-5 for R/V table, see comments there
-5 NO TOLERANCE ANALYSIS
-4 formatting/grammar/misc

46/60

Easy Cube Clock

Design Review

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TA: Ankit Jain
ECE 445 – Senior Design
March 3, 2014

Figures are not all numbered correctly and some are not referenced (in-text, IEEE style) or named in their captions. Equations are poor resolution/illegible. You will be graded on the quality of your writing (clarity of explanations, professional tone/formatting, grammar, etc) in addition to the technical content, so make sure to proofread.

1.0 Introduction

1.1 Statement of Purpose

Today's alarm clock market is full of inexpensive, but hard to use alarm clocks. It is our observation that there is a need for an alarm clock that is easy to set, and turn on and off with little instruction. For this project we will design and build an accelerometer enabled alarm clock with a focus on ease of use, cost reduction, and manufacturability.

1.2 Objectives

1.2.1 Goals:

- Easy to use, no instruction manual necessary
- Cost effective for mass production
- Finished product will be in a 3D printed housing

1.2.2 Functions:

- Accelerometer enabled alarm
- Shake to snooze feature
- Touch enabled backlight

Best to combine Goals/Benefits, and also Functions/Features.

1.2.3 Benefits:

- Intuitive to users of all ages
- Eliminates frustrations of modern alarm clocks

1.2.4 Features:

- Battery life of more than 1 year
- Accuracy with no more than 2 minutes loss per year

1.3 Concept Sketch

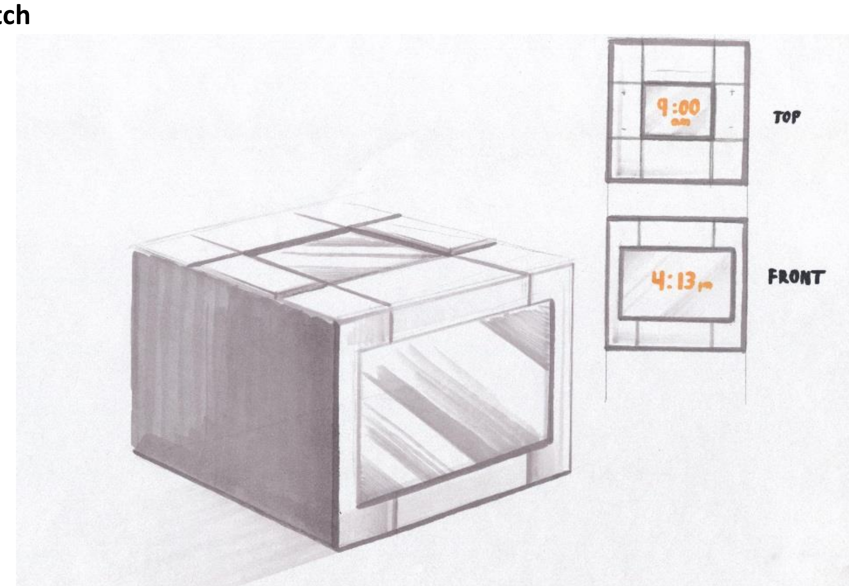


Figure 1: Concept Sketch – This sketch is a basic visualization of the project. The final case design will take place later as prescribed by the schedule. Drawn by Bradley Surmin

2.0 Design

2.1 Block Diagrams

Figure 2 presents the overall system layout. The main idea is the microcontroller processes inputs from the user/environment, and the Real Time Clock, and in turn outputs signals to the top/front displays and buzzer.

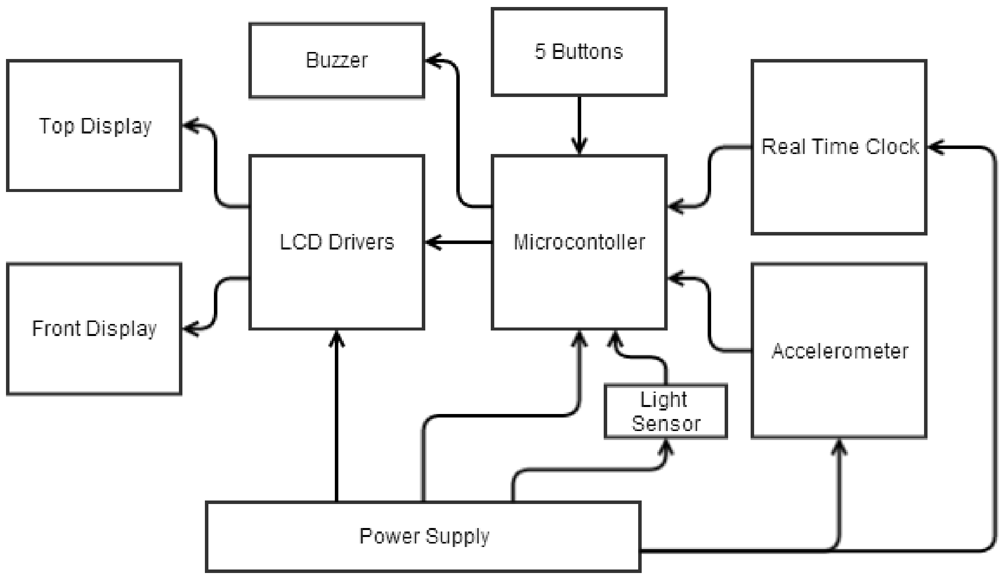


Figure 2:Top Level Block Diagram

2.2 Block Descriptions

2.2.1 5 Buttons:

There will be 5 buttons on the clock to make for an intuitive user interface. The method for reading button states will be simply implemented in hardware, as there will be a pin on the controller dedicated to each button. The controller will sense when a button is pulled to a low voltage. The software portion of the buttons will require handling interrupts so the buttons behave in a responsive manner.

2.2.2 Real Time Clock:

The time keeping ability of a microcontroller alone is not practical for a desk clock. To augment the time keeping, there will be a Real Time Clock (RTC) chip that will keep track of the seconds, minutes, and hours to a very high precision. In addition, the RTC chip will incorporate a backup battery to enable the main clock batteries to be replaced without resetting the time.

2.2.3 Accelerometer:

Beyond the 5 buttons, users will be able to interact with the clock through the accelerometer. Primarily the accelerometer will communicate with the controller, then enabling turning off and on the alarm / backlight, and shake to snooze.

2.2.4 Power Supply:

All electrical devices in the clock will draw on the power supply. This includes a power source (batteries) and a voltage regulator to create 3.3V and 5V sources for the various components on the board.

2.2.5 Front and Top Display:

The LCD displays feature an LED backlight, and will be controlled by driver circuitry. The front display will show the current time on four 7-segment LCDs, while the top display will show the alarm time.

2.2.6 LCD Driver Circuit:

The LCD driver circuit will take signals in a standard data protocol from the microcontroller and will decode these signals to control the two 7-segment LCD displays and the LED backlights.

2.2.7 Light Sensor:

The light sensor will be a small photocell that will have a resistance based on the lighting conditions. The microcontroller will perform an A/D conversion and use the information to control the backlight.

2.2.8 Buzzer:

The buzzer will act as the audible alarm, which will be controlled by the microcontroller. The can be driven by a simple DC signal and will output a specific frequency.

2.2.9 Microcontroller:

The PIC microcontroller we will use will control the operation of almost all of the different parts. It acts as the brain of the device and will handle functions such as processing button presses, sending signals to the LCD drivers to control both displays, enabling the buzzer when the alarm is set to go off, get input from the accelerometer to know the orientation of the device, and get input from the photocell.

3.0 – Block Details

3.1 Block Details – Power Supply

Power Supply	
Inputs	2 AA Batteries @ 3.0 V
Outputs	3.3 VDC ± 5% to accelerometer, PIC microcontroller, real time clock
	5.0 VDC ± 5% to front display, top display, buzzer, photoresistor

The power supply will consist two Maxim MAX856 3.3V/5V Step-Up, high efficiency, DC-DC converters powered by two AA batteries connected in series with a Schottky diode to provide 2.7 volts. Both voltage converters take the input of 2.7 volts and bring the voltage up to 3.3 volts and 5 volts. These output modes maybe selected by setting pin 2 to ground for 5 volts, and VIN for 3.3 volts (Figure 1)[i]. These are fixed voltage regulators so no external resistors are necessary to regulate voltage output, only filter capacitors and an inductor will be chosen according to specifications on the datasheet.

