Research on the method about designing of solar-wind complex generation street light system and the enhancement of the reliability of its power system by realizing MPPT maneuver using DSPIC30F4013

Kang Kyong-Mo[a], Ri Un-Chol[a*], Kim Yun-Chol[b], Kim Shong-Jae[b] , Ri kyong-Ju[a], Cho Zhongo-Huan[a]

[a] **Ham Hung University of hydraulics and power ,Ham Hung , Democratic People's Republic of Korea**

[b] **Kim Chaek Industrial University, Pyongyang , Democratic People's Republic of Korea**

AUTHOR or CONNETION INFORMATION

* E-mail: riunchol927@126.com

ABSTRACT

This article describes the design principles, design conditions, and design methods of combined wind power and solar power generation system, and discusses a new method for improving the Increasing trust of solar-wind complex generation street lighting system by DSPIC30F4013.

In addition, by using the characteristics of this piece with four PWM control outlets, it is possible to smoothly perform the MPPT control of several DC-DC converters, to give a new steering algorithm, and to control the DC-DC converter To improve the stability and the life of the battery, thereby raising the trust level of thesolar-wind complex generation street lighting system.

1. Introduction

The reality of today, which requires more energy due to the gradual depletion of fossil energies and the continuous development of the economy, requires the wider use of various renewable energies.

Wind energy and solar energy can be said to account for a large part of them.

However, wind and solar energy are subject to many factors such as climate, season, natural environment and weather.

Wind turbine, solar power generation, and power utilization efficiency improvement are important advances in terms of new energy generation technologies.

From this, it is important to reasonably determine the output of the wind turbine generator, the output of the Solar Board, and the capacity of the battery so that the power system using the wind and solar energy in each environment and conditions produces the most stable output.

It also must rationalize the control system such as MPPT steerable DC-DC converter and its pilot program.

2. Design rule of hybrid wind and photovoltaic power system

Design of hybrid wind and photovoltaic power system is consist of 2 parts, are system design and device design.

The important purpose of system design of hybrid wind and photovoltaic power system is to calculate number of photovoltaic panel array, wind turbine and battery of the system can act reliably, also, it is to calculate relation between the best reliability and cost, that is, it is to take system reliability into best and system cost into smallest.

Generally, device design progress selecting suitable equipments, it is consists of photovoltaic panel determination, wind turbine determination, inverter determination, cable determination, bolster determination, design of control measure system, arrester and design of power supply system. Therefore, in the design of the hybrid wind and photovoltaic power system, must consider just synthetically system design and device design.

In the each other different hybrid power system, their contents are not equal. Designs of off-grid hybrid power system and grid-based hybrid power generation system will be different.

Off-grid scenery and complementary wind power generation systems and grid-based hybrid wind power generation system design methods and considerations.

Before the wind and solar power generation system design, need to understand and get some basic data necessary for calculations and equipment selection. Such as wind and solar power generation system installed location, include location, latitude, setting accuracy and altitude, weather information for the area, monthly total solar radiation, direct radiation and scattered radiation, annual average temperature and maximum, minimum temperature, the longest continuous rainy days, the maximum wind speed and hail, snow and other special weather conditions.

1) Hybrid wind and solar power generation system design must have three basic conditions.

(1) Local wind energy resources and solar resources, such as sunshine intensity, temperature, wind speed and other basic resource data；

（2）Load equipment configuration, power, power source supply voltage range, load characteristics, whether the continuous power supply；

（3）Power characteristics of wind turbines and solar cells.

2) System design contents

（1）Load characteristics, power and power consumption statistics and related calculations；
（2）Calculation of daily average wind power generation；
（3）Solar cell square daily average power generation calculation；
（4）Battery capacity calculation；
（5）The optimal design matching between wind turbines, photovoltaic panel modules and batteries；
（6）Determination of the angle of solar cell array installation；
（7）System operation forecast and system economic benefit analysis.

3) Device design content

（1）Selection of wind turbines, photovoltaic panel modules, controllers, inverters and batteries；
（2）Foundation design of installation of photovoltaic panel modules and wind turbine, bracket structure design, installation process design, selection and design of power supply and other ancillary equipment；
（3）Program and device of control and monitoring system.

3. Streetlight design of hybrid wind and photovoltaic power system used DSPIC30F4013

1）Design reference basis

（1）This system must take advantage of wind and solar renewable energy, ensure uninterrupted power supply throughout the year, is powered continuously for 3 days without continuous wind and solar energy supplementation.

（2） Suitable environmental working conditions：temperature -15~45℃; relative humidity 93％;

altitude 10~500m ；annual mean wind speed 3.5m/s or more; wind speed 2~30m/s；moment extreme wind speed 40m/s.

