A Broadband Design of H-Shaped Microstrip Antenna with Capacitive Feeding

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Abstract

A H-shaped Microstrip patch antenna with capacitive feed is presented here. To overcome various problems in other feeding, capacitive feeding scheme has used which consist of radiator patch and feed strip. The design of antenna incorporates the capacitive feed strip which is fed by coaxial probe. Slot is used in the radiating patch along radiating edges of the proposed design to attain the improved bandwidth. Constant radiation pattern with improved VSWR bandwidth of nearly 46%, for operating frequency of 5.1GHz is easily achieved. The effects of key design parameters like air gap between substrate and ground plane etc. are studied.

1. Introduction

Microstrip antennas are most popular because of its numerous advantages in wireless communication systems that typically require antennas with small size, light weight, low profile, and low cost, and that are easy to fabricate and assemble [1]. Basic geometries of these antennas suffer from a narrow bandwidth, which is of the order of a few percent of the operational frequency. In order to increase the rate of data transfer, modern wireless system designs call for increased antenna bandwidth than these geometries can handle. To meet these demands, several schemes have been suggested in recent years for the design of printed antennas with large bandwidths. On the other hand, MSAs have also been modified to meet the demands of the modern wireless communication applications [2] by several broadbanding techniques. These techniques used in microstrip antennas include the use of thick and air filled substrates, employing parasitic elements either in coplanar [3] or stacked configurations [4]. Various feeding schemes are given in many standard books [1]. Many of these feeding techniques can improve the bandwidth, but provide asymmetry in radiation pattern. With considering all these effects, use of a capacitive feed strip [5] with coaxial feeding strip is proved to increase the bandwidth [6]. A microstrip antenna with a proposed innovative patch provides the improved BW with nearly symmetrical radiation pattern.

2. Basic Antenna Configuration Details

Figure.1 shows the basic geometry of the antenna 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 if rectangular patch [6] an innovative shape for radiator patch is used with slot. The antenna substrate is placed above the ground plane at air gap g RO3003 is used as a substrate with dielectric constant=3, loss tangent=0.0013, and thickness h=1.56mm. The design of antenna is used for the operational frequencies of 5.1 GHz which is based on the formulae available from standard books [1, 7]. A return loss of -24.7db with return loss bandwidth of 45% and VSWR is 1.138 with VSWR bandwidth of 46% is obtained at 5.1GHz. The effective permittivity of the two-layer configuration is found 1.172. Specification of the antenna for 5.1 GHz are length(L) 15.5mm, width(W) 13.12mm, length of feed strip(s) 3.7mm, width of feed strip(t) 1.8 mm, length of slot($W1$) 8.2, width of slot 1.55mm, separation of feed strip 0.75mm, air gap(h) 6mm. Probe diameter 0.8 mm, relative dielectric constant(ε_r) 3.0 and thickness of the substrate 1.56 mm. Also there is a slot at the corner to avoid spurious radiation and to go the radiations to non radiating edges.

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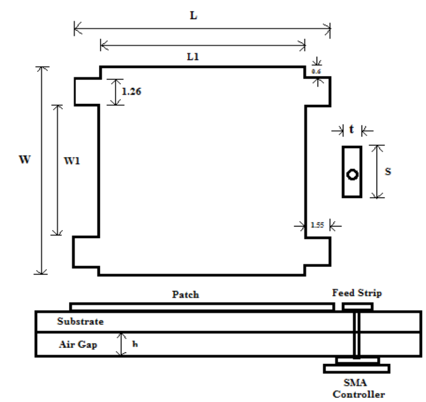

Figure.1: Slotted Patch Configuration

3. Effects of Design Parameters on Antenna Performance

The design of the innovative patch proposed here, is affected by various parameters. Characteristics of an antenna can be optimized by properly choosing the size of feed strip, by separation between the substrate and the radiator patch and the height of air gap.

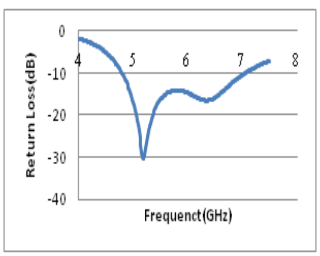

Figure.2: Return Loss

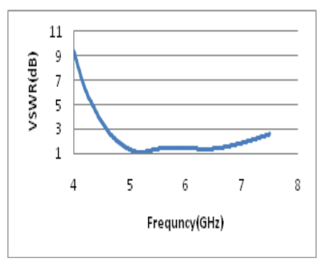

Figure.3: VSWR

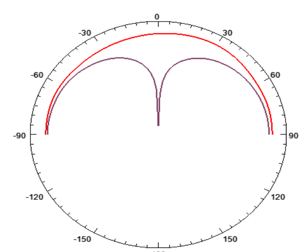

Figure.4: Radiation Pattern

3.1 Effect of Air Gap (*h*)

The fringing fields from the edges increases as height of the substrate is increased. Here air gap has used along with substrate which leads to increases height of substrate. It is well known that whenever the effective substrate height increases or permittivity decreases, it result into wider bandwidth. It may be noted that increasing the air gap results in reduction of the effective permittivity for the patch and change in the feed reactance (increases the inductance of the feed pin and decreases the capacitance of the feed strip) [4]. Effects of variation of air gap on the VSWR bandwidth of the antenna is listed below.

