Energy Harvesting Platform

Group 8

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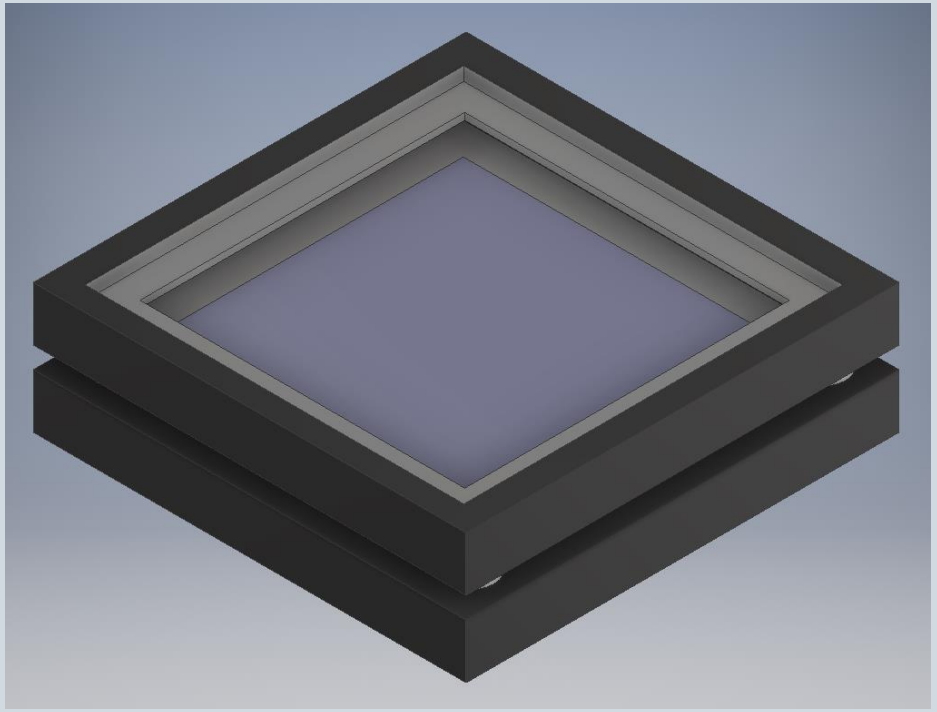
Motivation

- Non-renewable energy sources harm the environment
- Unreliable power grids in under-developed areas
- Interruption of power from natural disasters
- Restricted to specific locations of power supply
- Clean energy is the future

Solution

- Dual-source energy harvesting
  - Solar energy
  - Electromechanical energy
- Reliable – no external power source needed
- No interruption from natural events
- Unrestricted, portable power source
- Both sources of clean energy



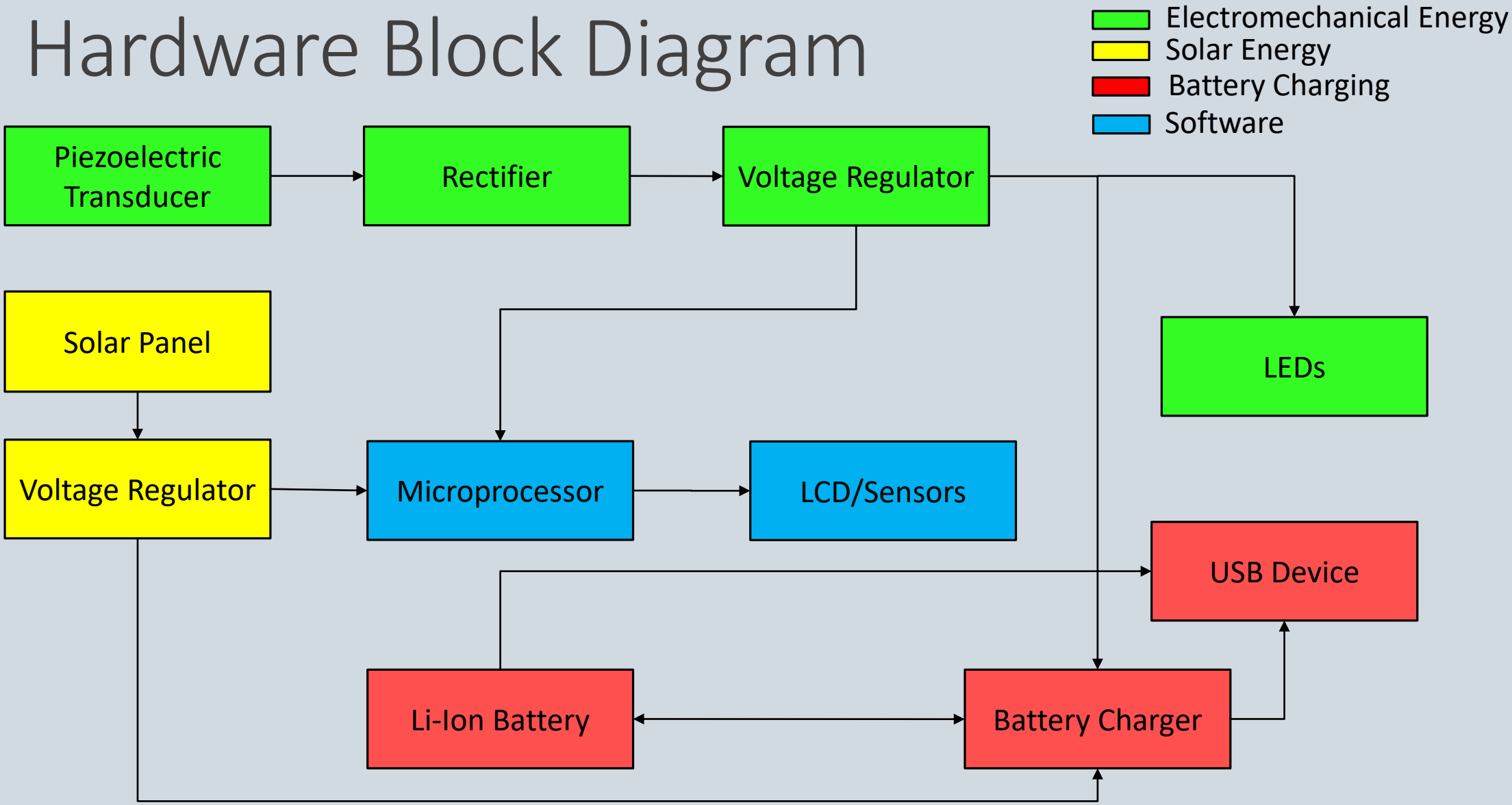
Goals and Objectives

- Charge two batteries simultaneously
  - External Lithium-Ion battery
  - USB device containing a Lithium-Ion battery
- Power LEDs from electromechanical energy source
- Monitor power output

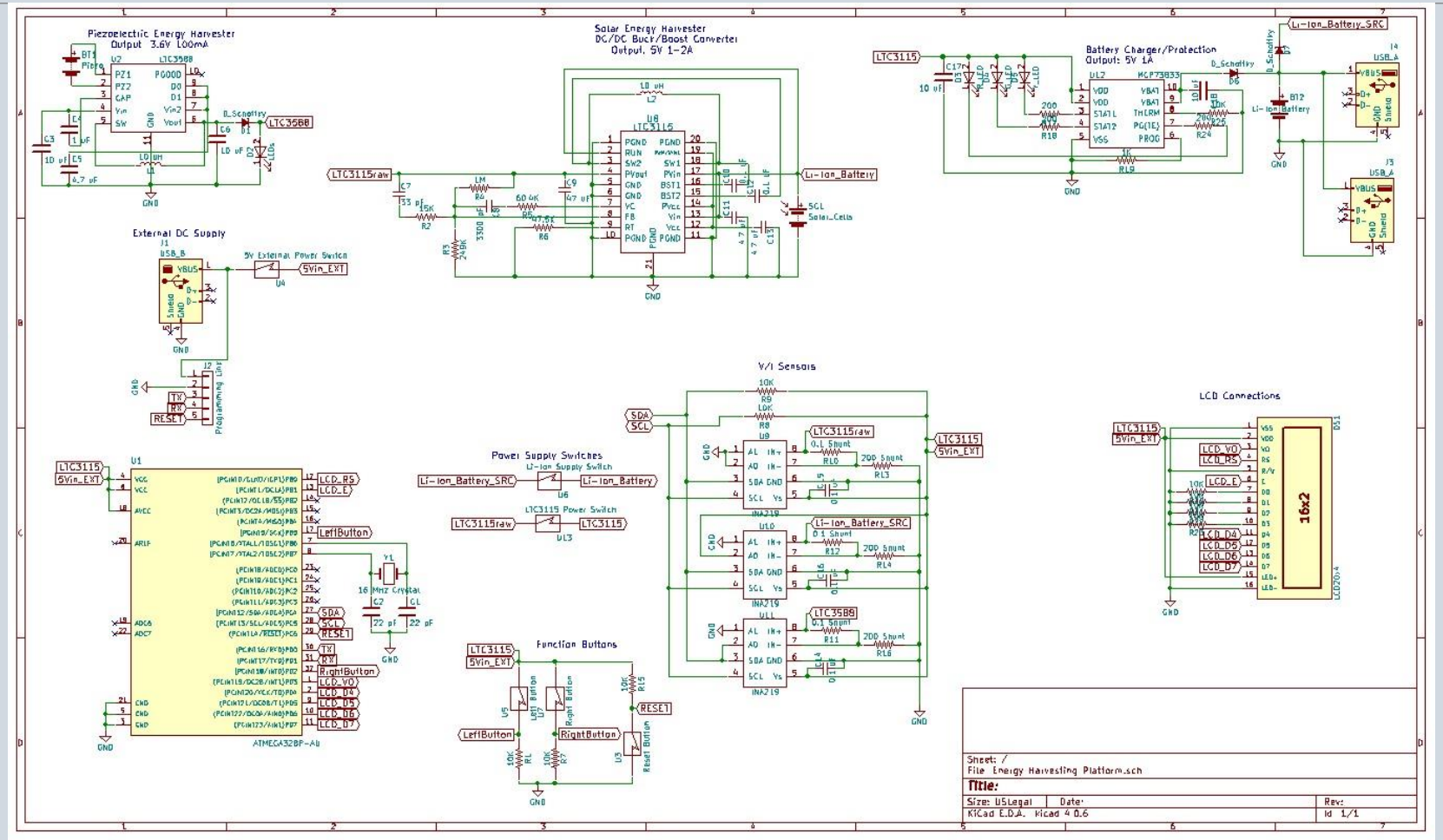
Specifications

Characteristic	Requirement
Dimensions	≤ 15” x 15”
Battery Capacity	≥ 2500mAh
Cost	≤ $400
Output Power	≥ 5W
LEDs Flash	≤ 5 steps

