A) Objectives
The goals of this lab were to create a PCB Layout, introduce a systems-level approach to embedded system design, and to design for test purposes. The systems-level approach included mechanical considerations, availability of parts, cost considerations, and power considerations.

B) Hardware Design
One page description of the battery is on page 3.
One page description of the box is on page 4.
Three pages showing the new component you created and an example PCB using it are pages 5-7.
Two mechanical drawings were shown to TA during prelab.
Final circuit diagram of the embedded system, SCH file are pages 8 and 9.
Top copper printout of the PCB layout is page 10.
Bottom copper printout of the PCB layout is page 11.
Cardboard mockup of the PCB layout can be printed out from page 12.

C) Software Design
None

D) Measurement Data
Bill of Materials (quantity, package type, cost, and supply current) starts on page 13.
Explain how you chose the battery (Preparation 2) The maximum current was 250 mA but the average was around 200 mA for our song which included periods of time when the speak was off. To compensate for this we chose to design for a battery at 225 mA. 225 mA * 24 hrs = 5400 mAhrs. The battery we chose was the *Tenergy Polymer Li-Ion 1-2C 3.7V 5400mA.* Since the voltage is only 3.7 V, we would need two of them to get above 5V for our 5V regulator to work properly.

E) Analysis and Discussion
Explain the testing procedure you would suggest for the system (Procedure 1)
First, provide 5-9V power to the board using the power headers. Verify that the LED (D1) is on. Use the test access points, GND and Vcc, to verify that the voltage is 5V at Vcc. Use the test point REF2V5 to verify it is 2.5V. Load software to output a 1 kHz sine wave to the speaker headers (J5). Test TLV5616 pin 7 output if there is no signal on J5. The software will also toggle the sine wave on and off upon switch press. This can be used to verify that the switches work. Press and hold the reset switch and verify that the sine wave turns off during switch press and returns on depress.
Explain any differences between estimated current (Procedure 2) and actual measured current measured when doing the lab.
Since the average current was measured while we played our song, this is not solely indicative of all the current requirements that a user may come up with. Therefore we chose a midpoint between the maximum and average current to design for the battery.

NiMH Single Cells
NiCd Single Cells
Li-Ion Single Cells
Li-Polymer Single Cells
LiFePO4 Batteries
Battery Packs
PCB/BMS
Battery Chargers
Li-FeS2 Batteries
Li-MnO2 Batteries
Li-SOCl2 Batteries
Power Inverters

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Company Products Li-Polymer Single Cells Tenergy Polymer Li-Ion 1-2C 3.7V 5400mAh (807295) (Item Number: 30136)
Li-Polymer Single Cells Tenergy Polymer Li-Ion 1-2C 3.7V 5400mAh (807295) (Item Number: 30136)

View Full-Size Image

View Full-Size Image

Tenergy Polymer Li-Ion 1-2C 3.7V 5400mAh (807295) (Item Number: 30136)

Item Number: 30136

Prismatic Polymer Li-Ion Battery, 3.7V, 5400mAh (807295) for Lighting and Laptop

Battery Chemistry	**Polymer Li-Ion**
Electrical	**3.7V, 5400mAh**
Model	**807295**
Max Charging Rate	**2785mAh (0.5C)**
Max Dis-Charging Rate	**5400mAh (1C)**
Cycle Life	**Up to 500 Times**
Weight	**103g**
Dimension	**95mm x 72mm x 8mm**

