nternational Journal on
dvanced Science
ngineering
nformation Technology

Vol.5 (2015) No. 5
ISSN: 2088-5334

Development and Evaluation of Solar-Powered Instrument for Hydroponic System in Limapuluh Kota, Indonesia

Perdana Putera[#], Sri Aulia Novita[#], Indra Laksmana[#], Muhammad Imran Hamid[*], Syafii[*]

[#] *Agricultural Machine and Equipment Department, Agricultural Polytechnic of Payakumbuh, Tanjung Pati, 50 Kota,26271, Indonesia*
E-mail: perdana@politanipyk.ac.id

[*] *Electrical Engineering Department, Andalas University, Limau Manis, Padang, 25163, Indonesia*
E-mail: imrandgmasse@yahoo.com

bstract— **This solar-powered instrument utilized in plant cultivation in hydroponic system was developed to minimize operational ost, to maintain continuity of electrical source and to release dependency from electric utility. The instrument consist of solar tracker o adjust photovoltaic panel position, aquarium pump to distribute the nutrition, humidity and temperature meter to measure umidity and temperature, respectively. To support the function of this instrument 40 watt energy should be provided per hour in verage. Following power measurement conducted in 50 Kota, 200WP of solar panel will produce roughly 70 watt at peak hour. The olar energy is stored to a couple of 100AH deep cycle battery, Arduino board microcontroller as brain of the system plays roles to ontrol dc motor and timer and to calculate data signal from RTC, humidity and temperature sensor. The data are then sent to LCD atrix 2x16 which will display the measurement. This instrument is expected to be used by hydroponics farmer in remote area.**

eywords— **Solar-powered instrument; Hydroponics system; Arduino**

I. Introduction

Decreasing of land area causes conventional agricultural ystem become uncompetitive because of price of land is ising day after day. Hydroponic agriculture cultivation echnology system provides an alternative way for farmers who have a narrow field or just have a yard to carry out gricultural business.

Hydroponics system has advantages such as: the density f plants per unit area doubled or land-saving; product uality (shape, size, flavour, colour, cleanliness or hygiene; lanting is not depend on the season or time and can be djusted in accordance with market needs. Hydroponic ultivation usually implemented at greenhouse to keep plant rowth optimally and to protect from external elements such s pests, rainfall and climate change. In addition

Continuity of energy supply becomes a main problem of ydroponic cultivation because of its dependence on energy ources. Especially when using full controlled system with a umber of equipment to be controlled such as sensors temperature, pH), controller and others require continuous lectrical energy. The use of generators is not efficient due o the cost and pollution generated.

Utilization of solar cell as a renewable energy at housing r transportation this moment is considered as solution to reduce dependency to fossil energy. Its usage for agriculture machine and equipment still not popular since it is expensive initial investment compare to the benefit obtained so that farmers prefer a machines which use combustion engine.

Solar energy utilization in agricultural equipment, for long-term, as an energy source is very promising, especially used as a hybrid with other agricultural energy sources material ie, straw and husks.

The focus of the research was to manufacture of hydroponic system that used solar power as source of energy for the instrument. The prototype of this instrument can be utilized for farmers who are in remote areas and minimize operational costs in the hydroponic cultivation such as NFT system and others that require continuity of electrical power source. Other benefit is also to release dependence on the electric company. The design tool based on the computer simulations performed using Matlab and Pspice software

This research was conducted in kabupaten Limapuluh kota which located between 0°25'28,71" - (-) 0° 22'14,52" longitude, between 100°15'44,10" – 100°50'47,80" latitude. The land area is 3.354,30 km^2. Lima Puluh Kota has a tropical climate. The rainfall in Lima Puluh Kota is significant, with precipitation even during the driest month. Base on Köppen and Geiger classification, this climate is classified as tropical rain forest climate (Af). The average annual temperature in Lima Puluh Kota is 26.7 °C. In a year, the average rainfall is 2353.7 mm.

II. Development of Solar-Powered Instrument

Solar powered instrument for the hydroponic system consist of solar cell, solar charge controller, battery, inverter, temperature and humidity sensor, solar tracker system and hydroponic system.