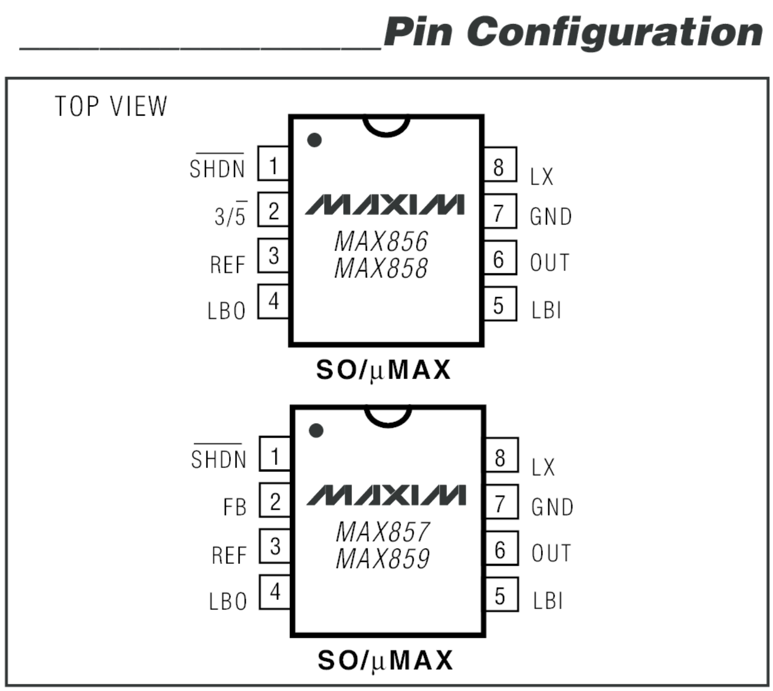


Figure 3

The voltage regulators are both switch-mode regulators controlled by a current-limited pulse frequency modulation control scheme, which allows for its very low quiescent current of typically 25 µA. The choice to use a switching regulator over a LDO linear regulator came from the need to have the most power efficient voltage regulator to ensure longest operation time. Even though LDO linear regulators are easy to configure and cost efficient, they are very inefficient at micro power regulation. With a current of about 7.8µA being drawn from the 3.3V logic circuit and negligible power from the LCDs, without backlighting and the buzzer disabled, it was necessary to use a regulator with very low power consumption at these levels.

For the 3.3V logic circuit, at 7.8µA drawn, the efficiency of the circuit is about 10% (Figure 2)[ii].

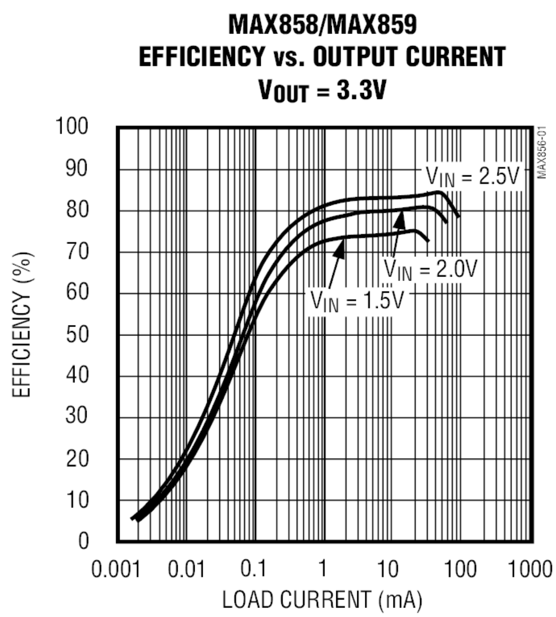


Figure 2

The amount of power drawn by the 3.3V circuit is as follows:

$$P_{3.3V\ in} = \frac{P_{3.3V\ out}}{\eta}, \eta = 0.1$$

$$P_{3.3V\ out} = 7.8\mu A * 3.3V = 2.574\ x\ 10^{-5}\ W$$

Stick with one scheme for units- "5V" instead of "5 volt" throughout.

$$P_{3.3V\ in} = 2.574\ x\ 10^{-4}\ W$$

For the 5 volt circuit, under normal operating conditions without backlighting and activated buzzer, the circuit effectively draws an immeasurable amount of power. As a result, the LCD displays maybe be assumed at no load conditions (Figure 3)[iii], which draws a total of 25µA typically.

From these conditions, it is possible to calculate the power consumption of the 5V circuit:

Minimum Start-Up Supply Voltage	I_{LOAD} = 0mA	0.8	1.8	V
Minimum Operating Voltage		0.8		V
Quiescent Supply Current in 3.3V Mode (Note 2)	I_{LOAD} = 0mA, $3/\overline{5}$ = 3V, LBI = 1.5V, V_{OUT} = 3.47V, (FB = 1.5V, MAX857/MAX859 only)	25	60	µA

Figure 5

$I_q = 25\mu A, V = 5V$

$P_{5.0V\ in} = 25\mu A * 5V = 1.25\ x\ 10^{-4}\ W$

It is now possible to calculate the total power dissipated and the time the circuit will be in an operational state with 2 AA batteries as the power source.

$P_{total} = 1.25\ x\ 10^{-4}\ W +\ 2.574\ x\ 10^{-4}\ W$

$P_{total} = 3.824\ x\ 10^{-4}\ W$

For the regulators to maintain the necessary voltage at 3V and 5V, 2.0V ≤ VIN ≤ 3.0V (Figure 4)[iv] . The average Alkaline AA battery holds about $2.60Wh$ at a voltage between $1.0V \leq$ Vbatt ≤ 1.5V. Using 2 Alkaline batteries will provide $2.0V \leq V_{in} \leq 3.0V$ with about 5.20Wh. The following calculations present how long the clock will be able to run using only 2 AA batteries without backlighting and buzzer.

$P_{total} = 3.824\ x\ 10^{-4}\ W$

$Watt * Hours_{batt} = 5.20Wh$

$$Total\ Operational\ Time = \frac{Power\ Capacity}{P_{total}} = \frac{5.20Wh}{3.824\ x\ 10^{-4}\ W}$$

$$Total\ Operational\ Time = \frac{13598.3\ hours}{24\ hours} = 566.597\ days$$

For the backlight and buzzer at 5 volts, the power consumption is as follows:

$P_{4\,LEDs} = 4 * 5V * 20mA = 400mW$

Output Voltage	2V ≤ V_{IN} ≤ 3V	MAX856, $3/\overline{5}$ = 0V, 0mA ≤ I_{LOAD} ≤ 100mA	4.80	5.0	5.20	V
		MAX856, $3/\overline{5}$ = 3V, 0mA ≤ I_{LOAD} ≤ 150mA	3.17	3.3	3.43	
		MAX857, V_{OUT} = 5V, 0mA ≤ I_{LOAD} ≤100mA	4.80	5.0	5.20	
		MAX858, $3/\overline{5}$ = 0V, 0mA ≤ I_{LOAD} ≤ 25mA	4.80	5.0	5.20	
		MAX858, $3/\overline{5}$ = 3V, 0mA ≤ I_{LOAD} ≤ 35mA	3.17	3.3	3.43	
		MAX859, V_{OUT} = 5V, 0mA ≤ I_{LOAD} ≤ 25mA	4.80	5.0	5.20	

Figure 6

$P_{Buzzer} = 5V * 20mA = 100mW$

$P_{total} = 500mW$

The buzzer was tested by hand using a bread board, 110 ohm resistor, and a power supply. The following table presents the amount of current drawn at certain voltages, and how audible the sound is from the buzzer.

Volts	Current(mA)	Sound
1.0	8	Very high pitched, faint
1.5	10.4	High pitched, more audible than 1.0V
2.5	20	Very audible, lower pitched
3.0	28	Very loud, almost same pitch as 2.5V

Figure 7

Since the amount of power dissipated by these components is very high, their outputs will be PWMed to help preserve power consumption. Once parts arrive, optimizing PWM will take place with microcontroller and instantaneous power consumption for 5 second intervals will be calculated.

An inductor is necessary to allow the voltage regulators to boost 3.0V to 3.3V and 5.0V. According to the datasheet, inductance value is not too critical and it is recommend to use 47µH[v]. Smaller inductances will result in higher peak inductor currents, but at the low levels we are using the voltage regulators, the inductance value will be optimized. See figure 6 for connection information.

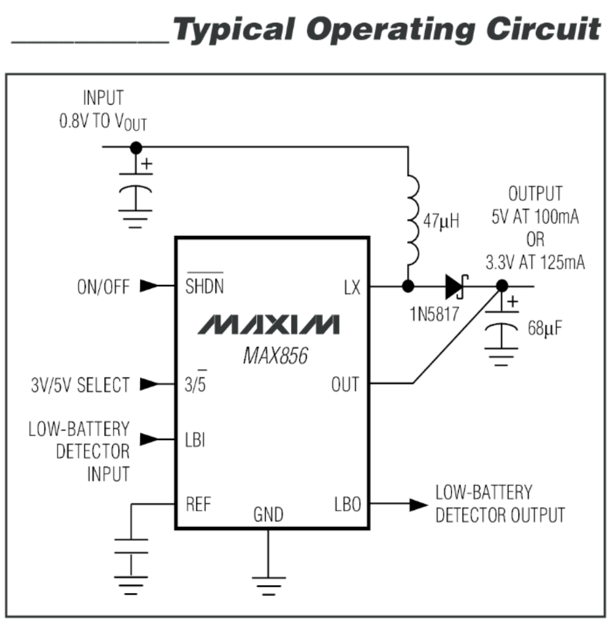


Figure 8

Three capacitors will be required for operation of each regulator. Two 68µF capacitors will be placed on the input and the output to provide filtering and manage the voltage ripple caused by the switch-mode (see figure 6). According to the datasheet, it is recommended to use 68µF capacitors, which provides a 50mV ripple when stepping up 2V to 5V at 100mA. At the low current levels the clock will be using, the voltage ripple will not be as important. However, once regulators arrive, capacitor values will be optimized for operation. It is also recommend to place a 0.1 µF capacitor between REF and ground if it is not being used[vi]. See figure 6 for full connection information.