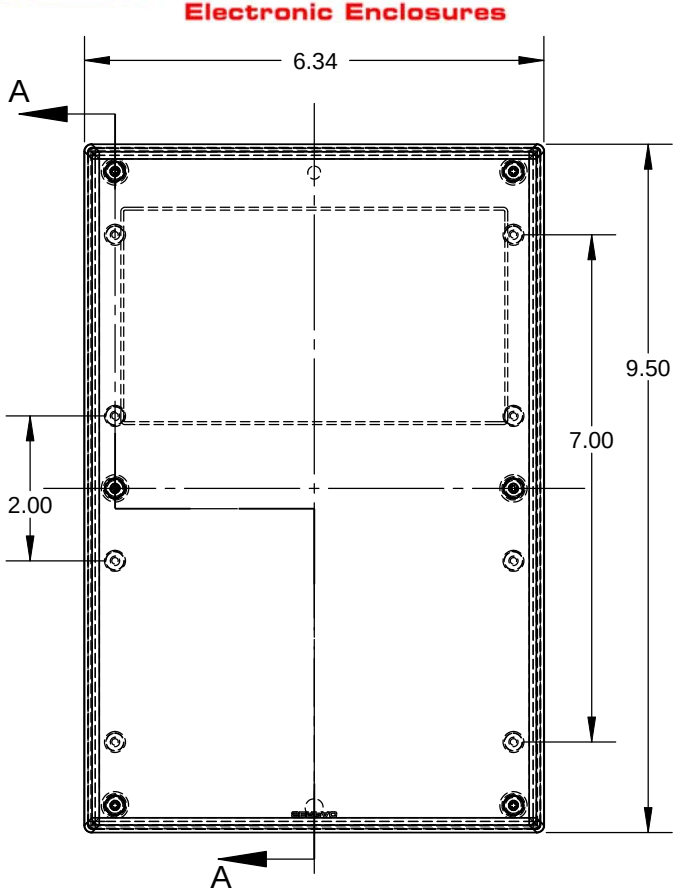
Cautions

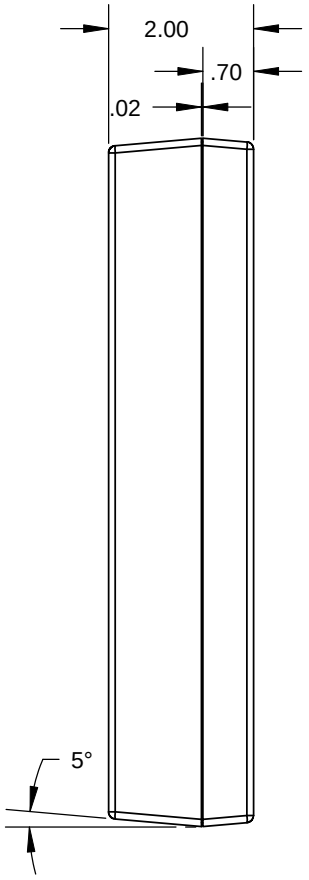
- **Li-ion cells are very sensitive to charging characteristics and may explode if mis-handled.**
- Make sure user has enough knowledge on Li-Ion rechargeable batteries in charging, discharging and assembly before use.
- We are not responsible for any damage caused by misuse or mishandling of these Li-Ion batteries

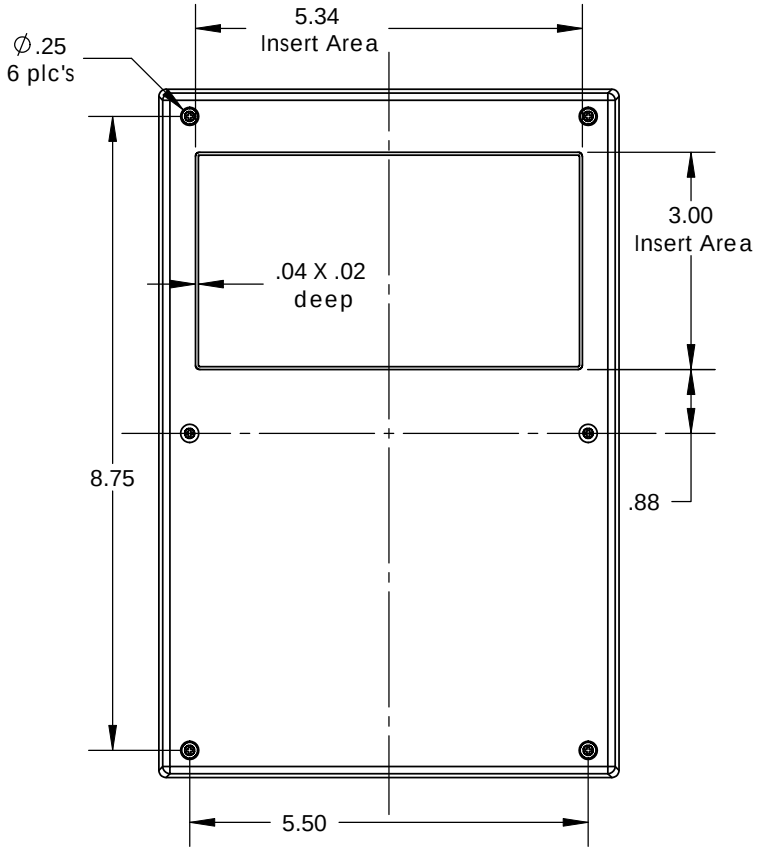
Vendor InformationVendor Information

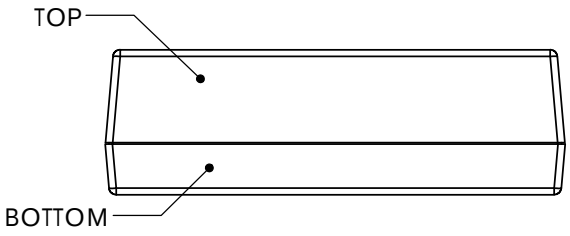
SERPAC 192 (user print)