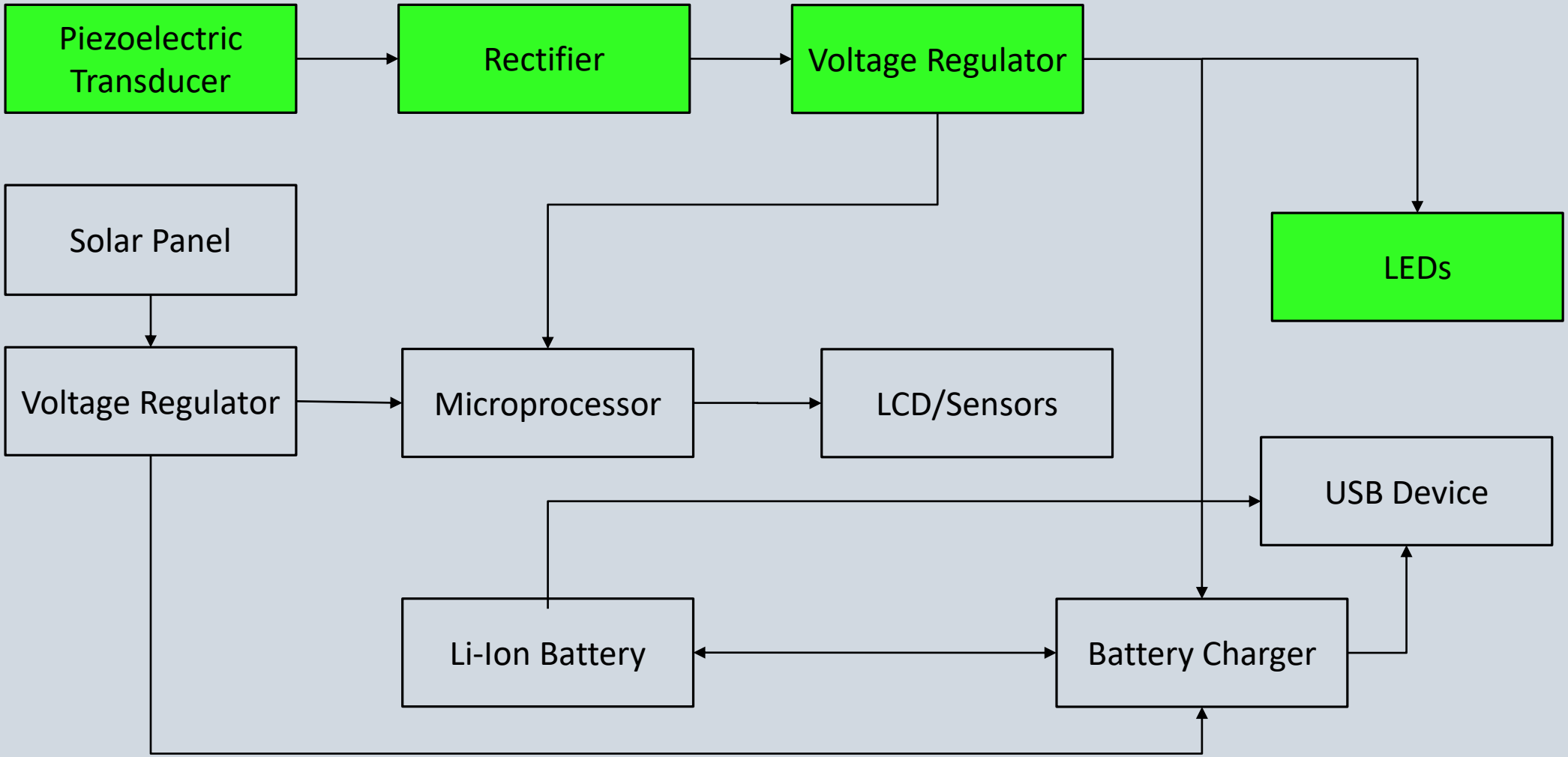
Hardware Block Diagram



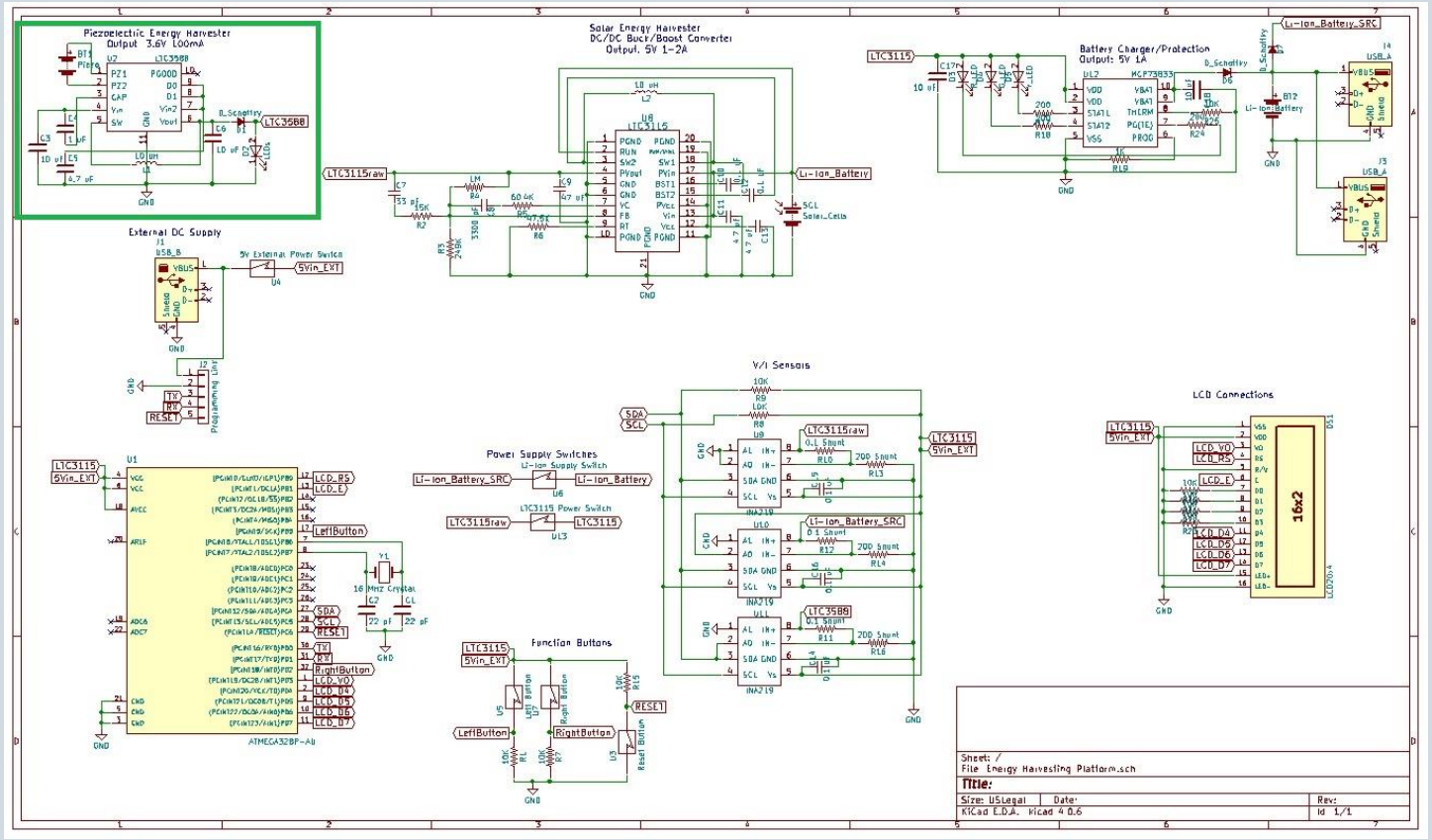
Schematic


Piezoelectric Energy Harvester
Output 3.6V 100mA
Solar Energy Harvester
DC/DC Buck/Boost Converter
Output, 5V 1-2A
Battery Charger/Protection
Output: 5V 1A
External DC Supply
5V External Power Switch
Power Supply Switches
Li-Ion Supply Switch
LTC3115 Power Switch
V/I Sensors
LCD Connections
Function Buttons
ATMEGA32BF-AU
16x2
Sheet: /
File: Energy Harvesting Platform.sch
Title:
Size: USLegal
Date:
Rev:
KiCad E.D.A. kicad 4.0.6
Id: 1/1

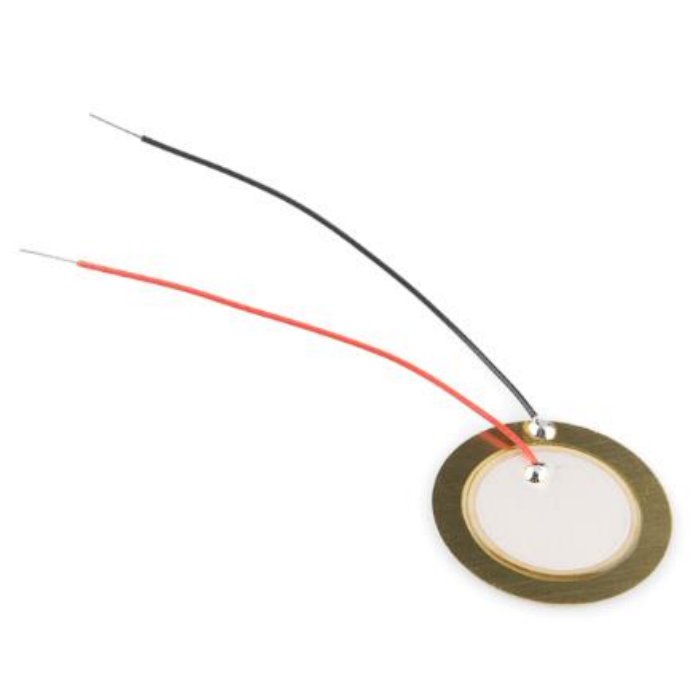
Piezoelectric Energy Harvesting Circuit



Schematic – Piezoelectric Circuit



Piezoelectric Transducers



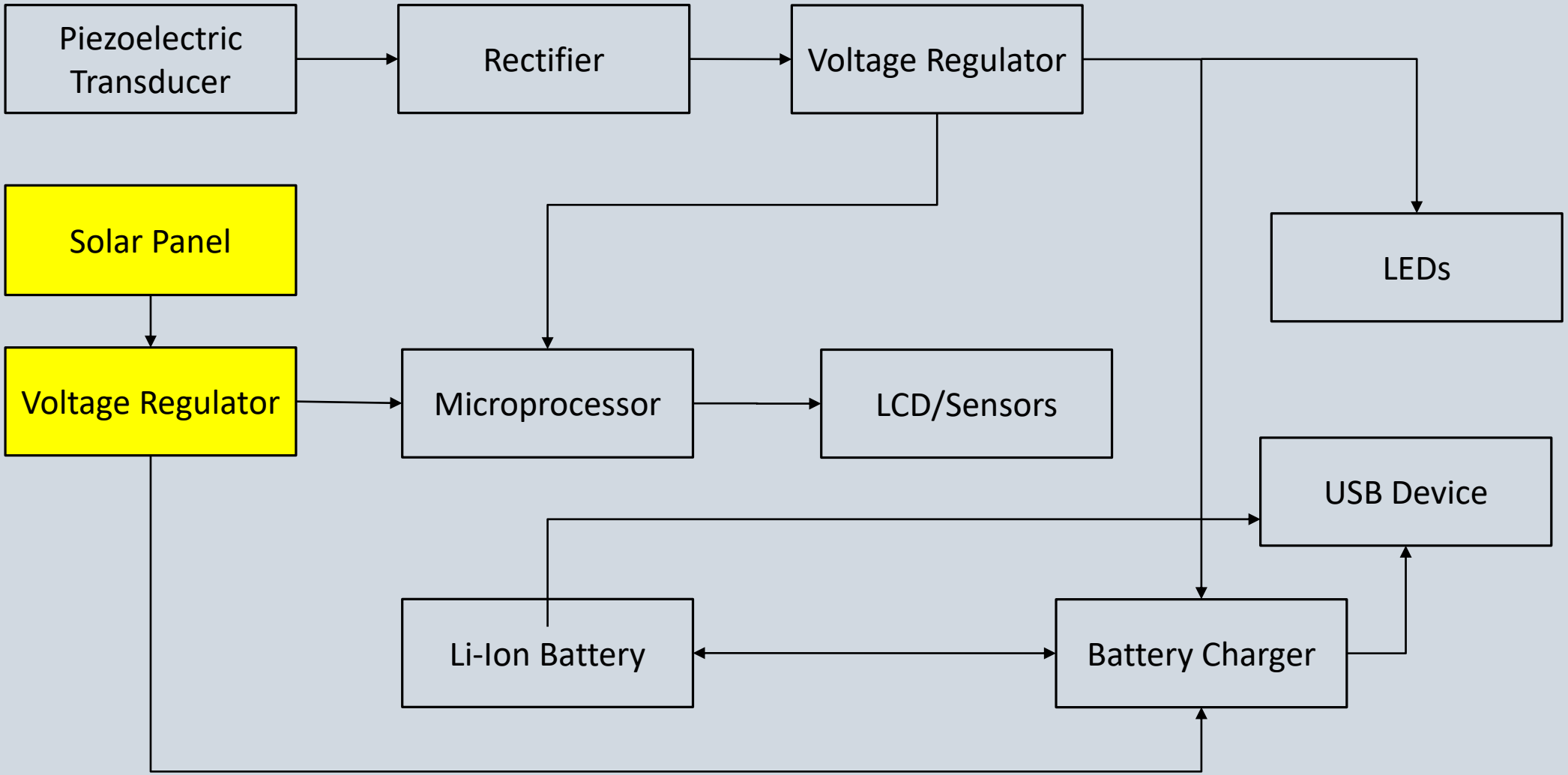
- Converts mechanical stress applied to a crystal into electrical energy
- Will be implemented in a platform in high foot-traffic places
- More voltage is produced when wired in series, more current is produced when wired in parallel
- Generates dampened sinusoidal AC power