Schottky Diode is recommended for optimal performance[vii]. See figure 6.

Provided Ripple Simulations[viii]:

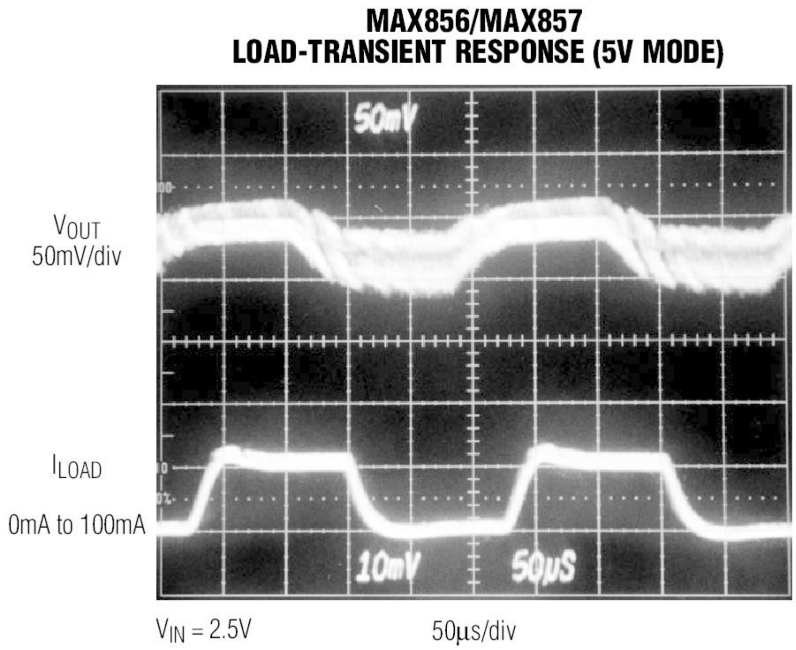


Figure 8

3.2 Block Details – Photo Diode

Photodiode dynamic range simulation:

In MATLAB:

```
% as the light level increases, the resistance decreases
r = [16:500]; % variable photocell resistance in kilohms

V = 5; % voltage across photoresistor voltage divider
R = 270; % series resistance in kilohms

%voltage divider
vout = V*(r./(R+r));

plot(r,vout)
title('Vout vs Resistance in Photocell');
xlabel('Resistance in Photocell (k\Omega)');
```

ylabel('Vout (Volts)')

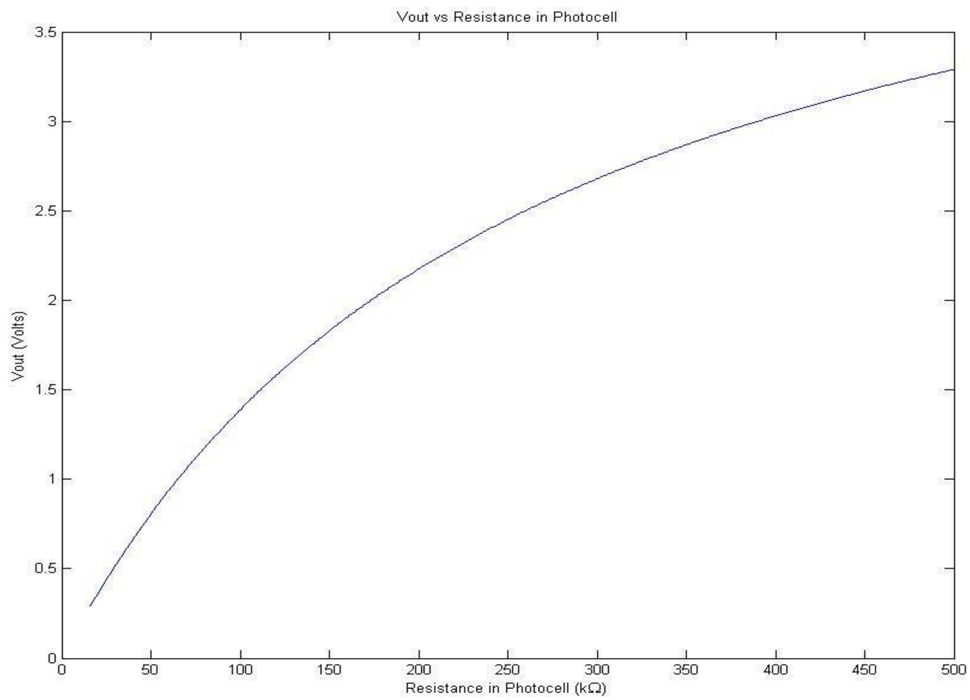


Figure 1

In Figure 1, Vout will go directly into the microcontroller, and will cover nearly the entire 3.3V dynamic range of the A/D converter. This is desirable so 270 kilohms is a good series resistance for the photoresistor.

3.3 Block Details - 5 Buttons:

Button verification will happen in multiple stages. To start, there must be confirmation that the controller is set to receive/process button presses. Next, the buttons on the PCB should be tested to interface with the controller to ensure proper PCB construction. Finally, the end product must be tested and tweaked so multiple actuations feel right, and do not compromise any functions of the buttons. This data is best recorded in simple notes indicating valid connections.

3.5 Block Details – Real Time Clock

It is well known that the accuracy of a clock is dependent on a stable oscillating frequency. The accuracy can be quickly estimated using an oscilloscope over a range of temperatures. The real time chip's counter can be verified by leaving the clock on for a series of uninterrupted days to see that the crystal oscillator's frequency errors correlate with the overall drift (likely on the order of seconds). It would be useful to leave the clock on for a full year to evaluate its long term drift, but that is not possible for the time scale of this project. All data from this verification should be recorded in a table and graphed to show the drift over time.

3.6 Block Details – Accelerometer

For starters, it should be ensured that the accelerometer can exit low power mode when motion is present, and then determine right-side up or upside down orientation. The motion readings and orientation data should easily be extracted from the communication lines. The comparative power consumption between low power and normal modes of operation should be evaluated using an ammeter on the batteries. All data from this verification should be recorded in a table.

3.7 Block Details – Microcontroller

The PIC microcontroller will be used in the process of testing most of the other parts. During these tests, we will ensure the reliability of the interaction between the microcontroller and each other part, including the concurrent operation of each part as we add on to the system. We will attempt to press buttons in an attempt to find flaws in our code. We will test every feature of the alarm clock and leave it on for days at a time to ensure correct operation.

There is no explanation of your state machine/flow diagram anywhere in this document...

