

## Alternating Current and Direct Current Generator

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**Abstract.** Spinning a wire loop within a uniform magnetic field in a convenient fashion induces a voltage between the loop terminals. This effect can be used to build an electric power generator, such as the one described in this paper. A coil attached to a shaft spins within the magnetic field of a "U" shaped magnet. Three conveniently designed conductive disks allow the electrical load of the generator to be fed either with alternating current or direct current.

**Keywords.** Alternating Current, Direct Current, Generator, Magnetic Field, Induced Voltage.

### 1. Introduction

Although diverse forms of energy (mechanical, thermal, chemical etc.) can be converted into electrical energy, the expression *electric generator* is reserved, in the industry, only for the machines that convert mechanical energy into electrical energy. The generators that produce direct current (DC) are called *dynamos* and the ones that produce alternating current (AC) are called *alternators*.

The device described in this paper is a generator capable of supplying an electrical load with the desired type of current: alternating current or direct current.

### 2. AC generator principle of operation.

Figure 1 illustrates the principle of operation of an AC generator. A wire loop rotates within the magnetic field generated by a magnet, which induces an AC voltage between the loop terminals. The periodic change of the voltage polarity is due to the change of the position of the coil relatively to the magnetic poles. The amplitude of the voltage depends on the magnetic field strength and is also directly proportional to the rotating speed [1, 2, 3, 4]. If the magnetic field is uniform and the rotation speed is constant, the voltage induced between

the loop terminals is sinusoidal with zero mean value (Fig. 2). Its frequency is equal to the number of revolutions per second executed by the loop.

Each terminal of the loop is connected to a metallic ring. The contacts with rings are made by means of fixed brushes. If the brushes are connected to an electrical load, an alternating current will be established in the circuit.

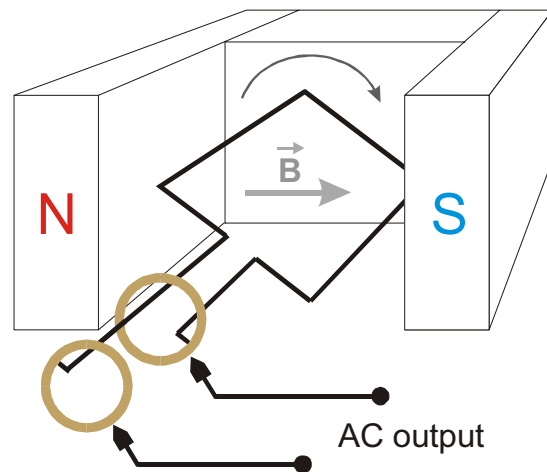


Figure 1. AC generator.

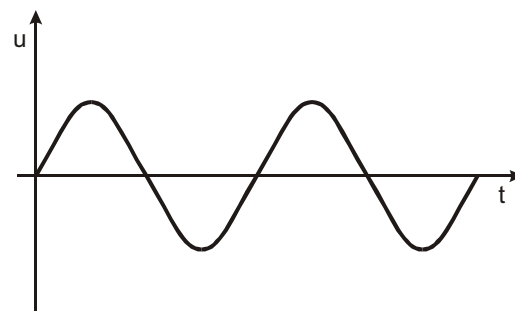


Figure 2. AC generator output.

### 3. DC generator principle of operation.

The described AC generator may be transformed into a DC generator, substituting the contact rings by a mechanical switch. As illustrated on Fig.3, a simple switch may be done

with a metal ring divided into two isolated halves (segments), which are mounted in the axis. This type of commutator is denominated collector.

Each terminal of the loop is connected to a segment of the collector. When the loop rotates, an AC voltage is induced in the coil, exactly as in the AC generator. But, before reaching the load, the induced voltage is transformed into a DC voltage by the collector (Fig. 4), which works as a mechanical rectifier. The contact segments of the collector move to a different brush each half turn of the loop, keeping a unidirectional current flowing through the electrical load of the circuit [1].

The rotation speed has to be well determined so that the final result is the expected one. As stated before, the rotation speed influences the induced voltage amplitude and frequency.

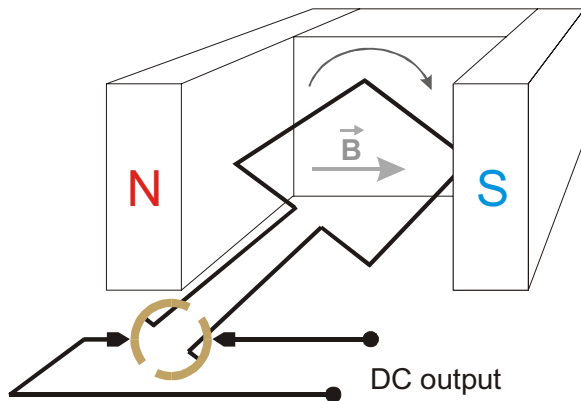


Figure 3. DC generator.

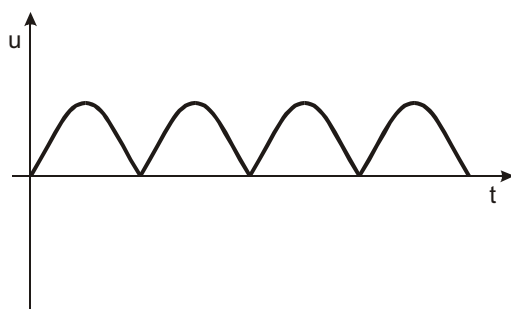


Figure 4. DC generator output.

