Evaluation of Edge Effects in Measuring of a Rectangular Microstrip Resonator Antenna

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Abstract – **It is well known that in measuring of a microstrip resonator antenna it is necessary to pay attention on the "edge effect", which reflects in determining the resonator length (L). In this paper a research is made of the varying of the extended incremental length ($\triangle L$) depending on the substrate characteristics - relative dielectric constant (ε_r) and the height (h).**

Keywords – **Edge effect, Relative dielectric constant, Height, Extended incremental length.**

I. Introduction

Microstrip resonator antennas are used in spacecraft and aircraft, in satellite connections, where small weight, cost, performance technology and aerodynamic profile are very important. They have other applications in mobile and wireless communications where a great amplification, scanning possibility and low spurious radiation are required.

The main advantages of the microstrip antennas are:
- varying with the form of the antenna;
- possessing mechanical robust;
- easy correction of the characteristics;
- easy matching;
- a possibility for polarizations regulation;
- working on two polarization with one structure;
- small weight and dimensions.

The disadvantages of the microstrip resonator antennas are as follows:
- not resistant on high power (power limited to 1 or 2 W);
- narrow frequency bandwidth (about 1 to 2%);
- bad polarization purity;
- low efficiency;
- spurious feed radiation.

These disadvantages can be overcome by using different geometric shapes, shields, materials and different feeding methods.

For microstrip antennas' dielectric substrates are used dielectric materials with low dielectric constant, low losses and good mechanical characteristics.

The aim of the present papers is to research the dependence of the edge effect when varying the substrate dielectric constant (ε_r) and the height (h), which is very important when projecting such type of antennas.

II. Theory

The edge effect is a result of the fringing of the electric lines at the end of the microstrip resonator, as shown in Fig. 1.

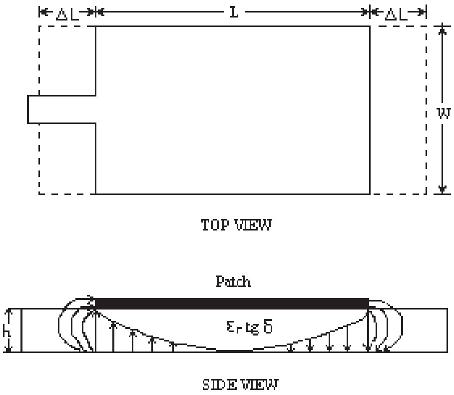

Fig. 1. Microstrip resonator.

The cause for that electric field configuration is the implementation of the boundary conditions in electrodynamics, namely that the electric lines are always open lines and they start and finish perpendicularly to the metal surface. It is clearly shown in Fig. 1 that the E vector lines at the edge and out of the edge of the microstrip resonator can not finish at the top surface of the metallic strip without fringing their shape. This fringing is the reason the effective resonator dimensions which define resonant frequency to be bigger than the real technical dimension (L) with an extended incremental length $\triangle L$.

The edge effect exhibition is due to the fact that the patch dimensions are finite along his length and width. The extended incremental length $\triangle L$, according to [1], depends on the effective dielectric constant of the dielectric substrate and the height and is given with the following formula:

$$\triangle L = 0.412 \cdot h \cdot \frac{(\varepsilon_{reff} + 0.3)\,(W/h + 0.264)}{(\varepsilon_{reff} - 0.258)\,(W/h + 0.8)}\ , \qquad (1)$$

where h is the height of the substrate; ε_{reff} – effective dielectric constant; W – width of the patch.

The patch width, according to [1], is a function of the wavelength and the dielectric constant and it is given with the following expression:

$$W = \frac{\lambda_0}{2}\sqrt{\frac{2}{\varepsilon_r + 1}}\ , \qquad (2)$$

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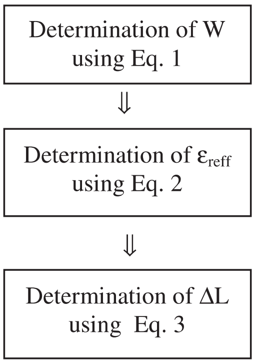
where λ_0 is the central resonant wavelength, which the resonator works in; ε_r relative dielectric constant of the substrate.

