The Power Budget

Power is Heath (1/2)

Do not underestimate the heath in your system

Even if your microcontroller may barely get warm:

- **Linear power supplies tend to get hot**
- **Switching power supplies are not 100% efficient, either**
- **"Big" 0603 SMD resistors are 0.1W only**
- **A led may draw substantial current (a Neopixel is up to 50mA)**

If you run on 24V, even the resistor divider can hit you

- **A 1k pull-up resistor to 24V outputs 0.6W when driven low**

And then the environment temperature may rise. Or fall.

- **The lab is warm, but sometimes the client wants more**
  - **Clients may ask for up to 70 degrees ambient temperature**
  - **Or down to -40 degrees**

You may need cooling, but sometimes heathing too.

Power is Heath (2/2)

Approaching the power problem

- (Ab)use the copper planes in your PCB
- Enlarge your power lines if you need more current
- Don't be shy in adding capacitors where needed
- Make good thermal connections to the external case
- Use passive heat sinks if needed
- Consider (and discard) active fans

Measure everything in your system

- Get aquainted to the concept of thermal resistance
  - Which means reading datasheets from page 1 to page end.

Choose your components with proper temperature ranges

- This requirements is for all components in the system
  - Which means reading datasheets from page 1 to page end.

Power Saving Issues

Sometimes, unfortunately, you must run on batteries

- Every milliamp (or even microamp) is important
- Fortunately, this doesn't apply to alway-on acquisition devices

Working on the microcontroller

- Lowering the frequency (power is rated in W/MHz)
  - Cons: effects on performance but also pwm, spi, uart, ...
- Lowering the voltage (most devices run down to 1.8V)
  - Cons: I/O voltage issues with peripherals
- Entering sleep/deep-sleep modes
  - Cons: dealing with wake-up in sw

Working on the power supplies

- Evaluate switching over linear (but consider costs)
- Consider the indivdual chips (the popular 7805 draws 6mA!)

Working on peripherals

- You can turn off all peripherals, if possible

Some Power Figures

This is the power consumption of some common devices

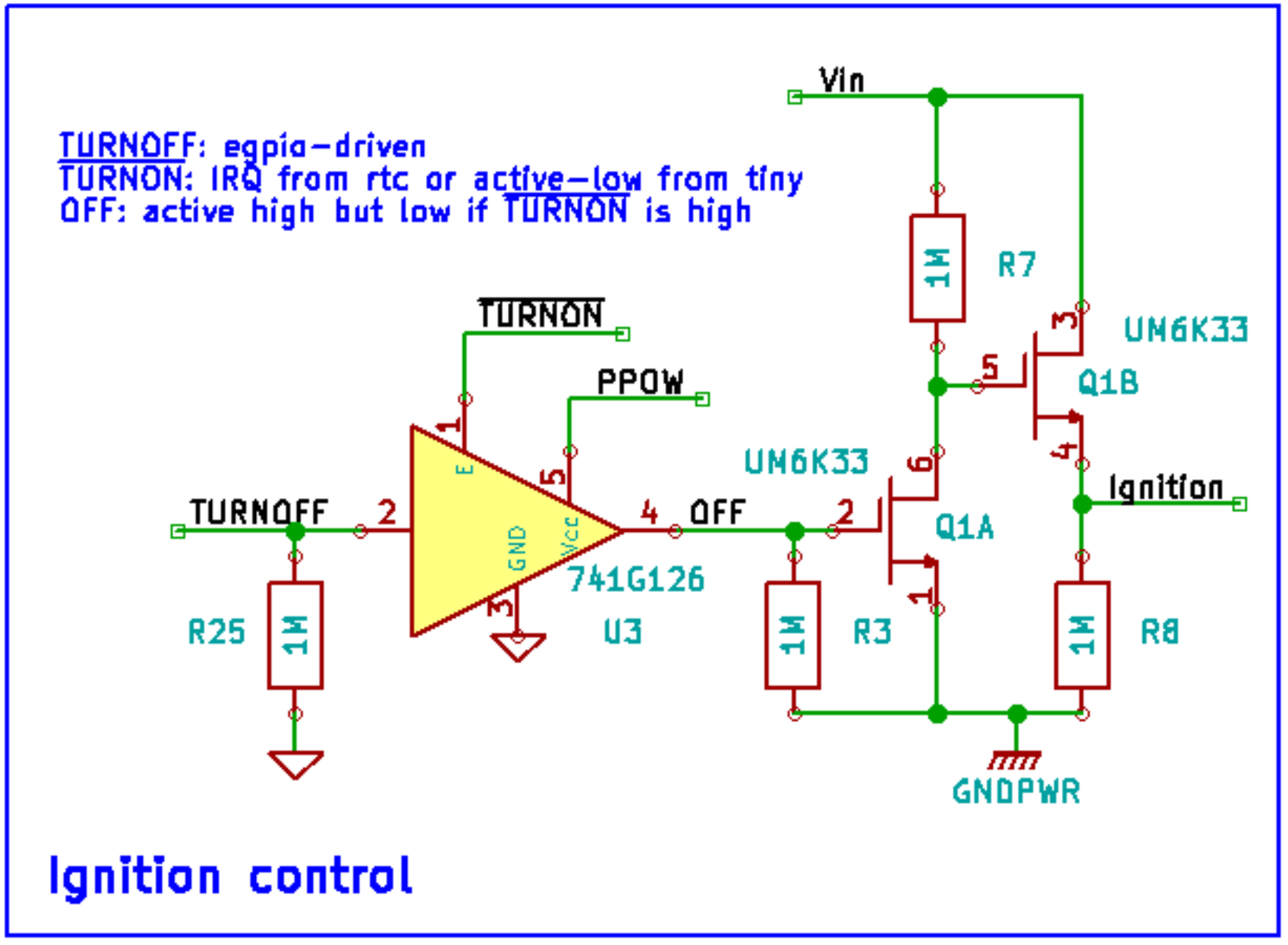
- **LPC11U35: 7mA (50MHz), 2mA (12MHz), 300uA (deep sleep)**
- **LM75B (thermometer, i2c): 280uA, 4uA**
- **MCP9700 (thermometer, analogue): 6uA**
- **SPI flash: 40mA/10mA/20uA**
- **I2C eeprom: 2mA/0.5mA/1uA**
- **20bit ADC: 200uA/20uA**
- **4ch DAC: 800uA**
- **Voltage reference: 140uA**

Clearly, we can easily get over 1mA while doing nothing

Turning the System Off (1/2)

An interesting alternative, is turning the system off

- With an RTC (PCF85363A: $1, 0.5uA)
- With a microcontroller (ATTINY202: $0.4, 10uA)
- Possibly with an always-on GPIO extender (PCAL6416: $0.8, 1uA)



Turning the System Off (2/2)

Another option is the attiny-10 ($0.3, 50ua @ 128kHz, 5V)

- **More size efficient, less power efficient**

It can run at 5V and turn on/off the 3V3 for the "real" system.

- **And (like the 202 in prev. page) it can communicate with the "big" uC**

But, most importantly, the main uC must be able to flash this auxiliary uC.