Lab 6 Post Lab Report
Grace Zhuang (gpz68) and David Chun (dc37875)

A) Objectives (Requirements document from the Lab for which you selected to layout the PCB)

1. Overview

1.1. Objectives: Why are we doing this project? What is the purpose?

The objectives of this project are to design, build and test an alarm clock. Educationally, students are learning how to design and test modular software and how to perform switch/keypad input in the background.

1.2. Process: How will the project be developed?

The project will be developed using the TM4C123 board. The system will be built on a solderless breadboard and run on the usual USB power. The system will use external buttons, LEDs, and a speaker. There will be 4 hardware/software modules: button input, time management, LCD graphics, and sound/LED output. Each module will be designed and tested independently. After each module is tested, the system will be built and tested.

1.3. Roles and Responsibilities: Who will do what? Who are the clients?

EE445L students are the engineers and the TA is the client. David and I will split the hardware/software modules for parallel coding, and then come together to build the hardware and debug the system.

1.4. Interactions with Existing Systems: How will it fit in?

The system will use the TM4C123 board, a ST7735 color LCD, a solderless breadboard, and be powered using the USB cable.

1.5. Terminology: Define terms used in the document.

power budget - allocation of power available for consumption by the system
device driver - collection of software routines that perform I/O functions
critical section - occasions within a software module where if an interrupt were to occur, an error could result
latency - response time of the computer to external events
time jitter - deviation from periodicity
modular programming - the process of sub-dividing a computer program into separate sub-programs

1.6. Security: How will intellectual property be managed?

The system may include software from Tivaware and from the book. No software written for this project may be transmitted, viewed, or communicated with any other EE445L student past, present, or future (other than the lab partner of course). It is the responsibility of the team to keep its EE445L lab solutions secure.

2. Function Description

2.1. Functionality: What will the system do precisely?

The clock will perform the following functions:

1) *It will display hours and minutes in both graphical and digital forms on the LCD. The graphical output will include the 12 numbers around a circle, the hour hand, and the minute hand. The numerical output will be easy to read.*
2) *It will allow the operator to set the current time using buttons.*

3) It will allow the operator to set the alarm time, including enabling/disabling alarms, using buttons.
4) It will make a sound at the alarm time.
5) It will allow the operator to stop or snooze the sound.
6) It will allow the operator to start and stop a stopwatch.
7) An LED heartbeat will signify when the system is running.

2.2. Scope: List the phases and what will be delivered in each phase.

Phase 1 is the preparation; phase 2 is the demonstration; and phase 3 is the lab report. Details can be found in the lab manual.

2.3. Prototypes: How will intermediate progress be demonstrated?

A prototype system running on the TM4C123 board, ST7735 color LCD, and solderless breadboard will be demonstrated. Progress will be judged by the preparation, demonstration and lab report.

2.4. Performance: Define the measures and describe how they will be determined.

The system will be judged by three qualitative measures. First, the software modules must be easy to understand and well-organized. Second, the clock display should be beautiful and effective in telling time. Third, the operation of setting the time and alarm should be simple and intuitive. The system should not have critical sections. All shared global variables must be identified with documentation that a critical section does not exist. Backward jumps in the ISR should be avoided if possible. The interrupt service routine used to maintain time must complete in as short a time as possible. This means all LCD I/O occurs in the main program. The average current on the +5V power will be measured with and without the alarm sounding.

2.5. Usability: Describe the interfaces. Be quantitative if possible.

There will be four button inputs; mode, increase, decrease, and confirm. The mode button can be used to switch between modes. The modes available will allow users to 1) set the time, 2) set the alarm and activate the alarm, 3) display the current time, and 4) run a stopwatch. The user will be able to set the alarm and time by hours and minutes. The buttons will be debounced. After approximately 30 seconds of inactivity, the display will return to displaying the current time.

The LCD display will show the time using a graphical display typical of a standard analog wall clock, as well as a digital clock display. The current mode (CLOCK, SET TIME, ALARM, STOPWATCH) will also be displayed at the top of the LCD. When the alarm goes off, a sound will be produced, and can be muted in 2 ways. The user can turn off the alarm by pressing one of the buttons, or the user can snooze the alarm for a set number of minutes by pressing a different button. If snoozed, the alarm will right again after the snooze time passes. The alarm will be loud enough to hear from 3 feet away.