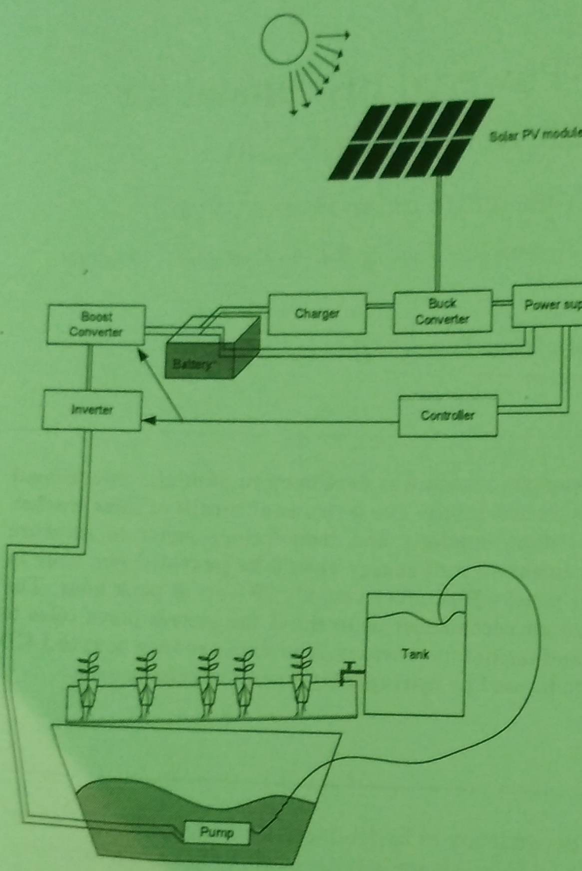

Fig. 1 solar-powered instrument for hydroponic system

A. Hydroponic systems

It can be seen from Fig1 that the system consist of reservoir as nutrient liquid container, a 25 W water pump was used to make the nutrient flows up to the tank this pump can draw approximately 13 litre per minute. One of the most popular hydroponic system is nutrient film technique (NFT). For this system, the flow speed of the nutrient liquid on growing media was about 1 litre per minute which is adjusted by using water tap. So the amount of time for pump to be on was less than 1 hour per day. A floating switch was placed in the tank to control electrical current to the pump. The availability of the tank is highly recommended to avoid the pump runs 24 hour per day. Overall system work is supported by power that came from solar panel module.

B. Solar panel module

A solar panel is made up of several photovoltaic solar cells to form higher power the Solar PV module production is continuously growing since it produce electricity without fuel consumption. The solar PV systems using modular technology so that it can be configured for va ranging from watts to megawatts to fulfil either domestic energy needs.

Parameter of the solar PV used is as follow

Maximum power	: 100W
Maximum voltage	: 17.5 V
Maximum current	: 5.71 A
Open circuit voltage	: 21V
Short circuit current	: 6.4 A

In this case 2 solar PV module was used in pa it will produce twice as much power and curren above. In the commercial market, efficiency of so reach 18.3 %, for solar panel module, it would lower because of the blank space between solar c

C. Solar Charge Controller and battery

A solar charge controller has role as regulator charging and prevention of overcharging which lifespan of battery. It also limits the electric cur from battery.

In this system, the energy output from the systems is generally stored in a couple 100AH only the system gives power to the 25 W water p assuming the system can keep autonomy run continuously by considering depth of discharge

D. Inverter

Inverter is used to convert DC current into AC current from inverter may appear in: square square wave, multilevel and sine wave. Fig 2 sho inverter wave form is made.

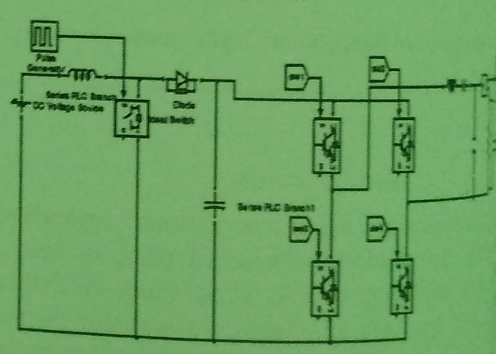

Fig. 2 boost converter and single phase inverter

Basic form of inverter is the square wave but inverter is not recommended because it has p compare to multi-level inverter and sine inver Multilevel inverter uses low frequency and the inverter is formed from high switching frequency is suitable for high power because it is more robust, and the latter, is more for medium and applicaton.This high frequency inverters is for considering this, for small-solar power instrum this hydroponic system, a 500 W sine wave support AC pump work.

