

First: _____ Last: _____ EID: _____

April 21, 2022, 12:30 to 1:45 pm. Open book, open notes, calculator (no, phones, devices with wireless communication). No devices with screens larger than a calculator or cell phone (basically, the screen cannot be visible to other students).

(25) Question 1. Consider the MAX549A, a two channel 8-bit DAC. V_{DD} is the 3.3V supply. REF is a 3.0V analog reference for the DAC. GND is connected to ground. OUTA and OUTB are analog outputs.

(5) Part a) Give equations to prove this chip can be interfaced directly to the TM4C123 without voltage level shifters.

(5) Part b) Show the connections between Port B of the TM4C123 and the MAX549A.

(5) Part c) Describe how this DAC converts the 8-bit digital value (DAC_REGISTER) into an analog output using two or three sentences (no equations or numbers needed). *Hint:* this is different from the DAC in Lab 5.

(5) Part d) What is the fastest clock frequency possible? Show your work.

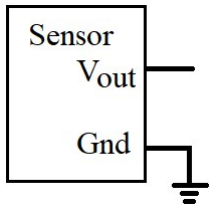
(5) Part e) What values for MS, SPO, SPH are needed to make this interface operational? Justify your answer.

(25) Question 2. You are given a GPIO input on PA7. There will be exactly one rising edge once a day when you go to sleep and exactly one falling edge when you later wake up. On average the period of the wave will be 1 cycle per day. Make a global variable called **Sleep** and set it every time you wake up to the number of seconds you were sleeping. Full credit is given for using one interrupt. *Hint:* this is NOT input capture. You do not write **PLL_Init**, **DisableInterrupts** or **EnableInterrupts**; otherwise, you write all the software needed. The main program is fixed and cannot be changed.

```
int main(void) {
    DisableInterrupts();
    PLL_Init(Bus80MHz); // set system clock to 80 MHz
    YourInit(); // you write this
    EnableInterrupts();
    while(1) {
    }
}
```

(25) Question 3. A pressure sensor has a single analog output (V_{out}), which is not differential. The range of pressures are 0 to 100 psi. V_{out} is a linear function of pressure. A pressure of 0 maps to $V_{out} = 0.1V$. A pressure of 100 psi maps to $V_{out} = 0.2V$. The desired pressure resolution is 0.1 psi. The frequencies of interest of pressure are 0 to 10 Hz, and desired frequency resolution of pressure is 0.01Hz.

(10) Part a) Design an analog circuit to interface this sensor to PD3, an ADC on the TM4C123. A pressure of 0 should map to an ADC input of 0V. A pressure of 100 psi should map to an ADC input of 3.0V. You may use any chips included in the labs 1 to 9. To make my grading easier, create an analog reference voltage of 1.50V.

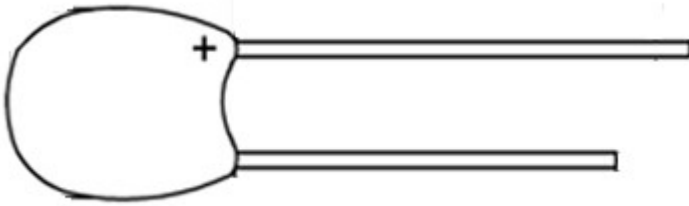


(5) Part b) What is the slowest possible sampling rate? Justify your answer.

(5) Part c) How do you configure the system to achieve a frequency resolution of 0.01 Hz? Justify your answer.

(5) Part d) Assume the 12-bit 0 to 3.3V ADC on the TM4C123. Derive an equation that maps the 12-bit ADC digital value in `ADC0_FIFO3_R` into the integer portion of the recorded pressure in the software.

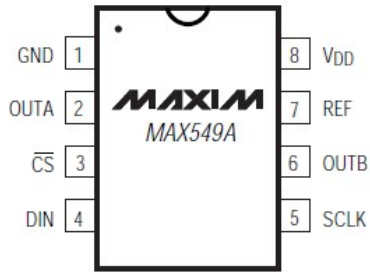
(5) **Question 4.** What is this Lab 6 component? There is a + symbol on the side of the longer lead.



