# MINI PROJECT

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## 1. Components that required for off-grid PV systems

- Solar panel
- Solar Charge Controller
- Battery bank
- Inverter
- Wiring & Frame
- Load (Home Appliances)
- Monitoring Device

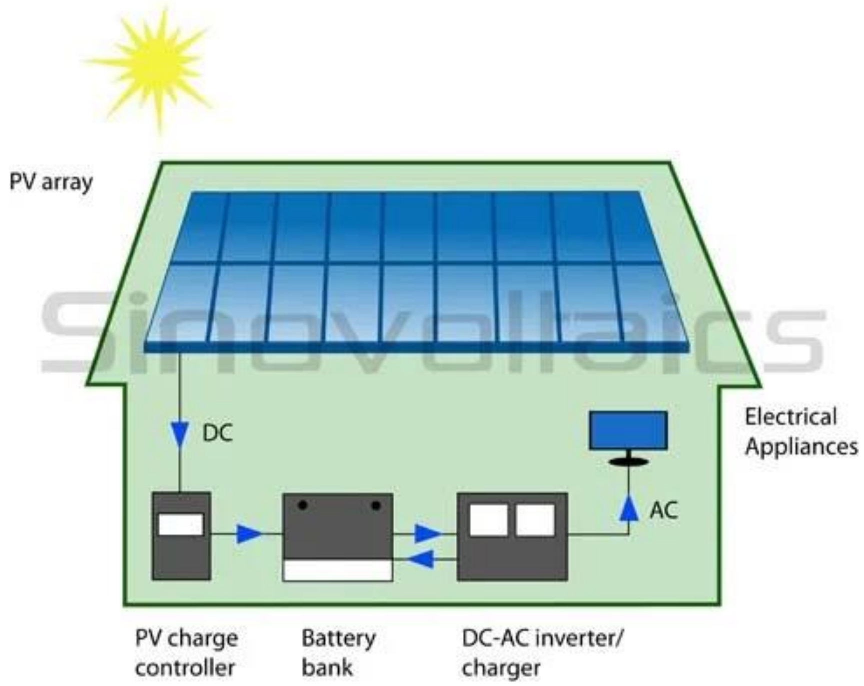


Figure 01: Off-Grid Solar PV System

2. **Average Power Consumption per day in the house**

Number of units used = 192 kWh
Number of days: = 31 Days (From 22/11/03 to 22/11/02)
Per day consumption = 192/31 = 6.2 kWh/day

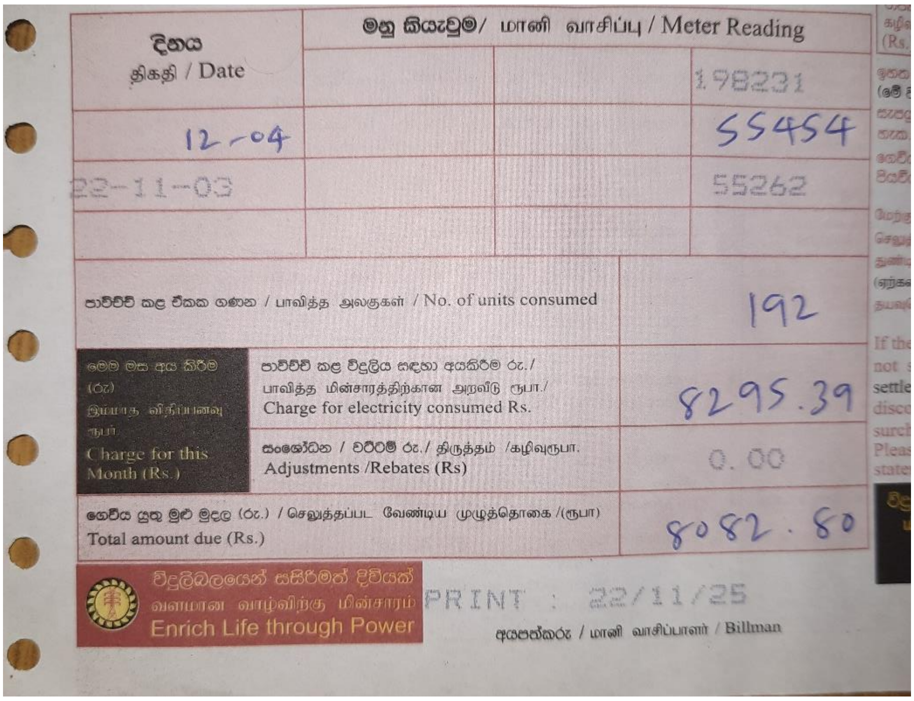


Figure 02: Electricity Bill of Last Month

3. **Required Parameters of the components**

<u>PV Array Sizing</u>

Solar Panels can operate in maximum capacity when solar intensity is at or above 1000W per a square meter. The number of hours with high solar intensity is assumed as 5 hours.

