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"AN ANALYSIS OF ADVANTAGES, DISADVANTAGES AND APPLICATIONS OF PLASMA ANTENNAS"

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ABSTRACT:

The use of plasma as a conductive element in microwaves has attracted increasing interest due to its unique and innovative properties in relation to conventional metallic circuits. At present, the industrial potential of plasma technology is well known and has been excellently demonstrated in many microwave technology processes, which include the use of an ionizing medium. The term plasma is often referred to as the fourth state of matter. As the temperature increases, the molecules become more active and transform in a solid-to-liquid sequence into gas and plasma. Using a heat plasma source and a tube filled with neutral gas, it is possible to make a graceful antenna. The plasma antenna can work better in star exploration as the weight of the product that must rise above the earth's surface must be less than the permissible limit. In the age of high-speed communication and perceptual radio, the plasma antenna has grown to form its beam, to mask the characteristics of fast switching and switching. By using non-thermal plasma sources in glass tubes containing neutral gases, a plasma antenna can be designed. This paper represents the basic process, advantages and disadvantages of plasma antennas along with their applications.

KEYWORDS: *Plasma antennas, fundamentals operation of plasma antennas, applications of plasma antennas and advantages and disadvantages of plasma antennas.*

INTRODUCTION :

The use of plasma as a conductive element in microwaves has attracted increasing interest due to its unique and innovative properties in relation to conventional metallic circuits. At present, the industrial potential of plasma technology is well known and has been excellently demonstrated in many microwave technology processes, which include the use of an ionizing medium. A column of ionized gas when used to radiate or receive an electromagnetic signal, and is said to be a plasma antenna. Plasma antennas are the receiver of antennas. This article reviews the current status of plasma antennas. Plasma was detected as an antenna in 1917, by J. Hereinafter referred to as "Ariel ionizing ray". In the 1960s, two military personnel proved this prediction with experiments. Kang W L, Rader M and Alexe I demonstrated at the 1996, IEEE International Conference on Plasma Science, Boston the construction of a glass tube antenna filled with low pressure gas. Then after measurements of the efficiency and radiation patterns of the plasma column antenna were developed by Gerard G. Borg and Jeffrey H. Harris in 1999. The properties of the plasma antenna depend to a large extent on the behavior of the electromagnetic wave propagating in the plasma. In the twenty-first century, many experiments have been carried out to characterize it. Between 1999 and 2002 T.R. Anderson, Igor Alekseev, J. H. Harris, J. J. Burg and some other notable scientists have patented some of the plasma antenna. Now the plasma antenna is capable of transmitting and receiving. There is some significant research conducted throughout the last decade. The length of the plasma column increases as the square root of the applied force. Therefore, by increasing the power, its effective length as well as the antenna's resonant frequency can be controlled. The properties of the plasma antenna differ from the copper antenna synchronously with the plasma frequency and the collision frequency and this property can be used to build a dynamically reconfigurable antenna. The plasma array antenna, length and number of elements can be controlled by operating parameters such as input power and working pressure. An innovative combination of selectable multi-beam antenna, smart plasma antenna, stacked plasma antenna arrays, and high-directional antenna are in a row in development. They will meet the delicate demands of today's wireless, defence and security markets.

OBJECTIVES OF STUDY:

1) To understand the features of plasma antennas.
2) To studyadvantages and disadvantagesof plasma antennas.
3) Tounderstand fundamental operations of plasma antennas.
4) To study applications of plasma antennas in various field.

HYPOTHESIS OF STUDY:

Plasma antennas have several advantages along with some disadvantages and its playing vital roles in today's high speed communication era.

MATERIAL AND METHODS:

In this paper, "researcher has adopted analytical and descriptive study methods and secondary data. The data and information which is used in the paper is drawn from reliable and creditable resources such as related books by various authors, related research papers, various journals and articles on the plasma antennas which available on online and offline" mode.

REVIEW OF LITERATURE:

Borget Al. (2000)

This paper analysis in certain applications, the surface wave-driven plasma column can replace metal as a guiding medium in radio frequency antennas. These plasma antennas offer low radar detection potential and negligible cross-coupling when de-energized. Experimental results have been presented confirming that the two most important physical issues, antenna efficiency and noise, are not touched by the use of plasmas. It is also shown that the relatively high efficiency of the plasma column driven by the surface wave can be predicted by simple computation.

