A NOVEL TECHNIQUE FOR PHOTOVOLTAIC MAXIMUM POWER POINTTRACKING SYSTEM

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Abstract

Maximum power point tracking (MPPT),used in photovoltaic(PV) systems to maximize the photovoltaic array output power, irrespective of the temperature and irradiation conditions and of the load characteristics. In this paper a new MPPT system has been proposed consists of newly developed flyback type converter of a flyback transformer for high frequency linkage and synchronous switches for the connection to the AC utility grid and a maximum power point tracking (MPPT) controller without a current sensor .In this project the generated power of the PV array can be calculated by the equation using the voltage of PV array .The proposed PV power system which consists of two or more inverters ,can get large power than the conventional one, when the PV array is partially shaded by some constructions

Introduction

As conventional sources of energy are rapidly de-pleting and the cost of energy is rising, photovoltaic energy becomes a promising alternative source. Since it has some of the advantages i.e available in bulk, free of cost, Pollution free and Distributed throughout the earth. The main drawbacks are that the initial installation cost is considerably high and the energy conversion efficiency is relatively low. To overcome some of these problems, the following two essential ways can be used: 1) Increase the efficiency of conversion for the solar array and 2) Maximize the output power from the solar array.

The main reasons for the low electrical efficiency of photovoltaic systems are the nonlinear variation of output voltage and current with solar radiation levels, operating temperature, aging and load current. To overcome these problems, the maximum power point of the PV system (at a given condition) is tracked using on-line or off-line algorithms and the system operating point is forced toward this optimal condition by sensing both voltage and current[1],[2],[4],[5]. This paper presents a newly developed inverter consists of a fly back transformer for high frequency linkage and synchronous switches for the connection to the AC utility grid line with a MPPT system. The feature of the new system is both the simplicity of main circuit comparing[1],[2] to conventional ones by the reduction of switching devices and no expensive DC current sensor to control MPPT.In the proposed system ,there is no high frequency earth leakage current at all ,because the transformer can isolate the ground level between the PV array and utility grid line .In this system PC senses the voltage changes, then converts analogue signal in to digital which is used for the calculation of power .The DC current is estimated from the capacitor voltage in parallel to PV array and the switch on duration of the main switch[3] .Because MPPT requires the PV output power value that is given by the product of the PV voltage and current. Finally, we construct the parallel inverter system in which the outputs of inverters connect each other and show that the parallel system can get larger power than the conventional one when the PV array is partially shaded by some constructions