$PV\ power = Daily\ consumption/\ (sun\ peak\ hours \times \text{Efficiency of the system})$
$= 6.2\ \text{kWh}/\ 5h \times\ 0.8$
$= 1.55\ k\text{Wh}$

As shown in Figure 03 the according to the PV specifications,[1]

Type-MONOCRYSTALLINE module

$No.\ of\ PV\ panels = PV\ power/\ Rated\ power\ of\ a\ panel$
$= 1550W\ /\ 350\ \text{W}$
$\approx 5$


Figure 03: Solar PV Specifications

Battery Sizing

Battery type: Lithium Iron Phospate

Batter bank voltage: 24VDC

Battery configuration: 12VDC two batteries in series

Calculation for battery bank capacity,

Total energy per day = 6.2 kWh (based on electricity bill)

Total energy per day (inverter input, due to inverter loss) $= \frac{6200}{0.9} \approx 6.9\ kWh$

Depth of Discharge = 0.8

Battery capacity per day $= \frac{Total\ energy}{Battery\ bank\ voltage} = \frac{6900}{24} = 287.5\ Ah$

Total battery capacity per day $= \frac{\text{Battery capacity}}{\text{Depth of discharge}} = \frac{287.5}{0.8} = 359.4\ Ah$

Days of storage: 1 Day

Battery capacity requirement = 359.4 Ah

Selected battery capacity, due to the market availability, **400Ah 12VDC**

Figure 04: Lithium Iron Phosphate Batteries 400Ah 12V 95%* Efficiency

Inverter Sizing

The total peak demand of our house is around 3.5kW

Efficiency: 90%

Output voltage: 230VAC

Frequency: 50Hz

Battery input: 24V

Integrated 80A MPPT charge controller

Inverter Rating: **4kW**


Figure 05: Solar Inverter 4kW

Solar Charge Controller (SCC) Sizing

$V\text{max}\ of\ SCC = Voc\ of\ PV\ panel \times no.\ panels\ in\ string$

$= 46.9\ V \times 5$

$= 234.5\ V$

$\text{M}ax.\ charging\ current\ (ICC) of\ SCC = Isc\ of\ PV\ panel \times no.\ of\ strings \times 1.25$

$= 9.68\ A \times 1 \times 1.25$

= 12.1 A

Figure 06: Solar Charge Controller

Nominal power & peak efficiency-220 W, 98% Efficiency

Rated charge current- 15A

Breaker Selection

DC breaker near PV panels $DC\ rating = Isc \times no.\ panel\ strings \times 1.25$

$= 9.68\ A \times 1 \times 1.25$

$= 12.1\ A$

DC breaker at output of SCC $DC\ rating = Icc = 12.1\ A$

DC breaker before inverter $DC\ rating = P_{rated}\ inverter/\ battery\ system\ voltage$

$= 4000W\ /24V$

$= 166.67A$

AC breaker after inverter $AC\ rating = P_{rated}\ inverter/\ Utility\ voltage$

$$= 4000W/\ 230V = 17.4A$$

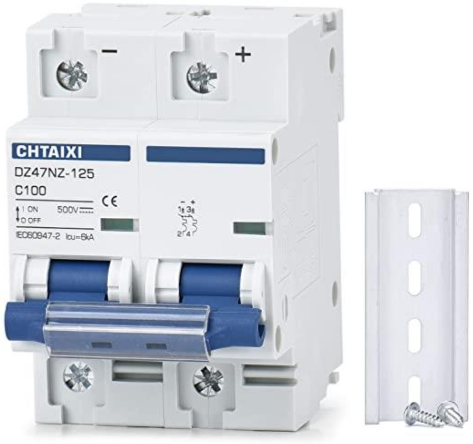


Figure 07: Circuit Breaker

4. **Identifying the control elements**

 - MPPT Charger Controller

Modern non-battery-based inverters include Maximum Power Point Tracking (MPPT). MPPT automatically adjusts system voltage such that the PV array operates at its maximum power point. For battery-based systems, this feature has recently been incorporated into better charge controllers.

