International Journal of Applied Information Systems (IJAIS) – ISSN : 2249-0868
Foundation of Computer Science FCS, New York, USA
Volume 6– No.5, November 2013 – www.ijais.org

Investigation of the Effect of Feed Variation on the Performance of a Circular Patch Microstrip Antenna

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ABSTRACT
In the design of circular patch antenna, the feed point locations SF=5, SF=6, SF=7 and SF=8 were selected and the simulated results compared and the optimum location adopted and implemented. The best feed point was located at SF=5mm where return loss RL is -37.81dB, followed by SF=6mm with return loss RL of -17.14dB and SF=7mm with return loss RL is -11.38dB. The feed point location at SF=8mm was rejected since it falls outside the acceptable figure of VSWR=2. The material used for the proposed antenna is FR-4 with the dielectric constant of 4.35 and dielectric loss tangent of 14e-3. The proposed antenna can find application in Wireless Local Area Network (WLAN) and cellular phone.

General Terms
Feed offset, feed pin radius, Feed variation, Antenna Magus, Circular patch microstrip antenna.

Keywords
Return loss, VSWR, Feed Point, Loss Tangent, Circular Patch

1. INTRODUCTION
The radiating elements patches of printed antennas have a variety of forms, as triangular, rectangular, square, elliptical, and circular among others [1],[2]. However, it has been found that circular structures have smaller dimensions related with the operation frequency [3]. The circular microstrip antenna offers a number of radiation pattern options not readily implemented using a rectangular patch [4]. The fundamental mode of the circular microstrip patch antenna is the TM11 [5],[6]. This mode yields a radiation pattern that is comparable to the lower order mode of a rectangular microstrip antenna. The circular structure offers another important advantage. The only control variable for the structure design is the patch radius, that is the reason circular or disk antennas are very popular and widely used nowadays. In 1998, Kraus proposed several methods to improve the bandwidth (BW) of circular antenna, by smoothing the transition between feed line and the antenna [7],[8]. This technique is easily applied to patch antennas with microstrip or coplanar feeding; radiator patch and ground plane can provide almost constant input impedance over wide bandwidths. Many techniques have been developed to improve the BW of circular planar antenna as introducing a slot into the circular patch, adding new resonant frequencies. In this work, we vary the feed location along the radius of the patch from the center to its left most edge. The coaxial probe feed used for this design has a radius of 187.5µm. The design was done with the center frequency of 2.4GHz.

2. DESIGN OF CIRCULAR PATCH ANTENNA
Consider a circular patch as shown in Figure 1 of radius a over a ground plane with a substrate of thickness H and relative dielectric constant ε_r. The resonant frequency is in the TM_{11} mode.

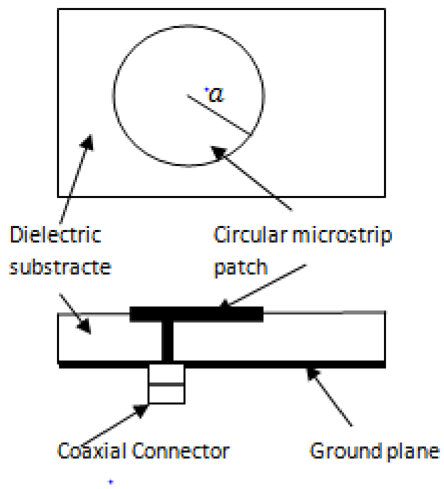

Figure 1. Geometry of circular microstrip antenna

The resonant frequency of a circular patch antenna is approximately given without considering the effect of probe radius by [9].

$$f = \frac{K_{nm} \times C}{2\pi a_{eff}\sqrt{\varepsilon_r}} \quad (1)$$

Where, a_{eff} is effective radius of the circular patch, C is velocity of light in free space and ε_r is relative permittivity of the medium. K_{nm} is the zero of the derivative of the Bessel function of order n. In our application we have considered the fundamental mode TM_{11}, for which K value is 1.84118. The expression for a_{eff} is given by [9].

$$a_{eff} = a\{1 + (\frac{2H}{\pi a \varepsilon_r})[\ln\left(\frac{\pi a}{2H}\right) + 1.7726]\}^{\frac{1}{2}} \quad (2)$$

Where, H is height of the dielectric substrate and a is the radius of the patch.

The design parameters of the circular antenna used in this work for a VSWR of 2 are given as in Table 1.

