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An Investigation of Rectangular Resonator Antenna Design

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***Abstract**: Open diectric resonators offers attractive features as antenna elements. In this article , a review of modes and different parameters of DRs of rectangular shape is analyzed. Futher, an expressions is derived for different parameters.*

Keyword :Dielectric Resonators.

Introduction: Dielectric resonators are now frequently employed in applications requiring small size, high Q Factor and temperature stable resonant elements at millimeter frequencies. Dielectric resonators fabricated out of low loss material ($\tan\delta \approx 10^{-4}$ or less) and high relative permittivity ($\varepsilon_r \approx 20$ to 100) are widely used in shielded microwave circuits such as in filters and oscillators. In these applications , a dielectric resonators can exhibit a very high unloaded Q - factor given by

$$Q_u \approx (1/\tan\delta)$$

Dielectric resonator antennas offer following attractive features:

1) The dimensions of a DR antenna are of the order of $\lambda_0/\sqrt{\varepsilon_r}$, where λ_0 is free space wavelength and ε_r is the dielectric constant of the resonator material. Thus, choosing a high value of dielectric constant , the size of the DR antenna can be significantly reduced.
2) There are no inherent conductor loss in dielectric resonators . This leads to high radiation efficiency of the antenna.
3) DRs offers easy coupling schemes to nearby all transmission lines used at microwave and mm wave frequencies.
4) The operating bandwidth of a DR antenna can be varied over awide range by properly choosing resonator parameters.
5) Each mode of DR antenna has a unique intenal and associated external electric field distribution. Therefore, different radiation characteristics can be obtained by exciting different modes of a DR antenna.

Theory: Cylindrical and spherical dielectric resonators always support degenerate modes which may be unwanted. Rectangular resonator shown in fig. 1, according to DWM method (dielectric waveguide model) of analysis it can be assumed that the resonator is a truncated section of an

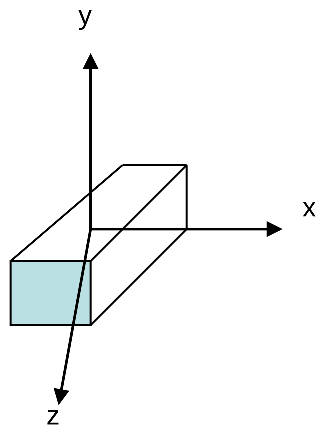

Fig.1. Isolated dielectric resonator.

Infinite waveguide. The EDC method was first developed by Knox and Toulios [4]. This method is an extension of an approach use by Marcatili [2] for analyzing a rectangular waveguide. This method is used for analyzing the propagation constants in dominant mode in different directions of DR and assuming that the wave is propagating in z direction.

According to Okaya and Barash[1], the modes of a rectangular resonators can be divided into two families: TE and TM. The presence of lower order TM modes was not confirmed experimentally. Therefore, in this section the lower - order TE modes are considered. For fig.1, of analysis it can be assumed TE^x, TE^y , and TE^z modes are possible. The lowest order mode for the structure is the TE^z_{111} mode, where it is assumed that the smallest dimension of the resonator lies in the z- direction. This mode radiates like a magnetic dipole oriented along the z- direction and located at the center [6]. Similarly , the TE^x_{111} and TE^y_{111} like x- and y- directed magnetic dipoles.

TE^z_{111} Mode: For this mode , the z - component of the magnetic field is assumed to be of the following form:

$$H_z = A \cos(k_x x)\cos(k_y y)\cos(k_z z)$$
$$E_z = 0$$

Where A is an arbitrary constant, and k_x, k_y and k_z denote, respectively, the wavenumbers in the x,y, and the z- directions inside the resonator. The other field components can be determined from the Hz component. The wave numbers k_x, k_y and k_z satisfy the following separation equation:

$$K^2_x + k^2_y + k^2_z = \varepsilon_r k^2_0$$

Where ε_r is the dielectric constant of the resonator, and k_0 denotes the free- space wave number corresponding to the resonant frequency[6].

The above equations are applied to find different parameters by using iterative method with initial value of resonant frequency.

Conclusion: The benefits of Rectangular dielectric resonator is presented and calculation of modes with different variables is explained. These equations with further illustration helps in designing of DR antennas.

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