Oil Well Monitoring System

Presented By:-

Louis Bengtson

Kaleb Stunkard

Jimit Shah

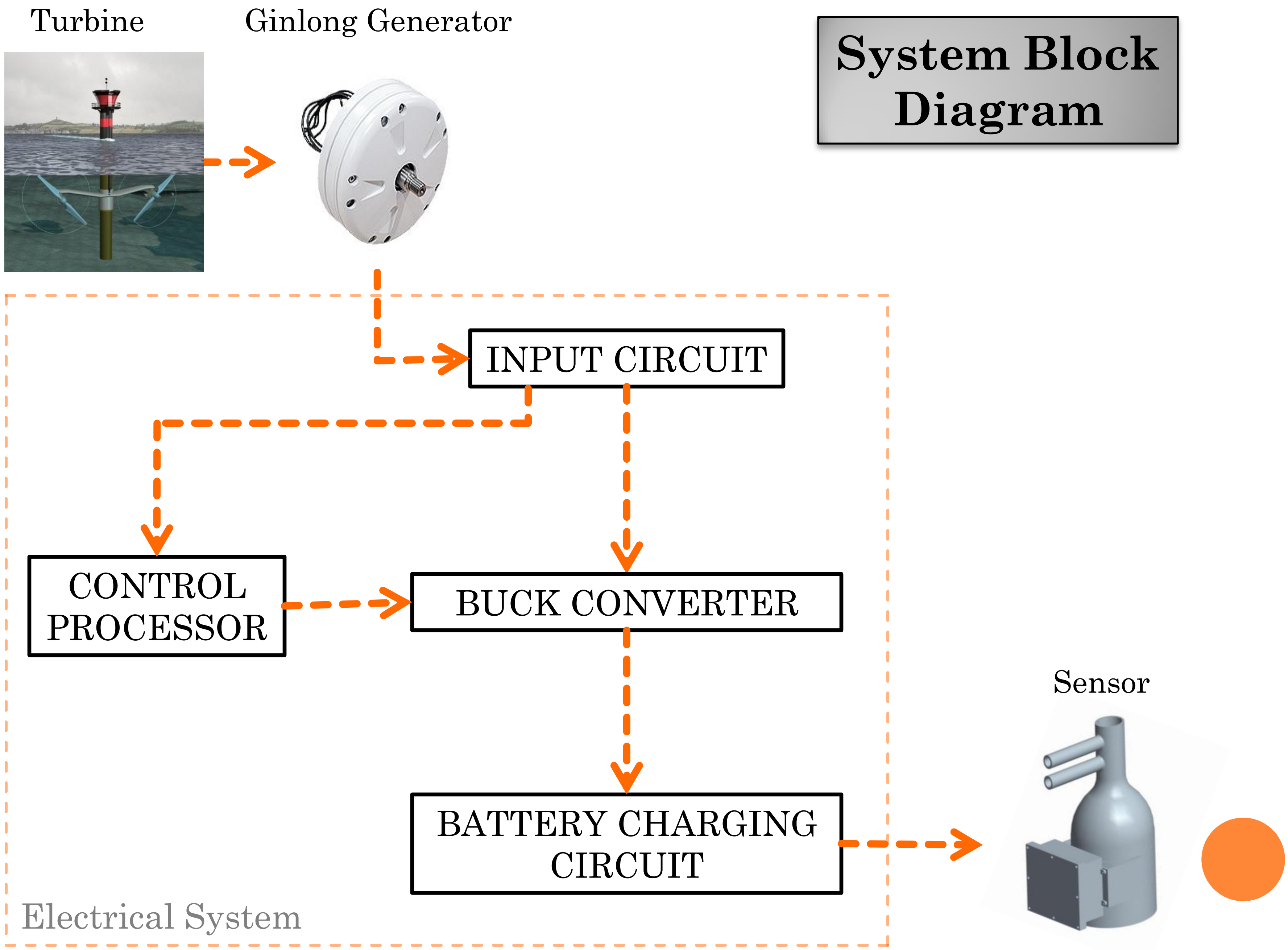
HARRIS

Motivation

- More than 27,000 oil wells permanently abandoned in the Gulf of Mexico.
- Currently, there is no monitoring system available.

- Four teams:
  1. Buoy Team (Mechanical Engineering)
  2. Bi-directional Turbine Team (Mechanical Engineering)
  3. Sensor Team (Mechanical Engineering)
  4. Electrical Team (Electrical Engineering)

System Block Diagram



Objectives

- Efficiently convert varying AC voltage to steady DC voltage.
- Be able to charge a battery that will supply the necessary output voltage to the sensors.
- Must be self powered.
- Components must be placed in an enclosure to be mounted on the buoy.
- Must be able to work in high and low pressure environment.
- Must be suitable for dry and wet conditions.

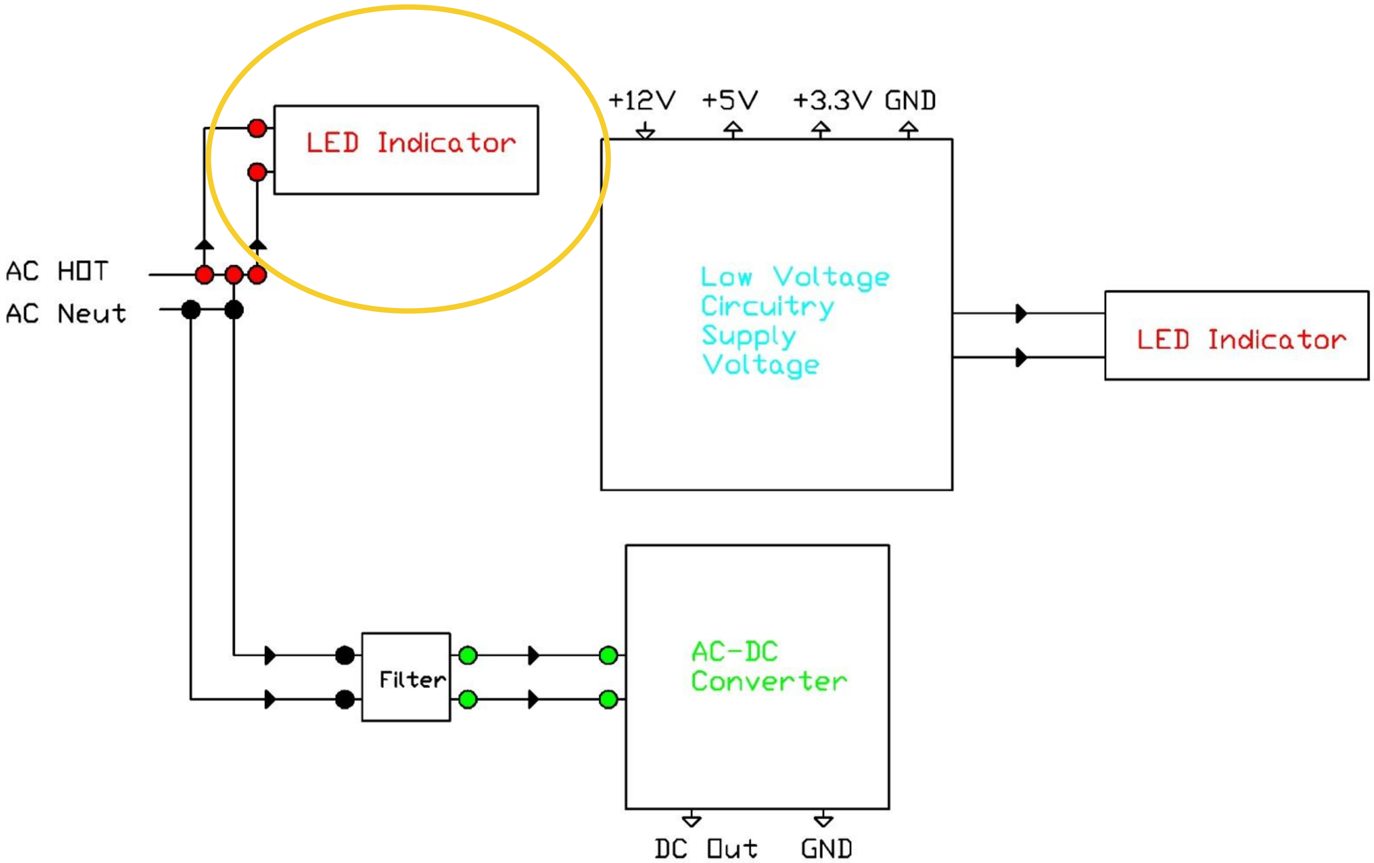
Specifications

- Input RPM range: 90 to 125 RPM
- Input Voltage range: 0VAC to 60VAC
- Output Current: 1A
- Output Voltage: 12VDC
- Cost: Less than $2,000
- Efficiency: 85%
- Operating Environments
  - Temperature: 25 to 110°F
  - Humidity: 100%

