Midterm — March 23, 2005

Total: 110 pts

Write and sign the honor pledge:

1. (1 pts) Print your name and UMID# on every sheet.

2. (1 pt each)

   (a) The amount of DARAM present on the C5510 is ________ Kwords.

   (b) The amount of SARAM present on the C5510 is __________ Kwords.

   (c) The C5510DSK CPU maximum cycle time is _________ ns.

   (d) The eXtended auxiliary registers each contain ________ bits.

   (e) The C5510 has _______ temporary registers.

   (f) The technical name for the norm that we used to scale for overflow in our IIR filter designs is the "__________ norm".

   (g) The C5510 always fetches _______ bytes from program memory every clock interval.

   (h) C5510 instructions vary in length and use from 1 to _______ bytes.

   (i) Each accumulator is made up of _______ registers.

   (j) The total number of bits contained in the registers forming an accumulator is ________.

   (k) Using C5510 circular buffer support, we can have circular buffers of at most_______ different sizes at the same time.

3. C5510 C5510 CPU consists of four different processing units.

   (a) (1 pt) Which processing unit inside the C5510 CPU fetches instructions from the memory?

   (b) (1 pt) Which processing unit controls the DSP program execution flow?

   (c) (1 pt) Which unit serves as the data access manager?

   (d) (1 pt) Which unit handles the data processing for most applications?

4. Small memory model.

   (a) (1 pt) What is the advantage of using small memory model?

   (b) (1 pt) Which run-time support library should we use?

   (c) (1 pt) What function do we use to **read** data from other memory pages?

   (d) (1 pt) What function do we use to **write** data to other memory pages?

5. Given: $\text{DFT}\{a, b, c, d\} = \{A, B, C, D\}$. Let $X(k)$ denote the **8 point DFT** of $\{a, a, b, b, c, c, d, d\}$.

   (a) (2 pts) Express $X(0)$ in terms of A, B, C, D.

   (b) (2 pts) Express $X(2)$ in terms of A, B, C, D.

6. Let $X(k)$ denote the **8 point DFT** of $\{a-b, a-2b, a-3b, a-4b, b, 2b, 3b, 4b\}$.

   (a) (2 pts) Express $X(0)$ in terms of a, b.

   (b) (2 pts) Express $X(2)$ in terms of a, b.

7. In Lab 7, we used `cfft32_NOSCALE( )` and `cbrev32( )` to compute the standard DFT (without $\frac{1}{N}$). Assume that we have an additional function `void conjugate(long *x, int Nx)` that will change the sign of `x[1]`, `x[3]`, $\cdots$.
   Given an array: `long x` = $\{a_0, b_0, a_1, b_1, a_2, b_2, a_3, b_3\}$, a_i and b_i are all real. Assume that:

   $$\text{DFT}\{a_0+jb_0, a_1+jb_1, a_2+jb_2, a_3+jb_3\} = \{A_0+jB_0, A_1+jB_1, A_2+jB_2, A_3+jB_3\}.$$

   Consider the following C code:

```
.
.
cfft32_NOSCALE(x, 4);     // line 1
cbrev32(x, X, 4);         // line 2
conjugate(X, 4)
cfft32_NOSCALE(X, 4);
cbrev32(X, y, 4);         // line 3
.
.
```

   (a) (1 pts) After line 1 is executed, x=?

   (b) (1 pts) After line 2 is executed, X=?

   (c) (2 pts) After line 4 is executed, y=?

8. Function fn was written in assembly and called by C. The prototype of fn is:

   void fn(int i1, int i2, int *p3, int *p4, int i5, int *p6, long l7, long l8);

   Specify the C5510 registers that store the following values:

   (a) (1pt) i1 __________

   (b) (1pt) i5 __________

   (c) (1pt) p6 __________

   (d) (1pt) l8 __________

9. When we compile a program, the memory is initialized to have various sections such as .const, .cinit., .text, .bss, .stack, .system, and etc.

