Low Cost Data-Logger and Monitoring System for Small Solar PV Energy System

PRESENTER
Debobrata Gupta

SUPERVISOR
DR. TARIQ IQBAL

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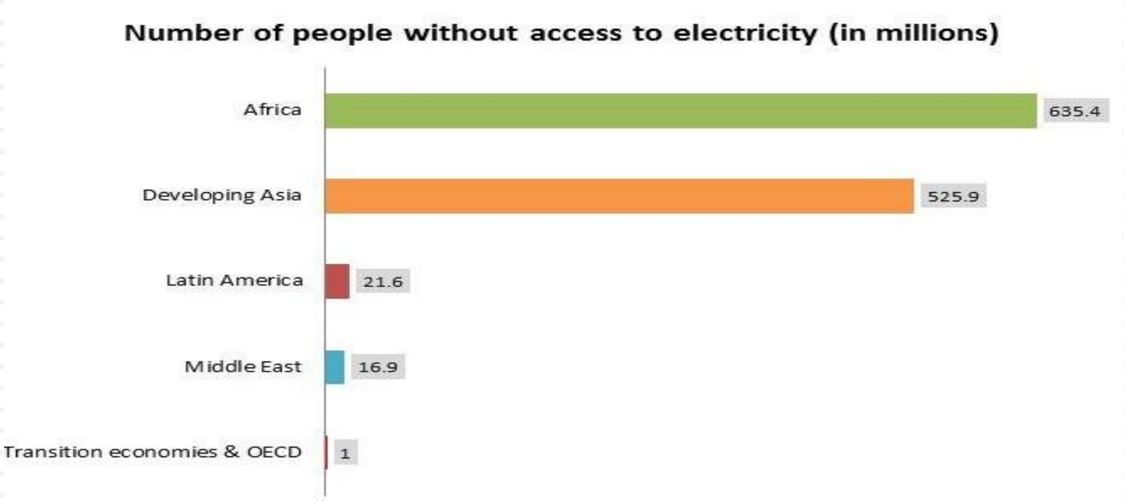
Memorial University of Newfoundland
St. John’s, Canada

Outline:

- Introduction
- Literature Review
- Load estimation and system sizing
- Design of data logger
- Design of a cell phone App
- Conclusion

Introduction:

- Energy is significant for development
- Urbanization & Technological advancement
- World consumption will rise 28% (2015-2040) (IEO,2017)
- over 20% of world population, do not have access to electricity



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- Bangladesh:
  - Low energy consuming country per capita (Islam et al.,2014)
  - Power shortage

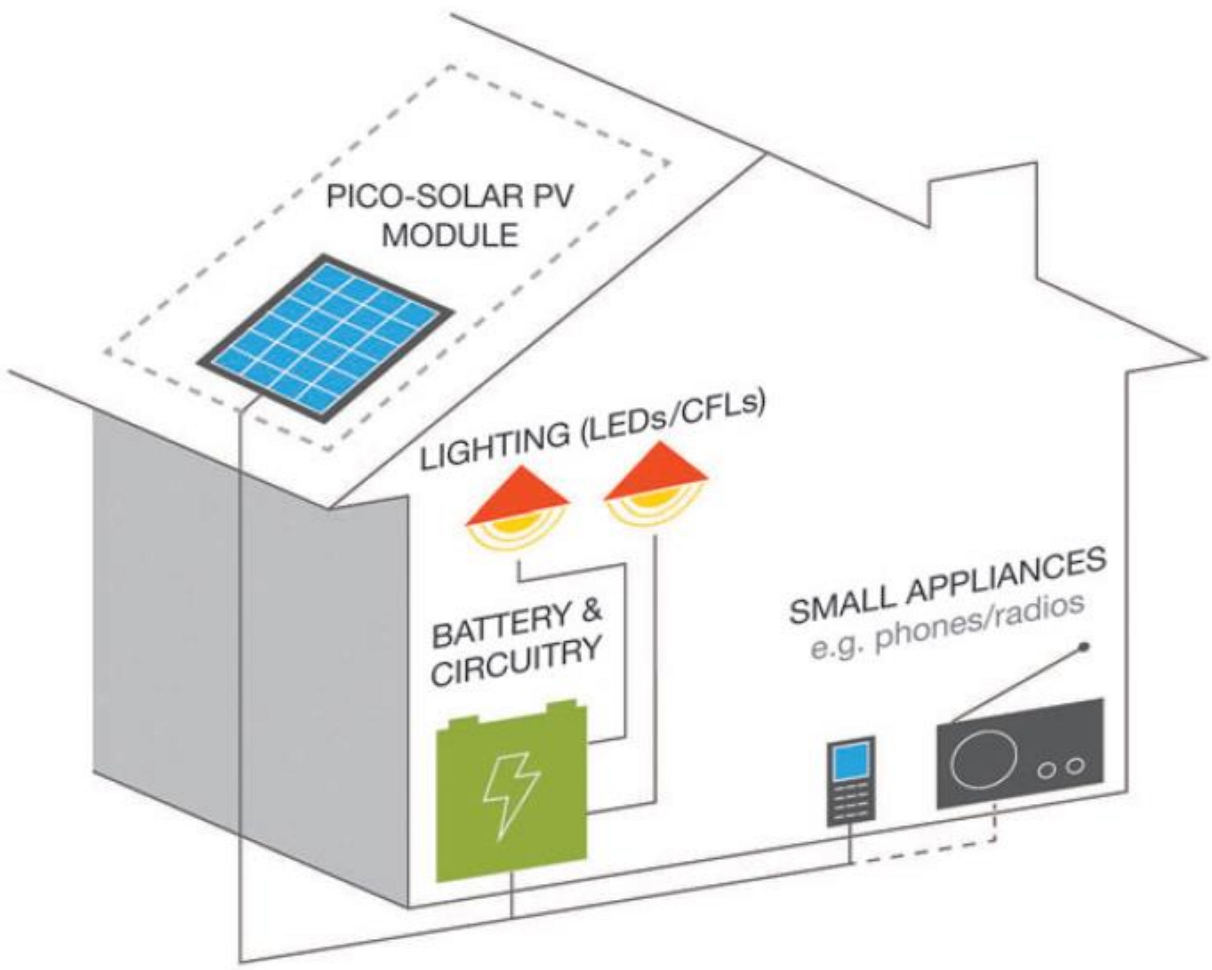
GDP: doubled in between 2010-2016 (World Bank,2016)

Consumption increases to 81.29% (2000-2016) (Power cell,2017)

40% people lack access to electricity (Hossain et al.,2017)

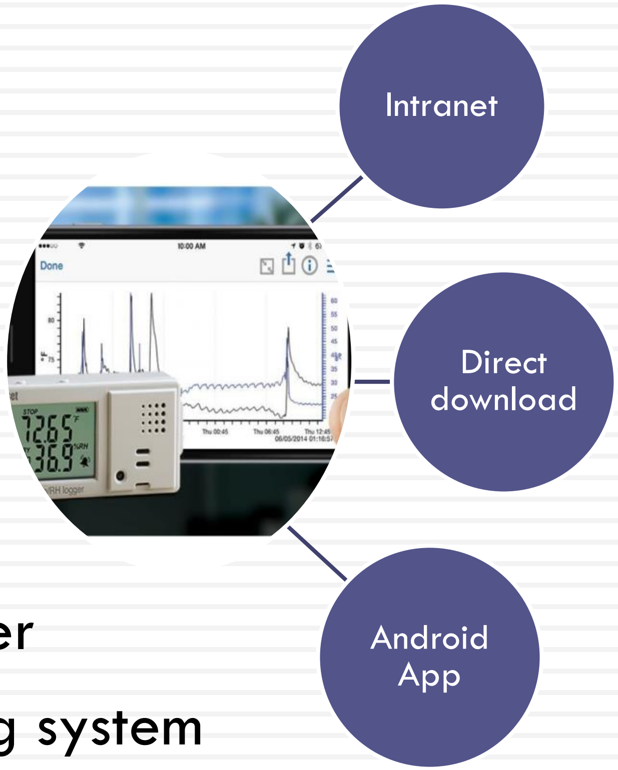
- Alternate Energy Source: SHS
- Up to May 2017, about 4.12 million SHSs

Solar Home System:



Motivation and Objective:

- Thesis Motivation:
  - Battery failure
  - Irregular use of panel
  - No regular maintenance or monitoring
  - Lack of awareness



- Thesis Goal:
  - Develop a low cost, low power datalogger
  - User friendly, easy access able monitoring system

Literature Review:

- Literature Survey:
  - Data Transfer Mechanism
  - Controller
  - Monitored Parameters
  - Sampling Intervals
  - Program Development Software
  - Monitoring Method

- 3 main category :
  - Hardware
  - Communication
  - Monitoring Software

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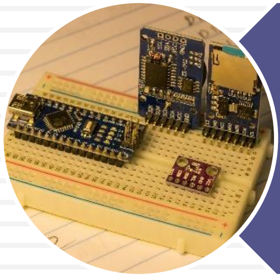
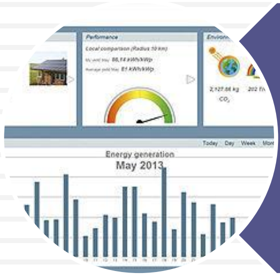


Hardware: Atmega, PIC, DAQ, PLC, Arduino

Communication: RS232,PCI bus, Satellite, RF, GSM, GPRS, TX5002, Ethernet, Zigbee, Wi-Fi



Monitoring Software: Turbo C, Assembly, LabView, Java, VB-SQL, Matlab, Mplab, Autobase, Blynk, Thinkspeak, EmonCMS, Adafruit

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- ## Lab-VIEW based real-time interface system:

"software tool that integrates several types of instruments into a single system which can offer online measurements of all data sources and compare simulation results with monitored data in real-time" (Aissa Chouder et. al.[6])

- ## Arduino based data logger:

"open-source electronic platform was developed to solve the current problem of monitoring photovoltaic (PV) systems especially for remote areas or regions in developing countries"(M. Vivar et. al.[7])

- ## Remote intelligent monitoring system:

"based on TinyOS for monitoring and management for PV power generation. This system had implemented remote monitoring and reverse control by the host computer, ARM gateways, wireless sensor networks and other components" (Jihua et al. [8]).

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Smart Remote monitoring system using IOT:

Shri hari prasath et al., presented their research in [10] to design and implement a Smart Remote monitoring system using IOT that can monitor the Solar PV PCU and stores data in the cloud database through an easily manageable web interface.