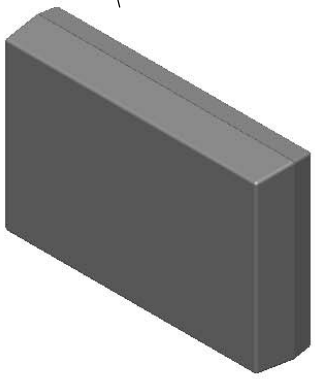
Electronic Enclosures

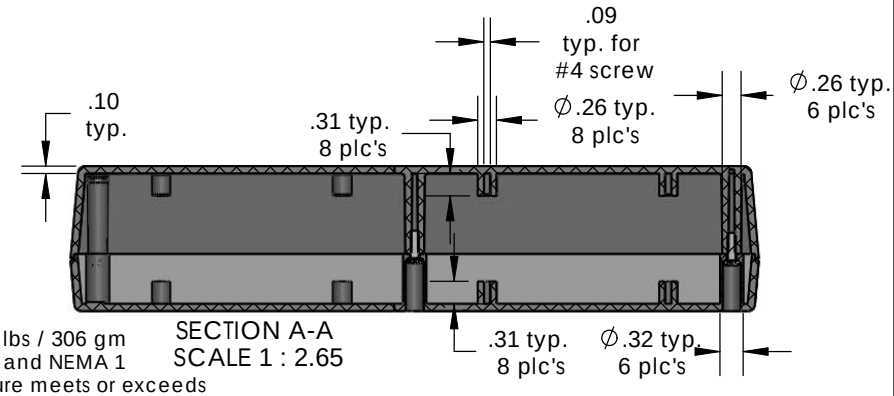












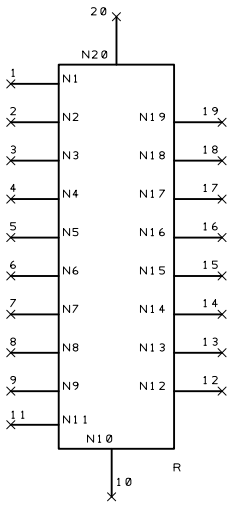
SECTION A-A
SCALE 1 : 2.65

PART NO.	DESCRIPTION **(Included)**	ACCSESSORIES **(Optional)**	
9-2	TOP	PART NO.	DESCRIPTION
19	BOTTOM	50	Non-skid Feet
6005	#4X3/8" Self tapping (6)	PS19	Perimeter Seal

Notes: Enclosure weight .67 lbs / 306 gm
1) Enclosure meets or exceeds IP40 and NEMA 1
2) When used with PS19 the enclosure meets or exceeds IP 66 and NEMA 4X, 12 and 13 MIL-STD-810G 506.5
3) Circuit Board drawings can be download at:
http://www.serpac.com/Products/Sseries/x9x/drawings/09X_top-CB.pdf
4) All components are RoHS Compliant.

