Electrical charge and discharge characteristics of battery under remote control of water level with PV pumping system

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Abstract. This paper presents introduction and load characteristics of stand-alone PV pumping system, which was especially designed for rice planting irrigation of small form units, under remote control of water level. By application of these systems, it is expected to increase agricultural fresh water reuse, and to save labor for water management. The feature of this system is simplicity with having the control function of matching to weather condition. We confirmed remote control of water level by using batteries under cloudy.

Keywords
PV pumping system, rice irrigation, weather control mode, water level, remote control

1. Introduction

The purpose of this study is to research the practical use of PV pumping system for rice planting irrigations that conforms small farming units. The application model of PV pumping system is shown in Fig.1. Rice plantings in paddy field require a lot of fresh water. The water management of rice planting in Japan is mainly to keep water depth, changing its level as rice plants grow. Main factors of water level control are irrigation input, drainage output, rainfall, evaporation, transpiration, percolation and leakage. We have examined remote control of water level for rice plantings by using PV pumping system.

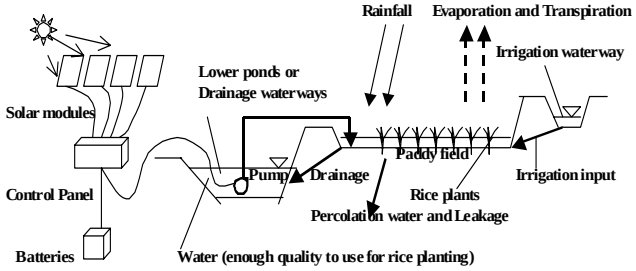

Fig.1 Application model of PV pumping system for rice planting irrigation

2. Experimental Apparatus

A. PV pumping system

We made an experimental system making use of the characteristic between solar modules' current and irradiation to control water level remotely by using valves and PV pumping system. The experimental system is a type of stand alone with batteries, DC 24V pump and control-panel with charge/load controllers. Main specification is shown in Table.1 and its outward appearance is shown in Fig.2.

Fig.2 Experimental system

Table.1 Main specifications

Items	Q'ty	Specifications
1.System	-	Stand-alone type, DC24V system
2.Solar modules	4	128W,1200mm×800mm
3.Controllers	2	Charge and Load Controller
4.Batteries	2	DC12V enclosed cell
5.Pump	1	DC24V 8.5A 4m^3/ h ×1.3m

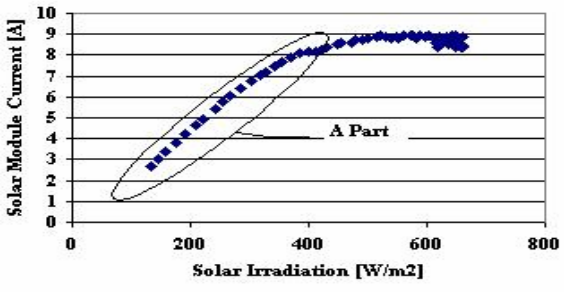

Fig.3 Example plots of solar module current loaded pump, against solar irradiation in a day of which weather changed from fine to cloudy.

This control method is the following. From the value of solar modules' current loaded DC-pump, it checks indirectly weather condition at that time. This idea is to use approximate proportional relation between solar modules' current and irradiation when the load and the system voltage are about constant, and within the modules' current ranges under dc-pump rated ampere. At that time batteries supply the shortage of current for load.

The example of this relation is shown in Fig.3. A-part indicated in Fig.3 is the proportional relation. It is simple way to grasp solar irradiation that is changed by weather changes, without special sensors.

Table.2 Pump-operating time control mode

Control mode	Solar module' current at load	Maximum pump-Operating time
Clear Fine	Over 7.0[A]	360[min]
Fine	7.0 ~ 3.0[A]	240[min]
Cloudy	3.0 ~ 1.5[A]	120[min]
Rainy	Under 1.5[A]	0[min](=stop)

We set temporarily the pump-operating time mode as like Table.2 for testing to get energy effectively according to the weather change.

B . Remote control system of water level

Figure 4 shows remote control system of water level in paddy field. We will be able to control water level of paddy field by using personal computer and mobile telephones as we stay in our laboratory. Warm water will be beforehand supplied from lower pond to upper paddy field according to forecast of the cold day. The rice plant is protected by deep waters. So that, it is expected to increase agricultural fresh water reuse, and to save labor for water management.

