Design of Circular Loop Antenna with Step Change in Loop Width

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***Abstract:*A novel printed loop antenna is designed introducing a C-shape portion to the left arm of the circular loop antenna. The proposed antenna gives frequency range from 3.5 to 6.20GHz. It is observed that lower frequency band depends on the C-shaped structure of circular loop antenna. However, the upper frequency band depends on the coupled tapered transmission line. Balun transformer of Z=50Ω to 80Ω is merged with the proposed antenna to enhance the bandwidth having frequency range of 2.7 to 7.1 GHz. Antenna is designed on FR4 substrate and can be used for various application such as ISM band, WLAN band and UWB application.**

Keywords: Circular Loop Antenna, Bandwidth Enhancement, Tapered transmission lines.

I. INTRODUCTION

Wireless communication demand is increasing day by day. Due to this increasing demand, quality and capacity of modern wireless system is also increased. Because of different demands and requirements, Improvement in wireless communication is also introduced in antenna technology.

In [1], the authors have introduced a printed rectangular loop antenna with L-shaped portion to its arm giving UWB frequency range of 3.1 GHz to 5.1 GHz. In our proposed antenna, we have change our idea by using a circular loop antenna and introducing a C- shaped structure to its arm to achieve frequency range which can be used for various application. The purpose of the proposed antenna is to Enhanced Bandwidth by giving Step Change to the Loop Width of circular loop antenna. Due to its circular shape, Antenna has N number of position available to give Step change to its Loop Width for Bandwidth Enhancement and to analyze Antenna performance.

II. ANTENNA STRUCTURE AND SIMULATED RESULTS

The proposed structureof C-shape circular loop antenna is a printed loop antenna made up of single metallic layer and printed on FR4 substrate with dielectric constant of $\varepsilon r = 4.4$, loss tangent $\tan \theta = 0.02$ and thickness of 1.59 mm. A coupled tapered transmission line is also printed on same side of Similar metallic layer. The best performance of an antenna can be obtained by increasing the loop width. Hence, Antennais modified by giving a step change to loop width.
Simplecircular loopantenna is takento analyze the antenna Performance and then a step change is given to its loop width because of which bandwidth is enhanced. A C-shape of step change loop width is form to the left side of circular loop

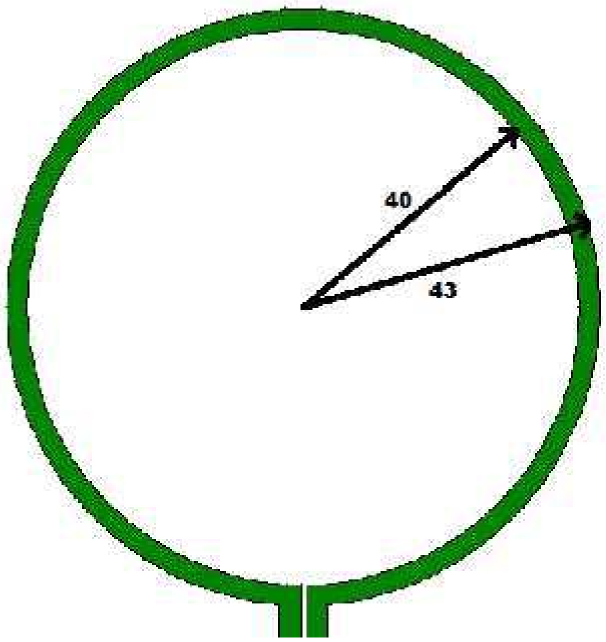

Fig. 1. Simple circular loop antenna

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antenna. Hence, it is also called as C-Loop Antenna. Also, to analyze the effect circumference length of step loop width is increased.At the end, tapering is given to the coupled transmission lines for impedance matching.

Simple circular loop antenna of inner radius 40mm and outer radius 43mm having loop width of 3mm is taken which gives out frequency range of 3.5 to 5.1 GHz. Now this circular loop antenna is modified by giving a step change to its loop width which is our proposed antenna.

