THE THEORETICAL STUDY OF THE EFFECT OF PARASITIC ELEMENT TO INCREASE THE BANDWIDTH FOR RING MICRO-STRIP ANTENNA

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ABSTRACT

Micro-strip patches are the new generation of antennas due to their many attractive features, including low profile, lightweight, have simple geometries, are inexpensive to fabricate and can be easily made conformal to the host body. In the present theoretical investigation regarding Ring Micro-Strip Antenna we have investigated the effect of parasitic elements to improve the bandwidth of Ring Patch Antenna.

Keywords: Bandwidth, Fringing Field, Impedance Matching, Parasitic Element, Ring Microstrip Antenna.

I. INTRODUCTION

In future mobile communication systems requires low profile, lightweight, as well as the ease in which these radiators can be integrated with photonic and micro wave monolithic integrated circuit (MMIC) technologies [1]. One of the major drawback of the microstrip antenna is its narrow band-width. The bandwidth of a patch antenna can be substantially increased through the use of thick substrate. The grounded dielectric substrate supports surface wave modes, however, it lowers the antenna efficiency. Various methods have been investigated recently for improving the narrow bandwidth of microstrip antennas. Well known methods are addition of a parasitic patch on the top of the original patch [2], proximity coupling of feed line to the patch antenna [3], and impedance matching of input port by stub lines [4]. Among these techniques the effect of parasitic elements receives much more attention, mainly due to additional advantage of adjusting the beam width, gain, and efficiency by the parasitic patch [5]. Another approach for improving the bandwidth performance of patch antenna is to add parasitic elements to the antenna structure [6, 7]. This reduces the impedance variation of the antenna with frequency which enhances bandwidth performance. Parasitic elements are designed to resonate close to the resonant frequency of the driven radiator element, leading to a desirable tuned response. It is also called double-resonance phenomenon technique [8].
II. THEORETICAL ANALYSIS

The element supplying power directly from source (i.e. Transmitter) usually through transmission line is called as driven element. But a parasitic element is not fed directly instead parasitic element drives power by radiation from nearby driven element. In other words, parasitic element obtains power solely through electromagnetic coupling with a driven element because of its proximity to that driven element. There are various methods for dealing with the analysis of the parasitic elements placed close to a driven element. One approach to the analysis is to compute the capacitance that exists between the parasitic and the driven antenna elements. Consider the ring microstrip geometry as shown in fig. 1.

![Fig. 1: Geometry of the ring patch antenna coupled with a parasitic element](image)

The capacitances can be expressed in terms of even and odd mode values for the two modes of propagation for rectangular patch [9]. The distribution of the capacitances of the ring microstrip is shown in Fig. 2 for the two modes.

**MAGNETIC WALL**

![Magnetic Wall Diagram](image)

**ELECTRIC WALL**

![Electric Wall Diagram](image)

Fig. 2: Distribution of capacitances of (a) even mode (b) Odd mode propagation
The even mode capacitance shown in fig. 2 (a) can be divided into three categories. Thus

\[ C_{\text{even}} = C_p + C_f + C'_f \]  

(1)

Where \( C_p \) is the parallel plate capacitance between the strip and the ground plane, \( C_f \) is the fringing capacitance obtained from uncoupled microstrip and \( C'_f \) is the fringing capacitance due to the presence of another microstrip. These capacitances have been obtained for a ring microstrip patch as given below.

\[ C_p = 2 \varepsilon_0 \varepsilon_r \frac{a}{H} \]  

(2)

\[ C_f = \frac{1}{2} \left[ \frac{\varepsilon}{cZ_0} \right] \]  

(3)

\[ C'_f = \frac{C_f}{1 + A \left( \frac{H}{S} \right) \tanh \left( 10 \frac{S}{H} \right)} \]  

(4)

where \( c, \varepsilon, \varepsilon_r \) and \( Z_0 \) are the speed of light in free space, the effective dielectric constant of the substrate and the characteristics impedance of the ring microstrip, respectively. The expression of \( C'_f \) is obtained empirically such that the resulting value of even-mode capacitance is comparable with numerical results. The value of \( A \) in the expression (6.4) for \( C'_f \) is given by

\[ A = \exp \left[ -0.1 \exp (2.33-5.06 a/H) \right] \]  

(5)

The odd mode capacitance, shown in Fig. 6.2 (b) is expressed by –

\[ C_{\text{odd}} = C_p + C_f + C_{gd} + C_{ga} \]  

(6)

where \( C_{ga} \) and \( C_{gd} \) are the capacitances for the fringing fields across the gap in the air region and in the substrate region, respectively.

Once the capacitances are known, the impedances for the even and odd modes are computed separately using the cavity model. The resultant input impedance of the system is given by-

\[ Z_{\text{in}} = Z_{\text{in, even}} + Z_{\text{in, odd}} \]  

(7)

The impedance bandwidth is then found by calculating the input impedance at each frequency. The antenna bandwidth is a width (i.e. range) of frequency over which the antenna maintains certain required characteristics like gain, front to back ratio or S.W.R. pattern (shape or direction), polarization and impedance. In general, the bandwidth of an antenna, as said, mainly depends on its two characteristics e.g. impedance and pattern. The band-width of microstrip antenna is defined as, the frequency range over which the value of the input VSWR increases from unity to a tolerate limit values. The bandwidth of microstrip antenna [10] is given by
\[ BW = \frac{s - 1}{Q_T \sqrt{s}} \] ..........................(8)

Where ‘s’ is the distance between two patches under consideration.

Using parasitic elements to improve the match of the radiator to the feed line may increase the bandwidth of ring microstrip antenna. One technique is to add parasitic elements, indeed, the coupling between the driven structure and parasitic elements odds capacitance to the structure. The configuration of coupled parasitic element structure antennas are classified into two categories- edge-coupled structure and capacitively fed structure, respectively.

III. EDGE-COUPLING STRUCTURE ANTENNAS

The ring microstrip antenna geometry with a parasitic edge coupled element is shown in fig. 3

![Fig. 3: Antenna geometry of a RMSA using edge coupled parasitic elements](image)

Various experiments were carried out in [11] to study the effect of gap width on the performance of antenna structure. To further increase the bandwidth, the parasitic element having unequal radius \(a_1 \neq a_2\). This produces a triple-resonance phenomenon and widens the bandwidth. The technique of edge-coupling structure of Ring Micro-Strip Antenna is a popular method for enhancing the impedance bandwidth.

IV. RESULTS AND DISCUSSION

Thus in the present theoretical investigation regarding Ring Micro-Strip Antenna, we have investigated the technique of widening the bandwidth of low-profile ring microstrip antenna. The widely used technique consists of adding parasitic elements to the antenna structure. In future this research work is much useful for increasing the bandwidth of ring microstrip antenna for nano-dimension.

V. REFERENCES