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DESIGN AND SIMULATION OF ELECTRICAL LOAD BASED MODEL FOR ROOFTOP SOLAR PLANT USING LABVIEW

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Abstract

This paper presents an analysis of variations in the input of the mono-crystalline silicon PV cell under different temperature and irradiance levels using LabVIEW as the simulation tool. The base of the study is mathematical modeling of PV cell characteristics using one-diode equivalent model in LabVIEW. The tool which is designed to compute and it can displays various parameters like Current–Voltage (I–V) curves, optimal load and Number of Panels, open-circuit voltage (Voc), short-circuit current (Isc) and saturation current (Io) over a range of cell temperature, irradiation levels and development of a LabVIEW model for number of solar panel required for load requirement.

The user need to provide the essential parameters as inputs on the front panel in LabVIEW which we can obtain from the datasheet which are given the for standard test conditions (STC) by a manufacturer. The project aims to simulate and explore the potential of solar PV system in different Temperatures and Irradiance using LABVEIW.

Key Words: LabVIEW, Solar Panel, load requirement

1. Introduction

Renewable energy sources offer great potential for reducing the green house gases emission and other environmental impacts of electricity production. Each kilowatt-hour (kWh) generated from renewable resources saves the environment from the burning of fossil fuels. The coal fired and the natural gas fired power plants produce 1.05Kg and 0.75Kg carbon respectively [1]. The sun is a glint ball of gas that sends out huge amount of rays every day. However only less than 50% of solar radiation reaches the earth, where 20% is absorbed by atmospheric gases and 30% is reflected back to the space [2]. The sun radiates its energy at the rate of about 3.838 10^{23}kW/s [3]. Most of this energy is transmitted radially as electromagnetic radiation, which comes to about; 1.4kW/m^2 at the boundary of the atmosphere. A square meter of the earth's surface can receive as much as 1 kW of solar power after traversing the atmosphere, averaging to about 0.5 over all hours of daylight. This is significant potential for the use of the photovoltaic solar energy in country like Libya which receives abundant amounts of solar radiation around the year. Libya is an oil producing country located in the middle of North Africa, with 6 million inhabitants distributed over an area of 1,750,000 Km^2 and with sun duration of more than 3500 hours per year [4].

Grid-connected PV systems have many technical advantages such as flexibility, simplicity to install in any area where the solar irradiation is available, as non-polluting, emitting no noise and requiring little maintenance [5], [6]. Therefore, many countries are encouraging customers to install PV systems in order to generate their own power, to reduce electricity bills and to increase the contribution of renewable energy to limit carbon dioxide (CO2) emissions. Generally the PV system comprises of PV generator which is a set of series-parallel electrically interconnected solar panels. PV panels are delivered are given in terms of the nominal peak power of the panel at standard test conditions (STC) by the manufacturers. PV generator gives the total installed power. It is the sum of nominal peak power of each solar panel present in the PV installation [7]. A grid-connected system comprises of the modules and an inverter. The inverter converts the direct current (DC) electricity generated by the PV array into alternating current (AC) electricity that is synchronized with the mains electricity. Excess electricity generated at any time is fed into the grid.

The grid-connected inverter will be designed for the peak power and must obey conditions that deal with issues like power quality, detection of islanding operation, grounding; MPPT and long-life [8]. Inverter maximum power is referred to the total installed power of the PV generator and has to optimize the energy injected to grid. Since the expected irradiance in the physical location of the PV installation is lower than the nominal or standard one, a current practice is to select the inverter maximum power than the nominal peak power of the PV generator. This practice is known as under sizing of the inverter [7], [8]. The nominal power of the PV generator corresponds to standard irradiance conditions. Under low irradiance, a PV array generates power at only a part of its nominal capacity and the inverter thus operates under part load conditions with lower system efficiency [7].

2. DESIGN METHODOLOGY

The methodology for this study includes the preparation of the inputs and calculations required for the simulation process. Determination the possibility of solar photovoltaic generation potential & number of panels required, so that installation can carried out easily even during fluctuating loads. Also for calculating the output efficiency of the PV module is taken as 18%. In addition it is in the design that the solar energy assumed to be available for 6 hours during the normal day.