2.6. Safety: Explain any safety requirements and how they will be measured.

The alarm sound will be VERY quiet in order to respect other people in the room during testing. Connecting or disconnecting wires on the protoboard while power is applied may damage the board.

3. Deliverables

3.1. Reports: How will the system be described?

A lab report described below is due by the due date listed in the syllabus. This report includes the final requirements document.

3.2. *Audits: How will the clients evaluate progress?*

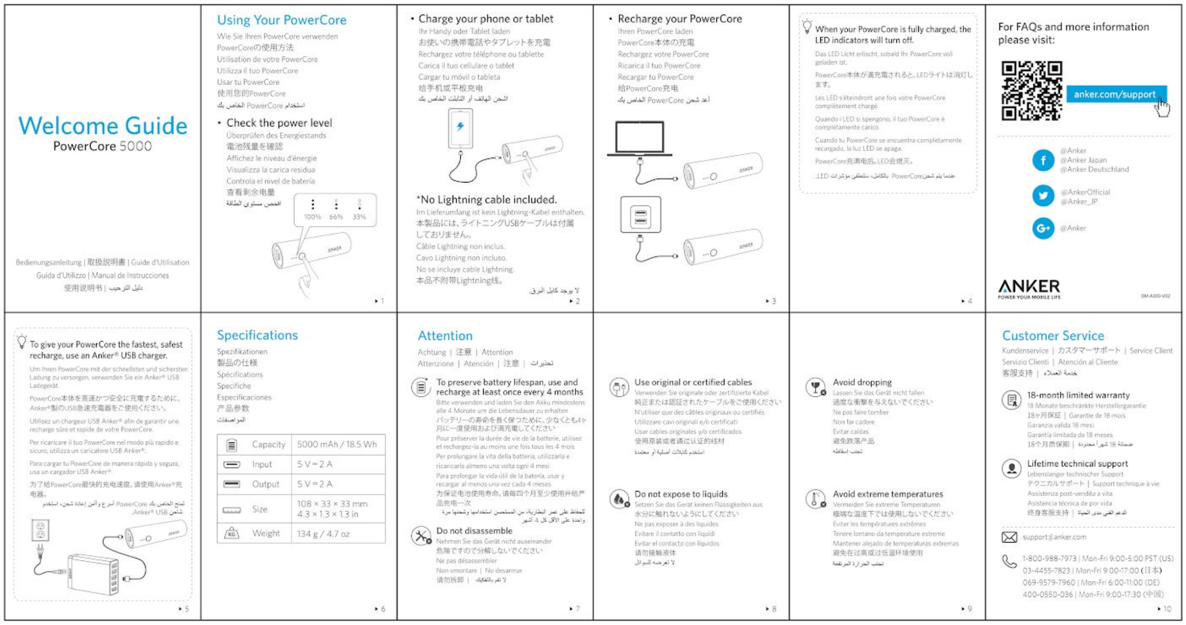
The preparation is due at the beginning of the lab period on the date listed in the syllabus.

