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4 Conclusions

The determination of the five model parameters allow, by means of using them inside the proposed set of electric and thermal equations, a right evaluation of the output variables of the module, such as: voltage, current, and power.(section 2.1).

Compared with traditional STC curve, the curve based on electrical model with calculated parameters is much closer to the realistic one(Fig. 3.1 and Fig. 3.2). And the electrical-thermal model can be used to demonstrate the relationship between temperature and voltage as well as energy output(Fig. 3.3).

From this study it is possible to notice that do not exist just one set of parameters but they vary with ambient variables. However it has been proved that using a set of parameters that is formed by parameters close to the average values, whatever are the climate conditions the I-V characteristic of the module is very close to the measured one (Fig. 3.4). Chosen the set of parameters, the proposed model allow to perform sensitivity analysis of the effect of the meteorological variables on the performance of the module.

In the future task, in particular some constructive or installation solutions can be studied so as to maximize the energy that can be drawn by a photovoltaic plant, in particular when it is integrated in a building. In fact in this case the thermal problems have priority over other technical issues.

3 Experimental Results

Thermal or electrical?

The presenter tested the proposed model using a polycrystalline photovoltaic module type 125G-2 provided by the manufacturer KYOCERA, based on the Standard Test Condition (STC) parameters. The STC is defined with cell temperature 25°C, irradiance level 1000 W/m2 at spectral distribution of Air Mass 1.5 solar spectral content. To compared the experiment result with the real statistics, the measured meteorological data of midday June 27^{th}, 2007 was used.

The using of STC and PVSYST V3.4 which is PC software package parameters in the proposed model allow us to plot an I-V curve(real line) qualitatively close to measured one (dashed line) but it is evidently not so close, shown as Fig 3.1.

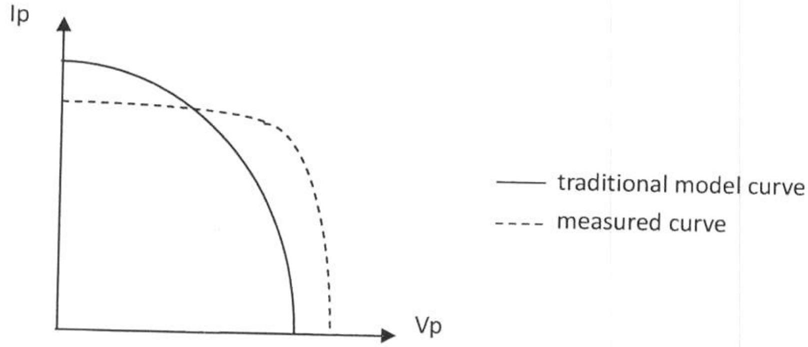

Fig. 3.1 IV Characteristic Comparison Between Real Data And Calculated Data

In Fig. 3.2 the characteristics I-V of a Polycrystalline module (Kyocera 125W) using both electrical model with calculated parameters in section 2.1 and measured data. From the comparison between these two curves it is evident that the calculated parameters allow to obtain a very realistic curve.

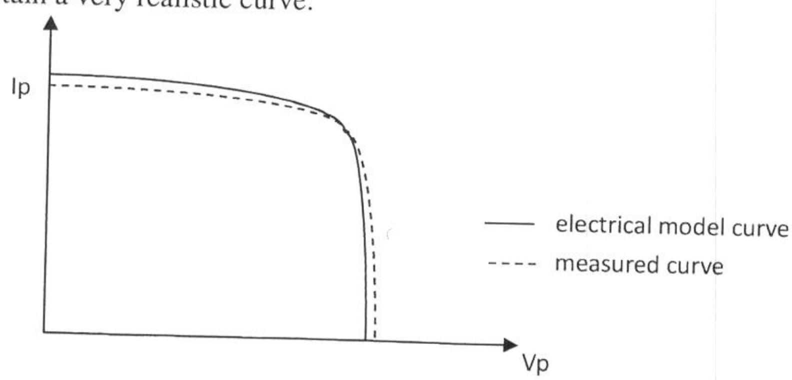

Fig. 3.2 IV characteristic comparisons between real data and calculated data

2.2 Thermal model

To determine the PV cell temperature it is necessary to study carefully the thermal behavior of the PV module. This study has been carried out considering the PV modules made of three layers, for each of them a thermal balance has been performed. This is shown as Fig. 2.4.

