Name:_____

EE 107: Final

Autumn 2016

December 7, 2016

Time: 60 minutes

Information

· This exam is closed book/notes. Use of any other printed material, electronic devices or any other aid will be treated as a violation of the Stanford Honor Code.

· This question-cum-answer booklet has a total of 9 pages (including the cover page and two blank pages).

· The exam consists of 3 questions totaling 40 points. You have 60 minutes to complete the exam.

Instructions

· Write your solutions neatly and legibly in the space provided for each question. If you need more space, use the last two (blank) pages.

· Write your name in the space provided on each sheet.

· The reverse side of each sheet is your scratch space. We will NOT grade anything written on the reverse side

Name:_____ **SUNet** _____

ID:_____@stanford.edu

In accordance with both the letter and the spirit of the Stanford Honor Code, I declare that I neither received nor provided any assistance on this exam.

Signature: _____

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Problem	**1**	**2**	**3**	**Total**
Score				

ADC and DAC [17 Points]

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1. If you want to use the ADC on an MCU to sample an input signal, how do you determine the sampling frequency of the ADC? (5 points)

Connect the input signal to an oscilloscope and measure its spectrum to identify the frequency f of the signal. Then the ADC sampling frequency needs to be higher than 2*f.

2. Assume you have a 1-bit ADC with a threshold of V_T mV and you add noise uniformly varying between $-V_N$ mV to $+V_N$ mV noise on top of the ADC input. After sampling, you find that for N_1 samples, the 1-bit ADC outputs 1, which means the value measured is larger than V_T mV. For the rest N_2 samples, the 1-bit ADC outputs 0, which means the value measured is smaller than V_T mV. Can you use V_T, V_N, N_1, and N_2 to estimate the amplitude of the input signal based on the 1-bit ADC measurement? Please describe the assumption you made in your solution. (5 points)

Assume $V_{in}<V_T$, then $(V_{in}+V_N-V_T)/(V_T-V_{in}+V_N)=N_1/N_2$

(-1 if you just give an expression without any steps/explanation/justification)

3. Assume you have a 2-bit ADC with a threshold of V_{T1}, V_{T2}, V_{T3} mV ($V_{T1}<V_{T2}<V_{T3}$) and you add noise uniformly varying between $-V_N$ mV to $+V_N$ mV noise on top of the ADC input. After sampling, you find that for N_1 samples, the ADC outputs 00, which means the value measured is smaller than V_{T1} mV. For N_2 samples, the ADC outputs 01, which means the value measured is bigger than V_{T1} mV but smaller than V_{T2}. For N_3 samples, the ADC outputs 10, which means the

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value measured is bigger than V_{T2} mV but smaller than V_{T3}. For N_4 samples, the ADC outputs 11, which means the value measured is bigger than V_{T3} mV. Can you use V_{T1}, V_{T2}, V_{T3}, V_N, N_1, N_2, N_3, and N_4 to estimate the amplitude of the input signal based on the ADC measurement? Please describe the assumption you made in your solution. (7 points)

Assume $V_{T1}<V_{in}<V_{T2}$, then $(V_{in}+V_N-V_{T3})/(V_{T1}-(V_{in}-V_N))=N_4/N_1$

(0 for just giving a wrong formula without anything else)
(-1 if only very-special cases are considered, for example, only specific Ni's are non-zero)

Wireless Networking [10 Points]

1. You can use Bluetooth, ZigBee, or WiFi to provide wireless connections. Please describe your choice of radios for the following applications. (5 points)

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Application 1 - you want to provide wireless connection for streaming 30 frames per second 1024*768 videos from a VR device to cloud.
Application 2 - you want to provide wireless connection for streaming 400Hz accelerometer sensor data from a Fitbit wristband to a computer.
Application 3 - you want to provide wireless connection for controlling the fountain in your yard.

App 1 none of the three radios can support the raw data streaming from the camera.
App 2 Bluetooth because it supports point-to-point low-power and low-rate wireless communication.
App 3 ZigBee because the range of wireless is long is on the order of 10m~20m.

2. This figure shows the power consumption of transmitting a 100 bytes packet via the WiFi radio. Before transmitting the WiFi packet, the WiFi radio power consumption is 10uW. During the WiFi packet transmission, the WiFi radio power consumption is 1W. However, when the WiFi transmission is done, the WiFi radio power consumption does not come back to 10uW. Instead, the WiFi radio still consumes 100mW of power, which is called tail power consumption

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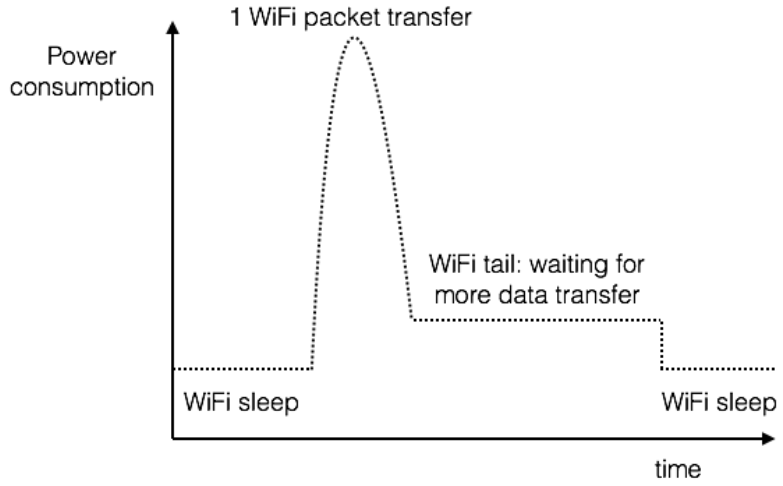
in WiFi radio. Can you propose a solution to reduce the WiFi radio power consumption without changing the WiFi radio hardware and physical layer? (5 points)



Instead of transmitting 1 WiFi packet each time, patch the packets and do bulk transmission to minimize the tail energy overhead.

(No points for physical layer changes like data rate and power.)
(-1 for saying to increase packet size; we don't have control over that; what we need to do is to combine packets different packets given to us before transmitting it out)

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Design and debugging [13 Points]

1. You are writing a client program which tries to setup a socket connection with the server. However, the server does not respond. Can you describe FIVE possible bugs and the order that you want to check each of them? Please describe the assumption you made. (5 points)

Server crashes.
Server address is wrong.
Server port number is wrong.
Client socket is not open.
Client tries to setup UDP connection while server accepts TCP connection.

2. You are going to deploy a wireless sensor network in a farm to monitor the temperature and humidity of plants in a 1km by 1km area. The sampling rate of the temperature and humidity sensor is 1Hz. You want to design a system that connects to each sensor via wireless radio and streams the sensor data back to cloud. Can you sketch a design about how to build the wireless sensor network? Please discuss the following questions.

- Which wireless technology are you going to use? Your answer could be WiFi, BLE, ZigBee, SigFox, LTE. Please describe the pros and cons of the chosen technology and why you chose it. (5 points)
- If you have deployed sensors, is it possible for you to know the temperature and humidity data on a location where no sensor is deployed? If yes, please describe your solution. If no, please describe your reasons. Please describe any assumption you made. (3 points)

WiFi and LTE are not good ideas because of their high power consumption.
BLE is not a good idea because of range limitations.

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I prefer using ZigBee or SigFox. Both have low power consumption and support decent data rate.

Yes. Interpolation using the data obtained from sensors.

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