Other instruments

1) Temperature-humidity and display

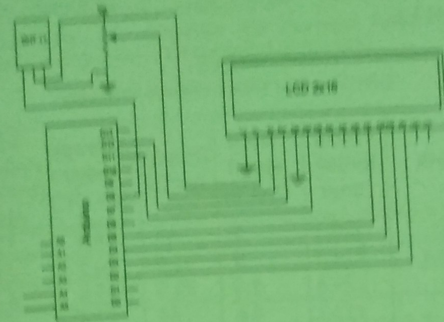

Fig 3. Electrical connection between Arduino, humidity-temperature sensor and Liquid Crystal Display

Temperature-humidity sensor used was DHT 11. This sensor detected the humidity and the temperature in analogue form. After been changed into digital signal in ADC in microcontroller, this data was converted into value that can be shown in LCD.

2) DC Motor dan RTC

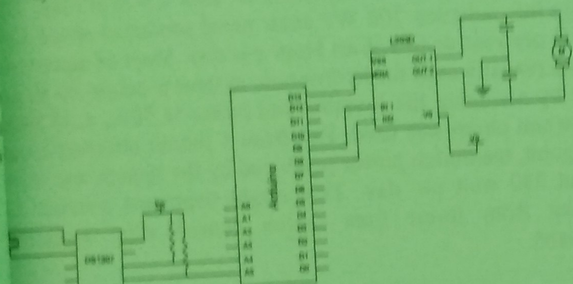

Fig 4. Electrical connection between Arduino, RTC and slow speed DC Motor

Real Time Clock (RTC) was used to keep track of the current time while DC motor was used to drive position of solar panel. The difficulty of using dc motor was to adjust the position even for the slow speed dc motor.

III. Simulation of The System

A. MATLAB Simulation of Solar PV Module

Solar PV modul was simulated base on parameter of PV modul

$$I = I_{pv} - I_o\left[\exp\left(\frac{V+IR_s}{aV_T}\right)-1\right]-\frac{V+IR_s}{R_{sh}} \quad (1)$$

$$V_T = \frac{N_s KT}{q} \quad (2)$$

$$I_{pv} = \frac{G}{G_n}\left[I_{pvn}+K_I(T-T_n)\right] \quad (3)$$

$$I_o = I_{on}\left(\frac{T}{T_n}\right)^3 \exp\left[\frac{qE_g}{ak}\left(\frac{1}{T_n}-\frac{1}{T}\right)\right] \quad (4)$$

$$I_{on} = \frac{I_{scn}}{\exp(V_{ocn}/aV_{Tn})-1} \quad (5)$$

For simulation of solar panel in Standar Test Condition, it is derived as figure 5 and figure 6. It can be seen