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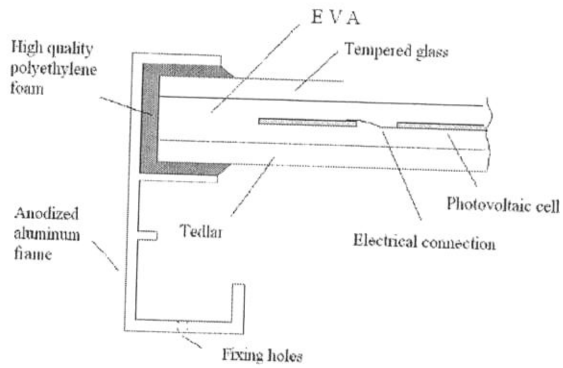

Fig. 2.4 Photovoltaic Module Sections

The presenter proposed this model based on two main assumptions :

1) The temperature has been supposed uniform in each layer and it varies along the y-axis;

2) The thermal capacitances of the layers have been supposed negligible (steady state study)

Considering the generic structure made of the layer (glass, photovoltaic cell, Tedlar), the following set of three equations can be written, based on thermal balances:

$$a_g G + \left(\frac{\lambda_g}{d_g}\right)(T_{pv} - T_g) = h_{cga}(T_g - T_a) + h_{rgs}(T_g - T_a)$$

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$$\left(\frac{\tau_g a_{pv}}{(1-(1-a_{pv})(1-\tau_g))} - \eta\right) G = \left(\frac{\lambda_g}{d_g}\right)(T_{pv} - T_g) + \left(\frac{\lambda_t}{d_t}\right)(T_{pv} - T_t)$$

$$\left(\frac{\lambda_t}{d_t}\right)(T_{pv} - T_t) = h_{cta}(T_t - T_a)$$

Where I_{ph} is photoproduct current, T is surrounding temperature, T_a is reference temperature. CT is temperature coefficient. S is intensity of illumination, in standard case, S=1000w/m2. I_{sc} is the short circuit current.

$$I_D = I_0[\exp(\frac{qU}{AKT}) - 1]$$

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Where I0 is the diode negative saturation current, q is electron charge=1.6×10-19C. K is Boltzmann constant, which is 2.3×10-23eV/K. T is absolute temperature, A is P-N junction curve constant. When it is open circuit:

$$I_o = I_{ph} - I_D = 0$$

$$I_{ph} = I_0[\exp(\frac{qU}{AKT}) - 1]$$

$$U_{oc} = \frac{AKT}{q} In(\frac{I_{ph} + I_0}{I_0})$$

Since I_{ph} >>I0,

$$U_{oc} = \frac{AKT}{q} In(\frac{I_{ph}}{I_0})$$

In order to estimate the optimal PV model that fits best the measured I-V curves, the parameters are need to be calculated. Firstly, the estimated five parameters (R_s, R_{sh}, I_{SCpref}, I_{0pref} and n.) were used to calculate current and voltage, and the measured G and T_{pvi} were calculated by the following equations in section 2.2, then using open circuit cell temperature to substituted to get a first set of module parameters, and then by iterative process to get the parameters in real working conditions. These parameters can be used to calculate the current, voltage, and power. They will be used in the following experiments in section 3.

2 Basic Knowledge Review

2.1 Electrical Modeling

PV cells convert solar energy into electricity based on the photoemission of P-N junction. When sunlight falls on the surface of semiconductor, the internal valence electron in N zone and P zone are excited by photons, escaping from covalent bond, and its status changes from valence band to conduction band. Thus a lot of unbalanced electron-hole pairs are produced. Caused by the traction of P-N junction on minor carriers, they draft to each other area, establishing a photoproduct electric field. When connect with external circuit, electricity output can be obtained. The whole process is shown as Fig. 2.1.