MPPT algorithms are typically used in the controller designs for PV systems. The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times[2].

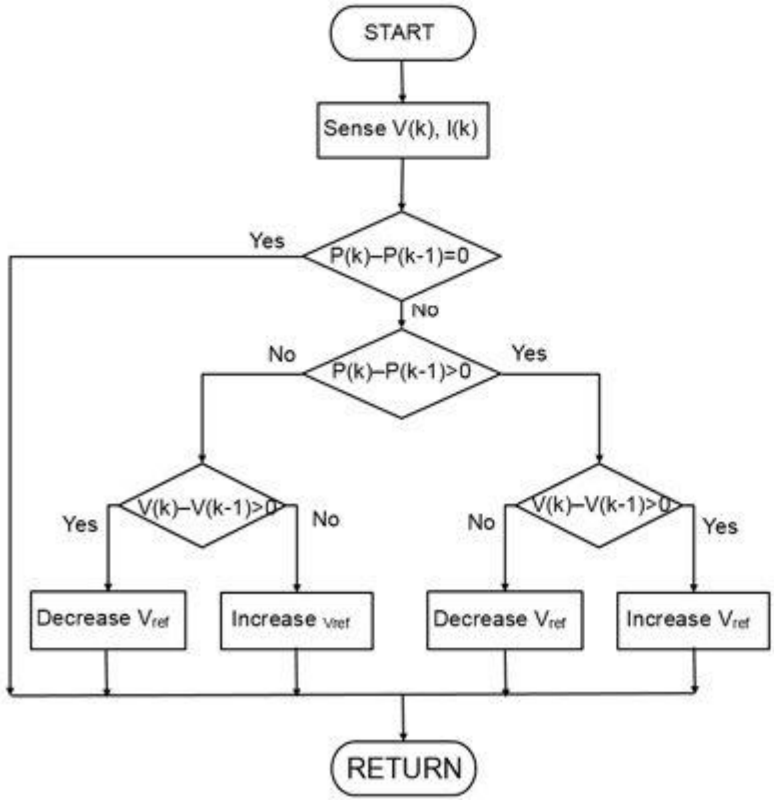


Figure 08: MPPT algorithm

- <u>Inverter</u>

Inverter converts DC (Direct Current) to AC (Alternating Current). For the off grid solar PV connections Stand-alone Inverter is used  in isolated system and not connected to the utility grid and simplest of all kinds. Other tasks of Inverter are Ensuring that the cycle of alternating current cycles is 60 cycles, Reducing voltage variations, Ensuring that the condition of the AC waveform is suitable for the application. Unipolar PWM algorithm is used in combination with the feedback controlling algorithm in the Inverter.

