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REVIEW ON DIELECTRICS LOADED MICROSTRIP ANTENNAS

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Abstract

The present chapter is dedicated to describe the effects of dielectric loading on the performance characteristics of the microstrip antennas. The concept of dielectric loading on microstrip lines dates back in year 1980, when I. J. Bahl & S. Stuchly proposed a variational method to describe the microstrip line covered with a lossy dielectric sheet. They found that characteristics of microstrip covered with a thick sheet of high dielectric constant are drastically affected.

Keywords: Microstrip Antennas.

Introduction

A microstrip radiator (antenna) consists of conducting patch on a ground plane, which is separated by a dielectric substrate of relative permittivity in the range of 1.1 to 12. However, low dielectric constant substrates are generally chosen for maximum radiation. The concept of such antennas was undeveloped until the revolution in electronic circuit miniaturization and large-scale integration in 1970. While, the early research work of Munson on microstrip antennas for use as a low profile flush mounted antennas on rockets and missiles has proven that these antennas can be used for various purposes. The radiating patch and the feed lines are usually photo etched on a dielectric substrate. The basic configuration of a microstrip antenna is shown in Figure.

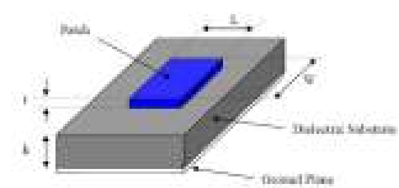

Figure Basic configuration of a microstrip patch antenna

Various mathematical models have been developed for this antenna and its applications being extended to many other fields. The number of research work carried on these antennas shows its gaining importance in microstrip technology. The conducting patch of the microstrip antenna can take any shape; rectangular, square, circle, triangular.etc but rectangular and circular configurations are the mostly preferred, Figure.

For a rectangular patch, the length L of the patch is usually $0.3333\ \lambda_o < L < 0.5\ \lambda_o$, where λ_o is the free-space wavelength. The patch is selected to be very thin such that $t \ll \lambda_o$ (where t is the patch thickness). The height h of the dielectric substrate is usually $0.003\ \lambda_o \leq h \leq 0.05\lambda_o$. This is because other structures are difficult to analyze. A microstrip antenna is characterized by its input impedance, gain, bandwidth, efficiency and radiation patterns. The length of the antenna is nearly half wavelength in the dielectric; it is a very important parameter, which governs the resonant frequency of the antenna hence other parameters.

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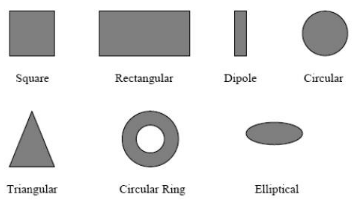

Figure: Various microstrip patch configurations

Microstrip patch antennas radiate primarily because of the fringing fields between the patch edges and the ground plane. For good antenna performance, a thick dielectric substrate having a low dielectric constant is desirable since this provides better efficiency, larger bandwidth and better radiation. However, such a configuration leads to a larger antenna profile. In order to design a compact microstrip patch antenna, substrates with higher dielectric constants must be used which are less efficient and result in narrower bandwidth. Hence a trade-off must be realized between the antenna geometry and antenna performances.

Review On Dielectrics Loaded Microstrip Antennas

The present chapter is dedicated to describe the effects of dielectric loading on the performance characteristics of the microstrip antennas. The concept of dielectric loading on microstrip lines dates back in year 1980, when I. J. Bahl & S. Stuchly proposed a variational method to describe the microstrip line covered with a lossy dielectric sheet. They found that characteristics of microstrip covered with a thick sheet of high dielectric constant are drastically affected. The effect of dielectric cover is more pronounced for small values of *w/h* ratio, *w* is width line and *h* is height of dielectric substrate. This is because the fringing fields which interact with the covering sheet increases for smaller values of *w/h* ratio. Their studies were focused on the variation of characteristic impedance, effective dielectric constant, and conductor as well as dielectric losses with *w/h* ratio for different dielectric loaded materials. In addition it has been reported that above parameters also varies with *d/h* (*d*- thickness of cover). In particular for *d/h* = 0.02, the values of effective dielectric constant decreases with increase in ratio *w/h*. However for larger values of *w/h* ratio effective dielectric constant increases for smaller values of *d/h*. The effective dielectric constant decreases with the increase in *w/h* values because in this case fringing field decreases with increasing w/h values. For large *w/h* ratio the structure behaves like a microstrip and the effective dielectric constant increases. It is also found that conductor loss and dielectric loss increases with increases in *d/h* values, whereas dielectric loss decreases with increasing w/h ratio.