ALL DIMENSIONS ARE ± .010" 3/23/10 **(2 of 2)**

619 Commercial Ave. Covina, CA 91723
Ph. (626) 331-0517 Fx. (626) 331-8584 www.serpac.com


20
N20
1
N1
2
N2
N19
19
3
N3
N18
18
4
N4
N17
17
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N5
N16
16
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N6
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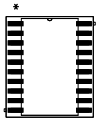
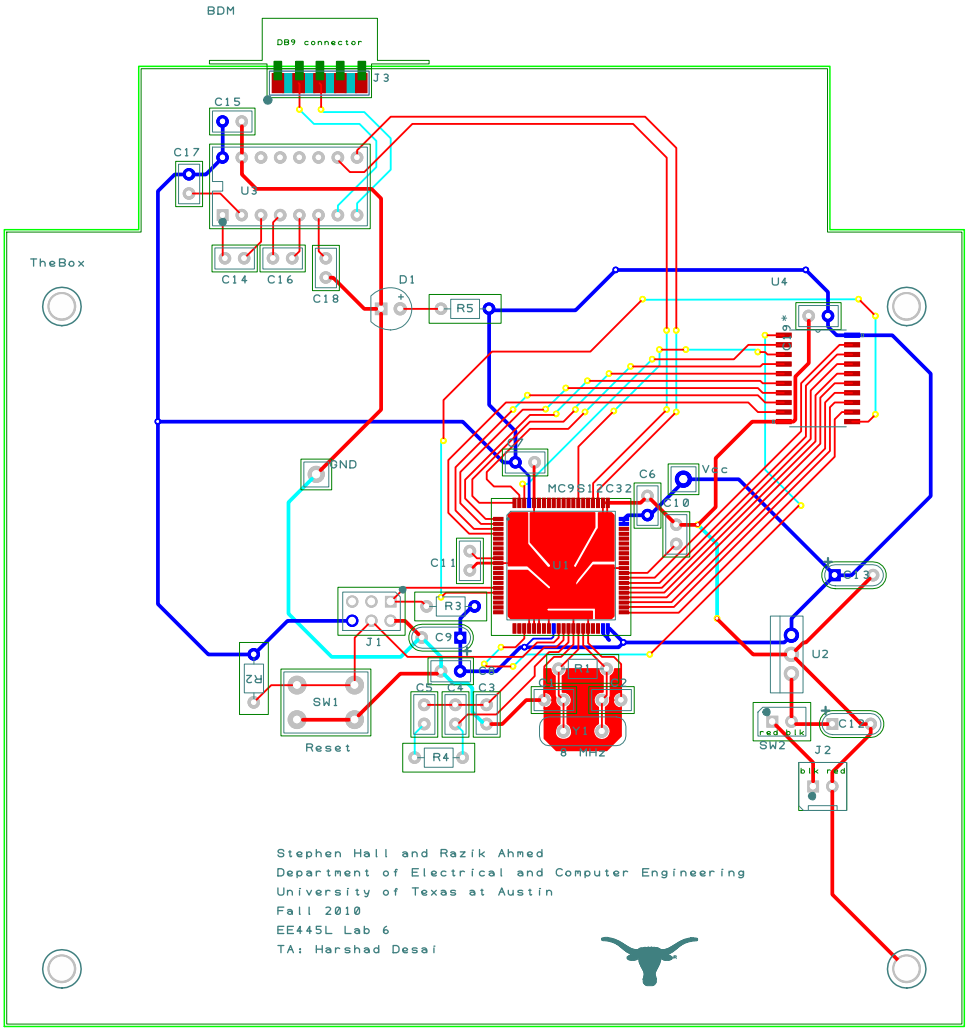
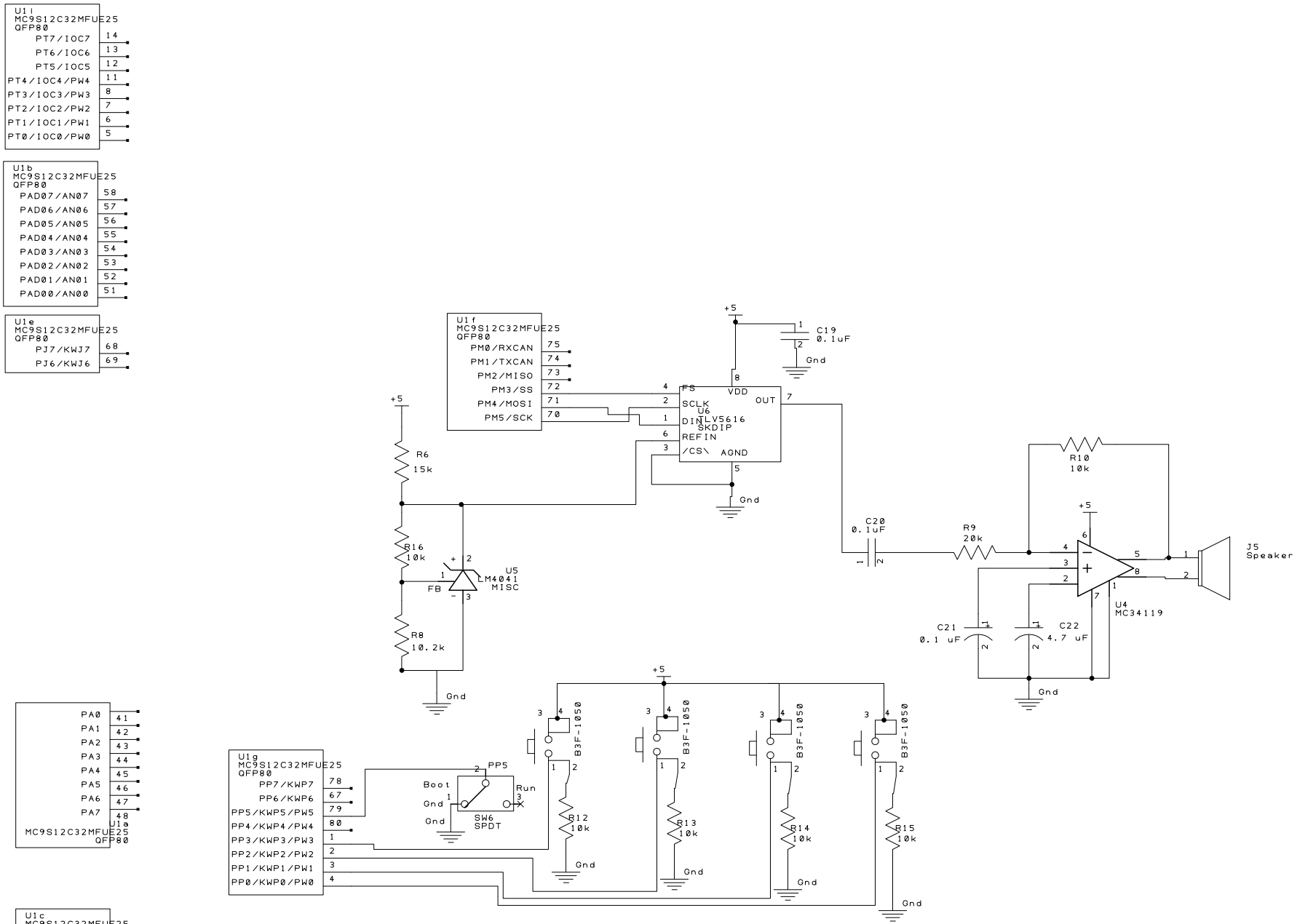
R