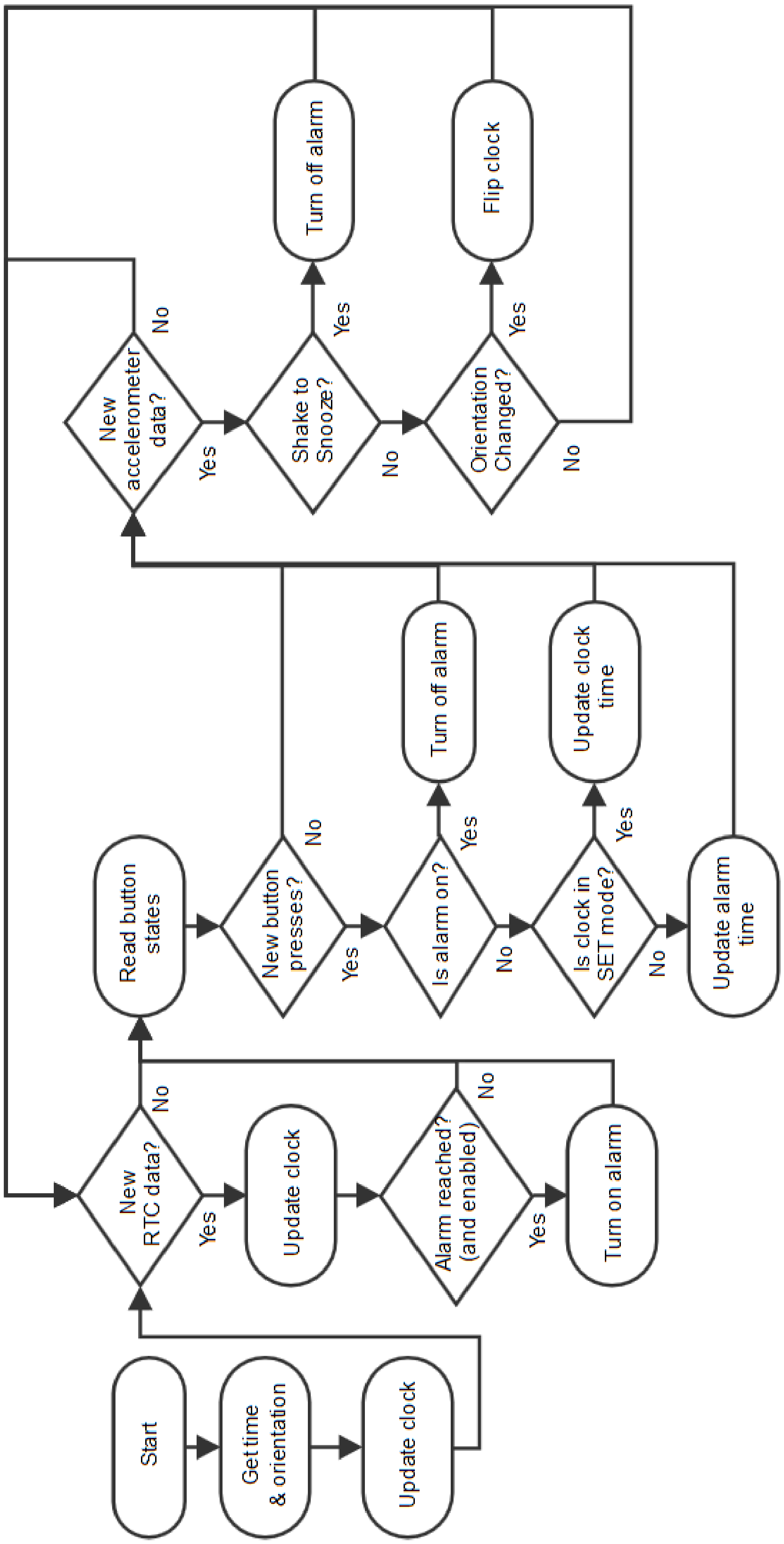


Figure 9

Good job on the tolerance ranges for Reqs & the detailed steps in Ver. The test blocks should be broken into lists of multiple steps for clarity, like a lab instruction manual.

4.0 - Requirements and Verifications

4.1 – Power Supply

Power Supply: Verification and Requirements	
Capacitors 68 µF ± 10% Capacitor 0.1µF ± 10%	1. To measure the values of the capacitors, they shall be placed in series on a bread board with a 100Ω resistor. A function generator will provided 3 volt peak to peak, 1KHz square wave to the circuit. An oscilloscope will then be placed across the capacitors and the voltage characteristics graph will be recorded. From the graph, using the rise time to which the voltage raises .707 percent of its max value, the capacitance will be calculated using $\tau = R * C$ and recorded. Values should be between 61.2 µF ≤ C ≤ 74.8 µF, 0.09 µF ≤ C ≤ 0.11 µF
Inductor value ± 10%	1. To measure the value of the inductor, it will be placed on a bread board in series with a resistor with a function generator providing a 3 volt peak to peak, 1KHz square wave. An oscilloscope will be placed across inductor and the voltage characteristics graph will be recorded. The graph will be triggered and the decay time to .707 of the original value will be measured. Using $\tau = L/R$, the inductance will be calculated and recorded. Values should be between 43.2µH ≤ C ≤ 52.8 µH
Voltage Regulator 3.3V ± 5%, 5V ± 5% **For ALL your regulators, you need to define an output current at this output V level or a load (impedance), whatever makes sense for your application.**	1. The 3.3V voltage regulator will be connected according to figure 6 and provided schematic. A 3 Vdc input will be provided and an oscilloscope will be connected between Vout and ground. The output voltage and corresponding voltage ripple will be recorded. 3.135 ≤ Vout ≤ 3.465V 2. The 5V voltage regulator will be connected according to figure 6 and provided schematic. A 3 VDC input will be provided and an oscilloscope will be connected between Vout and ground. The output voltage and corresponding voltage ripple will be recorded. 4.75 ≤ Vout ≤ 5.25V 3. Voltage source will be initially set to 3.0V and an oscilloscope will be attached to the output. The power supply voltage will be lowered to 2.0V, the lower limit of VIN, and the output will be monitored to see when VOUT drops below needed bounds for correct operation.

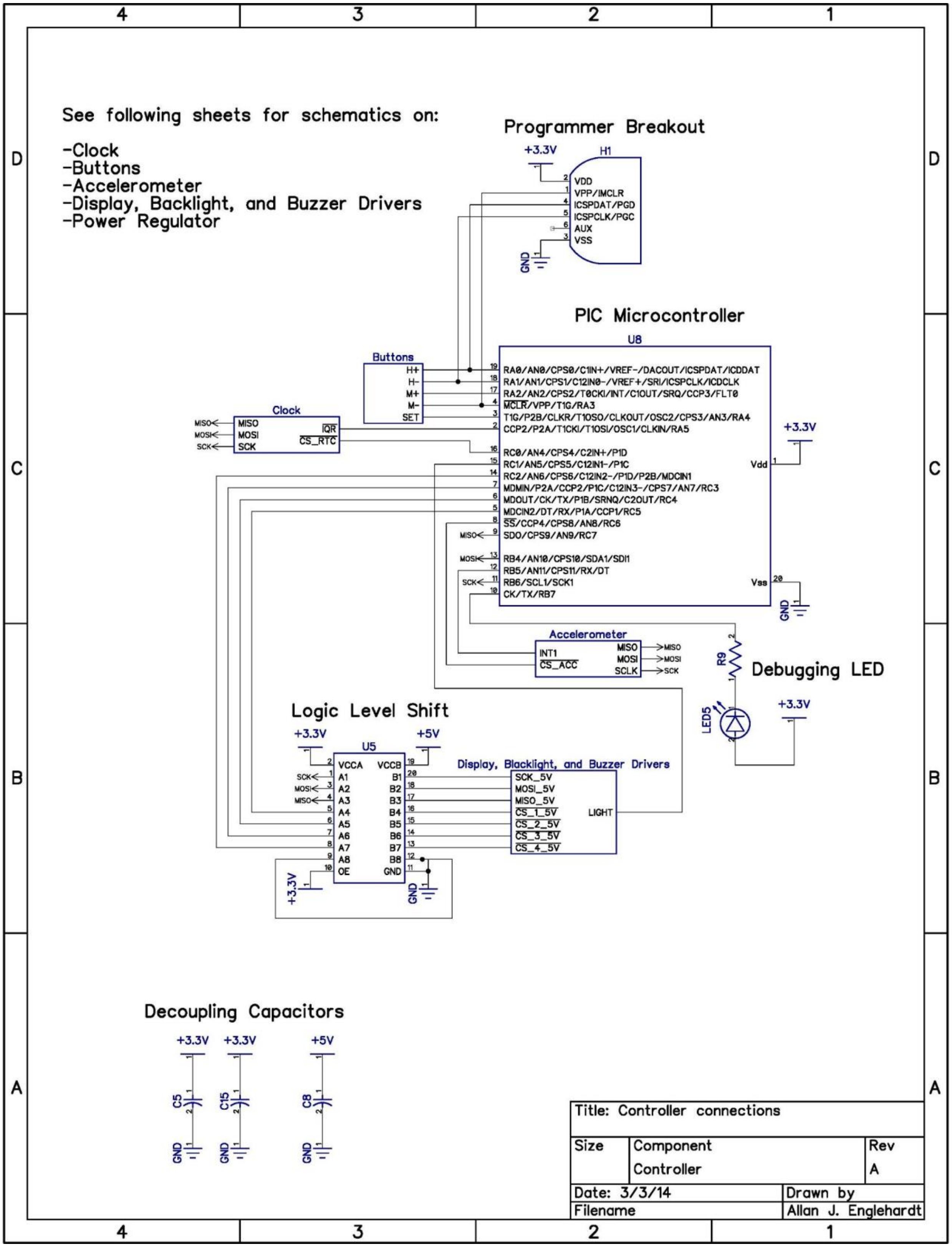
l is NOT a req *for* the micro- it is already addressed in the voltage regulator section
2 needs to outline requirements for ADC (resolution, bandwidth, precision, etc)
3-#5: Instead of describing functionality, these should be SPI transmit/receive signal integrity characteristics (timing from CLK-to-MISO OSI, usually). You could find SPI bus specs online and link to that in Req, then outline how to measure in Ver (i.e. "probe this line with scilloscope channel __, put cursors at __ voltage levels, measure time between these signals...")

Voltage Regulator 5V, 100mA ± 5%	4. To measure the output current of the 5V voltage regulator, a 50 Ω resistor will be connected in series with a digital ammeter in between Vout and ground. A 3 VDC power supply will be connected to VIN and the current will be measured. Current values should fall in between 95mA ≤ Iload ≤ 105mA.