   (a) (1 pt) Which section contains all of the executable code?

   (b) (1 pt) Which section contains local variables?

   (c) (1 pt) Which section contains global variables?

10. Implementation of division on C5510.

    (a) (1 pt) What numerical method did we use to find the reciprocal?

    (b) (2 pt) What is the iteration formula we used to compute the reciprocal of a number α? To be more specific, given the n_{th} iteration result x_n, write down the formula to compute x_{n+1}.

(c) (2 pt) In Lab 3 and HW3, what is the initial value x_0 we would choose for the numerical method to compute the reciprocal of $\alpha = 0.75$?

11. McBSP and CODEC.

(a) (1 pt) How many McBSP ports does a C5510 processor have?

(b) (1 pt) Through which McBSP do we control the CODEC on the C5510 DSK?

(c) (1 pt) Through which McBSP do we transfer the data between the processor and the CODEC?

(d) (1 pt) What is the name of the CODEC chip on the C5510 DSK?

(e) (1 pt) The CODEC is connected to which jacks on the DSK?

(f) (1 pt) Which C function (file) needs to be called at the very beginning of our program before the CODEC can be used?

12. A student wrote the following code to read off dip switches and output the results on the LED's:

```
int DIP;
int SWITCH;
long * ptr = 0x300000;
DIP = *ptr & ?A?;
SWITCH = DIP >> ?B?;
*ptr = SWITCH;
```

(a) (1 pt) What memory model did the student use?

(b) (2 pt) ?A? should be?

(c) (2 pt) ?B? should be?

13. Assume the use of a *B*-bit word size.

(a) (1 pt) What is the value of the largest unsigned integer value that can be represented?

(b) (1 pt) What is the value of the largest positive two's complement integer value that can be represented?

(c) (1 pt) What is the value of the most negative two's complement integer value that can be represented?

(d) (1 pt) What is the value of the largest unsigned Q(B-1) value that can be represented?

(e) (1 pt) What is the value of the largest positive Q(B-1) value that can be represented?

(f) (1 pt) What is the value of the most negative two's complement Q(B-1) value that can be represented?

14. Interrupt and Lab 7.

(a) (1 pt) What are the three sources of interrupts?

(b) (1 pt) What is the .asm file in our lab code that specifies the function to execute for every interrupt?

(c) (2 pt) In Lab 7, real-time FFT, what is the major reason for us to use the interrupt support? Can we not use it?

(d) (2 pt) In Lab 7, what is the most useful method to reduce the fluctuation of the FFT display?

15. Check the syntaxes of the following assembly instructions and answer whether they are correct or not. If an instruction is wrong, you have to specify why it is wrong.

    (a) (1 pt) `MPY AC0, T0, AC1`

    (b) (1 pt) `MACK T0, #3, AC1`

    (c) (1 pt) `XCC Line11, T1==#1`

    (d) (1 pt) `RPTLOCAL Line11, BRC2`

16. Windowing.

    (a) (1 pt) In Lab 7, we tried three different windows (default ones, Kaiser window not included). Other than the rectangular window, what are the other two windows?

    (b) (1 pt) Among the three windows, which one has the smallest sidelobes?

(c) (1 pt) Among the three windows, which one has the narrowest main-lobe?

(d) (1 pt) Among the three windows, which one has the best local resolution?

(e) (1 pt) Among the three windows, which one has the best global resolution?

17. Oversampling and ΣΔ ADC.

(a) (3 pts) List the three reasons for oversampling.

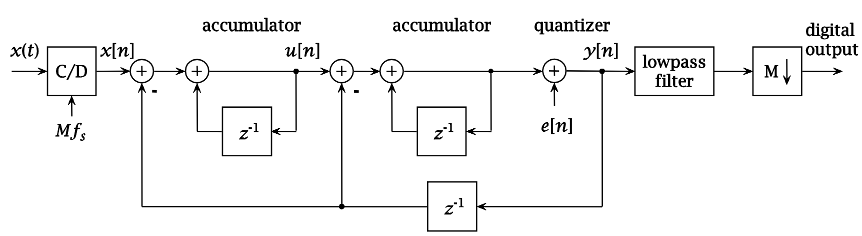

Figure 1: 2^{nd} order ΣΔADC

(b) (1 pts) If we use the 2^{nd} order ΣΔ ADC in Fig. 1 for AD conversion. What is the relation between $X(z)$, $E(z)$, and $Y(z)$?

