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Research Paper

LOADING OF MICROSTRIP ANNULAR RING ANTENNA WITH POSTS

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The microstrip antenna is widely used for present communication purposes. In this paper, we investigate the annular ring antenna loaded with post and discuss the different positions of post in the structure. The cavity model is used for the analysis of the purposed antenna structure. The analysis is done with the help of IE3D software. The simulated results are compared with numerical results.

Keywords: Loaded annular ring antenna, Resonant frequency

INTRODUCTION

The microstrip antenna is low profile antenna widely used for present communication. These antennas have many advantages over conventional antenna, but narrow bandwidth is one of its disadvantages [1]. To improve the bandwidth of these antennas we can load the antenna structure. The loading can be done either by shorting post or by diode. In this paper, we load the microstrip annular ring antenna with post and obtain the results. The loading antennas are more popular in the communication and mobile applications because of its advantages such as tenability, compactness and dual frequency operation. The loading of the antenna with the post can be done by symmetrically and asymmetrically based on the location of the post.

THEORY

The analysis of the proposed antenna is based upon the cavity model where we consider that the height of the substrate is electrically small. In this section we discuss the loading of antenna symmetrically and asymmetrically. The basic ring geometry with shorting posts is shown in Figures 1 and 2. The annular ring antenna has inner radius a and outer radius b is loaded with the post of radius. Due to the loading with the post the given structure is divided into two regions, where the line of axis is through the line of axis and the centre of the patch.

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Asymmetrically Loaded Antenna

The posts are loaded asymmetrically means the posts are not equispaced in the circular disk, i.e., $\text{¤}_i \neq 0^\circ or 180^\circ$. The electric and magnetic field equations for the analysis are given by equations [2]. The electric and magnetic fields satisfy the following boundary conditions

$$E_z(2) = E_z(1) \text{ at } r = c \qquad ...(1)$$

$$H_{\text{¤}}^{(2)} - H_{\text{¤}}^{(1)} = \sum_{i=1}^{P} E_z^{(2)}/(Z_0.2\Delta)$$

$$\text{at } r = c \qquad ...(2)$$
$$for\, \text{¤}_i - \text{~}/2 < \text{¤} < \text{¤}_i + \text{~}/2$$

where Z_0 is the impedance per unit length of the shorting post given in [3].

For Eigen mode n= 0 or when $\text{¤}_i \neq 0^\circ or 180^\circ$ the resonant frequency of the asymmetrical loaded annular ring antenna is given in [2].

Figure 1: Geometry of Asymmetrically Loaded Annular Ring Antenna

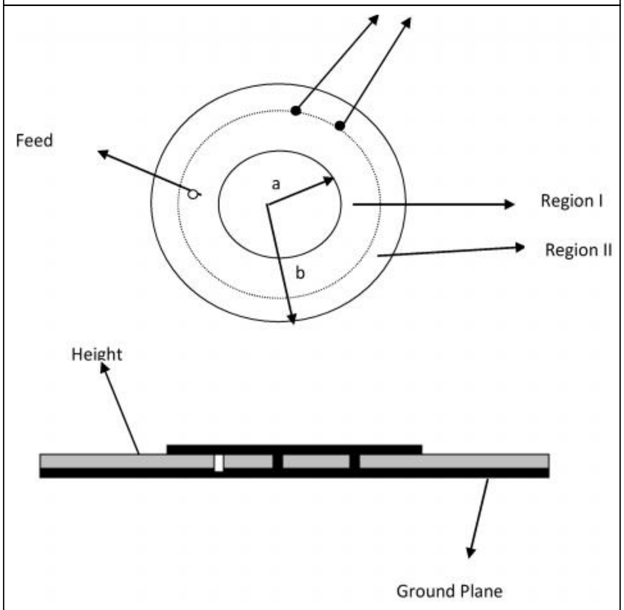
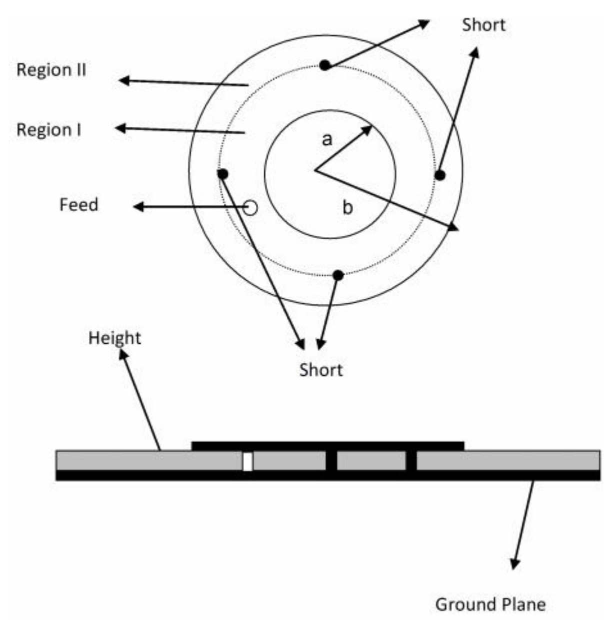


