# Effective Power Output Single Phase Inverter Design in Home Scale Application with Arduino Microcontroller as Control Pulse

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**Abstract-**This paper discusses the design scheme of an inverter system which converts the DC voltage collected from a battery into AC voltage. The output is a sine wave, with the voltage at 220v and 50 Hz frequency output. The system consists of a bipolar transistor driver and push pull inverter with step-up transformer circuit and a passive filter. The power supply supplies the DC voltage needed to activate the opto couplers, which are connected to the bipolar transistor driver of the push pull inverter circuitry. The opto-couplers work as an isolation for the power inverter circuit. Pulse Width Modulated (PWM) pulses are generated by a microcontroller Arduino mega and provided to the trigger of driver circuitry. The inverter power outputs a PWM sine which is later conditioned to pure sine by step-up transformer. Finally, at the end of the inverter circuits is equipped with a low pass filter to suppress distortion, to produce a full-wave signal output which is closer to pure sine.

**Keywords**—*single phase inverter; PWM; microcontroller.*

## I. INTRODUCTION

In the conditions of the current energy crisis, the scientists are competing to find and examine the utilization of alternative energy sources to maintain of sustainable and availability of these energy sources. The availability fossil fuels as the main energy source is very limited and constantly under threat of scarcity because they the use of this energy on a large scale and continuously. Moreover numbers pollution resulting from fossil fuel power generation is very large. Therefore, the need for new alternative energy sources that are renewable (renewable resources) to replace fossil energy sources. New alternative energy sources that can be renewed has been much advanced by previous researchers as Tri et al. [1] and Radhityo [2].

To be able to utilize the resources that relatively small electrical energy as pico hydro, photo voltage, and micro wind turbine are needed a storage and regulator system as shown in figure 1. The regulator is required to make a voltage or DC voltage generated energy sources, able to provide charging current to the battery. The battery function is store the electrical energy received from the source through the regulator. The inverter function is converting the DC voltage that has been stored in a battery, into the AC voltage in accordance with the purposes of the load that is 220-240 Volts.
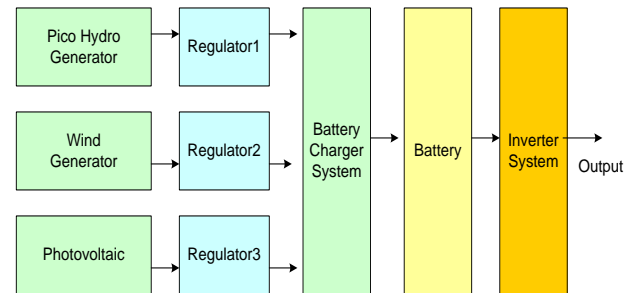


Figure 1. Hibrid regulator block diagram

The inverter voltage source is the most frequently used topology for grid-connected single-phase PV systems, due to its capability to inject current to the grid with low harmonic content. However, its nature is not fully compatible with low power single-phase applications because the input voltage is commonly lower than the peak voltage of the grid, which results in more topologies that are complex. The AC power produced by a power inverter should be generated alternating current, 220 volts / 50 Hz, according to Indonesian electrical standard (PUIL). The problem is electricity in the systems may not be cycling in phase with each other. Moreover, in order to ensure the flow of electricity form source to grid, the source must be kept at some higher voltage than the grid voltage value. A grid tie inverter monitors the power from the grid, ensures the incoming power from inverter stays 220 volt output voltage and 50 Hz frequency.

## II. LITERATURE REVIEW

The development of hybrid electric power source system has been proposed in previous research as proposed by [1]. Tjahyono suggests the use of the hybrid system of wind energy and solar energy. Design of Fuzzy control application voltage wind turbines on hybrid technology system conversion of solar and wind energy has been put forward also by [2]. Utilization of solar energy for residential purposes in one community has been used in Peru expressed by

[3], in his article titled "Technical and Financial Feasibility of a Stand-alone Photovoltaic System for Rural Electrification in the Andean South Region of Peru ". Meanwhile [4] have proposed a combination of electrical energy generation system of wind turbines with pico hydro turbine in a high-rise building, in his article titled "A Novel Approach of Electrification of the High ise Buildings at Dhaka City during Load Shedding Hours".