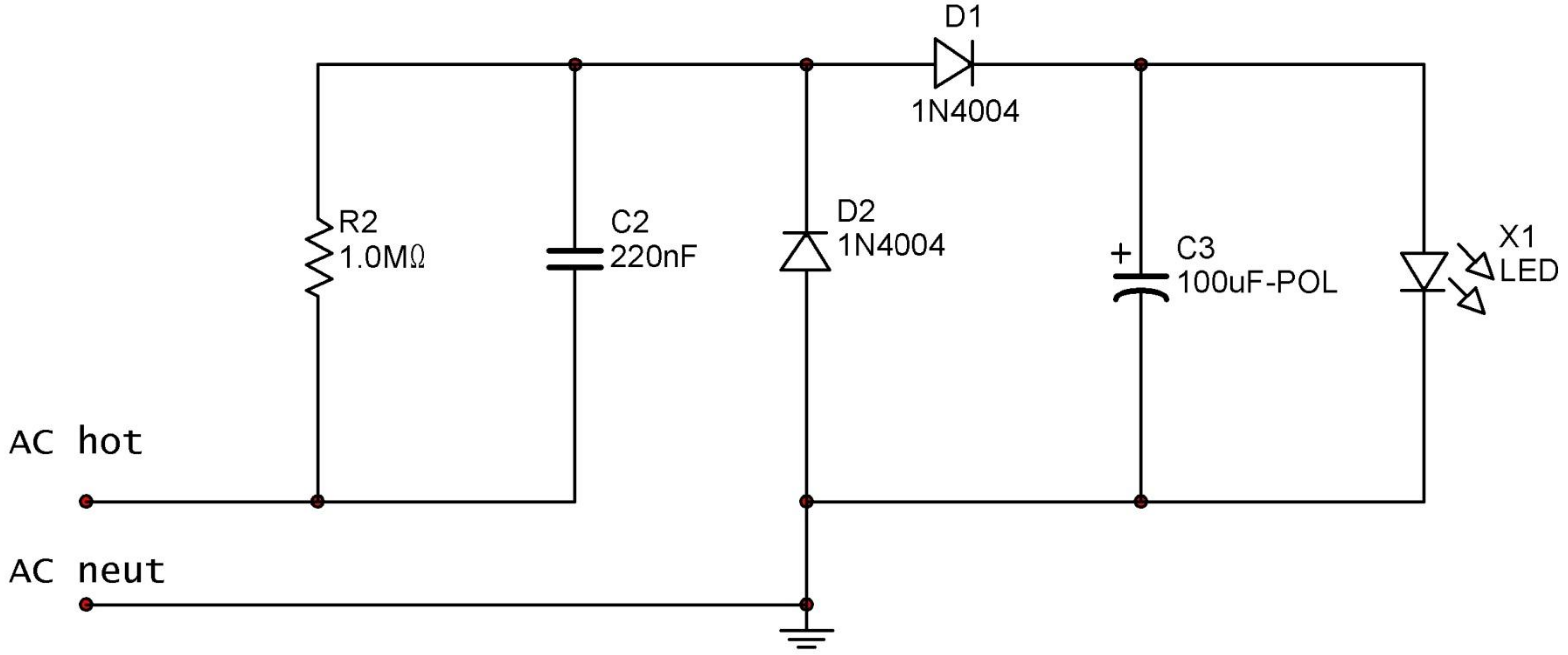
Input Circuit

- Kaleb Stunkard

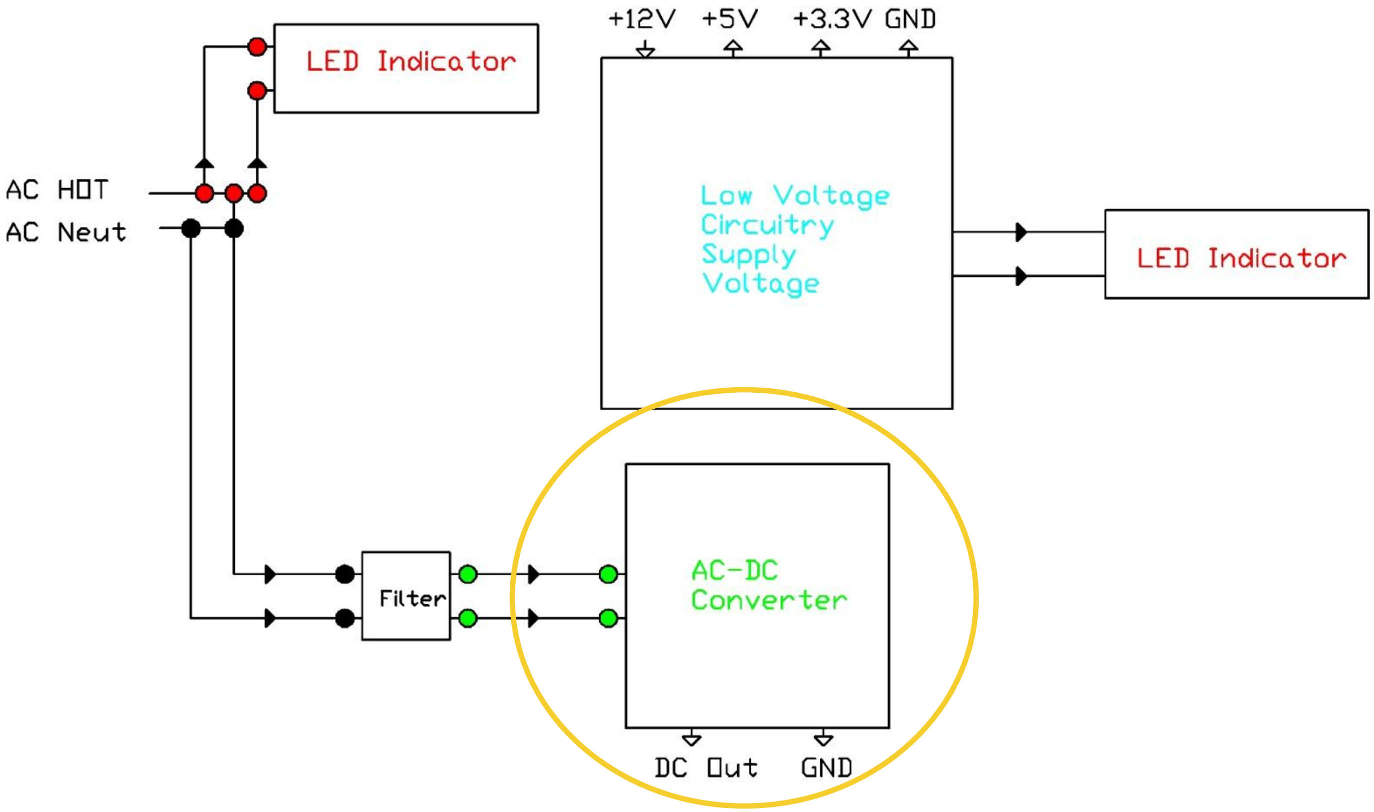
Input Power Block Diagram



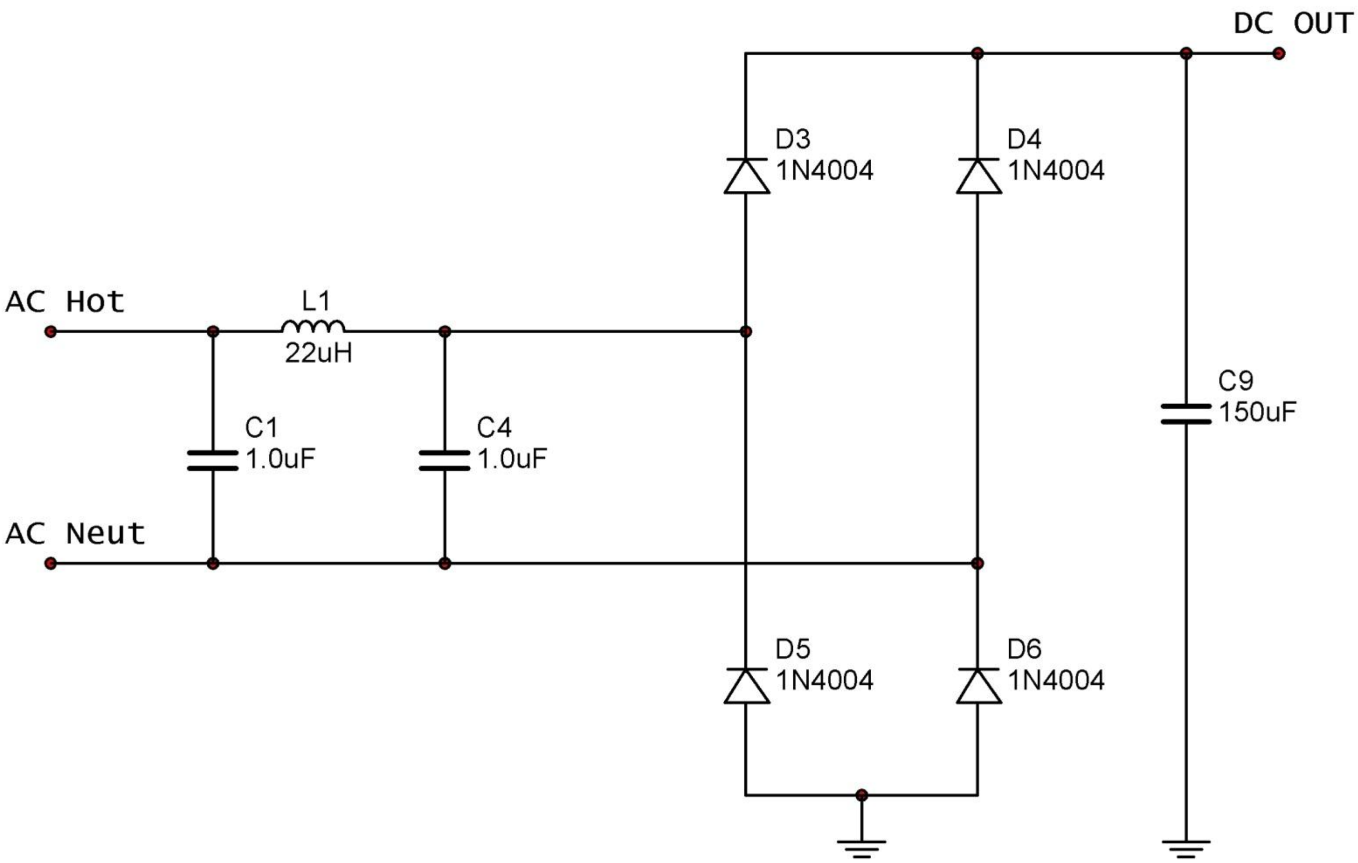
LED Indicator Schematic



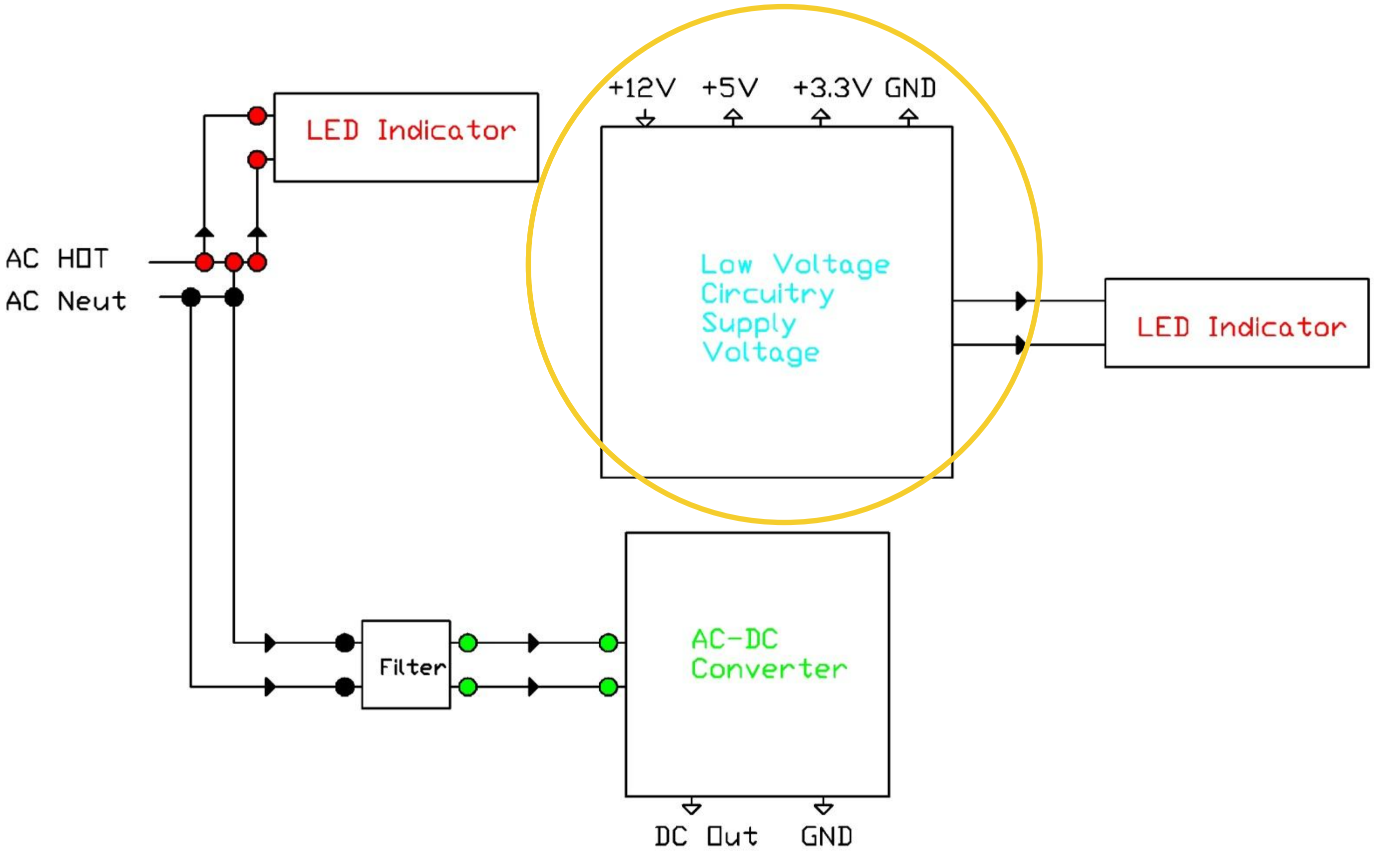
Input Power Block Diagram