3.3. *Outcomes: What are the deliverables? How do we know when it is done?*

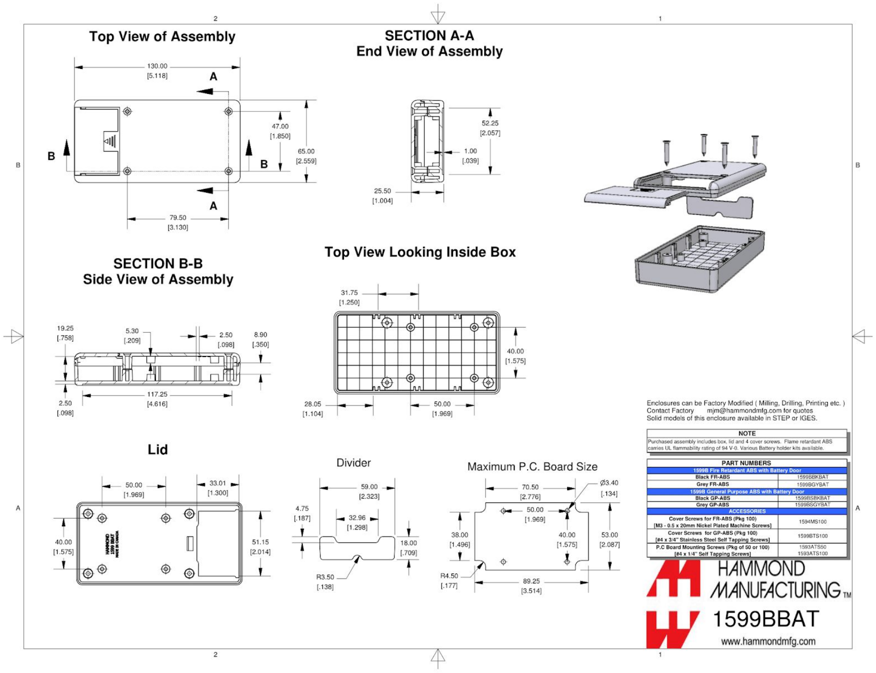
There are three deliverables: preparation, demonstration, and report.

B) Hardware Design

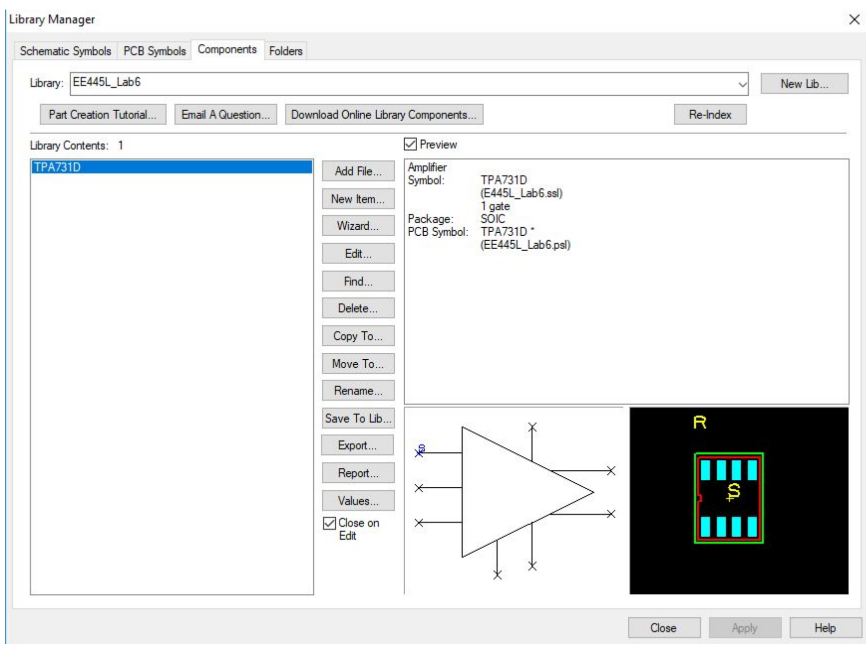
One page description of the battery (printout from the web) (Preparation 2)