Satellite based System:

An android based design of an electronic system for the measurement and control of the physical parameters like water temperature, solar collector's fluid temperature, solar radiation level, etc. to monitor and consequently optimize thermal-solar plant functioning is presented by J. M. Bright[12] .

IoT and MQTT based System:

S. Begum et al. [13] have implemented an Operation & Maintenance (O&M) system using predictive analytics and supervisory control and data acquisition (SCADA) with the help of internet cloud along with IoT devices.

Example of Datalogger and Monitoring Software:

Data Logger

Monitoring Software

Price Comparison:

Sl. No.	Name	Manufacturer	Price (CAD)
1.	Geo Solo II PV	GEO	$126.97
2.	Eco Eye Smart PV	Eco Eye	$130.36
3.	Owl Intuition PV	OWL	$135.45
4.	Solar Cache Wi-Link Kit Comprehensive Energy Monitor	DSM Energy Control Ltd.	$659.02
5.	SMA Data Manager M powered by ennexOS	SMA Solar Technology AG	Not found
6.	Solarfox® Solar Display Systems	SOLEDOS GmbH	$575.78

Available Commercial Systems:

Data logger	Advantages	Disadvantages
PICOLOG 1012	• Relatively cheep (€200) • Very user friendly interface • Repetitive unlimited samples with unique file names • Real time mathematical calculations • 12 input analogue / digital channels • 2 output digital channels • Remote download	• Time stamp per sample missing • Must be permanently connected to a PC
DAQPro 5300	• User friendly interface • Onboard memory for medium data storage	• Modestly prices (€800) • 8 input analogue channels • Limited number of samples • Mathematical calculations after data collection • One alarm output reduces input channels by 1 • No remote download
CAMPBELL Scientific CR800	• User friendly interface • Onboard memory for extensive data storage • Remote download • 4 output digital channels • Resistance measurements • Pulse counter	• Very expensive (€1000) • 6 single-ended analogue input channels • Mathematical calculations after data collection

SHS in a Rural Area

Load Estimation and System Sizing:

- Load estimation:

Load	Qty.	Watts	Total Watts	Hours/ Day	Wh	Total Wh
LED Light	3	3	9	4	36	51
Mobile Charger	1	5	5	3	15	

Contd…

- System Sizing:
- Panel size (m^2) = $\frac{Total\ kWh\ use\ by\ appliances\ per\ day}{(solar\ hours\ per\ day) \times efficeny\ factor}$

=0.1905 m^2 ~= 20Wp (is 0.2056 m^2)

- Battery capacity in Amp-hours (Ah)

$$=\frac{energy\ reqirement\ in\ Wh\ per\ day \times days\ of\ autonomy}{battery\ DoD \times system\ voltage\ (V)}$$

= 18.75 Ah

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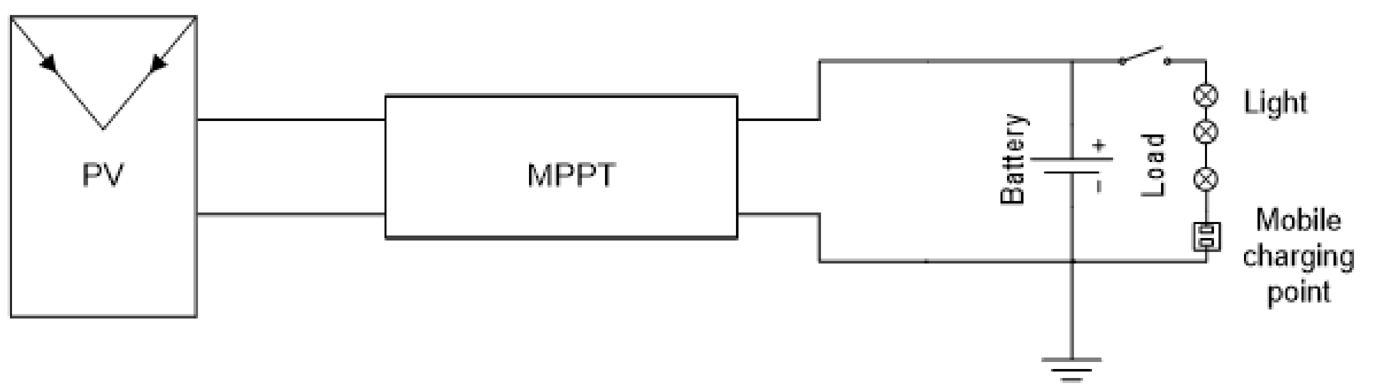
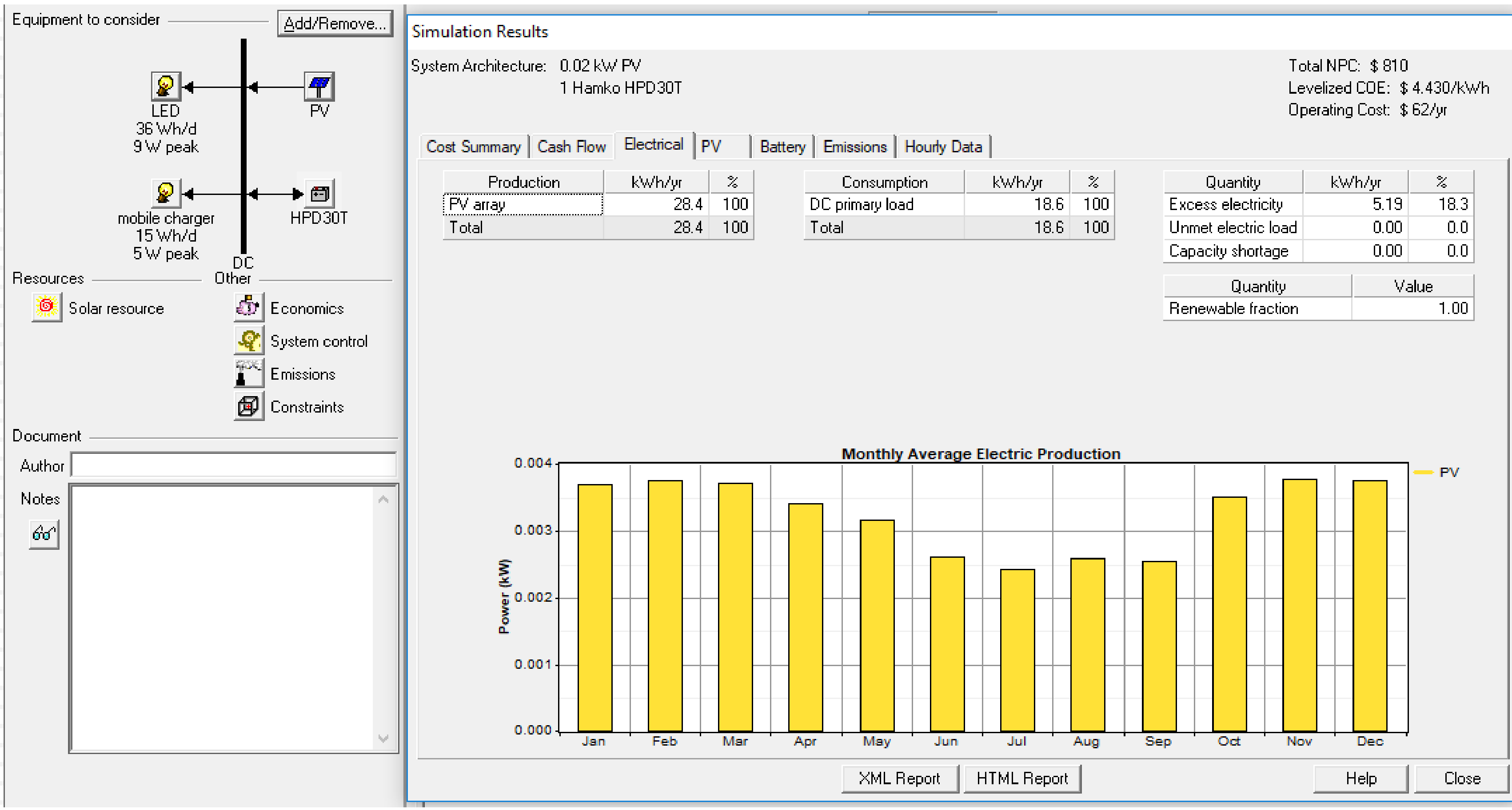
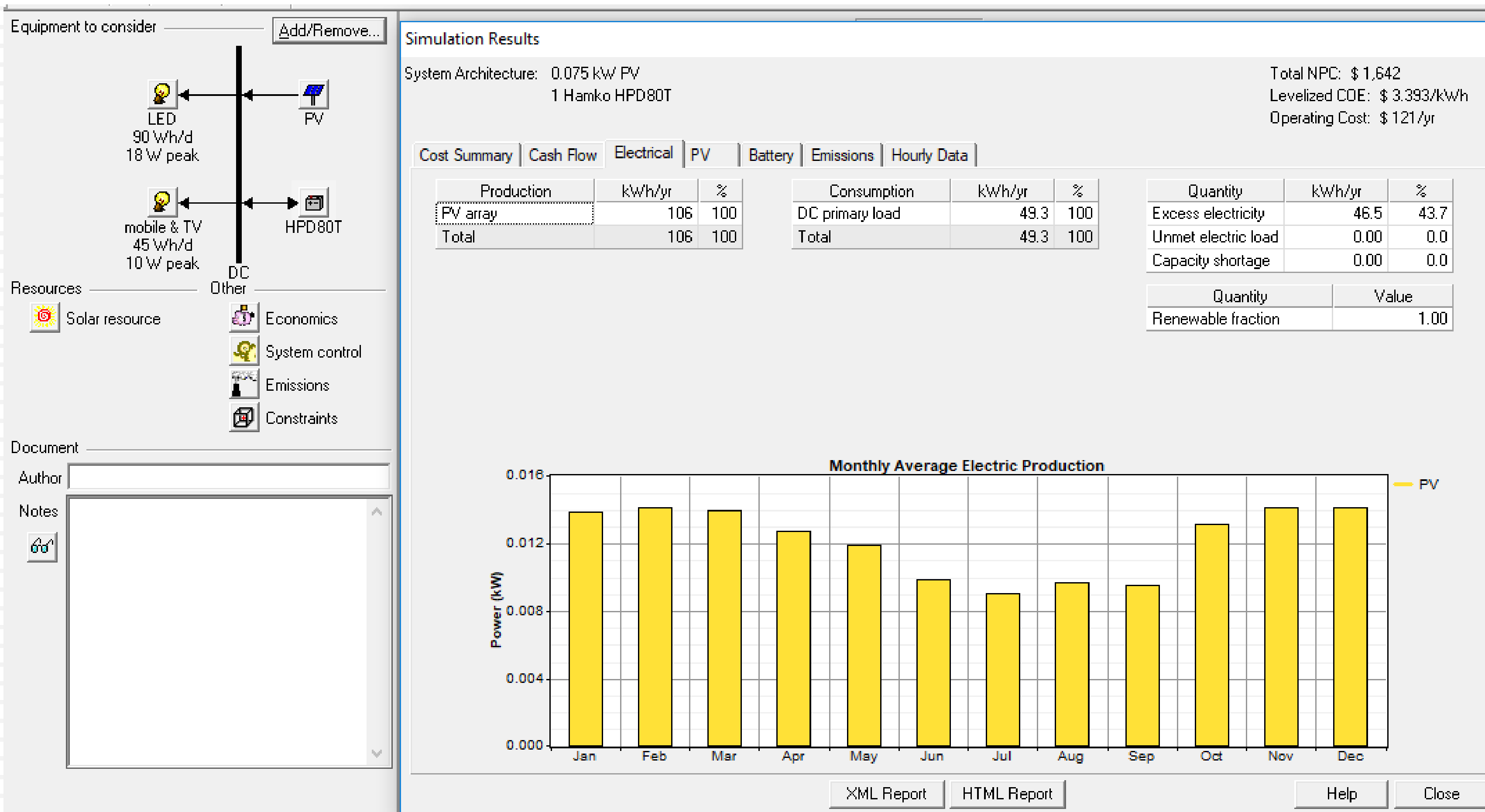