Rectifier/Regulator

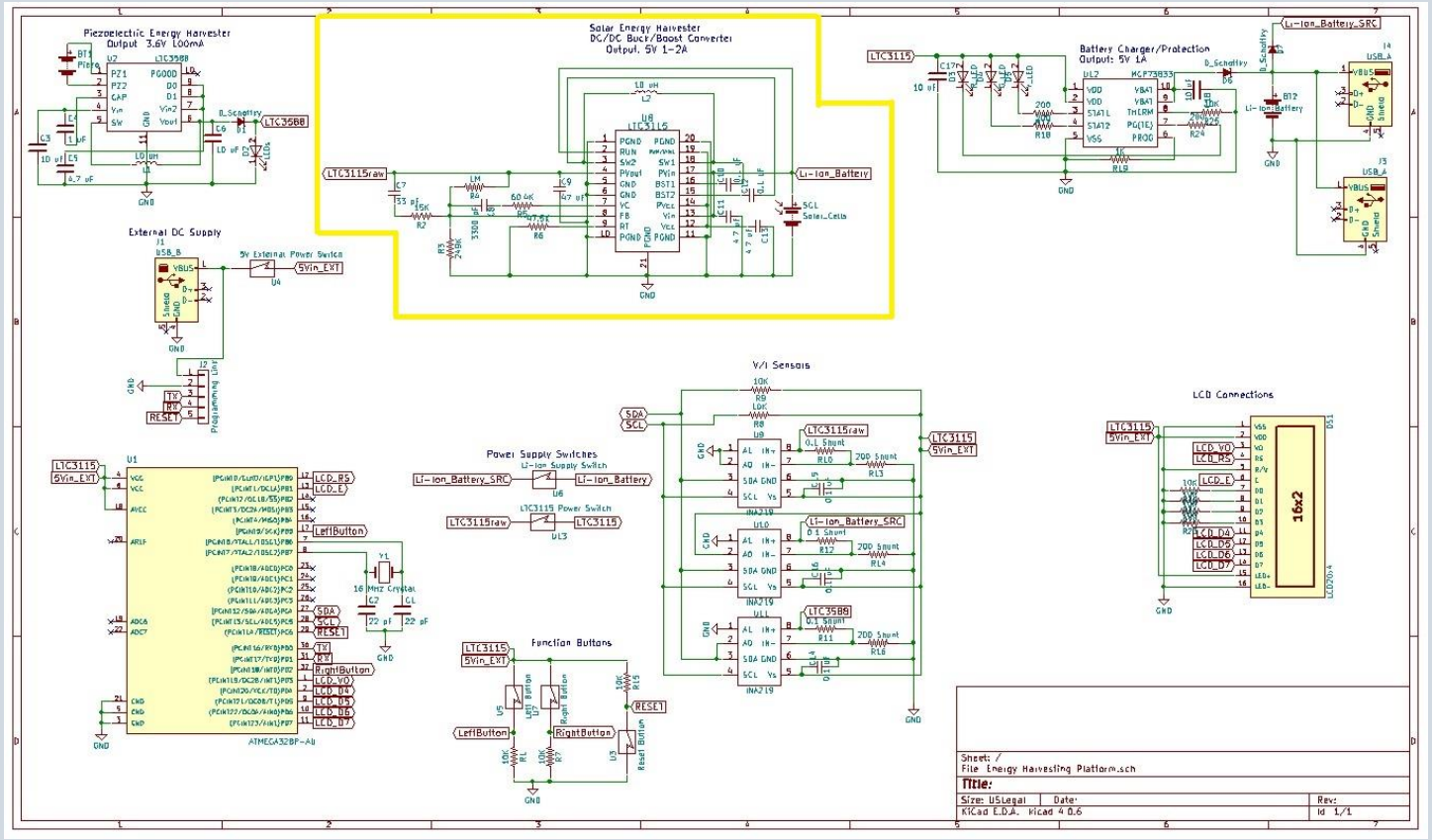
LTC3588-1

Rectifier	Forward Voltage	Quiescent Current	Max Input Voltage	Average Current Output
LTC 3588-1	Selectable Output Voltages (1.8, 2.5, 3.3, 3.6)	950nA	20V	100mA
HD01	1V	N/A	70V	800mA
DF01	1V	N/A	70V	1A

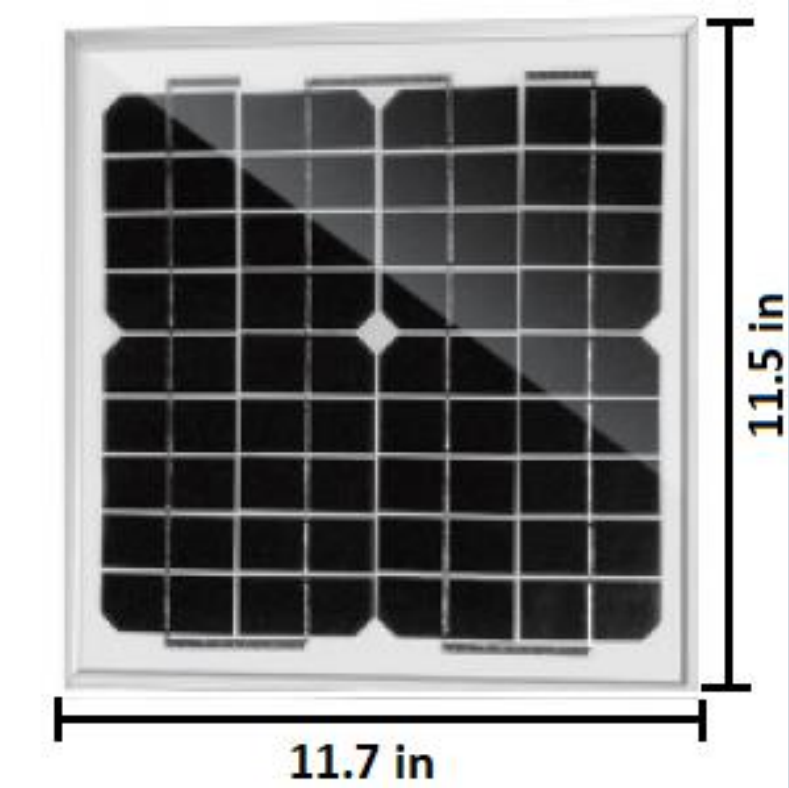
Solar Energy Circuit



Schematic – Solar Energy



Solar Panel Selection



ACOPower 10W Panel

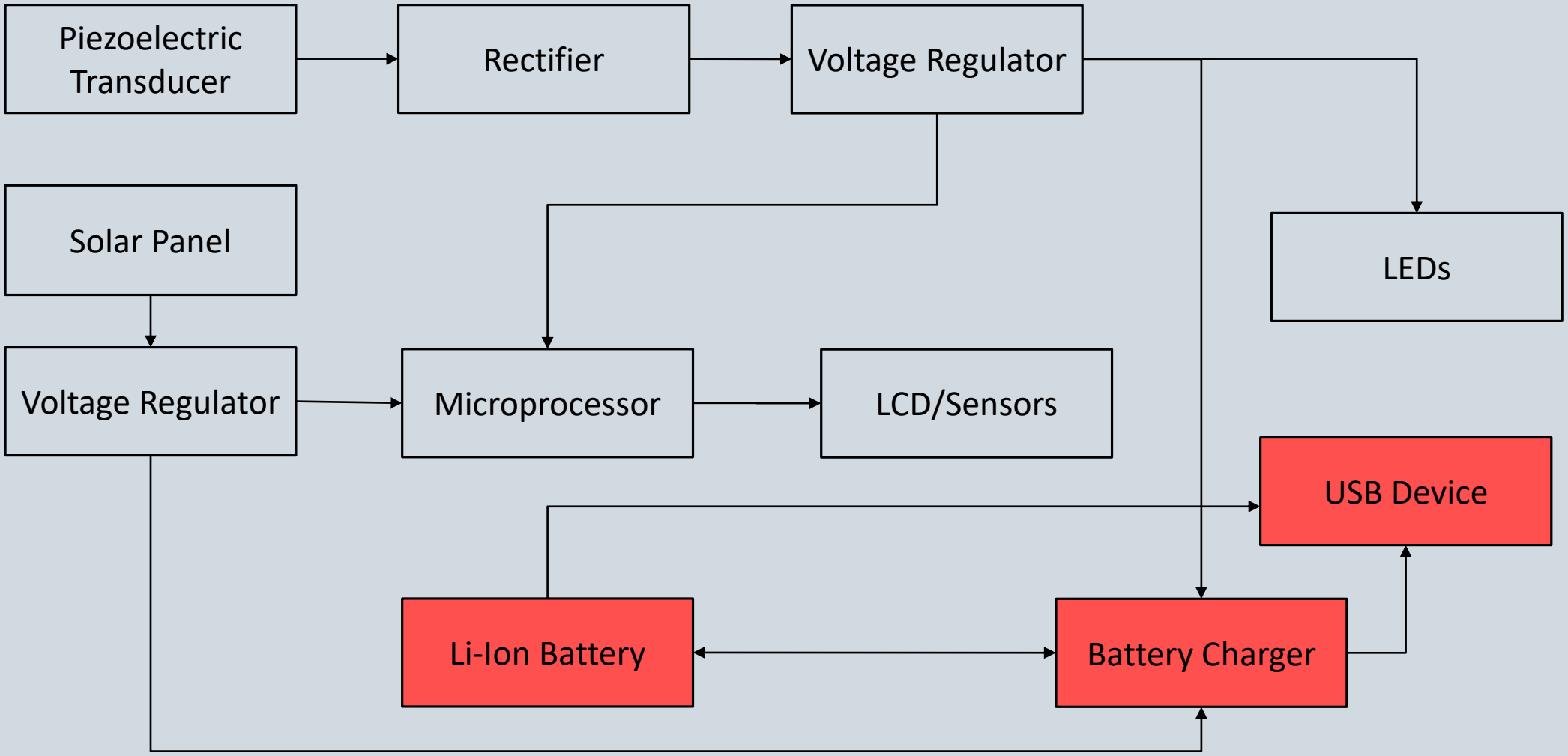
Solar Panel	Output Power	Dimensions	Efficiency
Nuzumas 3W Panel	3W (12V @ 250mA)	5.7” x 5.7”	13-16%
ACOPower 10W Solar Panel	10W (17V @ 570mA)	11.5” x 11.7”	10.74%
Solarland SLP003-12U	3W (17V @180mA)	7.4” x 7.7”	13%