R

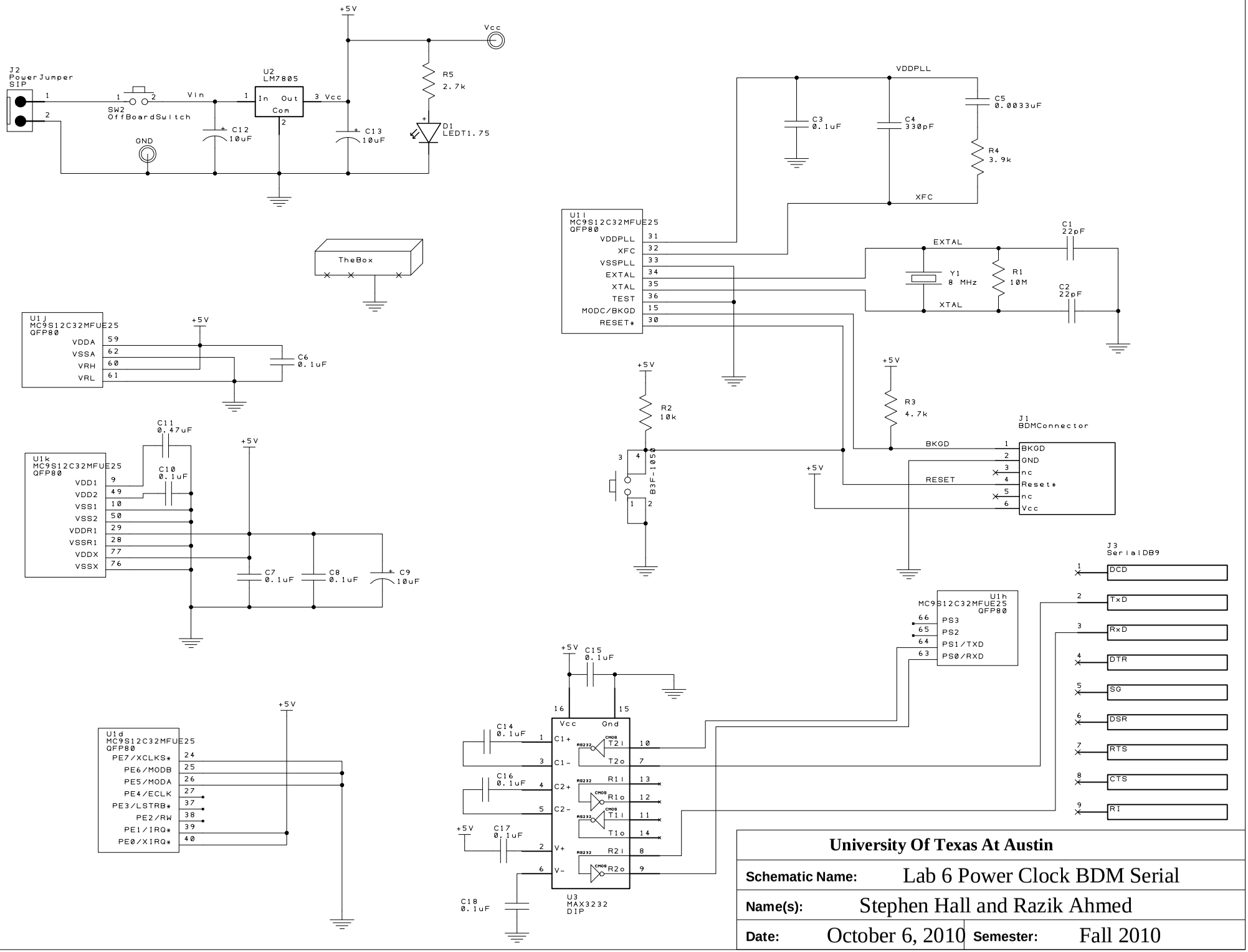



BDM
DB9 connector
J3
C15
C17
U3
C14
C16
C18
D1
R5
U4
TheBox
GND
Vcc
MC9S12C32
C6
C10
C11
U1
C13
R3
J1
C9
R2
SW1
Reset
C5
C4
C3
R4
R1
8 MHz
U2
SW2
C12
J2
Stephen Hall and Razik Ahmed
Department of Electrical and Computer Engineering
University of Texas at Austin
Fall 2010
EE445L Lab 6
TA: Harshad Desai



