Maximum power point tracking strategy of disturbance Solar Panels output current

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Abstract. Because the output of solar panels is influenced by external environment easily, and in order to ensure the energy generated by solar panel can be used as much as possible, so the maximum power point tracking technology is particularly important. In this paper, to achieve the maximum power point tracking of the solar panel output through the flyback converter. Using the method of perturbation the output current of the converter, though adjusting the duty ratio of flyback converter switch makes solar panels to the maximum power output. It has the advantages of simple structure, low cost and high efficiency. This control strategy can be applied to a system that has variety of energy supply.

Introduction

As the stage of solar panels on the conversion efficiency of light is relatively low, the output characteristics are nonlinear, and because of the change of the outside temperature, light and other factors on the impact to the output, the output voltage and power are instability. In order to make full use of the solar panels generate electricity, we must track its maximum power point to make the solar panels can output its maximum power [1].

In addition, because of the instable power outputted by solar panels, unable to load in a stable working condition in solar independent power supply systems, so other energy are needed to supply energy to load with solar panels together, such as batteries, electric, fuel cells.

At this stage, the maximum power point tracking technology of solar panels have been relatively mature. Control algorithms commonly used are: constant voltage method (CVT), perturbation and observation method (P&O), the incremental conductance method (I&C) and fuzzy logic control method and so on [2]. Those control algorithms achieve maximum power point tracking by controlling the output voltage of solar panels. However, to the solar panels and other energy combined power supply system, in order to ensure the load to be able to get a stable voltage and power, usually adopts double closed loop control. Current loop as the inner loop to control the solar panels output maximum power and the voltage loop as the outer loop to control the load can have a stable voltage [3]. This paper mainly discusses the maximum power point tracking through disturbance the output current of solar panels. The most fundamental is by changing the flyback converter switch duty ratio relation to achieve maximum power point tracking.

The characteristics of solar panels

The output characteristic equations of solar panels are:

$$I_{PV} = I_{ph} - I_D - \frac{U_{OC} + I_L R_S}{R_{sh}} = I_{ph} - I_O \left[\exp\left(\frac{q(U_{OC} + I_L R_S)}{AkT} \right) - 1 \right] - \frac{U_{OC} + I_{PV} R_S}{R_{sh}} \tag{1}$$

$$I_O = I_{do} \left(\frac{T}{T_{ref}} \right)^3 e^{[\frac{qE_g}{nk}(\frac{1}{T_{ref}} - \frac{1}{T})]} \tag{2}$$

$$I_{ph} = I_{SC} \left(\frac{S}{1000} \right) + C_T (T - T_{ref}) \tag{3}$$

$$I_{SC} = I_O[exp\frac{qU_{OC}}{AkT} - 1] \tag{4}$$

In these equations: I_{PV} is the output current of solar panels; I_{ph} is photo-generated current; I_D is dark current; I_O is the reverse saturation current; I_{SC} is the short circuit current of solar panels; U_{OC} is the output voltage of the solar panel; q is the electron charge, 1.6×10^{-19}C; A is the diode emission coefficient; K is the Boltzmann constant, 0.86×10^{-4}eV/K;T is the cell temperature, the absolute temperature; T_{ref} is the absolute zero temperature, -297℃; R_S is the equivalent series resistance; R_{sh} is the equivalent parallel resistance; I_{do} is the reverse saturation current; $E_g$is the Department of energy; S is illumination intensity; C_T is the temperature coefficient [4].

Strategy of maximum power point tracking by controlling output current of solar panel

Commonly used maximum power point tracking algorithm is by controlling the output voltage of solar panels to achieve the maximum power point tracking [5]. But in the system of solar and other energy combined power supply, control the output voltage of the solar panel is not conducive to design the double closed loop control system. The control strategy of maximum power point tracking by control the output current is proposed based on this. Following is analysis of its working principle.

As can be seen from theEq.1, output current of solar panels I_L is a function with the output voltage U_{OC} as independent variable, i.e. $I_L=f(U_{OC})$.

$$U_L = \frac{N_2}{N_1}\frac{D}{1-D}U_{OC} \tag{5}$$

In Eq.5, D is the flyback converter switch duty ratio; U_L is the voltage across the load;$N_1$is the transformer primary winding; N_2 is the transformer secondary winding [6].