System Block Diagram

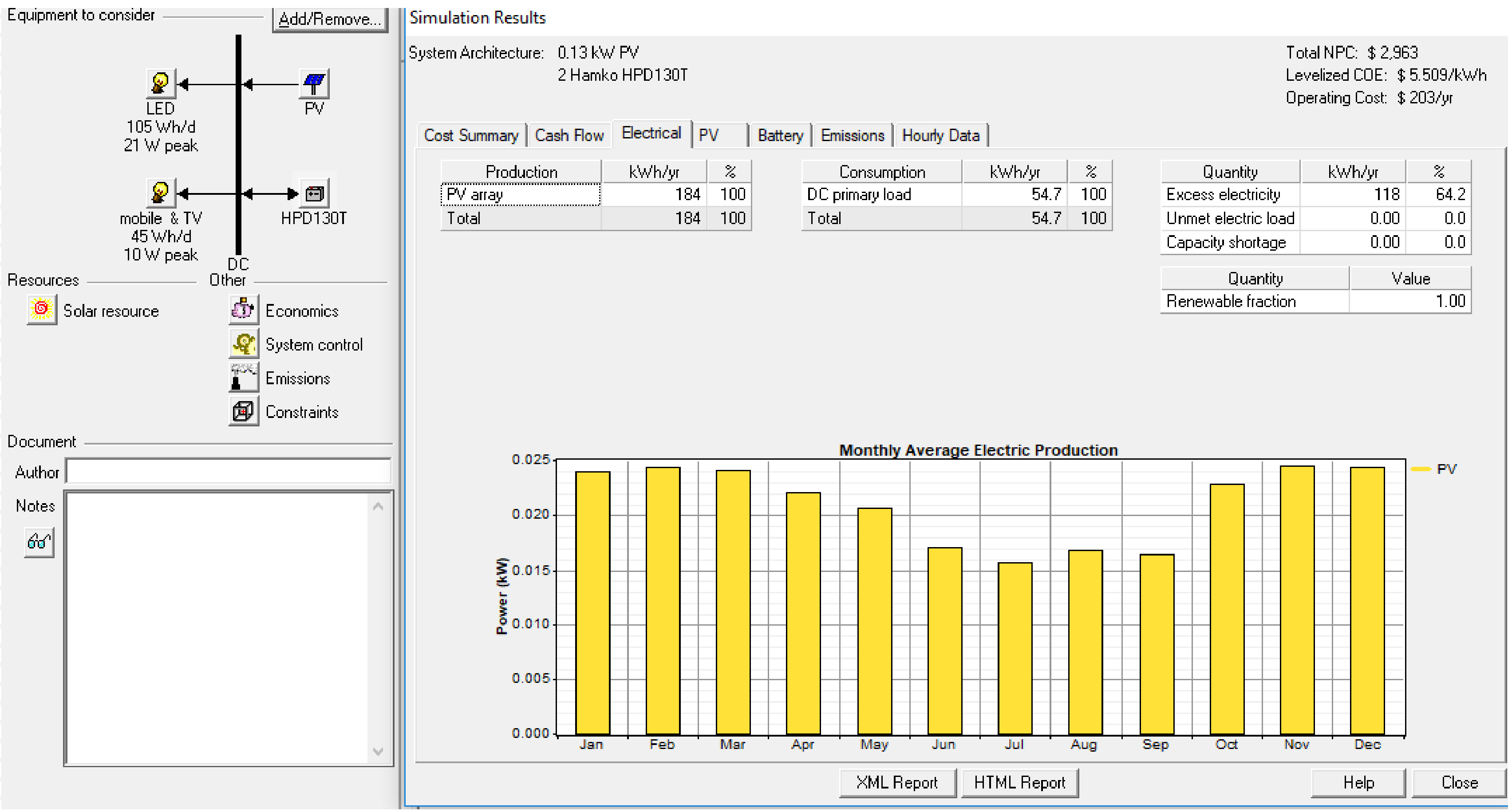
Homer Simulation and Optimization:



System Modeling of 20 Wp SHS in HOMER

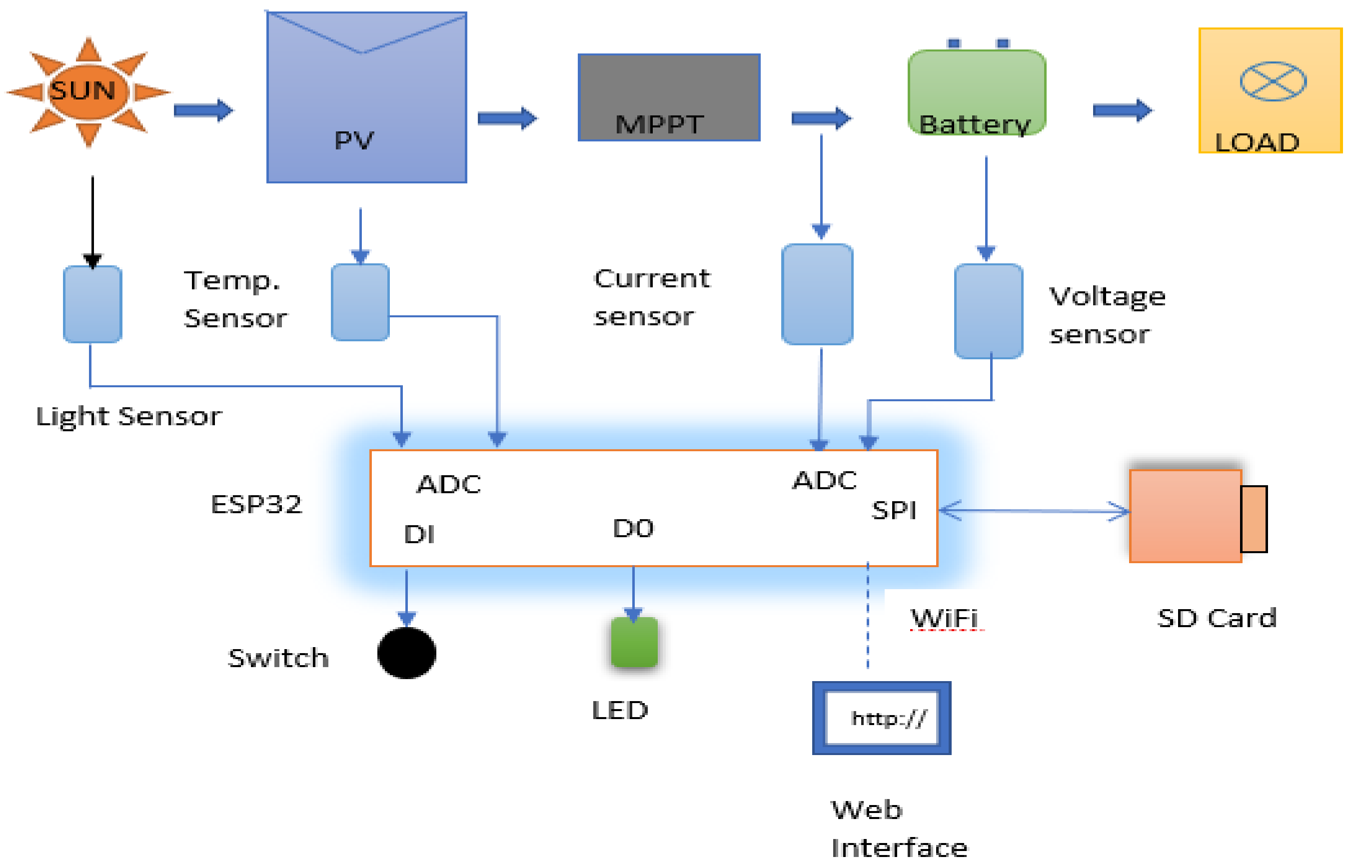


System Modeling of 75 Wp SHS in HOMER



System Modeling of 130 Wp SHS in HOMER

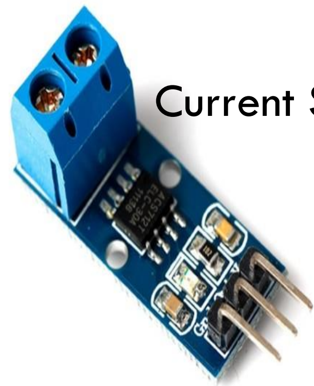
Data Logger Design:



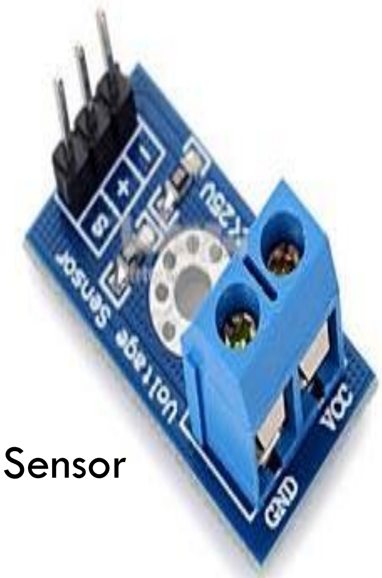
Block Diagram of Designed Data Logger

Micro-controller & Sensors:

