Lab 11: Final Embedded System

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1. Overview

1.1. Objectives

This is the final project for EE 445L, where we utilize all the skills and knowledge we learned during the semester and integrate them into one complete embedded system. This report documents the system our group designed and implemented.

1.2. Roles and Responsibilities

As a group, we design and implemented the project together. We started from designing the hardware of our system–the schematics and PCB, then moving on to write the low level device drivers for each of the input/output device we use. At the end, we complete the project by soldering all the components onto the PCB and implement the high level software. The clients for the project are the graders; the TAs and Professor McDermott.

1.3. Interactions with Existing Systems

We are not connecting to any other existing systems.

2. Function Description

2.1. Functionality

We are implementing a home security system. Initially upon startup, the system prompts the user to set the passcode. At this point, the user is the owner of the system arming the system. After the password is set, the system entered the state where it is waiting for a password to be entered and the servo moves to the locked position.

At this point, the guest can come come up to the system and either try to enter a password or simply hit the bell button. Pressing a key on the keypad or the bell will send a signal to activate the camera feed which allows the owner of the security system to see the guest outside the door. 10 seconds of inactivity allows the screen displaying the camera feed to shut off in order to conserve power. The guest can attempt to enter the 4 digit passcode by using the keypad on the front of the device. If the guest enters the wrong passcode 3 times in a row, the system is set to the alarm phase, where it locks the user out of entering more attempts. If the guest enters the correct password within the three allotted attempts, access is granted and the servo turns to unlock the door. After approximately 5 seconds, the system returns to the armed state with the servo in the door locked position, and prompts the new guest to enter a password to unlock the door.

A microphone is used for communication across the door (imagine the monitor is somewhere far from the door). In our system, audio from the microphone is hooked up to a headphone audio jack so you can listen to what is going on behind the door. Ideally this audio jack should be replaced by a speaker, and both the voice and system audio should be outputted from the speaker, but we had some hardware issue with the speaker and made a DESIGN DECISION to use the audio jack instead. Also, ideally there is supposed to be a speaker and a microphone both the outside and inside, but for demonstration purpose we only use one set.