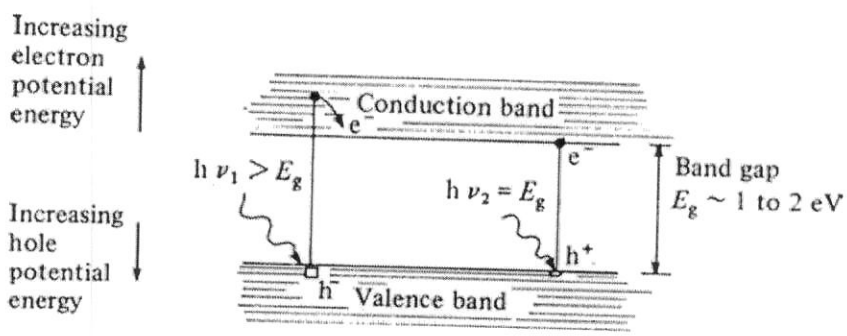
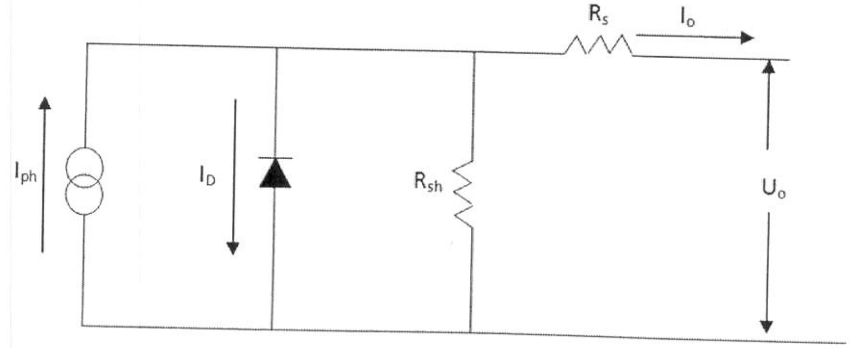


Fig. 2.1 P-N Junction



1 Introduction

In the introduction part, the presenter talked about the problem stopping solar PV system from widely applying, and the motivations and objectives of his research work.

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1.1 Problem Statement

There are three major problems in front of us. Firstly, when a solar panel expose under sunshine, the major part of solar radiation is converted into thermal energy rather than electrical energy by the increasing of model temperature. The conversation efficiency would be reduced in this way. Secondly, in order to improve the efficiency, some solar systems not only generate electricity but also produce low temperature hot water or air, which is called PV/T hybrid systems. Therefore, how to compromise the temperature for both cells and fluids to achieve optimal efficiency is another problem. Thirdly, energy production is not constant which is affected by wind direction and speed, ambient temperature, total irradiance, humidity and other variables, how to make a precise prediction of energy output by predict the module temperature is another thing we need to overcome.

1.2 Motivations

As we all know, the storage of fossil fuel is becoming less and less all over the world. It is exigent to find alternative energy resources to support industry activities and human life in the close future. Solar energy can be regarded as an unlimited energy resource in this point of view. Secondly, the process of converting fossil fuel energy into electrical energy causes serious environment issues; however, solar energy is a clean energy resource and its conversation process would not cause any pollution problem. Last but not the least, solar PV system in an essential part for

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ABSTRACT

With the energy consumption demand becoming larger and larger in recent years, traditional fossil energy is not able to support industry activities and human life enough, and the pollution problems caused by the process converting fossil fuel into electricity depredate gravely our environment. Therefore, the clean and renewable energy generally attracted people's attention. In this report, one of the most popular and applicable source of ? renewable energy, Solar PV energy, would be specifically discussed. expand

PV modules generate electricity, but the electrical output is only one component of the total energy produced by a photovoltaic array. A typical photovoltaic (PV) module has ideal conversion efficiency in the range of 15%. The remaining energy produced is heat, which is neither captured nor utilized. This heat increases the operating temperature of the PV modules, which actually decreases their overall performance.

The traditional methods to calculate the cell temperature, such as NOCT(Normal Operating Cell Temperature), is the most approximate and do not take into account the real ventilation of PV modules. In order to achieve more precise temperature which is varied by wind direction, wind speed, humidity, irradiance and other variables, an electrical-thermal model is presented in the Md Abdul Adud Shikder's research, and the conclusions are validated by experimental results.

Key words: Photovoltaic cell thermal factors, PV modules modeling, Power measurement.

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A Seminar Report

On Topic of Advance Temperature Modeling Of Solar PV

(The Master of Applied Science Thesis Defense For Md Abdul Adud Shikder)

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