（3）Supply voltage：DC12V/24V.

（4）Load condition：30W streetlight 1，Average 7 hours work.

2）Design process

（1）Battery capacity

If load is under full load， Requirements of the battery after full charge must be sustained to provide 3 days of load power.

$$Ptd = (UCD_c)\eta \qquad (1)$$

Here P-total power of load，Ah；t- Daily using hours, h； d- Self-sufficiency days；

U- Battery voltage, V； C- Battery capacity, Ah； η- Circuit loss, take 0.9;

D_c- Battery discharge depth，take 70％.

Therefore, $30 \times 7 \times 3 = 12 \times C \times 0.7 \times 0.9$ C=83Ah

Use a standard battery 85Ah/12V.

（2）Power determine of wind turbine

Because the average annual wind speed 3.5m / s or more， wind speed 2~30m/s，Instantaneous limit wind speed 40m / s, Therefore, Belongs to a rich area of wind energy resources，determine the amount of electricity provided by solar cell power generation into 1/3 of the total consumption, the amount of electricity by wind power into 2/3. When the Solar cells can not generate electricity by weather condition and continuous rainy days, the wind turbine takes over entirely.

$$P_1 \times 20 \times 4h/d = (UCD_c)\eta + Ptd \qquad (2)$$

Here，total system power is $P = 30W/0.9 = 33.3W$, monthly wind power provides electricity for 20 days.

$$P_1 \times 20 \times 4 = 12 \times 85 \times 0.7 \times 0.9 + 33.3 \times 7 \times 20 \qquad P_1 = 67.2W$$

According to wind turbine standard and the actual installation and use reliability，take $P_1 = 100W$. Actually, use a wind turbine.

（3）Determine of Solar cell power

Based on weather data and there natural environment, take sun exposure time into 6h/d.

Total system power is $P = 30/0.9W = 33.3W$, monthly wind power provides electricity for 10 days.

$$P_2 \times 10 \times 6h/d = (UCDc)\,\eta + Pt \times 10 \qquad (3)$$

$$P_2 \times 10 \times 6h/d = (12 \times 85 \times 0.7) \times 0.9 + 33.3 \times 7 \times 10 \qquad P_2 = 49.5W$$

According to the standard of solar cells and convenient installation, take $P_2 = 50W$

（4）Controller selection

According to the load needs，controller capacity must be greater than or equal to the total power consumption. This system select and use 50W hybrid wind and photovoltaic power controller possessed completely protecting function.

Table1. The main equipment parameters of wind and solar power system with horizontal axis wind turbine

Device name	Models and standards	Quantity	Equipment size and features
wind turbine	100W, 12V	1	10m/s, 6kg, diameter 1.2m, permanent magnet wind turbine，starting wind speed 2m/s, safe wind speed 50m/s, maximum power 130W
battery	12V, 85Ah	1	
photovoltaic panel	50W, 12V	1	755×54×30mm, highest voltage 17.28V
controller	50W	1	

（5）Control system

Control system has power main circuit and control circuit. Power main circuit is consists of the wind turbine, photovoltaic panel, batteries, two DC-DC converter for MPPT of wind turbines and photovoltaic panel, a battery charge management control DC-DC converter, rectifier, load.

Control circuit is consists of sensing circuit for each part voltage and current, PWM control circuit, unload the load and control circuit, DSPIC30F4013 with a few PWM control terminal.

Switching elements are used RFP054 and IRF540.

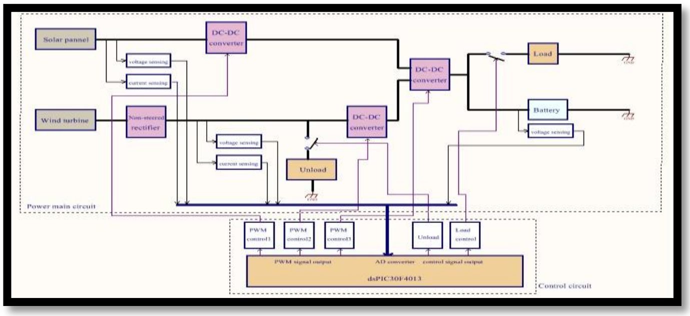


Fig 1. The overall control system diagram

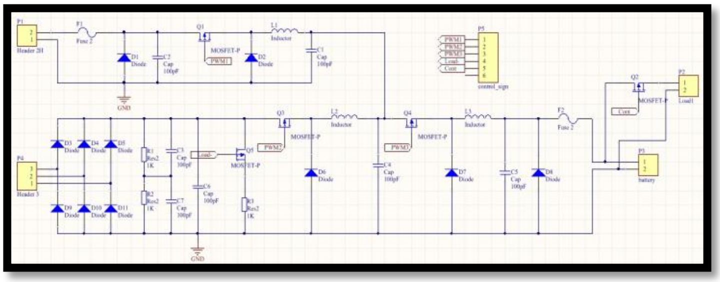


Fig2. Power main circuit

(6) Control circuit

The most important part of the control circuit is the DSPIC30F4013 configuration. The terminal arrangement can be given as follows.