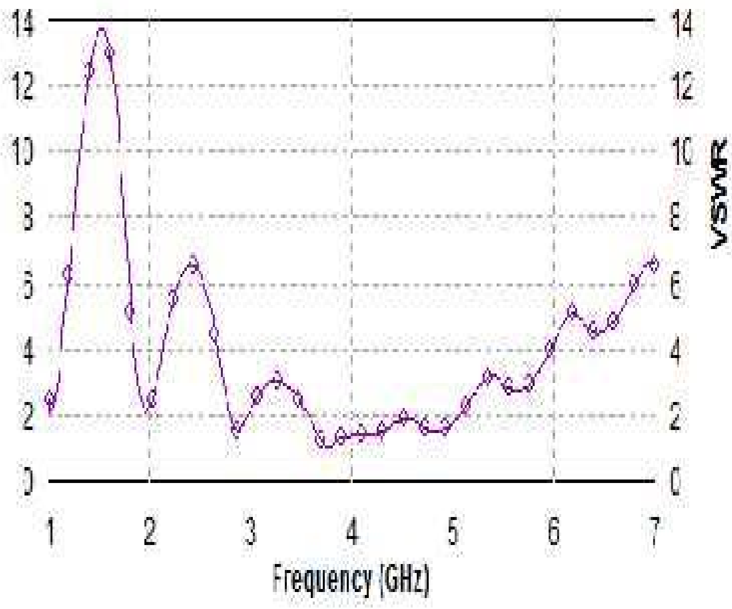

Fig. 2. VSWR of Simple circular loop antenna [7]

The proposed antenna has outer radius of 43mm and inner radius of 40mm having loop width of 3mm. C-shaped structure of circular loop antenna has step change to its outer radius of 45mm and inner radius of 33mm having loop width of 12mm from angle 100° to 260°.The frequency range which is obtained without tapering to the coupled transmission line is from 3.5 to 5.7 GHz and if tapering is given to the coupled transmission lines then upper frequency band is increased and frequency range is obtained from 3.5 to 6.15 GHz. Henceit is clearly analyzed that due to tapering upper frequency band is increased from 5.7 GHz to 6.15 GHz. Therefore it was observed that lower frequency band is obtained due to C–shape portion of loop antenna and upper frequency band is obtained due to its coupled tapered transmission lines. A step change to its loop width of C-shape helps to enhance the bandwidth and a taper transmission line is chosen for good impendence matching and to minimize the reflection due to which upper frequency band of bandwidth is obtained.

The achieved impedance bandwidth is in the order 2.65 GHz for VSWR ≤ 2. Some compared results are shown to show that the proposed structure dimension gives better result than others.

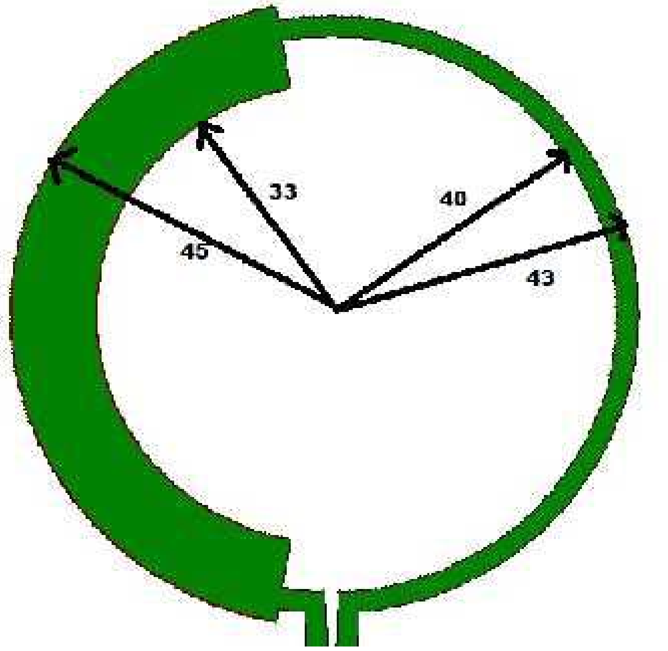

Fig. 3. Proposed antenna structure with coupled tapered transmission lines [7]