2.2. Performance

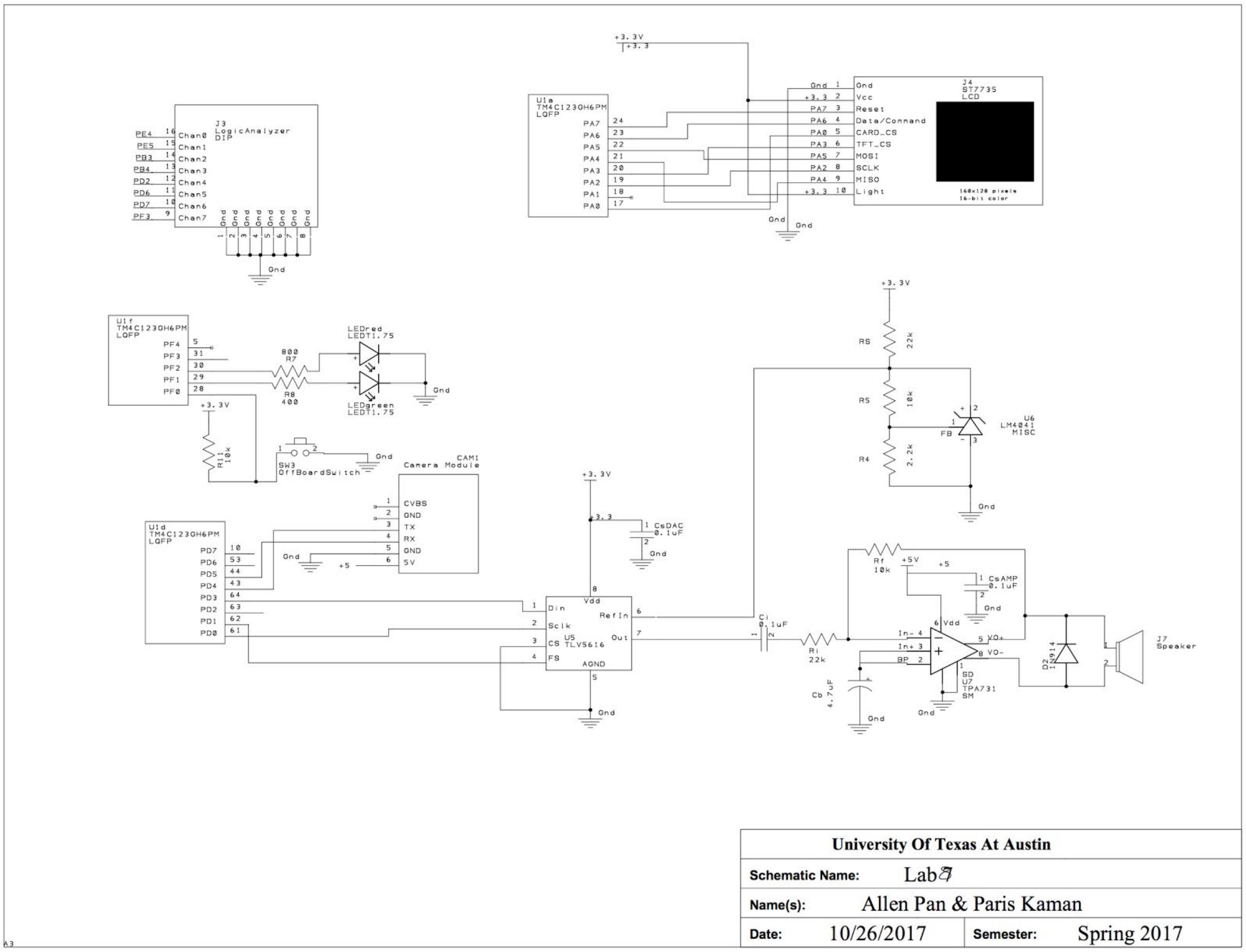
The system has low latency for the I/O devices to feel responsive to the user. All sensors and actuators operate in real-time and the latency can hardly be noticed. The only noticeable delay is when the monitor is being turned on, due to the nature of video processing. The button and keypad are debounced.
The microphone has a gain of 40dB and the sound output from the earphones does have a good quality.