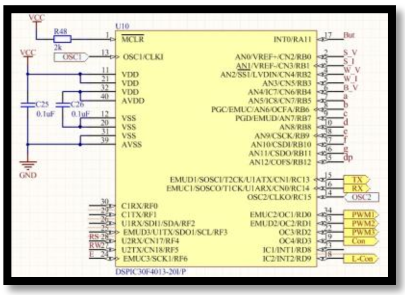
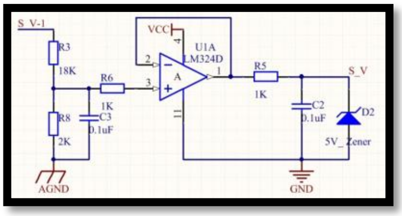


Fig 3. terminal arrangement of DSPIC30F4013

Current can measure using sensor AC712 or LT108-S7. The voltage is measured with LM324 and voltage stabilizer, output 5V or less using voltage division.



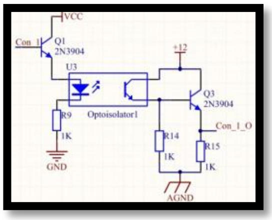


Fig 4. Voltage sensing circuit Fig 5. Output control circuit

The output control circuit separates the control board and the analog sides by a light coupling element and a ground.

PWM output control circuit can make up by LM324 and light coupling element. In the protection side of control circuit, ground is divided into analog ground and digital ground. There is a coil between the two grounds.

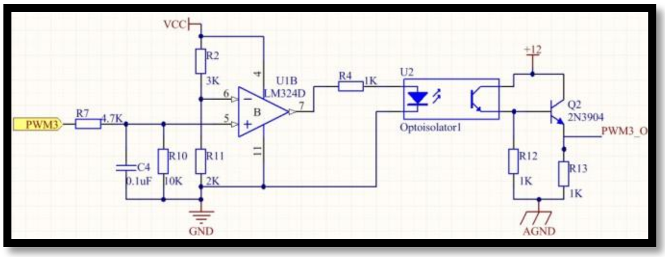


Fig6. PWM output control circuit

Display circuit made up by LCD1602.

MPPT control algorithm is following.

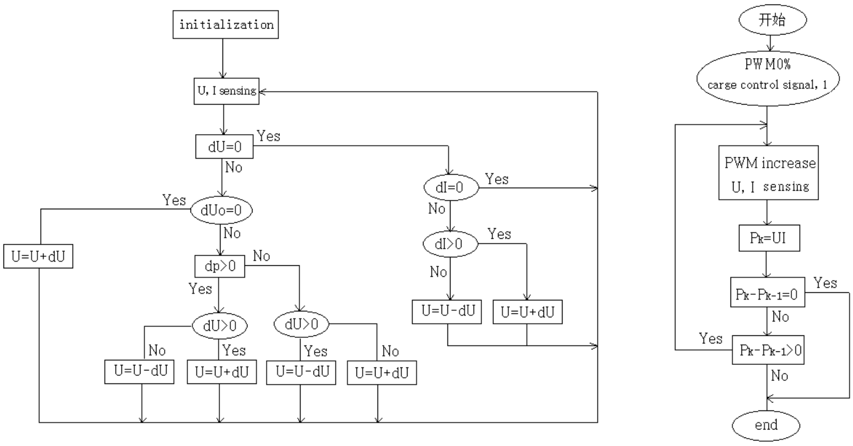
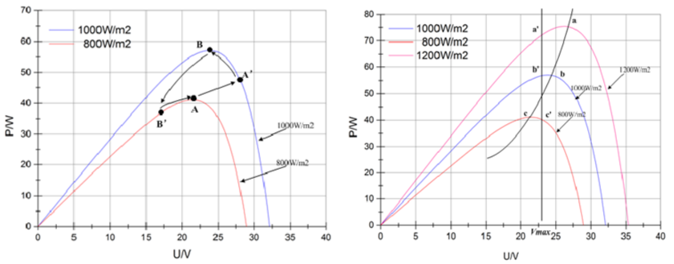


Fig7. MPPT control algorithm

4. Results Analysis

The output power of the Solar Board by the MPPT pilot program flow chart is manipulated as follows in the designed system.



a) b)

Figure 8. MPPT outlet output characteristic curve of Solar Board

When the light intensity changes from 800W / m2 to 1000W / m2 and again to 800W / m2 in a of Fig. 8, the output steering point moves to A - A '- B - B' - A.