Kumar, R., & Bora, D. (2010)

This study conducted experiments on current and conduction distributions, field, power modes, directivity and efficiency of this plasma antenna. In addition, a metallic copper parabolic antenna is built and the antenna parameters are compared with the plasma antenna. Our results indicate that the energy content of the harmonics of the plasma antenna is more pronounced compared to the copper antenna (which only generates a fundamental frequency). However, the power patterns of both antennas are quite similar. To provide a more qualitative understanding regarding the generation of harmonics in the plasma antenna field, a bispectrality analysis is performed to study the nonlinear interactions in the current fluctuations. Some specific features of the plasma antenna were examined in our study, which may enhance the possibility of plasma antenna application in relation to the conventional metal antenna.

Russo et al. (2010)

This paper studies the possibility of using the surfaguide device as a plasma source for plasma antenna application and it has been experimentally examined. The surfaguide was optimized, realized, and used to ignite the plasma column for use as a radiating structure: coupling to the network of radiated signals and the efficiency of the plasma antenna were measured to show that surfaguide could be used effectively to create and maintain plasma in a conductive medium. A plasma diagnostic technique has also been developed to assess the length of the plasma column and the conductivity of the plasma with respect to the power supplied. These measurements highlighted that the properties of the plasma antenna are strongly influenced by the pump signal and thus this signal must be optimized in order to obtain the highest conductivity.

Patel et al. (2014)

This paper examines the use of radio antennas that are currently under implementation using a metal conductor as a guiding medium for electromagnetic radiation. Plasma antennas use an ionizing medium. In this paper we discussed the basic theory, the operation of the plasma antenna. We have also introduced the features, advantages and applications for the same.

Jaafar et al. (2016)

This paper presents a novel design for a reconfigurable plasma antenna array using a commercial fluorescent tube. A circular reconfigurable plasma antenna array is proposed to collect the radiated beam by an omnidirectional antenna (monopole antenna) operating at 2.4 GHz in a given direction. The antenna design consists of a monopole antenna located in the center of a circular aluminum floor. The monopolar antenna is surrounded by a cylindrical shell of conducting plasma. The plasma shield consists of 12 commercial fluorescent tubes lined up in series that contain a mixture of argon gas and mercury vapor that upon electrification forms plasma columns. The plasma behaves as a conductor and acts as a reflector of radiation, in the case where the frequency of the plasma, ωp is higher than the operating frequency.

Jain, P. K., & Kumar, R. (2018)

This paper aims to verify plasma antenna parameters to help improve plasma antenna dimensions (plasma antenna length and radius). Five different plasma antenna configurations were simulated with the help of a High Frequency Structure Simulator (HFSS 13.0). Observations were made on the variation in antenna parameters such as resonance frequency, directivity, gain pattern, and radiation with the radius and length of the plasma column. The results of the study indicate that the plasma column of radius $r < 1.5$ cm shows better performance in terms of directivity and gain than the plasma column of radius $r > 0.5$ cm. In addition, the tunability of the plasma antenna with respect to resonance frequencies was studied. Moreover, the simulation results were matched with the experimental results, for example, trend and radiation patterns, providing more interesting results that cannot be measured due to experimental limitations.

Tejasree et al. (2020)

In this article, the researchers propose a circuit-shaped hybrid nano-pattern antenna with a SOI (silicon on insulator) configuration in a footprint region of 1100 x 800 nm 2. It is designed to operate in the frequency range from 160 to 240 THz and resonate at 193.5 THz. For the purpose of impedance matching, the proposed antenna in a circle was fed by the SOI component waveguide and implemented with a FEM based solver (CST MWS) instrument and observed that the proposed antenna results in a bandwidth, gain and efficiency of 67.6 THz, 5.25 dBm and 91.10%, speaking at a resonant frequency of 193.5 terahertz. The proposed antenna is feasible and can be manufactured with the help of standard semiconductor manufacturing processes. The proposed antenna can be used for many foil meter applications such as optical emission, image detection, heat transfer, optical sensing, energy harvesting, and scattering.

