MINI PROJECT
OFF-GRID SOLAR PV SYSTEM

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01. Components of an off grid solar PV

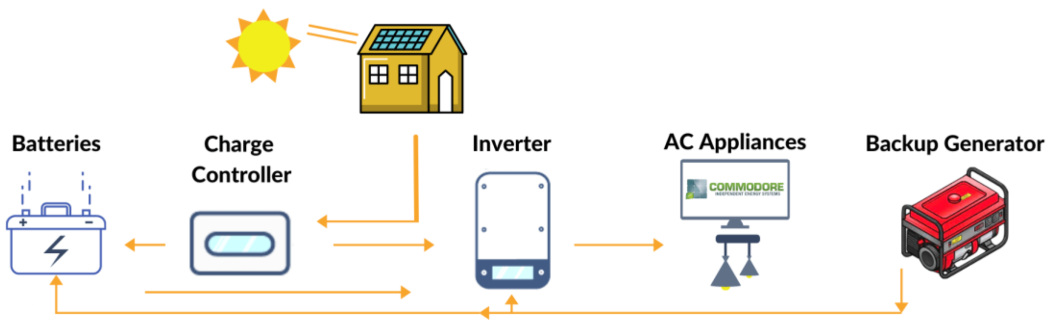

Figure 01: Components of an off grid solar pv system

PV Modules
Modern PV modules , also known as solar panels, are constructed from many silicon-based photovoltaic cells also known as PV cells. PV Modules are the source of power in a photovoltaic system. Simply put these modules produce DC electricity, which gets stored in battery banks, but needs to become AC power via an inverter for it to be used in homes. Have the ability of choosing between monocrystalline, polycrystalline, and black PV modules, with an output of 275 to 370Wp.

Controller
The controller delivers power from the PV to the battery bank. When the battery bank is almost full, the controller will taper off the charging current to maintain the required voltage needed to fully charge the battery and always keep it topped off. Top-of-the-line controllers use MPPT technology to maximize the utilization of solar panels, these are made with advanced circuit design and deliver ultra-high power conversion efficiency.

Off-grid Inverter
The off-grid inverter is specifically designed for high-efficiency off-grid power systems. It draws power from the battery, so it can convert it from DC to AC.

Solar Controller and Inverter
Solar panels generate DC electricity which must then be converted to alternating current (AC) for use in our homes and businesses. This is the primary role of a solar inverter.

Batteries
Off-grid solar systems need specialized off-grid inverters and battery systems that are large to store enough energy for 2 or more days. Hybrid grid-connected systems use lower-cost hybrid batteries, and only require a battery that is large enough to supply energy for 5 to 10 hours depending on the use.

Backup Generator
To maintain power during an outage, you'll need to install solar battery storage or a backup generator with your solar system.

02. <u>Average power consunption per day</u>

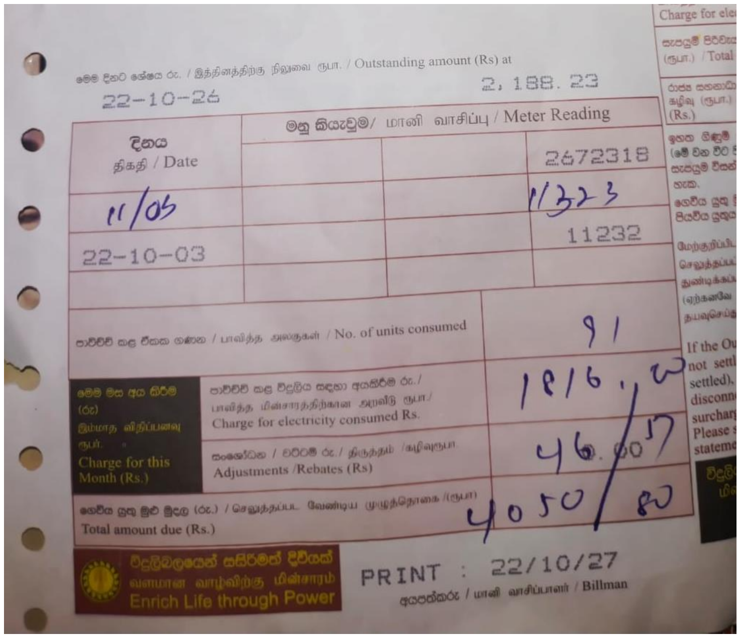
Outstanding amount (Rs) at
22-10-26
2,188.23
Meter Reading
Date
2672318
11/05
11323
22-10-03
11232
No. of units consumed
91
Charge for electricity consumed Rs.
1816,00
Charge for this Month (Rs.)
Adjustments /Rebates (Rs)
46.057
Total amount due (Rs.)
4050/80
Enrich Life through Power
PRINT : 22/10/27
Billman

Figure 02: Electricity usage for month of October

Number of units used	=	91 kWh
Number of days:	=	33 Days (From 03/10/22 to 05/11/22)
Per day consumption	=	91/31 = 2.94 kWh/day

03. <u>Required parameters of the components</u>

Solar Panel Sizing

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 (Gampaha).