Hypothesis devices in flyback converter are all ideal devices, no loss, so output power equal to input power. The output power of the solar panel, i.e. the input power of flyback converter is:

$$P_{in} = U_{OC}I_{PV} = U_L\frac{N_1}{N_2}\frac{1-D}{D}I_{PV} \tag{6}$$

Suppose:

$$P^*_{flyback} = \frac{N_1}{N_2}\frac{1-D}{D}I_{PV} \tag{7}$$

So

$$P_{in} = U_L P^*_{flyback} \tag{8}$$

Because the voltage across the load U_L is stable, so the relationship of input power P_{in} and $P^*_{flyback}$ is proportional. When $P^*_{flyback}$ is maximum value, the P_{in} is maximum value too [7]. As can be seen from theEq.7 and Eq.8, when P_{in} and $P^*_{flyback}$ are all maximum value, the switch duty ratio is the same, so we can control the duty ratio of switch to achieve maximum power point tracking [8].

Fig. 1 is a flow chart of the algorithm of maximum power point tracking of solar panel by controlling output current.
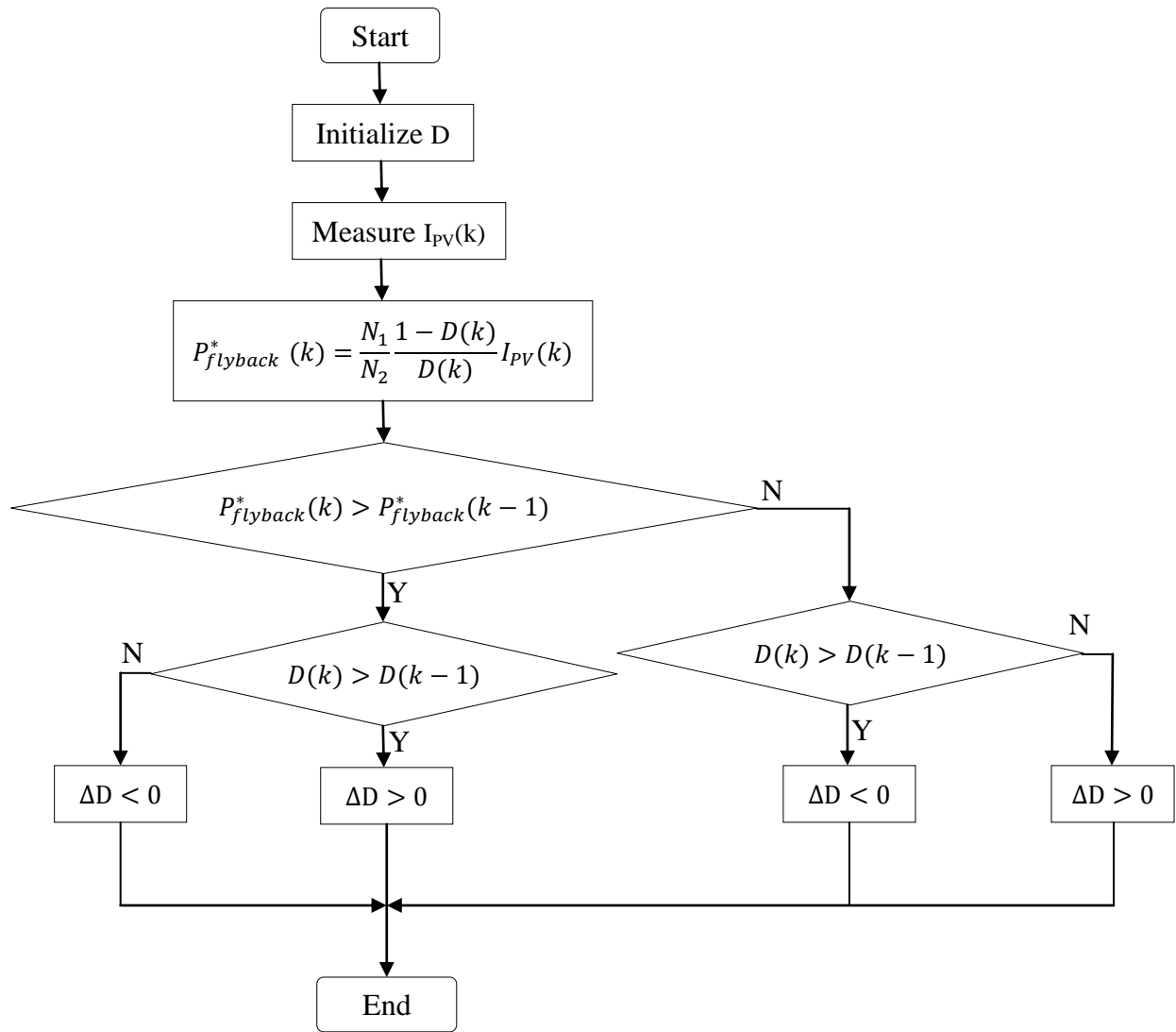
```
                    ┌─────────┐
                    │  Start  │
                    └────┬────┘
                         ▼
                    ┌──────────────┐
                    │  Initialize D │
                    └──────┬───────┘
                           ▼
                    ┌──────────────────┐
                    │  Measure I_PV(k)  │
                    └────────┬─────────┘
```