Many previous researchers have conducted a study on Prime Mover / regulator or stabilizer for use in hybrid renewable energy systems as proposed by Binddeshwar Singh [5] with his colleagues in 2012. They reviewed were from 2009 up to 2012, and found as many as 30 pieces of manuscript discusses Renewable energy resources as a prime mover; 34 pieces of Self Excited Induction Generator; 9 pieces of manuscript about AC / DC / AC converter; 14 pieces of manuscript about the power factor; 10 pieces of manuscript about the switching frequency [5]. This shows that the trend of research on the prime mover / regulator occupies the second highest position after Self Excited Induction Generator coupled with 9 pieces of manuscript about AC / DC / AC converter that is very closely linked to the system of the renewable energy regulator.

### III. CONCEPT AND DESIGN

The design of 1 phase inverter are consists of three main parts: a control pulse generator, driver and power amplifier circuit. Control pulse generator serves as a pulse generator that will control the frequency and signal form of inverter[6]. Pulse generator circuit consists of the microcontroller Arduino. Driver circuits serves to set the trigger pulses to be supplied to the power amplifier voltage output voltage and current that can reach the desired value. This driving circuit consits of a combination midle amplifier bipolar transistor, diodes and resistors. Power amplifier is very important in an inverter system to provide enough power at the output. Power amplifier comprises ten pairs of TIP 3055 transistors with the step-up transformer 12 to 220 V AC.

Generator pulse circuit with Arduino microcontroller generates of pulses trigger with the duty cycle and specifik frequency so as to reduce harmonics and distortion signal at the output of the inverter. Arduino is programmed to generate a pulse width modulation (PWM) output [7]via pin 10 and pin 11. The PWM generated pulse by the pins both alternately provide each trigger to half positive and half negative swing at the output of the inverter.

While the driver amplifier delivers the appropriate trigger voltage, so it can work on the power amplifier in his area. The block diagram and

schematic circuit with Driver pulse generator is shown in figure 2 and figure 3 respectively.



| Pembangkit / pembentuk pulsa (pulse generator/ maker) | Penguat pendorong tegangan (voltage driver amplifier) |
|---|---|

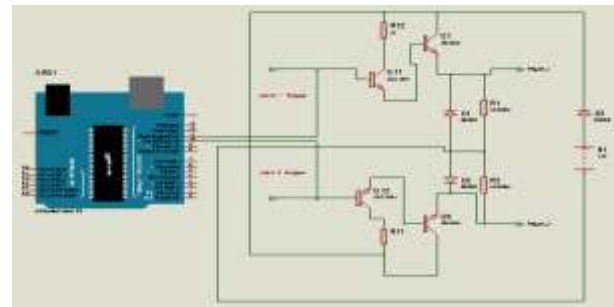Figure 2. Block Diagram of pulse generator and driver amplifier



Figure 3. Pulse Generator and Driver Amplifier Circuits

This power amplifier is applying push-pull amplifier system whit the transformer. This push pull amplifier systems utilizing the capacity of the power transistor TIP 3055 that has the capacity capability collector-emitter (VCE) 60 Volt voltage and 90 Watt power. If desired Inverter 900 Watt power capacity, it would require at least ten TIP 3055 transistors. These amplifiers working in pairs alternate 3055, which is one of the transistors amplify the positive half swing of the sine wave and the other amplify the negative swing, so that on the secondary side of the transformer will resulting full-wave signal. The power amplifier circuit is shown in Figure 4.
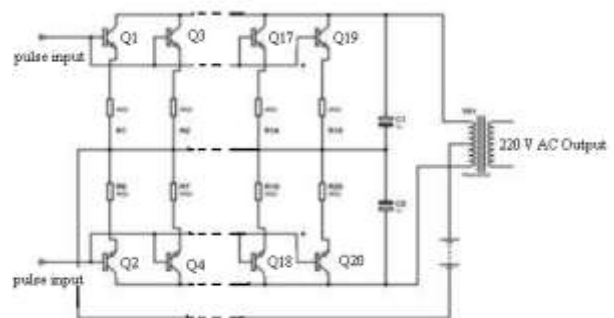