Figure 2: Geometry of Symmetrically Loaded Annular Ring Antenna



$$\frac{F_n^{(2)\prime}(tx)}{F_n^{(2)}(tx)} - \frac{F_n^{(1)\prime}(tx)}{F_n^{(1)}(tx)} - \sum_{i=1}^{P} \frac{£_n}{k_{np}cX_T} = 0 \qquad ...(3)$$

where

$$t = \frac{r_2}{r_1}, \quad x = k_{np}r_1, \quad t_2 = \frac{r_1}{\Delta}$$

$$X_T = \frac{j\text{µ«}}{2\text{®}}\{\ln(\frac{2}{\text{¥}k\Delta}) + \frac{\text{®}}{2}J_0(kc)N_0(kc)\}CF$$

Thus from the above equation it is clear that the resonant frequency of such antenna is independent of the angular variations. At any angular location for $P = 1$ and $n \neq 0$ the dual resonance is produced.

SYMMETRICALLY LOADED ANTENNA

In this we investigate the antenna loading with single and multiple posts, when post is loaded symmetrically. Symmetrically loading antenna means the post are equispaced in the circular disk, i.e., $\text{¤} = 0^0 or 180^0$. The symmetry is obtained when the post is located in same line with feed point and the centre of the patch. The electric and magnetic fields equation is given by [1]. The electric and magnetic fields satisfy following boundary conditions:

$$E_z^{(2)} = E_z^{(1)} \quad at\ r = c \qquad ...(4)$$

$$H_\phi^{(2)} - H_\phi^{(1)} = \sum_{i=1}^{P} E_z^{(2)} / \left(Z_0 . 2\Delta\right)$$

$$at\ r = c\ for\ \phi_i - \psi/2 < \phi < \phi_i + \psi/2 \qquad ...(5)$$

where Z_0 is the impedance per unit length of the shorting post and ψ is the angle subtended by the post. The resonance frequency of the symmetrically loaded annular ring antenna is obtained by [3]

$$\frac{F_n^{'(2)}(tx)}{F_n^{(2)}(tx)} - \frac{F_n^{'(1)}(tx)}{F_n^{(1)}(tx)} - \sum_{i=1}^{P} \frac{\varepsilon_n(1+\cos(2n\phi))}{2k_{np}cX_T} = 0 \qquad ...(6)$$

Thus from the above equation it is clear that the resonant frequency of the symmetrically loaded annular ring antenna is depends upon the angular variation of the post.

RESULTS AND DISCUSSION

The design parameters used for the microstrip annular ring antenna loaded symmetrically as well as asymmetrically with the shorting posts are $\varepsilon_r = 2.2$, $h = 1.59\ mm$, $a = 30\ mm$, $b = 60\ mm$, feed point location $r_0 = 35\ mm$ and $\Delta = 1$ mm and 2 mm. Equation (3) and (6) are used to find the resonant frequency of the annular ring antenna loaded symmetrically as well as asymmetrically with the posts. The results of these antennas are compared with the simulated results obtained with the help of IE3D software based on MoM. Tables 1 and 2 shows the comparison of the measured values and computed values of asymmetrically and symmetrically loaded antenna respectively. From these results it is clear that the measured value is very close to the computed value for both the antennas. Figures 3 and 4 shows the resonant frequency of the antennas at different location of the post. For $\Delta = 1$ mm and 2 mm the graphs show that the values of the numerical and simulated results are nearly same. The results are in complete agreement.

The major results for asymmetric loading are listed as follows:

- The resonant frequency strongly depends upon the radial location of posts. However the relative variation of these modes is different for different radial locations.
- TM_{11} is the dominant mode for asymmetric loaded antenna. For the antenna under consideration, the reduction in resonant frequency is as much as 3 times as compared to the unperturbed patch.
- The resonant frequency increases with increasing the radius of post.
- The metallic post incurs a small amount of power loss, therefore the gain of the antenna will be reduced.

