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Abstract. Epileptic power supply, scarcity of fuel, and the ever increasing demand for power supply have given rise to the development of several off-grid and on-grid power alternatives. A single phase to three phase rotary phase converter is a machine that can generate three phase power supply from an existing single phase source. This is a cheap means of generating three phase power especially in some residential environments where access to three phase power is limited. Some home equipment such as air conditioners and refrigerators run on three phase power also workshop owners and technicians have need to operate three phase machinery which may include table saw, drilling machine, lathe machine, and any machinery that runs on three phase power.

1. Introduction

Several types of converters have been implemented, In November 2012, Shivanagouda. Patil and Aspalli [1], proposed and implemented the principle of operation of a three phase induction motor from a single phase supply. The system made use of a half bridge rectifier along with split capacitors combination, half bridge inverter and triac combination and a 16 bit High efficiency digital signal controller.

The single phase to three phase rotary converter is quite different from all other types of converters. This is because it makes use of an automotive alternator to generate a three wire alternating voltage [2], [4].

2. Methodology

The single phase to three phase rotary converter consists of a single phase motor and an automotive alternator, the single phase electric motor is used to drive the automotive alternator [3]. The motor is powered from a 220-230V single phase supply, it is mechanically coupled to the automotive alternator using a pulley drive system.

2.1. Alternator operation

It is a three-phase generator with an in-built rectifier circuit comprising of six diodes circuits to convert the alternating current output from the stator of the alternator to Direct current [5]. As the sheave or pulley is been rotated by a belt attached to the crankshaft of the automobile engine, across a stationary set of three-phase windings, there are magnet spins, i.e. the stator, which is mainly connected in a star configuration [6]. An electromagnet, and not a permanent magnet, is a spinning or rotating magnet. Alternators are designed so that their magnetic field intensity can be regulated, and the output voltage can even be autonomously controlled by rotor velocity[7]. The battery power energizes the rotor magnet coil, which is called the field coil, in order to take a large amount of electrical power input to the alternator rotor to produce an excitation that will enable it to generate adequate output power.

For the purpose of this project the rectifier circuit has to be removed and the three phase alternating current output wires initially connected to the rectifier circuit is rewired out of the stator. Also a wire is center tapped between the stator coils to form the neutral wire while the field wires remain in place. . A 12/240v 2AM transformer is used to step up each leg of the alternator output. A 12 75AH battery is used to excite the rotor coil [8].

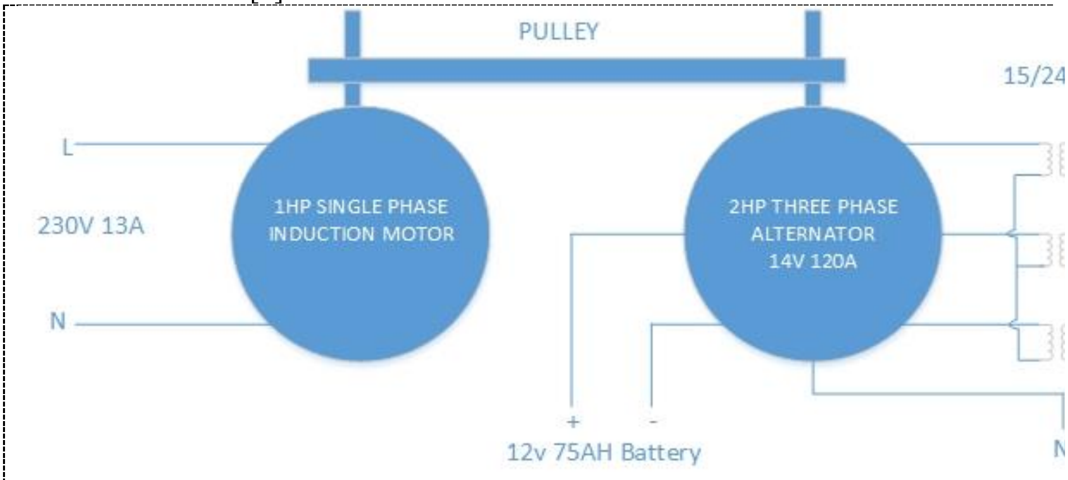

Figure 1. System/design architecture

3. Construction

To drive the alternator with a single phase motor, a pulley had to be constructed on the shaft of the single phase motor. The alternator comes with an already fitted 70mm diameter pulley and it requires a speed of about 2500 rpm to generate its rated voltage and the motor speed is 1300 rpm, so to increase the speed on the alternator pulley a larger pulley was constructed on the motor. The size of the pulley was determined using velocity ratio.