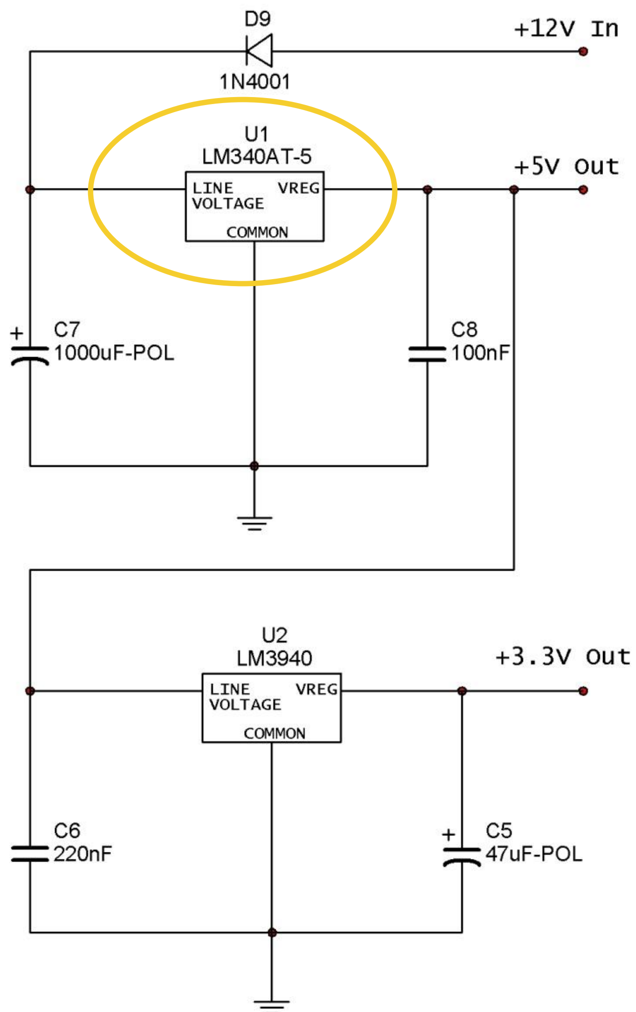
AC-DC Converter Schematic



Input Power Block Diagram



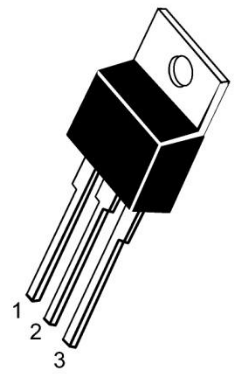
Low Voltage Circuitry Supply Schematic



LM340AT – 5

T SUFFIX
PLASTIC PACKAGE
CASE 221A

Heatsink surface
connected to Pin 2.