DC-DC Buck-Boost Converter

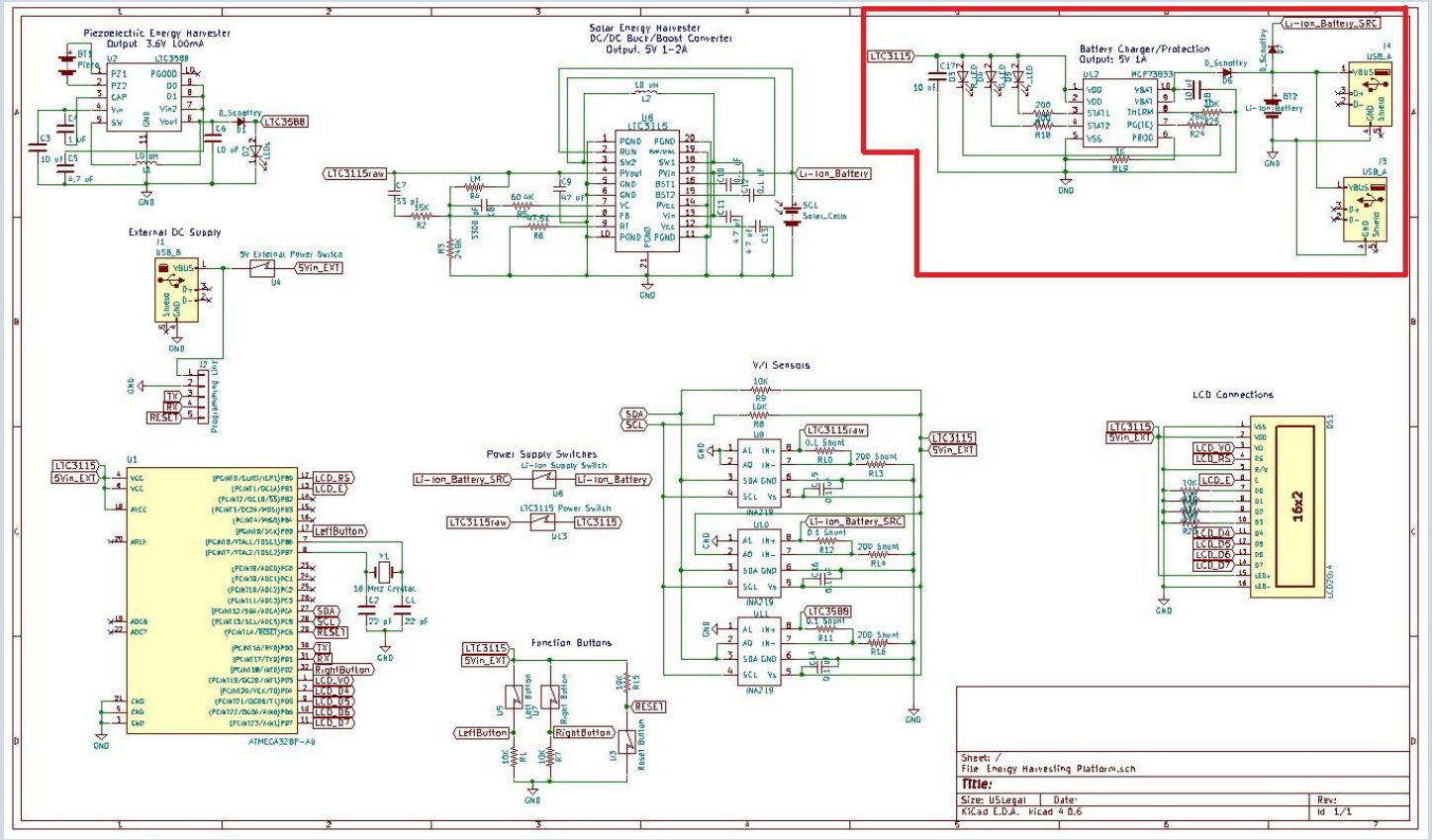
LTC 3115-1

Name of Regulator	Input Voltage Range	Output Voltage Range	Output Current	Efficiency	MPPT Capability
LM2576	7-45V	3.3, 5, 12V	3A	75-88%	No
TPS63070	2-16V	2.5V-9V	3.6A	95%	No
LTC3115-1	2.7-40V	2.7-40V	2A	95%	No
LTC3130-1	2.4-25V	1V-25V	850mA	95%	Yes
LT3652	4.95-32V	<14.4V	2A	75-90%	Yes

Battery Controller Circuit

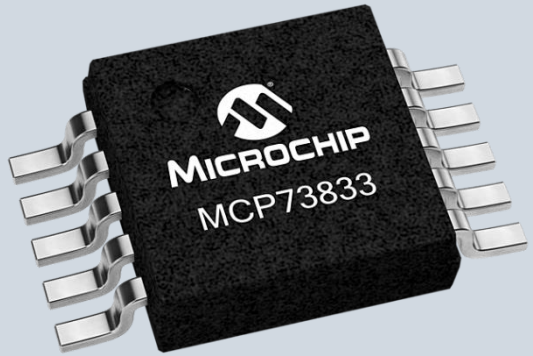


Schematic – Battery Charge Controller



Battery Charge Management Controller

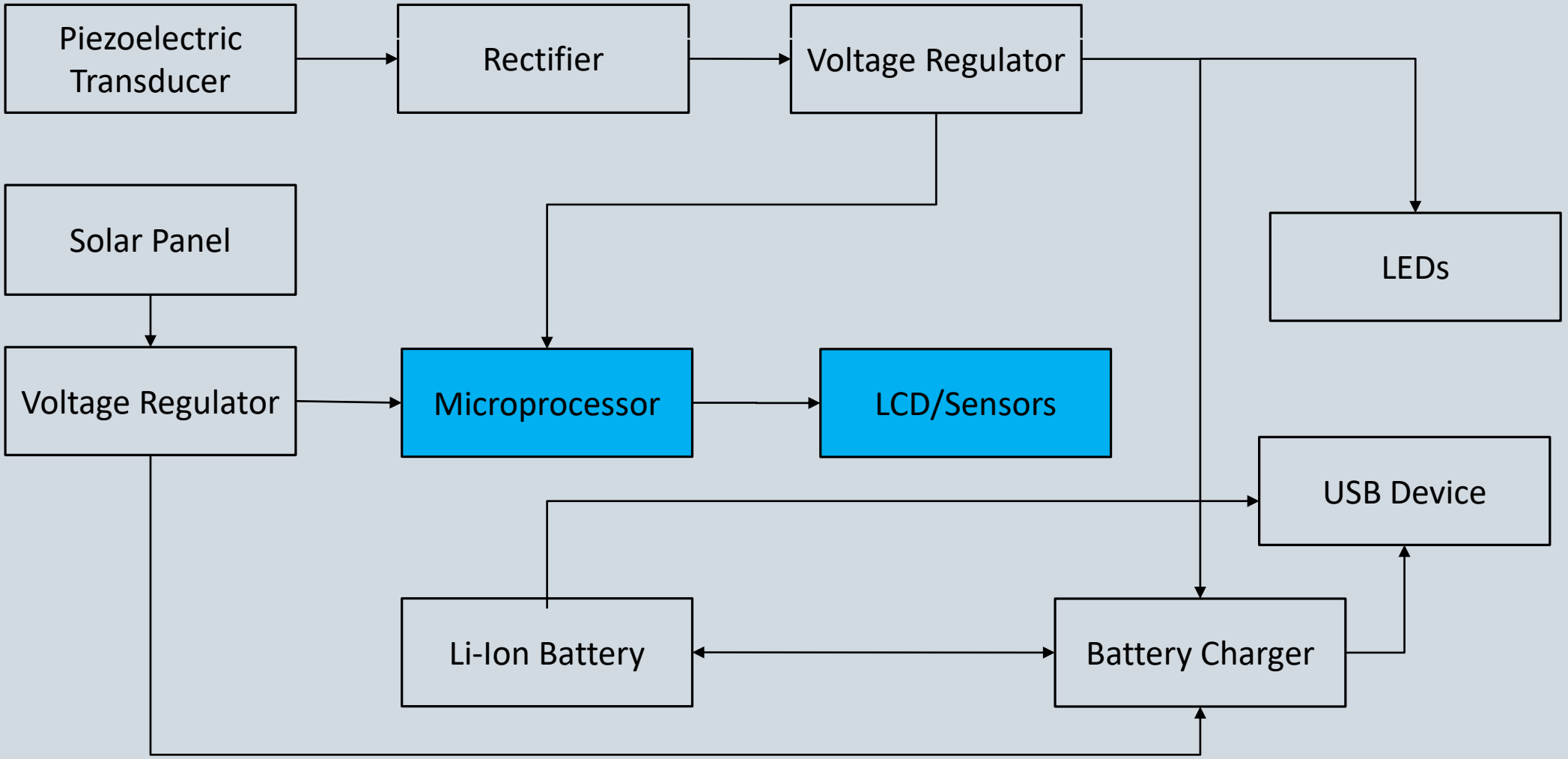
- Microchip MCP73833
- Output
  - 5V
  - Programmable current up to 1A
- Specifically designed for Lithium-Ion batteries
- Automatic monitoring of end-of-charge and temperature
- LED status indicators for power, charging, and end-of-charge



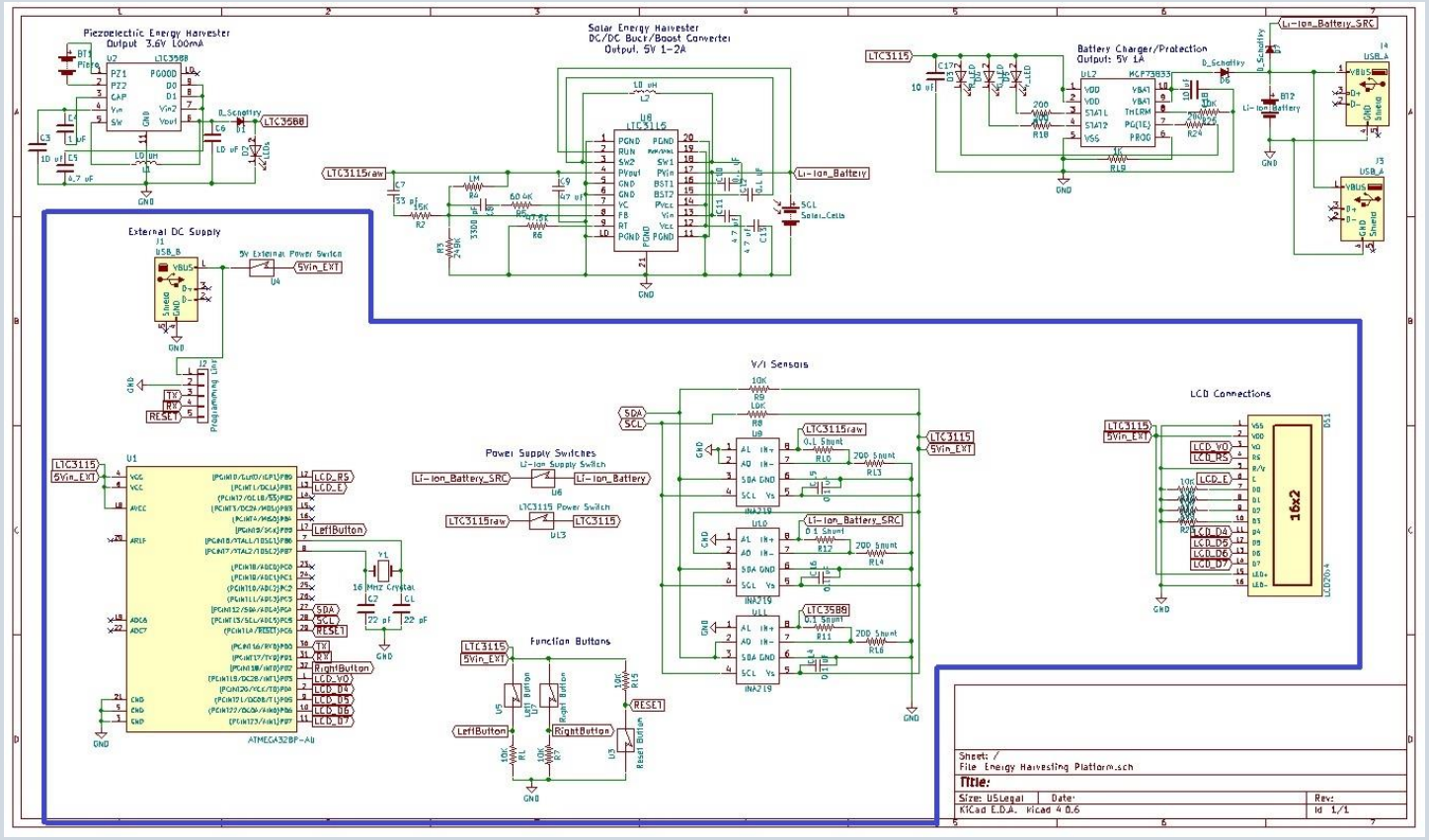
Lithium-Ion Battery

- Output voltage: 3.7V
- Capacity: 4400 mAh
- Specifically designed to work with MCP73833