Consider the **peak sun hours per day as 5 hours** and the **Efficiency of the system as 80%**;

$$\text{Requiered Solar Panel Power} = \frac{\text{Requierd Power}}{\text{No.of Sun Hours per day} \times \text{Efficiency of the system}}$$

$$\text{Requiered Solar Panel Power} = \frac{2940 \text{ Wh/day}}{5 \text{ h/day} \times 0.8} = 735\ W$$

INE300M polycrystalline Solar PV is selected which is commercially available in Sri Lanka.

Figure 03: INE300M polycrystalline Solar PV

INE Poly 60 Cell Series

*Dimension: 1640*992*35MM*

INE300M, peak power 300 W

INE 60 Cell poly high efficient series uses high efficient cell that is one of the most efficient poly modules.

(Suitable for all high efficient application systems including household, commercial and large power stations, which can guarantee the users gain most generated energy and improve profits under the same spaces.

*This series of products have passed certification of TUV, UL, IEC61730/61215, CSA, CE, MCS, ISO9001/14001, all of which are authoritative as they are widely accepted in solar industry.)_*

As the peak power is 300W:

$$\text{No. of Solar panels required} = \frac{735\ W}{300\ \text{W}} = 2.45$$

Therefore, the required power can be acquired by three series connected 300W solar panlels

Inverter Sizing

Found out that the maximum load in my house is around 2 kW.

Efficiency of the inverter = 90%

Output voltage = 230 VAC

Frequency = 50 Hz

Battery input = 12 V

Therefore, the required inverter capacity 2 kW. According to the market availability 3kW inverter have to be selected.

Battery Sizing

Consider a **Lithium Ion battery** with **12 VDC** of battery bank voltage;

Per day power consumption = 2.94 kWh

Depth of Discharge = 0.8

Power efficiency (Due to inverter loss) = 0.9

Required Battery Capacity per day;

$$\text{Battery Capacity (Ah)} = \frac{\text{Total Watt} - \text{hours per day used by appliances}}{\text{Depth of Discharge} \times \text{Efficiency of the Battery} \times \text{Nominal Battery Voltage}}$$

$$\text{Battery Capacity (Ah)} = \frac{2940}{0.8 \times 0.9 \times 12} \approx 340.28\ Ah$$

Therefore, the require battery capacity is 340.28 Ah. According to the market availability 350Ah 12 VDC battery have to be selected.

Figure 04 : Lithium Ion battery

Nominal Voltage:12V

Nominal capacity:350Ah

Charging voltage:12.6V

Discharge cut-off voltage:9V

Charging current:10A-20A

Discharging current:100A

*Dimension:215*395*490mm*

Weight:16kg

Charge Controller Sizing

Consider a MPPT type Charge Controller;

Maximum charging current = 20 A

From the charger control datasheet;

Max PV input power = 260 - 2000 W

PV input voltage (V_{oc}) = 55 V

MPPT Charger Controller

The MPPT analyzes the output of the PV module, compares it to the battery voltage, and determines the best power that the PV module can generate to charge the battery. It then converts that power to the optimal voltage to allow the battery to receive the maximum current. Additionally, it has the ability to power a DC load that is linked directly to the battery.

Figure 06: 20A 30A 40A Lumiax solar mppt charge controller

Type:
MPPT
Application:
Charger Controller, Lighting Controller, Solar System Controller
Work Time (h):
24 hours/ dusk to dawn/ timer
Max PV Power:
260W~2000W
Max PV Voltage:
55V/100V/150V
System voltage:
12v/24v/48v optional
Battery type:
Liquid/GEL/AGM/Lithium
Load current:
20A/30A

Inverter Sizing

Output voltage: 230VAc

Frequency: 50Hz

Battery input: 12V

Continues load limit: 3kW (Because, my house maximum load is 2kW and next market available inverter is 3kW)