The ratio was worked out mathematically thus:

Velocity Ratio:

$$VR = \frac{speed\ of\ driven(rpm)}{speed\ of\ driver\ (rpm)} = \frac{N2}{N1} = \frac{d1}{d2} = \frac{2500}{1300} = \frac{25}{13}$$

Therefore d1:d2 = 2:1 approximately

Where:

N2 – required speed of alternator

N1 – speed of the motor at full load

d1 – diameter of driver pulley (single phase motor)

d2 - diameter of driven pulley (alternator)

3.1. Design Calculation

3.1.1. Motor Input Power.

$$P1 = \frac{P2}{n\cos\varphi}$$

$$= 0.75 \times 10^3/0.95 \times 0.85 = \ 0.93\text{KW}$$

3.1.2. The Belt's Velocity.

The belt's velocity may be expressed as:

$$v = \frac{\pi d_m n_m}{12}$$

Where

$v = velocity\ of\ belt\ (rpm)$

$n_m = speed\ of\ motor\ (rpm)$

$d_m = diameter\ of\ motor\ pulley\ (in)$

$v = 3.14 \times 5.51\ \times 1380/12 = \ 1989\ rpm$ $\cong$ 2000 rpm

3.1.3. Torque Developed.

$$T = \frac{63025 P_{hp}}{n}$$

Where

$P = output\ power(hp)$

$n = speed\ of\ rotation(rpm)$

$T = Torque\ developed\ (lb\ in)$

$T = \ 63025 \times 1/1380 = 46\ lb\ in\ = 5.2\ Nm$

3.1.4. Horsepower Transferred.

If the belt's tension and velocity are known, the horsepower transferred can be calculated as

$$P_{hp} = \frac{F_b\ V_b}{33000}$$

Where:

$P_{hp} = power\ (hp)$

$F_b = belt\ tension\ (lb_f)$

$v_b = velocity\ of\ belt\ (ft/min)$

If torque and the revolution per minute of the motor are known, then, the horsepower transferred can be calculated as:

$$P_{hp} = \frac{Tn}{5252}$$

Where:

$P_{hp} = power\ (hp)$

$T\ = torque\ (ft\ lb_f)$

$n = speed\ (rpm)$

$3.8 \times 1380/5252 = 0.99\ \cong 1HP$

3.1.5. Alternator Pulley Speed.

$$N_d = \frac{D_m \times N_m}{D_a}$$

Where:

$N_a = \ alternator\ pulley\ speed(rpm)$

$D_m = diameter\ of\ motor\ pulley\ (in.)$

$N_m = motor\ pulley\ speed(rpm)$

$D_a = diameter\ of\ alternator\ pulley(in.)$

$$N_d = \frac{5.51 \times 1380}{2.76} = 2755\ rpm$$

3.1.6. The Speed's Ratio.
This can be calculated as:

$$SR = \frac{n_f}{n_s}$$

Where:

$SR = speed\ ratio$

$n_f = speed\ of\ fastest\ machine$

$n_s = speed\ of\ slowest\ machine$

$$\frac{2755}{1380} = \ 1.996$$

4. Conclusion

The output voltage of the alternator was for phase voltages 25V, 23V, 15V and line voltages 43V, 39V, 26V. This imbalance in the output voltages is due to the way the alternator was wound. Further advancement and improvements on this research work would improve its capacity. These improvements would be to balance the output of the transformer, and also to step up this output voltage using transformers. This project has shown the possibility of generating three phase power cheaply using an automotive alternator. Also it has helped in the understanding of how alternators work and they can be used as converters.

I recommend for any future implementation of any project of this kind, that speed and torque should be put into consideration as they are the determinant factors of the output or capacity of the system. Also it should be noted that the power rating of the loads must not be as high as that of the alternator and the motor used

Acknowledgements

The authors wish to appreciate the Center for Research, Innovation, and Discovery (CU-CRID) of Covenant University, Ota, Nigeria, for partly funding of this research.

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