Microcontroller Circuit



Schematic – Microcontroller/LCD/Sensors



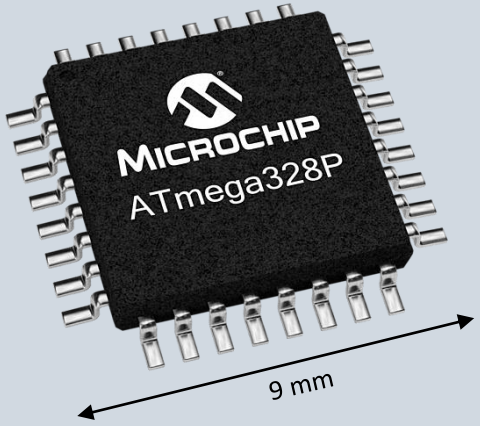
Power Monitoring System

- Main functions:
  - Provide real- time update on source power outputs
  - Print data to LCD
  - Provide battery current draws
  - Overall overview of system performance and efficiency
- Design Considerations:
  - Low power system
  - High accuracy analog measurement
  - Simple numerical display
  - Cost and space efficient
  - Easy to troubleshoot

Microcontroller Considerations

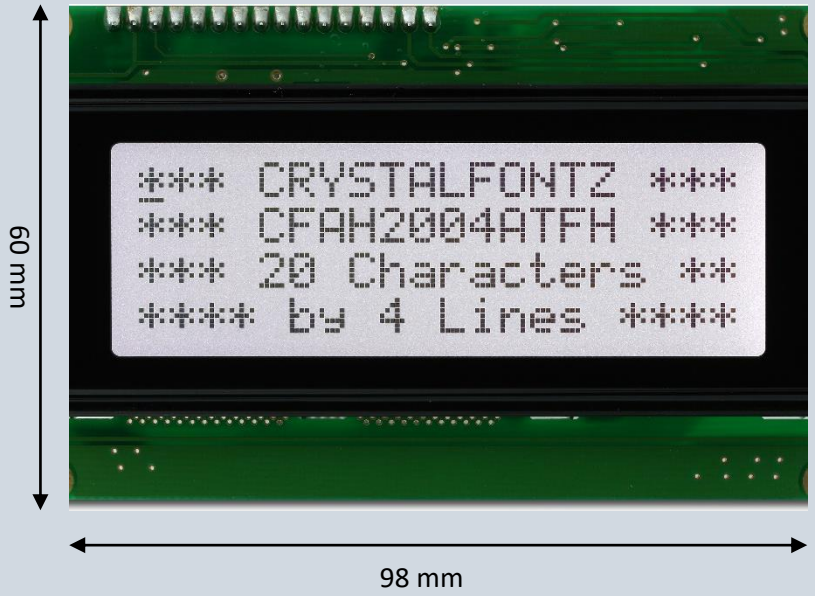
Specifications		MSP430G2553	PIC16F18877	ATMEGA328/P
ADC	ADC Bits	10	10	10
	ADC Channels	8	35	8
Cost	Price Per Unit (USD)	$2.50	$1.89	$1.90
Power Consumption	Power Consumption (mW)	0.414 mW	0.0576 mW	0.360 mW
	Lowest Operating Voltage (V)	1.8 V	1.8 V	1.8 V
Clock Frequency	Clock Frequency (MHz)	16 MHz	32 MHz	20 MHz
Memory Capacity	RAM (KB)	0.5 KB	4 KB	2 KB
	Flash Memory (KB)	16 KB	56 KB	32 KB
GPIO	Pin Count	20	36	32
	Max Voltage Applied to any Pin (V)	3.9 V	3.9 V	6 V

Microchip ATmega328P



- Compatible with already owned Arduino Uno
- Extensive documentation
- Low cost
- Higher max voltage ratings on pin
- Sufficient ADC specifications
- Considerable amount of GPIO Pins
- Good ADC resolution and amount of channels

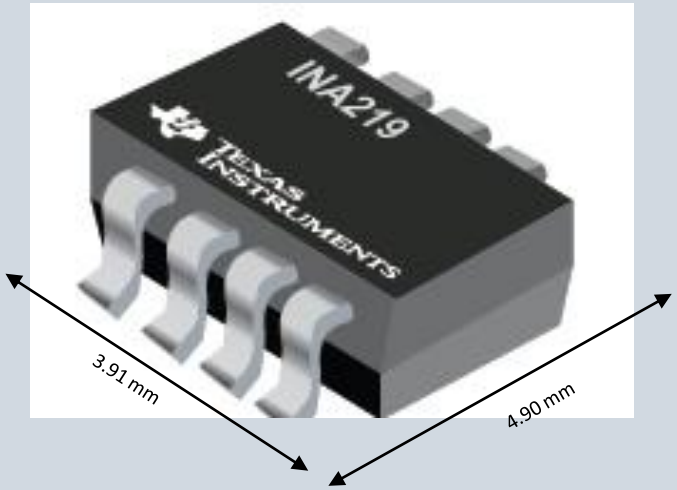
LCD Character Display



- 20 character by 4 line display
- 4 – bit to 8 – bit parallel interface:
  - Easier to implement
  - Faster data transfer
- Space effective
- Transflective polarizer:
  - Allows for indoor and outdoor viewing
- Minimum operating voltage: 4.5 V
- HD44780 compatible controller

INA219 High Side DC Current Sensor

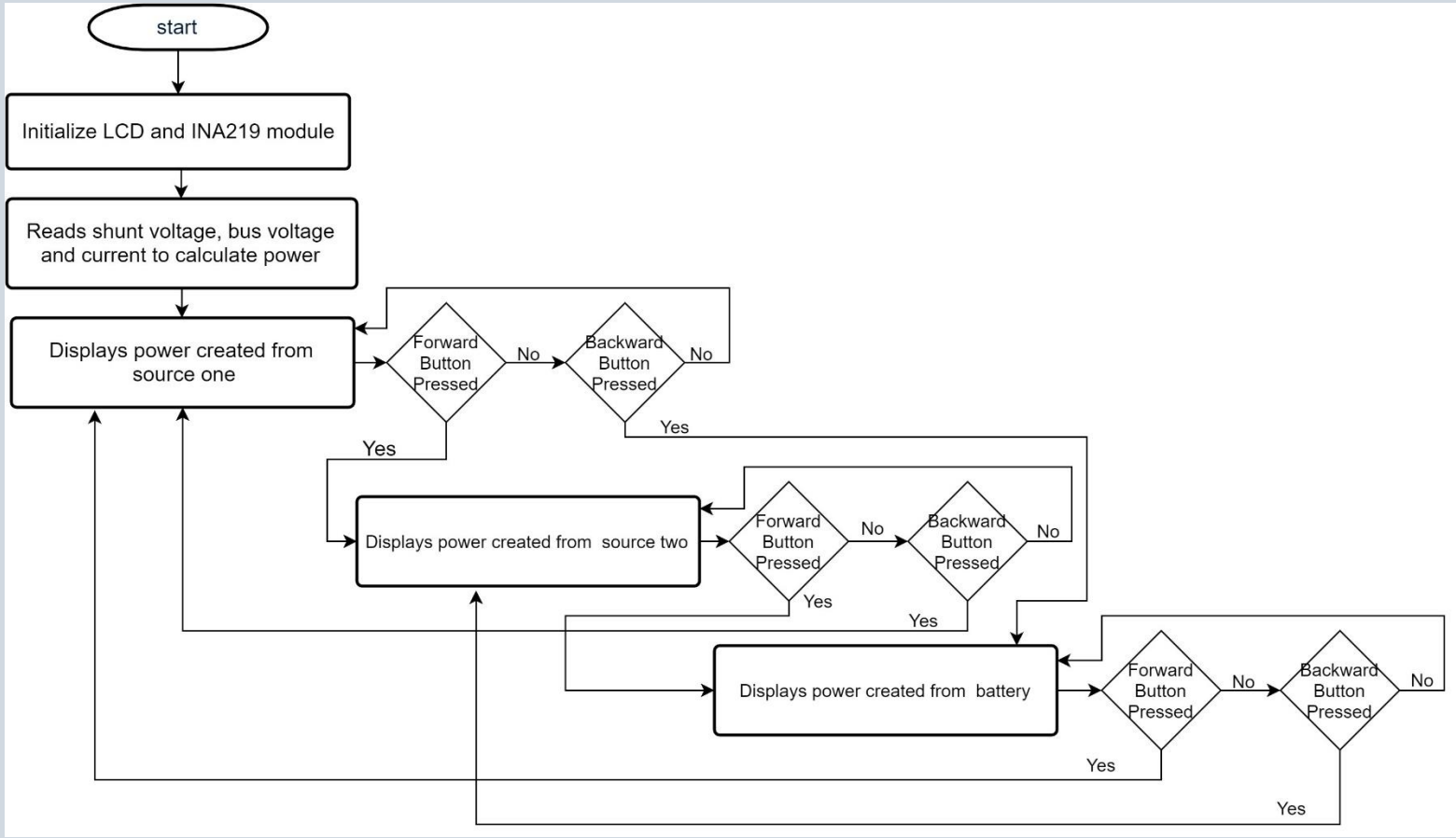
- Detects bus voltage from 0 – 26 V
- Voltage, Current and Power monitoring
- High accuracy within 0.5%
- I2C interface:
  - 16 programmable slave addresses to use multiple modules
- Built in Configurable ADC
- Register calibrations
- Low cost and space efficient



Software Design Implementation

- Perform analog measurements and power calculations
- Display voltage, current and power outputs from sources
- Read battery ratings to monitor current draw
- Cycle data for easier readability
- Simplify code with built in libraries to reduce code density