The effective dielectric constant, according to [1], depends of the substrate dielectric constant and height and the width of the patch:

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2\sqrt{1 + 12\cdot\dfrac{h}{W}}}\,. \qquad (3)$$

The simulation analysis, which was made, has the aim to show the variation of the dimension $\triangle L$ as function of the given parameters ε_r, h and the resonant frequency f_r = 10 GHz. The algorithm of the research is given bellow:



III. Results and Conclusions

The results can be explained with the physical processes in the microstrip line and according to [3] they are as follows:

1. As the dielectric constant ε_r increases, the electric field concentrates more in the microstrip line.

2. As the substrate height h increases, the quasitransverse electromagnetic wave concentration becomes weaker.

3. As the substrate height h increases, the quality factor Q becomes lower and subsequently the frequency bandwidth becomes larger.

4. As the dielectric constant ε_r becomes larger, the influence of the height h decreases.

The results can be explained with the physical processes in the microstrip line and according to [3] they are as follows:

1) Fig. 2 shows that with the increase of ε_r, the effective extended incremental length $\triangle L$ decreases and the decrease rate gets lower with the increase of ε_r.

2) It can be seen in Fig. 3 that the increase of the extended incremental length $\triangle L$ as a function of the height h, is linear. But as higher ε_r is, lower the increase rate of $\triangle L$ is lower and ε_r influence decreases.

The conclusions that were made correspond completely with the well-known statement, according to [6], that the higher ε_r is, the quasi-stationary field is more stuck around the microstrip line. When ε_r value is very high, an effect of "saturation" takes place and it is connected with the constant delay coefficient $\kappa = V_\Phi / C$, which is near to the value $1/\sqrt{\varepsilon_r}$.

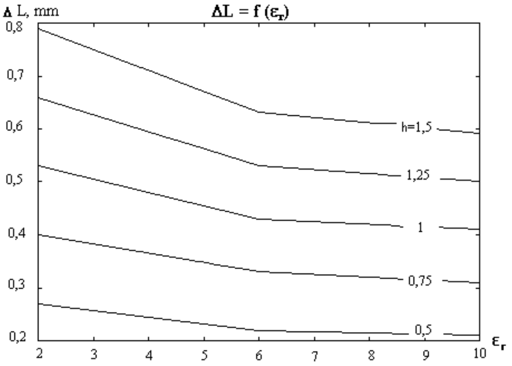


Fig. 2. Results from the research of the extended incremental length ($\triangle L$, mm) as a function of the substrate relative dielectric constant (ε_r) with parameter - height (h, mm).

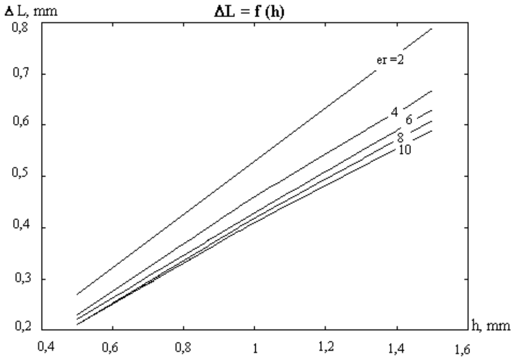


Fig. 3. Results from the research of the extended incremental length ($\triangle L$, mm) as a function of the substrate height (h, mm) with parameter - dielectric constant (ε_r).

IV. Recommendations

The following recommendations can be made on the base of Figs. 2 and 3:

1.]When it is necessary in design to achieve lower value of the extended incremental length $\triangle L$, there has to be used small substrate thickness h. In this case it is not necessary to use relative dielectric constant ε_r with a high value.

2. A smaller value of the effective extended incremental length $\triangle L$ can also be achieved with a high value of ε_r, when it is required by the frequency band and the microwave technology, for instance using of a ceramic substrate.

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