
CS 150 Digital Design

Lecture 23 – Course Wrap-Up

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Sad fact: Computers turn
electrical energy into heat.
Computation is a byproduct.

Energy and Performance

Air or water carries heat
away, or chip melts.



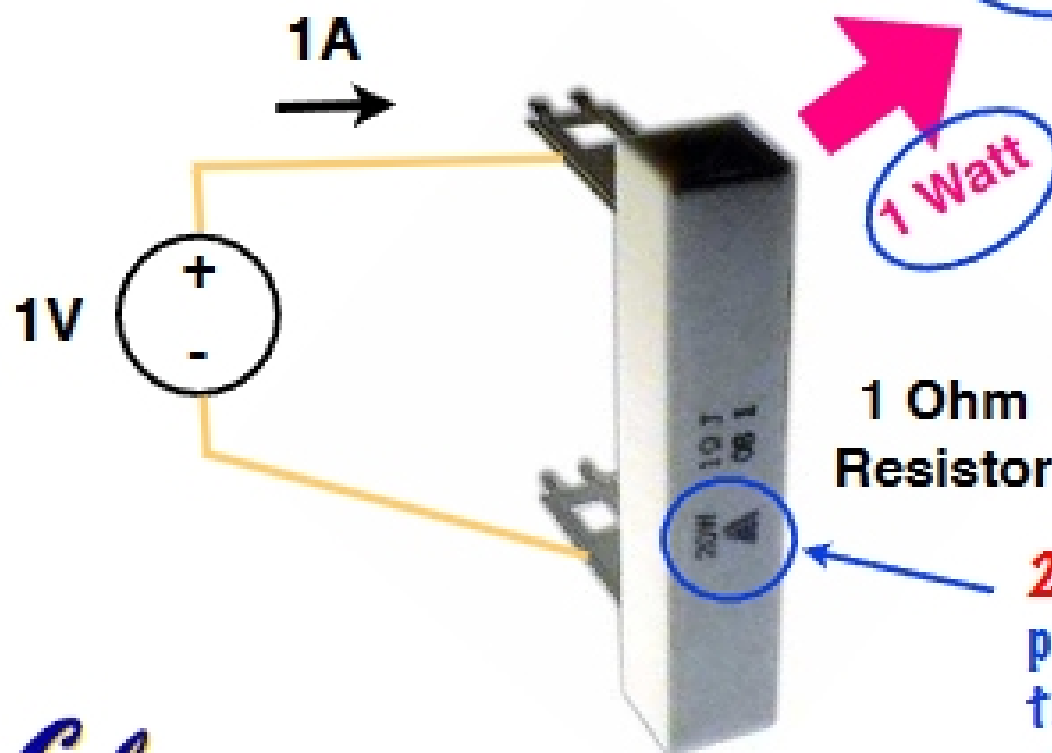
The Joule: Unit of energy. Can also be expressed as **Watt-Seconds**. Burning 1 Watt for 100 seconds uses 100 Watt-Seconds of energy.

This is how electric tea pots work ...

1 Joule heats 1 gram of water
0.24 degree C

1 Joule of Heat Energy
per Second

1 Watt
The Watt: Unit of power. The amount of energy burned in the resistor in 1 second.



20 W rating: Maximum power the package is able to transfer to the air. Exceed rating and resistor **burns**.



Cooling an iPod nano ...



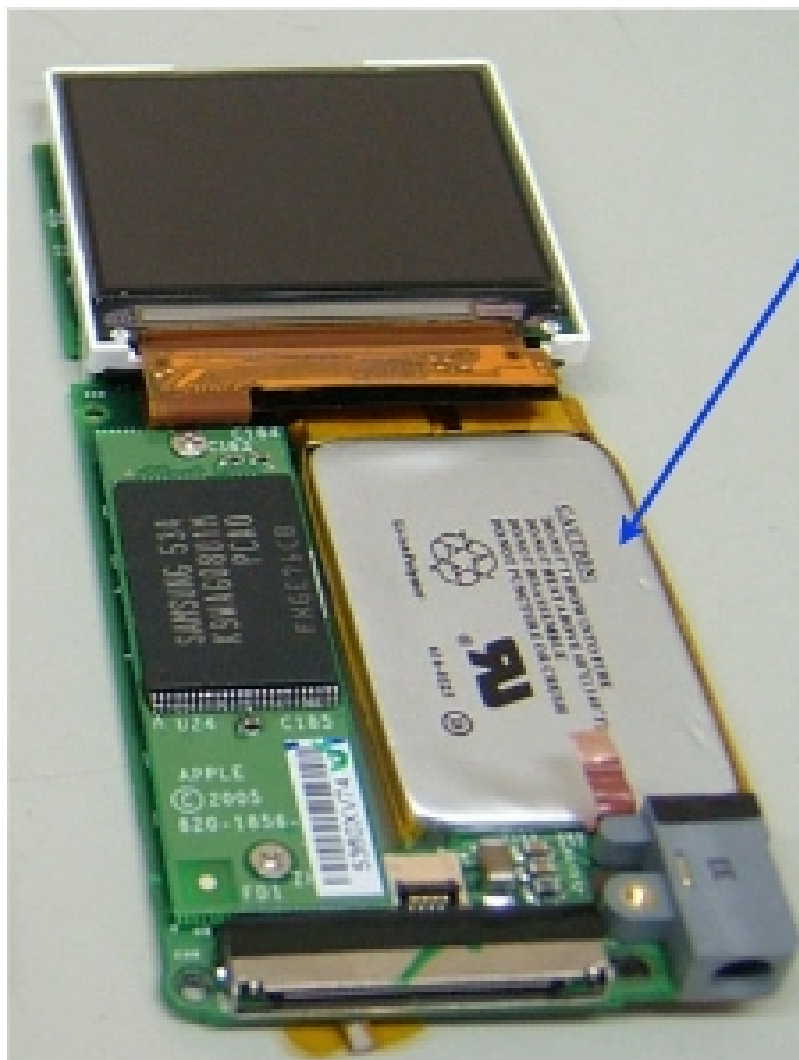
Like resistor on last slide, iPod relies on passive transfer of heat from case to the air.

