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Design and Construction of Fuelless AC Generator Using Alternator Interfaced With an Inverter

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ABSTRACT

AC Generators are useful appliances that supply electrical power during a power outage from national grid and prevent discontinuity of daily activities or disruption of business operations. Generators are available in different electrical and physical configurations for use in different applications. This work develops a design, Construction and Characterize fuelless AC Generator that generates electrical energy from an alternator interfaced with an inverter. The prime mover is DC electric motor which was connected to the alternator armature shaft. The DC electric motor was powered by rechargeable 24V/75Ah battery, and as it rotates it provides energy to the alternator resulting in generation of AC voltage. Part of the output voltage was rectified to provide 12V for recharging of the battery for it not to be drained. The other part was connected to which was connected to an inverter to provide 220V to the output circuit breaker for the utility load. A control panel was also in cooperated for monitoring and regulation for output voltage. The results were obtained using multi-meter to read the output voltage at different load conditions and also measure the voltage output from different components of the control circuit. This gave stable 220V output voltage which was connected to load.

KEYWORDS: *Generation, alternator, DC motor, charging*

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1. INTRODUCTION

Regular supply of power is the characteristic of any developed economy. Any country whose power supply is not constant will not develop quickly as investors will not like to invest in that country Abonyi S. E Uju I U [2007]. Powerful electrical generators work to send electrical power across national grid for distributions throughout cities. The same way these generators harness their power, smaller electrical generator distribute power to houses for household appliances since power from national grid are not reliable. Making a simple generator is easier than the average handyman may think. This work tends to produce a generator from salvaged electric motors and alternators to create enough energy to contribute to or even fully cover home electricity needs.

Lack of investment and timely routine maintenance had caused significant deterioration in plant output and is a key explanatory factor in the lingering electric power crisis Ajav, E., & Adewumi, I. (2014). Since the privatization of PHCN in 2013 in accordance with the Electricity Power Sector Reform Act 2005 and subsequent unbundling of PHCN into a transmission company of Nigeria, TCN, 6 generating companies, Gen-Cos, and 11 distribution companies, Dis-Cos power is yet to be stabilized in Nigeria Onochie, U., Egware, H., & Eyakwanor, T. (2015). Currently, the transmission capacity of the Nigerian Electricity Transmission system is made up of about 5,523.8 km of 330 KV lines and 6,801.49 km of 132 KV lines B. Nnaji (2011). With an average production capacity of 5.3MW electric output power for a population of over 200 million one can infer that power is grossly inadequate. Also with the constant in the price of petroleum products it becomes necessary that alternative power sources are developed – hence the development of fuelless generator.

A fuel-less generator is a device that stores power and can be used to run almost anything requiring an electric current. Existing generator use fuel as the source energy but this generator uses current from battery. The battery can also be recharged by simply connecting them to solar panels. And there is no stinky exhaust. It can also power itself and simultaneously supplies power Onochie, U. etal (2015). The benefits of fuelless generator include; the fuel less generator can be operated for hours at a time without the use of fuel. It is environmentally friendly as it produces no noise (noiseless operation), smokeless. In fact, it is possible for the machine to be kept indoors. Very low maintenance.

2. Literature Review

The developed of a fueless generator by using local material was done by J.O Otulana etal (2015). They used 1hp direct current motor, powered by a 12 volts battery, which spines the 0.95KW alternator to generate electricity with Out-put power of 1Kva, and at the same time recharging the battery by means of a diode.

Electricity Generation from a Fuelless Engine in an Isolated Power Generation System was produced by S.Bala Iyappa (2014). Nonconventional energy sources has become evident due to Because of fast depletion of conventional energy sources a non conventional approach is been implemented

now. Example solar, wind and tidal energy is becoming popular renewable energy sources. These processes tend to reduce dependence on the use of petrol/diesel generators.

The effect of environmental pollution which leads to degradation or depletion of ozone layer is one of the major problems caused by the use of generator with fossil fuels. Other problem includes land and water pollution, noise pollution, increase in price of fossil fuel year in year out, among others. The Faradays energy generator can be modified for continuous electrical energy supply (Adiyat et.al, 1993). The basic components the fuelless generator consists of DC motor, Alternator voltage regulator, Battery charger, rechargeable battery, control panel and Main Assembly/Frame.

