RESONANCE CHARACTERISTICS OF MICROSTRIP ANTENNA AS A FUNCTION OF SUBSTRATE THICKNESS

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ABSTRACT

A set of measurements of annular ring slot antennas on substrates of varying thickness is presented. The most important factors in design of microstrip circuit and antenna are choice of the best substrate thickness and the dielectric constant to have low losses. In this case an attempt has been made by selecting various dielectric thicknesses to study return loss. For this, an annular ring slot microstrip antenna (ARSMSA) is designed at 3.0 GHz and simulated on different substrate thicknesses ranging from 0.5mm to 3.0 mm using Zeland IE3D software. The variation in return loss is found from -5.869dB to -42.16.

Keywords: Microstrip Annular Ring Slot Antenna (ARSMSA), Return Loss, VSWR, Dielectric Thickness

I. INTRODUCTION

Recent interest has developed in radiator etched on electrically thick substrates as these antennas are used for high frequency applications. However, microstrip antennas inherently have narrow bandwidth. In many cases, their increased impedance bandwidth is also paid for poorer radiation characteristics. Recent interest in millimeter wave systems and monolithic fabrication, however, has created a need for substrates that are electrically thicker, and/or have high permittivity. Increased bandwidth is another reason for interest in electrically thicker substrates. Anomalous results have been previously observed for printed antennas on such substrates. Many of the theoretical models, which worked well for thin, low dielectric constant substrates, fail to give good results for thicker or higher permittivity substrates.

In order to determine the range of validity of these models, and to provide a database of measured data for the testing of improved models, this paper describes the results of a comprehensive set of measurements of annular ring slot microstrip antennas. Ten individual antennas were designed and simulated with different substrate thickness viz.(0.2mm, 0.5mm, 0.75mm, 1.25mm, 1.75mm, 2.0mm, 2.5mm, 2.75mm and 3.0mm).The dielectric constant is assumed constant as 4.2 and fed with a coaxial probe. The measured resonant frequencies are reported for each case. The simulated results are then compared with the antennas on different thickness of substrates.

II. ANTENNA GEOMETRY AND DESIGN

The geometry of the proposed antenna is shown in Fig.1.The ground plane lies at the bottom side of the antenna with a very compact size of 21.75mm × 31mm × (0.5 to 3.0) mm. The radiation elements of the proposed antenna consist of an annular ring slot, operating approximately at 2.9 GHz (however a slight variation is also noticed in table 1 which is negligible for wideband operations).m. The operating frequency is taken as 3 GHz. The other parameters are calculated using [7] and found as: W=31mm, h= (0.5 to 3.0) mm (assumed), ε_{eff}=4.63, L_{eff}=23.2mm, ΔL=0.72mm and L=21.75mm at ε_r=4.2. For a rectangular microstrip antenna the resonant frequency is given as:

$$f_r = \frac{c}{2(L+\Delta L)\sqrt{\varepsilon_r}}$$

Where length extension (ΔL):

$$\Delta L = 0.412\, h \frac{(\varepsilon_{eff}+0.3)\left(\frac{W}{h}+0.264\right)}{(\varepsilon_{eff}-0.258)\left(\frac{W}{h}+0.8\right)}$$

Optimum value of W:

$$W=\frac{\lambda_o}{2}\left(\frac{(\varepsilon_r+1)}{2}\right)^{-1/2} \text{ and } \frac{\Delta f_r}{f_r}=\frac{\sqrt{\varepsilon_r}-\sqrt{\varepsilon_{e0}}}{\sqrt{\varepsilon_o}} \text{; also } \sqrt{\varepsilon_e}=\sqrt{\varepsilon_{eo}}+\Delta\sqrt{\varepsilon_e}$$

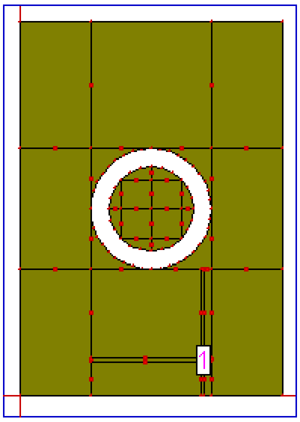

Fig.1: annular ring slot antenna with W=31mm, h= (0.5 to 3.0)mm (assumed), ε_{eff}=4.63, L_{eff}=23.2mm, ΔL=0.72mm and L=21.75mm at ε_r=4.2. fed by coaxial probe at (15.15mm, 2.975mm)

III. MEASUREMENTS AND RESULTS

Microstrip antenna of annular ring slot shape is designed at 3.0 GHz. various substrates thickness has been used to simulate the antenna. The ARSMSA is fed by a coaxial probe at (15.15mm, 2.975mm). The antennas were tested for VSWR and return loss using Zeland IE3D software. A careful simulation study of resonant frequency, bandwidth and return loss of the antenna was undertaken and the results of return loss are presented. . The radiation elements of the proposed antenna consist of an annular ring slot, operating approximately at 2.9 GHz (however a slight variation is also noticed in table 1.

