MODELLING AND SIMULATION OF PV SYSTEM FOR MAXIMUM POWER POINT TRACKING USING MATLAB/SIMULINK

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Abstract**—** Photovoltaic (PV) generation involves the direct conversion of sunlight into electrical energy. In recent years it has proved to be a cost-effective method for generating electricity with minimum environmental impact. Due to the environmental and economic benefits, PV generation is now being deployed worldwide as an embedded renewable energy source and extensive research is being performed in order to study and assess the effectiveness of PV arrays in Distributed Generation (DG) systems either as a potential energy source or as energy reserve in combination with other types of distributed energy resources. This paper presents the modelling and MATLAB simulation of a stand-alone polycrystalline PV Array system and investigates load following performance efficiency under various loading and weather conditions as well as suitability with regard to enhancing power supply reliability to critical loads. The modelling of the PV array that has been performed in this research using MATLAB Simulink is based on the calculation of parameters for the Thevenin's equivalent circuit of each cell of the array.

Index Terms**—** PV Array, MATLAB/ Simulink

I. INTRODUCTION:

The use of new efficient photovoltaic solar cells (PVSCs) has emerged as an alternative measure of renewable green power, energy conservation and demand-side management. Owing to their high initial cost, PVSCs have not yet been fully an attractive alternative for electricity users who are able to buy cheaper electrical power from the utility grid. However, they can be used extensively for water pumping and air conditioning in remote and isolated areas, where utility power is not available or is too expensive to transport. [1] Renewable energy resources will be an increasingly important part of power generation in the new millennium. Besides assisting in the reduction of the emission of greenhouse gases, they add the much- needed flexibility to the energy resource mix by decreasing the dependence on fossil fuels [3].

Photovoltaic arrays present a nonlinear I-V characteristic with several parameters that need to be adjusted from experimental data of practical devices. The mathematical model of the photovoltaic array may be useful in the study of the dynamic analysis of converters, in the study of maximum power point tracking (M.P.P.T) algorithms and mainly to simulate the photovoltaic system and its components using simulators.[4]

The electricity available at the terminals of a photovoltaic array may directly feed small loads such as lighting systems and DC motors. Some applications require electronic converters to process the electricity from the photovoltaic device. These converters may be used to regulate the voltage and current at the load, to control the power flow in grid-connected systems and mainly to track the maximum power point (MPP) of the device.[4] Taking in to account the temperature and sun's irradiance, the PV array is modelled and its voltage current characteristics and the power and voltage characteristics are simulated. This enables the dynamics of PV system to be easily simulated and optimized. It is noticed that the output characteristics of a PV array are influenced by the environmental factors and the conversion efficiency is low. Therefore a maximum power tracking (MPPT) technique is needed to track the peak power to maximize the produced energy.[5]

II. MODELING OF PV ARRAY

Each cell of the PV array has been modeled as a Thevenin's equivalent circuit comprising the Thevenin's voltage source (*V*th) with the Thevenin's resistance (*R*th) in series. The values for *V*th and *R*th have been calculated from the double diode model of a typical polycrystalline PV cell that expresses the *V-I* characteristic of a PV cell by the equation as given below:

$$I = I_{ph} - I_{s1}[e^{\left(\frac{V+IR_s}{v_t}\right)} - 1] - I_{s2}[e^{\left(\frac{V+IR_s}{Av_t}\right)}] - \frac{V+IR_s}{R_p} \quad \ldots\ldots\text{Eq.(1)}$$

$$\text{where, } v_t = kT/e \quad \ldots\ldots\text{Eq.(2)}$$

In the above equation, *V* and *I* are the terminal voltage and current respectively, *k* is Boltzmann's constant, *T* is the absolute temperature and e the electronic charge. The parameters *Iph***,** *I*sl, *I*s2, *R*s and *R*p of the double diode model are the photocurrent, the saturation currents of the two diode terms, the series resistance and the parallel resistance, respectively. The diode parameter *A* is usually set to 2 for approximating the Shockley-Read-Hall recombination in the space-charge layer in the photo-diode. The remaining parameters are calculated from the values of irradiance *E* (W/m2) and ambient temperature *T* (°K) using the following empirical relationships obtained from experimental polycrystalline cell characterization as reported in earlier works.