Kambojet al. (2021)

This study reveals that the typical arrangement of dots forms a nested plasma antenna array, where radiation parameters can be reconfigured with size, number, spacing between dots and plasma density. The study resulted in the current useful development in the field of reconfigurable RF antenna which is a research interest in radar for beam guiding and communications applications.

FUNDAMENTAL OPERATION:

Using a heat plasma source and a tube filled with neutral gas, it is possible to make a graceful antenna. The plasma antenna can work better in star exploration as the weight of the product that must rise above the earth's surface must be less than the permissible limit. The operating procedure for the plasma antenna is to first fill a neutral gas (e.g., argon) into the vacant glass tube. At some repair pressure, the tube is sealed; Care must be taken to apply pressure sufficiently below the glass cracking pressure. Connect a non-thermal plasma generating power source e.g., RF and microwave discharge. At lower frequencies, the accelerating ions in the field move towards the electrodes and produce secondary electrons, similar to what happens in a DC discharge. With increasing frequency, the ions, and thus the electrons as well, are no longer able to reach the electrode surface during the acceleration phase of the excited external field. Connect the signal source or receiver probe to the coupling sleeve above the glass tube of the plasma antenna, it is better to use a good connector as the coupling cap. Take care of the spacing between the bushings and the arrangement of the power supply. By controlling the applied energy, change the effective length of the plasma column, thus obtaining the desired result. By changing the operating parameters, such as working pressure, source frequency, input power, glass tube radius, plasma column length, and neutral gas, the effective length and efficiency of the plasma antenna must be changed. Experiments were also carried out on a fluorescent tube as a plasma antenna, and the simplest model of a plasma antenna was demonstrated. Using this model, show that the frequency above 200 Hz is sufficient to obtain a stable plasma state in the plasma column, and use it as a plasma antenna.

FEATURES PLASMA ANTENNAS:

An essential distinguishing feature of the plasma antenna is that the gas ionization process can manipulate the resistance. When deionized, the gas has infinite resistance and does not react to radiofrequency radiation. When deionized, the gas antenna will not scatter radar waves (providing stealth) and will not absorb high-energy microwave radiation (reducing the effect of electronic warfare countermeasures). The second essential distinguishing feature is that after a pulse is sent, ions can be removed from the plasma antenna, eliminating the resonance associated with traditional metallic elements. The resonance and noise associated with a metal antenna can severely limit the capabilities in transmissions of short, high-frequency pulses. In these applications, metal antennas are often accompanied by sophisticated computer signal processing. By reducing resonance and noise, we believe our plasma antenna provides increased accuracy and reduced computer signal processing requirements. These advantages are important in advanced applications of pulsed radar and high-speed digital communications.

1) Based on the development results to date, the plasma antenna technology has the following additional features:
2) No antenna resonance provides improved signal to noise ratio and reduced multipath signal distortion.
3) The low cross section of the radar provides stealth due to non-metallic elements.
4) Changes in ion density can lead to instantaneous changes in bandwidth over wide dynamic ranges.
5) After gas ionization, the plasma antenna has almost no ground noise.
6) During operation, the low ionization level plasma antenna can be separated from the adjacent high frequency transmitter.
7) Electronic circular scanning without moving parts can be performed at a higher speed than conventional mechanical antenna structures.

8) It has been mathematically demonstrated that by selecting gases and varying the density of ions, the electric aperture (or apparent signature) of a plasma antenna can be made to operate on par with a metallic isotope of greater physical size.
9) Our plasma antenna can transmit and receive from the same aperture provided the frequencies are separated over a wide range.
10) The plasma resonance, resistance, and electron charge density can be dynamically reconfigured. Ionizing gas antenna elements can be created and configured into a dynamically reconfigurable array of frequency, beamwidth, power, gain, polarization and direction - on the fly.
11) A single dynamic antenna structure can use time multiplexing so that many RF subsystems can share a single antenna resource reducing the number and size of antenna structures.