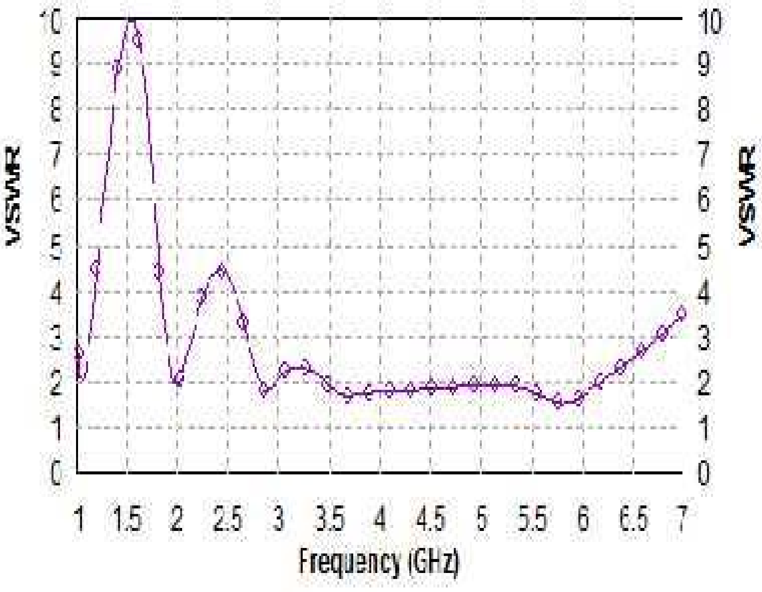

Fig. 4. VSWR of proposed Antenna [7]

Inner Radius (IR) In Mm	Outer Radius (OR) In Mm	Step Width IR In Mm	Step Width OR In Mm	Step width From angle to angle	Frequency Range In GHz
40	43	38	45	130 - 260	3.60 to 5
40	43	37	45	130 - 260	3.60 to 5.1
40	43	36	45	130 - 260	3.58 to 5.2
40	43	35	45	130 - 260	3.58 to 5.3
40	43	34	45	130 - 260	3.55 to 5.6
40	43	33	45	130 - 260	3.50 to 5.8
40	43	32	45	130 - 260	3.50 to 5.75
40	43	31	45	130 - 260	3.50 to 5.7
40	43	30	45	130 - 260	3.50 to 5.5
40	43	29	45	130 - 260	3.50 to 5.45

Table I. Calculated Results for change in inner radius step width

In above table, frequency range for different results is shown. It was observed that as we go on increasingthe inner radius ofstepwidth then it affects the lower frequencyband because of Which bandwidth is enhanced Inner radius step width of 33mm gives better frequency range as compared to others but after 33mm of inner radius step width frequency range is reduced.

Inner Radius (IR) In Mm	Outer Radius (OR) In Mm	Step Width IR In Mm	Step Width OR In Mm	Step width From angle to angle	Frequency Range In GHz
40	43	33	45	130 - 260	3.50 to 6.1
40	43	33	45	120 - 260	4.50 to 6.2
40	43	33	45	110 - 260	3.55 to 6.1
40	43	33	45	100 - 260	3.50 to 6.20
40	43	33	45	90 - 260	3.55 to 6.20
40	43	33	45	80 - 260	3.58 to 6.20
40	43	33	45	70 - 260	3.60 to 6.20

Table II. Calculated Results for increase in circumference of step loop width and effect of tapered transmission lines.

In table II, at different angle from 70 to 130 circumference step width is increased and tapering is given to coupled transmission lines because of which upper frequency band is increased. From 100° to 260° circumference step width gives better results as shown.

The Proposed antenna gives frequency range of 3.50 to 6.20GHz having bandwidth of 2.7 GHz. Bandwidth can be increased by changing the impedance of the proposed antenna.

