Comparison of Rectangular and T-Shaped Microstrip Antenna

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ABSTRACT

In this paper a comprehensive parametric study has been carried out to understand the effects of T patch antenna and Rectangular patch antennas to optimize the performance of the final design. The theoretical simulations are performed using SONNET software. The results are obtained for T-shaped antennas and rectangular patch antenna to compare the simulation results. From this comparison the T shaped antenna gives the best performance.

Key words: Microstrip antennas (MSAs), Voltage standing wave Ratio (VSWR), Dielectric constant.

I.INTRODUCTION

In telecommunication, there are several types of microstrip antennas (also known as a printed antennas) the most common of which is the microstrip patch antenna or patch antenna. A patch antenna is a narrowband, wide-beam antenna fabricated by etching the antenna element pattern in metal trace bonded to an insulating dielectric substrate with a continuous metal layer bonded to the opposite side of the substrate which forms a ground plane. Common microstrip antenna radiator shapes are square, rectangular, circular and elliptical, but any continuous shape is possible. Some patch antennas eschew a dielectric substrate and suspend a metal patch in air above a ground plane using dielectric spacers; the resulting structure is less robust but provides better bandwidth. Because such antennas have a very low profile, are mechanically rugged and can be conformable, they are often mounted on the exterior of aircraft and spacecraft, or are incorporated into mobile radio communications devices [1].

Microstrip antennas are also relatively inexpensive to manufacture and design because of the simple 2-dimensional physical geometry. They are usually employed at UHF and higher frequencies because the size of the antenna is directly tied to the wavelength at the resonance frequency. A single patch antenna provides a maximum directive gain of around 6-9 dBi. It is relatively easy to print an array of patches on a single (large) substrate using lithographic techniques. Patch arrays can provide much higher gains than a single patch at little additional cost; matching and phase adjustment can be performed with printed microstrip feed structures, again in the same operations that form the radiating patches. The ability to create high gain arrays in a low-profile antenna is one reason that patch arrays are common on airplanes and in other military applications.

II.Characteristics of MSA

The salient technical features of MSAs are

- They extremely low profile and conformal to the structure where it is mounted/installed.
- It is extremely light in weight and structurally robust
- The radiation characteristics are easily predicated clearly.
- It is very convenient for mass production at very low manufacturing cost.
- Miniaturization and light weight antennas.
- Easy to dual a frequency performance
- Ideally suited for MMIC fabrication which makes integration of radiator and feeding system simpler.
- Linear polarized MSAs do not need matching section or thick resonant cavity.
- Can be easily modified for shaped beam and desired polarizations.
- Since the height of that patch above ground plan is small, resonator exhibits a Q of 25 to 100.

III.Practical MSAs

MSAs can be used as a standard transmitting or receiver antenna transmitting and receiving characteristics can be calculated from the geometry and that it's driving point impedance. The transfer function, the driving point input impedance and resonant frequency of MSAs is strongly dependent on its intrinsic properties such as permittivity εr effective loss tangent then delta and coaxial feed line characteristics, effective width etc.

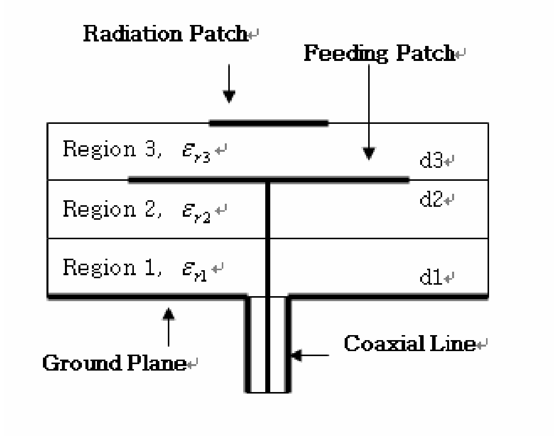
Impedance measurements largely help to perfect the antenna design. Intrinsic properties can be determined by the theory based on cavity model. These two approaches [2] were found useful to design standard MSAs for transmitting and receiving purposes. The electric field strength versus reciprocal distance is found to be approximately linear. This antenna is particularly useful for telemetry application and shielded room attenuations measurements.