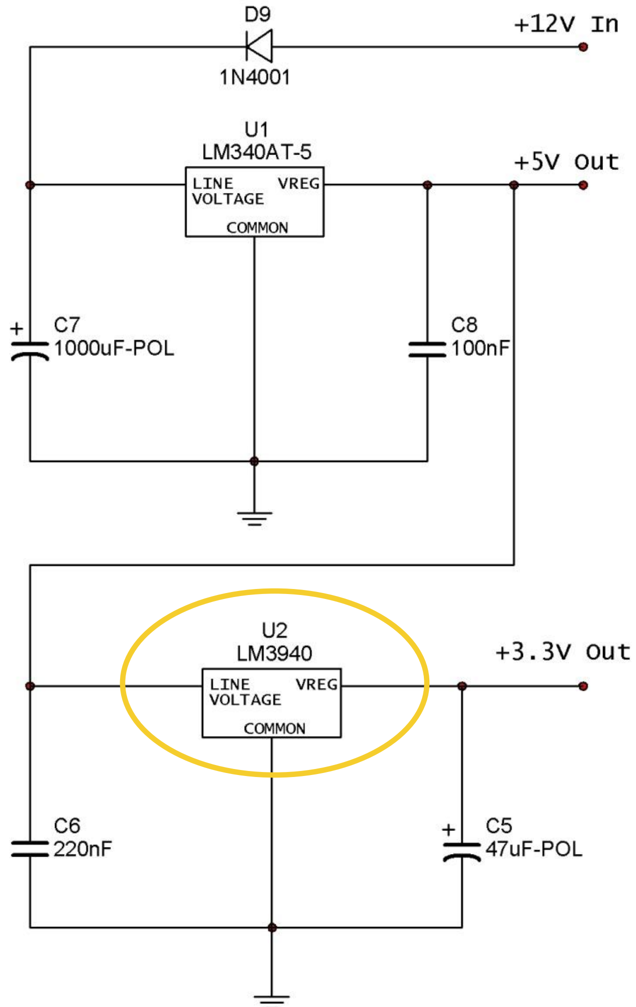


MAXIMUM RATINGS (T_A = 25°C, unless otherwise noted.)

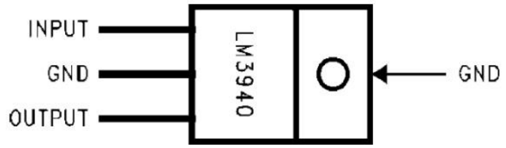
Rating	Symbol	Value	Unit
Input Voltage (5.0 – 18 V) (24 V)	V_I	35 40	Vdc
Power Dissipation Case 221A T_A = 25°C Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case Case 936 (D^2PAK) T_A = 25°C Thermal Resistance, Junction–to–Ambient Thermal Resistance, Junction–to–Case	 P_D $R_{\theta JA}$ $R_{\theta JC}$ P_D $R_{\theta JA}$ $R_{\theta JA}$	 Internally Limited 65 5.0 Internally Limited See Figure 13 5.0	 W °C/W °C/W W °C/W °C/W
Storage Junction Temperature Range	T_{stg}	–65 to +150	°C
Operating Junction Temperature	T_J	+150	°C

NOTE: ESD data available upon request.

Low Voltage Circuitry Supply Schematic

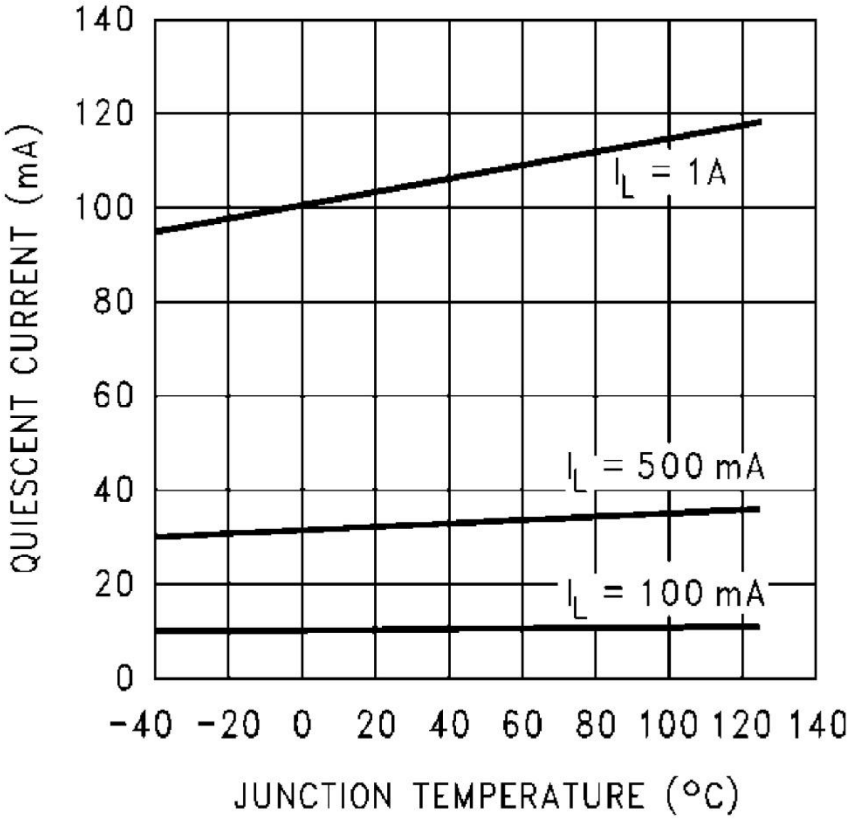


LM3940



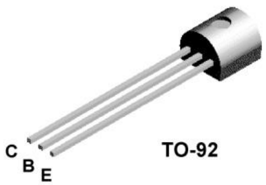
3-Lead TO-220 Package (Front View)
Order Part Number LM3940IT-3.3
NSC Drawing Number TO3B

Quiescent Current vs. Temperature



2N4401

2N4401



NPN General Pupose Amplifier

This device is designed for use as a medium power amplifier and switch requiring collector currents up to 500 mA.

Absolute Maximum Ratings*

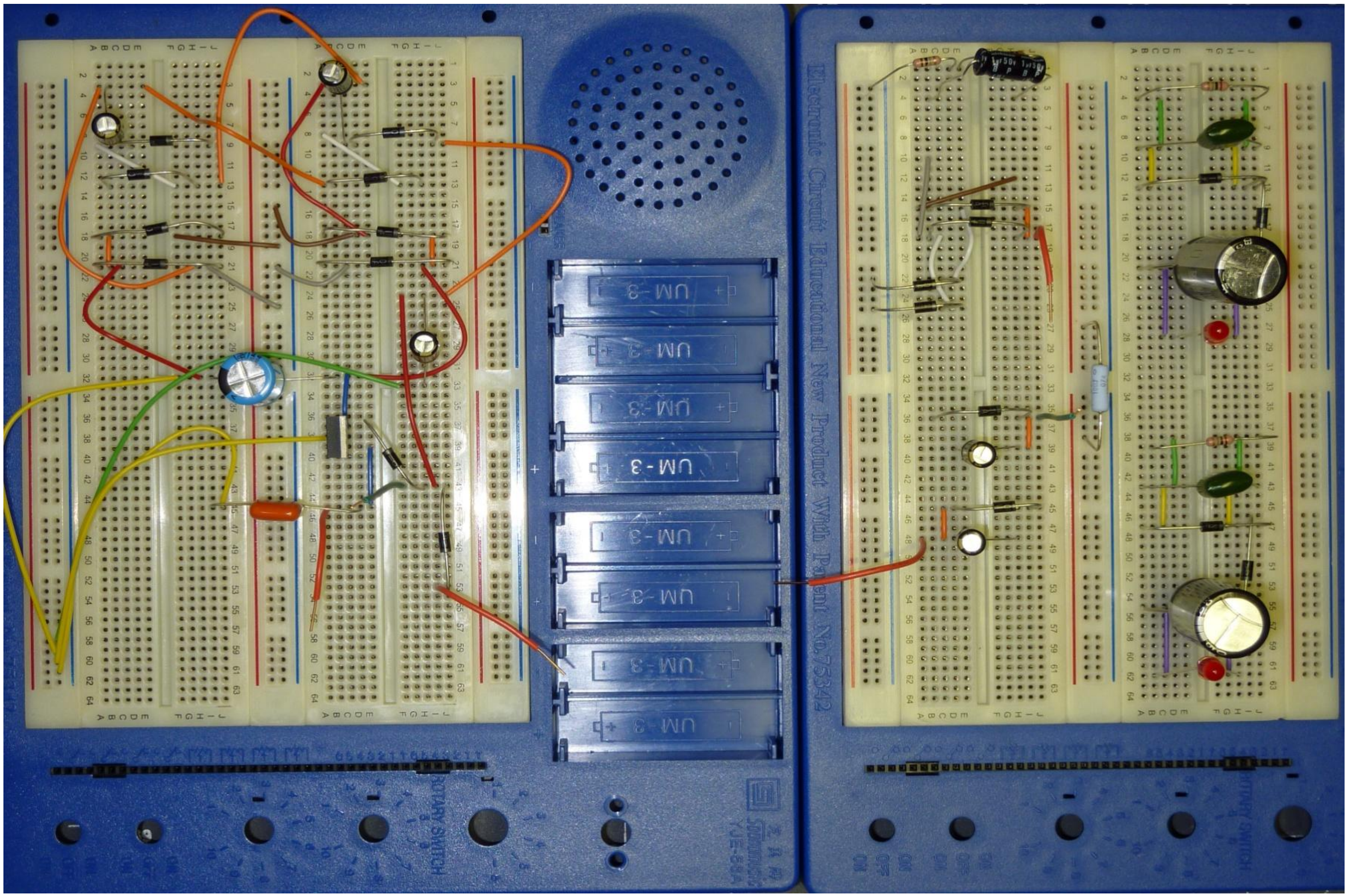
TA = 25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CEO}	Collector-Emitter Voltage	40	V
V_{CBO}	Collector-Base Voltage	60	V
V_{EBO}	Emitter-Base Voltage	6.0	V
I_C	Collector Current - Continuous	600	mA
T_J, T_{stg}	Operating and Storage Junction Temperature Range	-55 to +150	°C