Figure 05: 300-Watt Pure Sine Inverter European 12 VDC to 220/230 VAC

Continuous output power: 300 Watts

Surge power capability (peak power): 600 Watts

dc input / operating voltage: 10 to 15 Volts

Output voltage: 220/230 Volts ac

Output voltage regulation: +/- 3%

Output wave form: pure sine wave

Output frequency: 50 Hz +/- 2hz

04. Controlling elements

a. MPPT Charger controller

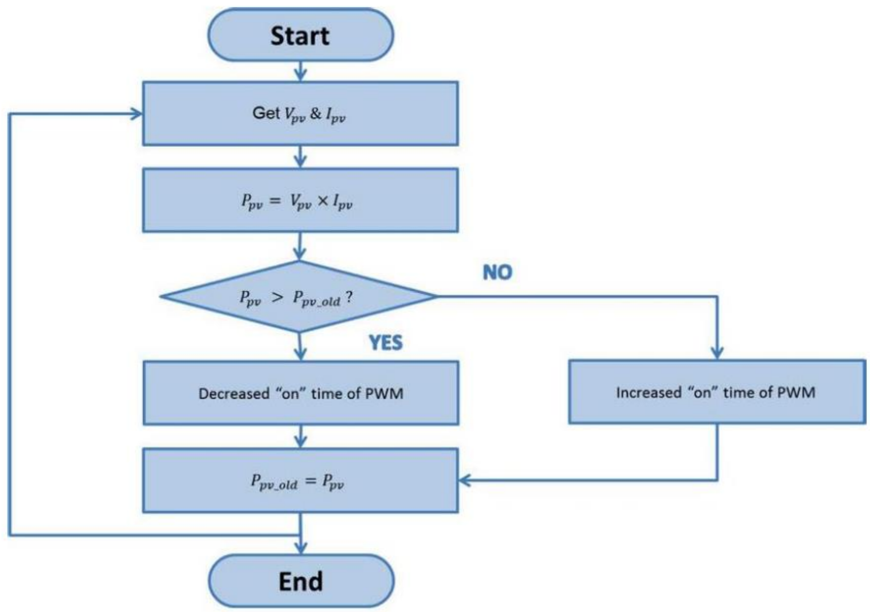

Figure 06: MPPT Algorithm

The MPPT charging controller consists of two major components. The MPPT controller and Boost controller are those. The battery charging is handled by the boost controller, while the MPPT controller provides the necessary power.

The MPPT algorithm is employed inside the MPPT controller. The boost controller uses the battery charging algorithm and PWM switching algorithm within, and it also offers battery protection functions.

b. Inverter

Inside the inverter Unipolar PWM algorithm is using with feedback controlling algorithm.

05. Simulation

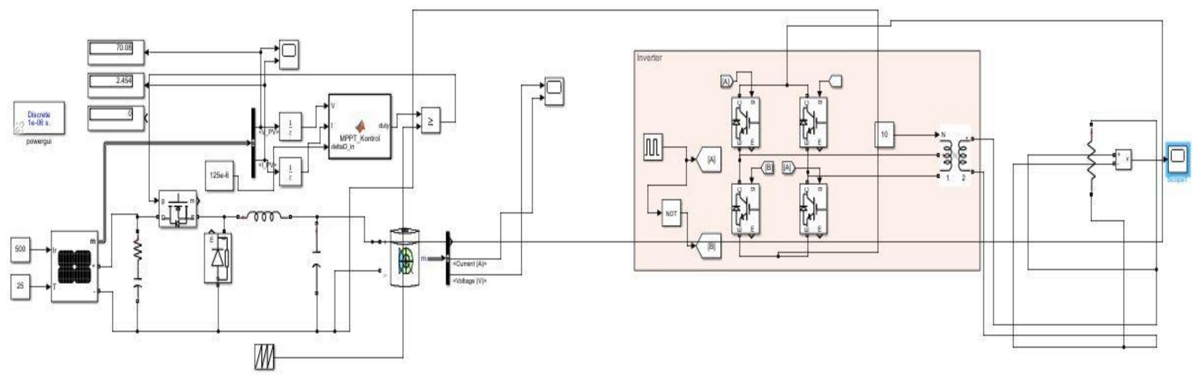

Figure 07: Simulation circuit for the solar system (MATLAB)