Figure 4. Power Amplifier circuits

### IV. METHODOLOGI

This research was carried out by simulation using Proteus ISIS-7 software, prototype manufacture and testing in laboratotium Power Engineering Department of Electrical Engineering ITP Padang, the stages as follows:

- Data collection specification components / equipment to beused in research.
- Selection of specification components / modules fit designcapacity.
- Simulation circuits by the proteus-ISIS 7 software.
- Testing characteristics supporting components.
- Testing of prototype.
- Measurement of the characteristics of devices.

## V. RESULTS AND DISCUSSION

By using the Arduino microcontroller program code generated PWM on pin 10 and pin 11 as shown in Figure 5. In the figures it is seen that the length of each period for the pin 10 and 11 is 10 mS. If the results are summed both period is 20 mS. Thus both the PWM peride will generate a frequency of 1 / (20 x 10$^{-3}$) = 50 Hz.
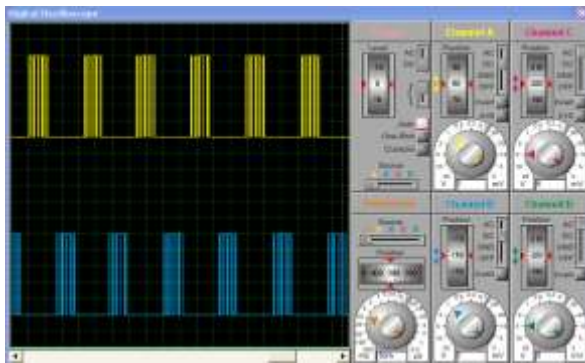


Figure 5. PWM pulse at pin 10 and pin 11 Arduino

Figure 6 is depict PWM pulse  oscilloscope photograph of  Arduino real measurements. In real measurements obtained a PWM pulse periode amount 9.14 ms only.
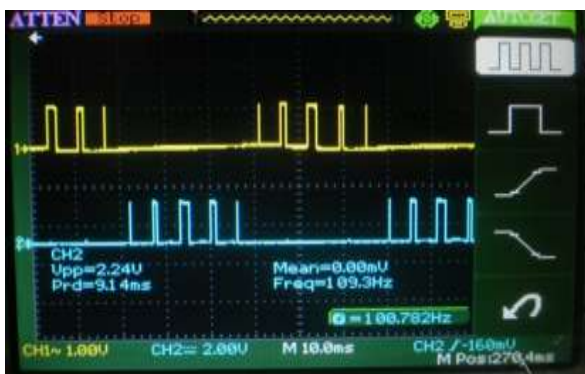


Figure 6. PWM pulse  oscilloscope photograph of real measurements

By connecting all circuits are pulse generator , drivers and power amplifiers, then obtained signal simulation on the inverter output  in the full wave sine form  as shown in Figure 7. Output signal has 106.5 V effective voltage and 30 ms periods at 12 v DC voltage source.  If given a DC voltage source of 24 V,

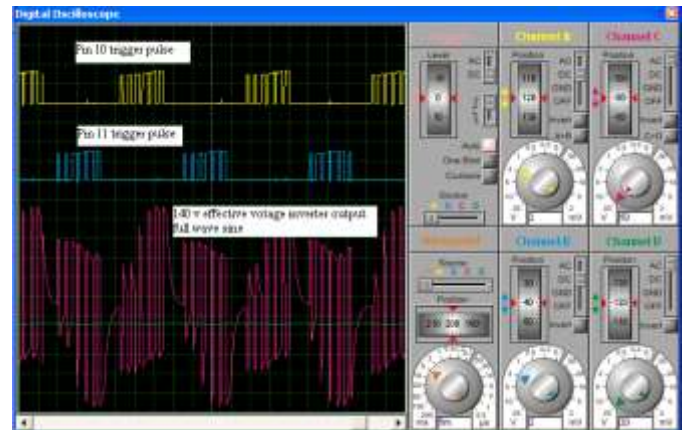the voltage output will reach 213 V as shown in Figure 8.



