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Measurement of $CuInSe_2$ solar cell AC parameters

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Abstract

The AC parameters (cell capacitance and cell resistance) of Copper Indium Diselenide ($CuInSe_2$) solar cell are measured using time-domain technique. The cell capacitance is calculated from the open circuit voltage decay (OCVD) and cell resistance with solar cell $I-V$ characteristics measured in dark. The solar cell exhibits high parallel resistance and low parallel capacitance. The doping concentration and built in voltage are derived from the $1/C_P^2$ versus bias voltage graph. The built-in voltage of the solar cell shows good agreement with measurements published in the literature.

Keywords: Solar cell; AC parameters; $CuInSe_2$

1. Introduction

Photovoltaic power generation has emerged as a very important non-conventional energy source. The technology of photovoltaics has evolved and matured to become an economical alternative to other power sources. The demand for high power and high efficiency has necessitated the use of high-speed switching charge controllers for solar array power conditioners. To design an efficient and reliable switching charge controller, the AC parameters of solar cell (especially the cell capacitance) has need to be understood.

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In high power PV systems, the load is continuously connected to the system and draws power continuously from it. Hence, the solar panels need to supply continuous power to maintain the battery in optimally charged state, in order to provide the required amount of power to the load. Due to this, the solar cell/panel is required to be switched between battery and the shunt switch (shorting the solar panel) rapidly. Solar cell is modelled as a parallel RC network with a series resistance as shown in Fig. 1. Due to the capacitance present in the solar cell, high voltage of solar array (across capacitance) gets discharged through shunt switch, present in PV system as a part of the charge controller, causing significant power loss, which is given by the [1]

$$P = \tfrac{1}{2} C V^2 f, \tag{1}$$

where, C is the solar array/panel capacitance, V is the bus voltage and f is the frequency of charge controller. Therefore, AC parameters, in particular, the solar cell capacitance is an important parameter in the design of fast acting and reliable charge controller. The solar cell capacitance includes two types of capacitances: (i) transition capacitance (C_T) and (ii) diffusion capacitance (C_d). Transition capacitance (C_T) is caused by the charges stored inside the space charge region and is given by [2]

$$C_T = A\sqrt{\frac{eN\varepsilon_0\varepsilon_r}{2(V_{bin} - V_d)}}, \tag{2}$$

where, A is the area of solar cell ($1\,\text{cm}^2$), e is the charge on electron, 1.602×10^{-19} C, N is the doping concentration, ε_0 is the permittivity of free space, 8.85×10^{-12} F/m, and ε_r is the permittivity of the semiconductor material (for $CuInSe_2$, $\varepsilon_r = 3.9$). The transition capacitance of solar cell can be expressed in terms of current as [2]

$$C_T = \frac{I}{(dV/dt)_{V=V_b}}. \tag{3}$$

The diffusion capacitance (C_d) is present due to the charges stored inside the bulk region or base region of solar cell. It is calculated from the effective carrier lifetime (τ) with the equation [2]

$$C_D = \frac{\tau}{R_P}, \tag{4}$$

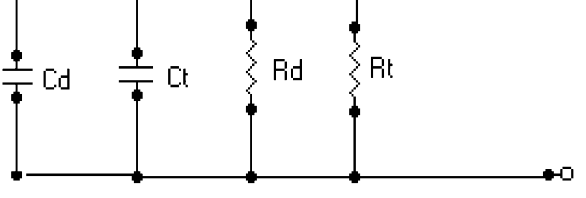

Fig. 1. AC equivalent circuit of solar cell.