$$I_{ph} = K_0 E(1 + K_1 T) \quad \ldots\ldots\text{Eq.(3)}$$

$$I_{S1} = K_2 T^3 . e^{\left(\frac{K_3}{T}\right)} \quad \ldots\ldots\text{Eq.(4)}$$

$$I_{S2} = K_4 T^{1.5} . e^{\left(\frac{K_5}{T}\right)} \quad \ldots\ldots\text{Eq.(5)}$$

$$A = K_6 + k_7 T \quad \ldots\ldots\text{Eq.(6)}$$

$$R_S = K_8 + \frac{K_9}{E} + K_{10} T \quad \ldots\ldots\text{Eq.(7)}$$

$$R_p = K_{11} . e^{K_{12} T} \quad \ldots\ldots\text{Eq.(8)}$$

*V*th has been calculated from Eq.(1) by putting *V*=*V*th and *I*=0 and rearranging the terms as follows:

$$V_{th} = R_p.[I_{ph} - I_{s1}[e^{\left(\frac{V_{th}}{V_t}\right)} - 1] - I_{s2}[e^{\left(\frac{V_{th}}{AV_t}\right)}]] \qquad \ldots\ldots\text{Eq.}(9)$$

Similarly, the short circuit current *I*sc has been calculated from Eq.(1) by putting *V=0* and *I=Isc* and rearranging the terms as shown in Eq.(10):

$$I_{sc} = \frac{R_p[I_{ph} - I_{s1}\{e^{\left(\frac{I_{sc}R_s}{V_t}\right)} - 1\} - I_{s2}\{e^{\left(\frac{I_{sc}R_s}{AV_t}\right)}\}]}{R_p + R_s} \qquad \ldots\ldots\text{Eq.}(10)$$

Rth has been calculated from the relation *R*th = *V*th/*I*sc. The overall model of the PV array calculates *Vth* and *Rth* for each cell from the values of irradiance and ambient temperature and then computes the DC voltage and current output at the PV terminal from the values of *V*th, *R*th, number of cells in series and number of cells in parallel. The DC voltage is then fed to a standard PWM converter model with voltage feedback for conversion to AC at the specified magnitude and frequency at the customer load terminals.

For each cell, R_{th} has been calculated as

$$R_{th} = \frac{V_{th}}{I_{sc}} \qquad \ldots\ldots\text{Eq.}(11)$$

For the entire array,

$$V_{thar} = V_{th}.N_s \qquad \ldots\ldots\text{Eq.}(12)$$

and

$$R_{thar} = \frac{R_{th}.N_s}{N_p} \qquad \ldots\ldots\text{Eq.}(13)$$

where, *Np* = no. of cells in parallel and *Ns* = no. of cells.

III. SIMULATION OF PV ARRAY IN MATLAB

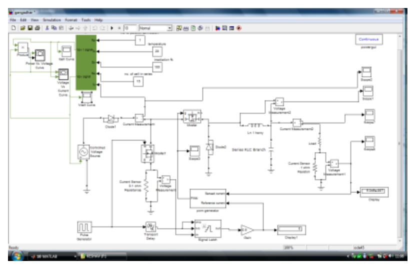

Fig1. Complete simulation model of the photovoltaic energy conversion system

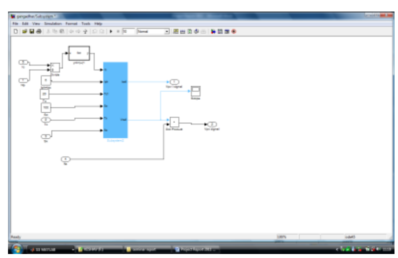

Fig2. Complete PV Cell Simulink model block

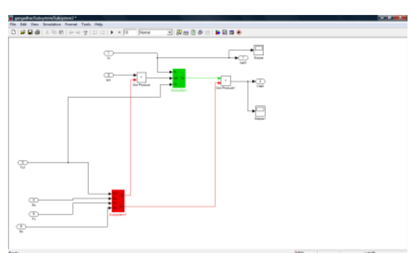

Fig3. Block diagram of the PV sub-module that gives out cell current and cell voltage