The increase in energy demand and high cost of electricity bill by the six distribution network in Nigeria prompted this research in an effort to provide electrical energy at an affordable rate for usage in an economical and safe way I O Adewumi B. A Adelekan (2016). The clean and low running cost, renewable energy has the ability of abundance energy and can be used wherever available .This fuelless generator use alternator. An alternator is defined as a machine which converts mechanical energy to electrical energy in the form of alternating current (at a specific voltage and frequency). Alternators are also known as synchronous generators. There are five different types of alternators which includes automotive alternators – used in modern automobiles. Diesel-electric locomotive alternators – used in diesel electric multiple units. Marine alternators – used in marine applications. Brushless alternators – used in electrical power generation plants as the main source of power and Radio alternators – used for low band radio frequency transmission.

The generator speed are adjustable and the free electrical energy produced by the fuel-less generators is to charge the battery used in staring the generator. Heavy electrical machinery that starts automatically or remotely generally makes use of contactors which rely on an electromagnetic force to close them to start the machinery. This force is created by an electric coil placed in the center of a laminated steel core. These coils are typically designed to operate at fairly low voltages of about 12 volts. This machine typically run on far higher voltages, hence there is need to a separate control voltage feed. Instead of having to run separate cables or install extra sets of bus bars, it is far simpler to use the main circuit voltage and step it down with a control transformer to the appropriate control voltage (Wisegeek, 2013)[11].

AC generators (alternators) can be categorized in many ways, but the two main categories depending on their design are: Salient Pole Type and Smooth Cylindrical Type. The Salient Pole Type are used as low and medium speed alternator. It has a large number of projecting poles having their cores bolted or dovetailed onto a heavy magnetic wheel of cast iron or steel of good magnetic quality. Such generators get characterized by their large diameters and short axial lengths. These generators look like a big wheel. These are mainly used for low-speed turbine such as in hydel power plant. The Smooth Cylindrical Type smooth solid forged steel cylinder having certain numbers of slots milled out at intervals along the outer periphery for accommodating field coils. These rotors are designed mostly for 2 poles or 4 poles turbo generator running at 36000 rpm or 1800 rpm respectively.

From the review, it is observed that a lot of effort has been put on generating electricity from the other sources different from the conventional method of using fuel engine. This work combined two methods that were done differently; i.e it combined the alternator and inverter to produce a stable ac voltage.

3. Methodology

The following are the major components the Fuel-less Power Generator powered by an alternator are as follows;

1. Battery 2. An electric motor. 3. Crank-shaft. 4. The alternator. 5. Inverter. 6. Charging unit. 7. Control panel

Battery

A 24 volts battery was used as source of power supply unit to the D.C motor in order to induce electromotive force (e.m.f). Lead acid battery is highly recommended for DC generating system. This serves as storage device for the direct current which is to be induced to provide the excited current needed to start the generator.

Figure 1: 24V/75Ah Battery

An electric motor

The DC electric motor is the prime mover. Its shaft is connected to the rotor of the alternator to provide it with the speed required to generate electric current. Electric motors are electric generators reversed in function. They convert electrical energy into mechanical energy. Power from the electric motor is transmitted into the alternator via rotating shaft driven system. Electric motor used for this research work has the following configuration; 9000rpm (Speed), 24V/75Ah.

The alternator

This is the part of the generator that produces the electrical output from the mechanical input supplied by the prime mover. It is made of an assembly of stationary and moving parts encased in housing. Electricity is generated when there is relative movement between the magnetic and electric fields. The components of an alternator are:

A. Stator – This is the stationary component. It contains a set of electrical conductors wound in coils over an iron core.

B. Rotor / Armature – This is the moving component that produces a rotating magnetic field in any one of the following three ways:

1. By induction – These are known as brushless alternators and are usually used in large generators.

2. (ii) By permanent magnets – This is common in small alternator units.

Alternator used for this research work has the following nominal parameters as specifications;, Voltage = 12V,

Current = 8.3 A,

Speed = 9000 rpm,

Minimum speed for accumulator charging initiation = 1500 rpm.