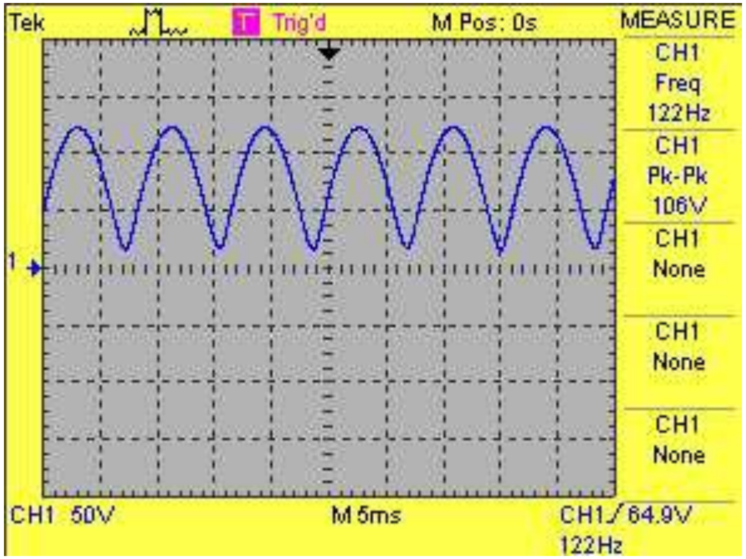
*These ratings are limiting values above which the serviceability of any semiconductor device may be impaired.

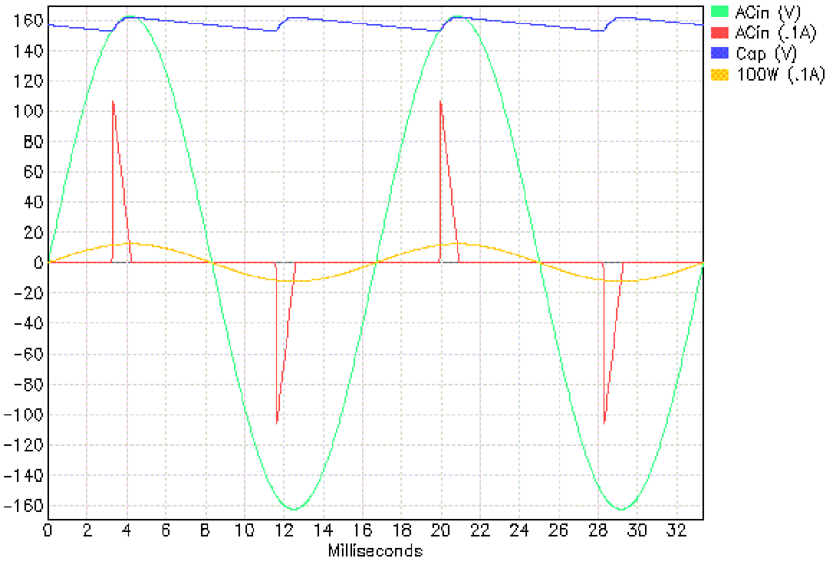
NOTES:
1) These ratings are based on a maximum junction temperature of 150 degrees C.
2) These are steady state limits. The factory should be consulted on applications involving pulsed or low duty cycle operations.

INPUT POWER PROTOTYPE

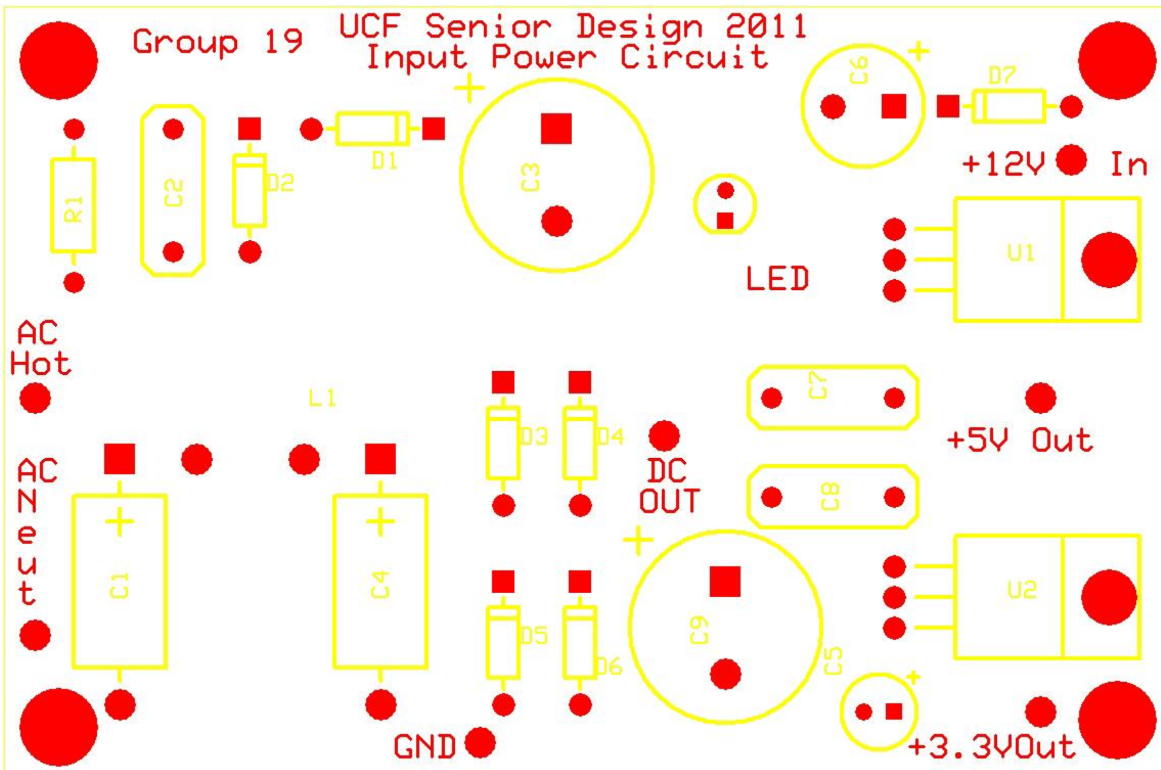


Results


Tek
Trig'd
M Pos: 0s
MEASURE
CH1
Freq
122Hz
CH1
Pk-Pk
106V
CH1
None
CH1
None
CH1
None
CH1 50V
M 5ms
CH1 ╱ 64.9V
122Hz


ACin (V)
ACin (.1A)
Cap (V)
100W (.1A)
160
140
120
100
80
60
40
20
0
-20
-40
-60
-80
-100
-120
-140
-160
0 2 4 6 8 10 12 14 16 18 20 22 24 26 28 30 32
Milliseconds