2.1 LOCATION DETAILS

City/District: Bangalore
State: Karnataka
Country: India
Longitude: 12.9716° N, 77.5946° E
Solar Irradiance: 5.83 kWh/m^2/day

3. LOAD PROFILE

3.1 SIMULATION FOR ROOF-TOP DESIGN

The user provides the necessary inputs such as type of appliances, number of appliances connected and Wattage. No. of Hours of each equipment is used as an average to calculate the daily requirement of power, and then the test conditions are varied for Temperature and Irradiance. The user can interact and access the controls at any point of Run-time to analyze the transient effects of the system.

The simulation is designed such as at first it should ask for the respective and necessary inputs from the user, which is required for the processing of the results. The following steps show the chosen algorithm to get the required Output.

i. Start the Simulation.
ii. Ask input for the load conditions.

iii. Calculate No. of equipment used.
iv. Decide no. of equipment to be used, no. of hours, wattage.
v. Compute the Power & Energy output required for deciding inverter & solar panels.
vi. Compute for number of solar panels required
vii. Stop the simulation

The PV system consists from main part which is PV cells which produces the power but there are other components are also needed to, control, convert and store the energy such as PV modules, batteries, charge controllers, and inverters. The PV system and its components are detailed in the block diagram as shown in the figure 2

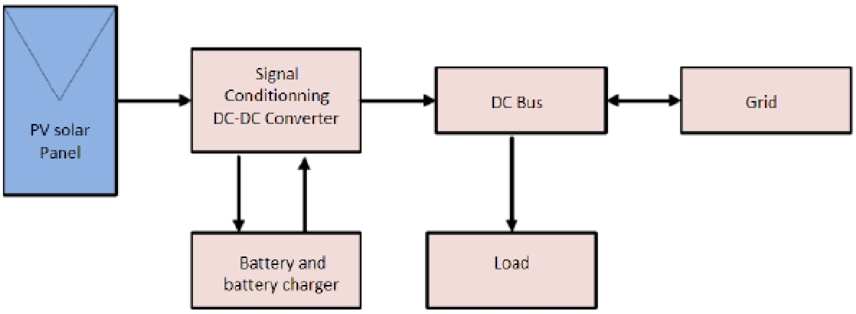

Fig 2 Block diagram for general PV system

3.2 **Calculations:**

Considering the a room consisting of Fans, lights, Desktop PC, Projector as the case study for our simulation, and a standard data-sheet for Voc, Isc, Pmax, Vmax, Imax, for a single panel we are calculating the No. of Panels which are required for designing the Roof-Top Mode considering the losses in power conversion and the Efficiency of 20%. Now, we calculate the total Power consumption by the equipments over the day.

Table 1 Details of load in watts & no. of equipment

EQUIPMENTS	WATTAGE	NO. OF EQUIPMENTS	TOTAL(W)
FAN	75	2	150
LIGHT	60	8	480
DESKTOP-PC	450	21	9.45Kw
PROJECTOR	280	1	280

Table 2 Details of load KWh

❖ USAGE

EQUIPMENTS	WATTAGE(W)	NO. OF HOURS	TOTAL(W/d)
FAN	150	5	750
LIGHT	480	3	1440
DESKTOP-PC	9.45(Kw)	5	47.25(Kw/d)
PROJECTOR	280	3	840
		TOTAL	50.28

* Considering 20% Efficiency at Generation and 25% of Extra for Losses and Over-load.

Total Load = (50.28)+(0.20*50.28)+(0.25*50.28).

= 72.90KWh ~ 75KWh

Availability of sunlight of 5 hours in a day for optimal generation of electricity

= 75KWh/5= 15KW.

Hence we need to generate 15kW of power in one hour from solar power plant. This amount of electrical power cannot be generated from single solar photo voltaic panel due to technical and manufacturing difficulties. Instead of single photo voltaic panel we can connect the PV panels in series and parallel combination to meet our power demand by using available standard PV panels of desired power of each panel and dimensions.

3.3. Solar Module Configuration

Solar Module Type considered is of make ELDORA VSP.72.AAA.03.04 (Polycrystalline) with technical details as follows

Voc	= 45.8v (DC).
Isc	= 8.92 A.
Vmax	= 37.5 V (DC).
Imax	= 8.40 A.
Pout	= 315 W.

3.4 NUMBER OF PANELS REQUIRED

The total No. of Panels required is calculated as shown below

Number of panels required = (total Wattage of the requirement)/ (wattage of one PV panel)

= (15/315) * 10^3= 47.6~ 48 Panels.