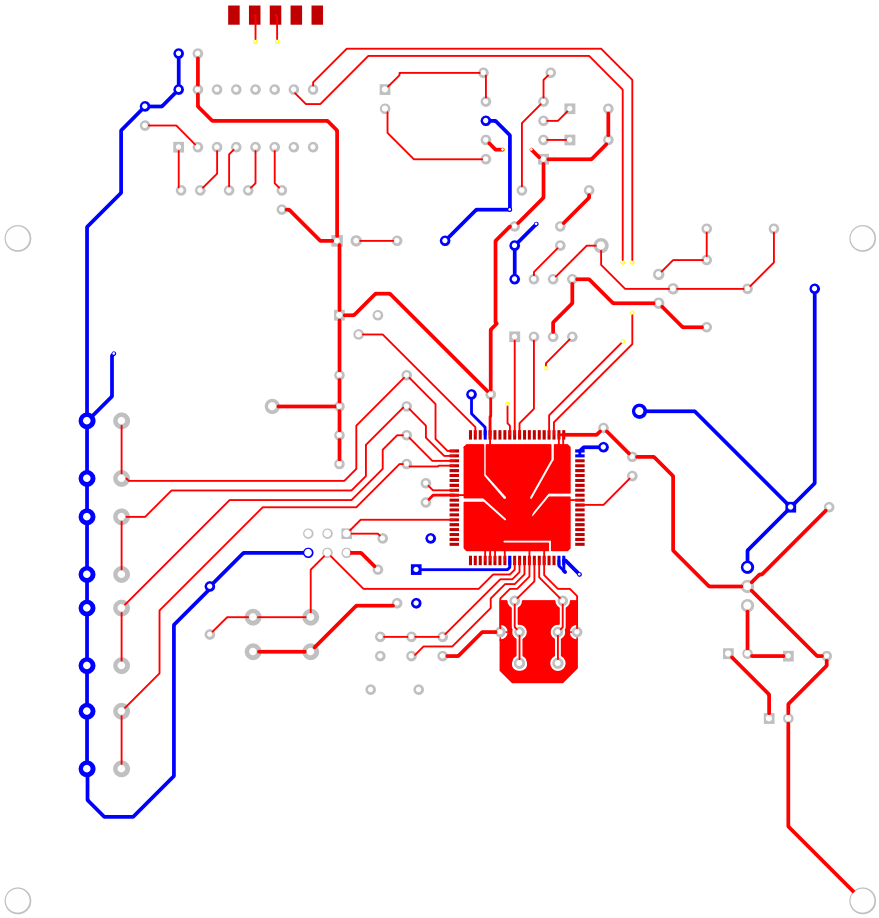
University Of Texas At Austin			
Schematic Name:	Lab 6 solution		
Name(s):	Stephen Hall and Razik Ahmed		
Date:	October 6, 2010	**Semester:**	Fall 2010