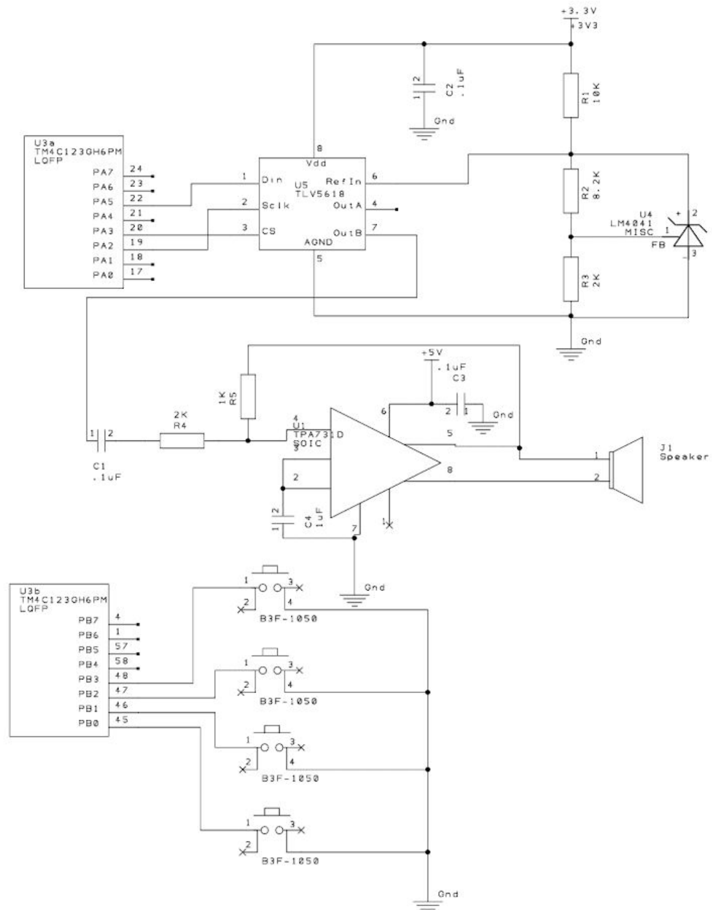


One page description of the box (like Figure 6.2, Preparation 3)

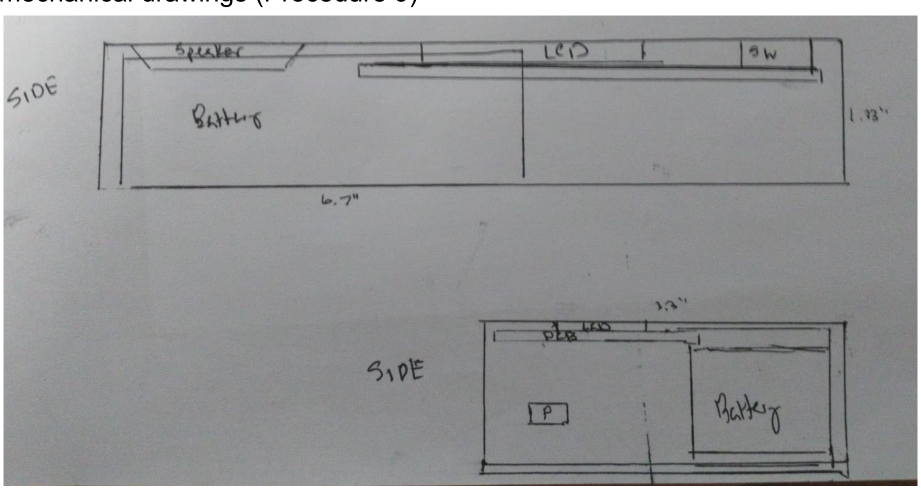


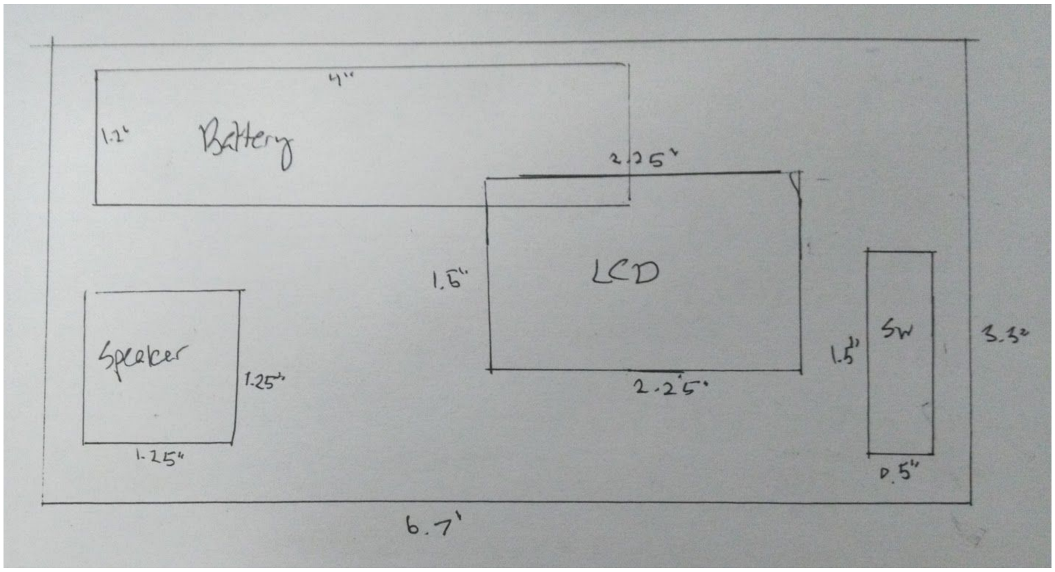
Three pages showing the new component you created and its usefulness and an example PCB using it