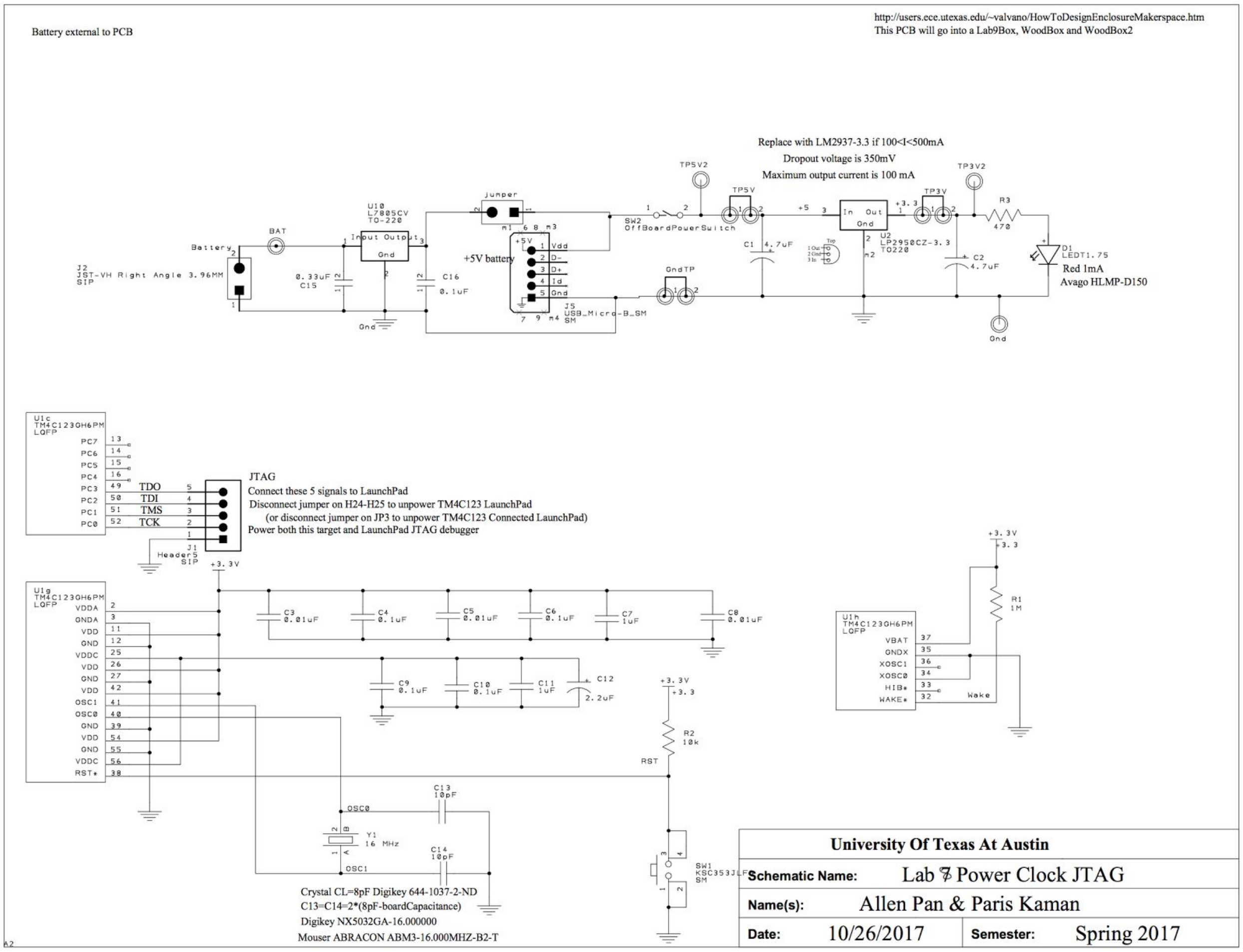
2.3. Usability

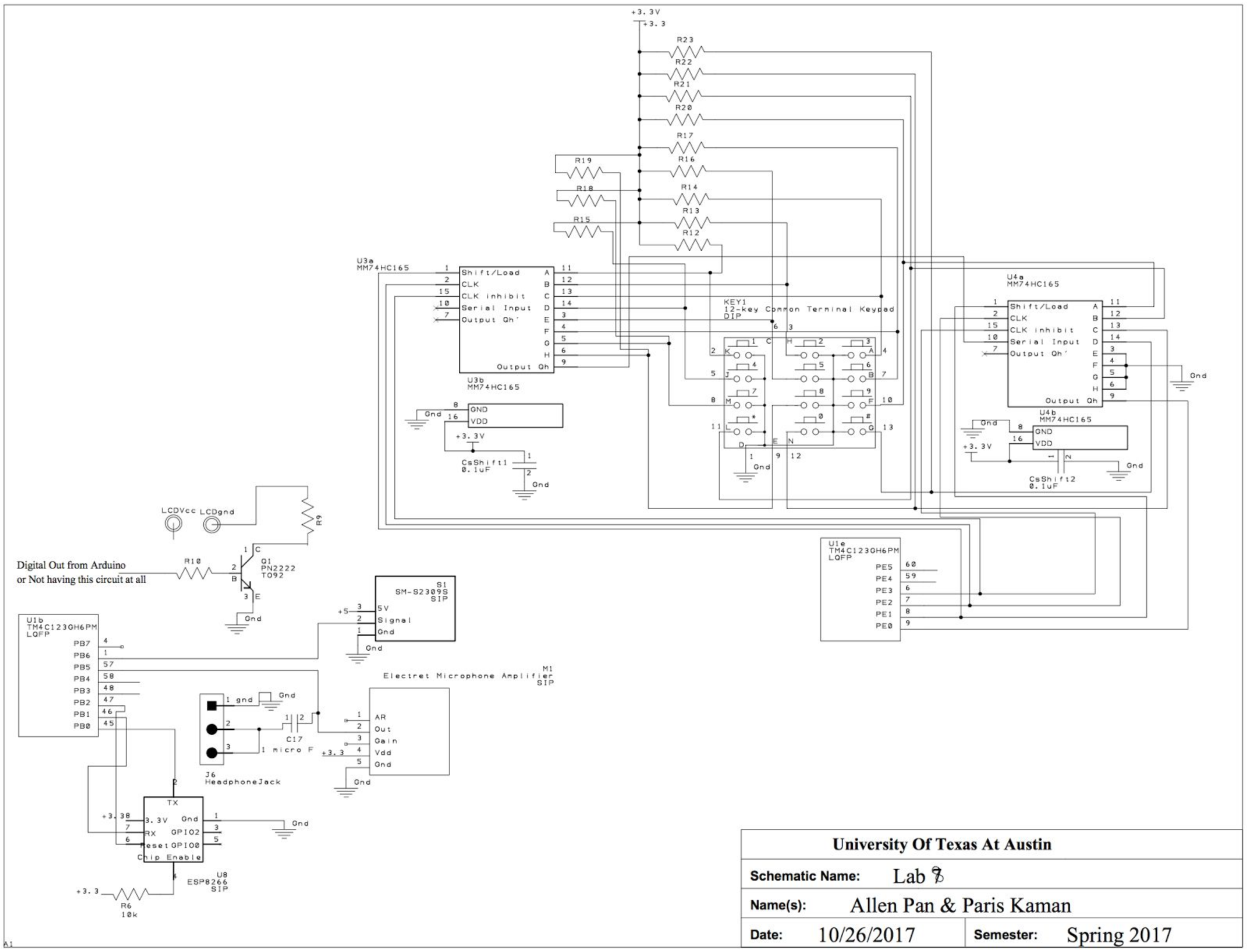
The system has a 12-button keypad, a button, a camera, a microphone as input, and have an audio output, a servo and 2 LCDs as output. The 12-button keypad and button are the only input the user will interact with directly while the others will provide input on their own if certain conditions are met.

3. Deliverables

3.1 Hardware Design




Battery external to PCB
http://users.ece.utexas.edu/~valvano/HowToDesignEnclosureMakerspace.htm
This PCB will go into a Lab9Box, WoodBox and WoodBox2
Replace with LM2937-3.3 if 100<I<500mA
Dropout voltage is 350mV
Maximum output current is 100 mA
J2
JST-VH Right Angle 3.96MM
SIP
Battery
BAT
U10
L7805CV
TO-220
Input Output
Gnd
0.33uF
C15
C16
0.1uF
Jumper
+5V battery
J5
USB_Micro-B_SM
Vdd
D-
D+
Id
Gnd
SW2
OffBoardPowerSwitch
TP5V2
TP5V
GndTP
C1
4.7uF
+5
U2
LP2950CZ-3.3
TO220
In Out
Gnd
TP3V
