ECE 271 – Microcomputer Architecture and Applications Lecture 23

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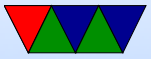
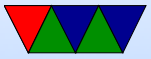
Announcements

- Read Chapter 21
- Turn in Midterm Take-Home Question #5
- Midterm will be graded eventually



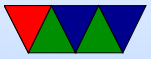
Notes from Lab#10

- Lots of config but otherwise straightforward?
- Original posting didn't work. Had photodiodes instead of photo-transistors, not swap-in replacements
- Luckily I found a stash of phototransistors from last year



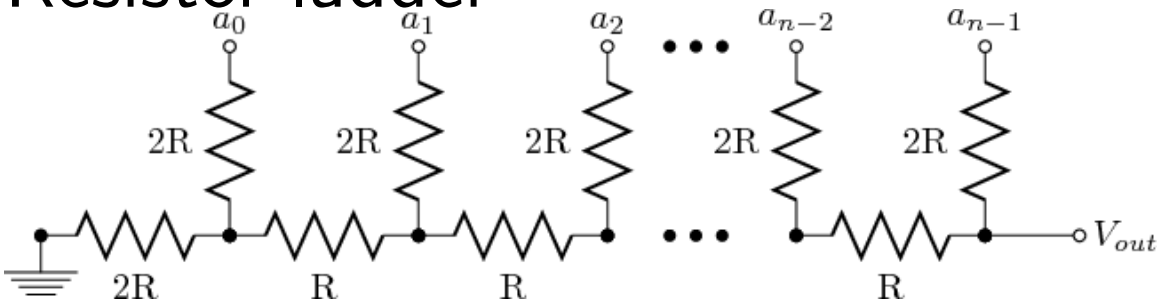
Digital/Analog Converters

- Opposite of ADC?



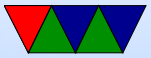
DAC circuit

- Draw one from the textbook?
- Resistor ladder



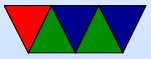
(wikipedia)

- Resistors designed to add voltages, $1/8 + 1/4 + 1/2$, etc.



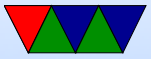
DAC Use

- Most common is sound card in your computer



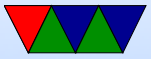
DAC custom circuits

- Story about how I made a sound card out of resistors and parallel port back in the day.
- You can bitbang VGA using GPIOs and resistors to create analog VGA signal on a Pi (uses lots of pins)



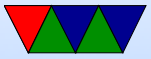
DAC Resolution

- Smallest change that can occur in the analog output.
- 5V 8-bit DAC, each bit increment is $5/2^8$=19.5mV
- CD audio has 16-bit



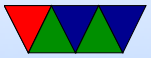
DAC Settling Time / Glitching

- Settling: Time it takes the update of output to settle to within X% of the wanted output.
- Glitch: if on updating the output it overshoots the desired level. “glitch” is often impulse area, area under the graph of glitch

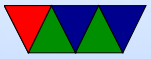


DAC on STM32L

- STM32L has two independent DACs
- Can be configured to 8 or 12 bits
- Can run together or separately. Why run together? (Stereo audio)
- Registers
  - DHR – data holding registers (DHR12R, DHR12L, DHR8R, DHR8L)
  - The L/R is left aligned or right aligned
- Can also add triangle wave and noise

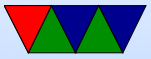


- What is noise good for? Drum effects?



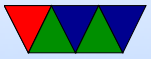
Conversion Trigger

- Can be triggered by hardware (a timer)
- Can be triggered from software, `DAC_SWTRIG`
  reset once data is loaded
- If both channels set to same trigger, will be triggered at same time



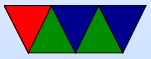
Buffered Output

- When connecting to external device (like headphones) the voltage might sag due to loading.
- If the headphone impedance is close to impedance of output, you get voltage divider and peak goes lower.
- You can enable an output buffer with high input impedance and low output impedance using the `DAC_CR_BOFF` bit in `DAC_CR` register.



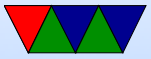
Lab#11

- Generate 440Hz output to



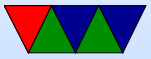
Generating a Sine Wave

- What does a sine wave look like?
- On a fast system with FPU you might do something like $output = (1 + sin(\frac{x}{180}\pi)) \times 2^{11}$ where x is in degrees. Sine varies from -1 to 1 but we want output 0 to 4096
- What to do without a sin() function?
- Can use Taylor series $sin(x) = \sum_{n=0}^{\infty} \frac{(-1)^n}{(2n+1)!} x^{2n+1} \approx x - \frac{x^3}{6} + \frac{x^5}{120} - \frac{x^7}{5040}$
- Easiest thing to do... table lookup! Pre-calculate the



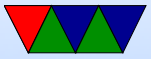
values, and when time to output just look up in table.

- `output=sine_table[x];`
- Can even optimize (on low memory). sine is symmetrical, so only need 1/4 of it in memory and you can special case 0-90, 90-180, 180-270, 270-360



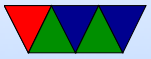
Output

- DAC1_OUT1 goes to pin PA4 and DAC1_OUT2 goes to pin PA5.
- PA4 doesn't actually exposed on the STM32L board, it goes to an on-chip opamp and you can program this via OPAMP and route the output through it to PA3?
- Want to output 12bit audio at 44.1kHz?
- Set up Timer4
- $\frac{f_{HSI}}{(1+PSC)(1+ARR)} = f_{sampling} = 44.1kHz$
  PSC=18 and ARR=18 then you get 44.3kHz which is



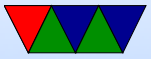
close

- Then build table. To have 440Hz sinewave:
  - $Stepsize = \frac{360degrees}{NumberofDACoutputsinsincycle}$
  - $= 360degrees / \frac{periodofsine}{timeintervalofDAC}$
  - $= 360degrees / (\frac{1}{f} / \frac{1/44.3kHZ}{)}$
  - $= 360degrees / \frac{44.3kHz}{f}$
- For $440Hz = 360/44.3k/440 \approx 3.576degrees$
- Generate sine table by ??



Digital Music

- Playing samples
- CD quality: 44.1kHz, 16-bit samples, stereo
- Need how many bytes/second?
- Compression, MP3



Digital Synthesizer

- Square waves? Triangle waves? Noise?
- Attack, Delay, Sustain, Release
- Amiga MOD music