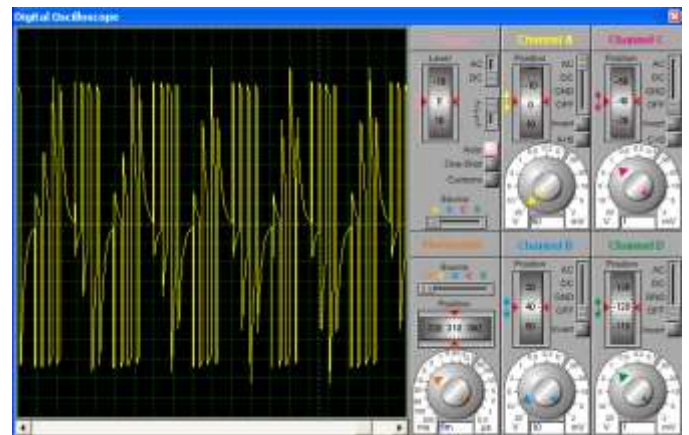Figure 7. All simulation pulse trigger and full wave inverter output



Figure 8. All simulation of trigger pulse and full wave inverter output with 24 V DC voltage source.

This inverter is equipped with the RC filter circuit. This RC filter with  frequency cut off  (Fc) 50 Hz selected 10 uF capacitor value so that the value of the resistor can be calculated referring to:

$Fc = 1(2\pi RC)$

Thus obtained 316 Ω resistor value, then the transfer function is:

$$G(s)= \frac{316.455696203}{s+316.455696203}$$

with a cut-off frequency = 50.3654883202 Hz. Meanwhile Bode diagram and Transient analysis are shown in Figure 9 and Figure 10 respectively.
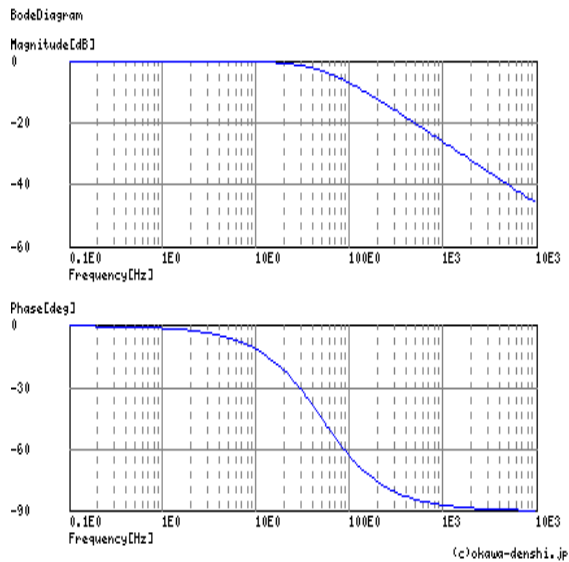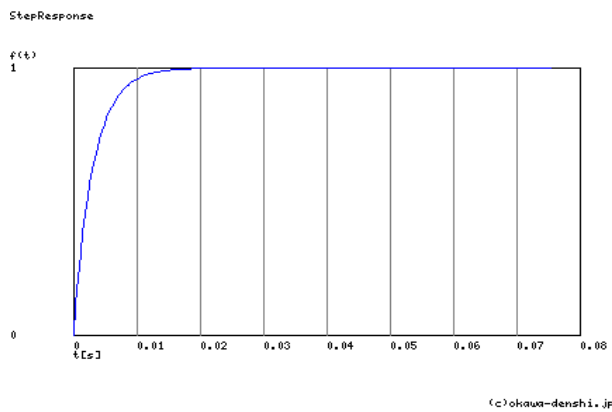
Figure 9. RC low pass filter Bode diagram