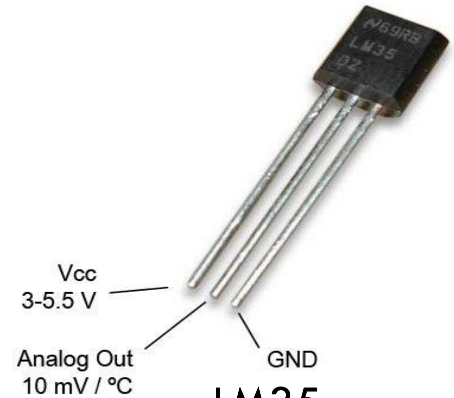
ESP 32



Current Sensor



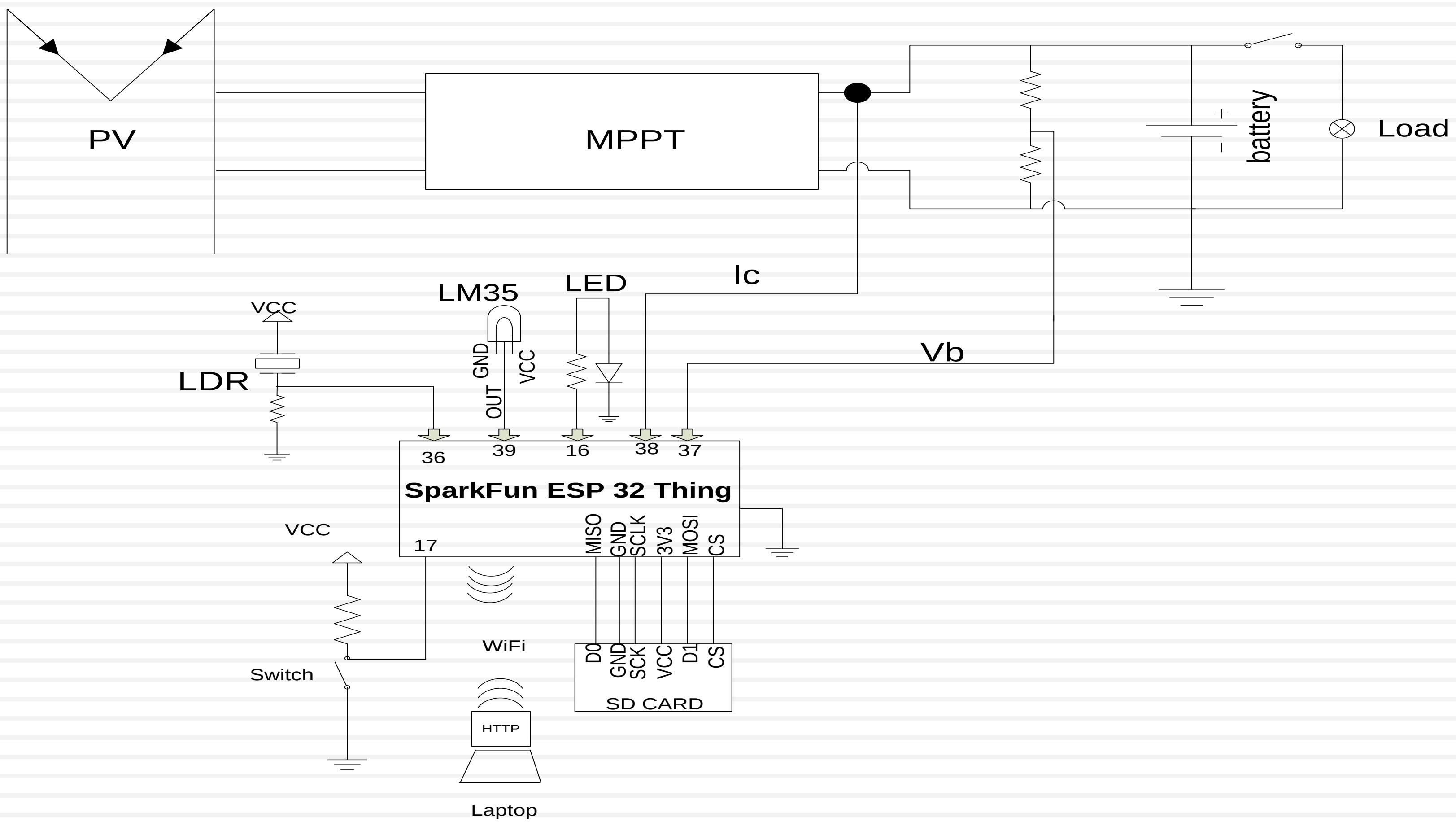
Voltage Sensor



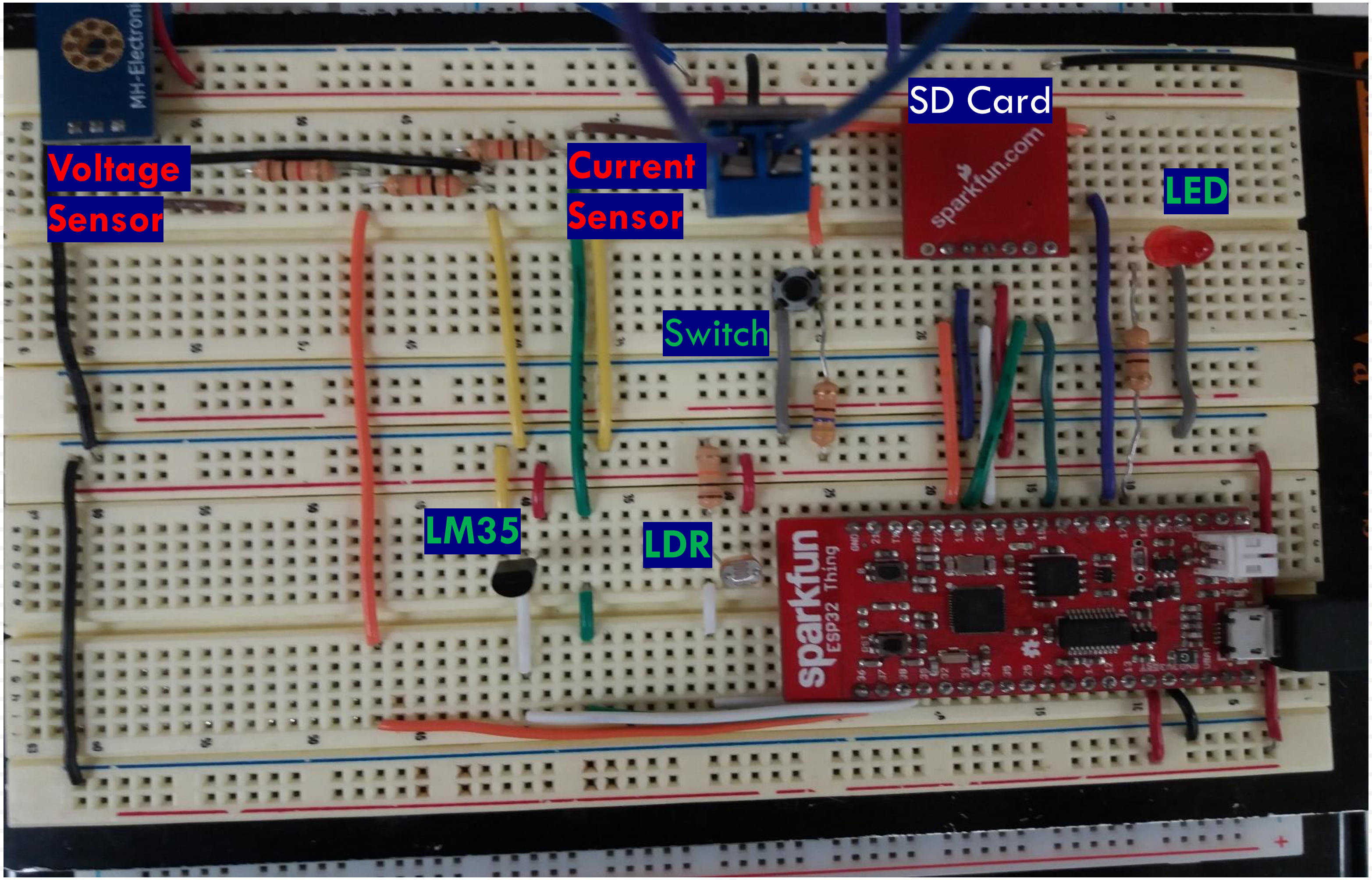
LM35

LDR

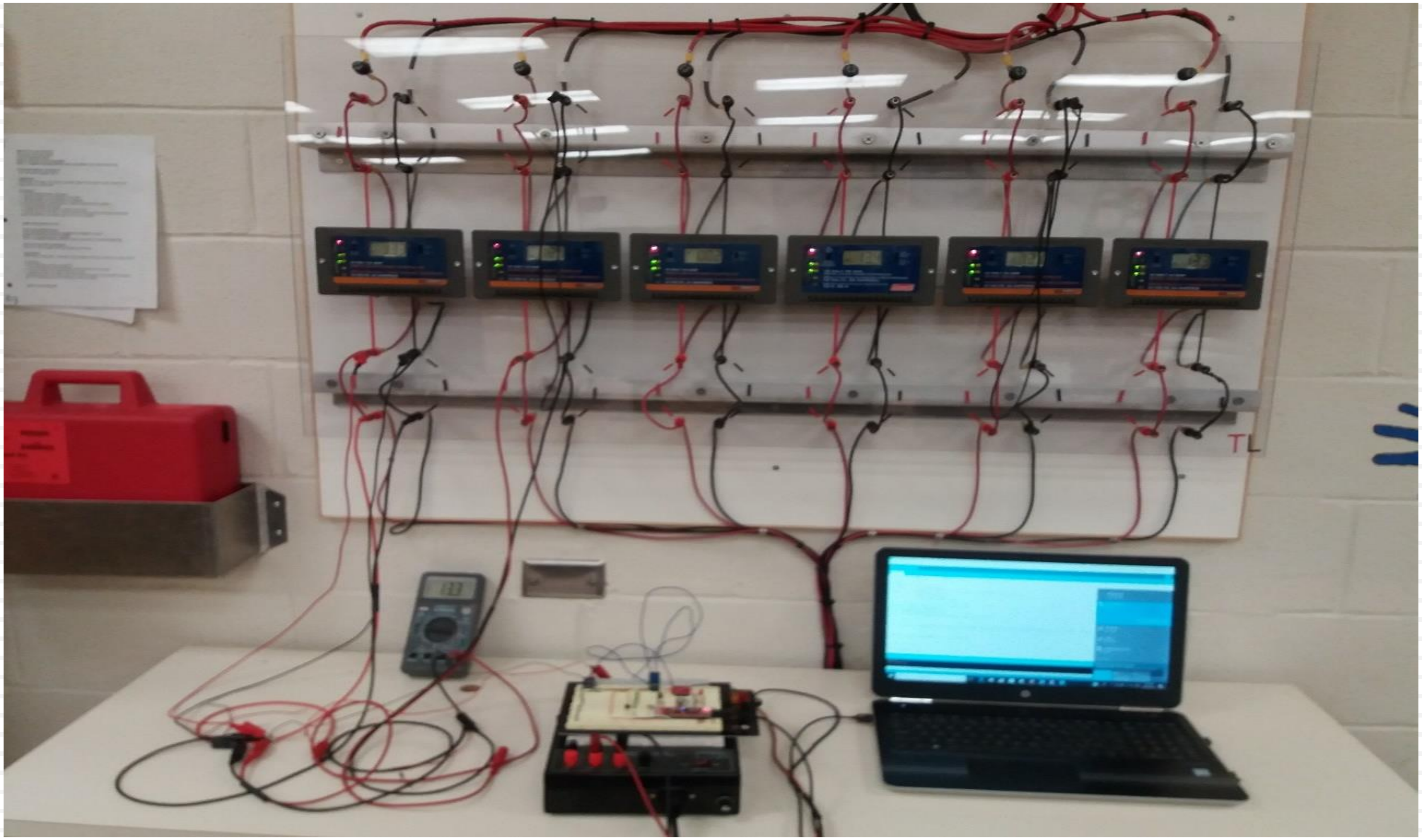
