Compact Microstrip Antenna loaded with T-Shaped Slots

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***Abstract*—A compact circular microstrip antenna loaded with T-shaped slot is presented. The same antenna is then enclosed in a metallic cavity to achieve further compactness. A 50% compactness is achieved using cavity backed configuration when compared with conventional circular microstrip antenna. Alternatively, miniaturization is also achieved by employing symmetry with respect to the feed-axis and using only half of the antenna configuration. The effect of notch and slot length on the resonant frequency is also investigated and observed that the resonant frequency of the antenna can be varied simply by varying either the notch length or the slot length.**

***Keywords*—cavity backing, cirular microstrip antenna, compact antenna,**

I. Introduction

Microstrip Antennas (MSAs) are extensively used in modern wireless communication due to their numerous advantages like low profile, light weight, ease of fabrication, integrability with microwave and millimeter wave integrated circuits, conformability to curved surface [1]. Compact MSAs recently received much more attention due to the increasing demand of personal mobile communication and other miniaturized communication systems. The size of regularly shaped MSAs operating in the UHF band is quite large because its resonant length is inversely proportional to frequency. So, for designing smaller antenna, the conventional microstrip antenna needs to be modified.

For achieving the microstrip antenna of smaller dimension at the fixed operating frequency, the microwave substrate of high permittivity can be used [2]. However, it degrades the radiation efficiency and bandwidth of the antenna. Thus, various methods have been employed during the past few decades to reduce the size of MSAs [3]-[11].

In this paper, we propose a compact circular microstrip antenna loaded with T-shaped slot. The variation in resonant frequency with slot length and notch length is investigated using Ansoft's high frequency structure simulator (HFSS v14) [12] based on Finite Element Method.

II. Antenna Structure

Fig. 1 shows T-Slot loaded circular microstrip antenna (CMSA) configuration. The antenna is designed on Rogers RT/Duroid 5880 substrate of relative permittivity 2.2 and loss tangent of 0.0009. The antenna is fed by a 50Ω coaxial probe. A pair of T-shaped slots are placed symmetrically with respect to feed-axis for achieving miniaturization. The vertical arm (notch) has the dimensions of length l_n and width w_n, and the horizontal arm (slot) has the dimensions of length l_s and width w_s. The optimized antenna design parameters are listed in Table I.

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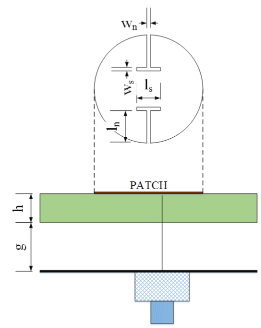


Fig. 1. Geometry of T-Slot Loaded Circular Microstrip Antenna

TABLE I. Antenna Design Parameters

Antenna Parameter	Value (mm)
Radius of circular patch, a	22
Substrate thickness, h	1.6
Air gap height, g	2.32
Notch Length, l_n	16.5
Notch Width, w_n	1
Slot Length, l_s	6
Slot Width, w_s	1

T-Slot loaded CMSA enclosed in a metallic cavity of radius 22.5 mm is shown in Fig. 2. The cavity size is chosen such that it influences the fringing fields associated with the antenna.

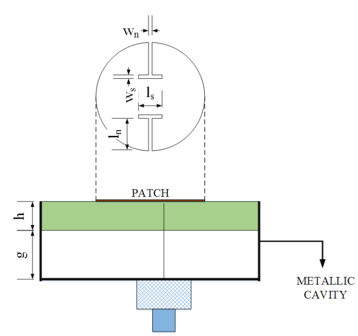


Fig. 2. Geometry of Cavity Backed T-Slot Loaded Circular Microstrip Antenna

By employing the symmetry with respect to feed-axis and using half of the configuration, we get a T-Slot loaded Semi-Circular Microstrip Antenna (SCMSA) as depicted in Fig. 3.

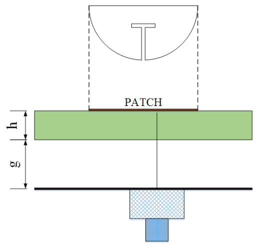


Fig. 3. Geometry of T-Slot Loaded Semi-Circular Microstrip Antenna

III. Results and Discussion

The characteristics of slotted patch antenna have been simulated using the Ansoft Corporation finite element method (FEM) based program High Frequency Structure Simulator (HFSS). With the introduction of a pair of T-shaped slot in the radiating patch, path of the equivalent excited patch surface current increases, reducing the resonant frequency of the antenna. The resonant frequency reduces from 3.05 GHz to 1.90 GHz. This corresponds to antenna size reduction of about 37.5% when compared with conventional CMSA. Further, enclosing the T-slot loaded CMSA in a metallic cavity, the resonant frequency decreases from 1.90 GHZ to 1.50 GHz. This corresponds to antenna size reduction of about 50% when compared with conventional CMSA. Fig. 4 shows the simulated reflection coefficient (S_{11}) versus frequency.

