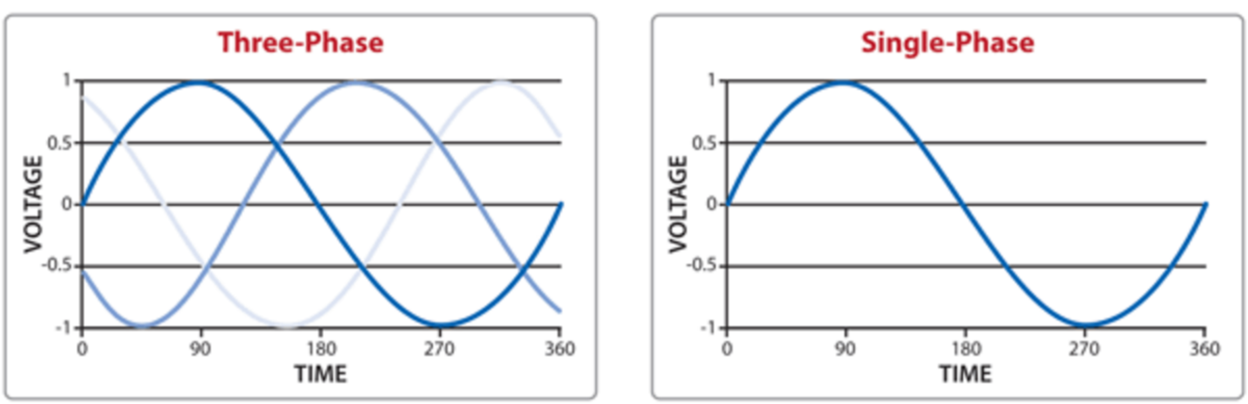
Written By: Arsalan Barolia

Two – Phase Generator Design Project Report

Single – Phase and Three – Phase Generators

Single-phase generator, also known as a single-phase alternator, and a three-phase generator are similar as both generators use alternating current (AC) to produce waves. However, they also have many differences. To begin with, both single and three phase generators deliver power differently. A single-phase generator delivers one constant wave of power where the level of power depends on the electrical current being supplied, therefore power levels can go to zero. A three-phase generator produces three continuous waves, in sequence, and represents the flow of power, like the single-phase generator. The three phases, starting at 90, 120, and 240 degrees are evenly spread over an entire cycle, 360 degrees. The benefits of a three – phase generator is that it resolves the issue of the voltage dropping to zero in addition to always allowing the power to remain above zero. A three-phase generator is more powerful and costly than single phase generators as single phase generators are commonly used in residential and rural applications and a three-phase generator are ideal for in industrial and commercial areas. *Figure 1 a)* and *b)* display a visual representation of the waves produced by a three and single – phase generator, respectively.



a) b)

Figure 1: Displays the waves generated by the three and single wave generators

Knowledge Applied Before Starting the Design

There are many sources of electricity, but the main resource are AC generators. An AC generator is a device that converts mechanical energy into electrical energy. Through lectures and various laboratory experiments, it was observed that when a coil of wire, coated cooper wire in this case, is placed near a magnet at rest, nothing happens. However, when the magnet starts to move or spin, the changing magnetic field produces an electric current in the wire as there is a change in flux, which will be discussed later. This enables the LED to light up when the magnets are spun when coils surround it.

Initially, iron strips were going to be implemented in the design however, they were not found at any hardware or plumbing locations, only steel was found. The coils would have been wrapped around the iron strips allowing for the magnetic field to be stronger. As iron is a soft magnet – a material easily magnetized and demagnetized – it allows for a sine and cosine wave to be formed. Whereas, if a material like steel, a permanent magnet – strongly resist demagnetization once magnetized – would have been used, the wave would eventually travel in a straight line as the magnet is already charged and thus, will not a sinusoidal wave on the oscilloscope.

Design

When designing the two – phase generator, the primary goal was to first create a single-phase generator where the second wave could then simply be added to the design. The design consisted of a wooden base where PVC pipes were placed to hold the copper wires (coated so the wires would not short circuit, when coiled), 4 Empire bar magnets, a glue gun, a spray paint bottle cap, and the breaking of hangers. The general idea of this design was attach the 4 magnets in alternating order, shown in *Figure 2*, which would spin, due to the drill, at high speeds and cause the LED, attached to the end of the stripped coated copper wires, to light up due to the change in flux. The LED was to test that the generator was functioning. *Figure 3* depicts the magnetic field lines of a magnet, and when spun,

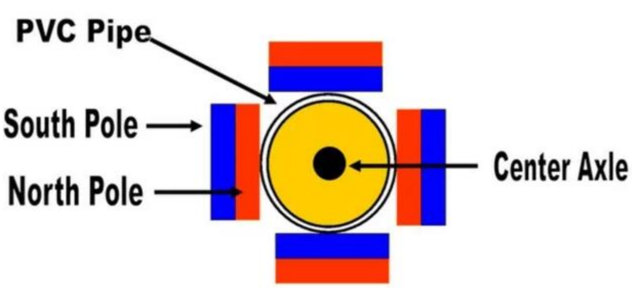


Figure 2: Arrangement of Magnets on PVC pipe

the magnetic lines are constantly changing from in to out or vice versa depending on direction of the spinning motion. The altering of magnetic field lines going in and coming out contribute to the flux, resulting in waveforms. *Figure 4* portrays the final design for the two – phase generator.