Schematic Diagram:



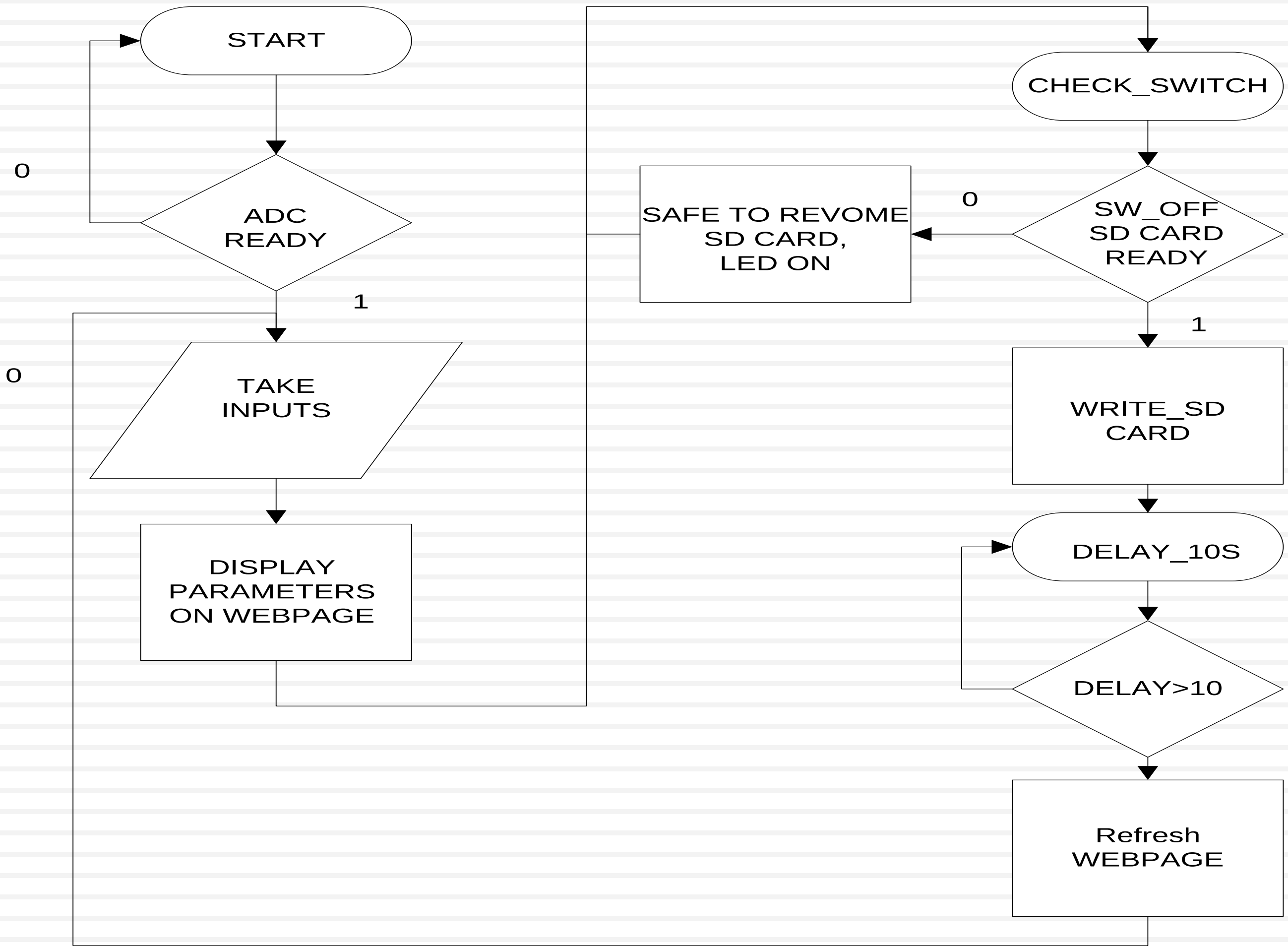
Hardware Prototype:



Experimental Setup:

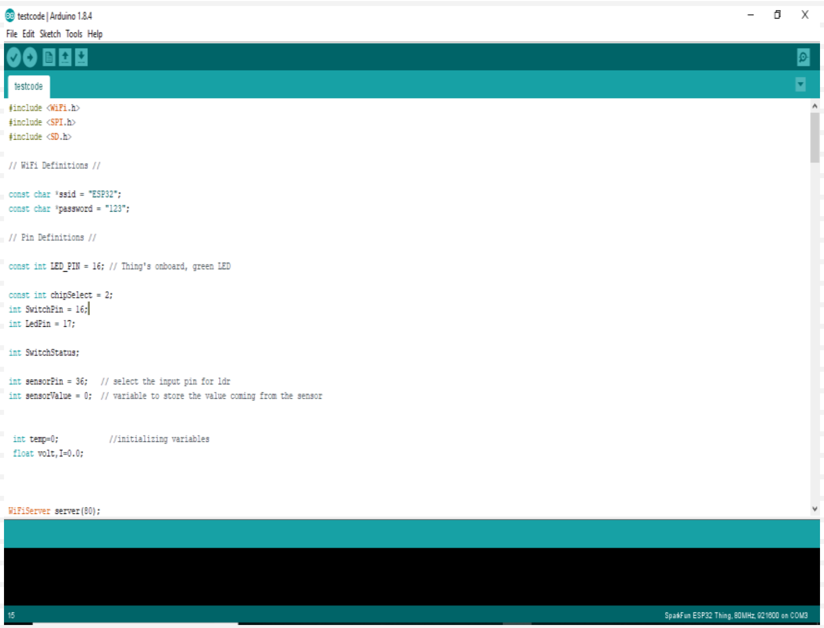


Data Logger Design Flowchart:

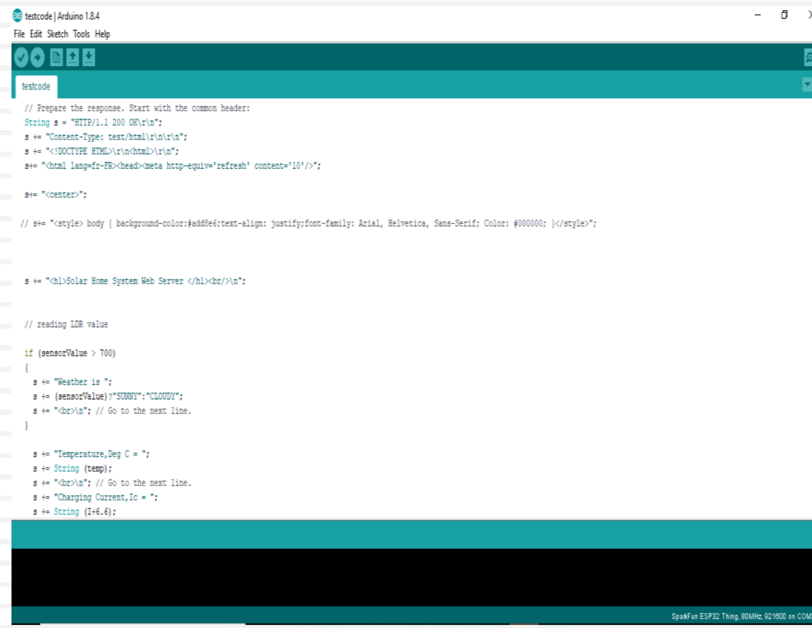


Coding:

Data logging

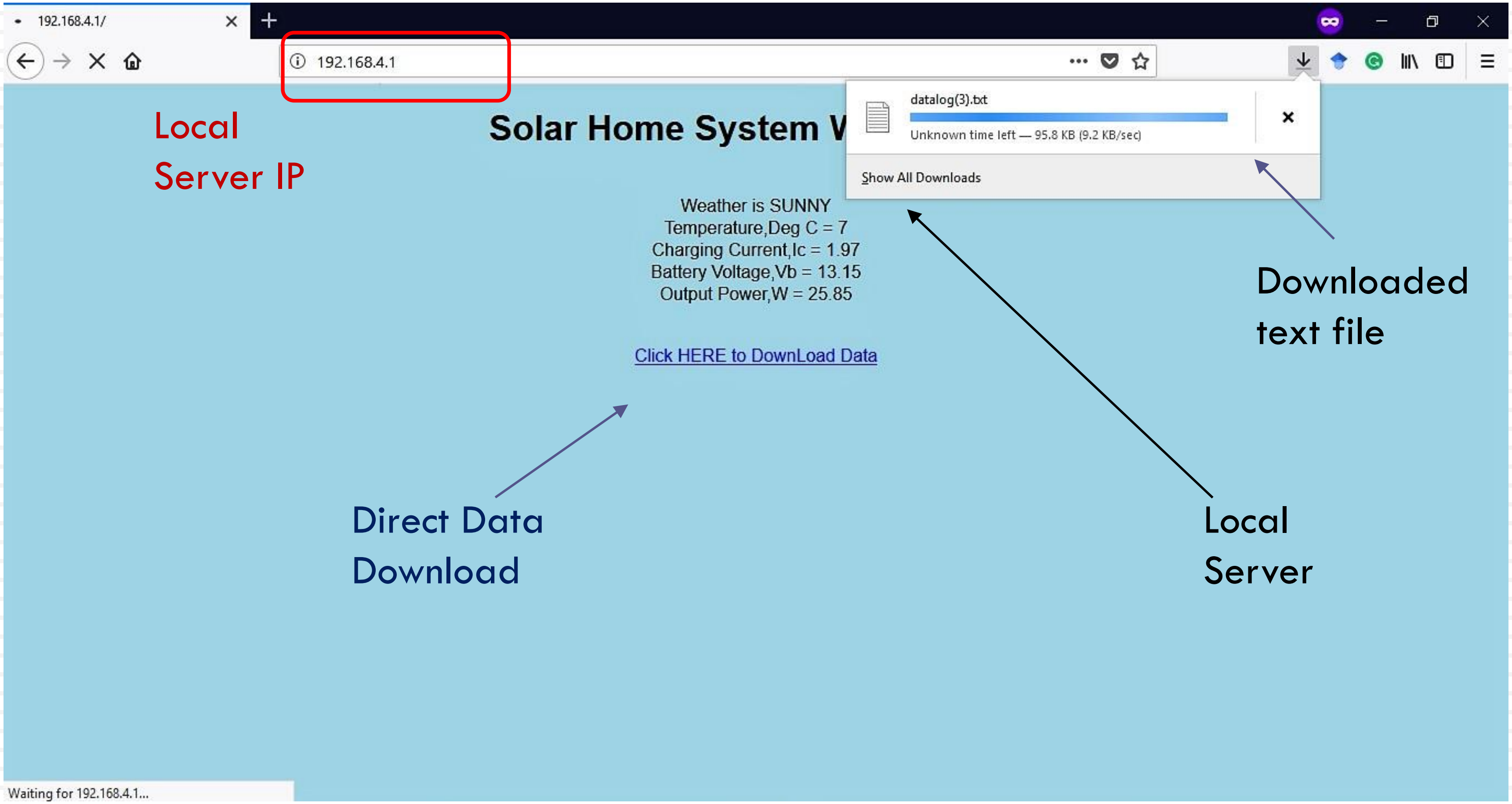


Web server

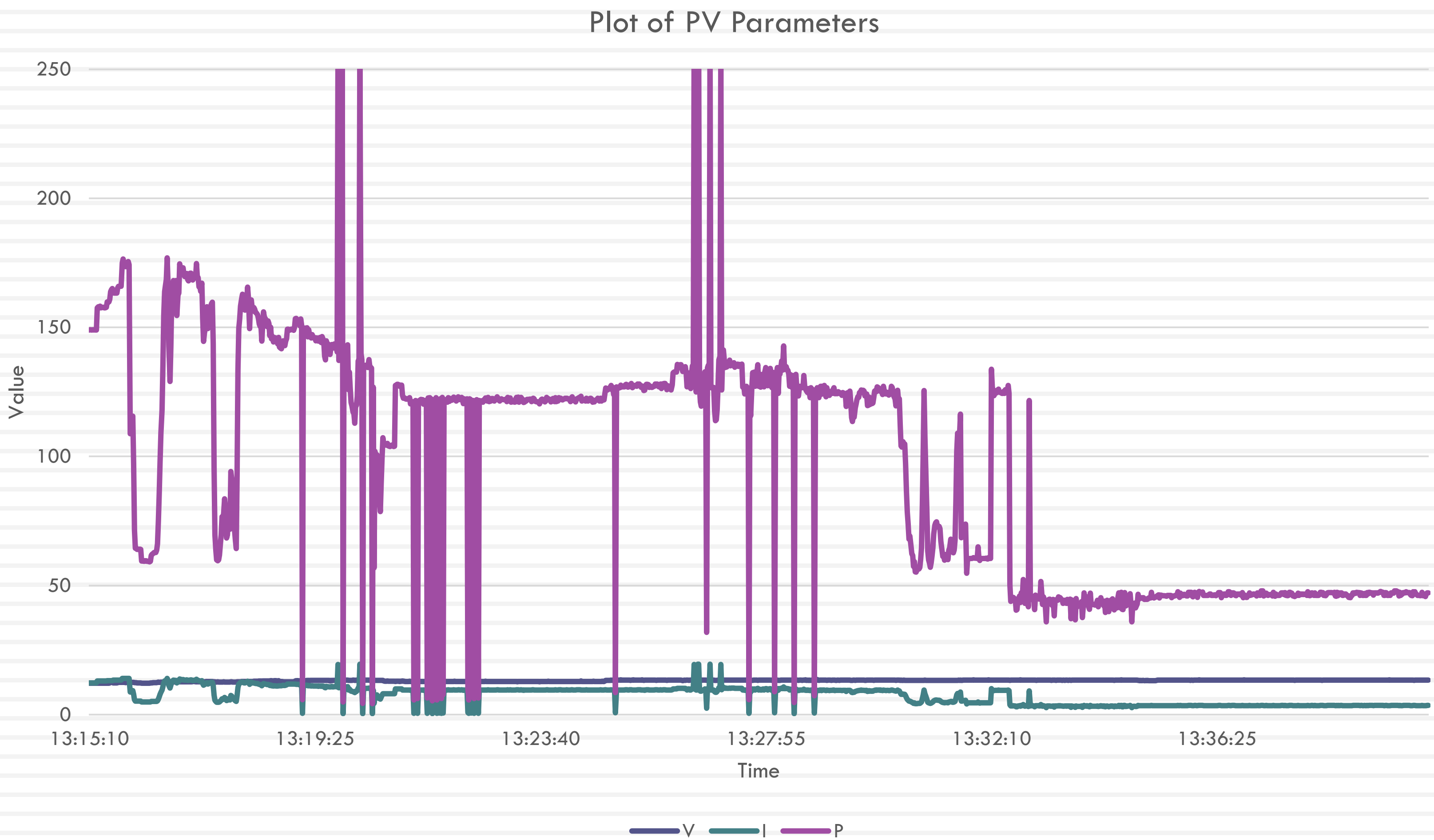


Arduino IDE

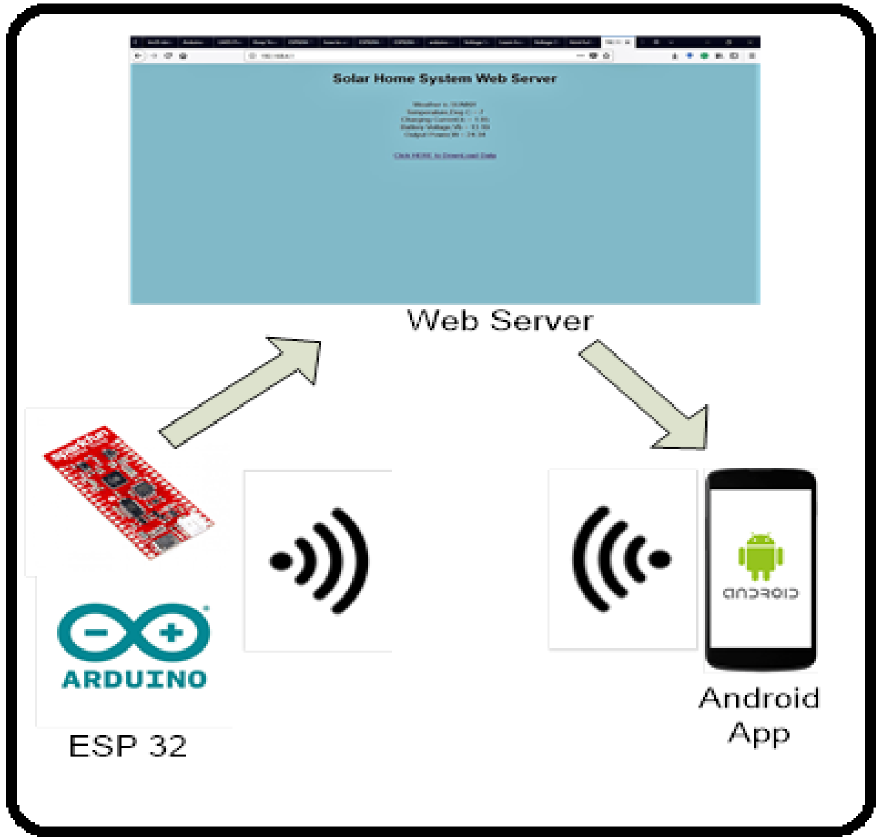
Web Server:


192.168.4.1/
192.168.4.1
Local
Server IP
Solar Home System V
datalog(3).txt
Unknown time left — 95.8 KB (9.2 KB/sec)
Show All Downloads
Weather is SUNNY
Temperature,Deg C = 7
Charging Current,Ic = 1.97
Battery Voltage,Vb = 13.15
Output Power,W = 25.85
Click HERE to DownLoad Data
Downloaded
text file
Direct Data
Download
Local
Server
Waiting for 192.168.4.1...