Figure 10 RC filter transient analyses

Once paired the filter to the inverter circuit then obtained sine output signals as shown in Figure 11. Figure 11 explains that with the addition of filters make the inverter output signal closer to purity.
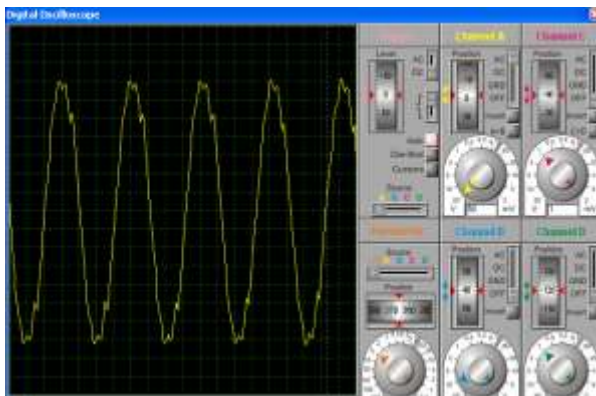


Figure 11. Inverter output with filter

## VI. CONCLUSION

In this research, simulation and hardware design of single phase inverters with PWM Arduino microcontroller as control pulse, can be inferred that has been obtained 240 V inverter output voltage with a frequency of 50 Hz, in conditions of 24 V DC voltage source and 100 Hz PWM pulse control both frequency respectively. Besides that, by have relied to the cut-off frequency for 50 Hz, the obtained value of resistor and capacitor filter RC 316 Ohm and 10 uF respectifely.

### REFERNCES

[1] Tri Tjahjono, Erwan Widodo, "Penggunaan Energi Angin dan Energi Matahari sebagai Sumber Energi Listrik dengan Sistem Hibrid", Prosiding Seminar Nasional Sains dan Teknologi ke-2, Fakultas Teknik Universitas Wahid Hasyim Semarang Tahun 2011, halaman A85-A90.

[2] Rhadityo Prabowo H.K, Imam Abadi, Ali Musyafa, "Rancang Bangun Aplikasi Kontrol Fuzzy Tegangan Turbin Angin Pada Sistem Teknologi Hybrid Konversi Energi Surya & Angin", ITS Paper 23305-241, 2012.

[3] Karen S, Villanueva Saberbein, Lu Aye. "Technical and Financial Feasibility of a Stand-alone Photovoltaic System for Rural Electrification in the Andean South Region of Peru", Journal of Sustainable Development, Vol. 5, No. 11, 2012 ISSN 1913-9063   E-ISSN 1913-9071 Published by Canadian Center of Science and Education.

[4] M. M. Ehsan, Enaiyat Ghani Ovy, Kazy Fayeen Shariar, S.M.Ferdous, "A Novel Approach of Electrification of the High ise Buildings at Dhaka City during Load Shedding Hours", International Journal of renewable energy research, Vol.2, No.1, 2012.

[5] Singh Bindeswar, Singh Surya Prakash, Singh Manvendra, Dixit Rahul, Mittal Nupur, Baranwal Aanchal, 2012, "Stand alone power generation by 3φ asynchronous generator: a comprehensive survey", International Journal of Reviews in Computing, Vol. 10 No. 2, July 2012, ISSN: 2076-3328, E-ISSN: 2076-3336, pp-36-51.

[6] M.Karuppiah, M.Saniyasirao, K.Karthikumar, "Improved Transformer-Based Full-Bridge Inverter", International Journal of Engineering Trends and Technology (IJETT) – Vol. 9 No. 8 - Mar 2014.  pp-369-374.

[7] R.Antony Raja Sekar, D.Arun Prasad, "Improved Transformerless Inverter for PV Grid Connected Power System by using ISPWM Technique", International Journal of Engineering Trends and Technology (IJETT). Volume-4 Issue-5, 2013, pp-1512-1517.