Plasma Speaker

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Abstract— A plasma speaker is an audio playback mechanism that uses an arc between two electrodes as a sound source. It works by heating air, causing it to expand. In short, Plasma speakers are a form of loudspeaker which varies air pressure via high-energy electrical plasma instead of a solid diaphragm. This releases a pressure wave, which is heard as sound. A plasma arc speaker is an improvement on the traditional diaphragm loudspeaker because the driver, electrical arc has very little mass and low inertia, reducing distortion. A plasma arc loud speaker has a better frequency response far exceeding the material of speaker cones. High quality plasma tweeters are very expensive, rendering them unsuitable for use in an average household. In this paper we discuss different types of plasma speakers, and present the electronic design and testing of a low cost plasma speaker. The technique is an evolution of William Duddell's "singing arc" of 1900, and an innovation related to ion thruster spacecraft propulsion.

Index Terms— Conventional Speaker, Fly-back transformer, Frequency Response, Directivity, Plasma speaker, plasma arc, modulator,

1 INTRODUCTION

Conventional speakers are constructed using a magnet and an inductor (coil). The inductor drives a diaphragm back and forth to produce varying pressure waves. These pressure waves are observed as sound. Conventional high frequency speakers have a number of disadvantages. One of the more difficult issues to address is the mass of the speaker. The suspension system, voice coil and the cone or dome of a conventional speaker all move to generate sound. Together, they add up to a mass greater than that of the air the speaker drives. Because of the inertia of this mass, the speaker is unable to respond quickly enough to an input signal which changes rapidly. Since a majority part of the music consists of rapid starting and stopping signals, the transient response, the ability of speaker to reproduce quick changes, suffers. This is especially true for high-frequency signals, which involve quicker changes in the signal. Another disadvantage is that high-frequency speakers are very directional.

Thus conventional speaker output is distorted by physical constraints innate in its design. These distortions have been the limiting factor in commercial reproduction of strong high frequencies since a very long time. The plasma tweeter provides a solution to all of these problems. The output of the use of plasma speakers as an option to conventional speakers is an even, linear output accurate even at extreme frequencies beyond any audible range. Such speakers are known for their clarity and accuracy.

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Fig.1 Our Plasma Speaker in operation

2 DESCRIPTION OF THE OPERATION

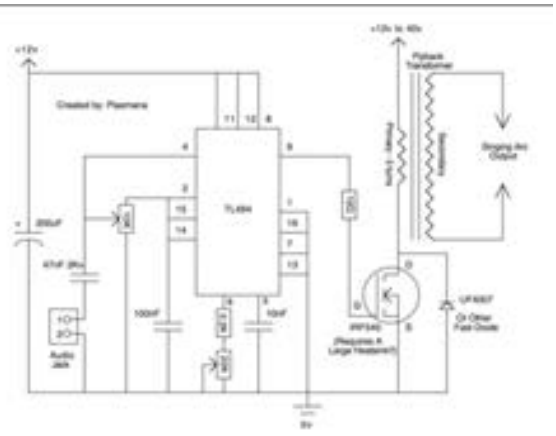

Fig. 2 Circuit Schematic

The operation of the circuit is kind of easy. IC TL494 acts as the oscillator and the audio modulator. As is evident from the circuit diagram, The audio input to the circuit is through the IC. It generates a high frequency wave (of about 50 kHz that is required to drive the flyback transformer. The arc discharge is then produced using the flyback transformer. Now the arc that is generated by the flyback transformer will cause the vibration of the air molecules at a frequency of the audio input as well as the high frequency that is generated by the flyback. Now the question one would ask is that if both the high fre-

quency and the audio input are present in the arc's vibration then how come it that we hear only the audio. The answer to that is quite simple. We do hear the high frequency sound sometimes. However the tuning of the 22K potentiometer in the circuit ensures that we are able to suppress it. In operation the 22K potentiometer is tuned in such a way that the high frequency arc vibrations fall above the usual hearing range of 20KHz.

A plasma arc is formed between the two electrodes of the transformer, and is generated when the field intensity between the two points becomes higher than the ionization potential of the material between them, the molecules begin to break down into ions and start conducting. The Ionization potential of air is an approx of 75 volts per .001 inch, or 3 million volts per meter at sea level. This can approximately be scaled to about 30kV per centimeter or 75kV per 2.5 cm, equalling 75kV per inch.