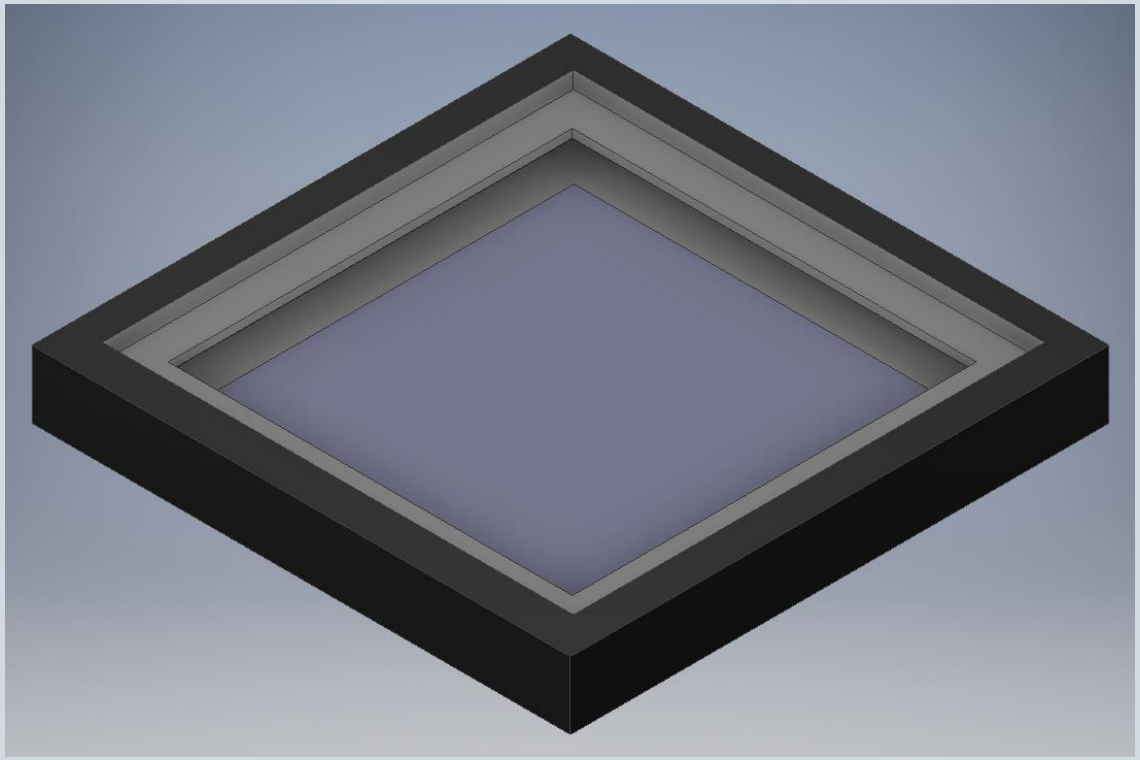
Software Flow Chart

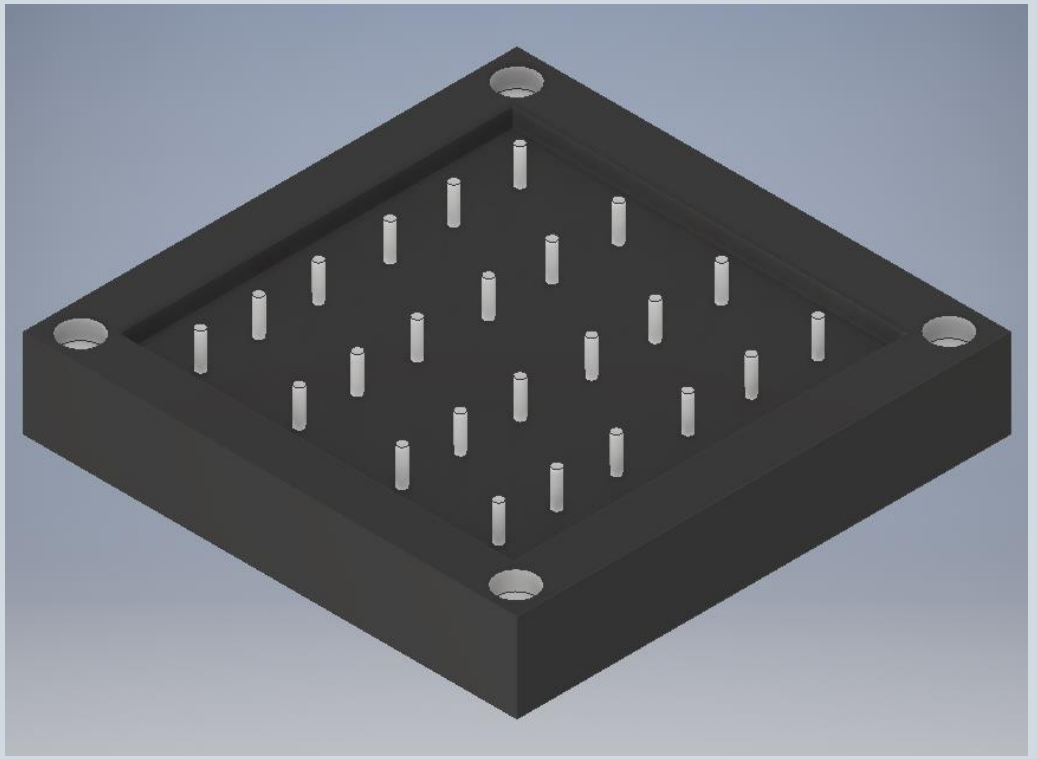


Arduino Uno and IDE

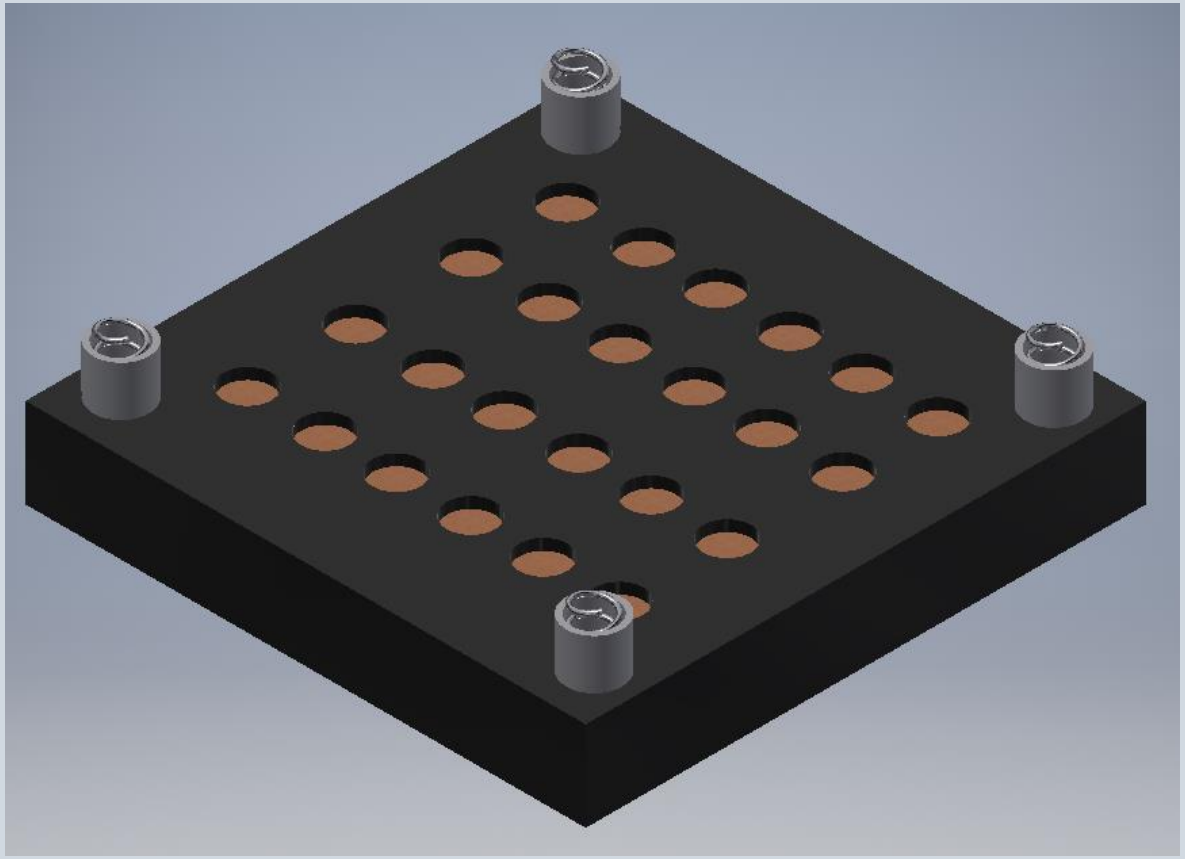
- Used as an external programmer
- Provides USB-to-serial converter
- Open source
- Compatible with the ATmega328P
- Arduino Software IDE:
  - C is used to program the microcontroller
  - Useful IDE included libraries

