ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #36277

Plasma antennas – a gentle introduction

Dr. Paul Benjamin Crilly, United States Coast Guard Academy

Paul Crilly is a Professor of Electrical Engineering at the United States Coast Guard Academy. He is also Chief/Department Chair of the Electrical Engineering and Cyber Systems Section. He received his Ph.D. from New Mexico State University, his M. S. and B.S. degrees at Rensselaer Polytechnic Institute, all in Electrical Engineering. He was previously an Associate Professor of Electrical and Computer Engineering at the University of Tennessee and was a Development Engineer at the Hewlett Packard Company. His areas of interest include laboratory development, antennas, wireless communications, signal processing, and instrumentation.

Julian Blanco, US Coast Guard Academy

Plasma antennas – a gentle introduction

Abstract – Abstract – In this paper, we describe the theory, practical construction, and experiments of a plasma antenna to radiate a VHF signal. The primary goal is to provide a introduction to plasma antennas to undergraduate electrical engineering students and eliminate some of the mystery surrounding this device. In our experiment, we implement a half-wave dipole whereby the conductor is a ionized gas or plasma that radiates a 120 MHz signal. The plasma is created using a 20 kHz source and mercury vapor gas contained in a florescent tube. We characterize the antenna's voltage standing wave ratio (VSWR), input impedance, radiation characteristics, bandwidth and then compare these to a similar halfwave metallic dipole antenna. Our learning objectives of this project are how to practically implement a plasma antenna using easily obtainable, low-cost components, and experience how ionized gas, acts like any other metallic antenna element, and thus can be an effective RF radiator. Furthermore, by doing the experiments, undergraduates will better understand dielectric breakdown, how dielectric breakdown in a gas forms a conductor, quantum mechanics associated with how color or spectrum of the discharge is a function of the elements in a gas. We consider the practical advantages and disadvantages of plasma antennas as compared to their metal counterparts which include how a plasma antenna when de-energized, is stealthy, how multiple plasma antennas can be configured for spatial multiplexing and how other plasma structures can be added to form reflectors, directors, etc.

Much of this work is based on below references [1-8].

References

1. F. Ulaby, E. Michielssen, U. Ravaioli, "Fundamentals of Applied Electromagnetics, 6E," Prentice Hall, 2010.
2. J. Cobine, "Gaseous Conductors," Dover, 1958.
3. T. Anderson, *Plasma Antennas*, Artech House, 2011.
4. J. Rayner, A. Whichello, and A. Cheetham, "Physical Characteristics of Plasma Antennas," IEEE Trans. On Plasma Science, vol. 32, pp. 269-281, 2004.
5. I. Alexeff, T. Anderson, S. Parameswaran, E. Pradeep, "Experimental and Theoretical Results With Plasma Antennas," IEEE Trans. On Plasma Science, vol. 34, pp. 166-172, 2006.
6. J. Zhao, Y. Chen, Y. Sun, H. Wu, Y. Liu and Q. Yuan, "Plasma antennas driven by 5-20 kHz AC power supply, AIP Advances, vol. 5, https://dol.org/10/10.1063/1.4938084, 2015
7. I. Alexeff, T. Anderson , E. Farshi, N. Karnam, and N. Pulasani, "Recent results for plasma antennas," Phys. Plasmas, vol. 15, https://doi.org/1010.1063/1.2919157, 2008
8. Silver, H., ed. 2011. The ARRL Antenna Book, 22nd ed. Section 4: Radio Propagation. Newington, CT American Radio Relay League.