Table 1: Comparison of Measured and Computed Values of Resonant Frequency of Asymmetrically Shorted Ring Resonator for n = 1 (First Dominant Mode)

No. of Posts	Resonant Frequency (GHz) for n = 1		% Error
	Computed	Measured	
1	0.9655	0.9653	0.021
2	1.12	1.09	2.3
4	1.6812	1.695	0.814
8	2.285	2.275	0.44
10	2.39	2.3922	0.09

Table 2: Comparison of Measured and Computed Values of Resonant Frequency of Symmetrically Shorted Ring Resonator for n = 0, 1 and 2 (First Dominant Mode)

No. of Posts	Resonant Frequency (GHz)					
	n = 0		n = 1		n = 2	
	Computed	Measured	Computed	Measured	Computed	Measured
1	0.214	0.2198	0.6678	0.6706	1.113	1.133
2	0.376	0.37	0.787	0.79	1.19	1.22
4	0.60	0.6127	0.79	0.7884	1.36	1.388
10	1.036	1.072	1.44	1.4	1.738	1.74

- In asymmetric loading the dual resonance is produced at any location for all normal modes except for *n* = 0. The resonance for each mode is independent of the angular location as long as ¤$_i \neq 0^{\circ}$ *or* 180° .

The major results for symmetric loading are listed as follows:

- The resonant frequency strongly depends upon the radial location of posts. The resonant frequency also depends on the radius of posts.
- The unperturbed ring patch has TM_{11} as dominant mode where as for the symmetrically shorted annular ring antenna is TM_{01} mode.
- For symmetric loading of post the frequency depend upon the angular location of posts where as in asymmetric loading the dual resonance is produced at any location for all normal modes except for *n* = 0. The resonance for each mode dependent on the angular location as long as ¤$_i \neq 0^{\circ}$ *or* 180° .

Figure 3: Comparison of Numerical and Simulated Values for Asymmetrically Loaded Antenna: Resonant Frequency with Radial Location of Posts (a = 30 mm, b = 60 mm, h = 1.59 mm, £$_r$ = 2.2 and P = 1)

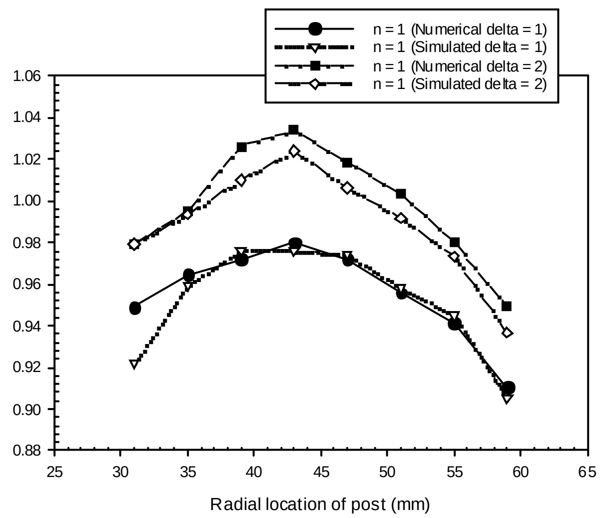
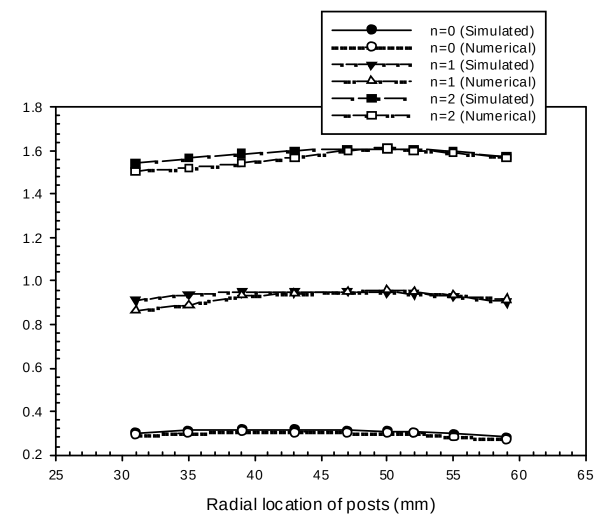


Figure 4: Comparison of Numerical and Simulated Values for Symmetrically Loaded Antenna: Resonant Frequency with Radial Location of Posts (a = 30 mm, b = 60 mm, h = 1.59 mm, £$_r$ = 2.2 and P = 1)



CONCLUSION

From the obtained results it is clear that the asymmetrically loaded annular ring antenna is independent of the angular variation of the post while symmetrical loaded antenna is not. The shorting post is one of the methods to enhance the bandwidth of the antenna. Future we can design a broadband antenna by loading the antenna with the varactor diodes and stubs.

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