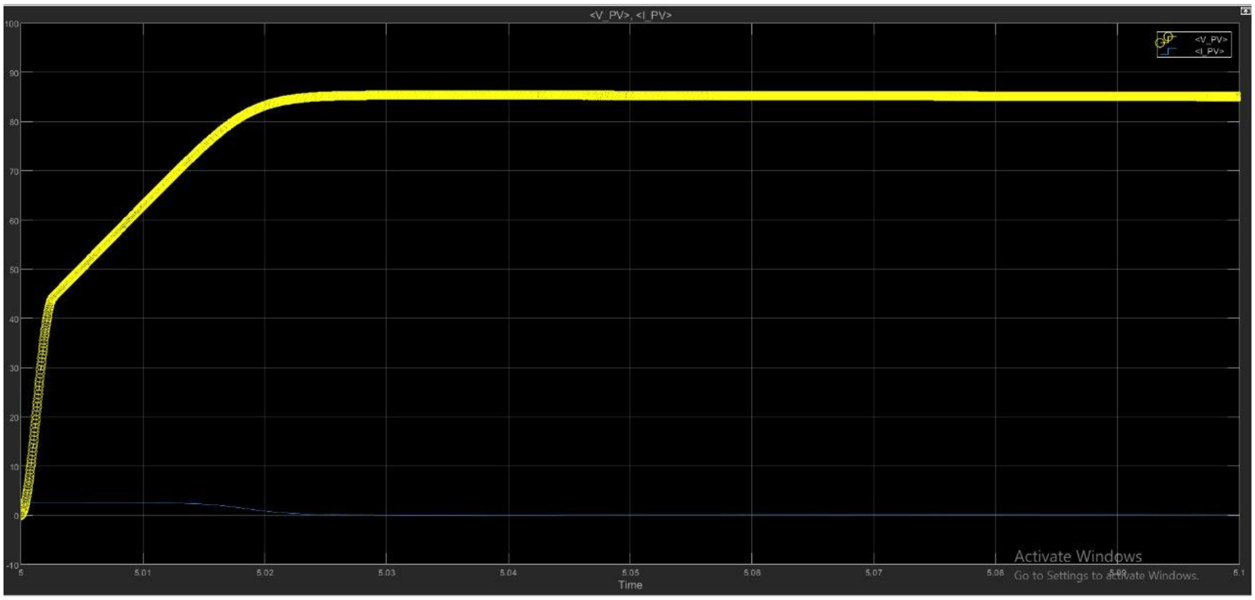

Figure 08: Output of the solar array (voltage and current)

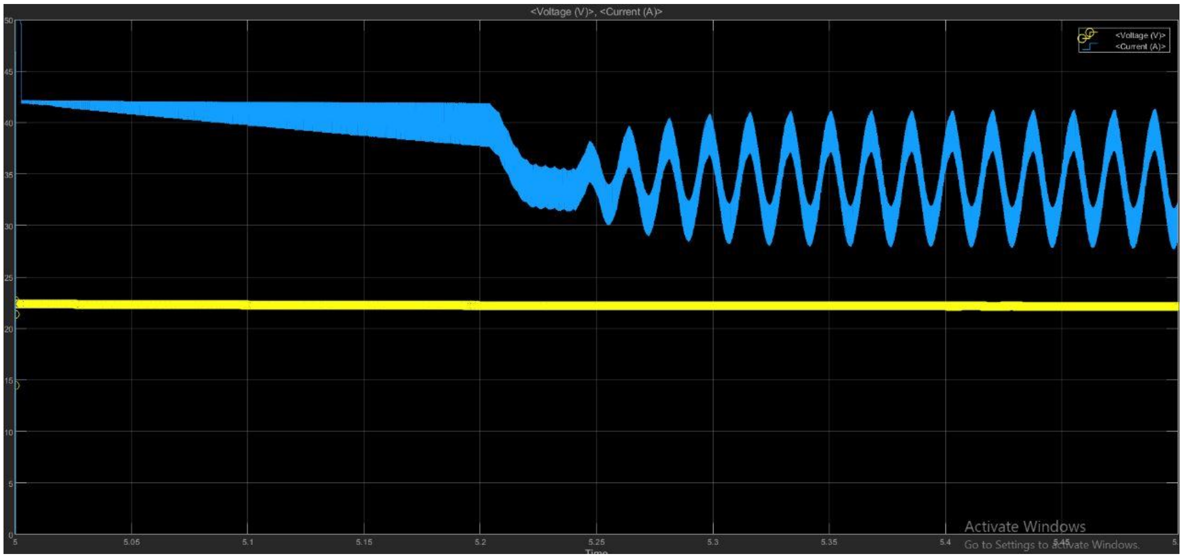

Figure 09: Output of the battery (voltage and current)