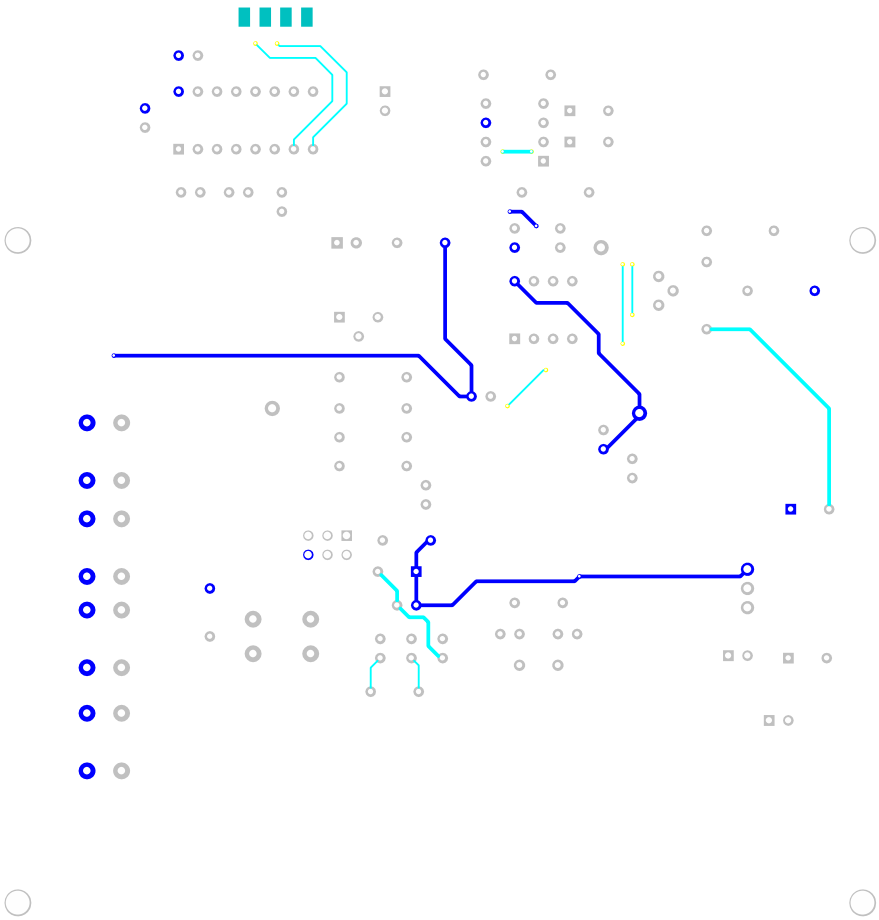
A1

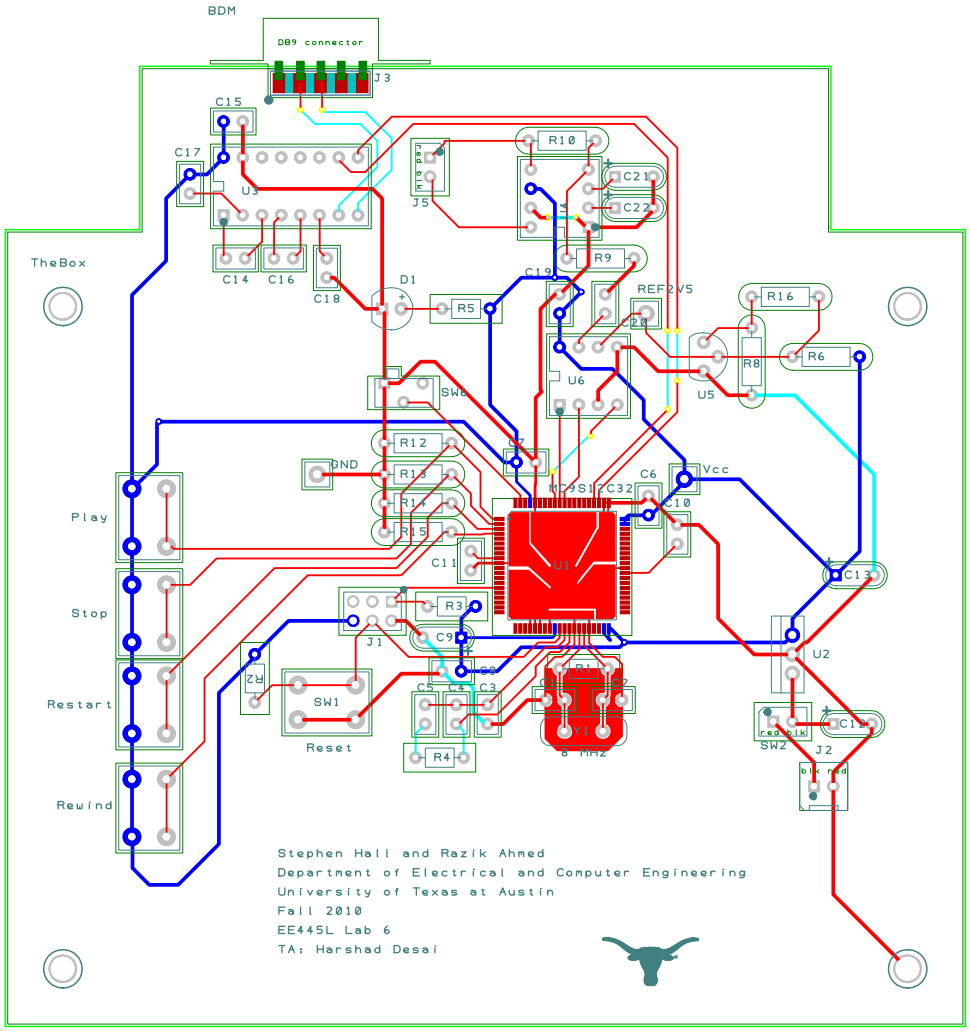


University Of Texas At Austin	
Schematic Name:	Lab 6 Power Clock BDM Serial
Name(s):	Stephen Hall and Razik Ahmed
Date:	October 6, 2010 **Semester:** Fall 2010

A2






BDM
DB9 connector
J3
C15
C17
U3
J5
R10
C21
C22
R9
C19
REF2V5
C20
U6
R16
R8
R6
U5
TheBox
C14
C16
C18
D1
R5
SW6
R12
R13
R11
R15
GND
Vcc
C6
C10
C11
C13
Play
Stop
Restart
Rewind
R3
J1
C9
C8
C5
C4
C3
R1
R2
SW1
Reset
R4
6 MHz
U2
SW2
J2
Stephen Hall and Razik Ahmed
Department of Electrical and Computer Engineering
University of Texas at Austin
Fall 2010
EE445L Lab 6
TA: Harshad Desai

Qty Note	REF DES Note		Bill of Materials
Quantity	REF DES	Type	Description
1		ASM	32-ohm speaker
1		ASM	Black case, 7"x 5-13/16"x 2"
11		CAP	Ceramic, X7R, 20%, 0.1uF
1		CAP	Ceramic, Z5U, -20/+80%, 0.47 uF
1		CAP	Ceramic, Z5U, -20/+80%, 0.0033 uF
2		CAP	Ceramic Z5U, -20/+80%, 22 pF
1		CAP	Ceramic Z5U, -20/+80%, 330 pF
3		CAP-Elect	Electrolytic 10uV 16V, 20%
1		CAP-Elect	Electrolytic 4.7uV 25V, 20%
1		CAP-Elect	Electrolytic 0.1uV 25V, 20%
1		CON	2-pin for TechArts power plug
1		CON	2-pin header
1		CON	2-pin jumper
1		CON	Test point, black
1		CON	Test point, red
1		CON	DB9 serial connector, female, board mount
1		CPU	MC9S12C32MFUE25, 80-pin QFP
1		CRYS	8 MHz crystal,50ppm,HC49/U
1		IC	78M05 500MA 5V TO-220
1		IC	MC34119, AUDIO LOW PWR 8-PDIP
1		IC	TLV5616 12-bit DAC
1		IC	LM4041CILPR shunt diode reference
1		IC	RS232 driver
1		IC	3-Terminal 1A Positive Voltage Regulator
1		JACK	DC Power MALE 2.1mm
1		JACK	Stereo Jack
1		LED	Green 2mA 5mm diffused
1		PCB	PCB plus shipping
1		RES	Carbon 1/6W, 5%, 2.7K
1		RES	Carbon 1/6W, 5%, 3.9K
1		RES	Carbon 1/6W, 5%, 4.7K
1		RES	Carbon 1/6W, 5%, 10K
1		RES	Carbon 1/6W, 5%, 10M
5		SW	B3F tactile push button switch
1		SW	On/off power switch
1		BAT	7.2 V 5400mAhr Battery
6		RES	Carbon 1/4W, 5%, 10K
1		RES	Carbon 1/4W, 5%, 10.2K
1		RES	Carbon 1/4W, 5%, 15K
1		RES	Carbon 1/4W, 5%, 20K