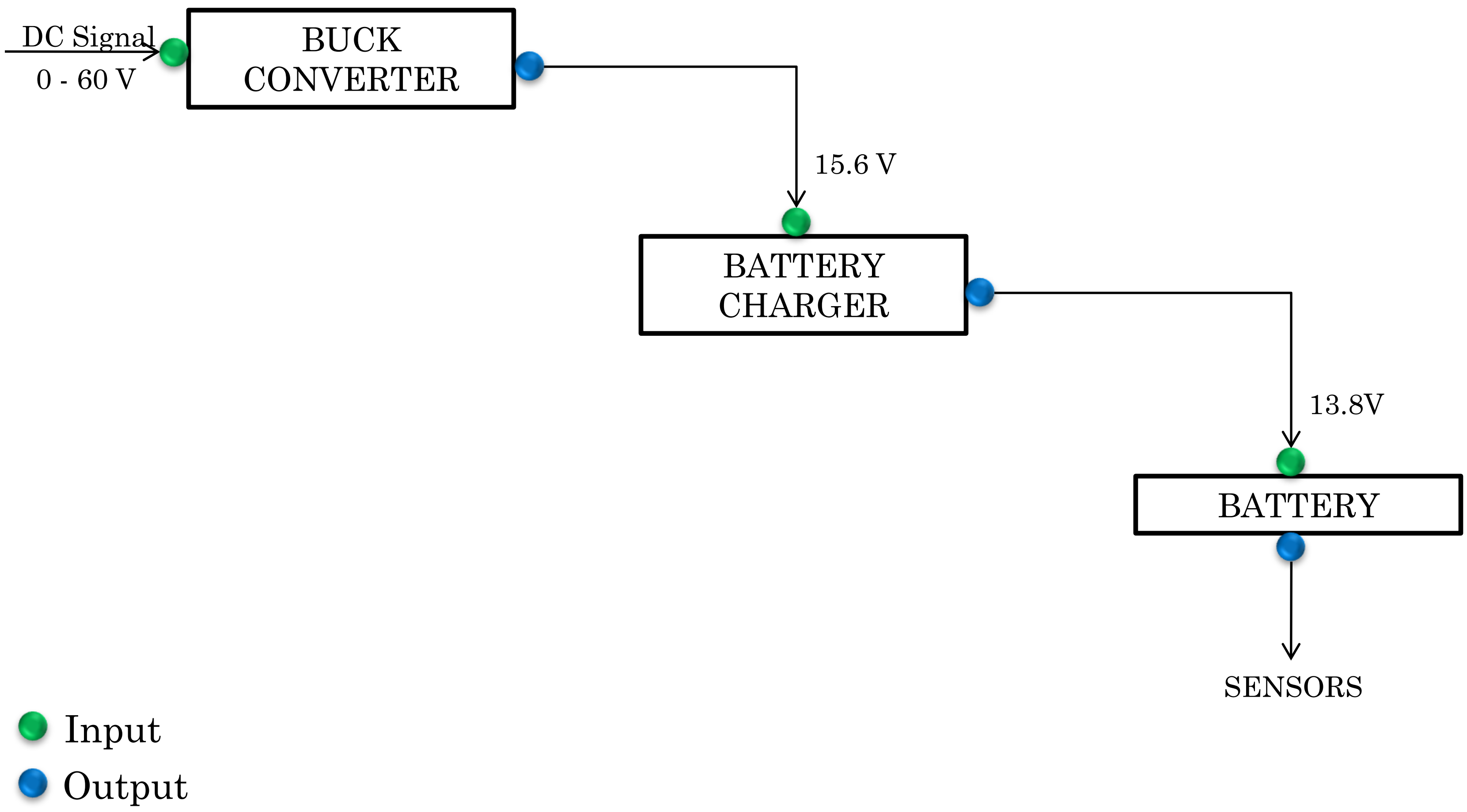
PCB


Group 19
UCF Senior Design 2011
Input Power Circuit
D1
D2
D7
R1
C2
C3
C6
+12V In
LED
U1
AC
Hot
L1
D3
D4
C7
+5V Out
AC
N
e
u
t
DC
OUT
C8
C1
C4
D5
D6
C9
C5
U2
GND
+3.3VOut

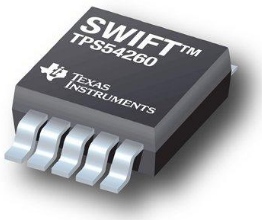
Buck Converter & Battery Charging Circuit

- Jimit Shah

Block Diagram



Buck Converter:
TPS54260 – Step Down Converter

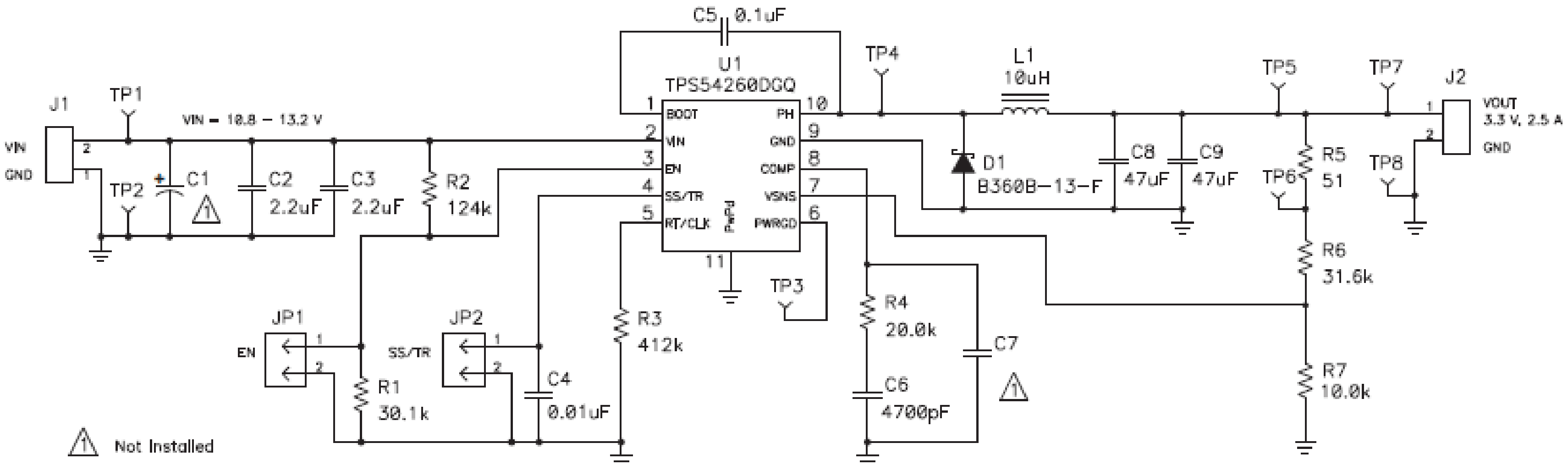


- Wide Input Range
  - 3.5V to 60V
- High Output Current
  - 0A to 2.5A
- Enable Pin
- Fixed Output Voltage
- EVM available

TPS54260 Electrical Characteristics

Parameter	Values		
	min	typ	max
Operating Input Voltage	3.5 V		60 V
Shutdown supply current		1.3 µA	4 µA
Output current range	0 A		2.5 A
Operating: nonswitching supply current		138 µA	200 µA
Enable threshold voltage	1.5 V	1.25 V	1.36 V
Current limit threshold	3.5 A	6.1 A	
Thermal shutdown		182 °C	

TPS54260EVM Schematic

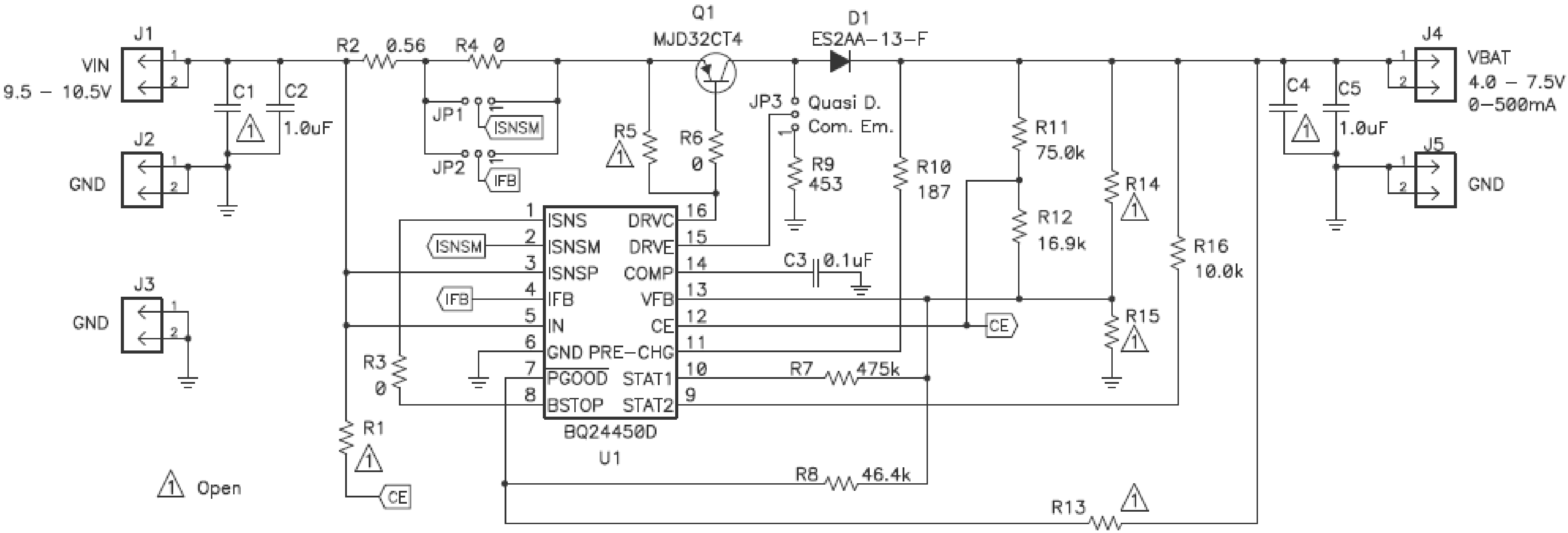


Replaced Components: R6, C8, and C9

Battery Charger:
BQ24450 – Integrated Charge Controller

- Designed for Lead Acid Batteries.
- Voltage and Current Regulation.
- Optimization and maximization of battery capacity over temperature.
- Ensure battery safety for charging at high temperature.
- EVM available