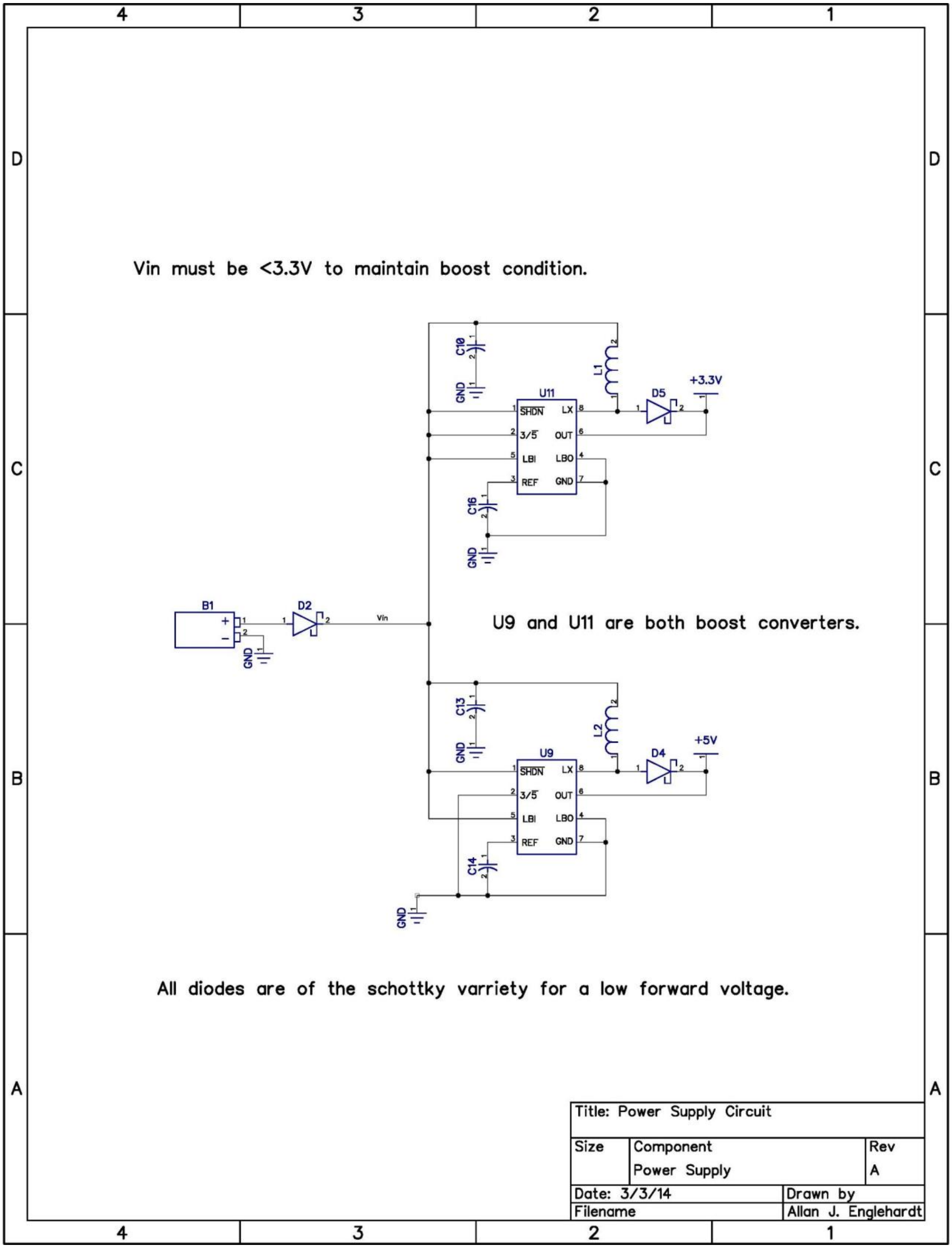
Requirements	**Verification**
PIC Microcontroller: 1) Module is supplied with 3.3V +- .2V 2) Module uses its A/D converter to read the voltage level from the photocell voltage divider circuit. The PIC expects a range of 0.292 to 3.247 V 3) Module uses SPI to interface with 4 I/O expanders to control the LCD displays, the backlight LEDs, the buzzer, and the load shedding pin for the photocell circuit. 4) Module uses SPI to request and receive data from the accelerometer whenever new data is available. New data is expected to be available when the interrupt pin detects a change in its logic value. 5) Module uses SPI to request and receive data from the RTC whenever new data is available. New data is expected to be available when the interrupt pin detects a change in its logic value, which we expect to be once every minute. 6) Module reads the input from the 5 buttons and adjusts the alarm/clock time accordingly.	PIC Microcontroller: 1) We will use a multimeter to verify a steady voltage supply within the range. 2) We will output the digital value read by the ADC on the PIC onto the LCD displays and record these values for different levels of brightness. 3) We will program the PIC with test cases to check every pin on the expander and verify that every output is what we expect. 4) The values read from the accelerometer will be displayed on the LCD displays to ensure we are getting sensible values. We will test reading the orientation by toggling an LED when the accelerometer is flipped. 5) We will display the time on the front display and make sure the time is updated accurately and consistently. 6) We will test the buttons initially by having each button press toggle an LED. Repeated tests should ensure we will not have issues with debouncing.
Buzzer #1 needs to be QUANTIFIED (usually uses dB SPL or dBA 1) Auditable at such a volume to wake up the user. 2) Operate in series with a 100 ohm resistor with 5V +- 0.2V applied across the circuit.	Buzzer 1) The buzzer's volume will be compared to that of a normal alarm. If loudness is comparable, it passes the test.
LCD Screens #2 needs to be at some minimum voltage -- "grounded" is too vague. 1) Each segment will turn on with a 5V +- .2V source applied. 2) Each segment will turn off when a segment is grounded.	LCD Screens 1) Each segment of display will be attached to a power supply an output in the range of 4.8V to 5.2V. 2) The segment will be grounded after turning

3) The current draw for each segment will never exceed 20 mA (~0 mA of current is expected in steady state.	on to ensure they turn off in a time imperceivable to the user. 3) While powering a segment, the common pin will be in series with a 1Mohm resistor. By turning the segment on an off in a periodic manner, the current through the segment can be monitored through the oscilloscope and calculated indirectly through ohms law. I = V/1Mohm
LCD, LED, and Buzzer Driver Circuit 1) All output pins can drive 20 mA at 5V (not simultaneously). 2) Outputs are capable of operating at a duty cycle of 20% (for LED dimming). 3) Current draw in standby mode (not driving any components) is < 1uA. **Wording on #1 needs to be clarified. Is it a single pin at a time, or up to 5 at a time? What does YOUR system need in order to function properly as YOU specified? That should be the requirement, not what the purchased devices can perform to.**	LCD, LED, and Buzzer Driver Circuit 1) Five at a time, each output pin will be attached from output to ground through a 230 ohm resistor and a ameter. There will also be a multimeter placed across the devices to ensure the output is 5V. If the device can provide > 20 mA at 5V+- for 1 minute, that set of pins will pass. 2) Each output pin will be connected to an oscilloscope, where the output waveform can be monitored. If a duty cycle of 20% is observable, when the driver is programmed in this mode, the device passes this test. 3) With all pins outputting a low (grounded) signal, the current into Vcc will be measured. If it is < 1uA, then the chip's parasite current acceptableablele level.