Proposed System

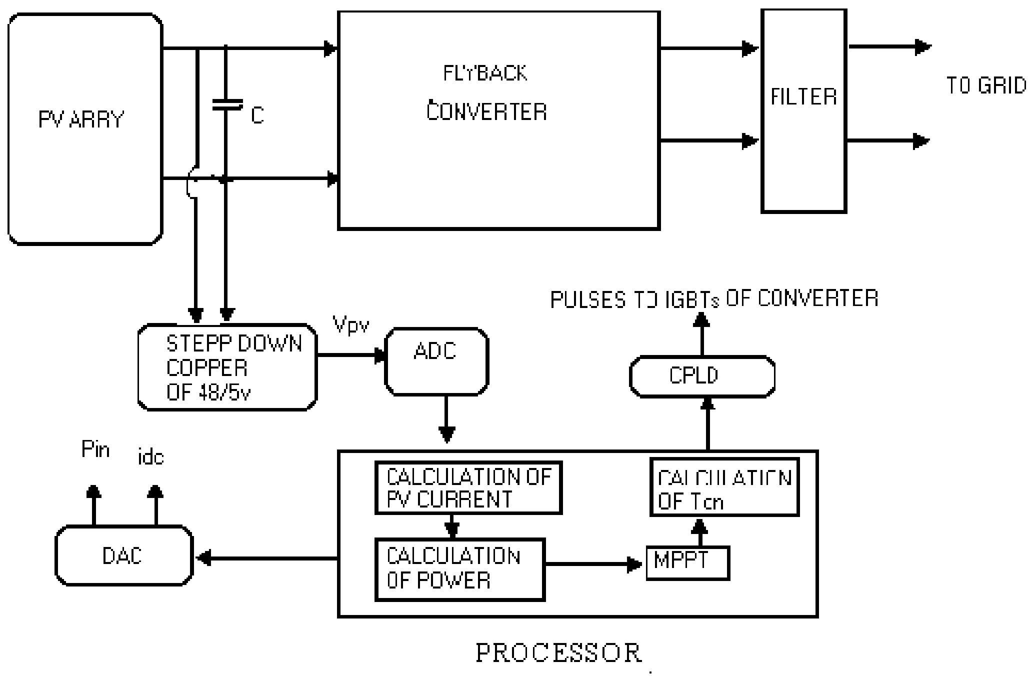

Fig .1 System block diagram

Fig 1 shows the proposed system configuration. Here to track the maximum power point, the PV power is controlled by the duty ratio of DC-DC converter in the conventional system. However, the duty ratio controls the wave form of the output current and a pulse train in one cycle of the grid frequency is determined to keep the wave form of the out put current sinusoidal in our proposed system. Therefore, the sampling rate of MPPT must be synchronized to the utility grid line frequency. To control the output power under these conditions, each duty ratio of the pulse train is calculated by multiplying a load factor to each duty ratio of the pulse train at the rated power. The process is as follows: At the beginning of it the voltage of PV array is detected through the A/D converter .The input power P_n is detected from PV voltage & PV current estimated from the following equations

PV current i_{dc} is given by the summation of the capacitor current i_c and the inductor current i_l ,as follows

$$i_{dc}=i_c+i_l \qquad 1$$

When the above equation is integrated in the term of switching time T_{sw} , the equation is shown as

$$\int_0^{Tsw} idc = \int_0^{Tsw} icdt + \int_0^{Tsw} ildt \qquad 2$$

Where $\int_0^{Tsw} idcdt = i_{dc}T_{sw}=Q_{dc}(k)$

$$\int_0^{Tsw} icdt = i_c T_{sw}=Q_c(k)$$

$$\int_0^{Tsw} ildt = i_L T_{sw}=Q_L(k)$$

If Vc(k) and Vc(k-1) be capacitor voltages at the end and beginning of k^{th} term

Then $\int_0^{Tsw} icdt =Q_c(k) =C\{ Vc(k) - Vc(k-1)\}$

If there is N samples in one cycle of frequency f then

$$i_c= fC \sum_{K=1}^{2N}\{Vc(k)-Vc(k-1)\}$$

If resistance of the inductor ignored then inductor current is given by

$$i_L =\frac{Vc(k)}{L}t+i_0(k)$$

Where $i_0(k)$-initial inductor current(ie zero b/s control is based on discontinues mode)
There for average inductor current for one cycle of frequency of N samples is given by

$$i_L= \frac{f}{2\ L} \sum_{K=1}^{2N} Vc\,(k)ton\ \hat{}\,2(k)$$

There for PV Current is given by

$$i_{dc}=i_c+i_L=fC \sum_{K=1}^{2N}\{Vc(k)-Vc(k-1)\}+\frac{f}{2\ L} \sum_{K=1}^{2N} Vc\,(k)ton\ \hat{}\,2(k)$$

Where ic, il are the current flowing through the capacitor and inductor L, v_{dc} is input voltage and t_{on} (k) switch duration of k^{th} pulse.

PV array output is estimated only by the PV array voltage because the inductor current is controlled with open loop. The processor compares the power P_n to the P_{n-1} that were calculated at the previous sampling .To get larger power than previous sampling, the load factor is determined to increase or decrease .Fig 3 shows the flow chart the interrupt routine of MPPT with out a current sensor

Fig 2 shows the proposed flyback type inverter system used here .The proposed inverter is one of high frequency link inverter. In this system, a photovoltaic array and a flyback type chopper circuit is connected in anti-parallel diodes with a filter capacitor C_2 and inductor L_f , which generates the alternating voltage.