(c) (2 pts) A 10-bit 2^{nd} order ΣΔ sampled at 16000 Hz is equivalent to an ordinary K-bit ADC sampled at 1000 Hz. K=?

18. If we implement the direct digital synthesizer (DDS) using a 16-bit phase accumulator and a sine table of size 128. Assume that the sampling rate f_s = 24 KHz. We want to generate a sinusoid of 900 Hz using the following code:

```
int sinetable[128] = { 0, ... };
unsigned int ac0 = 0;
unsigned int FTV = ?A?;
unsigned index;
unsigned forever = 1;
        .
        .
while (forever) {
    ac0 = ?B?;
    index = ?C?;
    value = *(sinetable+index);
    CodecOut(value);
}
```

(a) (1 pt) ?A? should be?

(b) (1 pt) ?B? should be?

(c) (1 pt) ?C? should be?

(d) (1 pt) Assume that we can use up to 1024 samples to compute the THD of the 900 Hz sinusoid. What is the DFT size that we should use to get the most accurate THD result?

19. Computing a non-polynomial function on C5510.

(a) (1 pt) What Matlab functions did we use to find the polynomial approximation to a non-polynomial function?

(b) (1 pt) Assume that Matlab returns the 2^{nd} order polynomial approximation $f(x) = 15.72x^2 + 0.57x - 10.24$. If the coefficients are stored in 16-bit words using Qn format. What is the largest n we can use?

(c) Assume that we end up using Q8 format for the coefficients and Q13 format for x. The function computation is done by the following assembly code:

```
BSET    SXMD
BSET    FRCT
MOV     ?A?,AC0
MPYR    T0,AC0,AC0
ADD     ?B?,AC0
MPYR    T0,AC0,AC0
ADD     ?C?,AC0          //line 1
MOV     rnd(hi(saturate(AC0<<?D?))), mmap(T0) //result in T0
BCLR    FRCT
RET
```

i. (2 pt) ?A? should be?

ii. (1 pt) What is the Q format of AC0 after the execution of line 1?

iii. (1 pt) If we want the result to be in Q13, then ?D? should be?

20. Group delay.

(a) (1 pt) Given the phase response $\theta(f)$ of a filter. If $\theta(f)$ is in degrees, what is the group delay of the filter in **seconds**?

(b) (1 pt) If $\theta(f)$ is in radians and the sample rate $f_s = 48$ KHz, what is the group delay of the filter in **sample periods**?

(c) (1 pt) Consider the waveforms in in Fig. 2. If we use $x(n)$ as the filter input and the resulting filter output is $y(n)$. Do we know the filter is linear phase or not?

