Plasma Antenna VSWR and Co-Site and Parasitic Interference Reduction or Elimination

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Abstract— Plasma antennas use partially or fully ionized gas as a conductor instead of metal. Plasma antennas can perform as metal antennas do but with reconfiguration, lower thermal noise at the higher frequencies, and lower side lobes in some experiments. At the higher frequencies, plasma antennas have lower thermal noise than metal antennas and the thermal noise of plasma antennas decreases with the operating frequency of the plasma antenna making them ideal for satellite antennas Plasma reflector antennas, plasma FM/AM radio antennas, various plasma transmitting antennas, high power plasma antennas, plasma frequency selective surfaces, plasma waveguides, plasma co-axial cables, and smart plasma antennas have been built. Alexeff and Anderson and [1]-[2] Anderson and Alexeff [3] have done theory, experiments, and have built prototype plasma antennas. Anderson [4] wrote a comprehensive book on plasma antennas. S. Sakai [5] et al have shown that a plasma antenna is a type of metamaterial

I. Introduction

Co-site interference and/or parasitic interference are greatly reduced using plasma antennas because the plasma antennas not in use can be turned off with the plasma being extinguished. Metal cannot be extinguished so interference of one metal antenna with another metal antenna nearby is a problem which can be solved or greatly mitigated by using plasma antennas. Higher frequency plasma antennas can transmit and receive through lower frequency plasma antennas. Higher frequency plasma antenna arrays can transmit and receive through lower frequency plasma antenna arrays. Hence you need not even have to turn off (extinguish) plasma antennas to eliminate or reduce mutual interference. One aspect of the test results we performed which are important and useful for co-site interference mitigation indicates that a plasma antenna's best operating frequency can be "tuned" by varying plasma current. Testing similar to these can be used to optimize plasma current in each antenna of a nested set of antennas. For example, a plasma antenna requires only 35 mA for maximum RF transmission (or for receiving) at 35 MHz; but it is 40 dB less sensitive to an adjacent transmitting antenna operating at 290 MHz. This is an example of a significant reduction in co-site and/or parasitic interference provided by plasma antennas.

II. MEASUREMENTS OF PLASMA ANTENNA CO-SITE AND PARASITIC INTERFRENCE AND VSWR

The word " transmission" used should be distinguished from the word "transmitting" as in an antenna transmitting electromagnetic waves. An incident electromagnetic wave on a plasma antenna of plasma frequency 190 MHz will pass through that antenna (transmission coefficient at 1) if the electromagnetic wave frequency from another antenna is above 190 MHz. Electromagnetic waves from an antenna in the 1200-2500 MHz frequency range passes through the 4 plasma antennas in all the other (lower frequency) bands. The plasma antennas in the 450-512 MHz frequency bands will transmit electromagnetic waves that pass through the next 3 lower frequency bands. Plasma antennas operating in the 225 - 400 MHz frequency band will transmit though the 2 lower frequency band plasma antennas. Plasma antennas operating in the 225-400 MHz frequency band will transmit through plasma antennas in the lowest 30-88 MHz frequency band. This significantly reduces or eliminates co-site and/or parasitic interference. This all depends on finding the right plasma density or plasma frequency for each plasma antenna in all 5 frequency bands that were tested. Any reflections in transmissions of any of the higher plasma antenna frequency bands through lower plasma antenna frequency bands will be eliminated as we optimize the plasma frequency for each plasma antenna frequency band to optimally reduce co-site and/or parasitic interference. Two new plasma antennas with operating frequencies in the VHF and UHF Public Service bands have been built. A six inch length vertical plasma antenna with an operating frequency of 482 MHz had a VSWR of less than 3:1, and a custom fabricated plasma antenna with a resonant frequency of 216 MHz had an excellent VSWR of 1.1:1. An excellent VSWR to optimize matching was found just by changing the plasma density or plasma frequency. The plasma antenna VSWR can be reconfigured just by reconfiguring the plasma current. This has no counterpart in metal antennas and is another advantage that plasma antennas have over metal antennas.

Note the differences between Fig. 1and Fig.2. The metal receiver antenna (Fig. 1) has a peak reception at 160 MHz, but also receives signals beyond 500 MHz with an attenuation of 30 dB or less. When a plasma antenna (Fig. 2) is used in a pair with the same metal transmitting antenna, the signal is more attenuated above 300 MHz; indicating that an adjacent metal transmitting antenna operating above 300 MHz will have less co-site interference with the receiver plasma antenna operating at lower frequency.