The Dielectric Covered Circular Microstrip Antennas

Effect on Resonance Frequency

As the antenna is a resonance device, its resonance frequency is the most important parameter, because it also affects other parameters such as bandwidth, gain and efficiency etc. The available literatures on dielectric loading patch antenna reveals that, dielectric loading significantly changes the resonance frequency hence causes detuning. K. M. Luk *et al.* in 1989 first studied the characteristics of circular patch under various dielectric cover thicknesses. Using Hankel transform analysis method for TM_{11} mode, they found that resonant frequency decreases with increasing the thickness of dielectric, while half-power bandwidth changes slightly as shown in Figure. While A. K. Bhattacharyya, in year 1991, derived the expressions for wall admittance, wall conductance and radiation efficiency of dielectric loaded circular patch antenna. In this study, he used principle of equivalence, which yields equivalent electric and magnetic surface currents for the outside fields, that is responsible for radiation. He concluded that for a small substrate thickness, the magnetic current model yields fairly accurate results, which deteriorates with an increase in the substrate thickness.

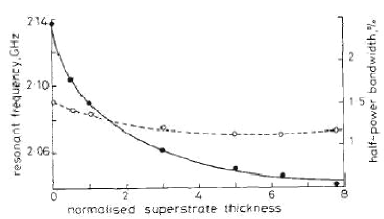

Figure Variations of resonant frequency and bandwidth with dielectric thickness

The radiation efficiency decreases initially and then increases with the thickness of the dielectric layer. The maximum value of the radiation efficiency is obtained in the case of an antenna with different substrate and dielectric materials than that of an antenna with substrate and dielectric of same dielectric. The wall admittance of the patch is representative of the total power output and this output power has two components; the space wall power (P_{sp}) and surface wave power (P_{su}).

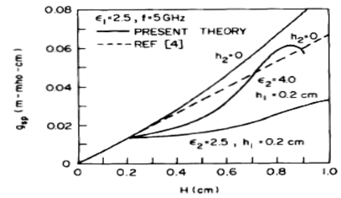

Figure Variations of space wave conductance‘s with substrate and dielectric thickness (a = 1.1 cm, f = 5 GHz)

The radiation efficiency is defined as

$$\eta = \frac{g_{sp}}{g_{sp} + g_{su}}\%$$

Where g_{sp} and g_{su}, are the space and surface wave conductance‘s respectively.

References

1. I. J. Bahl and S. S. Stuchly, ―Analysis of a microstrip covered with a lossy dielectric,‖
2. *IEEE Trans. Microwave Theory Tech.* Vol. MTT-28, No.2, pp. 104-109, Feb. 1980.
3. I. J. Bahl, P. Bhartia and S.S. Stuchly, ―Design of a microstrip antenna covered with a dielectric layer,‖ *IEEE Transactions on Antennas and Propagation*, Vol. AP-30, No.2, pp. 314-18, March 1982.
4. N. G. Alexopoulos and D. R. Jackson, ―Fundamental superstrate (cover) effect on printed circuit antennas,‖ *IEEE Transactions on Antennas and Propagation*, Vol. AP-32, pp. 807-816, 1984.
5. H. Y. Yang and N. G. Alexopoulos, ―Gain Enhancement methods for printed circuit antennas through multiple superstrate,‖ *IEEE Transactions on Antennas and Propagation,* Vol. AP-35, No.7, pp. 860-863, July 1987.
6. A. Bhattacharyya and T. Tralman, ―Effects of dielectric superstrate on patch antennas, *Electron. Letters*, Vol. 24, No. 6, pp. 356-358, Mar.17, 1988.
7. R.Q. Lee and A. J. Zaman, ―Effects of dielectric superstrates on a two-layer electromagnetically coupled patch antenna,‖ *Ch @ IEEE*, pp. 620-623, 1989.