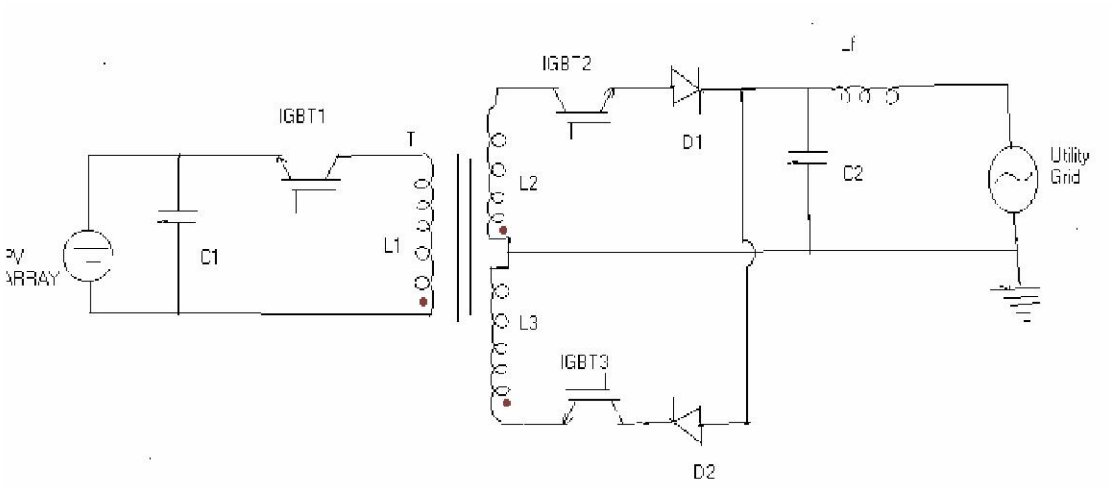

Fig.2 Circuit diagram of proposed inverter for photovoltaic system

It operates in three modes .The mode 1 is defined for the situation where IGBT1 of n system is on state and all the other IGBTs of system are off state condition .In other words ,the PV array energy is transferred to the transformer and the stored energy in the output capacitor is discharged to the utility grid line giving positive polarity .The mode2 is defined for the duration when the upper IGBT2 of the system is in on state and the rest are at off state condition, implying that both the stored energies of transformer and output capacitor of the system is released to the AC utility grid line giving a positive polarity .The mode 3 is the negative polarity conditions against mode 2.

Calculation of Transformer Inductance L

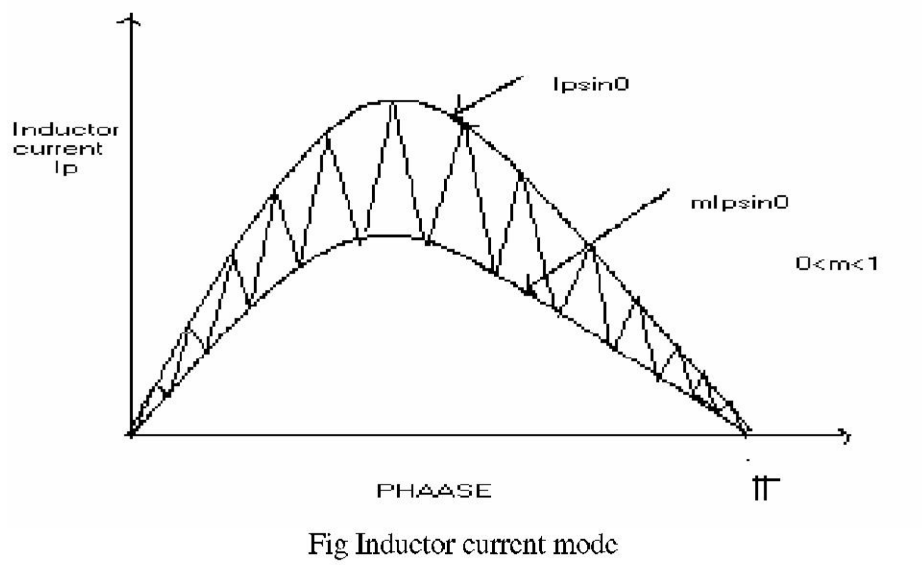

Fig Inductor current mode

From the Fig3, the waveform of current across the inductor the switch on period of IGBT given by

$$t_{on} = \frac{(1 - m)\, LIp}{Vdc} \qquad 3$$

The switch off period of IGBT given by,

$$t_{off} = \frac{(1 - m)\, LIp}{1.414\ Vac} \qquad 4$$

But total period (T) is the sum of switch on period of IGBT and switch off period of IGBT. There for T is given by