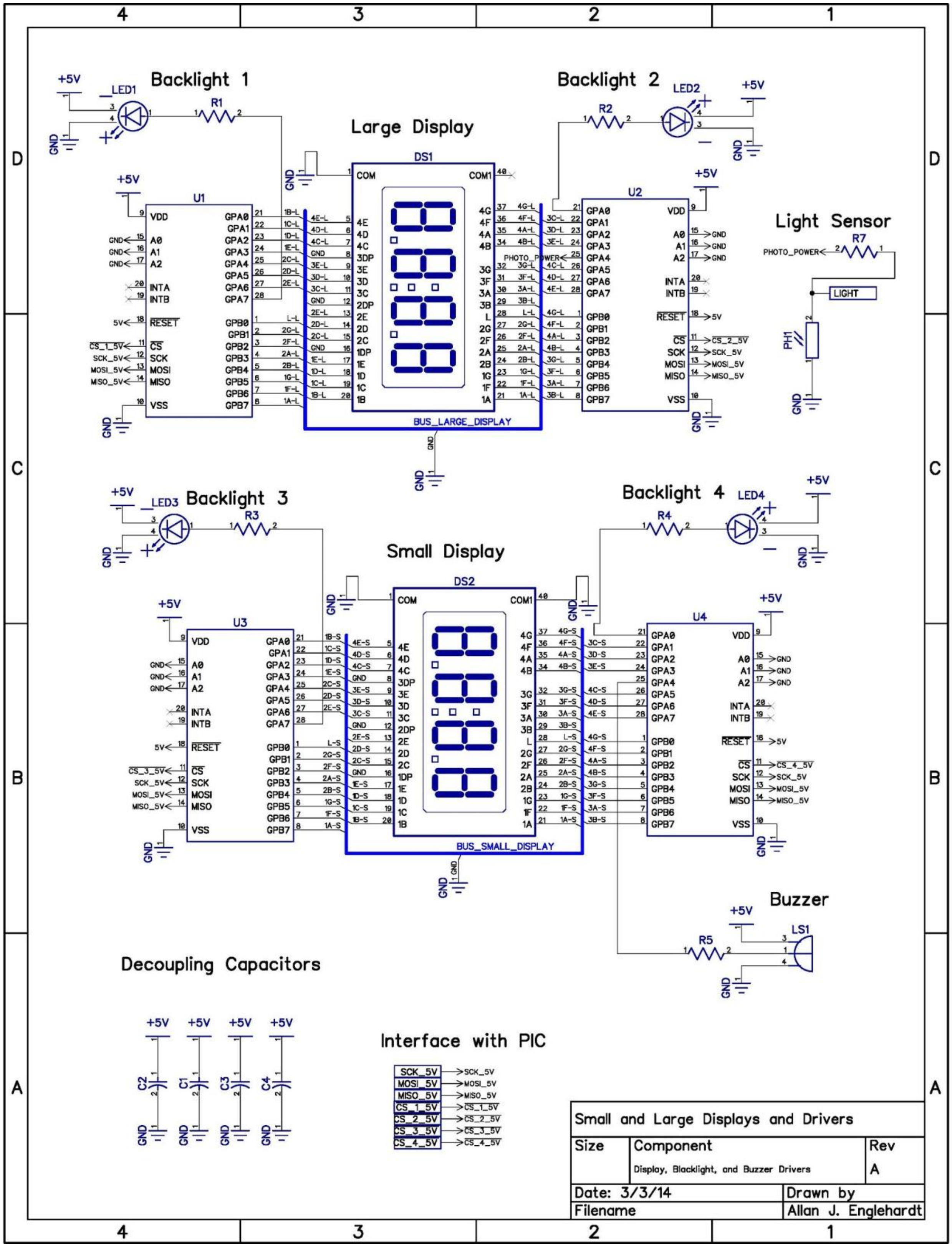
5.0 - Schematics



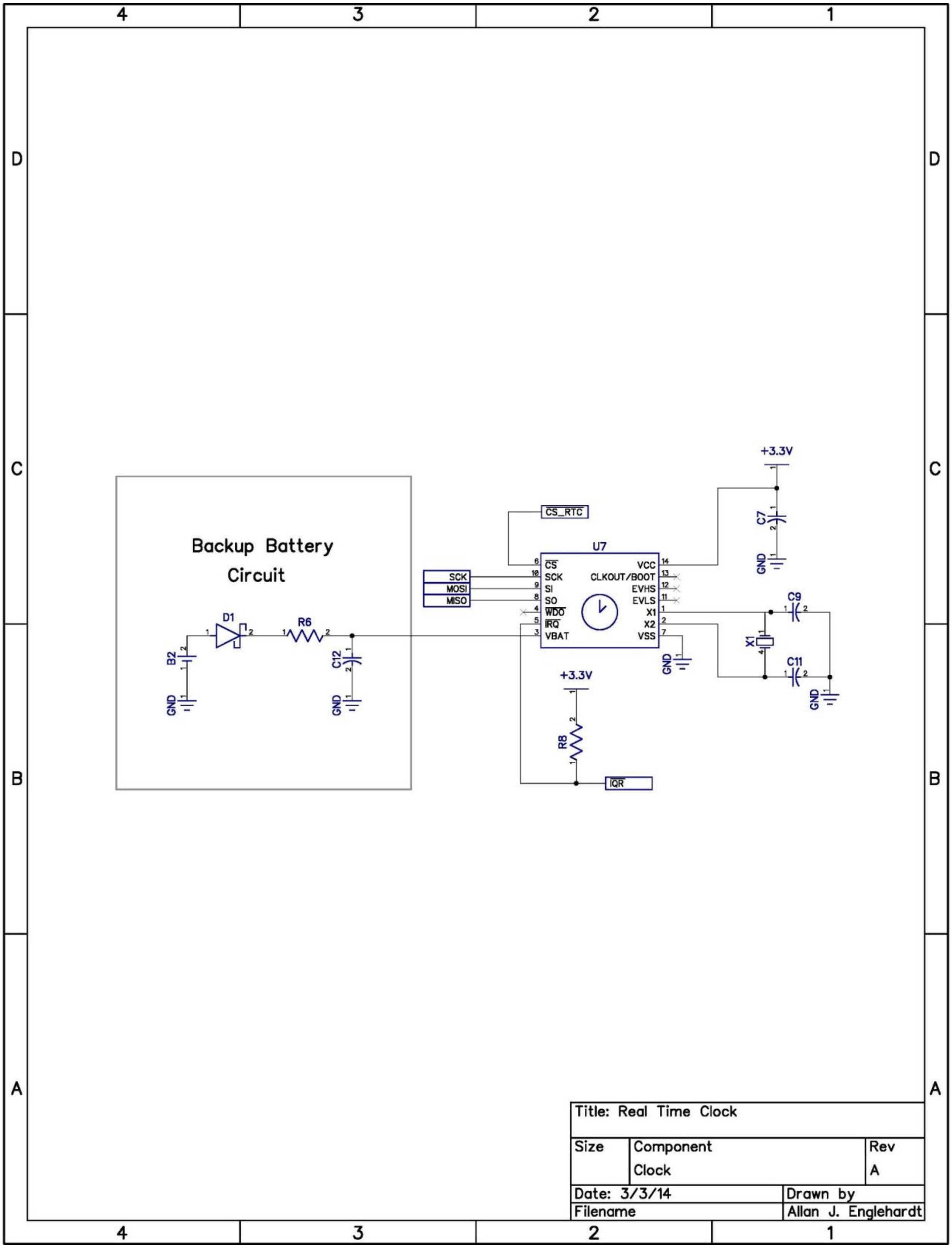
See following sheets for schematics on:
-Clock
-Buttons
-Accelerometer
-Display, Backlight, and Buzzer Drivers
-Power Regulator
Programmer Breakout
+3.3V
H1
VDD
VPP/IMCLR
ICSPDAT/PGD
ICSPCLK/PGC
AUX
VSS
GND
PIC Microcontroller
U8
Buttons
H+
H-
M+
M-
SET
Clock
MISO
MOSI
SCK
IQR
CS_RTC
RA0/AN0/CPS0/C1IN+/VREF-/DACOUT/ICSPDAT/ICDDAT
RA1/AN1/CPS1/C12IN0-/VREF+/SRI/ICSPCLK/ICDCLK
RA2/AN2/CPS2/T0CKI/INT/C1OUT/SRQ/CCP3/FLT0
MCLR/VPP/T1G/RA3
T1G/P2B/CLKR/T1OSO/CLKOUT/OSC2/CPS3/AN3/RA4
CCP2/P2A/T1CKI/T1OSI/OSC1/CLKIN/RA5
RC0/AN4/CPS4/C2IN+/P1D
RC1/AN5/CPS5/C12IN1-/P1C
RC2/AN6/CPS6/C12IN2-/P1D/P2B/MDCIN1
MDMIN/P2A/CCP2/P1C/C12IN3-/CPS7/AN7/RC3
MDOUT/CK/TX/P1B/SRNQ/C2OUT/RC4
MDCIN2/DT/RX/P1A/CCP1/RC5
SS/CCP4/CPS8/AN8/RC6
SDO/CPS9/AN9/RC7
RB4/AN10/CPS10/SDA1/SDI1
RB5/AN11/CPS11/RX/DT
RB6/SCL1/SCK1
CK/TX/RB7
Vdd
Vss
+3.3V
GND
Accelerometer
INT1
CS_ACC
MISO
MOSI
SCLK
R9
Debugging LED
LED5
+3.3V
Logic Level Shift
+3.3V
+5V
U5
VCCA
VCCB
A1
A2
A3
A4
A5
A6
A7
A8
OE
B1
B2
B3
B4
B5
B6
B7
B8
GND
Display, Blacklight, and Buzzer Drivers
SCK_5V
MOSI_5V
MISO_5V
CS_1_5V
CS_2_5V
CS_3_5V
CS_4_5V
LIGHT
Decoupling Capacitors
+3.3V
+3.3V
+5V
C5
C15
C8
GND
Title: Controller connections
Size
Component
Controller
Rev
A
Date: 3/3/14
Drawn by
Filename
Allan J. Englehardt