Aerospace vehicles, missiles and satellite borne vehicles are some of the practical antennas where MSA has been found useful. Here particularly the radiation characteristics of MSA get altered significantly in plasma medium. Here two modes of waves are considered. The electro acoustic waves generated and EM wave generated by the antenna. For small values of electro acoustics wave propagation constant there is significant change in the relative shape of radiation pattern due to plasma. However for higher values of Duroid (Di) the level of side lobe decreases to great extent. There is change in magnitude of the field intensity in plasma as compared to free space. With Di=0.5 radiation efficiency is lowest while exhibits more efficient when Di=2. [6, 8]

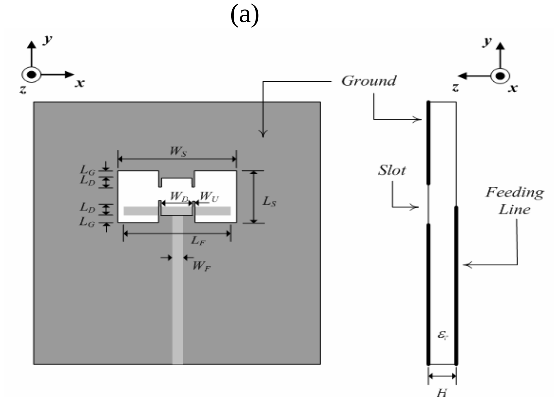
IV.RECTANGULAR PATCH ANTENNA

The most commonly employed microstrip antenna is a rectangular patch. The rectangular patch antenna is approximately a one-half wavelength long section of rectangular microstrip transmission line. When air is the antenna substrate, the length of the rectangular microstrip antenna is approximately one-half of a free-space wavelength. As the antenna is loaded with a dielectric as its substrate, the length of the antenna decreases as the relative dielectric constant of the substrate increases. The resonant length of the antenna is slightly shorter because of the extended electric "fringing fields" which increase the electrical length of the antenna slightly [5]. An early model of the microstrip antenna is a section of microstrip transmission line with equivalent loads on either end to represent the radiation loss.The dielectric loading of a microstrip antenna affects both its radiation pattern and impedance bandwidth. As the dielectric constant of the substrate increases, the antenna bandwidth decreases which increases the Q factor of the antenna and therefore decreases the impedance bandwidth. This relationship did not immediately follow when using the transmission line model of the antenna, but is apparent when using the cavity model which was introduced in the late 1970s by Lo et al [7].

V. T SHAPED MICROSTRIP ANTENNA



(a)



(b)

Figure 1. Multi-band Microstrip patch antenna of (a) Structure of layers and (b) geometry of the Antenna element

Fig 1 shows the geometry of the proposed antenna. In the Fig 1, all of the multi-layers thickness d1, d2 and d3 have 1.5mm, the relative permittivity in each layer. In order to have a high relative permittivity because it makes the size of the feeding patch with coaxial line this is possible with the smallest. Also, in order to expand the bandwidth of multilane the region 2 planned to have an air layer [3] and to raise the radiation efficiency of the antenna the region 3 select the low dielectric constant. Therefore, the multilayer structure consists of three substrate plates separated by air gaps. Here, the air gaps ensure the necessary volume necessary to achieve the required bandwidth. Two stacked square patches have been printed on the top and bottom substrates. The two patches are coupled electromagnetically which is a well know bandwidth enhancement technique [4]. Specially, the method will be able to change minutely a central frequency of the multi-band and a bandwidth, control the distance between the feeding patch and the parasitic patch.