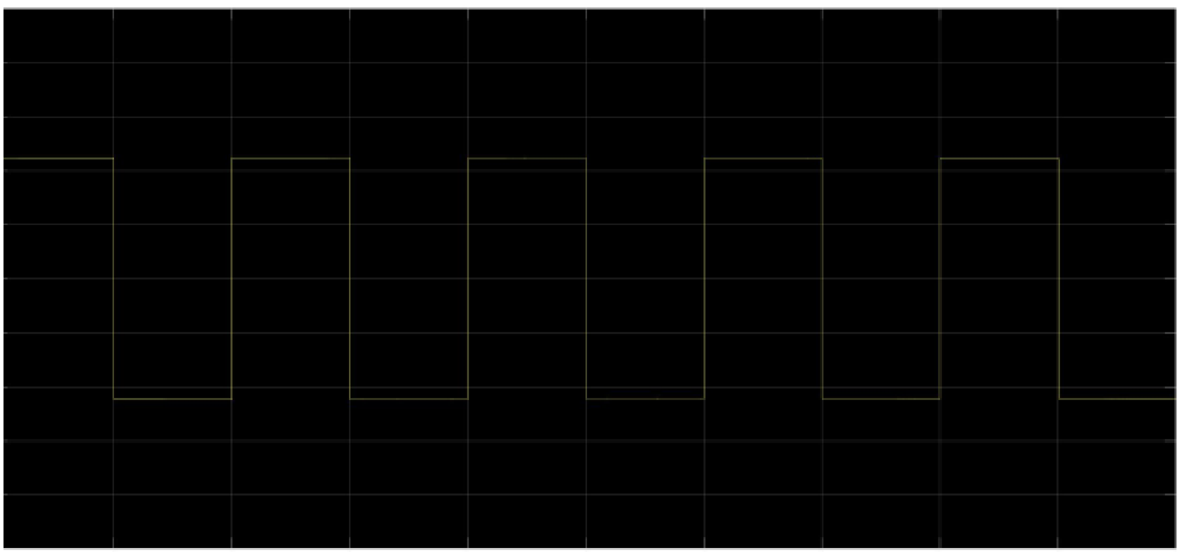

Figure 10: Output of the inverter

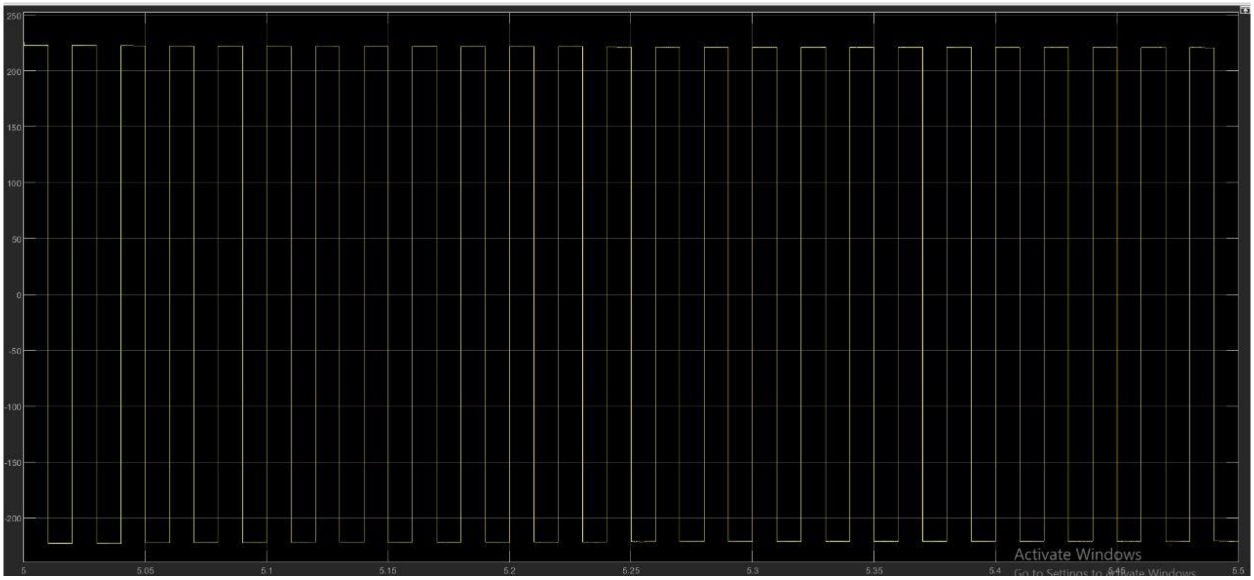

Figure 11: Final output of the solar system