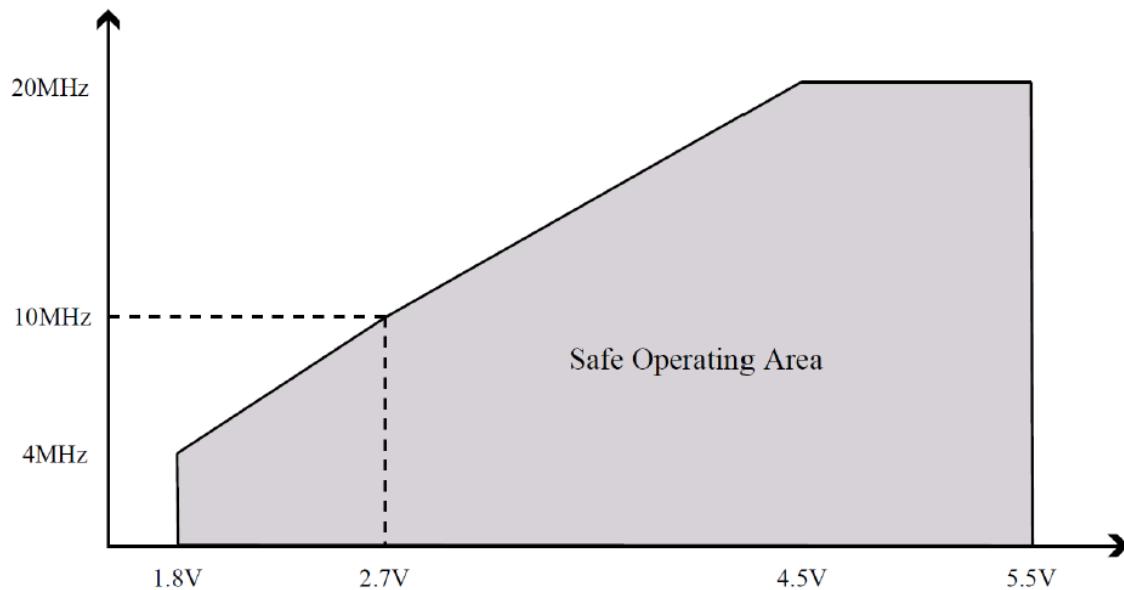
ATmega328p out of Arduino (Standalone)

- PC6 is the RESET PIN. It is active low. It must be tied HIGH to prevent resetting.
- A bypass capacitor ($0.1\mu F$) should be placed across VCC and GND.
- ATmega328p has 8MHz and 128kHz internal oscillators. External clock crystal is not necessary. However, the built-in boot-loader only works with 16MHz frequency.
- Connect the ADC power pins if you need to use ADC.



The Arduino can still be used to program the controller by connecting the RX, TX, and RESET pins.

- Why Arduino consumes more power:
 - Linear voltage regulator (70% efficiency)
 - Internal LEDs
 - USB-Serial conversion
- Voltage and clock speed need to be reduced in conjunction, otherwise CPU doesn't function properly.



- **Software Based Techniques:**

- Turn off external devices.
- Turn off ADC, Analog Comparator, Timers
- Set unused GPIO pins as output.
- Set to sleep mode.
 - Turn off brown-out detector during sleep.
 - Brown-out detector resets the microcontroller when the power supply falls below a specific level.
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- **Other Ways:**

- Cut off Vcc when idle
- Give power periodically (in response to sensor values via latching circuit)

Designing Power Efficient Systems:

- Turn off ADC and others (if not needed)

- Sleep mode
- Enable and use interrupts to wake up CPU.

Raspberry Pi 3

- Requires significantly more current due to being more complex and running a OS.
- Chip can't be removed unlike ATmega
- Uses Dynamic Voltage and Frequency Scaling (DVFS)
- The Pi is designed to run at specific voltages (core voltages are adjusted dynamically, but the main supply is usually 5V). Varying the *input* voltage (e.g., 4.5V, 4.0V, 3.5V) to a 5V-regulated system isn't standard and will just cause it to fail below the minimum required voltage (typically 4.6V for 5V input).
- Wifi, Bluetooth can be turned off for reduced power usage.
- **Suspend-to-RAM** is a low-power state for a computer system (including embedded systems like the Raspberry Pi) where the CPU and most peripherals are powered down, but the **main system memory (RAM) remains powered**.