$$T = t_{on} + t_{off} = 2Nf \qquad 5$$

Where N is the number of samples, f is the required frequency of output waveform By the equations (3),(4)&(5) inductance of transformer of fly back converter is given by

$$L = \frac{1.414\, Vdc Vac}{(1 - m) 2 N f Ip\, (Vdc - 1.414 Vac)} \qquad 6$$

Calculation of Switch on Duration

The inductor current at the arbitrary section number k is expressed as the function of time t, given by

$$I_b = I_p \sin\{\theta(k\text{-}1) + 2\Pi ft\} \qquad 7$$

Where θ -is a section in electrical angle

t- The time from the start point of k^{th} term in second- Utility grid frequency

As $2\Pi ft$ is small value i_L next approximation is given by

$$i_b = Ip\,\{\sin\theta(k\text{-}1) + 2\Pi ft \cos\theta(k\text{-}1)\} \qquad 8$$

On the other hand

$$i_L = \frac{Vdc - Vth}{R1} - \left(i_{L0} - \frac{Vdc - Vth}{R1}\right) e^{-\frac{R1}{L} t} \qquad 9$$

Where Vth & R1are the threshold voltage and slope –on –state resistance of IGBT1 respectively.

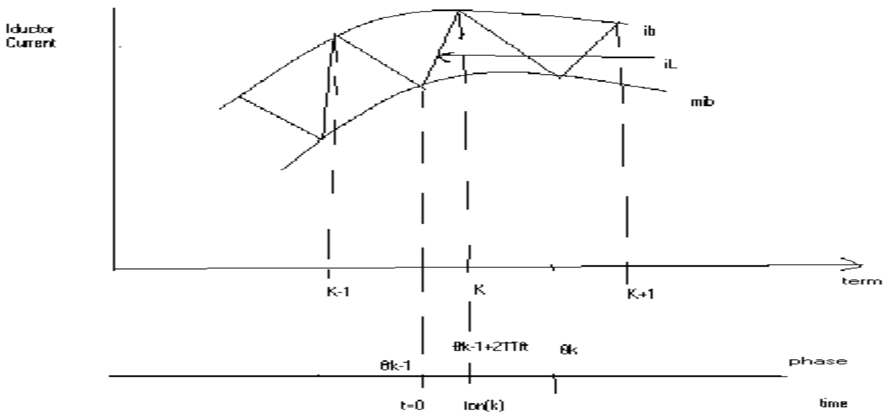

Fig 5.Waveform of Inductor current

As t is very small

$$i_L = \left(\frac{Vdc - Vth}{R1} - i_{L0}\right) \frac{R1}{L} t + i_{Lo} \qquad 10$$

When the intersection i_L & i_b is set to the switch on duration ton(k) for k^{th} pulse, given by

$$t_{on}(k) = \frac{iL0 - Ip\sin\theta(k-1)}{2\Pi f Ip\cos\theta(k-1) + (iL0/L - Vdc + Vth)} \qquad 11$$