**MATLAB Simulation**

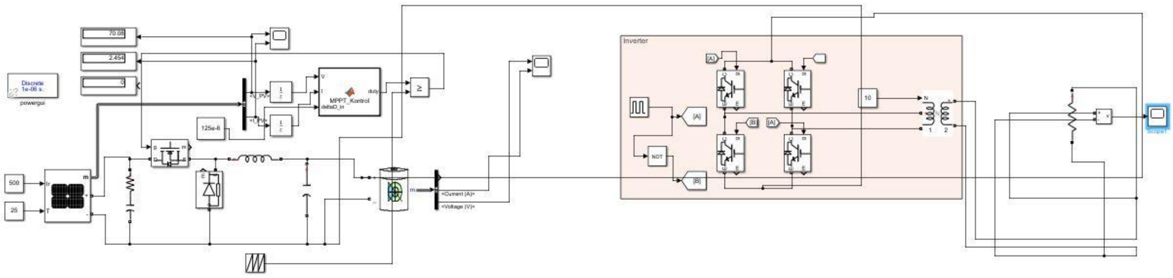

Figure 09: Simulation circuit of the off grid solar power system

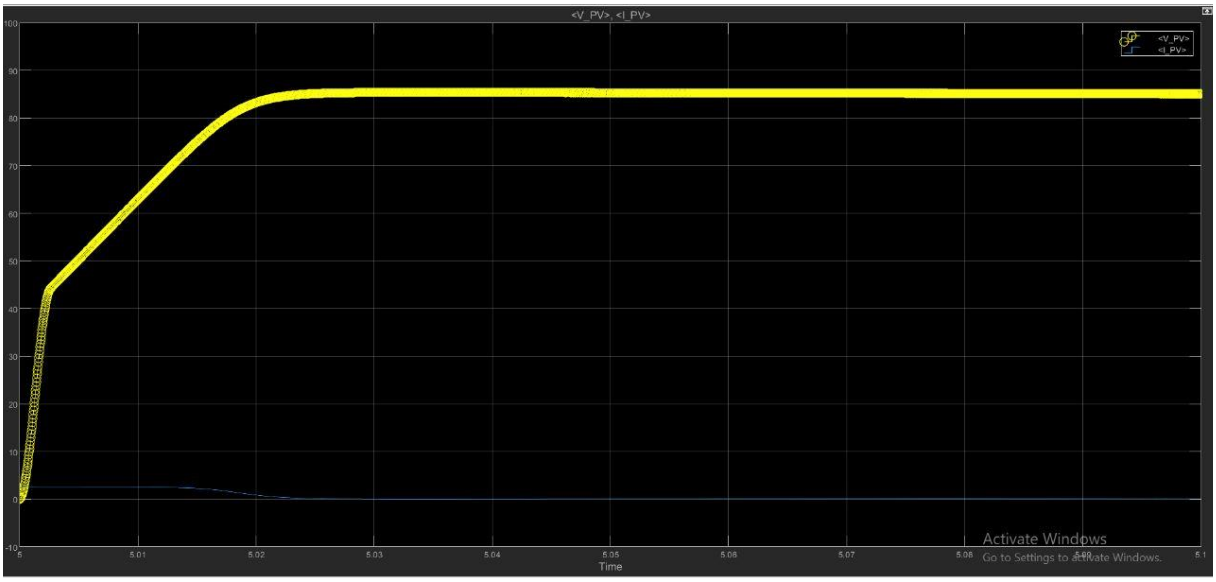


Figure 10: Solar Array Output

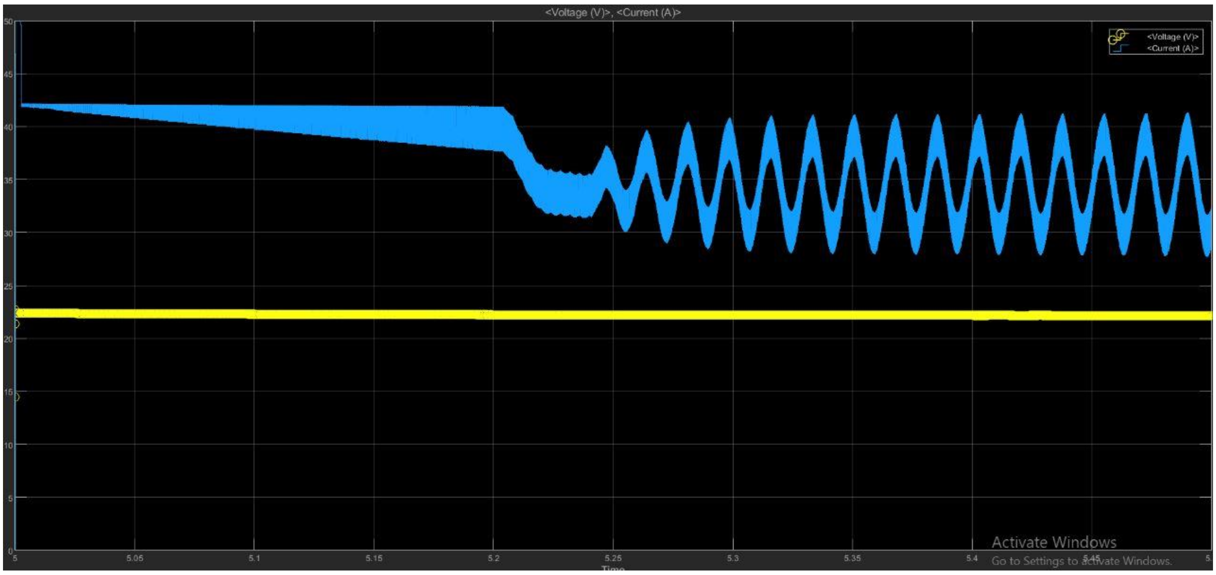


Figure 11: DC Battery Output

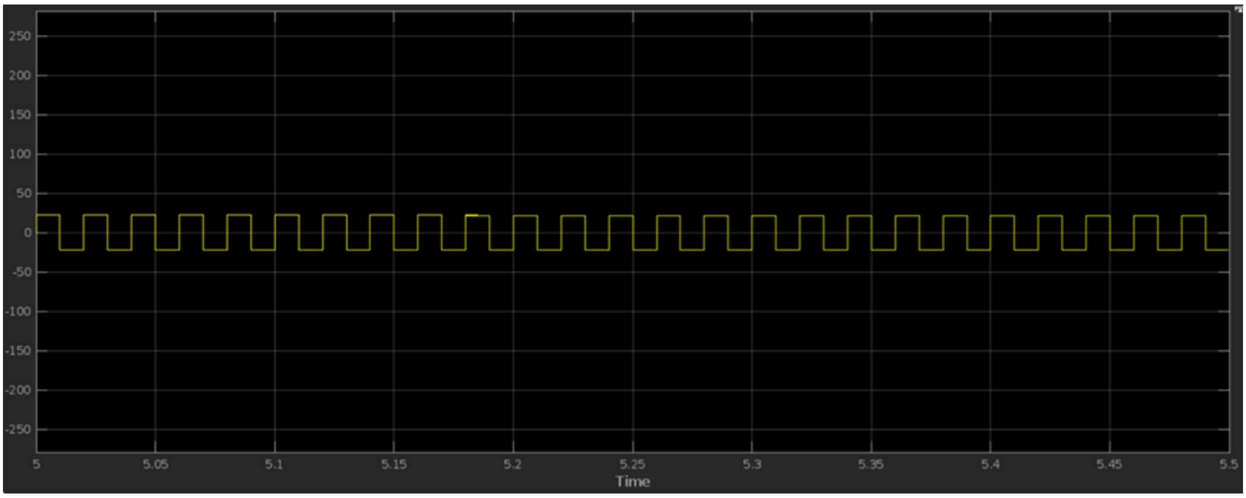


Figure 12: Inverter Output