(5) **Question 5.** A capacitor is labeled with the marking 123. What value is it in nF?

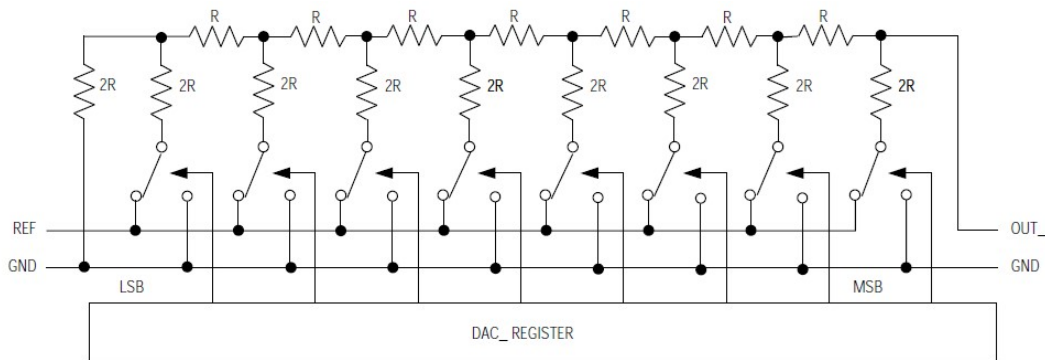
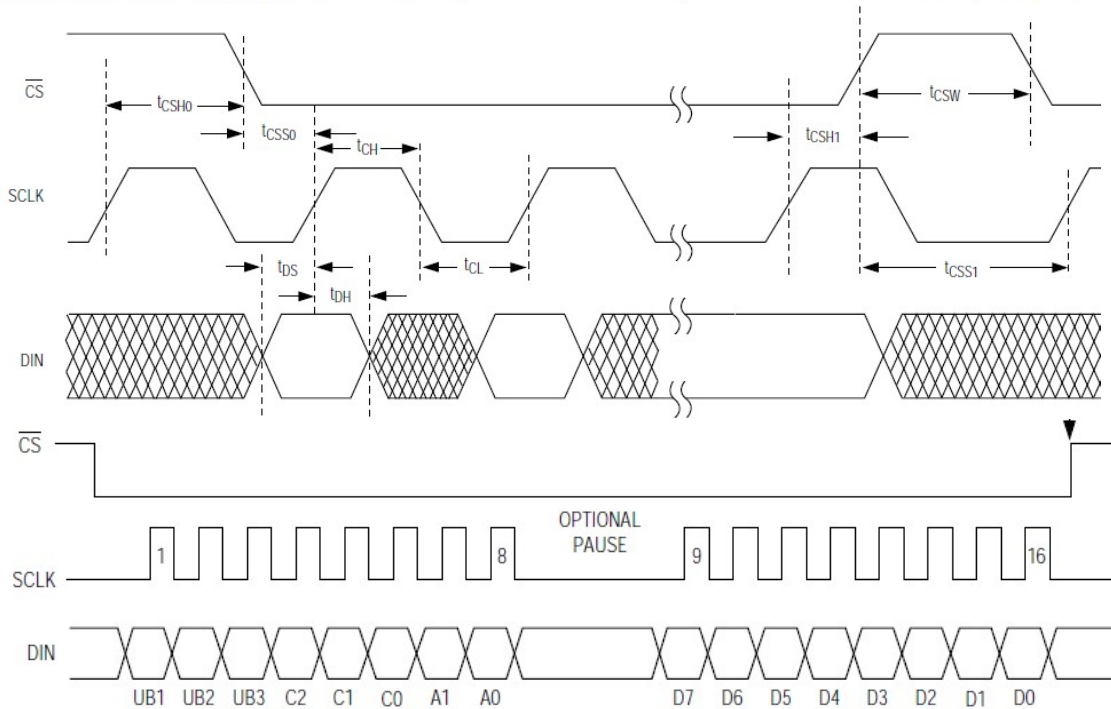
(15) **Question 6.** You are given a 1000 mA-hr 3.7V battery. A buck-boost regulator converts the 3.7V battery input to the 3.3V supply for the TM4C123 system. The bus clock of the TM4C123 is reduced to 1 MHz to save power. The efficiency of the buck-boost regulator is 90%. The software runs in two modes. Sleep mode draws 1mA of 3.7V battery current, and active mode draws 50 mA of 3.7V current. The active mode occurs once a second and lasts T seconds ($0 < T < 1\text{sec}$). The remaining $1-T$ time is in sleep mode. What is the maximum time T (in sec) you could run if the system needs to run for 1 week = 168 hours? Show your work.