BQ24450EVM Schematic



Replaced Components: R7, and R11

Battery:
Enercell 12VDC 7AH Sealed Lead-Acid Battery

Battery Technical Specs

Dimensions	
Product Height	3.84 inches
Product Width	5.94 inches
Product Depth	2.56 inches
Battery Features	
Chemistry	Sealed Lead Acid
Capacity	7000 mAH
Voltage	12 V
Rechargeable	Yes
Normal Charge	14.4 V – 15 V
Stand by/Trickle charge	13.5 V – 13.8V
Max initial charging current	2.1 A

MICROCONTROLLER

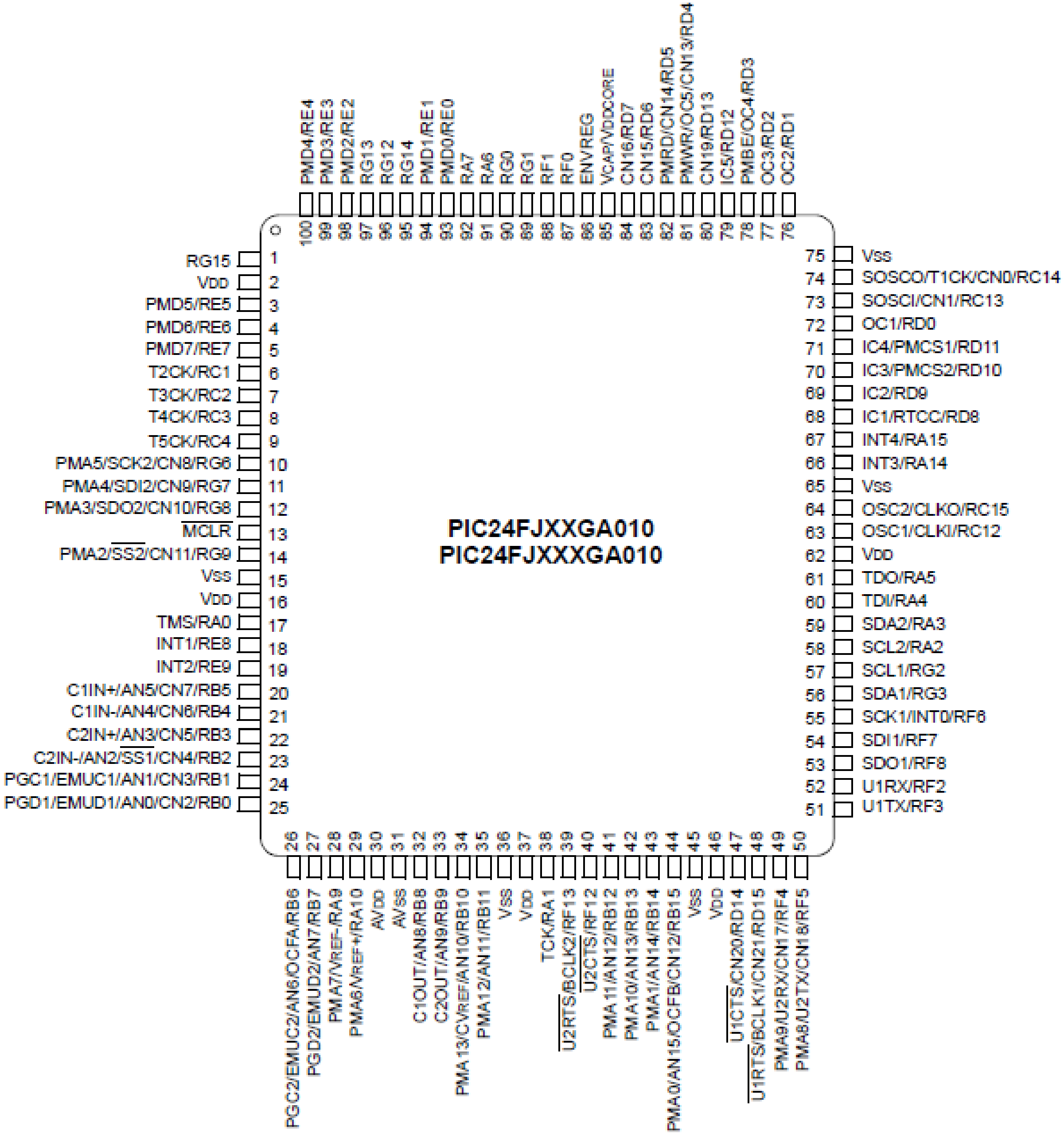
- Louis Bengtson

Advantages of PIC Microcontrollers

- PIC24FJ96GA010
- Extensive available parameters
- Inexpensive
- Programmable in C
- Compatibility with development tools
- Prospect of future improvements with reprogramming

PIC24FJ96GA010 Specifications

Parameters	Values
Program Memory Type	Flash
Program Memory (KB)	96
CPU Speed (MIPS)	16
RAM Bytes	8192
Internal Oscillator	8 MHz, 32 kHz
nanoWatt Features	Fast Wake/Fast Control
Capture/Compare/PWM Peripherals	5/5
Digital Communication Peripherals	2-UART, 2-SPI, 2-I2C
Analog Peripherals	1-A/D 16x10-bit @ 500(ksps)
Timers	5 x 16-bit
16-bit PWM resolutions	16
Temperature Range (deg C)	-40 to 85
Operating Voltage Range (V)	2.5 to 3.6
I/O Pins	85
Pin Count	100
Volume Pricing	$3.42

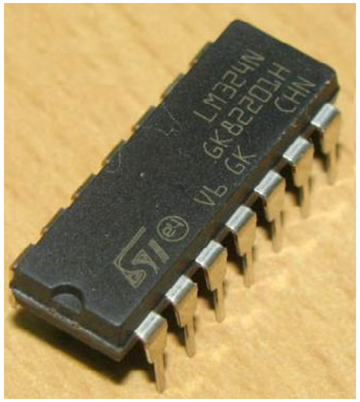

PIC24FJXXGA010
PIC24FJXXXGA010
1 RG15
2 VDD
3 PMD5/RE5
4 PMD6/RE6
5 PMD7/RE7
6 T2CK/RC1
7 T3CK/RC2
8 T4CK/RC3
9 T5CK/RC4
10 PMA5/SCK2/CN8/RG6
11 PMA4/SDI2/CN9/RG7
12 PMA3/SDO2/CN10/RG8
13 MCLR
14 PMA2/SS2/CN11/RG9
15 VSS
16 VDD
17 TMS/RA0
18 INT1/RE8
19 INT2/RE9
20 C1IN+/AN5/CN7/RB5
21 C1IN-/AN4/CN6/RB4
22 C2IN+/AN3/CN5/RB3
23 C2IN-/AN2/SS1/CN4/RB2
24 PGC1/EMUC1/AN1/CN3/RB1
25 PGD1/EMUD1/AN0/CN2/RB0
26 PGC2/EMUC2/AN6/OCFA/RB6
27 PGD2/EMUD2/AN7/RB7
28 PMA7/VREF-/RA9
29 PMA6/VREF+/RA10
30 AVDD
31 AVSS
32 C1OUT/AN8/RB8
33 C2OUT/AN9/RB9
34 PMA13/CVREF/AN10/RB10
35 PMA12/AN11/RB11
36 VSS
37 VDD
38 TCK/RA1
39 U2RTS/BCLK2/RF13
40 U2CTS/RF12
41 PMA11/AN12/RB12
42 PMA10/AN13/RB13
43 PMA1/AN14/RB14
44 PMA0/AN15/OCFB/CN12/RB15
45 VSS
46 VDD
47 U1CTS/CN20/RD14
48 U1RTS/BCLK1/CN21/RD15
49 PMA9/U2RX/CN17/RF4
50 PMA8/U2TX/CN18/RF5
51 U1TX/RF3
52 U1RX/RF2
53 SDO1/RF8
54 SDI1/RF7
55 SCK1/INT0/RF6
56 SDA1/RG3
57 SCL1/RG2
58 SCL2/RA2
59 SDA2/RA3
60 TDI/RA4
61 TDO/RA5
62 VDD
63 OSC1/CLKI/RC12
64 OSC2/CLKO/RC15
65 VSS
66 INT3/RA14
67 INT4/RA15
68 IC1/RTCC/RD8
69 IC2/RD9
70 IC3/PMCS2/RD10
71 IC4/PMCS1/RD11
72 OC1/RD0
73 SOSCI/CN1/RC13
74 SOSCO/T1CK/CN0/RC14
75 VSS
76 OC2/RD1
77 OC3/RD2
78 PMBE/OC4/RD3
79 IC5/RD12
80 CN19/RD13
81 PMWR/OC5/CN13/RD4
82 PMRD/CN14/RD5
83 CN15/RD6
84 CN16/RD7
85 VCAP/VDDCORE
86 ENVREG
87 RF0
88 RF1
89 RG1
90 RG0
91 RA6
92 RA7
93 PMD0/RE0
94 PMD1/RE1
95 RG14
96 RG12
97 RG13
98 PMD2/RE2
99 PMD3/RE3
100 PMD4/RE4

Microcontroller Functions

- Measure input voltage and battery voltage
- Display voltage readings to LCD screen
- Control the enable switch on the TPS54260EVM-597 DC-DC buck converter for hysteresis and over-voltage protection

Voltage Scaling

- Input and Battery voltage were scaled down by voltage dividers.
- Initially voltage divider produced loading effects at higher voltages.
- LM324N op-amp was used as a unity gain buffer to prevent current feeding into microcontroller.