#### 4. Generator' description

Instead of a simple loop, an iron core coil with 1241 turns of 0,16mm<sup>2</sup> varnished copper wire was used. The iron core and its windings are shown in Fig. 5.

The magnetic field used to induce a voltage between the coil terminals was provided by a

“U” shaped strong permanent magnet, shown in Fig. 6.

The most challenging part to build was a contact rings and collector unit (Fig. 7). It was made of three printed circuit board disks, coaxially mounted on the rotating axis.

The two smaller disks were kept with their entire conductive layer and were intended to supply the generated AC voltage. The conductive layer of the larger disk was cut into two halves, in order to implement the collector, which mechanically rectifies the generated AC voltage.



Figure 5. Coil with iron core.



Figure 6. Permanent magnet used to induce a voltage in the coil.

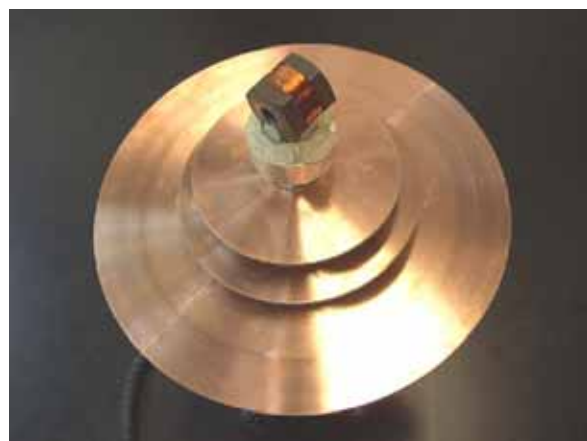


Figure 7. Three coaxial printed circuit board disks with coil on top.

Fig. 8 and Fig. 9 illustrate how the rings and collector unit was built in a more comprehensive way.

In Fig. 8, a cross-section of this unit is shown, revealing how electrical connections were made: one terminal of the coil was connected to one of the smaller disks and to one of the halves of the larger disk (collector); the other terminal was connected to the other smaller disk and to the other half of the larger one.

Fig. 9 shows a panoramic view of the assembly and the generator outputs responsible for supplying alternating or direct current to an electrical load. In order to make the generator operate properly, the DC output brushes positions must be displaced by 180° from each other. The AC output brushes may be placed anywhere on the respective disks.

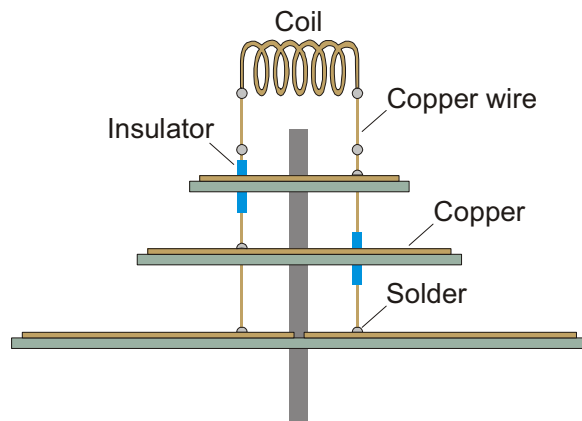


Figure 8. Connecting the coil to the three coaxial printed circuit board disks.

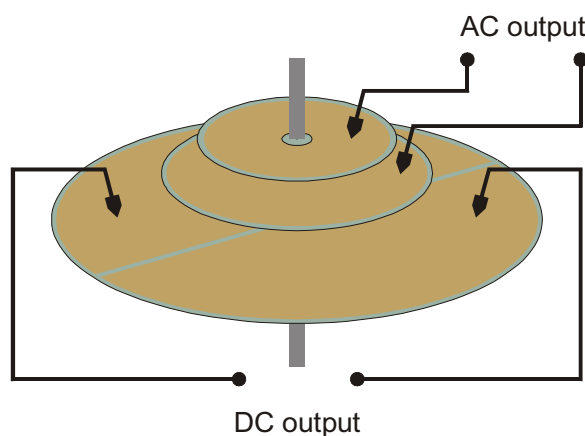


Figure 9. Outputs of the generator.

## 5. Results

The energy efficiency of this generator was not possible to determine. Although electrical

power could be easily measured, some sort of mechanical power meter was needed and it was not available. There are always mechanical and electrical power losses in the process of transforming mechanical energy into electric energy. Mechanical losses may be reduced by lubricating friction points.

The generator was put to rotate at 3000RPM; the measured induced voltage was 1,2V peak-to-peak, with a 50Hz frequency.

## 6. Conclusions

Spinning a wire loop within a uniform magnetic field in a convenient fashion induces a voltage between the loop terminals. Rotation speed influences the induced voltage amplitude and frequency. If an electrical load is connected to the loop terminals, a current will be established in the circuit.

The current generated by a basic electrical generator is alternating current. If the generator is intended to supply direct current, it must have a device working as a mechanical rectifier: the collector.

A device capable of generating both AC voltage and DC voltage has been presented. A coil attached to a shaft spins within the magnetic field of a "U" shaped magnet. Three conveniently designed conductive disks allow the electrical load of the generator to be fed either with alternating current or direct current.

This device is very useful to illustrate the principles of electrical energy generation. It also shows the main similarities and differences between AC and DC generators: the working principle is the same for both machines, but the AC generator has contact rings and the DC generator has a collector.

## 7. References

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