Plot on Excel:

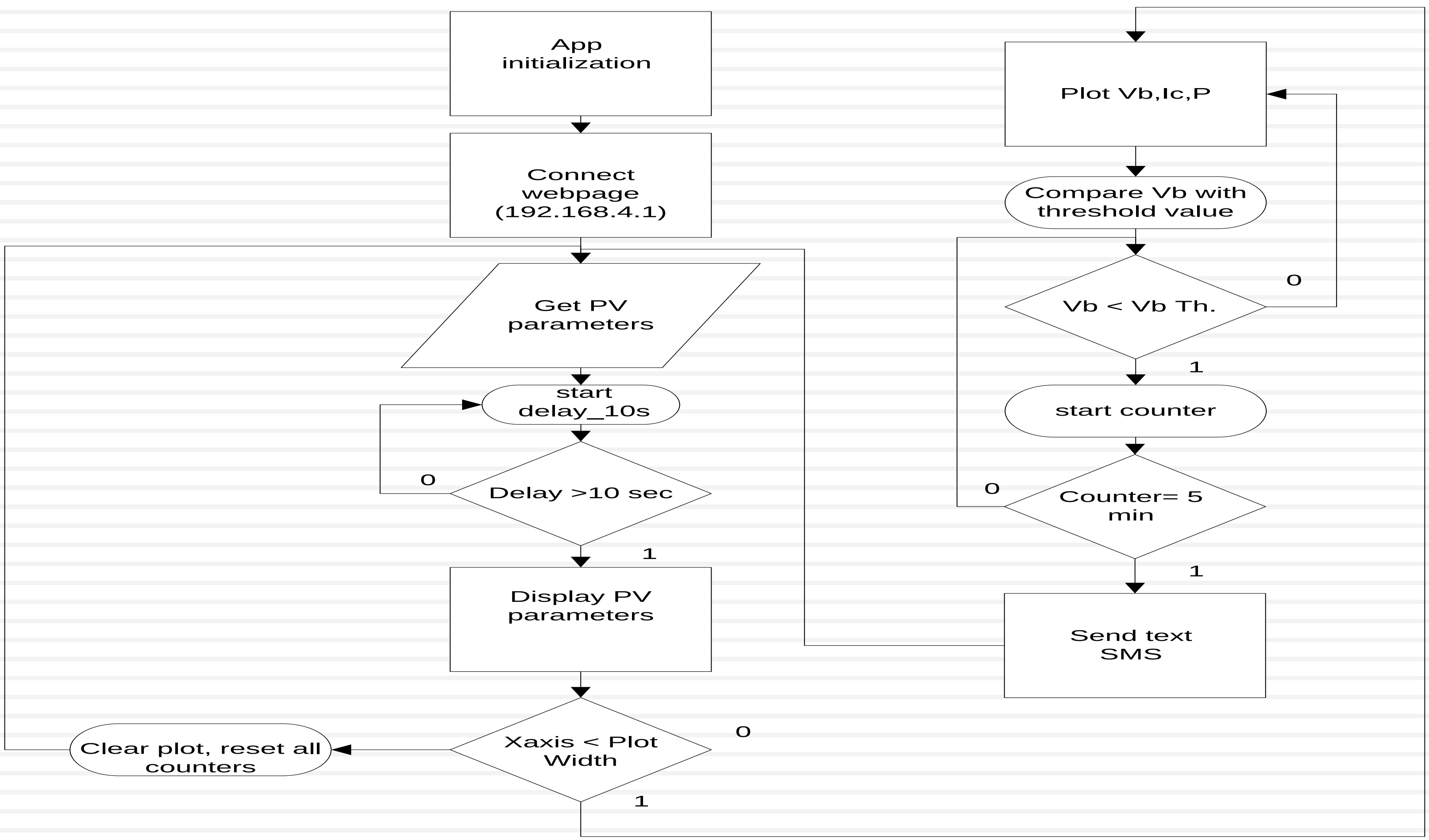


Android App Design:

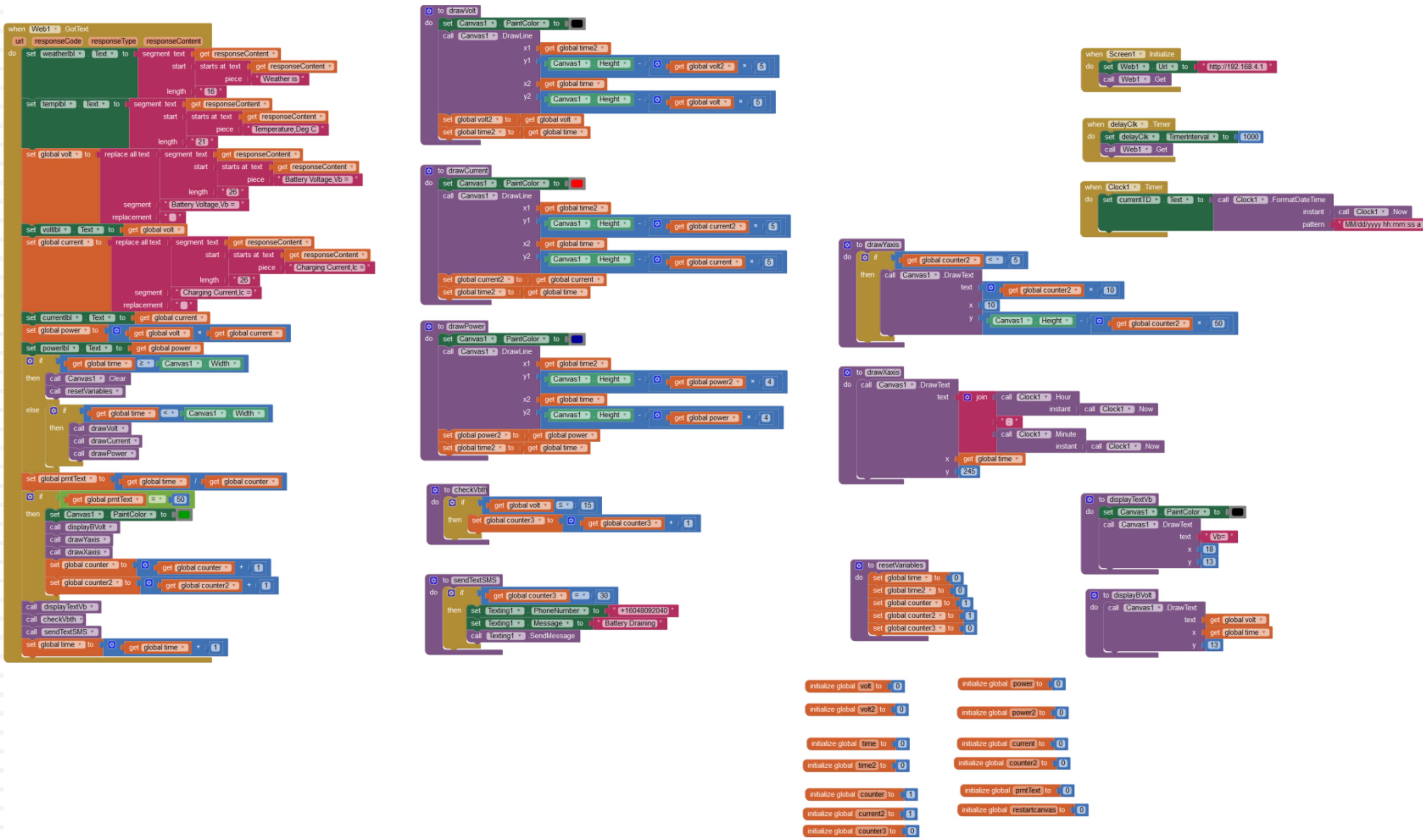


Android App Development Architecture

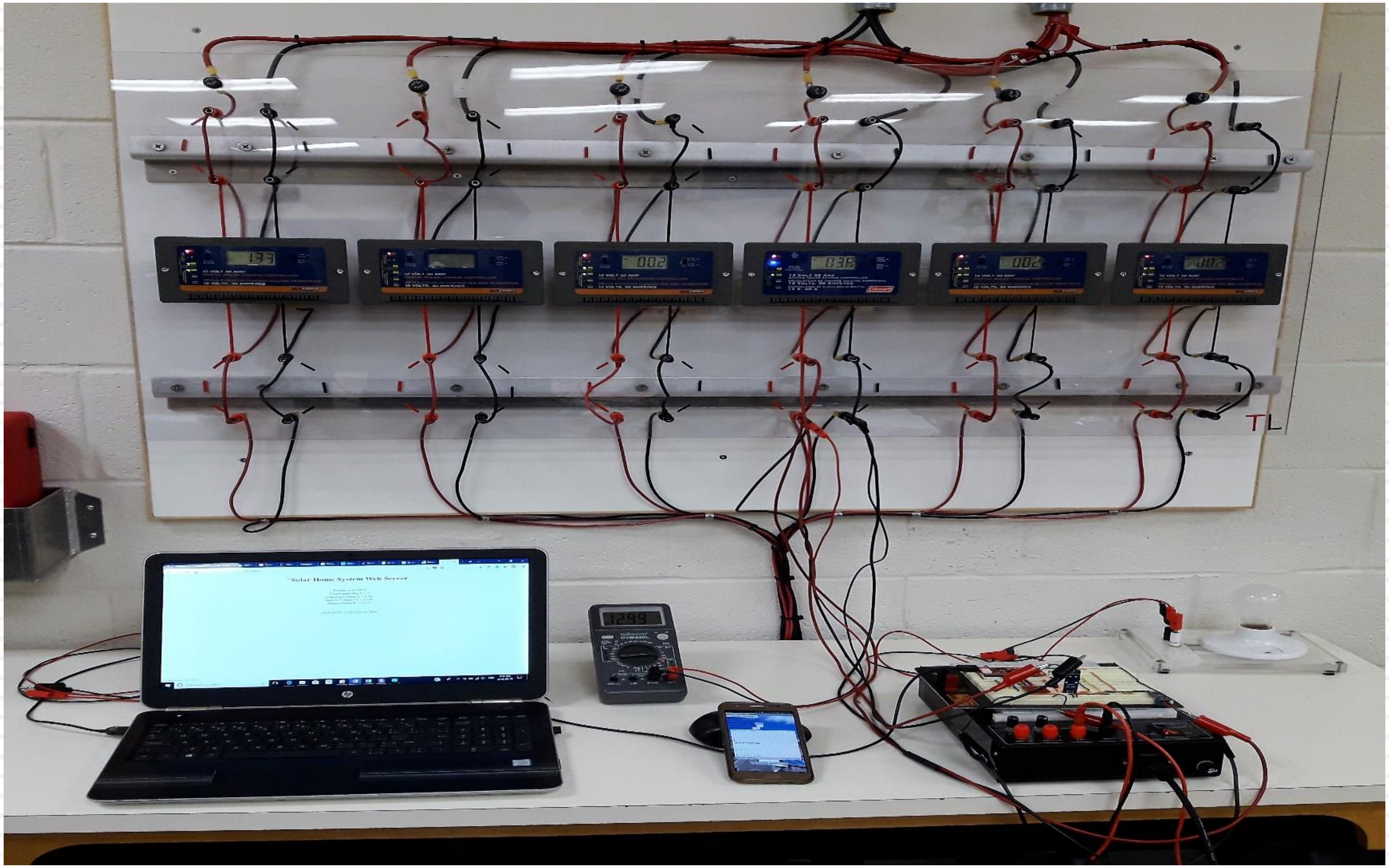
App Design Flowchart:



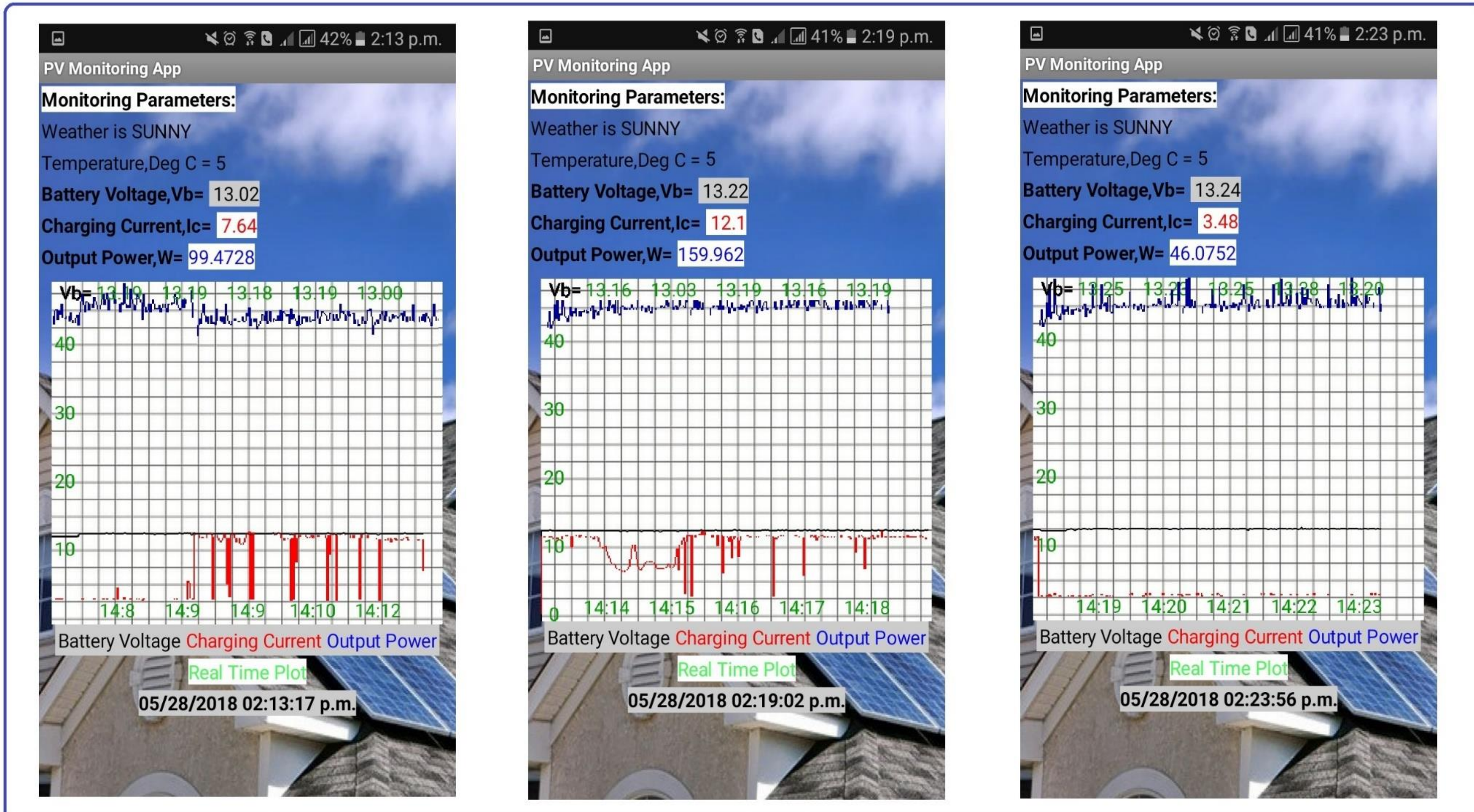
Scratch Code:



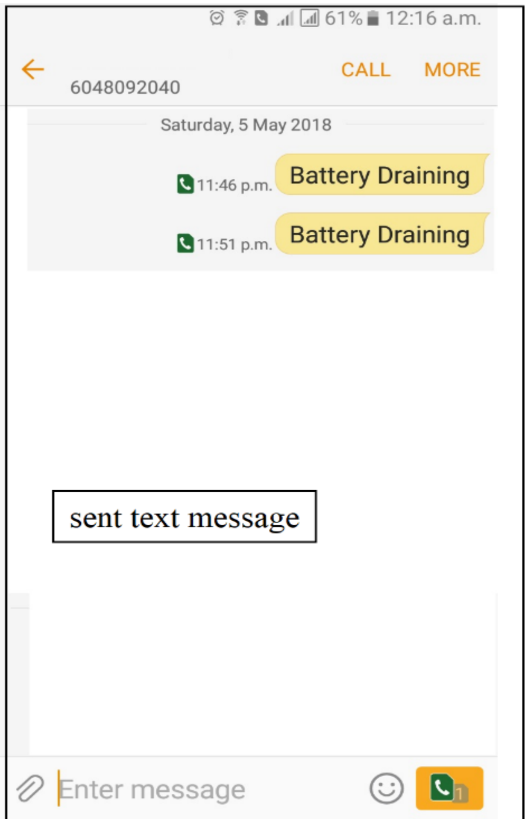
Hardware Setup:

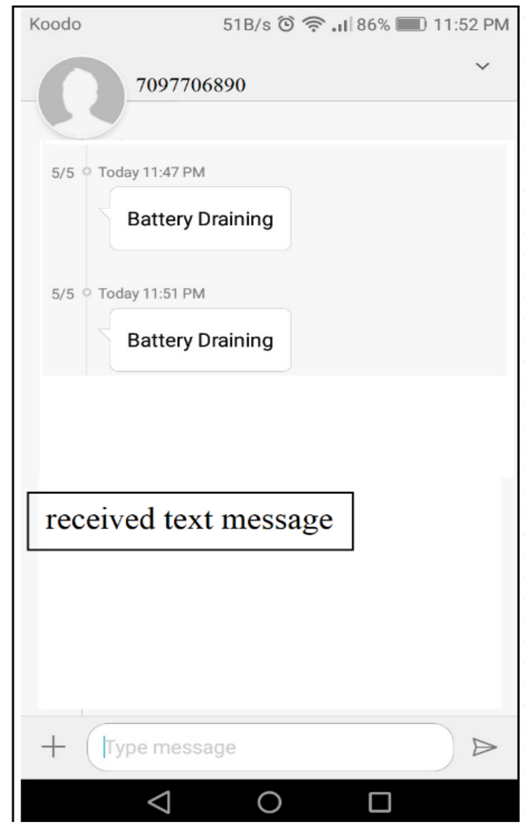


Plot on Cellphone App:



Text Message Alert Feature:





Cost Calculation:

NO	Item	Quantity	Price	Per Unit Price
1	Voltage Sensor	1	11.64	11.64
2	Current Sensor	1	2.76	2.76
3	Resistors	300	4.56	0.106
4	ESP32	1	19.95	19.95
5	Software Arduino IDE	---	Free	----
6	Software AI2 For Android App (IDE)	---	Free	----
7	LM35	1	0.9	
8	LDR	50	1.49	0.029
9	LED	500	4.68	0.009
10	Micro Switch	10	0.94	0.094
11	SD Card Socket	1	3.95	3.95
12	SD Card with Adapter (16GB)	1	9.98	9.98
13	Micro USB	1	1.93	1.93
	Total Cost C$		62.78 (Initial Cost)	50.45 (Per Unit Cost)

Power Consumption of Developed System

Overall System Cost Calculation

Power Consumption & % Error:

Device	Voltage Source	Current Drawn	Power
ESP32	3.3V	150mA	500 mW
Current Sensor	5V	12.5mA	62.5 mW
LM35	3.3	40mA	130.6
Voltage Sensor	5V	13mA	65 mW
SD-Card	3.3V	0.15mA	0.5 mW
Total Power Consumption			758.6 mW

Power Consumption of Developed System

Sample	Parameter Name	Measured Value	Actual Value	Error (%)
1.	Battery Voltage	13.22 V	13.06 V	+1.07%
2.	Charging Current	2.06 A	2.16 A	-4.6%

Error Calculation

Future Work:

- Larger PV and Community Based System
- Graphics on the Web Page
- File Removal Process for SD Card
- Database Option in the Monitoring App
- Customization for other Location

Publications:

- Abstract Accepted:

D. Gupta, Tariq Iqbal, “Pico-Solar Energy Systems for Lighting in Rural Areas of Bangladesh”, Costal Zone Canada Conference, July 2018.

- Journal Submission(Ongoing):

D. Gupta, Tariq Iqbal, “ Design of a Low cost Data-Logger and Android based Monitoring System for Pico Solar PV System ”, Hindawi, August 2018.

Reference: (partial)

- J. Conti, P. Holtberg, J. Diefenderfer, A. LaRose, J. Turnure and L. Westfall, “International Energy Outlook 2017 With Projections to 2040 (No. DOE/EIA- -0484 (2017))-*U.S. Energy Information Administration (EIA)*.[Online]. Available: https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf. [Accessed: 09-Dec-2017].
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- H. Gad and H. E. Gad, “Development of a new temperature data acquisition system for solar energy applications,” *Renewable Energy*, vol. 74, pp. 337–343, 2015.

- J. Conti, P. Holtberg, J. Diefenderfer, A. LaRose, J. Turnure and L. Westfall, “International Energy Outlook 2017 With Projections to 2040 (No. DOE/EIA- -0484 (2017))-*U.S. Energy Information Administration (EIA)*.[Online]. Available: https://www.eia.gov/outlooks/aeo/pdf/0383(2017).pdf. [Accessed: 09-Dec-2017].
- International Energy Outlook 2017, Energy Information Administration (EIA), available: https://www.eia.gov/outlooks/ieo/pdf/0484(2017).pdf
- "Electrification: So how many people are we actually talking about?" Energy Access - Africa. July 19, 2017. Accessed November 25, 2017. https://energyaccess-africa.com/2016/07/05/so-how-many-people-are-we-actually-talking-about/.

Thank You

The future is green energy,sustainability,renewable energy.
-Arnold Schwarznegger