3.5 INVERTER SELECTION

The Load on the inverter is calculated as shown below

Load on inverter = Actual Load+ 25% of actual load (Considering for future load)

= (72.90*0.25)+72.90

= 91.185 kWh ~ 92 kWh per Day

Considering 5 Hrs. Daily Use~ 19 Kw/hr/day

3.6 Front Panel:

Figure 3 shows the front end control panel and figure 4 shows the Back-End Block Diagram representation of the simulation which is processed in order to calculate the No. of Panels required to drive the load considered. The user is required to enter the load details which is then calculated to give out the power output and also the Number of panels required for the supply of load

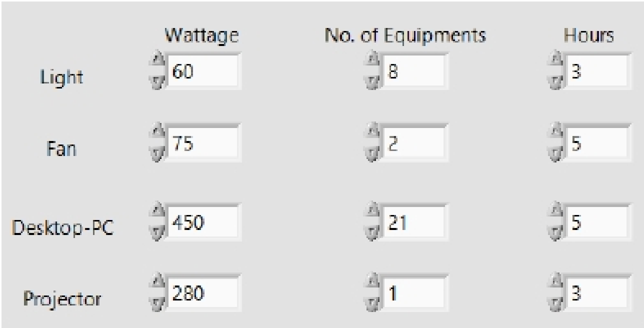

Fig 3 Front End Control Panel

3.7 Block Diagram:

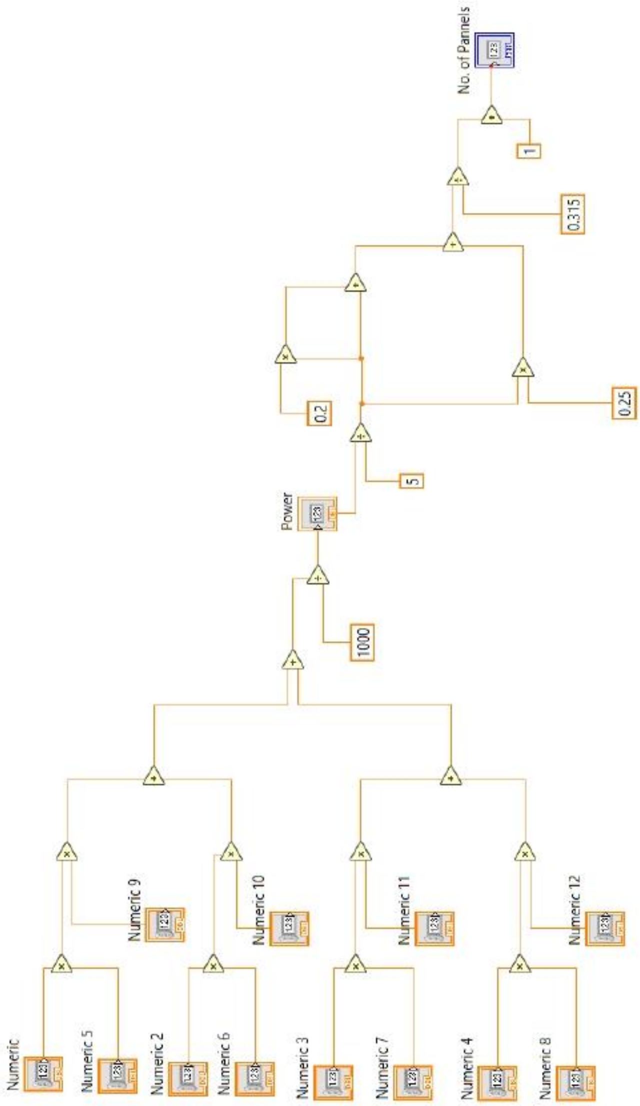

Fig 4 Block Diagram for Calculating number of Panels

4. Results:

The above Fig 5 is the Front-end Control Panel which controls the simulation for obtaining user provided the necessary inputs such as the No. of Equipments, Wattage, and the No. of Hours each equipment is used as an average to calculate the daily requirement of power and then the test conditions are varied for Temperature and Irradiance. The user can interact and access the controls at any point of Run-time to analyze the transient effects of the system

Fig. 5 simulated output

5. Conclusion:

The model is simulated in virtual environment software, which is LabVIEW. This software allows its user to change input parameter even when the system is processing. This enables the user to study the system in transient conditions.

The design and simulation results are in acceptable range of errors and the expected Output for deciding number of solar PV- panel required under varying conditions of load is obtained.

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