That is, it tracks only the maximum value of the output curve.

When the light intensity is changed to 900W / m2, 500W / m2, 800W / m2, the MPPT steered DC / DC converter outlet of the Solar Board is shown in Fig. b) with the following characteristics.

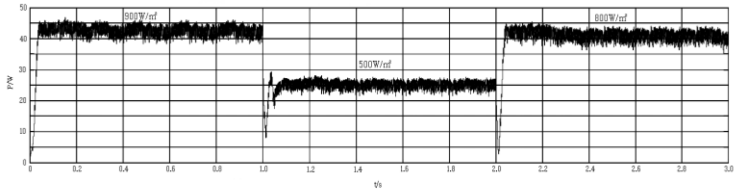


Figure 9. MPPT Steering DC / DC Converter outlet Measurement Waveform of Solar Board

The wind turbine also achieves MPPT control by the steering algorithm using the PWM control output of the DSPIC30F4013. When the wind speed changes to 10m / s, 8m / s and 10m / s, the DC / DC converter output power measurement waveform of the wind power generator is as follows.

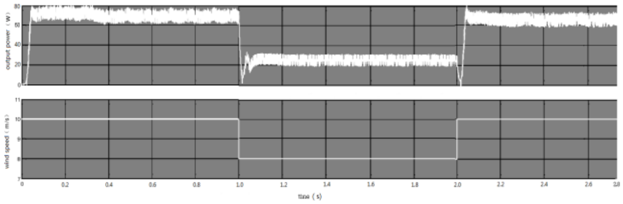


Figure10. Converter output power measurement waveform of the wind power generator

The other PWM outlets on the 30F4013 control the charge of the battery to ensure system stability and battery life. In normal operation, the charge current is controlled by a constant method.

Below we have shown the battery charge process measurement waveform of a system that is charged to 100% at 40% capacity.

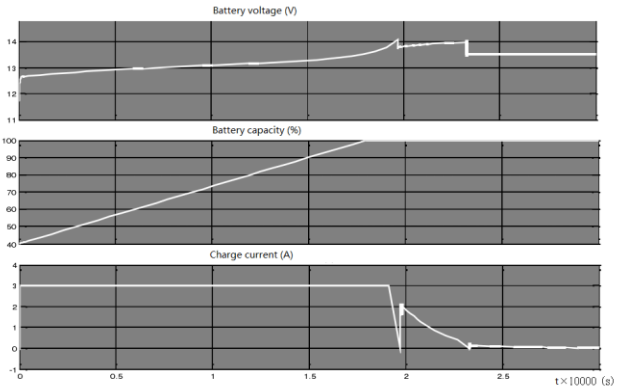


Figure11. Battery charge process measurement waveform

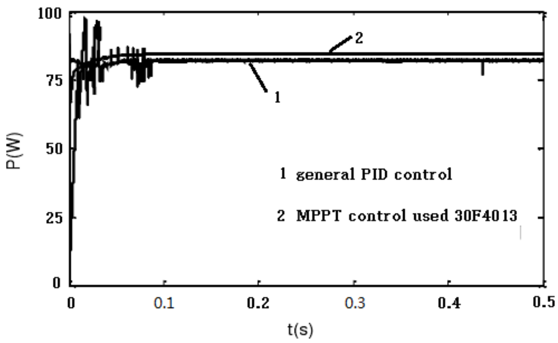
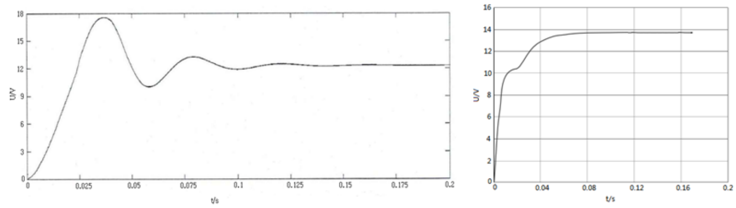


Figure 12. Analysis of output stability of system compared with conventional PID control



a) General PID control b) 4013 MPPT control

Figure 13. Voltage stability analysis of system compared with conventional PID control

5. Conclusion

In this study, design method of hybrid wind and photovoltaic power system of the each other differentarea and surroundings is described comprehensively. Through using of DSPIC30F4013 possessed 4

PWM functions realize MPPT control and charge contol, improve reliability of system, decrease cost of the control device.

The results of this study can be helpful in research to improve the reliability of the wind power and solar combined street lighting system.

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