TP3V2
R3
470
C2
4.7uF
D1
LEDT1.75
Red 1mA
Avago HLMP-D150
Gnd
U1c
TM4C123GH6PM
LQFP
PC7
PC6
PC5
PC4
PC3
PC2
PC1
PC0
TDO
TDI
TMS
TCK
J1
Header5
SIP
JTAG
Connect these 5 signals to LaunchPad
Disconnect jumper on H24-H25 to unpower TM4C123 LaunchPad
(or disconnect jumper on JP3 to unpower TM4C123 Connected LaunchPad)
Power both this target and LaunchPad JTAG debugger
U1g
TM4C123GH6PM
LQFP
VDDA
GNDA
VDD
GND
VDDC
OSC1
OSC0
RST*
+3.3V
C3
0.01uF
C4
0.1uF
C5
0.01uF
C6
0.1uF
C7
1uF
C8
0.01uF
C9
0.1uF
C10
0.1uF
C11
1uF
C12
2.2uF
R2
10k
RST
SW1
KSC353JLFS
SM
OSC0
OSC1
Y1
16 MHz
C13
10pF
C14
10pF
Crystal CL=8pF Digikey 644-1037-2-ND
C13=C14=2*(8pF-boardCapacitance)
Digikey NX5032GA-16.000000
Mouser ABRACON ABM3-16.000MHZ-B2-T
U1h
TM4C123GH6PM
LQFP
VBAT
GNDX
XOSC1
XOSC0
HIB*
WAKE*
Wake
R1
1M
University Of Texas At Austin
Schematic Name: Lab 7 Power Clock JTAG
Name(s): Allen Pan & Paris Kaman
Date: 10/26/2017
Semester: Spring 2017