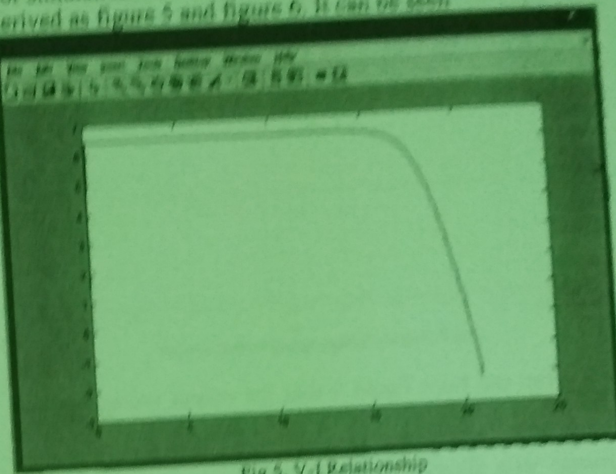

Fig 5. V-I Relationship

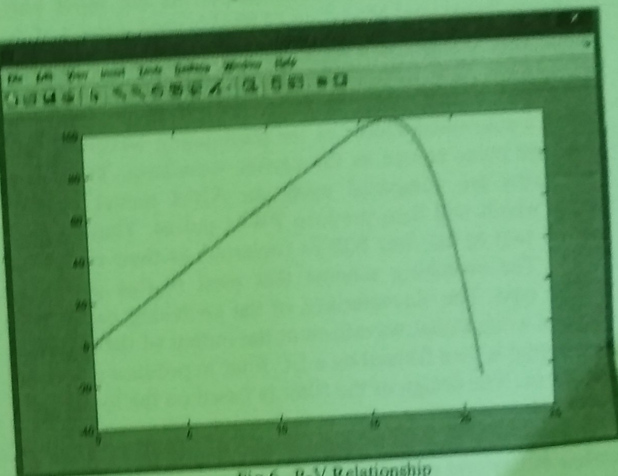

Fig 6. P-V Relationship

B. PSpice simulation of boost converter and inverter

The dc-dc converters are widely used in regulated switch mode dc power supplies and in dc motor drive applications. Often the input to these converters is an unregulated dc voltage and the average dc output voltage must be controlled to equal a desired level. For boost (step up) converter, As the name implies, the output voltage is always greater than the input voltage.

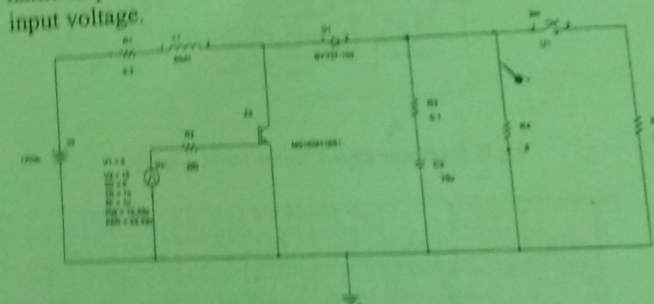

Fig 7. The switch model of boost converter

For the switch model in Figure (1), when the switch is on, the diode is reversed biased, thus isolating the output stage. The input supplies energy to the inductor. When the switch is off, the output stage receives energy from the inductor as well as from the input. In the steady state analysis, the output filter capacitor is chosen to be large to ensure a constant output voltage.

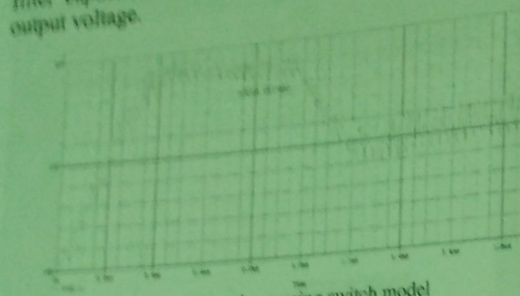

Fig 8 output voltage using switch model

We can see from figure 8 that the output voltage in the steady state has for half load is higher than full load.

Figure 9 shows the schematic circuit for the PWM inverter with filtering implementation. At the input part, Analogue Behavioral Modeling (ABM) is used instead of the comparator because of ABM can handle higher frequency range rather than comparator. The PWM inverter includes PWM and a full bridge inverter. PWM is produced by having a sinusoidal source as the modulating waveform and a voltage pulse source as the carrier waveform. These two waveforms are compared using an ABM model as said earlier which will then produce PWM pulses. These pulses will be sent to the four IGBTs (inverter) as their switching signal. The switching scheme that used in this design is bipolar type. The characteristic of the switching signal will produce a sinusoidal waveform at the output of the inverter. This signal is then filtered by a LC filter to produce a pure ac waveform. The design of the filter is based on the location of the first harmonic that exists at the output of the inverter.