They are produced in a variety of power and voltage levels and generally are always examined from many points of view, such as reliability, efficiency, dimensions, weight and costs.

Inverter

An is a power electronic device or circuitry that changes direct current to alternating current Musa, A. And G.S.M. Galadanci (2009). The resulting AC frequency obtained depends on the particular device employed. The type of inverter used on this work is a standard inverter that has 1500VA rating.

Control Unit

This unit performs the following work; converts direct current (DC) to alternating current (AC), removal of ripples, and rectification. The size of the alternator been used, will determine the capacity of the generating set.

Mathematically; $P = IV\cos\phi$ where,

P = Power output (watts) = ?

V = Voltage (Volts) = 220

I = Current (ampere) = 8.3A

Cos ϕ = 0.85

$$P = 8.3 \times 220 \times \cos.085 = 1552W$$

Therefore, the capacity of the generating set is $P = 8.3 \times 220 \times \cos.085 = 1552W$

The alternator which is a small domestic generator has three output lead cables which supplies, the load, capacitor and the diode.

Crank Shaft

The crankshaft acts as a link between the DC motor and the alternator which transfer the mechanical energy from the DC motor into the alternator to produce electric current. See appendix for calculation on shaft diameter selection

Battery charger

The start function of a generator is battery-operated. The battery charger keeps the generator battery charged by supplying it with a precise 'float' voltage. If the float voltage is very low, the battery will remain undercharged. If the float voltage is very high, it will shorten the life of the battery. Battery chargers are usually made of stainless steel to prevent corrosion. They are also fully automatic and do not require any adjustments to be made or any settings to be changed. The DC output voltage of the battery charger is set at 2.33 Volts per cell, which is the precise float voltage for lead acid batteries. The battery charger has an isolated DC voltage output that does interfere with the normal functioning of the generator.

Control panel

This is the user interface of the generator and contains provisions for electrical outlets and controls.

Different manufacturers have varied features to offer in the control panels of their units. Some of these are mentioned below.

(a) Electric start and shut-down – Auto start control panels automatically start your generator during a power outage, monitor the generator while in operation, and automatically shut down the unit when no longer required.

(b) Engine gauges – Different gauges indicate important parameters such as oil pressure, temperature of coolant, battery voltage, engine rotation speed, and duration of operation. Constant measurement and monitoring of these parameters enables built-in shut down of the generator when any of these cross their respective threshold levels.

(c) Generator gauges – The control panel also has meters for the measurement of output current and voltage, and operating frequency.

(d) Other controls – Phase selector switch, frequency switch, and engine control switch (manual mode, auto mode) among others.

Control circuit automatically switches ON or OFF the generator system. This was achieved by using Atmega8L microcontroller which samples the voltage level of the voltage divider circuit and execute analogue to digital conversion. The sampled signal was used to toggle the input signal of the transistor, display information about the generator on the Liquid Crystal Display (LCD) and also indicate the present operating state on the Light Emitting Diode (LED). The block diagram for the whole system is shown in Fig. 1 while the overall circuit diagram of the control circuit is shown in Fig 2.

