CDA 4203 Sec 001 Spring 2015
Computer System Design
Instructor: Dr. Srinivas Katkoori
Homework 4 – ADCs, DACs, and USB
Assigned on Wednesday, 15th April
DUE: 11:59PM, Friday, 24th April

Note:
1) Recommended submission is by Canvas.
2) If you handwrite the answers, you may want to scan and upload to Canvas.
3) Regular Credit: 40 pts; Extra Credit: 20 pts.

Your Name: John Gangemi **Your U#:** U6871412

ADCs and DACs

1. (5 pts.) Briefly describe the three main steps implemented in an Analog-to-Digital Converter.

   a. Sampling:
   Conversion of a continuous-time signal into a discrete-time signal by taking samples at regular intervals.

   b. Quantization:
   Conversion of discrete-time, continuous-valued signal into a discrete time, discrete values (digital) signal.

   c. Coding:
   Assigning unique binary number to each quantization level where "L" levels require 2^b bits.

2. (10 pts.) Given an analog output signal whose voltage should range from 0 to 10V, and an 8-bit digital encoding, provide the encodings for the following desired voltages: (a) 0V, (b) 1V, (c) 5.33V, (d) 10V, what is the resolution of the conversion?

   a. 0V:
   $(2^n-1)(Vin/Vmax) = (2^8-1)(0V/10V) = 0d = 00000000b$
   b. 1V:
   $(2^n-1)(Vin/Vmax) = (2^8-1)(1V/10V) = 25.5d = 25d = 00011001b$
   c. 5.33V:

$(2^n-1)(Vin/Vmax) = (2^8-1)(5.33V/10V) = 135.915d = 136d = 10001000b$

d. 10V:

$(2^n-1)(Vin/Vmax) = (2^8-1)(10V/10V) = 255d = 11111111b$

3. (10 pts.) Given an analog input signal whose voltage ranges from 0 to 5V, and an 8-bit digital encoding, calculate the correct encoding for 3.5V, and then trace the successive-approximation approach (i.e., list all the guessed encodings in the correct order) to find the correct encoding.

$(2^n-1)(Vin/Vmax) = (2^8-1)(3.5V/5V) = 178.5d = 178d = 10110010b$

$V=(vref)*(d/(2^n-1))$

i=7 SAR[7]=1; d=128; V=5*128/255= 2.5<3.5

i=6 SAR[6]=1; d=128 + 2^6; V=5*192/255= 3.76>3.5 reset

i=5 SAR[5]=1; d=192 - 2^5; V=5*160/255= 3.14<3.5

i=4 SAR[4]=1; d=160 + 2^4; V=5*176/255= 3.45<3.5

i=3 SAR[3]=1; d=176 + 2^3; V=5*184/255= 3.6>3.5 reset

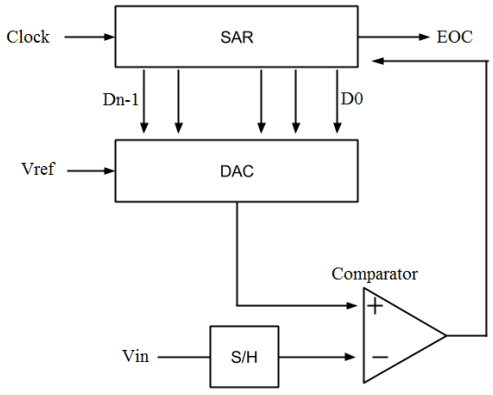
i=2 SAR[2]=1; d=184 - 2^2; V=5*180/255= 3.53>3.5 reset

i=1 SAR[1]=1; d=180 - 2; V=5*178/255= 3.49<3.5

i=0 SAR[0]=1; d=178 + 1; V=5*179/255= 3.51<3.5 reset

= 10110010b

4. (5 pts.) Sketch the successive approximation ADC circuit and explain how it works.



- Binary search through codes
- Compared with actual signal

DAC = digital to audio converter
EOC = end of conversion
SAR = successive approximation register
S/H = sample and hold circuit
Vin = input voltage
Vref = reference voltage

5. (5 pts.) What are the main advantages/disadvantages on an R-2R DAC?

Advantages:
- It's easy to match resistors
- Selecting low values of resistance will achieve good response time
- Opamp always sees a constant impedance at its input leading to better accuracy

Disadvantages:
- Resistor tolerance must be small and therefore more expensive to fabricate

6. (5 pts.) What is Nyquist's theorem? What problem do we encounter if we do not meet Nyquist's sampling rate?

"If the highest frequency contained in an analog signal xa(t) is Fmax = B and the signal is sampled at a rate Fs > 2 Fmax then xa(t) can be exactly recovered from the its sample values using interpolation function"

If you do not meet Nyquist's sampling rate then you will lose signal information.

(Extra credit 20 pts) USB 2.0 Protocol

7. (5 pts.) What are the different speeds supported by USB 2.0 protocol? For each speed, (a) identify the supported data transfer rate; (b) give an example of a peripheral.

Low speed:
1.5 Megabits per second

Full speed:
12 Megabits per second

High speed:
480 Megabits per second

8. (5 pts.) What are different types of Tokens? For each token type, briefly explain its purpose.

- Setup: Inform the target device the host wants to send data
- Out: Inform the target device the host wants to send data
- In: Inform the target device the host wants to fetch data

9. (5 pts.) What are the four types of data transfer? Compare them in terms of polling interval, priority, and delivery guarantees.

- Interrupt: fixed/periodic; high; 64 bytes per period
- Isochronous: fixed/periodic; high; 1023 bytes per period
- Bulk: variable; low; data integrity
- Control: variable; medium; data integrity

10. (5 pts.) How is the plug-n-play feature work to identify full-speed and low-speed peripherals?

Full speed peripherals will use a pull up resistor attached to the D+ line to signal its protocol speed whereas the low speed has a pull up resistor attached to the D- line.