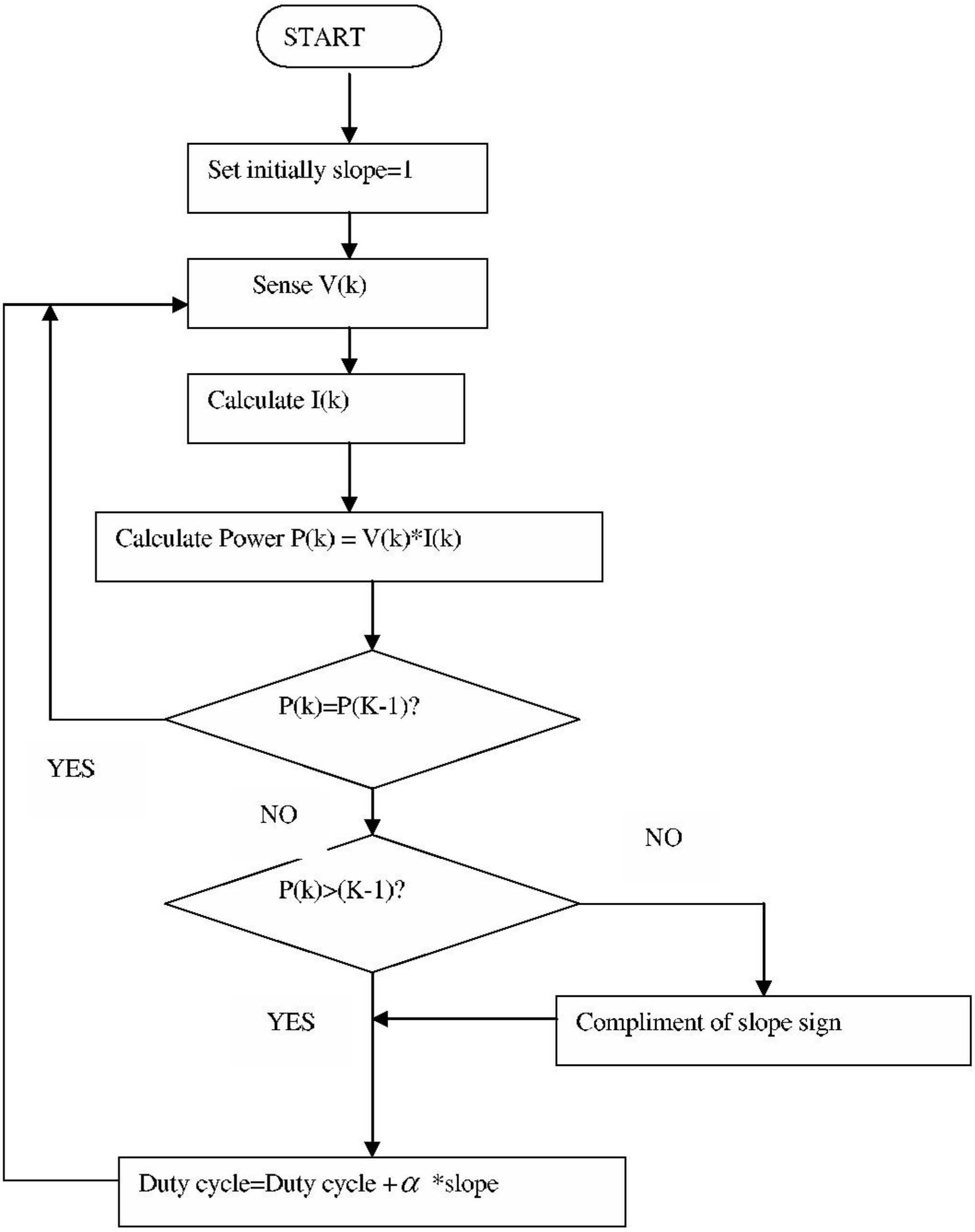

Fig 6 Flowchart of the interrupt routine of MPPT without Current sensor

Simulation Results

Fig (6), Fig (7), Fig(8), Fig(9), Fig(10),and Fig(11) shows the simulation results of output voltage, out current, sampled output voltage, sampled out current, variation of power with the voltage and variation of current with the voltage of PV array of 48V respectively

Conclusion

We proposed a newly developed flyback type inverter and a maximum power point tracker with out a current sensor. Also it can be constructed the parallel inverter system in which the outputs of inverters connect each other ,and the parallel system can get larger power than the conventional one when the PV array is partially shaded by some constructions