The results obtained are given in table 2**.** It can be observed that, variation in return loss is found from -5.869dB to -42.16 dB obtained for various substrates thickness.

Table I

Return Loss for Different Dielectric Thickness and Resonance Frequency

Return Loss(dB)→ Frequency (MHz)↓	Thickness of Dielectric Substrate (mm)									
	0.2	**0.5**	**0.75**	**1**	**1.25**	**1.75**	**2**	**2.5**	**2.75**	**3**
2.874	-1.331	-4.535	-2.263	-2.287	-2.697	-4.578	-6.12	-11.48	-17.1	-27.63
2.879	-1.686	-6.325	-2.728	-2.652	-3.072	-5.149	-6.878	-13.09	-20.33	**-30.49**
2.889	-2.995	-16.05	-4.283	-3.757	-4.156	-6.748	-9.012	-18.31	**-42.16**	-20.31
2.896	-4.432	**-19.8**	-5.964	-4.817	-5.141	-8.151	-10.91	-25.01	-25.02	-16.72
2.897	-4.697	-17.19	-6.301	-5.016	-5.322	-8.404	-11.26	-26.72	-23.74	-16.28
2.905	-6.446	-8.187	-9.83	-6.917	-6.981	-10.7	-14.52	**-29.89**	-17.68	-13.61
2.912	**-5.869**	-4.776	-16.16	-9.894	-9.413	-14.03	-19.62	-19.53	-14.27	-11.67
2.913	-5.701	-4.57	**-16.8**	-10.24	-9.689	-14.41	-20.22	-19	-14.02	-11.52
2.92	-3.933	-3.069	-15.19	-14.52	-13.07	-18.86	**-24.26**	-15.05	-11.95	-10.18
2.927	-2.515	-2.115	-9.302	**-16.68**	-17.46	**-20.66**	-18.49	-12.24	-10.23	-8.999
2.93	-2.198	-1.901	-8.068	-15.32	**-17.87**	-19.24	-16.8	-11.54	-9.775	-8.672

Table II

Return Loss (Maximum Value) for Different Dielectric

Dielectric thickness	Maximum dB value
0.2	**-5.869**
0.5	**-19.8**
0.75	**-16.8**
1	**-16.68**
1.25	**-17.87**
1.75	**-20.66**
2	**-24.26**
2.5	**-29.89**
2.75	**-42.16**
3	**-30.49**

The **plots** of return loss for different dielectric thickness are given from figure 2 to figure 11. However, other parameters such as VSWR, radiation resistance and smith chart are not included this time.

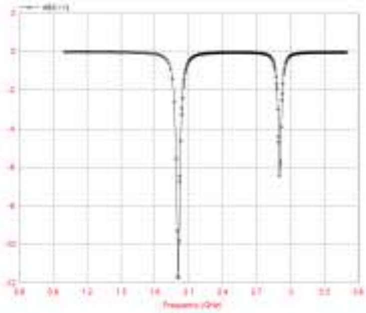

Fig.2: Return Loss (Substrate Thickness 0.2mm)

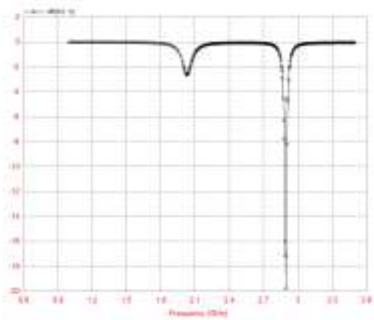

Fig.3: Return Loss (Substrate Thickness 0.5mm)

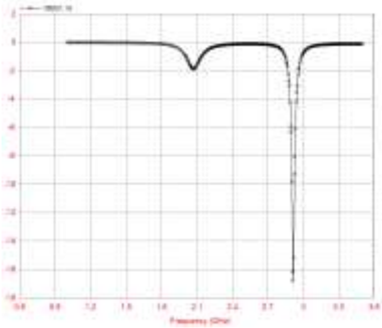

Fig.4: Return Loss (Substrate Thickness 0.75mm)