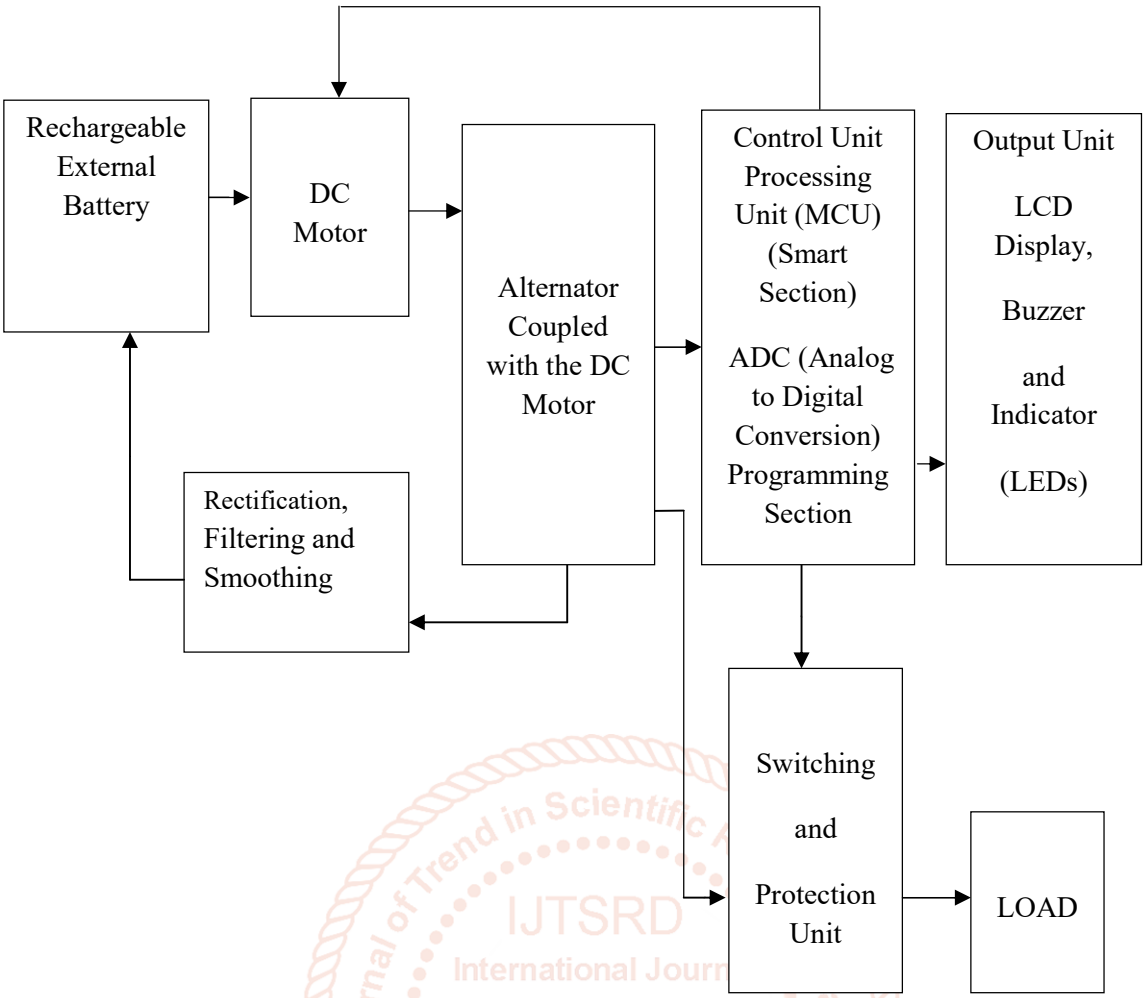

Fig. 1: AC Power Generator System Block Diagram

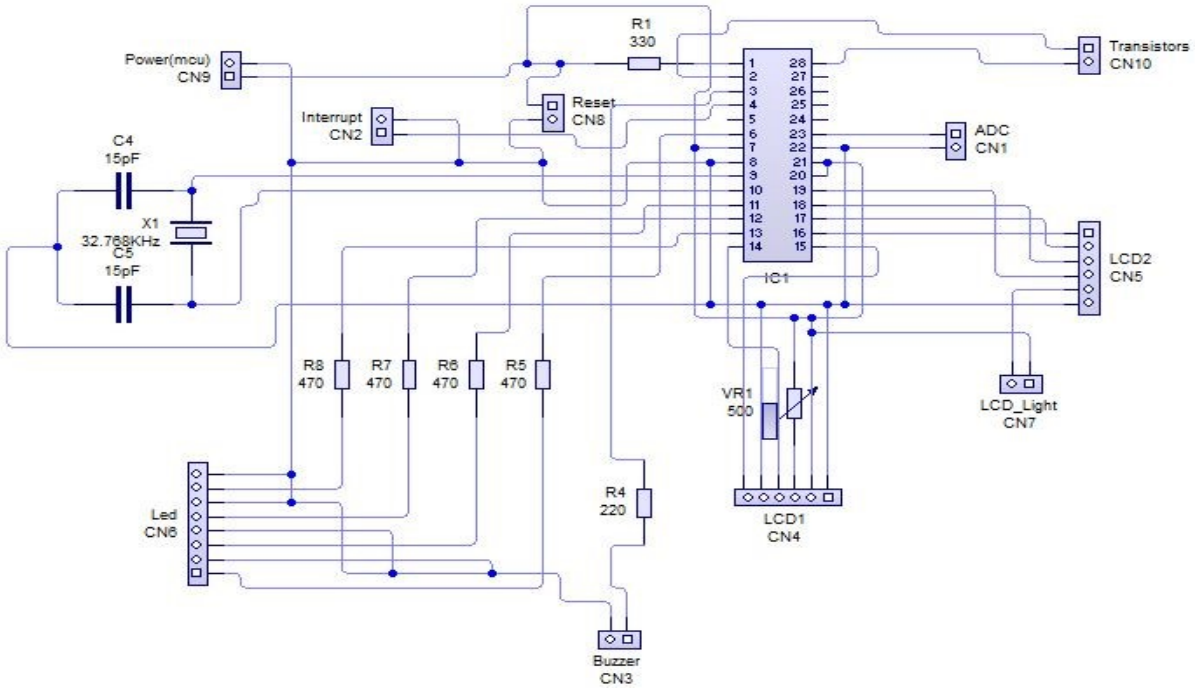

Fig. 2: Circuit Diagram of the Control Unit

4. Main Assembly/Frame

All generators, portable or stationary, have customized housings that provide a structural base support. The frame also allows for the generated to be earthed for safety. The frame was constructed using 1 inch iron pipe. The size of the frame is 18 inches x 12 inches x 15 inches. i.e it has a rectangular shape, with spaces created on the base of the frame for electric motor, alternator and the battery for their coupling. The frame is enclosed on three sides with perforated metal sheets leaving one side open as the entrance for the coupling.

An angle iron of dimension (1.5mm x 1.5mm) was cut length 21mm x 10mm and was welded to the base of the main frame for fitting the electric motor, while an angle iron was cut into length 20.5mm x 12mm and was welded to the frame for fitting the

alternator. An iron plate was measured and cut into the length of 60mm x 19mm and welded to the frame base the seat of battery and the self-charging panel of the generating set.

5. Construction

The fuel-less generating set are constructed by coupling the various components that make up the generator. First a crankshaft that will connect the electric motor to the alternator was fabricated. Then various holes for coupling the electric motor, alternator, panel for the control unit with bolts and nuts were bored. Thereafter the various components were coupled in the main frame already fabricated. The diode was connected to green cables and capacitor to the yellow cables, while the DC electric motor was connected to the equivalent terminals of the battery. The output terminal was connected to the output of the alternator.