Two mechanical drawings (Procedure 9)

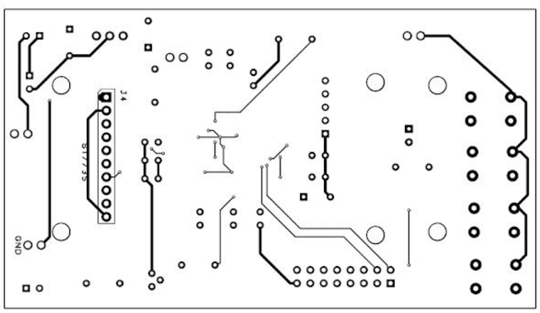


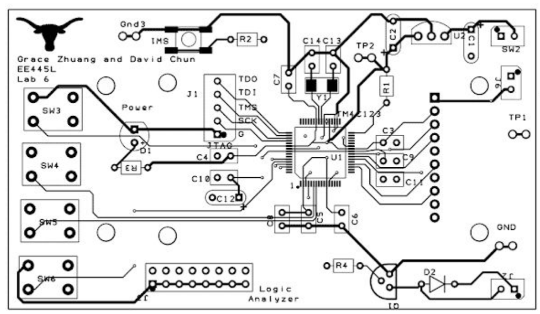


Final circuit diagram of the embedded system, SCH file

Attached in .zip folder

Cardboard mockup of the PCB layout (with top copper/silk on top and bottom copper/silk on bottom)





C) Software Design none

D) Measurement Data

Bill of Materials (quantity, package type, cost, and supply current) (Procedure 2)