Table 1. Design parameters for the circular patch antenna

1	Center frequency (f_o)	2.4 GHz
2	Patch diameter (D)	34.33mm
3	Feed offset (SF)	5, 6, 7 and 8mm
4	Feed pin radius (R)	187.5µm
5	Substrate height (H)	1.5mm
6	Relative permittivity (ε_r)	4.35
7	Loss tangent (Tanδ)	14e-3
8	Input impedance (Rin)	50Ω

A coaxial probe type feed was used in this design, as shown in Figures 1 and 2. The center of the patch is taken as origin and the feed location is given by the feed offset (SF) from the origin. The feed point is to be located at a point on the patch. A trial and error method was used to locate the feed point. For different locations of the feed point, the return loss (RL) is compared and the feed point is selected where the return loss is most negative. The software used to model and simulate the circular patch antenna is the Antenna Magus 4.4[10].

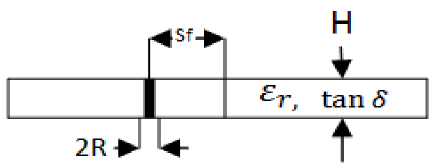

Figure 2a side view of the design patch

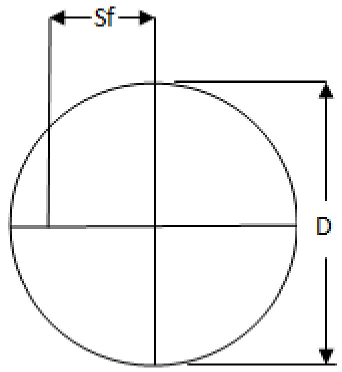

Figure 2b Top view of the design patch

3. RESULTS AND ANALYSIS

The results in Table 2 are obtained from Figure 3 to Figure 5 after varying the feed location along the radius of the patch from the origin (center of patch) to its left most edge. The center frequency is selected as the one at which return loss is minimum. The VSWR bandwidth can be calculated from the input impedance plot. The bandwidth of the antenna can be said to be those range of frequencies over which the RL is less than -10dB corresponds to a VSWR =2 which is an acceptable value.

From Table 2, we observed that the center frequency increases as the feed point moves away from the origin to the left most edge. Similarly, the return loss RL increases as feed point or offset moves away from the origin (that is, -37.81dB for 5mm, -17.14dB for 6mm, -11.38dB for 7mm and -8.625dB for 8mm). VSWR also increases as feed offset moves away from the origin from 1.026, 1.323, 1.739 and 2.177 for 5mm, 6mm, 7mm and 8mm respectively. We have also observed that the VSWR bandwidth increases from 47MHz to 50MHz for SF=5mm and 6mm, but decreases to 38MHz for SF=7mm and 0MHz for 8mm.

Table 2. Effect of feed location on center frequency, return loss and bandwidth

Feed location (SF)(mm)	Minimum VSWR	Return loss (RL) (dB)	Center freq (GHz)	VSWR BW (MHz)	Freq. @ which VSWR=2 (GHz)
5	1.026	-37.81	2.413	47	2.390 , 2.437
6	1.323	-17.14	2.416	50	2.391, 2.441
7	1.739	-11.38	2.419	38	2.401, 2.439
8	2.177	-8.625	2.423	-	-