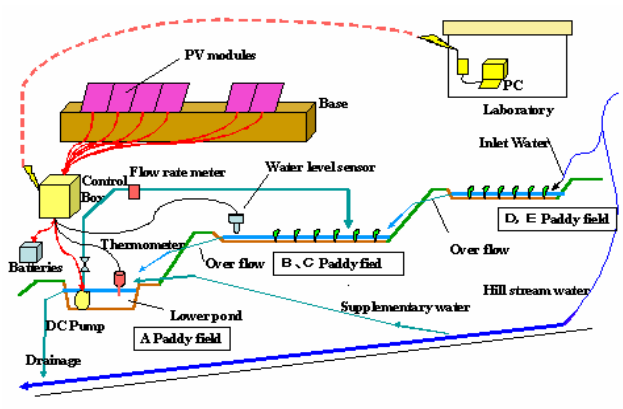

Fig.4 Remote control system of water level in paddy field

C . Energy Management System

Electrical charge and discharge characteristics of batteries were measured under fine and cloudy days. Figure 5 shows energy management system. PV array is used to convert sunlight into DC electricity. We used two controllers. One of them is the load controller and another one is the solar charge controller. The switchover between charge control mode of the batteries and DC load control was easily done by establishment of pin . When voltage was over the value established, the load was cut off automatically and damage of battery due to over discharge was prevented.

In Fig. 5, the lower tank mocks an irrigation pond, which saves warm water. The upper tank mocks paddy field. In preparation for cold day, deep water level is established for upper tank, which mocks paddy field, from the weather forecast. The establishment of water level was done by personal computer in our laboratory. When it was warm, lower water level was established at the upper tank and a valve was opened. Water flowed from the upper tank to the lower tank when the pump was stopped. The time during stop of the pump is indicated at the section in which the pump input current is zero as shown in Fig.6.

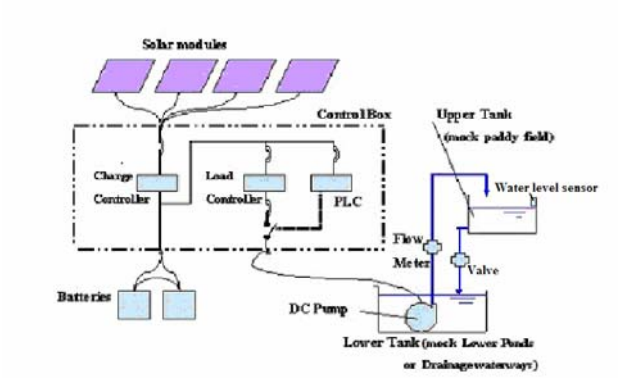

Fig.5 Energy management system

3. Results and Discussion

By operating this experimental system under the weather of Hachinohe city in northern part of Japan during 25 days, the pumping ability is enough for pumping quantity of 20m^3/day at 1.3m effective head.

Figure 6 shows the example of dynamic characteristics of current and solar irradiation when the pump was driven under fine day. Typical electrical characteristics are shown in Table.3. Energy flow is shown in Fig.8. Solar modules generate output power 401.5(W). The pump input power 78.5 (W) and battery charge power 189.4(W) are supplied from controller.