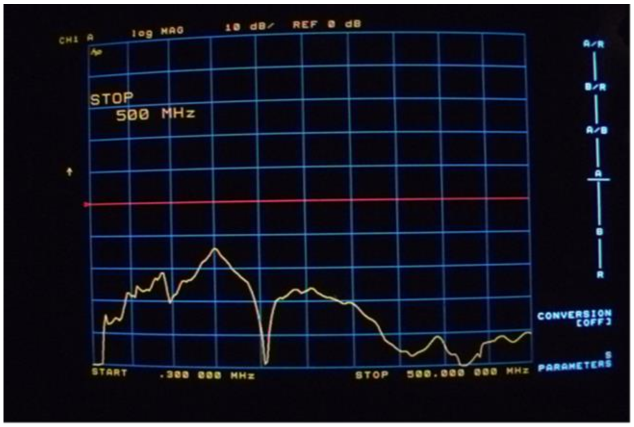

Fig. 1. Transfer curve for the following conditions: Transmitter antenna is a 19 inch vertical metal dipole antenna, The receiver antenna is a 46 inch vertical metal dipole antenna. The network analyzer span is 0.3 MHz to 500 MHz. There is 10dBm/div.

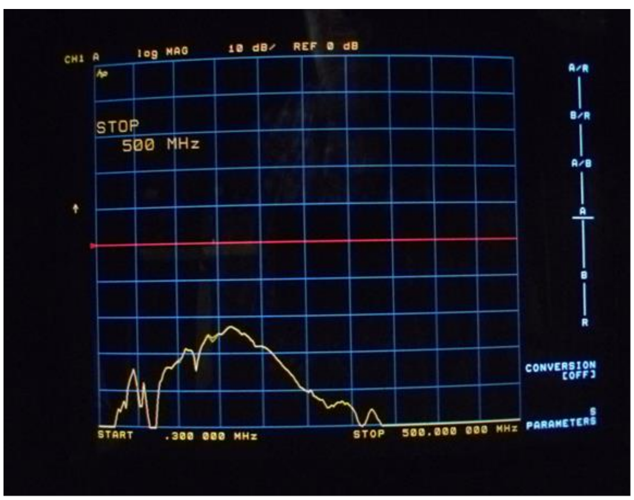

Fig. 2. Transfer curve for the following conditions: The transmitter antenna is a 19 inch vertical metal dipole antenna, The receiver antenna is a 46 inch **plasma antenna** with 60 mA DC drive current. The network analyzer span of 0.3 MHz to 500 MHz. There is10 dBm/div. Note the reduction in co-site interference as indicated by the received signal above 300 MHz, compared with the metal antenna receiver.

III. CONCLUSIONS

We had success in reducing co-site interference in testing the plasma antennas in these 5 frequency bands but we have not developed the technology yet to adjust the plasma frequency or density to exactly what we want it to be. Consequently we could not optimize the plasma frequency or density in each of the 5 frequency bands to eliminate co-site interference in the prototypes. This capability will be developed in future work by developing software to control the plasma frequency or density in each frequency band. The plasma antennas have very good VSWR over their bands of interest. This was done without the matching and tuning that would have been needed for metal antennas. Plasma antennas were built and tested to operate at frequencies between 30 MHz and 1500 MHz. Vertical antennas were tested with RF coupling to each antennas by a capacitive sleeve located near the lower end of the glass discharge tube. At frequencies below 500 MHz, a DC current is used to ionize and maintain the plasma discharge. Above 500 MHz, the DC current required for operation as an antenna causes excessive heating of the glass envelope and electrodes. To solve this problem, current is pulsed to several Amperes for about 5 microseconds; with a repetition rate of 1500 Hz. Therefore the average current is greatly reduced to less than 20 mA. Ion density, however, decays slowly after the fast pulse ends, and plasma frequency is relatively constant and remains higher than the antenna operating frequency. Unlike a conventional metal antenna, the frequency of plasma antenna for optimum efficiency can be tuned by varying discharge current. As an example, our plasma antenna operating at 50 MHz is much less susceptible (by 40 dB) to co-site interference from a nearby antenna transmitting at 170 MHz. Another way to lower co-site interference is to place a plasma shield around an antenna to reflect interference from a nearby antenna transmitting at lower frequencies. Our plasma shield consists of an array of plasma discharge tubes placed side by side around the antenna. Plasma discharge current is set at an appropriate value to assure that desirable signals pass unimpeded through the shield, but lower frequency interfering signals are reflected away by the shield. For further reading on plasma antennas refer to “Plasma Antennas” by Theodore Anderson and published by Artech House [4].

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