EE345L Fall 2010	October 15, 2010		EE345L pays for the PCB	
Manufacturer	Mfg. P/N	Distributor	P/N	Unit cost
		AllElectronics	SK-230	$0.50
		BGMicro	CAS1007	$1.00
		Jameco	544921	$0.14
Kemet	C320C474M5U5TA	Digikey	399-4309-ND	$0.40
Kemet	C320C332M5U5TA			$0.40
		Jameco	15405	$0.03
		Jameco	15410	$0.03
Panasonic - ECG	ECE-A1CKA100	Digikey	P807-ND	$0.22
Panasonic - ECG	ECE-A1EKA4R7	Digikey	P812-ND	$0.14
Panasonic - ECG	ECE-A1EKA4R7	Digikey	P752-ND	$0.14
		AllElectronics	CON-242	$0.70
		AllElectronics	SBH-2	$0.10
		AllElectronics	SBC-2	$0.27
Keystone Electronics	5001	Digikey	5001K-ND	$0.29
Keystone Electronics	5000	Digikey	5000K-ND	$0.29
		Jameco	15771	$0.65
Freescale	MC9S12C128MFUE			$5.00
		Jameco	14728	$0.59
National	LM78M05	Jameco	192233	$0.19
Freescale	MC34119	Jameco	316865	$2.25
TI	TLV5616	TI	TLV5616CP	$6.66
TI	LM4041CILPR	TI	LM4041CILPR	$0.90
STMicroelectronics	ST232CN	Jameco	2001171	$0.58
Fairchild	LM7805	Digikey	rLM7805CT-ND	$0.65
		Jameco	101179	$0.55
		AllElectronics	MJW-12	$0.09
Avago Technologies	HLMP-4740	Digikey	516-1327-ND	$0.29
Advanced Circuits		Advanced Circuits		$49.06
Yageo	CFR-12JB-2K7	Digikey	2.7KEBK-ND	$0.02
Yageo	CFR-12JB-3K9	Digikey	3.9KEBK-ND	$0.02
Yageo	CFR-12JB-4K7	Digikey	4.7KEBK-ND	$0.02
Yageo	CFR-12JB-10K	Digikey	10KEBK-ND	$0.02
Yageo	CFR-12JB-10M	Digikey	10MEBK-ND	$0.02
Omron Electronics	B3F-1052	Digikey	SW405-ND	$0.17
		BGMicro	SWT1010	$0.85
Tenergy	807295	Tenergy	30136	$55.99
Yageo	CFR-12JB-10K	Digikey	10KEBK-ND	$0.02
Yageo	CFR-12JB-10K2	Digikey	10K2EBK-ND	$0.02
Yageo	CFR-12JB-15K	Digikey	15KEBK-ND	$0.02
Yageo	CFR-12JB-20K	Digikey	20KEBK-ND	$0.02

Cost	PCB Artist	Where to	Inventory
$0.50	Speaker	Prof	
$1.00	CAS1007	Prof	
$1.54	Ceramic0.2	Prof	
$0.40	Ceramic	Prof	
$0.40	Ceramic	Prof	
$0.06	Ceramic	Prof	
$0.03	Ceramic	Prof	
$0.66	Electrolytic	some	
$0.14	Electrolytic	some	
$0.14	Electrolytic	some	
$0.70	PowerJumper	Prof	
$0.10	Jumper2	Prof	
$0.27	goes with SBH-2	Prof	
$0.29	testpoint	Prof	
$0.29	testpoint	Prof	
$0.65	SerialDB9	Prof	
$5.00	MC9S12C128	Prof	8
$0.59	XTAL	Prof	
$0.19	LM7805CT	Prof	
$2.25	MC34119	not free	
$6.66	TLV5616	free sample	
$0.90	LM4041	free sample	
$0.58	MAX3232	Prof	
$0.65	LM7805CT	www.digikey.com	
$0.55	PowerJack	Prof	
$0.09	HeadphoneJack	Prof	
$0.29	LEDT1.75	Prof	
$49.06		http://www.4pcb.com/	
$0.02	0.125Wresistor	Prof	
$0.02	0.125Wresistor	Prof	
$0.02	0.125Wresistor	Prof	
$0.02	0.125Wresistor	Prof	
$0.02	0.125Wresistor	Prof	
$0.85	B3F-1050	Prof	
$0.85	BOXMOUNTBUTTON	some	
$55.99		tenergybattery.com	
$0.14	0.25Wresistor	Prof	
$0.02	0.25Wresistor	Prof	
$0.02	0.25Wresistor	Prof	
$0.02	0.25Wresistor	Prof	

$132.01	Total Cost