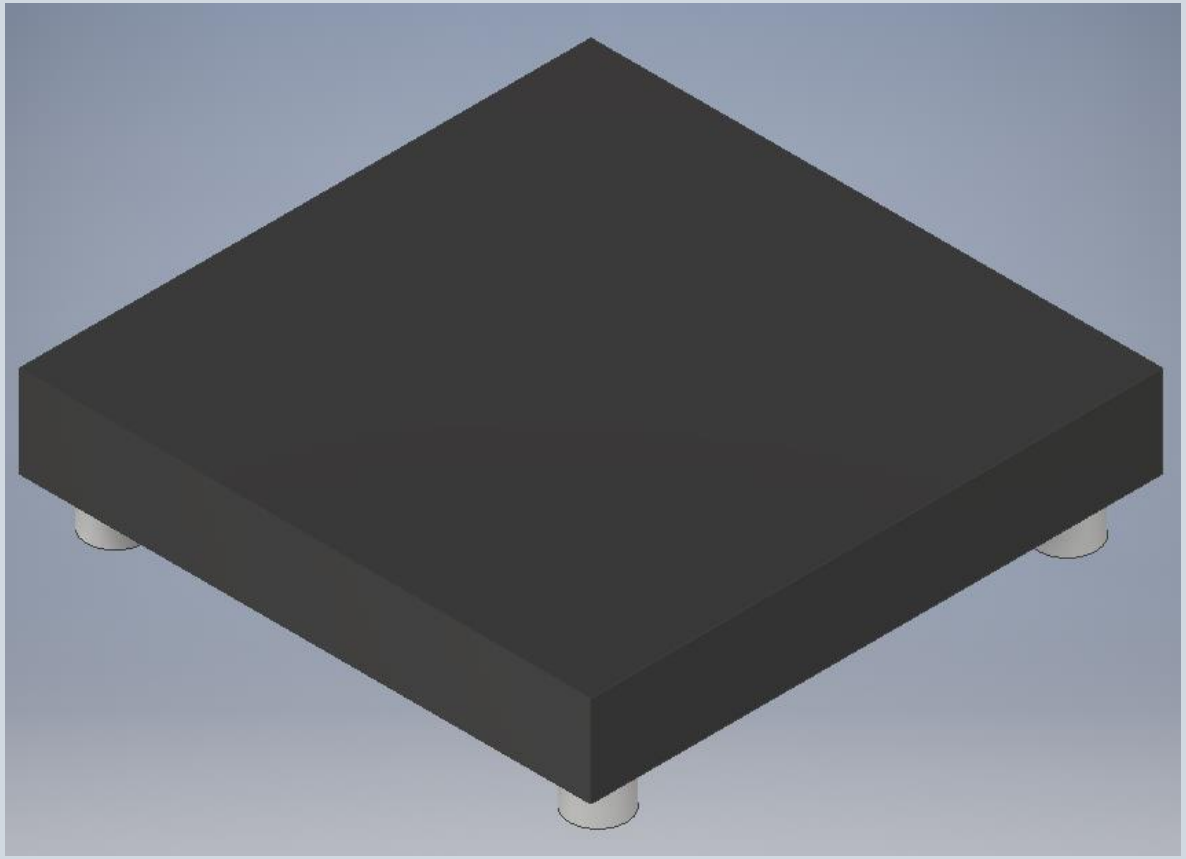
Platform Top Half



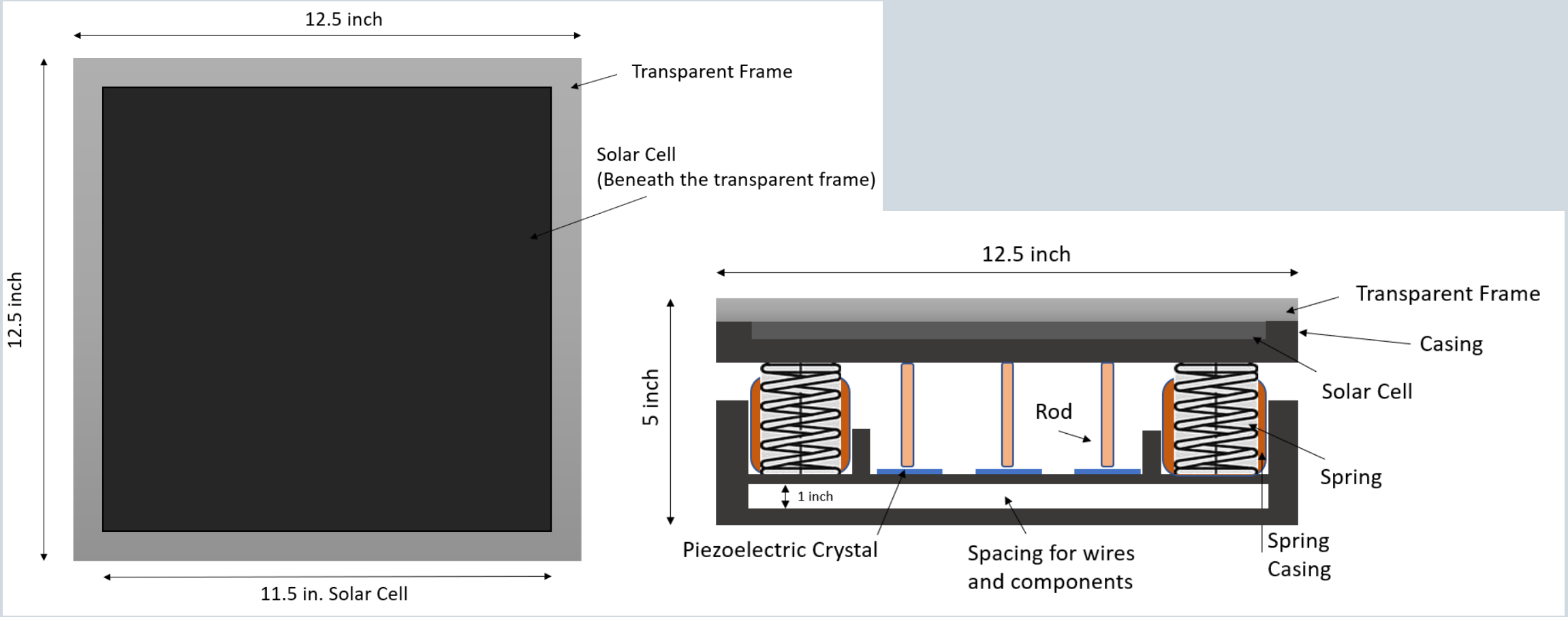


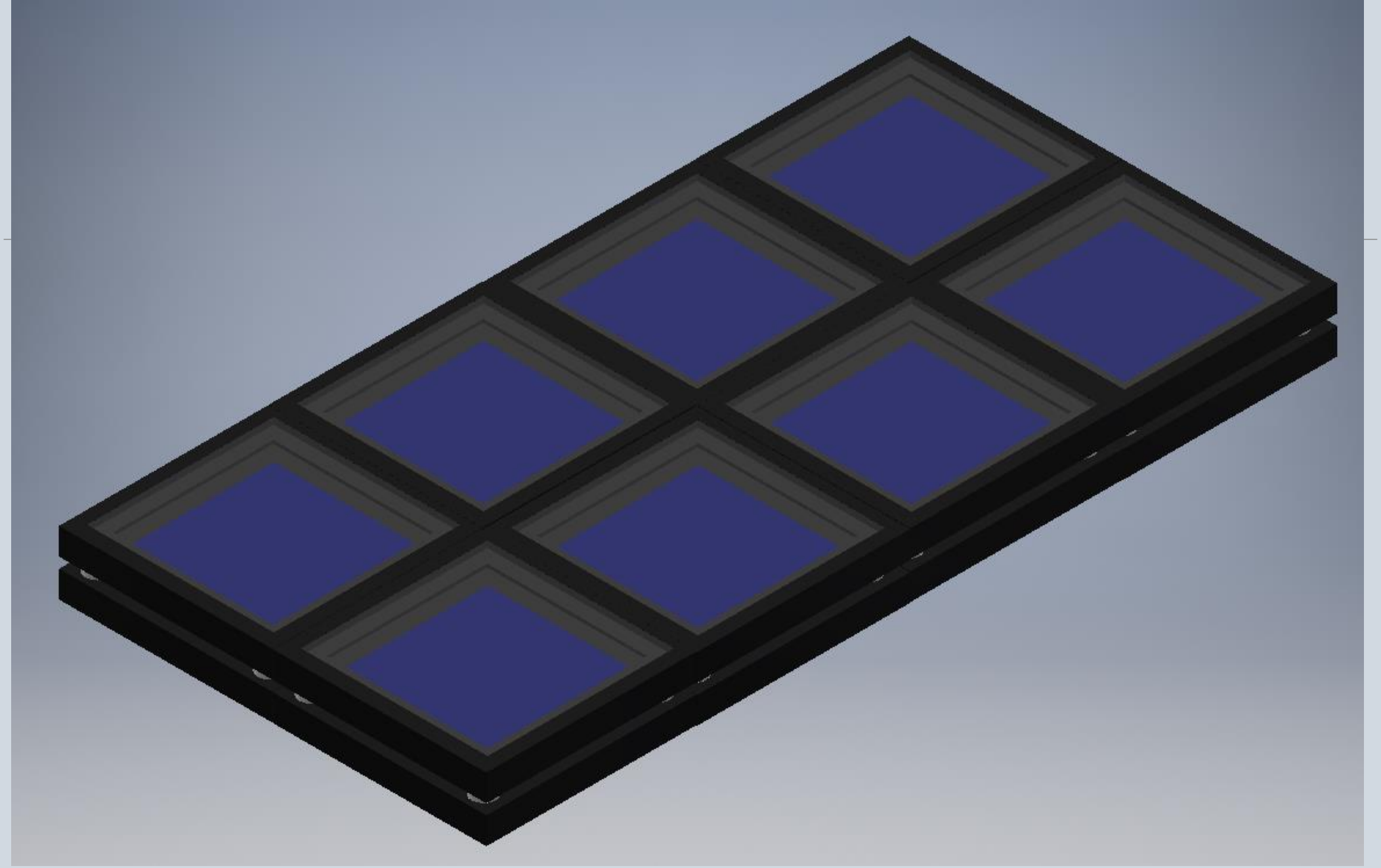
Platform Bottom Half



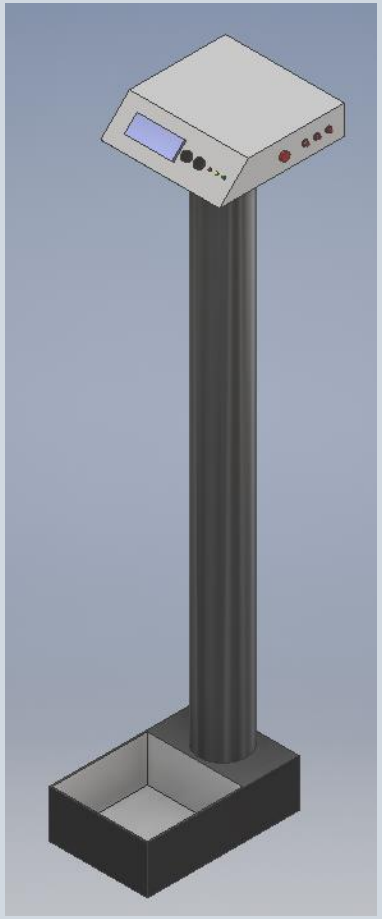


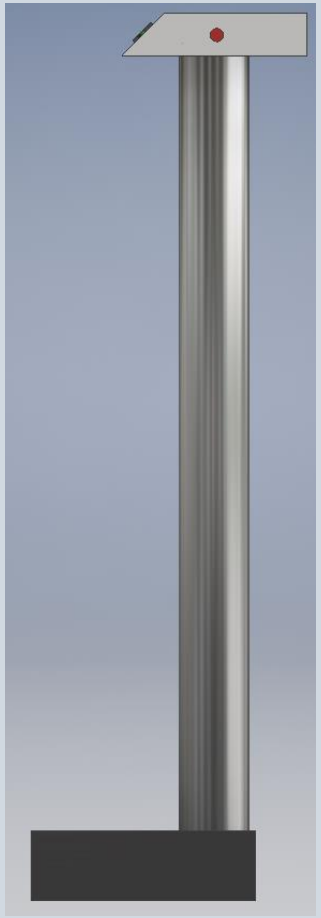
Top and Side View



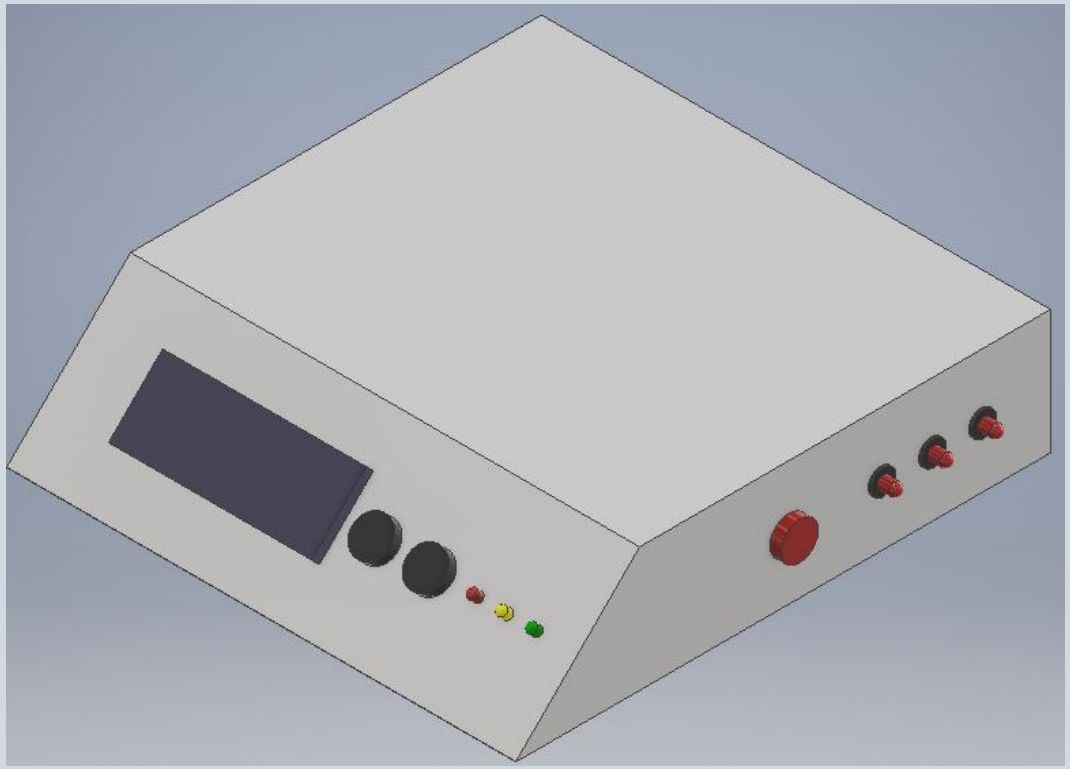


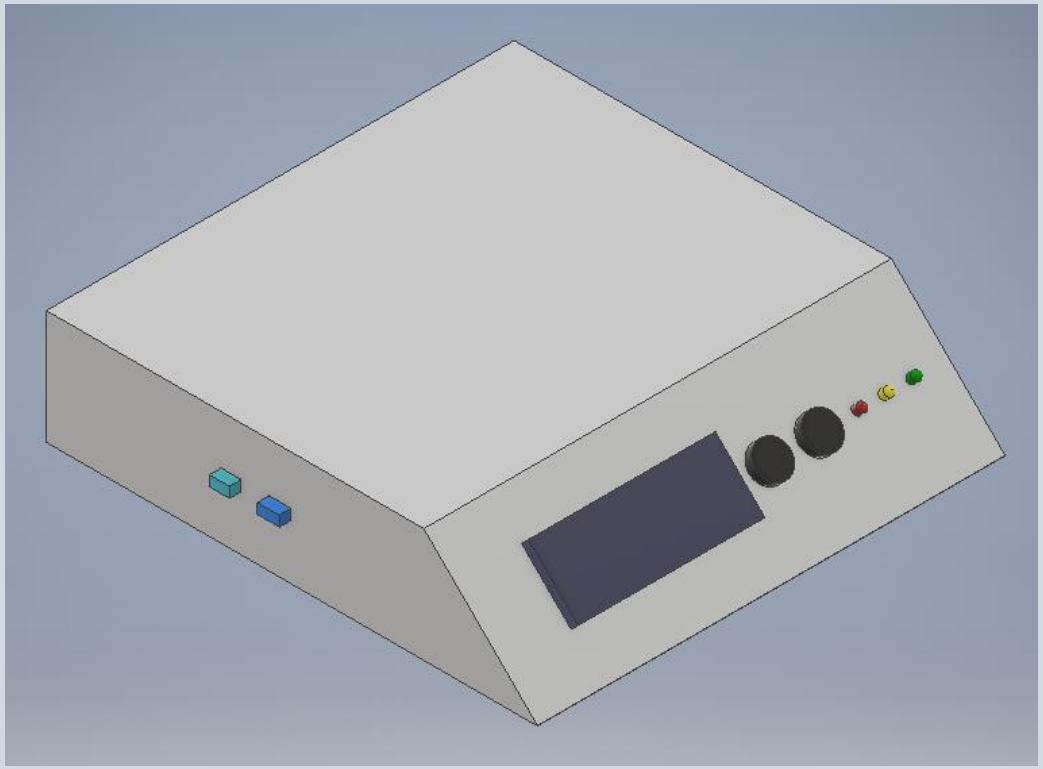
Demonstration Design





User Interface Module



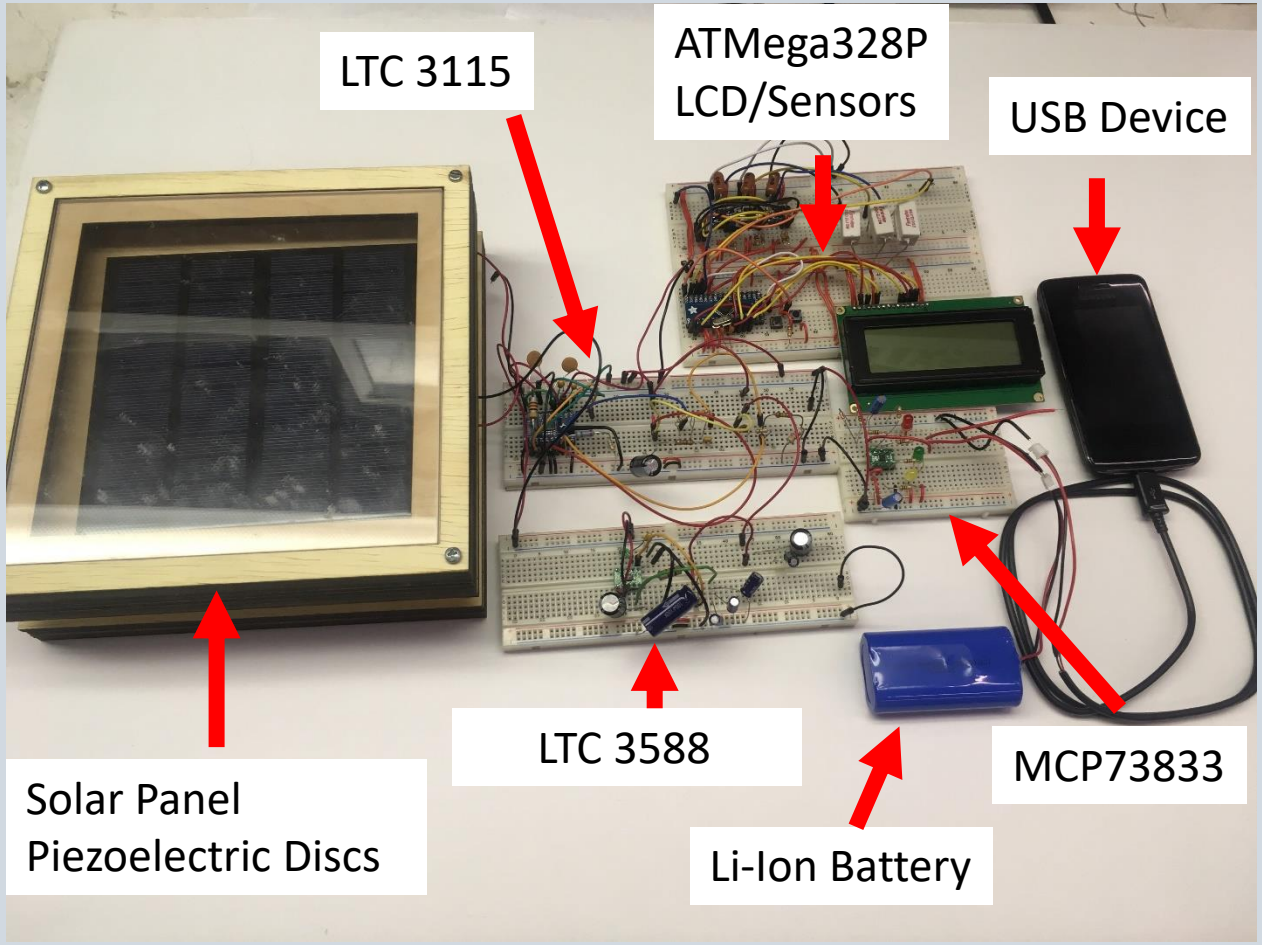


Material Selection

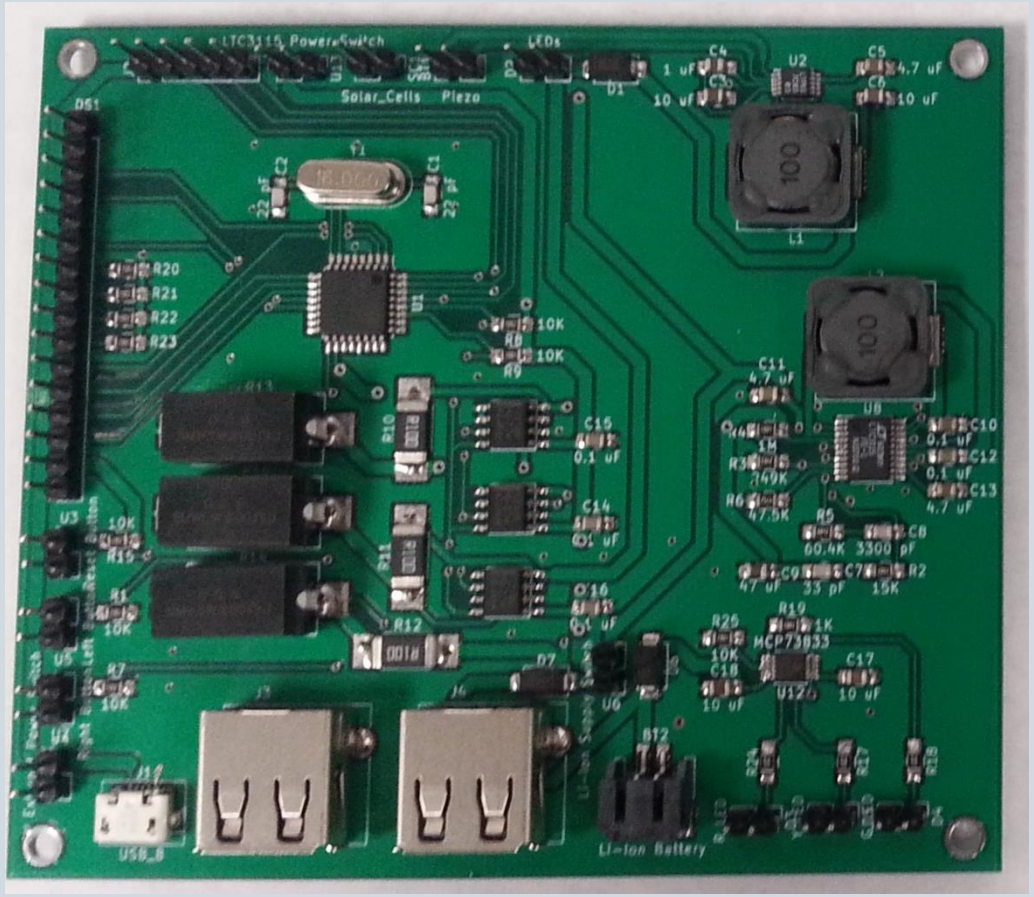
Casing			
Wood Type	Pros	Uses	Maintenance
White Cedar	Corrosion resistant Insect resistant Weather resistant	Fences Posts Canoes	Once a year
Jarrah	Does not decay Resist rotting Resist insects	Flooring Heavy Construction Furniture	2-3 times per year
Birch	Sold in sheet at craft stores and home supply stores Thin and easy to cut Low Cost	Cabinets Flooring	Rarely

Transparent Covering		
Material	Pros	Cons
Glass	Transparent	Difficult to cut to without proper tools Easy to break
Polycarbonate Plastic	Transparent Sturdy	Cannot be cut with laser cutter Difficult to cut even with glass cutting tools
Clear Plastic	Transparent Easy to work with	Melts under too much heat
