Polarization Improvement through Sinuous Antenna Arm Modification

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***Abstract* – The arms of a sinuous antenna are modified and the effects are investigated in terms of the polarization and group delay. Conventional sinuous antennas (CSA's) operate over a broad bandwidth. However, they show unwanted spikes when their polarization and group delay are plotted as functions of frequency. These spikes are thought to originate from the sharp ends and the bends of the arms. This paper shows that the spikes can be suppressed significantly by removing the sharp ends and the bends of the arms.**

***Index Terms* — Sinuous antenna, polarization, group delay.**

1. Introduction

Sinuous antennas have ultra-wideband characteristics, such as stable input impedance and consistent gain over a broad bandwidth [1]. However, they show unwanted spikes in the frequency spectrum of the gain. In order to suppress the spikes, sinuous antenna designers removed portions of the sharp ends of the sinuous arms [2]-[4]. Recently, we identified the sources of the spikes as the resonant mode current near the sharp ends and the bends of the sinuous arms [5]-[7]. The resonant mode current can be effectively suppressed by removing a certain portion of the sharp ends and the bends. In this paper, we show that the polarization and the group delay are also improved by removing those parts.

2. Sinuous antennas

Generally, sinuous antennas are made in the form of four sinuous arms in a self-complementary fashion, which is shown in Fig. 1(a) and denoted as the conventional sinuous antenna (CSA). The arms of the CSA are based on the sinuous curve defined as [8]

$$\phi(r) = (-1)^p \alpha_p \sin\left(\frac{\pi \ln\left(\frac{r}{R_p}\right)}{\ln \tau_p}\right), \tag{1}$$

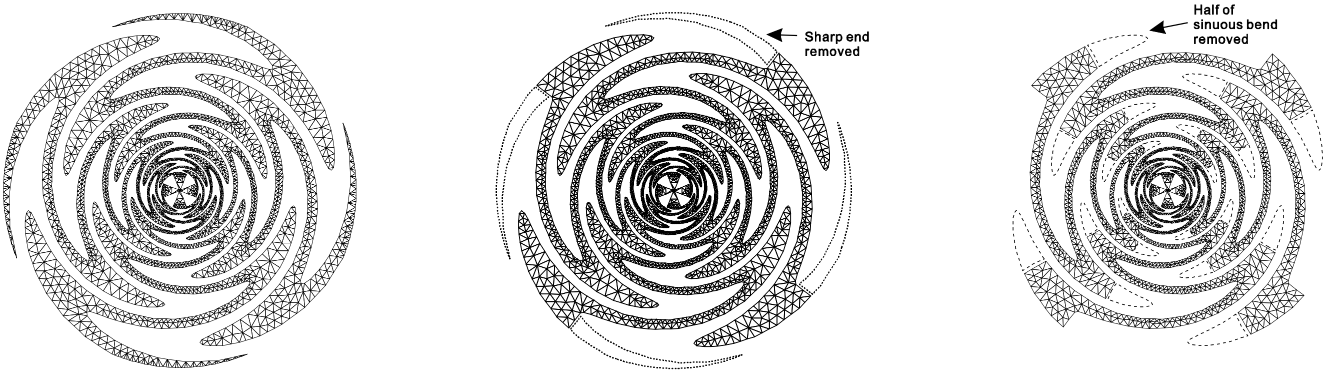
where

$$R_p < r < R_{p+1} \text{ in } p \text{ cell},$$
$$R_{p+1} = \tau_p R_p,\ p = 1,2,\ldots P.$$

In Eq. 1, ϕ and r are polar coordinates, P is the number of repetition cells, α_p is the maximum angular width of cell p, and R_p is the outer radius of cell p. In this paper, the sinuous antenna is designed with the parameters $P = 8$, $\alpha_p = \pi/3$, $\tau_p = 0.75$ and $R_1 = 0.05$ m. The parameters α_p and τ_p are chosen to be the same value for all p. The shape of the arms near the drive point is chosen to be the bow-tie pattern in order to less disturb the higher operating frequency.

Fig. 1 also shows two sinuous antennas with modified arms. Fig. 1(b) shows the sharp-ends-removed sinuous antenna (SERSA), where the sharp ends of the sinuous arms are removed. Fig. 1(c) shows a sinuous antenna whose arms are modified in such a way that the half portion of the sinuous bends are removed. The sinuous antennas in Fig. 1(c) is denoted as the modified sinuous antenna (MSA).