Why? Users don't want fans in their pocket ...

To stay “cool to the touch”
via passive cooling,
power budget of 5 W.

If iPod nano used 5W all the time, its battery would last 15 minutes ...

Powering an iPod nano (2005 edition)



1.2 W-hour battery:
Can supply 1.2 watts
of power for 1 hour.

$1.2 \text{ W} / 5 \text{ W} = 15 \text{ minutes.}$

More W-hours require bigger battery
and thus bigger "form factor" --
it wouldn't be "nano" anymore :-).

Real specs for iPod nano :

**14 hours for music,
4 hours for slide shows.**

**85 mW for music.
300 mW for slides.**

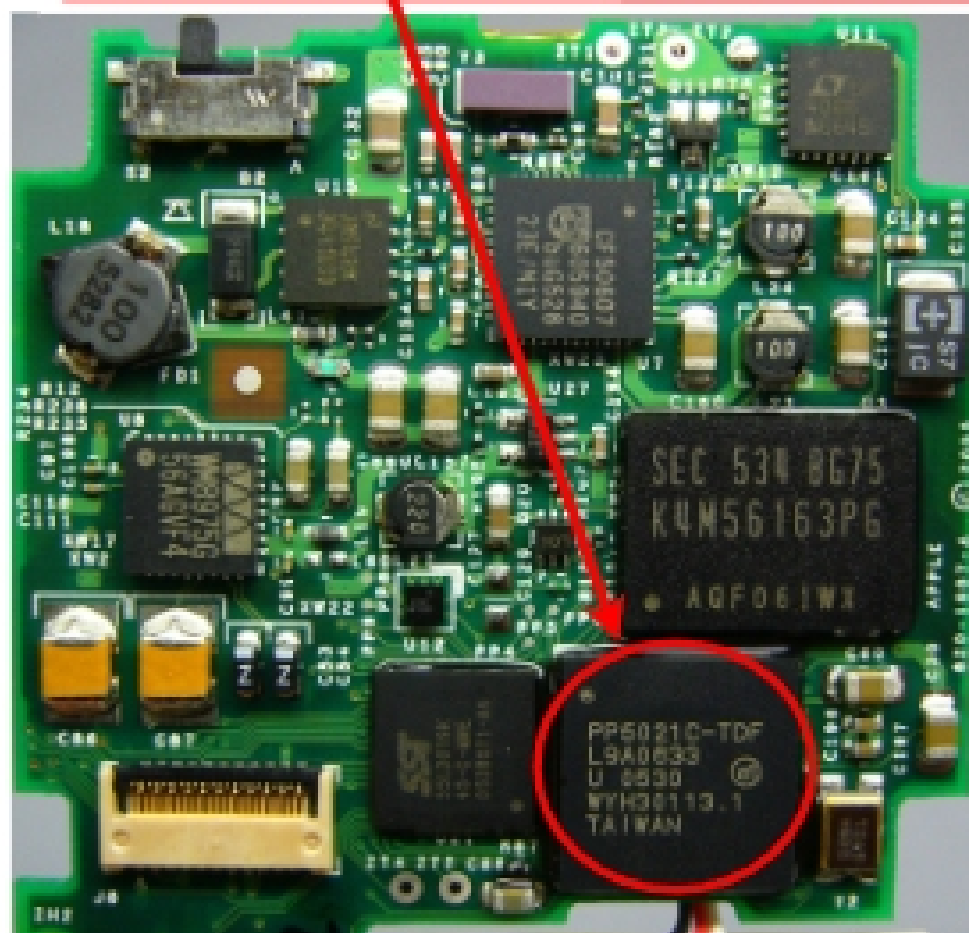
Finding the (2005) iPod nano CPU ...



A close relative ...

PP5020 

digital media management system-on-chip



**Two 80 MHz CPUs.
One CPU used for
audio, one for slides.**

**Low-power ARM
roughly 1mW per
MHz ... variable
clock, sleep modes.**

**85 mW system
power realistic ...**