Bill of Materials			September 3, 2017	"not free" means you have to buy it		"free sample" means you have to order it			
EE445L Fall 2017			EE445L pays for the PCB	"Cabinet means in one of the six black cabinets in professsor's office (bring a print out of your SCH")					
				"McDermott" means ask McDermott, quantity and style will vary (bring a print out of your SCH circuit)					
Qty Note	Estimated Current			"Box means in box in your McDermott's office (bring a print out of your SCH circuit)					
Quan		Type	Description	Manufacturer	Mfg. P/N	Distributor	P/N	Unit	Cost
1		ASM	32-ohm speaker			AllElectronics	SK-230	$0.50	$0.50
1		ASM	Black case, 7.5" by 4.3" by 2.2"	Hammond	1591ESBK	Mouser	546-1591ES-BK	$5.18	$5.18
4		CAP	Ceramic, Z5U, -20/+80%, 0.1 uF			Digikey	399-4151-ND	$0.05	$0.18
3		CAP	Ceramic, Z5U, -20/+80%, 0.01 uF			Digikey	399-4148-ND	$0.40	$1.20
2		CAP	Ceramic C0G, 10%, 10 pF	Murata 50V 5%	RDE5C1H100J0P1H03B	Digikey	490-8629-ND	$0.31	$0.62
1		CAP-Tant	Tantalum, 16V, 20% 2.2 uF	AVX Corporation	TAP225M016CCS	Mouser	581-TAP225M016CCS	$0.29	$0.29
2		CAP-Tant	Tantalum, 16V, 10% 4.7 uF			Jameco	94035	$0.22	$0.44
2		CAP-Tant	Tantalum, 20V, 10%, 1 uF			Digikey	478-1833-ND	$0.32	$0.63
1		CON	2-pin header			AllElectronics	SBH-2	$0.10	$0.10
4	18mA	CON	Test point, black	Keystone Electronics	5001	Digikey	36-5001K-ND	$0.23	$0.92
1		CON	Logic Analyzer connector	FCI	68021-208HLF	Digikey	609-3344-ND	$0.27	$0.27
1		CON	JTAG 1 by 5 male header					$0.29	$0.29
1	8 mA	CPU	TM4C123GH6PM 64-pin LQFP	TI	TM4C123GH6PMI	Mouser	595-TM4C123GH6PMI	$11.55	$11.55
1	8mA	CRYS	NX5032GA-16.000000	NDK	NX5032GA-16.000000	Digikey	644-1037-1-ND	$0.51	$0.51
1	50uA	DIODE	1N914 diode	Fairchild	1N914	Digikey	1N914B-ND	$0.05	$0.05
1	100mA	IC	LP2950 3.3V regulator, 100 mA TO-92	TI	LP2950-33LPRE3	Digikey	296-31455-1-ND	$0.19	###
1	1mA	LCD	18-bit color 128*160 1.8" TFT LCD displ	Sitronix	ST7735R	Adafruit	358	$19.96	$19.96
1		LED	Red 1.6V 1mA 5mm diffused	Avago Technologies	HLMP-D150	Digikey	516-1323-ND	$0.29	$0.29
1		RES	Carbon 1/6W, 5%, 470	Yageo	CFR-12JB-470R	Digikey	470EBK-ND	$0.02	$0.02
2		RES	Carbon 1/6W, 5%, 10K	Yageo	CFR-12JB-10K	Digikey	10KEBK-ND	$0.02	$0.05
1		RES	Carbon 1/6W, 5%, 1M	Yageo	CFR-12JB-1M0	Digikey	1.0MEBK-ND	$0.02	$0.02
1	10mA	SW	Tactile Switch, surface mount	C&K Components	KSC353JLFG	Mouser	611-KSC353JLFG	$0.86	$0.86
4		SW	B3F tactile push button switch	Omron Electronics	B3F-1052	Digikey	SW405-ND	$0.17	$0.68
1		SW	On/off power switch			BGMicro	SWT1010	$0.85	$0.85
1	10mA	TRAN	PN2222 NPN transistor	Fairchild Semiconductor	PN2222	Digikey	PN2222BU-ND	$0.13	$0.13
1		CON	Micro USB Type B, surface mount	Hirose Connector	ZX62D-B-5PA8(30)	Mouser	798-ZX62D-B-5PA830	$0.47	$0.00
TOTAL	209mA								

Explain how you chose the battery (Preparation 2)

At 209mA max current draw, the 5000mAh battery will last 24hrs (23.9hrs) which we believe is acceptable for a rechargeable clock. If we used a larger 20000mAh battery, we could run our lab for 3.98 days.

E) Analysis and Discussion (1/2 page maximum)

Test Buttons: No software needed

- *Connect a scope to test point V1 corresponding to SW 1 to ensure switch 1 operates correctly*
- *Connect a scope to test point V2 corresponding to SW 2 to ensure switch 2 operates correctly*
- *Connect a scope to test point V3 corresponding to SW 2 to ensure switch 3 operates correctly*
- *Connect a scope to test point V4 corresponding to SW 2 to ensure switch 4 operates correctly*

Testing Software: Run TM4C software clock as normal

Testing Software: Verify the clock outputs the correct hour and minute mark

- *Connect a scope to test point V6 for PF1 corresponding to the interrupt trigger for incrementing the time displayed*
  - *Verify PF1 properly increments at 60 second intervals*

Testing Software: Set alarm on running TM4C software clock

- *Connect a scope to test point V6 and V7 corresponding to the LED snooze outputs to verify the visual snooze properly executes*
- *Connect a scope to test point V8 for PF2 corresponding to the interrupt trigger for alarm length, both time to alarm and snooze alarm*
- *Connect a scope to test point V5 corresponding to the output of the DAC to verify the alarm sounds matches the sound waveform*