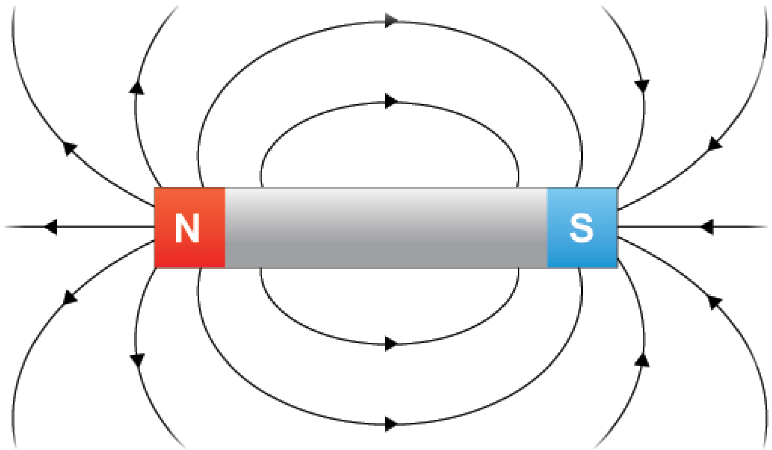


Figure 3: Magnetic field lines of a magnet

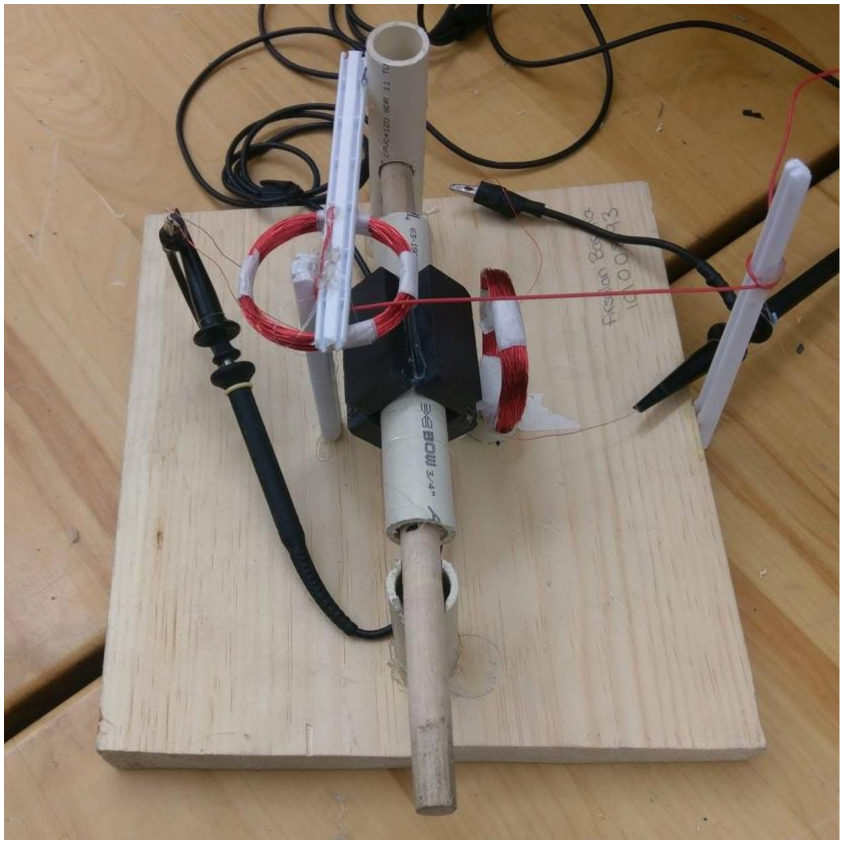


Figure 4: Final Product of the two – phase generator

In depth, a wooden base was chosen as a flat and sturdy plane to spin the half inch dowel, with a length of 10 inches, a minimum of 5 Hz. Since the ½ inch dowel was not able to fit all four magnets in the orientation mentioned in *Figure 3*, a PVC pipe was used which had a larger amount of surface area for the magnets stick on. Although 2 magnets could have been used, each with opposite poles since the flux would still change, the strength of the magnets were not strong enough to supply the voltage needed. Hence, the use of 4 magnets. One coil, wounded 212 turns with a diameter of 2 inches was placed very close, not touching, to the magnet that a single waveform was generated. Creating the second waveform was not difficult once the single waveform was done as a duplicate coil, also 212 turns and a diameter of 2 inches, was placed 90 degrees apart to achieve a phase difference of 90 degrees. The hangers were used to help keep the 2nd coil from falling and ensuring that the coil didn't move resulting in a different phase difference. *Figure 5* indicates the 2 waveforms generated by the Tektronix TDS 3012 oscilloscope from the two – phase generator.