The ionized gas thus formed is plasma, from where the name of plasma arc is derived. Once the plasma arc is created, it is easier to maintain it because the heat produced by the ionization keeps the air ionized. Even if it cools slightly it remains easier to ionize at the next pulse. As the voltage is linearly related to the distance, the arc can jump the relation between distance and frequency is analyzed because of the difficulty of measuring such high voltages.

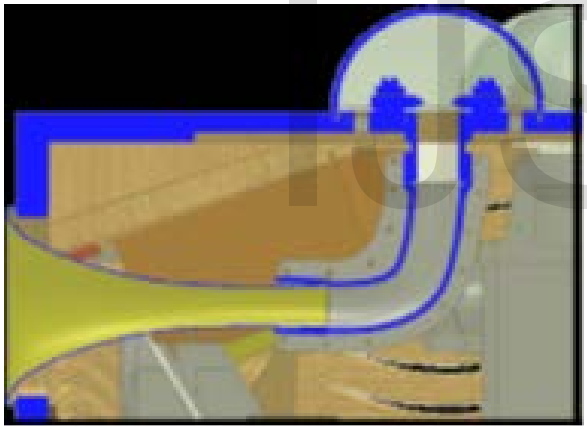

Fig. 3 Plasma Arc Enclosure System

Thus we can conclude the heart of our circuit apart from the audio modulator circuit is the flyback transformer.

3 FLYBACK TRANFORMER

A flyback transformer is a DC to DC converter. It creates a high voltage on a large number of windings on the secondary coil by taking a small voltage as an input at a small number of windings on the primary coil. If this charge does not ionize the air in the gap, that is the charge is not sufficient enough, it is accumulated by the large diode inside the flyback which prevents the voltage from getting equalized. This works because when the low voltage is applied at the primary coil, it creates a magnetic field being at a very high current. This magnetic field stores magnetic flux. When the current is withdrawn, the magnetic field collapses in on the transformer core and all the energy gets dumped back into the windings of the transformer. This flux is transferred to each winding, and due to the large number of windings on the secondary coil, the voltage created is very high. When the above process occurs, the transformer is said to be in a state of flyback and hence the name.

If one of these pulses does not possess enough energy to ionize the gap, the energy in the secondary is stored because of a large diode which prevents the electrons from flowing back into the coil and equalizing. Some flyback transformers have a capacitor in them, which assists in storing the charge. Following this, as the frequency is increased, the voltage that is outputted each second increases, because the magnetic field is created and collapsed more times each second.

Fig. 4 Flyback Transformer

However, this relationship does not continue forever. At a high frequency, the transformer goes into saturation. This implies that the magnetic field does not have time to fully collapse after each pulse. Since the magnetic field is not collapsing as far, less energy is being dumped into the windings of the secondary coil, and less voltage is generated. The magnetic field does not fully collapse due to the imperfect nature of the materials it exists in. If all materials were ideal, the magnetic field would be able to form and collapse at the speed of light, allowing for frequencies which are almost infinite.

4 ADVANTAGES

i) The main theme behind a plasma speakeris to make circuits that compensate for and even use the non-idealities of the components and that are able to handle the challenging frequencies and power levels at which they operate.

ii) The main advantage of plasma loudspeakers is the absence of membrane and moving parts, which makes them essentially free of any inertia. This results in a near to perfect transient

iii) Directivity measures how 'directional' a speaker is; that is, how the position of a listener may change the perceived or measured frequency response or volume. Directivity of a plasma speaker is better than a conventional speaker.

iv) Similarly, the performance of plasma speaker in terms

of sensitivity, frequency response and impulse response is better as compared to conventional speakers.

v) The plasma speaker has unparalleled performance and fidelity in the higher ranges.However, it is countered by a weakness and increase in distortion atlow levels. The unique nature of its "massless" driver gives it very low colouration, but again it is offset by an extremely insensitive, inefficient performance.

vi) Its omni-directional ability is potentially very valuable.

5 CONCLUSION

A plasma arc speaker was made and its operation was studied. By use of the plasma speaker we have attempted to study the phenomenon of electric discharge through the ionization of air molecules with the help of a flyback transformer. We thus infer that the results obtained using a plasma speaker are quite similar to those obtained by conventional speakers and thus we would support the use of plasma speakers in place of the conventional speakers.

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