When compared with T-Slot loaded CMSA, T-Slot loaded SCMSA has approximately the same resonant frequency and has similar radiation characteristics along with 50% compactness. Fig. 5 shows the simulated reflection coefficient (S_{11}) versus frequency for T-slot loaded SCMSA.

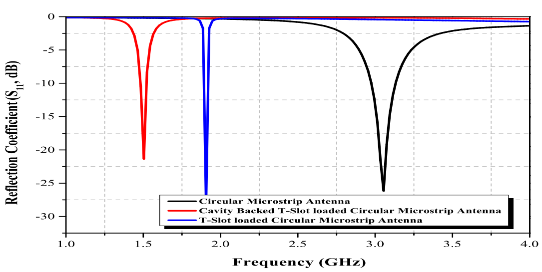


Fig. 4. Simulated reflection coefficient (S_{11}, dB) versus frequency (GHz)

The bandwidth of the antenna also reduces due to the decrease in electrical thickness of the substrate. A comparison in bandwidth is listed in Table II.

TABLE II. Bandwidth Comparison

Antenna Type	Bandwidth (MHz)
Conventional CMSA	158 (5.18%)
T-Slot loaded CMSA	27 (1.47%)
Cavity Backed T-Slot loaded CMSA	39.7 (2.65%)
T-Slot loaded SCMSA	26.5 (1.29%)

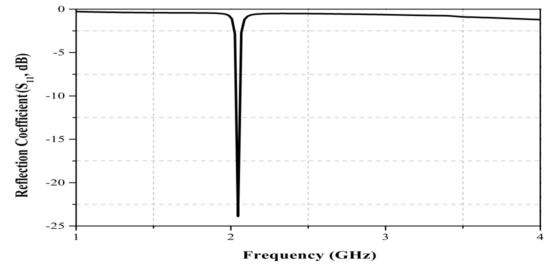
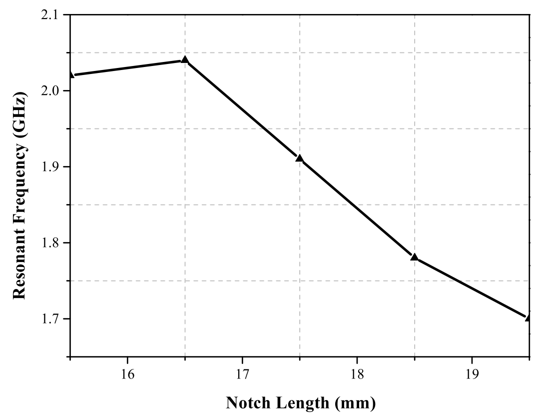
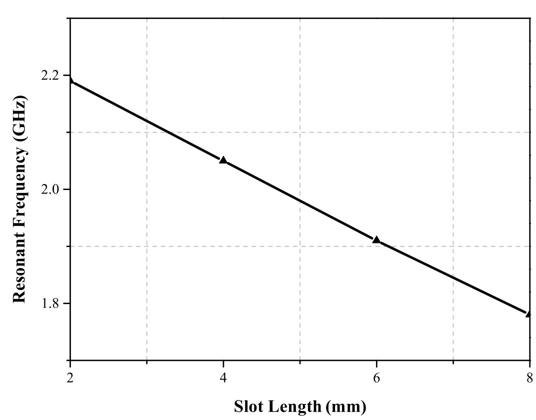


Fig. 5. Simulated reflection coefficient (S_{11}, dB) versus frequency (GHz) of T-Slot loaded Semi Circular Microstrip Antenna

Fig. 6(a) and Fig. 6(b) shows the variation of resonant frequency with notch and slot length, respectively. It is observed that the resonant frequency decreases on increasing either notch length or slot length. This behavior is mainly due to the increase in path of the equivalent excited patch surface current.