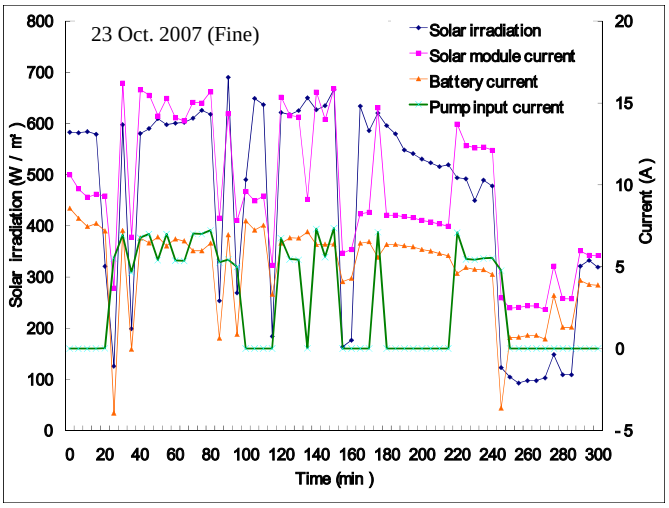

Fig.6 Characteristics of current and solar irradiation under fine

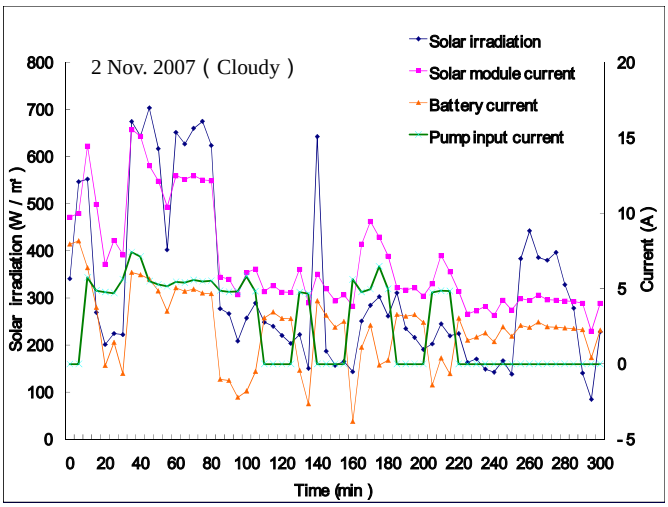

Fig.7 Characteristics of current and solar irradiation under cloudy

Figure 7 shows dynamic characteristics of current and solar irradiation under cloudy. Discharge current flows from condenser to pump. Typical electrical characteristics are shown in Table.4. Energy flow under cloudy is shown in Fig.9. Solar modules generate output power 138.3(W). The input power 69.2(W) from controller and discharge power 26.9(W) from battery are supplied to the pump. It appears that the remainder power was consumed in the control panel.

We were able to do the remote control of water level. The result indicates useful tendency that the batteries are able to cover energy by discharge for remote control of water level under cloudy.

Table.3 Typical electrical characteristics (Fine)

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Solar irradiation (W/㎡)	68.9
Solar module voltage (V)	28
Solar module current (A)	14.3
Solar module output power (W)	401.5
Battery charge voltage (V)	27.3
Battery charge current (A)	7

Pump input current (A)	5.4
Pump input power (W)	78.5
Module efficiency (%)	10.8

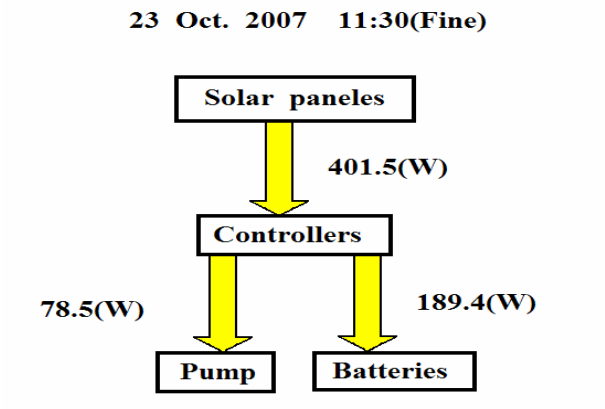

Fig.8 Energy flow(Fine)

Table.4 Typical electrical characteristics (Cloudy)

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Solar irradiation (W/㎡)	266.6
Solar module voltage (V)	24.7
Solar module current (A)	5.6
Solar module output power (W)	138.3
Battery charge voltage (V)	24.4
Battery charge current (A)	-1.1
Pump input current (A)	4.8
Pump input power (W)	69.2
Module efficiency (%)	9.6

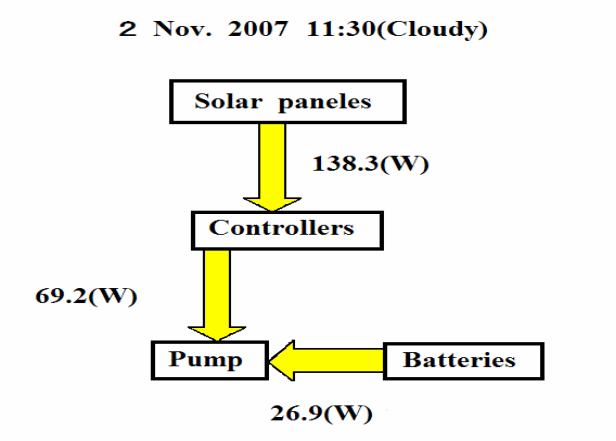

Fig.9 Energy flow(cloudy)

4. Conclusion

We checked enough validity of remote management of water level by using the experimental PV pumping system for rice planting irrigation and confirmed useful battery operating for cloudy day according to matching to weather conditions when pump was driven without solar irradiance sensors.

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