In order to obtain a 240Vrms at the output, in an ABM or analog behavioral modeling is used instead of transformer to step up the voltage

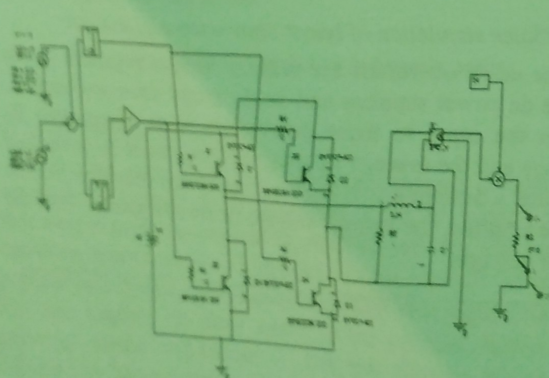

Fig 9. Schematic circuit for the PWM inverter

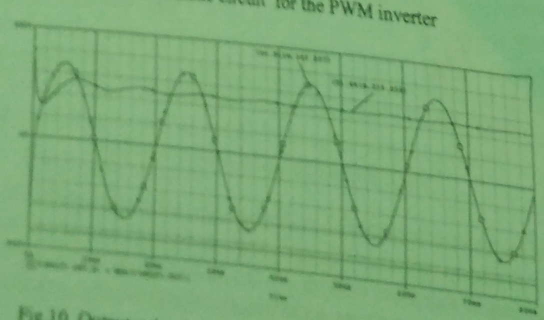

Fig 10. Output voltage of the PWM inverter and its RMS value

IV. Implementation of Solar-Powered In... in Limapuluh Kota

Point where this research conducted is located ... 09.5" S Latitude and 100°39' 52.2" E Longitude ... altitude 512 m.

TABLE I

MONTHLY WEATHER AVERAGE SUMMARY

Month	Precipitation (mm)	Wind speed (km/h)	Humidity (%)	Average Temperature (°C)	...
January	236.3	9	83	26.4	
February	214.3	9	82.6	26.7	
March	229.8	8.6	83.3	27.3	
April	257.7	8.6	84	27.3	
May	156.4	8.3	83.7	27.3	
June	124.6	8.6	82.7	26.6	
July	112.4	9	83.1	26.4	
August	135.3	8.6	82.8	26.4	
September	186.9	9	83.6	26.5	
October	196.2	8.6	83.8	26.7	
November	240.7	9	84.7	26.8	
December	263.1	9.4	84	26.5	

Source: Weatherbase.com and pvwatt.com

Average daily solar radiation is 4.09 kWH/m² ... using this radiation 200 WP solar panel produced ... kWH per year or 613 Watt Hour per day. Most of ... pump (usually used for hydroponic system is below ... that by assuming the inverter and motor is 50%, a ... aquarium pump was used. But from 1 month observ... the point, maximum power produced by the system w... about 380 watt per day. This might happened bec... smoke from forest fires which caused solar ... diffused.

V. Conclusions

A couple of standard 100 watt PV panel produce ... 600 watt hour per day in kabupaten 50 kota by n... unnatural parameter like smoke into account. The ... could only handle 25 water pump.

Nomenclature

I	Current	A
V	Voltage	V
K	Boltzman Constant	J/K
G	Irradiance	W/m²
T	Temperature	K
q	Charge of electron	C

Subscripts

scn	nominal short circuit
ocn	nominal open circuit
n	nominal

Acknowledgment

We would like to thank to Directorate General of ... Education for funding the research through Pekerti ... Grant.

REF...

S. Sumathi L. Ashok Kuma... *Conversion Systems*, Spring...

Otto, Tyler N., *Comparat... arrays*. San Diego State Un...

J Dooren bos. *Fao Irri...* Agriculture Organization C...

References

[1] S. Sumathi L. Ashok Kumar P. Surekha, *Solar PV and Wind Energy Conversion Systems*, Springer 2015

[2] Otto, Tyler N., *Comparative study of grid connected photovoltaic arrays.* San Diego State University, 2009

[3] J Dooren bos. *Fao Irrigation and Drainage Paper.* Food and Agriculture Organization Of the united nation 1977

[4] Akrem, Boost converter, Universiti Teknologi Malaysia. 2009

[5] 2015 The pvwatt website. [Online]. Available: http://pvwatts.nrel.gov

[6] 2015The weather website. [Online]. Available: http://www.weatherbase.com