Results and Discussion

The results were obtained using multi-meter to read the output voltage at different load conditions. These readings were obtained from the circuit breaker output and presented in table 1.

Table 1: Generator results under different Loads conditions

S/No	Components & Rating	Qty	Connected load (Watt)	Current (Amp)	Voltage Output (Volts)
1	Incandescent Lamp (100W)	5	500	0.83	220
2	Electric Iron	1	1000	12.5	220
3	AC	1	1500	15.0	220

The multi-meter was also used to measure the power input and output of various units. The voltage output from different components of the control circuit were obtained and presented in table 2.

Table 2: Test results on Power Supply unit from various components

S/No	Components	Voltage Outputs (V)
1	Inverter	24.00
2	Rectifier	20.80
3	7812 Voltage Regulator	11.78
4	7805 Voltage Regulator	4.86
5	Microcontroller	4.84
6	12V Relay	11.58
7	LED Connected in shunt	1.95

6. Conclusions

The design and construction of fuelless ac generator using alternator interfaced with an inverter and DC electric motor as prime mover has been implemented. It had two outputs voltages 12V for recharging of the 24V battery and 220V for the loads. It is important to note that in selecting the components for system, the DC electric motor rating must be higher than the rating of the alternator so that the maximum alternator output will be harnessed.

It is interesting to note that the voltage output of this generator is very stable because of the inverter connected to the alternator, from which it is connected to a load.

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