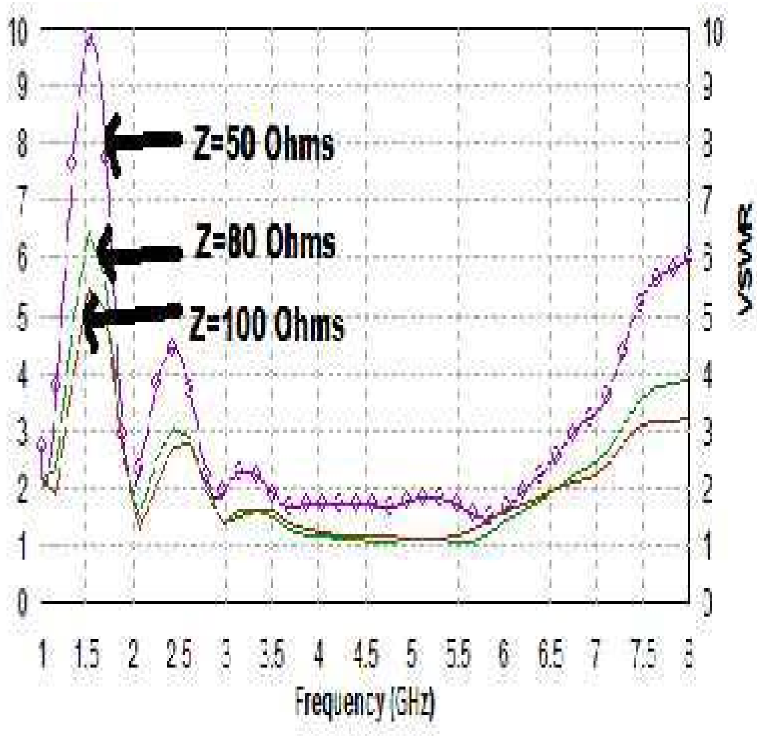

Fig. 5. VSWR of proposed antenna at Z=50Ω , Z= 80Ωand Z= 100 Ω

Sr. No.	Impedance Z	Frequency Range
1	Z = 50 Ω	3.50 to 6.20GHz
2	Z = 80Ω	2.75 to 6.55 GHz
3	Z = 100 Ω	2.80 to 6.55 GHz

Table III. Frequency range at Z = 50 Ω , Z = 80Ω and Z = 100 Ω

In table III, Frequency range of proposed antenna at different impedance is given in which Z = 80 Ω gives better bandwidth of 3.8 GHzas compared to other impedance. Therefore, a Balun [10] is needed to ensure the unbalanced to balance transformation of the proposed antenna and to match the impedance.

Baluntransformer[10] of Z = 50 Ω to Z = 80Ω is used and merged with the proposed antenna at Z = 80 Ω and then balun transformer is fed with Z = 50 Ω which gives frequency range from 2.7 to 7.1 GHz having Bandwidth of 4.4 GHz .Hence by using balun transformer bandwidth is increased .

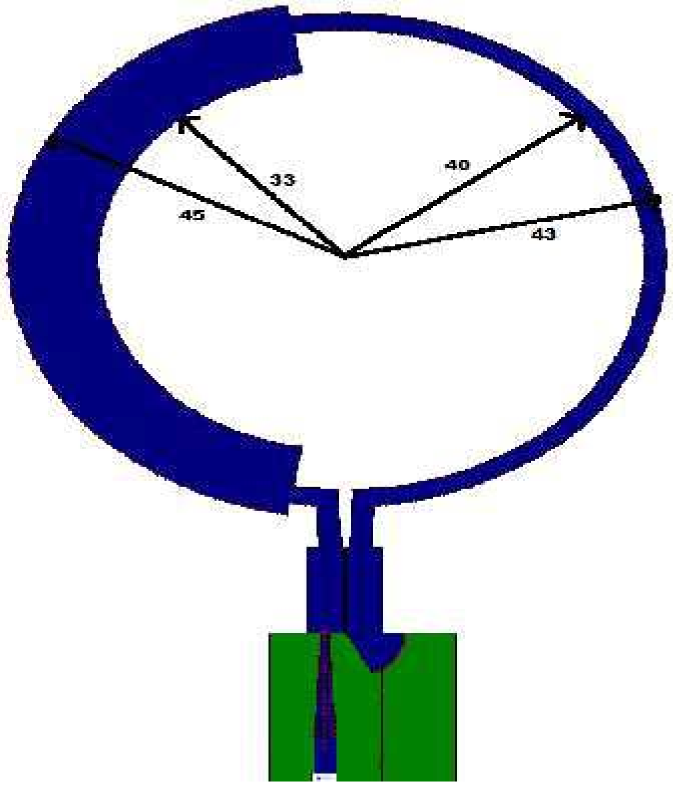

Fig. 6. Proposed antenna with Balun transformer of Z = 50 Ω to Z= 80 Ω [7],[10]