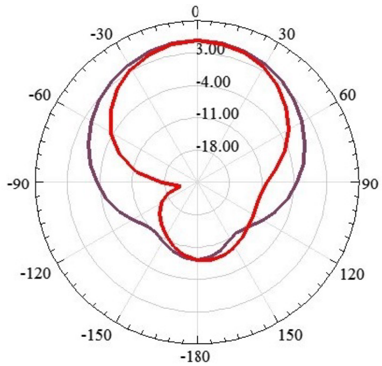
(a)



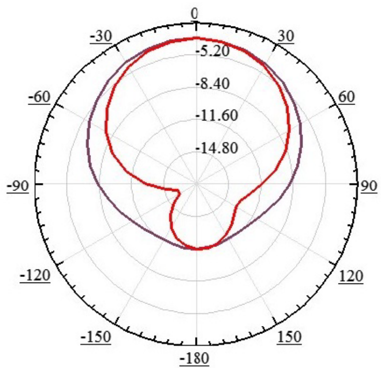
(b)

Fig. 6. Resonant Frequency versus (a) Notch Length (b) Slot Length

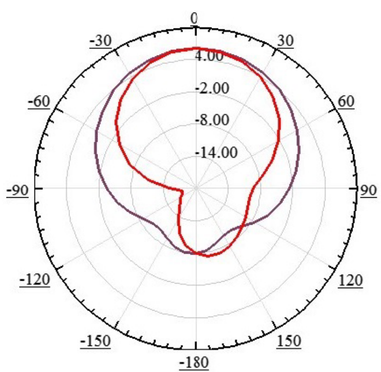
The simulated gain radiation pattern of the antenna structures are shown in Fig. 7(a) to Fig. 7(c).



(a)



(b)



(c)

Fig. 7. Simulated radiation pattern of (a) T-Slot loaded CMSA (b) Cavity Backed T-Slot loaded CMSA (c) T-Slot loaded SCMSA

IV. Conclusion

In this paper, a T-Slot loaded CMSA and SCMSA has been analyzed using Ansoft HFSS to achieve miniaturization. As compared to conventional CMSA, the antenna size reduction of about 37.5% has been achieved by using a pair T-shaped slot in the radiating patch. Enclosing the same antenna in a metallic cavity, result in further size reduction and this reduction is about 50% when compared with conventional CMSA. As compared to T-Slot loaded CMSA, a 50% compactness has been achieved by using T-Slot loaded SCMSA. It has also been observed that the antenna characteristics are highly dependent on slot and notch length. The resonant frequency of the antenna can be varied simply by varying either notch length or slot length.

The theoretical and experimental work will be reported in the future communication.

References

[1] Y. T. Lo, D. Solomon, and W. F. Richards, “Theory and Experiment on Microstrip Antennas,”*IEEE Trans. Antennas Propag.*, Vol. 27, pp. 137-145, 1979.

[2] K. L. Wong, *Compact and Broadband Microstrip Antennas*, John Wiley and Sons, 2011.

[3] K. P. Ray and G. Kumar, *Broadband Microstrip Antennas*, Boston: Artech House, 2003.

[4] R. Waterhouse, “Small Microstrip Patch Antenna,”*Electronic. Lett.*, Vol. 31, pp. 604-605, 1995.

[5] S. Satpathy, K. P. Ray, and G. Kumar “Compact Shorted variations of Circular Microstrip Antennas,”*Electronic. Lett.*, Vol. 34, pp. 137-138, 1998.

[6] G. Kosiavas *et al.*, “The C-Patch:A small Microstrip Element,”*Electronic. Lett.*, Vol. 25, pp. 253-254, 1989.

[7] J. George *et al.*, “New Compact Microstrip Antenna,”*Electronic. Lett.*, Vol. 32, pp. 508-509, 1996.

[8] S. Dey, and R. Mittra, “Compact Microstrip Patch Antenna,”*Microw. Opt. Tech. Lett.*, Vol. 13, pp. 12-14, 1996.

[9] K. L. Wang, C. L. Tang, and H. T. Chen, “A compact, meandered circular microstrip antenna with a shorting pin,”*Microw. Opt. Tech. Lett.*, Vol. 15, pp. 147-149, 1996.

[10] R. Bhattacherjee, B Gupta, D. R. Poddar, and S. K. Choudhary, “Dual-Slot loaded Compact Microstrip Antenna,”*Microw. Opt. Tech. Lett.*, Vol. 28, pp. 277-278, 2001.

[11] J. S. Kuo, and K. L. Wong, “A Compact Microstrip Antenna with meandering slots in the ground plane,”*Microw. Opt. Tech. Lett.*, Vol. 29, pp. 95-97, 2001.

[12] Ansoft HFSS ver. 14 [Online]. Available: http://www.ansoft.com/products/hf/hfss/