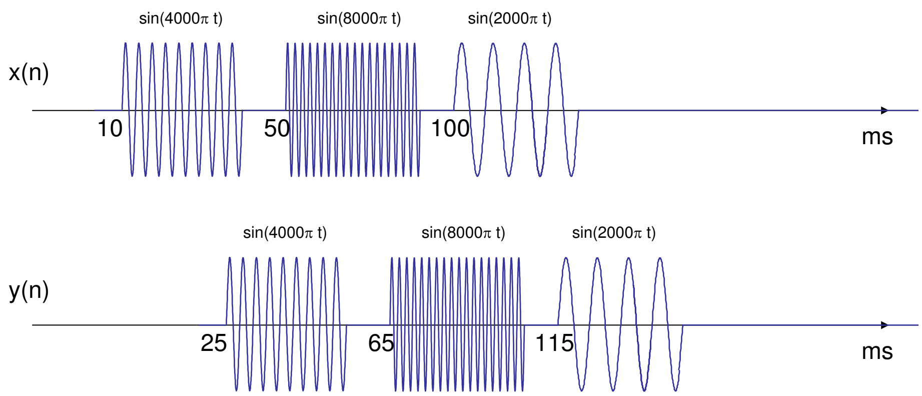

Figure 2: Input-output pair of the filter

21. A filter is implemented as shown in Fig. 3.

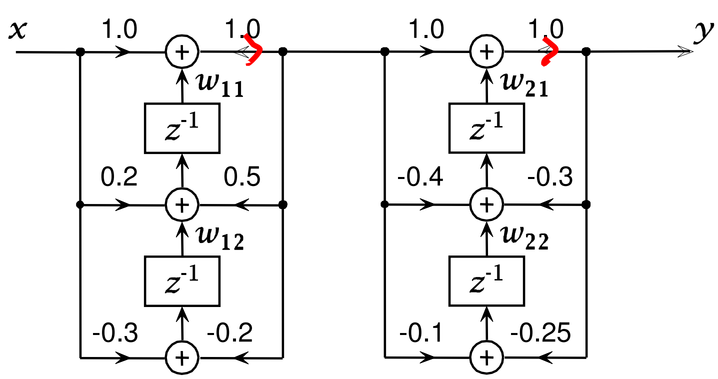

Figure 3: Biquad cascade

(a) (1 pt) What type of biquads are these (DF1, TDF1, DF2, TDF2)?

(b) (1 pt) What is the advantage of using this type of biquads?

(c) (3 pt) What is the transfer function $\frac{W_{2,2}(z)}{X(z)}$ from the filter input x to $w_{2,2}$?.

22. Consider the zero-pole plot of an IIR filter shown in Fig. 4.

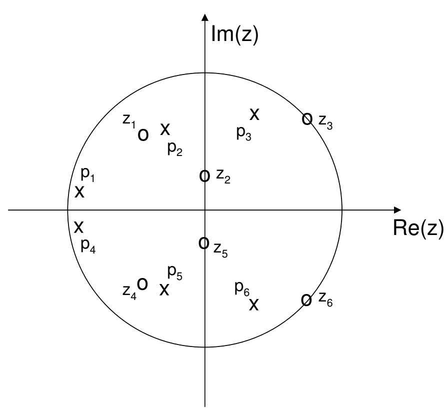

Figure 4: Zero-pole plot

(a) (2 pts) If we do the biquad decomposition to it as the way we did in Lab 6, we have:

Biquad 1: $\frac{(z-(\quad))(z-(\quad))}{(z-(\quad))(z-(\quad))}$

Biquad 2: $\frac{(z-(\quad))(z-(\quad))}{(z-(\quad))(z-(\quad))}$

Biquad 3: $\frac{(z-(\quad))(z-(\quad))}{(z-(\quad))(z-(\quad))}$

(b) (2 pts) What are the two major reasons to implement filters using biquad cascades?

23. Assume that we are measuring the transfer function of a filter $H(z)$. Using our Lab 6 code, two sets of data are generated: calibration.txt and tfmeas.txt. The data around 1000 Hz in these two files are shown below:

```
calibration.txt:
    freq. (Hz)  Input amp.  Output amp.  Input phase  Output phase
    1000        0.910       0.412        0.766        -0.508
    1010        0.910       0.414        0.754        -0.533

tfmeas.txt:
    freq. (Hz)  Input amp.  Output amp.  Input phase  Output phase
    1000        0.910       0.626        0.766        -0.723
    1010        0.910       0.725        0.754        -0.835
```

Note that the phases data is measured in 'half cycle'.

(a) (2 pt) What is the value of the magnitude response $|H(1000)|$?

(b) (2 pt) The phase response $\theta(1000)$ and $\theta(1010)$ in radians?

(c) (2 pt) From the previous results, find the group delay in sec. at $f = 1000$ Hz.