VI.DESIGN CALCULATION FORMULAE

RECTANGULAR PATCH ANTENNA

The operating frequency f_r =10 GHz

Thickness of the dielectric medium,

$$h \leq 0.3 \times \frac{c}{2 \times \Pi \times f_r \times \sqrt{\varepsilon_r}} \text{ -------------------- (1)}$$

Thickness of the grounded material alumina,

$$T = \frac{BW}{128 \times f} \text{ --------------------------------------- (2)}$$

Width of metallic patch,

$$W = \left(\frac{c}{2 \times f_r}\right) \times \left[\frac{\varepsilon_r + 1}{2}\right]^{\frac{-1}{2}} \text{ -------------------------- (3)}$$

Length of metallic patch, L

$$L = \frac{c}{2 \times f_r \times \sqrt{\varepsilon_{reff}}} - 2\Delta l \text{ ------------------------- (4)}$$

Where,

$$\Delta l = .412 \times h \times \left[\frac{(\varepsilon_{reff} + .03) \times (W + .264h)}{(\varepsilon_{reff} - .258) \times (W + .8h)}\right] \text{------ (5)}$$

$$\varepsilon_{reff} = \frac{\varepsilon_r + 1}{2} + \frac{\varepsilon_r - 1}{2} \times \left(1 + \left(\frac{12 \times h}{W}\right)\right)^{\frac{-1}{2}} \text{ ------------ (6)}$$

T-PATCH ANTENNA

We use the slot antenna fed to obtain the wide bandwidth by T-shaped microstrip antenna since this type antenna can achieve a good impedance match over a wide frequency range thorough the simple feed structure and also easily be implemented. To suppress harmonics, the T-shaped conductor line (W_u x L_D) connected with ground plane in the rectangular slot are applied. This conductor line and the gap (W_D) act as the LC resonator for filtering out the second and third harmonic frequencies. Since the length and width of the T-shaped conductor line are the critical parameters for suppressing the harmonics, we try to carefully adjust W_u, W_D [9]

.

Approximate lengths of the two arms;

$$L_1 = L - \delta L \text{ ---------------------------------- (7)}$$

$$L_2 = L - 2\delta L \text{ ------------------------------- (8)}$$

Approximate widths of the two arms;

$$W_1 = \frac{W}{4} \text{ ----------------------------- (9)}$$

$$W_2 = W_1 - \delta W \text{ ----------------------- (10)}$$

VII SIMULATON RESULTS

We have compared the rectangular patch antenna and T-patch antenna for the same dielectric constant 2.2 and also for the same length. The simulation results are shown in the Fig (2-4) for Rectangular patch antenna. The VSWR and magnitude response are shown in the Fig (5-7) for T shaped patch antenna. From this we can see that the VSWR is very less for the T-patch antenna when compared to the Rectangular patch antenna. Hence forth the matching is perfect and reflection loss is minimum.