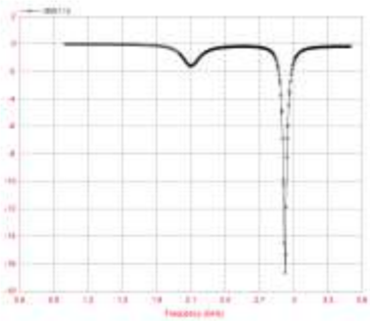

Fig 5: Return Loss (Substrate Thickness 1.0mm)

Fig.6: Return Loss (Substrate Thickness 1.25mm)

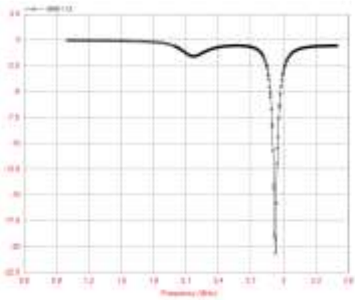

Fig.7: Return Loss (Substrate Thickness 1.75mm)

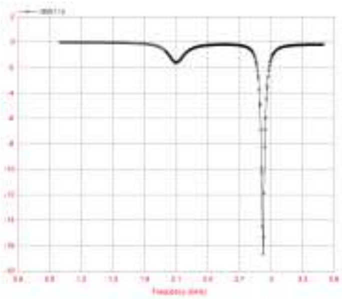

Fig 8: Return Loss (Substrate Thickness 2.0mm)

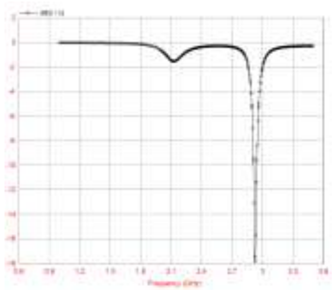

Fig.9: Return Loss (Substrate Thickness 2.5mm)

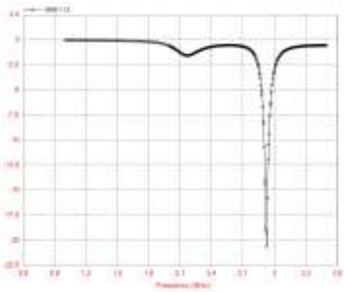

Fig.10: Return Loss (Substrate Thickness 2.75mm)

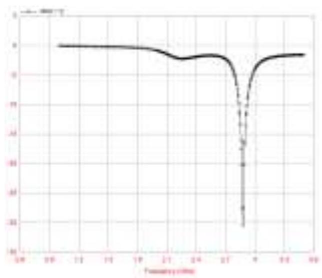

Fig 11: Return Loss (Substrate Thickness 3.0mm)

IV. CONCLUSION

This paper has presented a set of measurements of annular ring slot antennas on substrates of different thickness and fixed permittivity equal to 4.2.Therefore for the design of a radiator se1ection of suitable substrate thickness is very essential. The results shown in figure 12 are very useful f o r selection of suitable substrates for specific annular ring slot antenna applications. For the annular ring slot microstrip antenna (ARSMSA) designed at 3.0 GHz and simulated on different substrate thicknesses ranging from 0.5mm to 3.0 mm using Zeland IE3D software, the variation in return loss is found from -5.869dB to -42.16. A slight variation in resonance frequency is also noticed which can be neglected for wideband application.

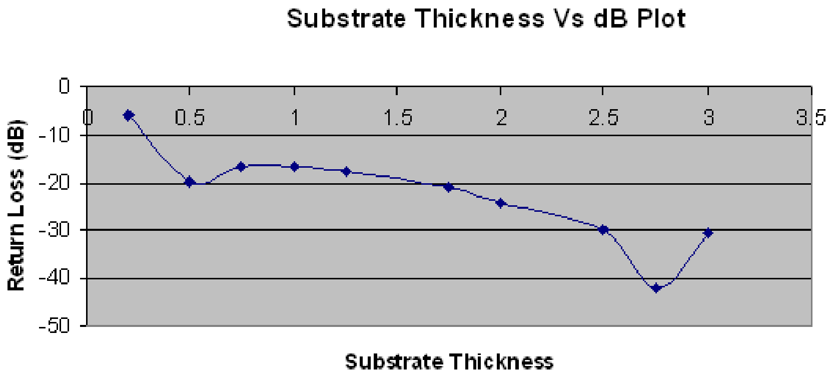

Fig 12. Return Loss vs Substrate Thickness Curve

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