Acrylic	Transparent Easy to work with Sturdy when layered	Could get scratch marks Could break under too much pressure

Prototype


LTC 3115
ATMega328P
LCD/Sensors
USB Device
Solar Panel
Piezoelectric Discs
LTC 3588
MCP73833
Li-Ion Battery

PCB


LTC3115 PowerSwitch
LEDs
Solar_Cells
Piezo
Li-Ion Battery
USB_B
MCP73833

Work Distribution

Responsibility	Sanjay	Travis	Kiara	Michael
Piezoelectric	Secondary	Primary		
Solar	Secondary	Primary		Secondary
Battery Charging	Primary	Secondary		
Housing/Mechanical			Secondary	Primary
Software	Secondary		Primary	Secondary
PCB Design	Primary	Secondary		

Financing

Item	Cost/Item	Quantity	Subtotal
12 pcs 27mm Piezo Discs	$19.99	2	$39.98
ACOPower 10W Solar Panel	$29.90	1	$29.90
Casing Materials	$49.98	1	$49.98
Lithium Ion Battery Pack 3.7V 4400 mAh	$19.95	1	$19.95
ATMega328P-AU	$2.07	1	$2.07
INA219BIDR	$2.38	3	$7.14
LTC3115	$7.93	1	$7.93
LCD Screen	$13.98	1	$13.98
LTC3588	$4.96	1	$4.96
MCP73833	$0.85	1	$0.85
PCB	$59.99	1	$59.99
Miscellaneous (Electrical Components)			$40
Total: $276.73			

Future Design Considerations

- Implement a design to charge batteries using the piezoelectric transducers
- Realize a circuit that utilizes MPPT
- Create a pathway using multiple platforms
- Develop a compact platform design

Questions?