Table 1: Effects of variation of air gap on the VSWR bandwidth of the antenna

Air gap width(h) in mm	5.0	5.4	5.8	6.0
Bandwidth(GHz)	2.23	2.32	2.21	2.1
% Bandwidth	43.7	45.4	43.33	42

It has observed that as air gap increased bandwidth decreases. We have observed the maximum bandwidth of 46.8% has obtained at air gap of 5.4mm. The air gap to get maximum bandwidth should be such that [6]

$$g = 0.16\lambda - h\sqrt{\varepsilon_r} \quad (1)$$

Where λ is wavelength corresponding to the center frequency of the operating band, h is the height of substrate and ε_r is the relative dielectric constant of the substrate. Result shows return loss of -24.7dB at center 5.1 GHz frequency and return loss percentage bandwidth of 44% in Figure.2.

3.2 Effect of Probe Diameter

Effect of variation of probe diameter on VSWR bandwidth of antenna is listed below.

Table 2: Effect of variation of probe diameter on VSWR bandwidth of antenna

Probe diameter in mm	0.8	0.9	1.0	1.1
Bandwidth(GHz)	2.23	2.32	2.43	2.26
% Bandwidth	43.7	45.1	46.8	44.78

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 of 47.84% has obtained at the gain of 5.4db.The maximum bandwidth is obtained at an air gap of 5.4 and separation distance is d=0.9mm by keeping of other parameters constant. It indicates that variation of other parameters with probe diameter doesn't affect effectively on the bandwidth.

3.3 Effect of the separation distance between Feed Strip and Radiator Patch (*d*)

The dimensions and location of the feed strip play important role in obtaining the wide bandwidth for the proposed antenna as distance between radiators Patch and the feed strip (d) on the impedance bandwidth of antenna. Actually the separation distance d is very small but variation in it affects the input impedance of an antenna [8]. As the separation distance is increased, the resistive part decreases and the reactive part increase. Slot has proved to balance the resistive part and reactive part. The effect of variation of separation distance is listed below.

Table 3: Effect of variation of separation distance on VSWR bandwidth of antenna

Separation distance(d) in mm	0.45	0.65	0.75	0.85
Bandwidth(GHz)	2.21	2.33	2.41	2.42

It has been observed from the result, VSWR bandwidth is increases by increasing the separation distance between radiator patch and feed strip. It is observed that the bandwidth increased only at separation distance from 0.25mm to 0.85mm, by keeping air gap at 6 mm. H-Shaped patch can attain percentage bandwidth nearly up to 46%[6] which provide improved bandwidth than other capacitively fed antenna[2].Proposed antenna can provide 5 to 6% improvement in bandwidth. Result shows VSWR 1.138 and VSWR bandwidth 45.17% in Figure.3.

3.4 Effects of the dimensions of Feed Strip

With increase in width of the feed strip the bandwidth slightly, if all other parameters are kept constant; but the bandwidth of antenna can be restored to the maximum value by decreasing the feed strip length (s). The resistive part of the antenna input impedance increases, whereas the reactive part decreases with increase in feed strip width [1]. The resulting antenna bandwidth is summarized in Table 4.

Table 4: Effect of width of feed strip on VSWR bandwidth of antenna

Feed Strip width(t)	1.2	1.5	1.8	2.0
Bandwidth(GHz)	2.45	2.38	2.33	2.12

Table 5: Effect of length of feed strip on VSWR bandwidth of antenna

Feed Strip length(s)	4.2	4.0	3.8	3.5
Bandwidth(GHz)	2.12	2.21	2.32	2.24

The bandwidth reduction caused by increasing the strip width (t) can be restored to a great extent by decreasing its length. This is consistent with the bandwidth presented in Table 5. The variation of changing the feed strip width, antenna input resistance increases and the input reactance decreases with an increase in the length of the feed strip. For $s \leq 2.5$ mm, the VSWR exceeds 2 at some frequencies in the band, that is, band splits into two parts [6]. For $s \geq 4.0$ mm, even though we get approximately the same impedance bandwidth, increasing the dimensions of the feed strip produces asymmetry in the radiation patterns (due to spurious radiation from the larger feeding patch)[1] and results in a reduction in useful bandwidth. Result shows the symmetrical radiation pattern in Figure.4.

4. Conclusion

A Broadband H-shaped Microstrip patch antenna capacitive feeding is presented here. The proposed patch is planar symmetrical. Different design parameters with their effects are studied. For the operational frequency of 5.1GHz, VSWR bandwidth nearly 46% and return loss bandwidth up to 45% has been obtained. Slot used here plays an important role in balancing resistive part and reactive part which affect the impedance matching. Variation in the dimensions of feed strip has studied and explained. A thick dielectric substrate with suspended geometry is helpful in increasing the bandwidth. The only drawback is that the feed strip causes the asymmetry in radiation characteristic at the higher frequency because of spurious radiation along the non-radiating edges of the patch. We are trying to design an antenna at various other frequencies to get similar or may be improved performance with selection of accurate air gap value with other parameters.

5. References

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