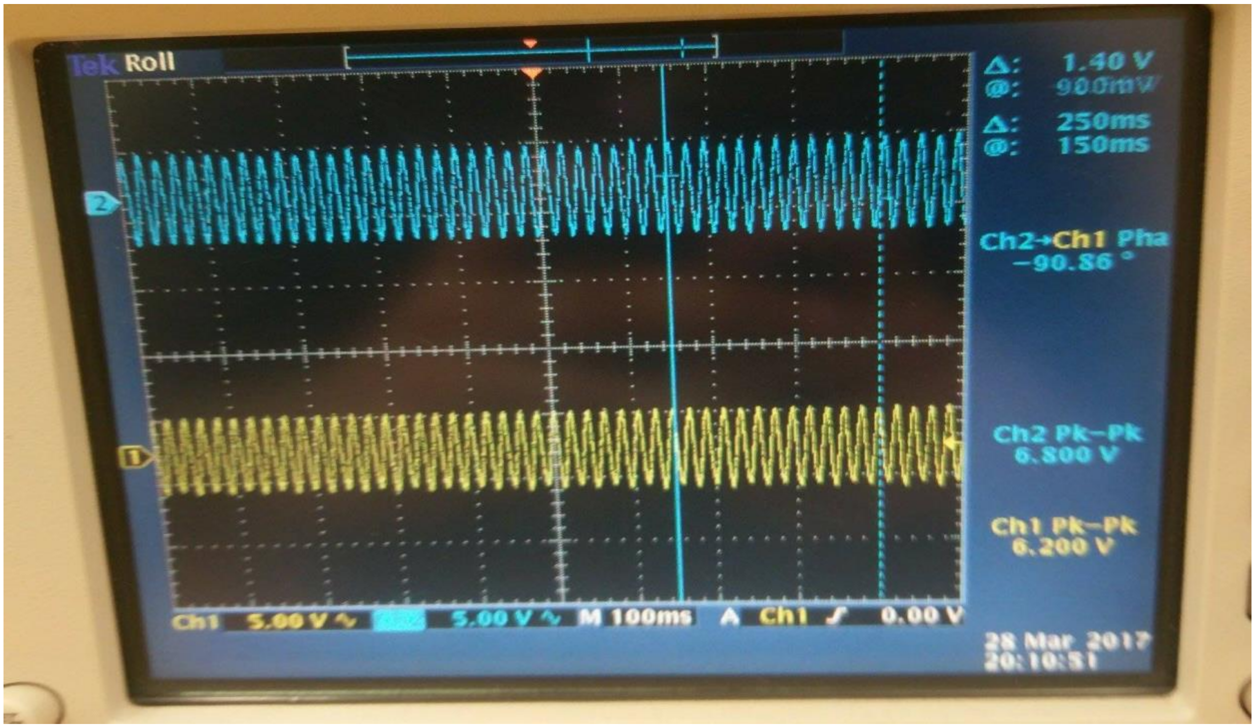


Figure 5: The 2 waveforms generated indicating that the phase difference between the two is 90 degrees

Calculations

The Empire bar magnets each have maximum pull of 3 pounds – provided by the manufacturer.

$$\varepsilon = \omega ABN\sin(\omega t) = \varepsilon_0\sin(\omega t)$$

→ Assuming B is constant

$$\varepsilon = \varepsilon_0$$

→ when $\sin(\omega t) = 1$ (at max)

$$\omega t = \pi/2$$

→ resulting in ω to be approximately 31.42 rads/sec when spun at 5 Hz

From the information calculated above, the strength of the magnet can be determined by using the maximum voltage provided by the oscilloscope as $\varepsilon = \varepsilon_0$.

V_{Max} = 6.4 V
ω = 31.42 rads/sec
A = $\pi r^2 = \pi(3.5\text{ cm})^2 = 0.003848\text{ m}^2$

→ each magnet had a length of 2.5 inches long, so a radius of 3.5 cm was selected for the coils

N = 200 turns
B = ?

$$6.4\text{ V} = \varepsilon_0$$

$$6.4\text{ V} = \omega ABN$$

$$B = \frac{6.4\,V}{(31.42)\,(0.003848)\,(200)}$$

$$B = 0.2647\text{ Tesla}$$

Now, the number of turns needed to light a 2.5 V LED can be determined. A red LED requires 1.9 V and a green LED requires 2.1 V. In this calculation, 2.5 V will be used as a precaution measure to ensure that both lights do indeed light up with respect to the number of coils used.

$$\varepsilon = \varepsilon_0$$

$$\varepsilon = \omega ABN$$

$$N = \frac{2.5\,V}{(31.42)\,(0.003848)(0.2647)}$$

$$N = 200\text{ turns}$$

This value indicates that approximately 200 turns are need to receive a voltage of 2.5 at 5 Hz to illuminate the LEDs.

Conclusion

The two – phase generator, designed, was tested using 2 LEDs, and both lit up. The maximum voltage the generator produces with 212 coated copper wires, with a diameter of 2 inches, is 6.4 volts. When using the Tektronix TDS 3012 oscilloscope, the phase angle between the two waves were 90 degrees. Therefore, this project was completed and designed successfully.

Written By: Arsalan Barolia