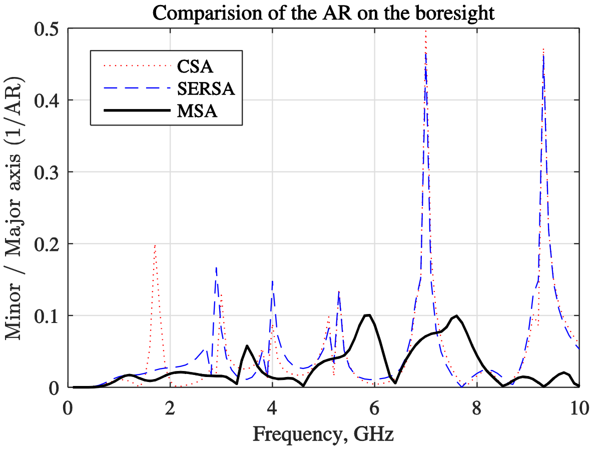
The antennas are numerically analyzed be the FEKO software, which is based on the method of moment (MoM) [9]. The meshes of CSA, SERSA and MSA are shown in Fig 1. Note that the sinuous antennas have two pairs of arms. Depending on how these pairs are excited, the antennas can have linear or circular polarizations. In this paper, one pair of arms is excited through a 267 **Ω** feed line, and the other pair is loaded with an ideal 267 **Ω** resistor [10]. Then, the antenna is supposed to radiate linearly polarize waves.



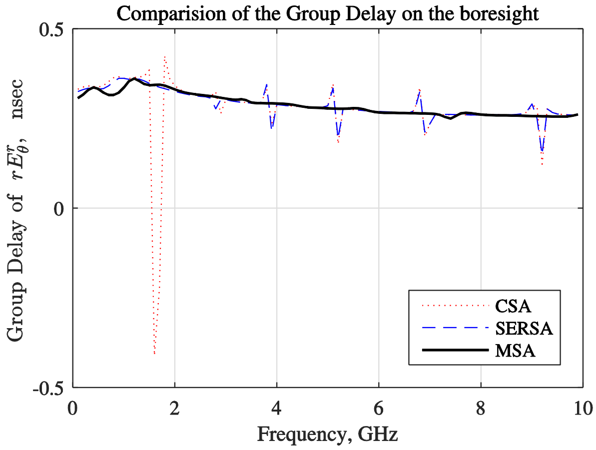
(a) CSA (b) SERSA (c) MSA

Fig. 1. Meshes of the CSA, SERSA and MSA for the MoM simulation.

3. Numerical results



(a) Minor / Major axis (1/AR)



(b) Group Delay

Fig. 2. (a) Minor/Major axis and (b) Group delay of the CSA, SERSA and MSA from the MoM simulation.

The lower cutoff frequency of the sinuous antenna is limited by the size. According to DuHamel, the lower cutoff frequency is determined by the largest active region, which is defined as [8]

$$R = \frac{\lambda}{4(\alpha_p+\delta)}. \qquad (2)$$

According the equation (2), lower cutoff frequency is near 1.25 GHz. Over the operating frequency bandwidth, the antenna is supposed to show consistent characteristics, including the polarization and group delay. However, Fig. 2 show that the CSA have inconsistent responses at some frequencies within the operating bandwidth.

Figs. 2(a) and (b) show the simulated axial ratio and group delay on the boresight of the CSA, SERSA and MSA. Fig. 2(a) shows the inverse of the axial ratio of antenna. For the linear polarization, this parameter is ideally zero. Fig. 2(b) shows the group delay of the wave transmitted from the antenna. A dispersionless antenna will have a constant group delay.

Fig. 2 shows that the CSA has spikes near the frequencies of 1.7, 2.9, 3.9, 5.2, 6.9 and 9.2 GHz. The spike near 1.7 GHz is believed to be due to the resonant mode current near the sharp ends of the sinuous arms. Notice that the SERSA, which does not have the sharp ends, shows the similar spikes except that its 1.7 GHz spike was suppressed. Other spiking frequencies are logarithmically scaled frequencies with a ratio of $1/\tau$ and believed to be due to the resonant mode current near the sinuous bends. Notice that, in the responses of the MSA, the spikes are significantly suppressed.

4. Conclusion

In this paper, the CSA, SERSA and MSA were investigated and their performance was compared in terms of the axial ratio and group delay. The CSA is an ultra-wideband antenna. However, it shows unwanted spikes in the frequency spectrum. These spikes are believed to be due to the resonant mode current near the sharp ends and bends of the sinuous arms. We showed that the spikes can be suppressed significantly by removing the sharp ends and bends.

Acknowledgment

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