Capacitive Feeding for Slotted microstrip patch

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Abstract

A Microstrip patch antenna having slotted sides with small capacitive feed has studied and discussed here. Slots on the proposed patch can be used to increase the bandwidth of antenna. It has observed that VSWR bandwidth nearly 45% can be easily achieved with the novel patch. A constant radiation pattern with improved bandwidth, for an operating frequency of 4.8 GHz can be easily achieved. Configuration of an antenna is easy to design. A very small feed strip is placed very close to the presented novel patch on the substrate above the ground plane. The given patch is act as radiating patch while feed strip couples the energy to radiating patch by capacitive mean. The model of antenna incorporates the capacitive feed strip which is fed by a coaxial probe by using equivalent approach. Effect of various parameters such as air gap between the substrate and the ground plane, probe diameter, the distance between the radiator patch and feed strip, and dimensions of the feed strip on the performance of the antenna has studied and there results has discussed here. A proposed patch can be used for various application in L-,S-,C- or X- band.

1. Introduction

There are numerous advantages of microstrip antennas in wireless communication system because of its desirable characteristic [1, 2]. But there are various disadvantages of microstrip antenna such as narrow bandwidth typically 1-5% and low gain which is the major limiting factor for the application of these antennas. To increase the rate of data transfer, increased antenna bandwidth is required. Various schemes have been suggested for the design of antenna to get large bandwidth. Although these antennas have good impedance bandwidths, but have bidirectional radiation pattern which further reduces the gain [3, 4]. Many other broadband techniques are used in Microstrip antennas include thick substrates, employing parasitic elements either in coplanar or stacked configurations with other approaches such as cutting slots inside the regular MSA geometries or changing the shapes of MSA to a diamond shape [5,6]. An antenna with small capacitive feed strip discussed here looks same as that of UWB microstrip antenna with capacitive feed [7] and single layer capacitive feed Microstrip antenna [8], but it contains a different shaped patch. A microstrip patch having slots across both radiating and non radiating patch with capacitive feeding has presented here. The bigger patch act as radiator while smaller patch placed very close to it acts as feed strip. Coaxial feeding is used to excite feed strip has used which is compatible with air gap below the substrate. Very small slots has used at the diagonals with slots across radiating and non radiating edges. Slots across radiating and non radiating edges can be used to increase the total surface current length thereby we can improve the radiation. The antenna discussed here has small dimensions compared to those used in earlier works to improve the bandwidth. Entire geometry of an antenna is easy to design which makes the structure of patch symmetrical. Results are analysed by using finite element method.

2. Basic Antenna Configuration

Geometry of the microstrip antenna has shown in Fig. 1 in which the larger patch act as radiator and small one serves as a feed strip which couples the energy to the radiators by capacitive means. Instead of having rectangular patch [7] an innovative shape for radiator patch is used in which length L is the complete length of radiating patch

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and length L_1=L/1.96, y =L/4.31, m=L/9.2 and t_2=L/37.97. Similarly W is the complete width of radiating patch, W_1=W/1.96, X=W/4.29and Z=W/10.37. Coaxial feeding is used here with the substrate which is placed above the ground plane at a air gap g. RO3003 is used as a substrate with dielectric constant=3, loss tangent=0.0013, and thickness h=1.56mm. A novel patch also includes smaller slots at the corners of the diagonals. The design of antenna is used for the operational frequencies of 4.8 GHz which is available approximately, appropriate formulae still not obtained. A return loss of -15.36db with return loss bandwidth of 45% and VSWR is 1.41 with VSWR bandwidth of 45% is obtained at 4.8GHz. The effective permittivity of the two-layer configuration is found 1.172.The rectangular slot has included inside the radiating patch which is significant in reducing the spurious radiation. Proposed antenna can provide 5 to 8% 0r more improvement in bandwidth

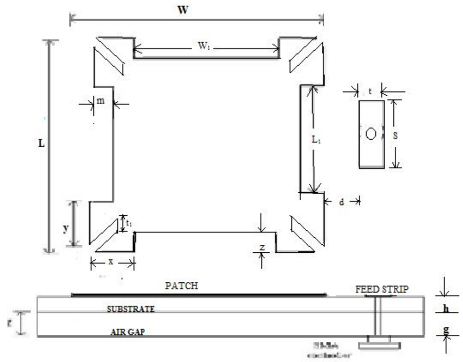


Fig.1 Geometry of novel patch antenna with small capacitive feed Strip.

3. Effects Of Design Parameters On Antenna Performance

The key design parameters of the antenna are air gap at which antenna substrate is located above the ground plane, the distance between radiator patch and the feed strip, probe diameter and the feed strip. By properly choosing the size of feed strip, by separation between the substrate and the radiator patch and the height of air gap, the bandwidth can be significantly improved.

3.1 Effect of air gap (g)

As we know increase in the substrate, decreases permittivity which results into wider bandwidth. Although the present configuration is different than a square patch but it appears nearly a square patch and looks symmetrical so when two resonant frequencies are close enough these may merge into single operational band with return loss below -10db but it occurs only at particular range of air gap. Effects of variation of air gap with probe diameter(R)= 0.94mm kept constant on the VSWR bandwidth of the antenna is given below.