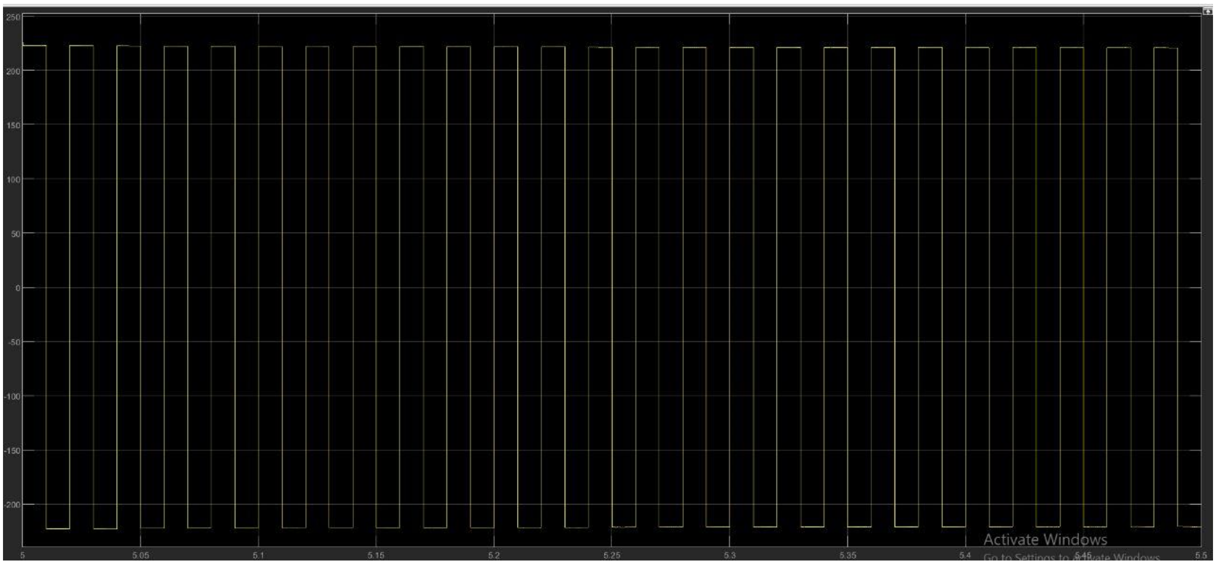


Figure 13: Output of the solar system

## References

[1] "Solar Panels | Solar Energy Solutions in Sri Lanka." https://www.ute.lk/energy/solar-power/ (accessed Dec. 04, 2022).

[2] "MPPT Algorithm - MATLAB & Simulink." https://www.mathworks.com/solutions/power-electronics-control/mppt-algorithm.html (accessed Dec. 04, 2022).