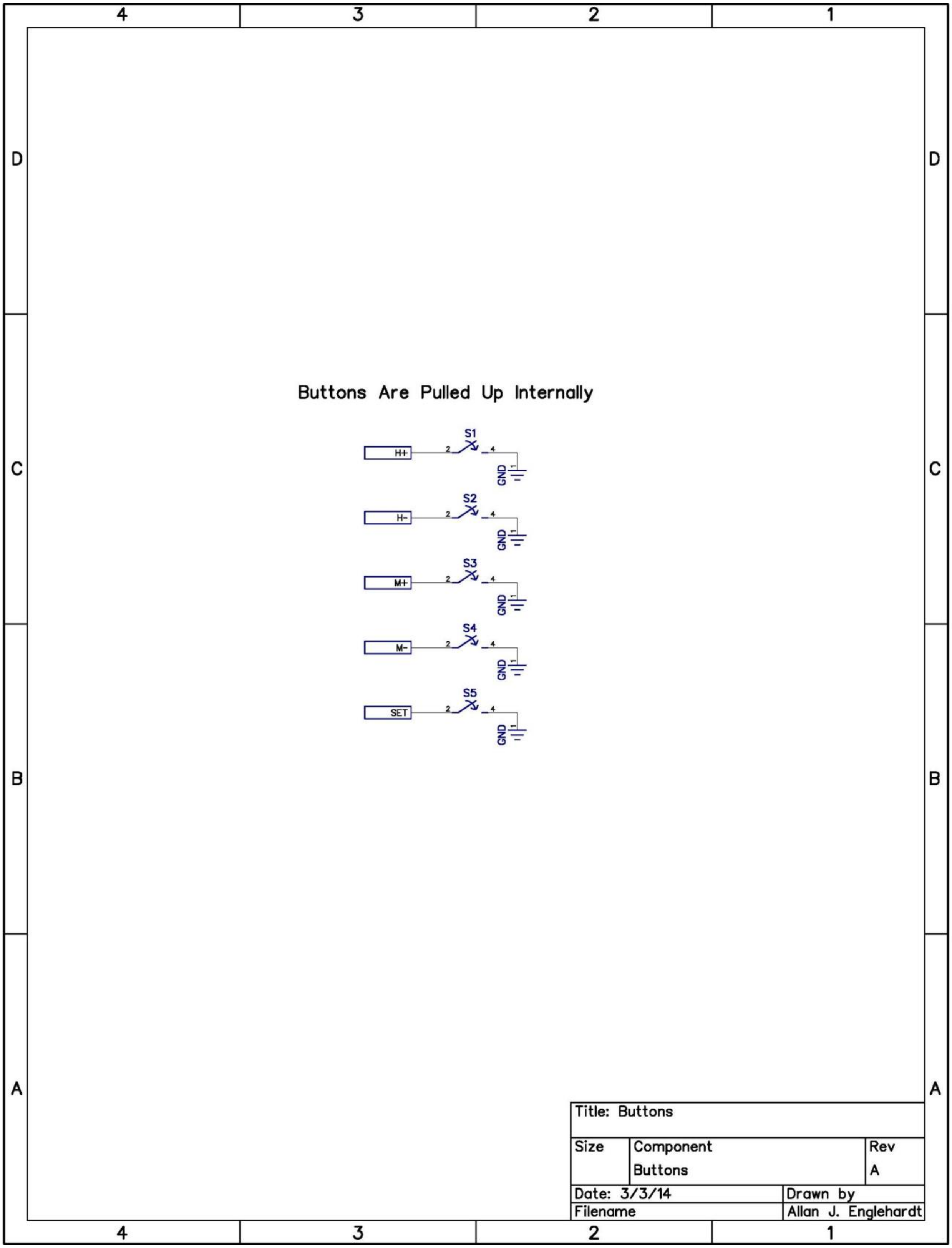


Vin must be <3.3V to maintain boost condition.
C10
GND
L1
U11
D5
+3.3V
SHDN
LX
3/5
OUT
LBI
LBO
REF
GND
C16
GND
B1
D2
Vin
GND
U9 and U11 are both boost converters.
C13
GND
L2
U9
D4
+5V
SHDN
LX
3/5
OUT
LBI
LBO
REF
GND
C14
GND
All diodes are of the schottky varriety for a low forward voltage.
Title: Power Supply Circuit
Size
Component
Power Supply
Rev
A
Date: 3/3/14
Filename
Drawn by
Allan J. Englehardt



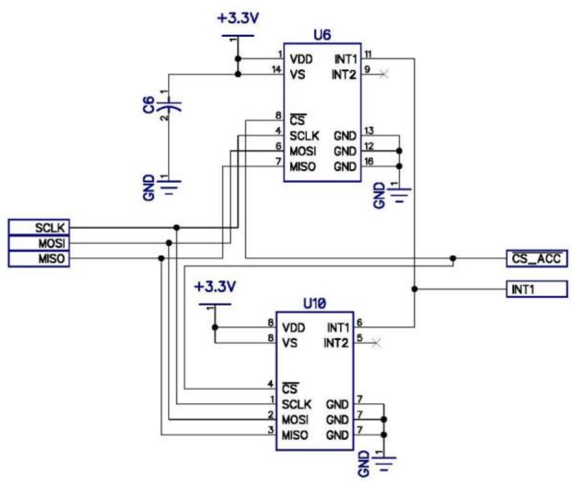
Backlight 1
Large Display
Backlight 2
Light Sensor
Backlight 3
Small Display
Backlight 4
Buzzer
Decoupling Capacitors
Interface with PIC
SCK_5V
MOSI_5V
MISO_5V
CS_1_5V
CS_2_5V
CS_3_5V
CS_4_5V
BUS_LARGE_DISPLAY
BUS_SMALL_DISPLAY
PHOTO_POWER
LIGHT
Small and Large Displays and Drivers
Size
Component
Display, Blacklight, and Buzzer Drivers
Rev
A
Date: 3/3/14
Filename
Drawn by
Allan J. Englehardt


Backup Battery
Circuit
B2
D1
R6
C12
GND
U7
CS
SCK
SI
SO
WDO
IRQ
VBAT
VCC
CLKOUT/BOOT
EVHS
EVLS
X1
X2
VSS
CS_RTC
SCK
MOSI
MISO
+3.3V
C7
C9
C11
X1
R8
IQR
Title: Real Time Clock
Size
Component
Clock
Rev
A
Date: 3/3/14
Drawn by
Filename
Allan J. Englehardt


Buttons Are Pulled Up Internally
S1
H+
S2
H-
S3
M+
S4
M-
S5
SET
GND
Title: Buttons
Size
Component
Buttons
Rev
A
Date: 3/3/14
Filename
Drawn by
Allan J. Englehardt

U6 is the ADXL362 IC and U10 is the ADXL362 breakout board.

U10 will be used if it is not possible to solder U6's LGA package.



U10 has decoupling cap on breakout board.

Title		
Size	Component Accelerometer	Rev A
Date: 3/3/14		Drawn by
Filename		Allan J. Englehardt

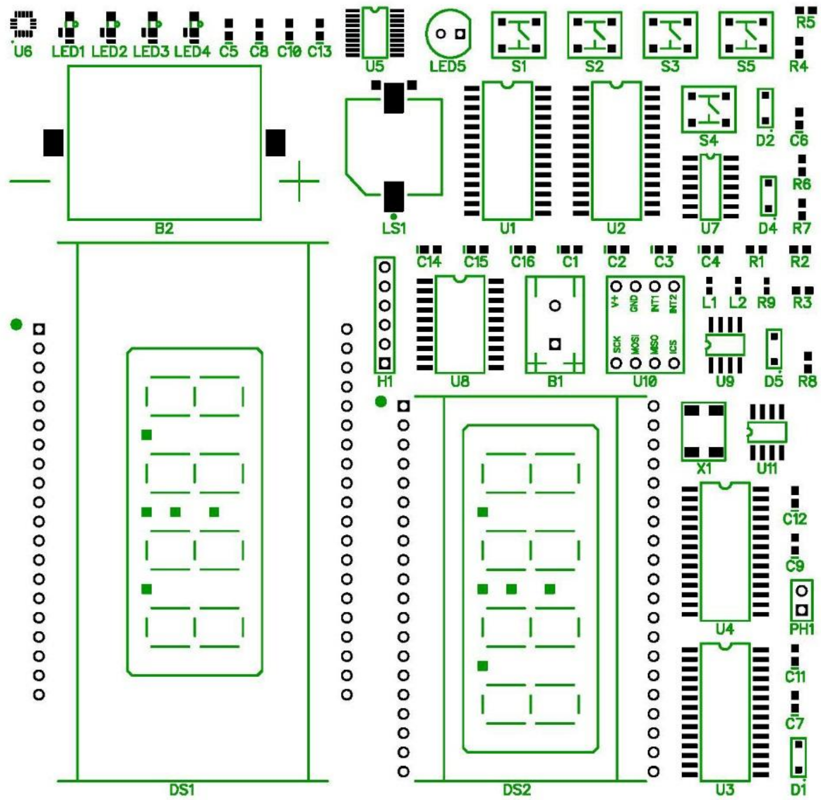


Figure 10

6.0 - Ethics

<u>Ethical Issues</u>

Our easy-to-use alarm clock promotes a healthy sleep schedule which promotes public health described in the first code of the IEEE Code of Ethics:

> *1. to accept responsibility in making decisions consistent with the safety, health, and welfare of the public, and to disclose promptly factors that might endanger the public or the environment;*

The quality and usability of an alarm clock depends on the accuracy of the clock. We will do an extensive analysis of the tolerance of our parts to ensure we can provide full disclosure about the true accuracy, following the third code.

> *3. to be honest and realistic in stating claims or estimates based on available data;*

Our alarm clock design introduces an accelerometer, which is uncommon for an alarm clock. By incorporating this into our design, we are demonstrating a different application for the same accelerometer technology used in smartphones.

4. to improve the understanding of technology; its appropriate application, and potential consequences;

Now that we have extensive documentation on our current design, we are having it reviewed by experienced electrical engineers. We will use the feedback we receive to improve our design, as stated in the seventh code.