-----MAX549A data sheet-----



PIN	NAME	FUNCTION
MAX549A		
1	GND	Ground
2	OUTA	DAC A Output Voltage
3	\overline{CS}	Chip-Select Input. A logic low on \overline{CS} enables serial data to be clocked into the input shift register. Programming commands are executed at \overline{CS} 's rising edge.
4	DIN	Serial-Data Input. Data is clocked into the 16-bit input shift register on SCLK's rising edge.
5	SCLK	Serial-Clock Input. Data is clocked in on SCLK's rising edge.
6	OUTB	DAC B Output Voltage
7	REF	External Reference Voltage Input for DAC(s)
8	VDD	Positive Power Supply (+2.5V to +5.5V)

DIGITAL INPUTS		Min	Max	
Input High Voltage	V_{IH}		$0.7V_{DD}$	V
Input Low Voltage	V_{IL}		$0.3V_{DD}$	V
Input Current	I_{IN}	$V_{IN} = 0V \text{ or } V_{DD}$	± 1	μA
Input Capacitance (Note 4)	C_{IN}		10	pF



----- TM4C123 data sheet -----

Parameter	Parameter Name	Min	Nom	Max	Unit
V _{IH}	GPIO high-level input voltage	0.65 * V _{DD}	-	5.5	V
V _{IL}	GPIO low-level input voltage	0	-	0.35 * V _{DD}	V
V _{OH}	GPIO high-level output voltage	2.4	-	-	V
V _{OL}	GPIO low-level output voltage	-	-	0.4	V
I _{OH}	High-level source current, V _{OH} =2.4 V ^a				
	2-mA Drive	2.0	-	-	mA
	4-mA Drive	4.0	-	-	mA
	8-mA Drive	8.0	-	-	mA
I _{OL}	Low-level sink current, V _{OL} =0.4 V ^a				
	2-mA Drive	2.0	-	-	mA
	4-mA Drive	4.0	-	-	mA
	8-mA Drive	8.0	-	-	mA
	8-mA Drive, V _{OL} =1.2 V	18.0	-	-	mA

Table 24-34. SSI Characteristics

Parameter No.	Parameter	Parameter Name	Min	Nom	Max	Unit
S1	T _{CLK_PER}	SSIClk cycle time, as master ^a	40	-	-	ns
		SSIClk cycle time, as slave ^b	150	-	-	ns
S2	T _{CLK_HIGH}	SSIClk high time, as master	20	-	-	ns
		SSIClk high time, as slave	75	-	-	ns
S3	T _{CLK_LOW}	SSIClk low time, as master	20	-	-	ns
		SSIClk low time, as slave	75	-	-	ns
S4	T _{CLKR}	SSIClk rise time ^c	1.25	-	-	ns
S5	T _{CLKF}	SSIClk fall time ^c	1.25	-	-	ns
S6	T _{TXDMOV}	Master Mode: Master Tx Data Output (to slave) Valid Time from edge of SSIClk	-	-	15.7	ns
S7	T _{TXDMOH}	Master Mode: Master Tx Data Output (to slave) Hold Time from next SSIClk	0.31	-	-	ns
S8	T _{RXDMS}	Master Mode: Master Rx Data In (from slave) setup time	17.15	-	-	ns
S9	T _{RXDMH}	Master Mode: Master Rx Data In (from slave) hold time	0	-	-	ns