ADVANTAGES OF PLASMA ANTENNAS:

The advantage of a plasma antenna is that it can appear and disappear in a few millionths of a second. This means that when the antenna is not required, it can be made to disappear, leaving behind a gas-filled column that has little effect on the electromagnetic fields near the tube. The same applies to pipes made of fiberglass and plastic, which are also under study.The other advantage of a plasma antenna is that even when it is ionized and used at the lower end of the radio spectrum, for example HF communications, it is still nearly transparent to fields at microwave frequencies.The same effect is observed with the use of the ionosphere, which is plasma. Every night, amateur radio operators bounce their signals off the ionosphere to achieve long-range communications, while microwave communications from satellites pass through the ionosphere.

- Reduced RCS
- Reduced interference and ringing
- Can change shape to control pattern and bandwidth
- Can change plasma parameters
- Glow discharge increased
- visible signature *
- Good RF coupling for electrically small antennas
- Frequency selectivity
- Stable and repeatable
- Efficient
- Flexibility in length and direction of path

DISADVANTAGES OF PLASMA ANTENNAS:

The use of plasma makes the antenna design intricate. It has other drawbacks too.

1) Impossible to penetrate walls: the semiconductor plasma antenna developed by the inventors was limited to high frequency and hence its use also became limited. Also, the signal from these antennas cannot penetrate walls. This can be solved by using reflectors to make the waves reach the destination.
2) More energy: more energy is used to ionize the gas; Hence the ionizer increases the power consumption of the antenna.
3) Stable and repeatable plasma volumes: Not all gas is ionized to become plasma, and some parts remain uniform. Thus, the volume of plasma formed during each time must be the same to generate stable electromagnetic waves. This can be achieved by keeping the current flowing through it constant, which will excite the same number of particles.

APPLICATIONS OF PLASMA ANTENNAS:

Plasma antennas find their applications in various fields due to their unique properties, characteristics and advantages over traditional metal antennas.

1) Military applications: Not seeing radar means that the signals sent by the plasma antennas are very difficult to detect by any outside person, and since the military needs to send and receive highly classified information without any external interception of the plasma antennas, it has qualities and capabilities that can be used to develop and produce equipment In military applications for the foreseeable future.
2) Faster Internet: Plasma antennas can provide a faster rate of data transmission and thus can be used to provide high speed Internet like Wi-Gig (Wireless Gigabit Alliance) which is faster than Wi-Fi.
3) Public Safety Nets: Public safety nets such as CCTVs are used to prevent crimes and track criminals and can also be accepted as video evidence in court. If these devices are tampered with or damaged by criminals, it is possible that a handler from the safety department will space out or redirect traffic with plasma antennas.
4) Radio and television broadcasting: The signal strength of the signals emitted by plasma antennas is relatively stronger than that of the conventional metal antennas used traditionally, and therefore they last longer without damping and are suppressed, and thus broadcast companies may require fewer relay stations and repeaters to transmit signals to other areas and from Then it may lower the cost of the broadcast system for service provider companies.
5) Space communications: Plasma antennas are relatively lighter than normal antennas, and thus can be used as communication devices in space vehicles such as jet aircraft, commercial aircraft, even in spacecraft and also in unmanned aerial vehicle sensor antennas.

Plasma antennas can also be used in many other applications such as on ships and submarines for stealth to complete the mission of their crew and also for fishing vessels for deep sea fish locating, ballistic missile detection and tracking, vehicle collision avoidance system, etc. Plasma antennas may be the future of high-frequency and high-speed wireless communications, and the good news is that plasma antennas will be within the reach of everyone within the next couple of years.

CONCLUSION:

Plasma antennas are comparable to metal antennas, but offer special properties useful in electronic warfare. Plasma antennas can be reconfigured, i.e. when the plasma antenna is turned off, turning the antenna into an electrical insulator, this property is useful for mounting reconfigurable antenna arrays. The plasma antenna usually adopts partially or completely ionized gas as the conduction medium rather than metallic materials. Compared with the traditional metal antenna, the plasma antenna has many peculiar characteristics. For example, it can be quickly turned on or off; This property makes the plasma antenna suitable for stealth applications in the fields of military communications. Also, if this type of antenna is used as an antenna array, the coupling between the antenna array elements is small. In particular, the radiation pattern of the plasma antenna can be reconfigured by changing the frequency and intensity of the pump signal, gas pressure, vessel dimensions, etc. Because of the above advantages, many researchers and scientific facilities show great interest in it

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