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Application of Bidirectional DC-DC Converter for Saving Energy on Photovoltaic

I Sulistiyowati[1,*], H Kurniawan[1], Jamaaluddin[1], E A Suprayitno[1] and R Rahim[2]

[1]Teknik Elektro, Universitas Muhammadiyah Sidoarjo, Jl. Raya Gelam 250, Candi, Sidoarjo, Jawa Timur, Indonesia
[2]School of Computer and Communication Engineering, Universiti Malaysia Perlis, Kubang Gajah, Malaysia

*indah_sulistiyowati@umsida.ac.id

Abstract. Photovoltaic is one of the most widely developed solar power system. The problem that often arises is the instability of PV output causes problems in the utilization of PV power for the load. In this paper is focused to maximize the power generated by Photovoltaic power dan bidirectional dc-dc converter and controlled by Arduino Nano. The tool that becomes the object of research is a photovoltaic that has been controlled by manual or by using a one-way converter, will be controlled using bidirectional two-way converter. The electronic circuit will be replaced with Arduino nano V3.0 which will control the bidirectional converter frequency.

1. Introduction

The sun as one of alternative energy besides petroleum is still continuously developed. As one source of energy that is always available and does not cause pollution and can be used for various purposes. Utilization of sunlight through the solar cell system is still and continues to be developed so that sunlight can be utilized to the fullest. The solar cell system requires batteries to store the electrical energy generated by the solar cells for later use when the sun does not shine. One of the advantages of using Bidirectional dc-dc converter is to reduce costs and improve efficiency, and improve the performance of the system itself [1-6]

Bidirectional dc-dc converter is the core of interconnected resources and storage elements and regulates the power flow so that it can be used to combine two different types of energy sources. Bidirectional dc-dc converters have galvanic isolation between battery load and fuel, two-way power flow, the ability to adjust different voltage levels, and can respond quickly to the demands of transient loads. So that the battery can be a burden and a source of energy in the same circuit. It is therefore a promising choice for many power-related systems, including hybrid vehicles or using battery sources, renewable energy systems and so on [7]

In [8] paper, they used fuzzy logic to control bidirectional dc-dc converter applied to dc drive. And in the [9] paper Bi-Directional Dc-Dc converter Drive with PIand Fuzzy Logic Controller. In the paper [10, 11] using proportional control to get more faster and a little overshoot of buck bust output.

In this study the topology of the charger circuit used a buck-boost converter that allows the source of energy to have a greater or less voltage than the battery. This converter can work both ways: the charging mode is to store energy into the battery when the load current is less than the DC bus's main point of service and the discharging mode is to channel the energy from the battery to the load when the

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load current exceeds the nominal value. Both modes work automatically according to the amount of load used. The amount of charging and discharging current is controlled by the Arduino nano.

2. Experimental method

This research is focused to maximize the power generated by photovoltaic and voltage stability on DC bus to obtain the efficiency of photovoltaic power and bidirectional module output will be displayed in LabVIEW.

The load used in this study is 50 W. To be able to show the system and its control works effectively under various conditions, the power of PV is equal to the load power. In this case, the selected PV power is 50 Watt. The PV module data specifications are shown by table 1. Where this model has the ability to supply a maximum power of 50 Wp when irradiated full solar sun (1000 W / m2) and temperatures around 25^0 C.

Table 1. PV module specification.

Parameter	Value
Maximum Power (Pmax)	50 W
Voltage @ Pmax (Vmp)	16 V
Current @ Pmax (Imp)	3,13 A
Short-circuit Current (Isc)	3,68 A
Open-circuit Voltage (Voc)	19,7 V
FF	0,71 V
Nominal Temperature	25°C

The tool that becomes the object of research is photovoltaic that have been used manually or by using a one-way converter, which will be used using bidirectional converter bidirectional. The electronic circuit will be replaced with Arduino nano V3.0 which will control the bidirectional converter frequency.

In designing arduino microcontroller program using C language program and using arduino idea software. Then compiled with hex format at once downloaded into arduino microcontroller.

Schematic image of the whole circuit of Bidirectional DC-DC Converter system can be seen in Figure 1. For inputs of voltage sensor and current sensor. As for the output of the PWM signal for the 5V power supply and GRD will be connected to the pin in the arduino nano the circuit can be seen in Figure 2.