C Programming Language Code

```
void main() {
ADPCFG = 0xFFFF;   // Configure AN pins as digital I/O
TRISA = 0;               // Initialize PORTA as output
LATA = 1;                 // Set PORTA to one
LCD_Init();
LCD_Cmd(_LCD_CURSOR_OFF);            // LCD (cursor off)
LCD_Cmd(_LCD_CLEAR);                        // Clear LCD
text  = "V in: ";                                  // assign text to string
text2 = "Batt V: ";
while (1) {
adc_rd  = ADC1_read(10);    // get ADC value – Input voltage
adc_rd2 = ADC1_read(11);   // get ADC value – Battery voltage
LCD_Out(1,1,text);               // print on LCD, row 1, collumn 1
LCD_Out(2,1,text2);            // print on LCD, row 2, collumn 1
ch3 = 0;
ch4 = 0;
```

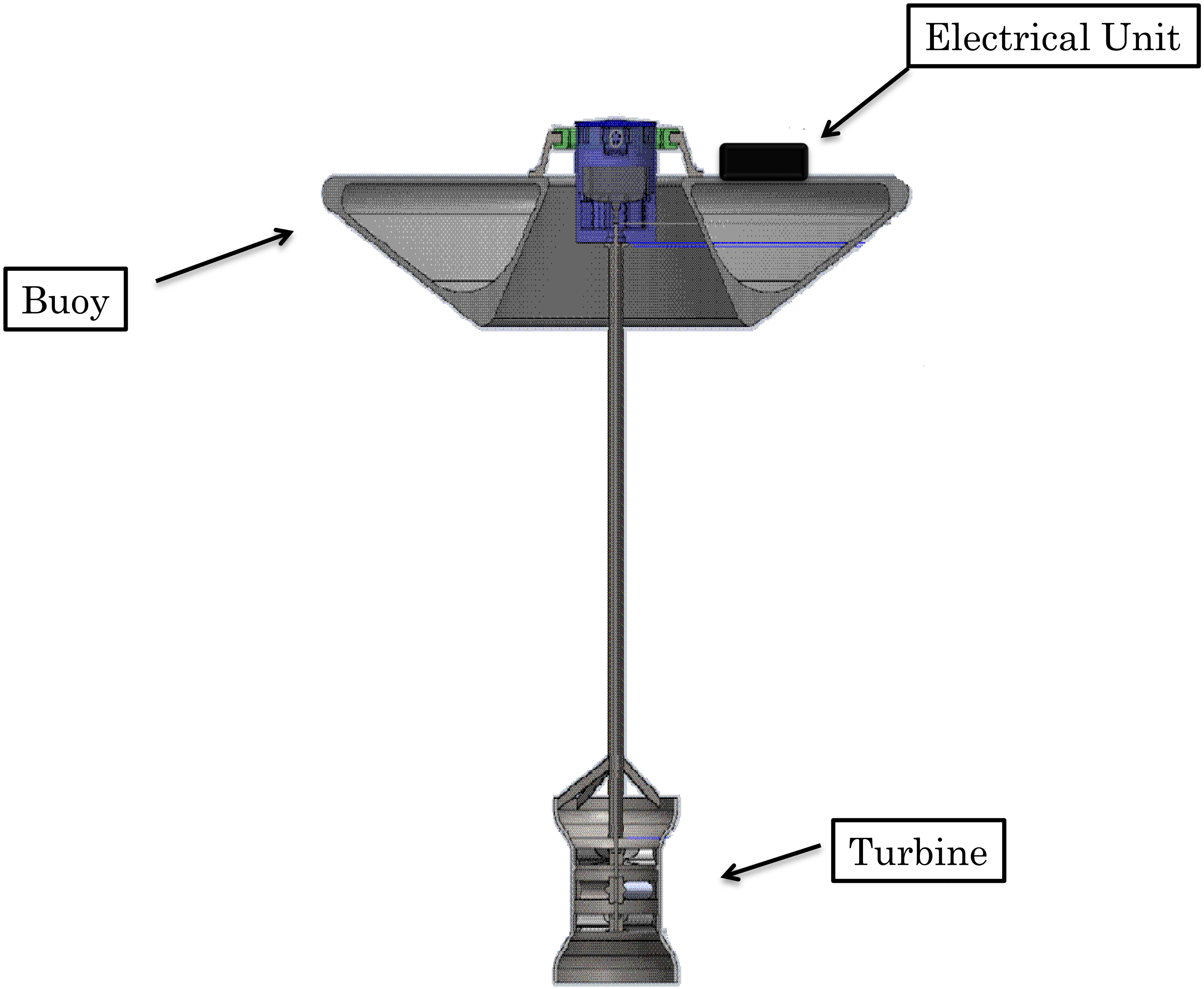
```
for(i=0;i<500;i++)
{
tlong = (long)adc_rd * 5000;    // convert adc reading to mV
tlong = (tlong / 1023);      // 2^10 -> 0-5000mV
ch = (tlong / 767);            // extract 10 volts digit
LCD_Chr(1,7,48+ch);       // write ASCII digit at row1, collumn 7
ch = (tlong / 77) % 10;     // extract volts digit
LCD_Chr_CP(48+ch);       // write ASCII digit at cursor point
LCD_Chr_CP('.');
ch = (tlong / 8) % 10;       // extract 0.1 volts digit
LCD_Chr_CP(48+ch);       // write ASCII digit at cursor point
LCD_Chr_CP('V');
LCD_Chr_CP(' ');
LCD_Chr_CP(' ');
```

C Programming Language Code Continued

```
tlong2 = (long)adc_rd2 * 5000;     // convert adc reading to mV
tlong2 = tlong2 / 1023;            // 2^10 -> 0-5000mV
ch2 = tlong2 / 3800;               // extract 10 volts digit
LCD_Chr(2,9,48+ch2);        // write ASCII digit row 2, collumn 9
ch2 = (tlong2 / 380) % 10;       // extract volts digit
LCD_Chr_CP(48+ch2);           // write ASCII digit at cursor point
LCD_Chr_CP('.');
ch2 = (tlong2 / 38) % 10;        // extract 0.1 volts digit
LCD_Chr_CP(48+ch2);           // write ASCII digit at cursor point
LCD_Chr_CP('V');

ch = (tlong / 800);              // 10 volts digit
ch3 = ch3 + ch;
ch2 = (tlong / 80) % 10;         // Volts digit
ch4 = ch4 + ch2;
Delay_ms(2);
 }
```

```
 // HYSTERESIS
ch3 = (ch3 / 500);         // Average 10 volts digit after 0.5 seconds
ch4 = (ch4 / 500);         // Average volts digit after 0.5 seconds
if((ch3 == 5 && ch4 >= 5) || ch3 > 5)
LATA = 0;                  // Disable the Buck over 55V
if((ch3 == 1 && ch4 <= 5) || ch3 < 1)
LATA = 0;                  // Disable the Buck under 15V
if((ch3 == 2 && ch4 >= 5) || (ch3 > 2 && ch3 < 5))
LATA = 1;                  // Enable the Buck between 25V and 50V
}
}
```


Electrical Unit
Buoy
Turbine

Future Developments

- GPS
- Use of Sepic topology instead of Buck topology
- Power Factor Correction
- Code Optimization

Budget

Item Description	Cost	% of Total Project Cost
Resistors	$ 5.56	0.39%
Capiators	$ 41.34	2.87%
Inductors	$ 31.92	2.22%
Diodes	$ 12.51	0.87%
Transistors	$ 15.35	1.07%
LEDs	$ 2.98	0.21%
Lead Acid Battery	$ 18.06	1.26%
Buck Converter EVM	$ 25.00	1.74%
Battery Controller EVM	$ 49.00	3.41%
Microcontroller	$ 3.42	0.24%
Blank MCU Cards	$ 56.60	3.93%
Breadboards	$ 64.89	4.51%
Breadboard Jumper Kits	$ 38.82	2.70%
PCB	$262.00	18.21%
Development Kit	$ 467.00	32.45%
Multimeter	$ 24.50	1.70%
Shipping Cost	$320.00	22.24%
	$1,438.95	

QUESTIONS?