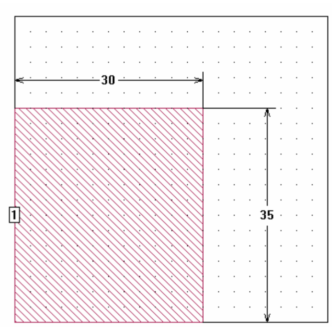


Fig 2 Rectangular patch antenna

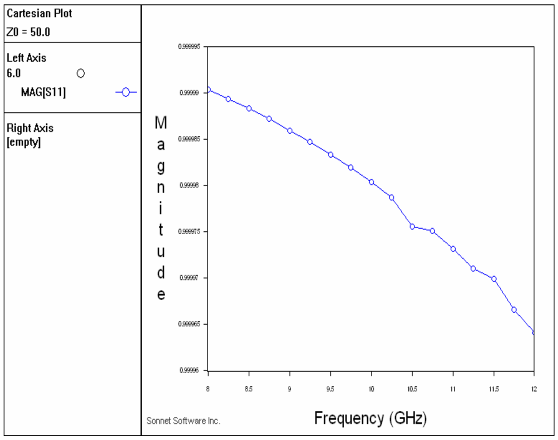


Fig 3 Magnitude Response for rectangular patch

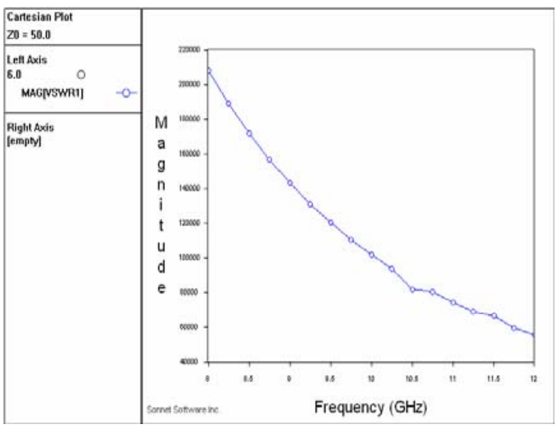


Fig 4 VSWR for rectangular patch

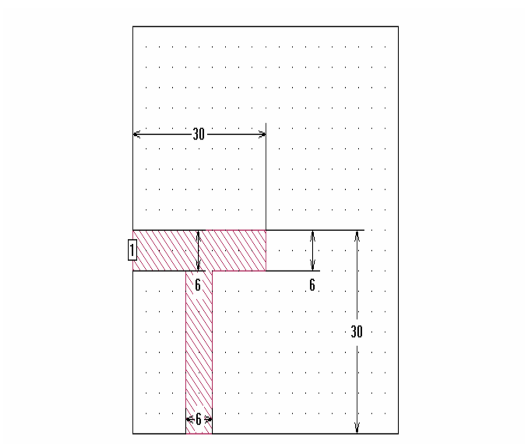


Fig 5 T-shaped patch antenna

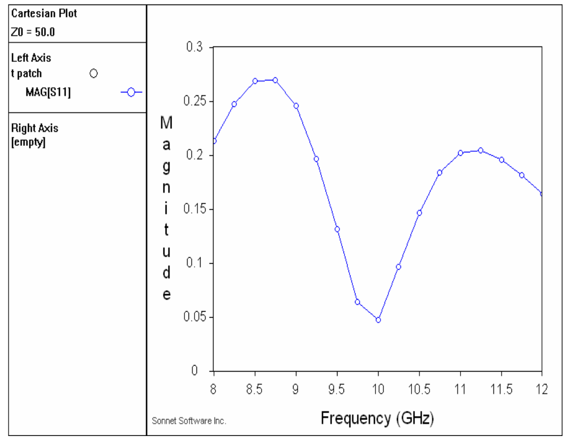


Fig 6 Magnitude response for T patch

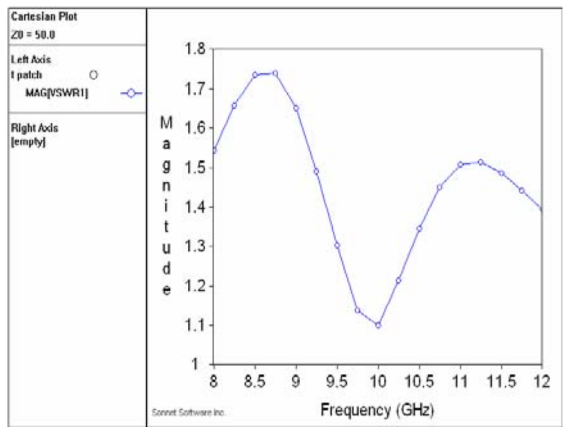


Fig 7 VSWR for T patch

VIII CONCLUSIONS

From the simulated results, we can say that T shaped patch antenna geometry provides wide bandwidth and also the VSWR is very less when compare to the Rectangular patch antenna for the dielectric constant Duroid.

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