$$P^*_{flyback}(k) = \frac{N_1}{N_2}\frac{1-D(k)}{D(k)}I_{PV}(k)$$

$$P^*_{flyback}(k) > P^*_{flyback}(k-1) \quad\quad N$$

$$Y \qquad\qquad D(k) > D(k-1) \qquad\qquad N$$

$$N \qquad D(k) > D(k-1) \qquad Y$$

| $\Delta D < 0$ | $\Delta D > 0$ | | $\Delta D < 0$ | $\Delta D > 0$ |

```
                    ┌─────────┐
                    │   End   │
                    └─────────┘
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Fig. 1 Flow chart of the algorithm of maximum power point tracking of solar panel by controlling output current

Simulation and results analysis

Using matlab/simulink build a simulation model of the solar panel to verify the effectiveness of the maximum power point tracking control strategy.Fig.2 is the output power curve of solar panels when illumination is 1000 W/m^2 and temperature is 25℃.
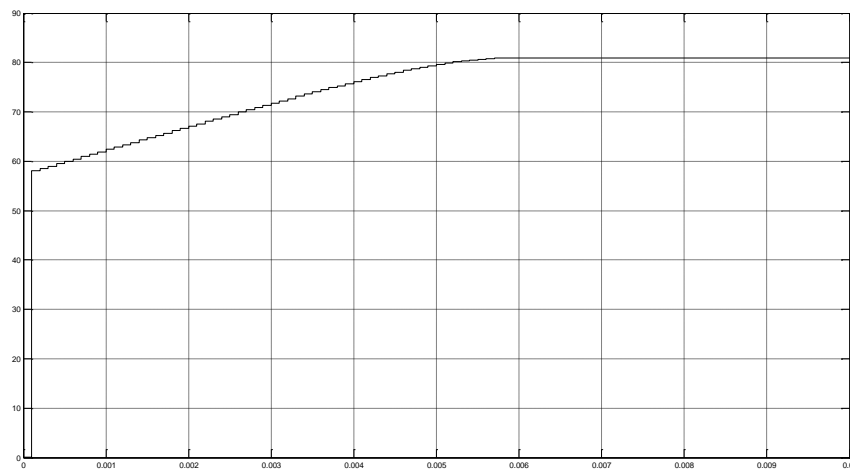

Fig. 2 Solar panel output power under control the output current

As can be seen from fig. 2 using the method of controlling the output current can achieve maximum power tracking. The output power of the solar panel reaches the maximum value requires a certain amount of time. When the output power of the solar panel reaches to its maximum power, the fluctuation is very small. The output power remains at the maximum value nearby basically unchanged.

Summary

This paper mainly studies the control strategy that though control of output current of solar panel to realize the maximum power point tracking. By adjusting the duty ratio of the switch in flyback converter to achieve control the solar panel output current. Through the use of matlab/simulink simulation results verify the feasibility of the control strategy. This control strategy makes the control of energy distribution in solar and other energy supply system easily, and is conducive to the promotion and use of solar energy.

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