7. to seek, accept, and offer honest criticism of technical work, to acknowledge and correct errors, and to credit properly the contributions of others;

We will be reviewing the design of another group and will do our best to help them improve their design and provide the appropriate feedback, consistent with the tenth code.

10. to assist colleagues and co-workers in their professional development and to support them in following this code of ethics.

7.0 Cost Analysis

7.1 Part Cost Analysis

RefDes	Value	Package	Description	Part #	Price	Bulk Price (Q >10000)
B1	N/A	2-Wire		BC2AAW	$ 1.04	$0.69
B2	N/A	Custom SMD		BA2032SM	$ 1.16	$0.72
C1	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB104	$ 0.10	$0.0032
C2	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB105	$ 0.10	$0.0032
C3	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB106	$ 0.10	$0.0032
C4	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB107	$ 0.10	$0.0032
C5	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB108	$ 0.10	$0.0032
C6	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB109	$ 0.10	$0.0032
C7	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB110	$ 0.10	$0.0032
C8	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB111	$ 0.10	$0.0032
C9	15pF	CAP_0603	Capacitor	CL10C150JB8NNNC	$ 0.10	$0.0051

C10	68uF	CAP_0603	Capacitor	FK11X5R0J686M	$ 0.86	$0.319
C11	15pF	CAP_0603	Capacitor	CL10C150JB8NNNC	$ 0.10	$0.0051
C12	100pF	CAP_0603	Capacitor	C1608C0G1H101J080AA	$ 0.10	$0.0051
C13	68uF	CAP_0603	Capacitor	FK11X5R0J686M	$ 0.86	$0.319
C14	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB104	$ 0.10	$0.0032
C15	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB104	$ 0.10	$0.0032
C16	0.1uF	CAP_0603	Capacitor	CC0603ZRY5V9BB104	$ 0.10	$0.0032
D1	N/A	SOD-123	Schottky Diode	MBR0520L	$ 0.36	$0.0584
D2	N/A	SOD-123	Schottky Diode	MBR0520L	$ 0.36	$0.0584
D4	N/A	SOD-123	Schottky Diode	MBR0520L	$ 0.36	$0.0584
D5	N/A	SOD-123	Schottky Diode	MBR0520L	$ 0.36	$0.0584
DS1	N/A	DIP-40	Large LCD Display	VI-415-DP-FH-W	$ 11.18	$5.064
DS2	N/A	DIP-40	Small LCD Display	VI-402-DP-FC-S	$ 5.85	$2.328
H1	N/A	6 Pin In	PICkit Connection	N/A	N/A	N/A
L1	47uH	IND_0603	Inductor	LBMF1608T470K	$ 0.19	$0.0675
L2	47uH	IND_0603	Inductor	LBMF1608T470K	$ 0.19	$0.0675
LED1	N/A	Custom_SMT	RT Angle LED (white)	SMLR13WBDW	$ 0.92	$0.302
LED2	N/A	Custom_SMT	RT Angle LED (white)	SMLR13WBDW	$ 0.92	$0.302
LED3	N/A	Custom_SMT	RT Angle LED (white)	SMLR13WBDW	$ 0.92	$0.302
LED4	N/A	Custom_SMT	RT Angle LED (white)	SMLR13WBDW	$ 0.92	$0.302
LED5	N/A	5mm_LED	TT LED	N/A	N/A	N/A
Ls 1	N/A	Custom_SMT	Buzzer	CT-1205-SMT-TR	$ 2.68	$0.8676
PH1	16k-500kohms	TT Standard	Photo Diode	PDV-P8103	$ 0.89	$0.35
R1	100 ohms	RES_0603	Resistor	RC0603JR-07100RL	$ 0.10	$0.0013
R2	100 ohms	RES_0603	Resistor	RC0603JR-07100RL	$ 0.10	$0.0013

R3	100 ohms	RES_0603	Resistor	RC0603JR-07100RL	$ 0.10	$0.0013
R4	100 ohms	RES_0603	Resistor	RC0603JR-07100RL	$ 0.10	$0.0013
R5	100 ohms	RES_0603	Resistor	RC0603JR-07100RL	$ 0.10	$0.0013
R6	1 kohms	RES_0603	Resistor	RC0603JR-071KL	$ 0.10	$0.0013
R7	270 kohms	RES_0603	Resistor	RC0603JR-07270KL	$ 0.10	$0.0013
R8	10 kohms	RES_0603	Resistor	RC0603JR-0710KL	$ 0.10	$0.0013
R9	75 ohms	RES_0402	Resistor	RC0603JR-0775RL	$ 0.10	$0.0013
S1	N/A	Surface_SPST	Tactile Switch	TL3315NF250Q	$ 0.19	$0.1117
S2	N/A	Surface_SPST	Tactile Switch	TL3315NF250Q	$ 0.19	$0.1117
S3	N/A	Surface_SPST	Tactile Switch	TL3315NF250Q	$ 0.19	$0.1117
S4	N/A	Surface_SPST	Tactile Switch	TL3315NF250Q	$ 0.19	$0.1117
S5	N/A	Surface_SPST	Tactile Switch	TL3315NF250Q	$ 0.19	$0.1117
U1	N/A	SOIC-28/300mm	SPI Expander	MCP23S17	$ 1.51	$0.95
U2	N/A	SOIC-28/300mm	SPI Expander	MCP23S17	$ 1.51	$0.95
U3	N/A	SOIC-28/300mm	SPI Expander	MCP23S17	$ 1.51	$0.95
U4	N/A	SOIC-28/300mm	SPI Expander	MCP23S17	$ 1.51	$0.95
U5	N/A	TSSOP-20	3.3V <-> 5V Logic	txb0108	$ 2.30	$0.9
U6	N/A	LGA-16	Accelerometer	ADXL362	$ 9.22	$4.8236
U7	N/A	SOIC-14/150mm	Real Time Clock	MCP795W10	$ 1.82	$1.33
U8	N/A	SOIC-20/300mm	PIC Microcontroller	PIC16LF1508	$ 1.27	$0.88
U9	N/A	SOIC-14/150mm		MAX856	$ 2.93	$1.6402
U10	N/A	SpFun Breakout		ADXL362	N/A	N/A
U11	N/A	SOIC-14/150mm		MAX856CSA	$ 2.93	$1.6402
X1	32.768 kHz	CUST_PKG		CM200C-32.768KHZFT	$ 1.31	$0.4725
				TOTAL	**$ 61.09**	**$28.3414**

Price for a one off PCB is $33.00

Price for a one off 3D print is $25.00

Total for Protype: $119.09

7.2 – Labor Cost

Name	Hourly Rate	Total Hours Invested	Total
AJ Englehardt	$40	150	$15,000
Jason Luzinski	$40	150	$15,000
Ben Riggins	$40	150	$15,000

7.3 – Grand Total

Section	Total
Labor	$45,000
Parts	$119.09
Total	**$45,119.09**

7.4 – Schedule

Week	Goals	Responsibility
2/2	Finish proposal and turn in for approval	AJ
	Select LCD display	Ben
	Create concept sketches for casing and buttons	Jason
2/9	Pick out optimal microcontroller	Ben
	Finalize user interface	AJ
	Estimate power consumption and design power circuit	Jason
2/16	Test LCD with breadboard and microcontroller	Ben
	Design part footprints in Eagle	AJ
	3D model parts in SolidWorks	Jason
2/23	Design LCD driver circuit	AJ
	State diagram for PIC	Ben
	Interface PIC with real time clock	Jason
3/2	Design PCBs	AJ
	Prepare for Design Review	Ben
	Design case	Jason
3/9	Order PCBs	AJ
	3D print prototype case at UIUC	Ben
	Organize cost and details for manufacturability	Jason
3/16	Assemble PCBs and test for errors	AJ
	Test button action and basic clock functions	Jason
	Program Accelerometer functions.	Ben
3/23	Redesign PCBs/Order new if errors are found	AJ
	Finalize aesthetics and 3D print final case	Jason
	Debugging of PIC program	Ben
3/30	Assemble clock	Jason
	Tweak clock functions and design parameters	Ben
	Optimize power consumption	AJ
4/6	Evaluate design and work on cost reduction	Ben
	Organize technical drawings	AJ
	Finalize mass production details	Jason
4/13-5/5	Design final presentation	All
	Demo	All

8.0 – Safety Statement

The nature of this device operating at maximum of 5V poses no serious safety risks. The primary concern will be building the device with a hot soldering iron and reflow oven. We will be sure to never work alone in the lab.

Report is missing Tolerance Analysis section.

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[i] Maxim 856 Datasheet Page 1, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[ii] Maxim 856 Datasheet Page 3, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[iii] Maxim 856 Datasheet Page 2, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[iv] Maxim 856 Datasheet Page 2, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[v] Maxim 856 Datasheet Page 9, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[vi] Maxim 856 Datasheet Page 9, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[vii] Maxim 856 Datasheet Page 6, Available : http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf
[viii] Maxim 856 Datasheet Page 5, Available: http://datasheets.maximintegrated.com/en/ds/MAX856-MAX859.pdf