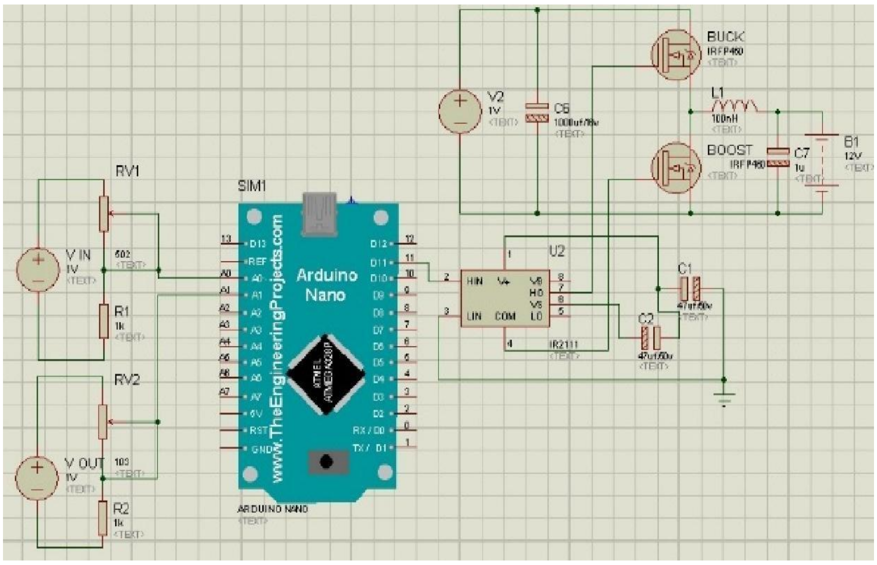

Figure 1. Bidirectional DC-DC Converter, voltage sensor, arduino schematic.

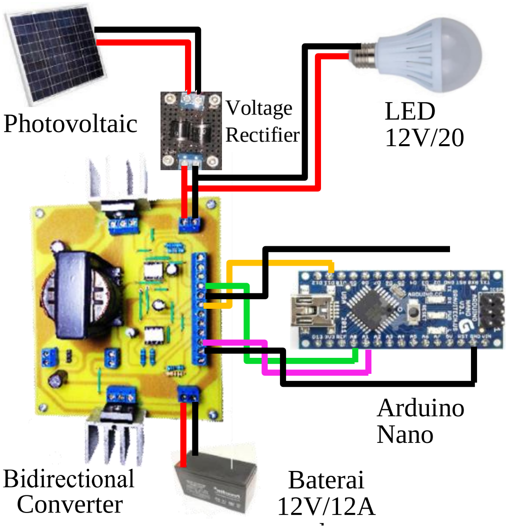

Figure 2. Arduino system.

There are several things done in this research:

- The bidirectional module accepts the voltage input from the photovoltaic and then passes to the battery according to the pulse of the Arduino nano.
- Arduino nano controls bidirectional module according to input from PV and output from load, if PV voltage is weak or load is too big then pulse sent to bidirectional module make boost mode and supply battery to load as desired voltage, if PV voltage is too big or the load is too small then the pulse sent to the bidirectional module makes the buck mode in accordance with the desired voltage and more power will be stored to the battery.
- Battery is used as storage / storage power that is not used when the load used is not used and also as an amplifier output voltage bidirectional converter.
- Load is Lamp of 12V DC 20W.

3. Results and discussion

3.1. Voltage sensor testing

This sensor is used for setting the battery voltage from 12 V to 5V.

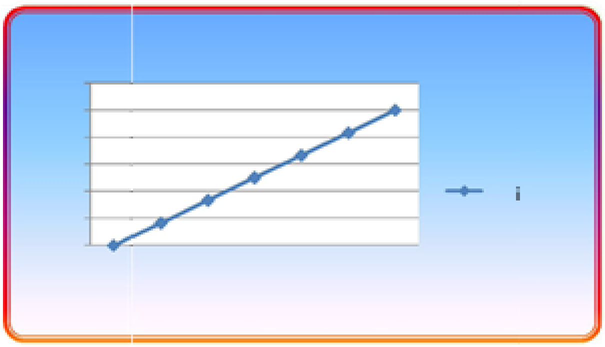

Figure 3. Graph of sensor voltage testing from 12V to 5V.

From the voltage sensor data on the battery shown in table form and in graphical form in Figure 3 can be seen that the test results of the voltage sensor for linear battery.

3.2. Testing TLP250 driver at 30 KHz frequency
TLP250 serves as mosfet driver, where TLP250 will increase PWM pulse from microcontroller having voltage rating 0-3 Volt to 0-12 Volt. Output voltage value of TLP250 obtained from calculation DxVin = Vout.

The result of TLP250 driver testing on duty cycle 10-100% and with insert voltage 12Vdc at frequency 30 KHz shown in Figure 4-6

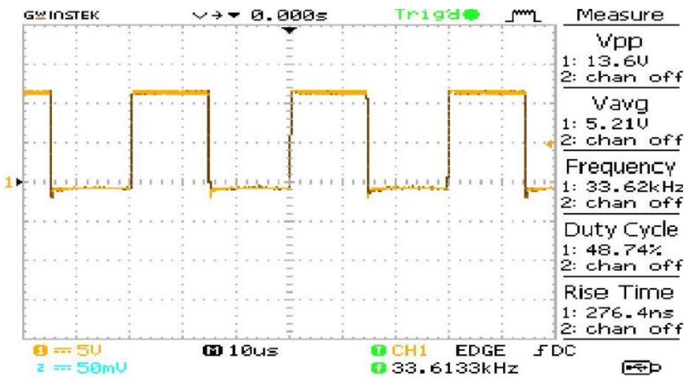

Figure 4. Duty cycle 10%.