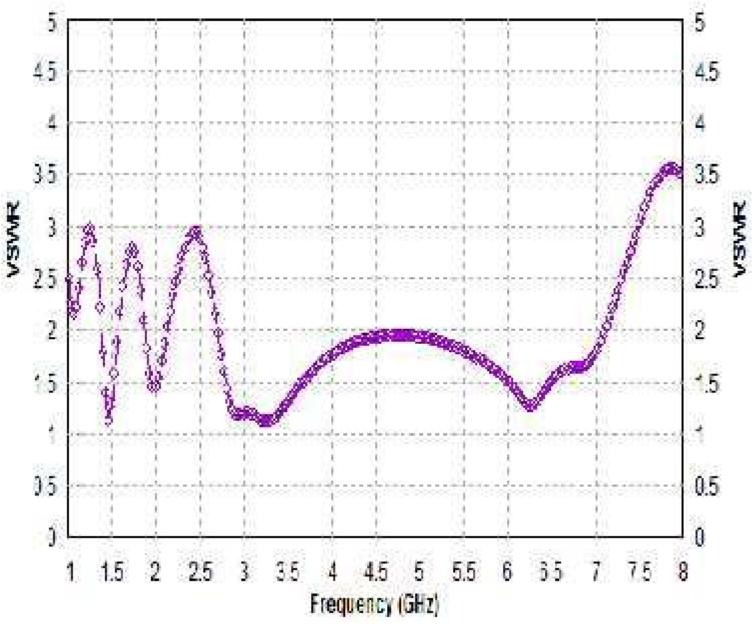

Fig. 7. VSWR of proposed antenna with balun transformer of Z = 50 Ω to Z = 80 Ω

III. Conclusion

A C-shape structure circular loop antenna was presented and demonstrated that by introducing C-shape to the left arm of the printed circular loop antenna and tapering to coupled transmission lines gives impedance bandwidth of 2.7 GHz. The proposed antenna is merged with Balun transformerZ = 50 Ω to Z = 80Ω having impedance bandwidth of 4.4 GHz which gives excellent performance and can be used for various application.

References

[1] K. Yekeh Yanzandoost and R. Konoh, “Design and analysis of an antenna for UWB system,” Jan 2005.

[2] Rong -Lin Li, Vincent F. Fusco, H. Nakano, “ Circularly polarized open loop antenna ”, *IEEE Transactions on antenna and wave propagation, vol. 59, NO. 9,September 2003.*

[3] C. A. Balanis, *Antenna Theory: Analysis and Design*, 2nd ed. New York: Wiley, 1996.

[4] G. Kumar and K.P. Ray, Broadband Microstrip Antennas. Norwood, MA: Artech House, 2003.

[5] O. P. Rustogi, “Linearly Tapered Transmission Line and Its Application in Microwaves,” *IEEE Transactions on Microwave Theory andTechniques,* vol. 17, pp. 166-168, March 1969.

[6] N. M. Martin and D. W. Griffin, “A tapered transmission line model for the feed-probe of a microstrip patch antenna,” *IEEE APS Symposium*,vol. 21, pp. 154-157, May 1983.

[7] IE3D Electromagnetic Simulation and Optimization Software, Zeland Software, Inc.

[8] J. C. Coetzee and J. A. G. Malherbe, “Generalized theory of a non-TEM transmission line taper without discontinuities,” *Electronics Letter,* vol. 26, no. 24, p. 2056, Nov 1990.C. A. Balanis, *Antenna Theory: Analysis and Design*, 2nd ed. New York: Wiley, 1996.

[9] K. Murakami and J. Ishii, “Time-domain analysis for reflection characteristics of tapered and stepped nonuniform transmission lines,”*Proceeding of IEEE International Symposium on Circuits andSystems*, vol. 3, pp. 518-521, June 1998.

[10] Wen-Hua Tu, Student Member, IEEE, and Kai Chang, Fellow, IEEE ‘’Wide-Band Microstrip-to-Coplanar Stripline/Slotline Transitions’’ IEEE Transactions on Microwave theory and techniques, vol. 54, no. 3, March 2006.

[11] Young-Ho Suh and Kai Chang, Fellow, IEEE ‘’ A Wideband Coplanar Stripline to Microstrip Transition’’, IEEE Microwave and Wireless components letters, vol. 11, no. 1, January 2001.