Table 1

Air gap width(g) in mm	6.0	5.8	5.9	5.7	5.6
VSWR Bandwidth(GHz)	2.34	2.36	2.327	2.397	2.4
% Bandwidth	36.3	49.2	48.19	49.98	50

It is observed that whenever air gap increases bandwidth decreases with gain. Maximum bandwidth of 50% can be obtained at air gap of 5.6mm. Variation in impedance of antenna depending upon air gap is the variation in inductance of the probe pin one of the reasons for the antenna impedance to be dependent on the air gap is the change in inductance of the probe pin[6] so the probe diameter if fixed at 0.94mm. But this can be compensated by varying the effective parameters such as separation distance d, width t and length s of the feed strip. The air gap to get maximum bandwidth should be such that [7]

$$\acute{g} = 0.16\lambda - h\sqrt{\varepsilon r} \tag{1}$$

Where λ is wavelength corresponding to the centre frequency of the operating band, h is the height of substrate and εr is the relative dielectric constant of the substrate.

3.2 Effect of probe diameter (R)

Effect of variation of probe diameter with air gap height g=5.8 mm on VSWR bandwidth is given below.

Table 2

Probe diameter(R) in mm	0.98	0.96	0.94	0.92
Bandwidth(GHz)	2.37	2.29	.2.28	2.27
% Bandwidth	48.23	47.8	46.44	46.1

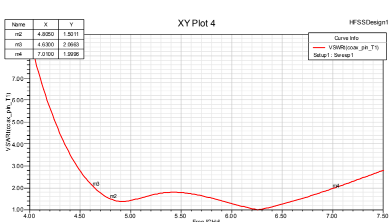
It has observed that, there is enhancement in the VSWR bandwidth if the probe diameter is changed as it reduces the inductance effects. Maximum VSWR bandwidth near to 45% can be obtained at the centre frequency of 4.8 GHz. The slight changes (reduction) in the probe diameter give approximately similar results in bandwidth. The maximum bandwidth is obtained at an air gap of 5.8mm and by keeping other parameters constant. It has observed that variation of other parameters with probe diameter doesn't affect effectively on the bandwidth.

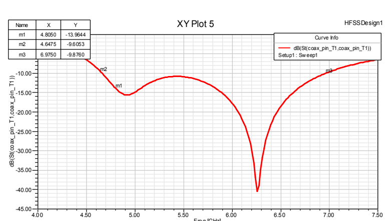
3.3 Effect the separation distance between feed strip and radiator patch (d)

Distance between radiator and the feed strip (*d*) is very important in capacitive feeding as it affects on impedance bandwidth because resistive and reactive part of impedance depends upon it. Actually the separation distance d is very small but variation in it affects the input impedance of an antenna. As the separation distance is increased, the resistive part decreases and the reactive part increase. Appropriate results yet not obtained with separation distances. It is observed from the result, VSWR bandwidth is increases by increasing the separation distance between radiator patch and feed strip. But this increment of the separation distance results in slightly improved bandwidth is observed within certain range. It is observed that the bandwidth increased only at separation distance from 0.1mm to 0.75mm, by keeping air gap at 5mm. Proper results are not observed for other values of the separation distance.

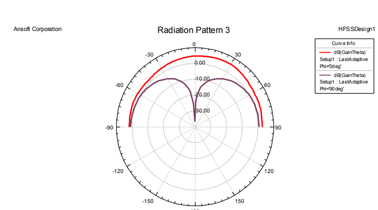
3.4 Effect of shape of the radiating patch

The dimensions and location of the feed strip play a critical role in obtaining the wide bandwidth for the proposed antenna. Various regular shapes can be used for the feed strip. Proper results have observed with triangular and semicircular feed strip. Exact dimensions of these shapes are still not observed. With regular shapes, irregular shapes can be also used for the feed strip. VSWR bandwidth nearly up to 50% [7] has observed by using triangular and semicircular feed strip.





(b)



(c)

Fig.2 (a) VSWR with small capacitive feed strip, (b) Return loss with small capacitive feed strip, (c) Radiation pattern of an antenna

4. Conclusion

A novel shaped Ultra wideband Microstrip antenna with small coplanar capacitive feed probe is studied and discussed here. The slotted sided patch has proposed here to get constant radiation pattern. The proposed patch is quite complex but it can redesigned for getting accurate results. Effect of sufficient design parameters has studied and explained. VSWR bandwidth close to 45% has been obtained for the operational frequency of 4.8 GHz. A try to make comparative study with rectangular radiating patch with small coplanar capacitive feed has done. Feed strip dimension is compared with radiating patch; it observed that the bandwidth reduces if it is of comparable with radiating patch. Also the feed strip dimensions cannot be reduced below limits to avoid problems in soldering the probe pin. Drawback is that the feed strip causes the asymmetry in radiation characteristic at the higher frequency end but is marginal at most frequencies of interest. We can design the antenna at any frequencies to get similar performance with selection of accurate air gap value and corresponding dimensions of Microstrip antenna.

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