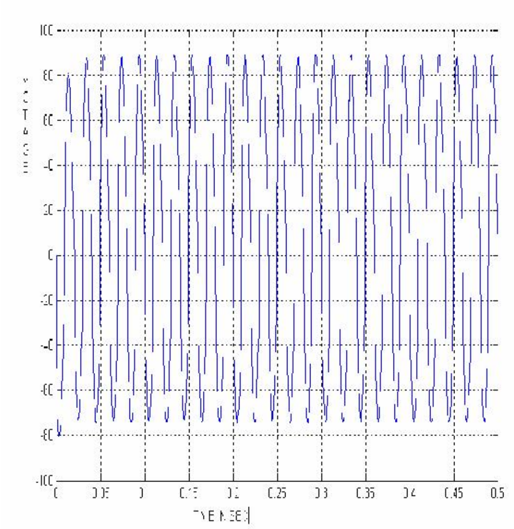

Fig 6. Output Voltage Waveform

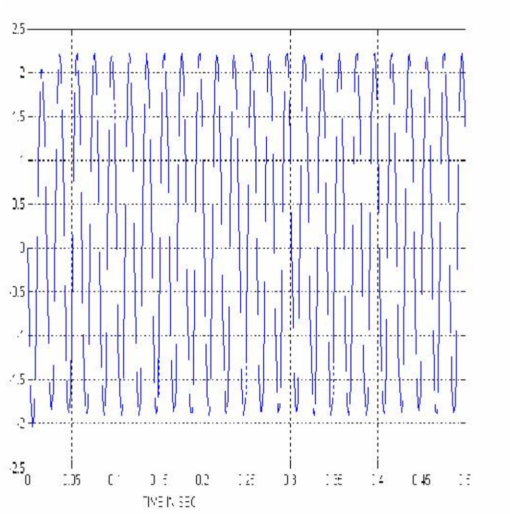

Fig 7.Output Current Waveform

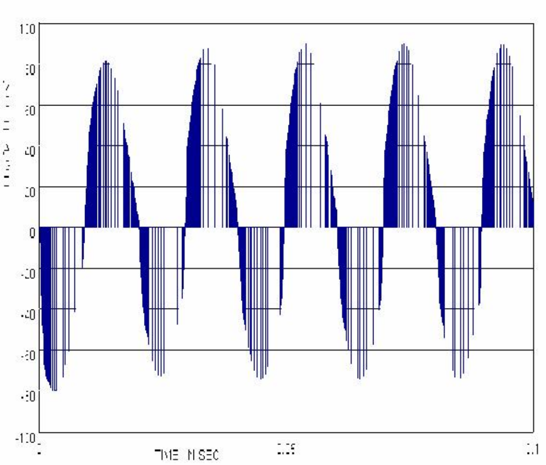

Fig 8.Out Put Voltage Waveform Showing the Samples Taken

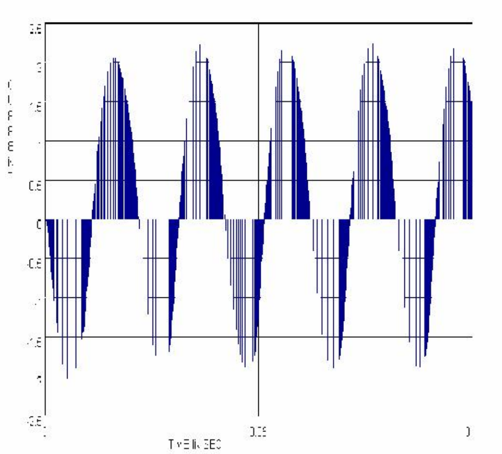

Fig 9.Out Put Current Waveform Showing the Samples Taken

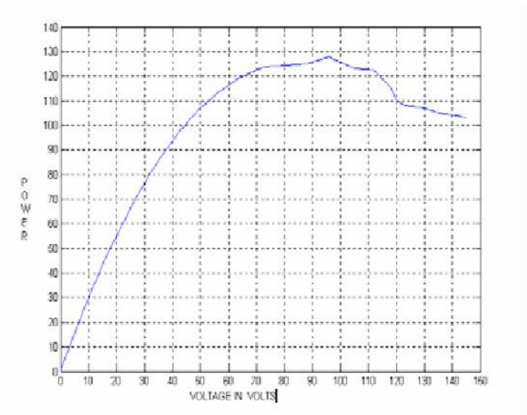

Fig 10.Power V/S Voltage Waveform

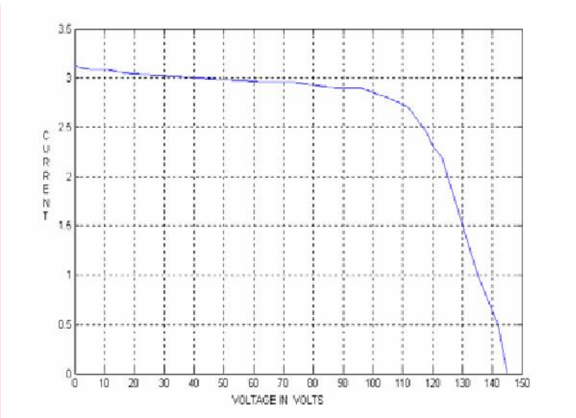

Fig .11. I-V Characteristics of PV array

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