First: Last:

April 4, 2024, 12:30 to 1:45 pm. Open book, open notes. No electronics devices.

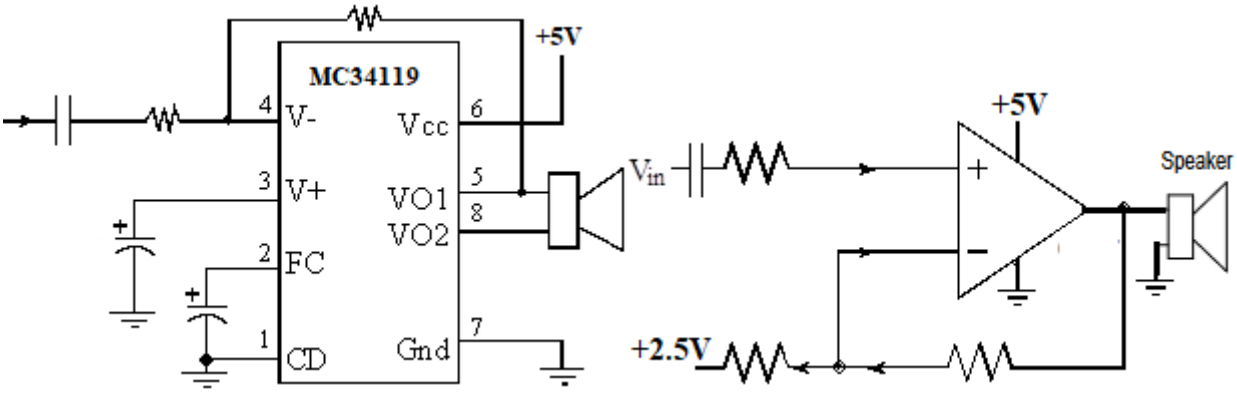
**(10) Question 1.** You have a system that measures parameter *x*. You are given the range as 0 to $x_{max}$ (2cm), and a signal to noise ratio as SNR in dB (60 dB). Explain how to use these parameters to choose the fixed-point system to represent *x*. Give the answer and the explanation.

Type the integer (signed or unsigned):

Resolution:

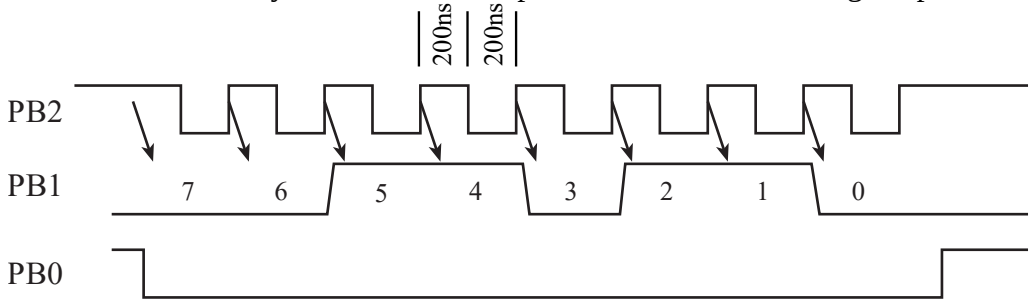
Precision the integer (8 16 or 32 bits):

**(5) Question 2.** Circle all the reasons to drive a speaker with the MC34119 versus with a rail-to-rail op amp.




| | |
|---|---|
| More power to the speaker | Higher voltage difference across the speaker |
| Higher voltage gain | Higher frequency response |
| Operates 0 to 5V | Blocks DC component, only passing AC sound |

**(20) Question 3.** There is a master microcontroller using SPI sending data about once every 1ms. One 8-bit data transmission requires about 2 us to complete. The SPI clock is approximately 2.5 MHz. The PB2 PB1 PB0 labels show the pin assignments on your slave TM4C123. These three pins are not supported by hardware SPI in the TM4C123, so you will have to implement the interface using simple GPIO input/output.




**(5) Part a)** What event should trigger an interrupt on your slave TM4C123? For example: "interrupt on both the rise and fall of PB1", or "interrupt periodically at 1ms". These are examples, neither is correct.

**(15) Part b)** Write the C code for the ISR in your slave that receives the data and puts each data byte into a software FIFO. You are given a FIFO module, and you can call **FIFO_Put(uint8_t data)** to save one 8-bit value. Assume these bit-specific definitions for the three pins.

```
#define PB0  (*((volatile uint32_t *)0x40005004))
#define PB1  (*((volatile uint32_t *)0x40005008))
#define PB2  (*((volatile uint32_t *)0x40005010))
```

```
void GPIOPortB_Handler(void){
  GPIO_PORTB_ICR_R = 0x07;      // acknowledge interrupt
```

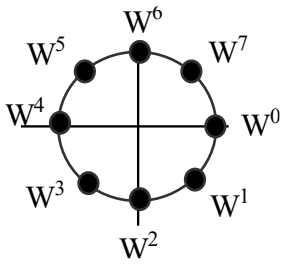
**(10) Question 4.** There are three 32-bit binary fixed-point numbers. All three are I27.Q5, meaning the value of the number is the integer times $2^{-5}$. You may assume that **i**, **j**, and **k** are declared in C with **int32_t i,j,k;** This software can only access **i,j,k** with no other variables allowed. Write C code that multiplies the first number times the second number and stores the product in the third number.

**(15) Question 5.** Design an analog circuit with the following transfer function: $V_{out} = V_1 + 2*V_2$. You may assume inputs $V_1$ and $V_2$ are such that output range will be 0 to 3.3V. You may use any chips shown in the book or presented in class. Show your work and label all chip numbers and resistor values. You do not have to show pin numbers. You do not need to add a low pass filter. Use E12 values

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | 12 | 15 | 18 | 22 | 27 | 33 | 39 | 47 | 56 | 68 | 82 |

**Table 9.1. E12 Standard resistor and capacitor values for 5% tolerance.**

**(10) Question 6.** Let **uint32_t x[8]** be eight ADC data values sampled at $f_s$=8 kHz. Derive an equation to calculate the magnitude of frequency component of the input at $f$=2 kHz




**(15) Question 7.** You are given a 1000 mA-hr 12V battery. A 100% efficient buck regulator converts the 12V battery input to the 3.0V supply for the microcontroller system. The bus clock of the microcontroller is reduced to 1 MHz to save power. To save even more power, the software runs in two modes. Sleep mode draws 10mA, and active mode draws 50 mA. The active mode runs for X percent of the time (%). The remaining 100-X percent is in sleep mode. What is the maximum percent X (in percent) you could run if the system needs to run for 100 hours? Show your work.

**(10) Do Q8 or Q9, not both**

**Question 8.** Explain how to use the **student's t-test** to experimentally determine ADC resolution. Draw figures to explain.

**Question 9.** Explain how the **Central Limit Theorem** applies to a measurement system.

**Part a)** What must you assume to apply the CLT?

**Part b)** What must software do to improve the SNR of the measurement?