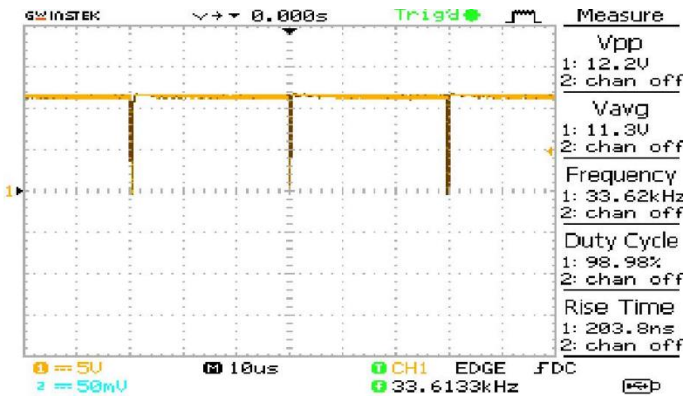

Figure 5. Duty cycle 50%.

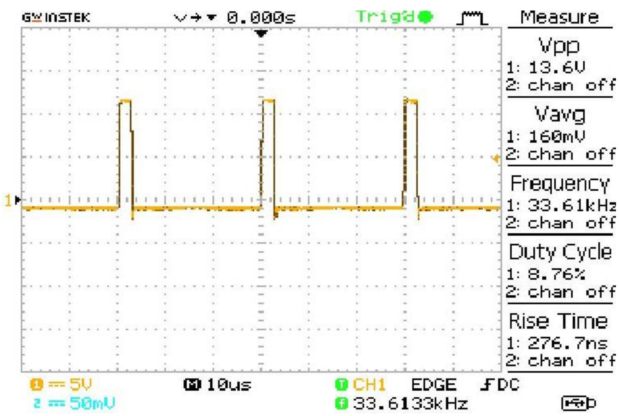

Figure 6. Duty cycle 100%.

From pwm output test data from Driver TLP250 with duty cycle ranging from 0% -100% shown in Figure 4 up to Figure 6 can be seen that the resulting rise time value ranges from 270ns up to 280ns and the resulting Vpp ranges from 12.2V up to 14V.

3.3. System testing and analysis

This bidirectional buck-boost circuit acts as a two-way dc-dc converter that can act as a buck converter and boost converter automatically at specified time. The bidirectional circuit of DC-DC converter is shown in Figure 4.29. The circuit test is performed in buck mode and boost mode interchangeably so that the data shown in Table 1 and Table 2 are shown.

Table 2. Boost mode test results.

DUTY CYCLE (%)	Iin (A)	Vout (V)	Iout (A)
22.3	0.188	12.85	0.13
22.4	0.217	13.05	0.14
22.5	0.265	13.9	0.15
22.5	0.34	14.3	0.16

From data of bidirectional circuit test result dc-dc converter in boost mode with vin 12V and with duty cycle starting from 22.3% -22,5% got output voltage which ranged from 12.85 up to 14.3v shown in Table 1. From bidirectional circuit testing data the dc-dc converter in boost mode has met the target that is to increase the voltage from 12 Vdc to 14 Vdc

Table 3. Testing of duty cycle control in Boost mode.

Set point	*Duty cycle* (%)	Vout (V)	Load (W)
14 V	22.3	14.0	5
	22.4	14.0	10
	22.5	13.9	15
	22.5	13.8	20

In testing of PID control in boost mode above got result at 4 times different load test obtained stable result with duty cycle change from 22.3% -22.5%

Table 4. Buck mode test results.

DUTY CYCLE (%)	Vin (V)	Vout (V)
18.1	20	14.1
19.1	19	14
20.4	18	13.8
21.4	17	13.9
22.3	16	14
24.5	15	13.7
22.5	14	13.5

From data of bidirectional circuit test result dc-dc converter in buck mode with vin 20V - 14V and with duty cycle starting from 18.1% -24.5% an output voltage ranging from 13.5V to 14.1V which will be used as a battery charger is shown in Table 3.

4. Conclusions

Based on the data obtained from all the tests that have been done can be concluded the test results converter in buck mode has been able to reduce the voltage from 14-20Vdc to 13, -14.1Vdc with duty cycle ranges from 18.1% -24% in positive current flow, in boost mode converter has been able to raise the voltage from 12Vdc to 14.3Vdc with duty cycle range 22.3% to 22.5%.

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