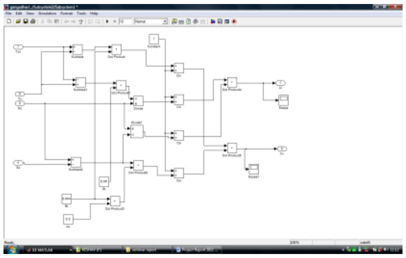

Fig4. Block diagram of PV sub-module that determines correction factors for current

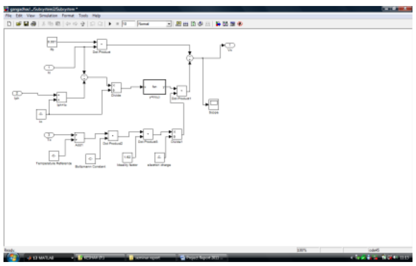

Fig5. Block diagram of PV sub-module that measures PV cell output voltage

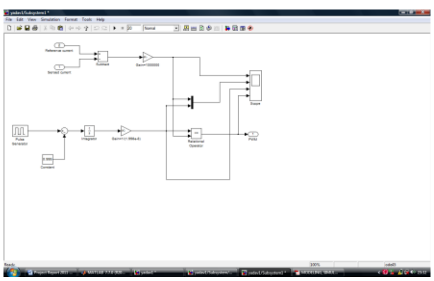

Fig6. Block diagram of the internal sub-modules of PWM generator

Fig7. Response of the output Current of the Photovoltaic array Icell

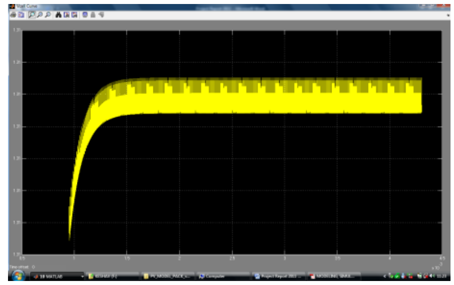

Fig8. Response of the output voltage from the photovoltaic array (Vcell Curve)

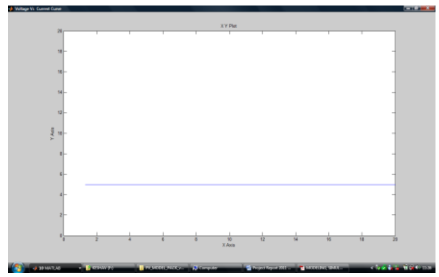

Fig9. Curve Between Output Current Vs. Output Voltage

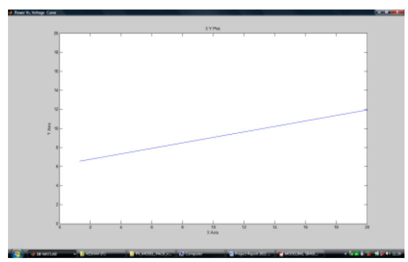

Fig10. Curve Between Output Power Vs Output Voltage

IV.CONCLUSIONS

From the observations made above, we conclude that the system developed is capable of extracting maximum power from the photovoltaic module at the same time providing a regulated DC supply.The ambient temperature of the system is assumed not to change for a reasonably long time (about 5 minutes). But practically, his may not be the case. The insolation may change in two to three minutes.

In such cases, we need to derive the reference voltage from the short circuit current of the PV panel. The value obtained can be latched as the reference voltage and MPP can be obtained automatically without any manual intervention.

We have prepared A PV energy conversion system for converting solar power into useable DC at 5V from 18V (DC) for charging batteries of low power devices like mobile phones. Standard Specification of the NOKIA-6303i classic Mobile Charger: Output: 5.0 V / 890 mA

We have Successfully Obtained the desired specification at the output of the converter MATLAB Simulink.The natural DC-DC converters to be applied as MPP Trackers are Buck-Boost, Cuk, Sepic or Zeta, because they have no non-operational region. However, as these converters are more complex and are more expensive than Buck or Boost, usually the designers choose the last two.

V.REFERENCES:

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