3.2 Software

Our software includes a number of modules and a main driver that defines the state machine which uses all the modules

Driver: The system boots into state 0

State 0: The owner is able to set the password for the system. After the password is set, the system enters state 2 (state 1 was scrapped so we pass from 0 straight to 2).

State 1 (inactive): Designed to be the motion detect state that would be entered after state 0 and then go to state 2 when motion was detected. Was bypassed due to problems with the motion detector in conjunction with the pcb.

State 2: The guest is able to enter a password guess to attempt to unlock the door. The guest gets 3 attempts to guess the right password. If the guest puts in the correct password, the system enters state 3. If all three attempts are used on incorrect guesses, the machine passes into state 4. Will re-lock the door.

State 3: Displays a welcome message and unlocks the door. A delay of about 5 seconds happens and then the machine returns to state 2.

State 4: Warns the guest that they have failed to enter the password correctly. This state was designed to play an alarm through the speaker but our amplifier IC was malfunctioning so we decided to make the alarm cues strictly visual. After around 5 seconds, the system returns to state 2.

Modules:

ST7735:

LCD that interacts with user input.

Speaker:

Output 1. The alarm and other system sound accompanying input and output, 2. the voice collected by microphone.

This module is not used in the final design, due to some hardware issue with the speaker circuit.

Alarm:

Intended to be a replacement for the speaker.

We coded the main driver so that it triggers the alarm when the bell is pressed or when the password is entered incorrectly for three times. But the hardware was not figured out to demonstrate this effect.

Servo:

Rotates the servo to simulate door lock and unlock. Used two different duty cycle to represent two positions.

Keypad:

12 keys for user input. Use shift register to realize parallel input.

In the state machine, each state we program the shift register to read the current input.

Button:

One button for the bell. Use a timer for debounce.

Microphone:

Collects the voice and use ADC to convert it to digital values.

ADC sample rate is 44100 Hz.

The software module is left out from the final driver, since the speaker did not work as expected

MotionDetect:

Use the motion detector in the camera module to detect motion, which controls the monitor. TVon and TVoff functions control the monitor by enabling and disabling the video signal from the camera board. TVon also starts a timer to count down for 10 seconds.

In the final design, the motion detection functions did not work properly, so we made the monitor respond to any key press and button press. The two functions that control video signal is still used as intended. So this module could be renamed to Monitor.

Serial:

UART0, communicates with the USB port for debug purpose.

DAC:

Used internally by Speaker.

Timer:

All periodic timers we will use in this project.

3.3 Measurement Data

The running system drew an average current of .97 A. We measured this by applying a 7.2V with DC power generator to the battery connector. 7.2V is what we get from our battery.

3.4 Video Link

https://www.youtube.com/watch?v=7I10A_XXOeU
(valid through the end of Fall 2017 Semester)