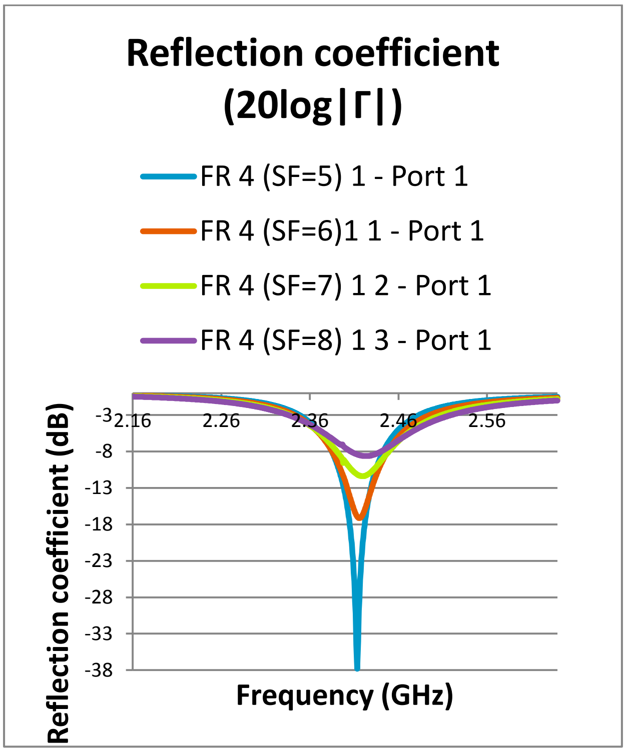

Figure 3. Reflective coefficient for feed location at SF =5, 6, 7 and 8mm

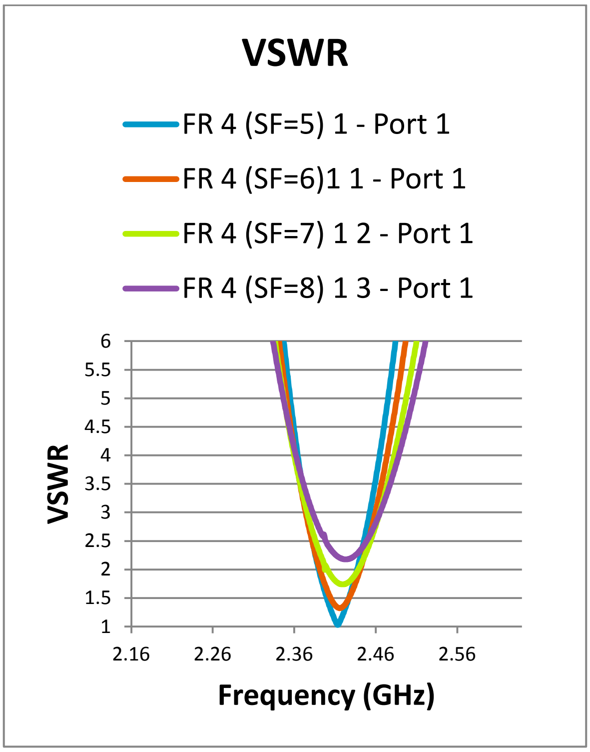

Figure 4. VSWR versus Frequency for feed location at SF=5, 6, 7 and 8mm

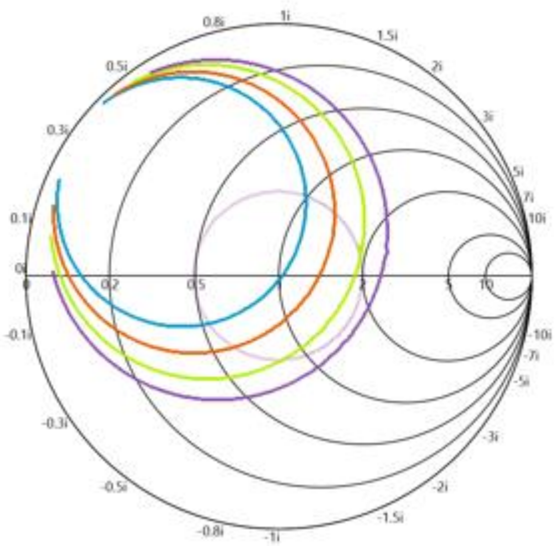

Figure 5. Input impedance (smith chart) for SF=5, 6, 7 and 8mm at VSWR = 2

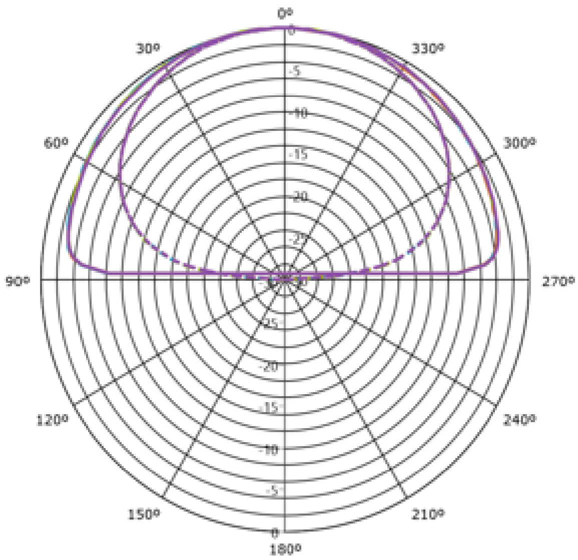

Figure 6. Gain elevation pattern for $\emptyset = 0$ and $\emptyset = 90$ degrees.

Figure 6 shows the gain of the antenna at 2.4 GHz for $\emptyset = 0$ and $\emptyset = 90$ degrees. Maximum gain is obtained in the

4. CONCLUSION

In this work, the aim was targeted at investigating the effect of feed location on the performance parameters of circular patch

broadside direction and is measured to be 2.878dBi for $\emptyset = 0$ and 2.874dBi for $\emptyset = 90$ degrees.

antenna, such as center frequency, return loss and bandwidth. We have selected four different feed points and the simulated results compared and the best location adopted and implemented. From table 2, the optimum feed point is found to be at SF=5mm where return loss RL of -37.81dB is obtained. The VSWR bandwidth of the antenna for this feed point location is 47MHz and a center frequency of 2.413GHz which is very close to the desired frequency of 2.4GHz. From the table, it is clearly shown that, feed point can affect the performance of circular patch antenna.

5. REFERENCES

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