UWB Loop Antenna as Reconfigurable Multiband Antenna

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***Abstract*— There are distinct and regular approaches to convert a wide band antenna into a multiband antenna. These techniques include current reconfiguration, structure reconfiguration and metamaterial. But these techniques are mainly applied to printed MS antenna, and dipole antenna. Such techniques are not available in case of loop antenna. This work is dedicated to the application of metamaterial to UWB printed loop antenna.**

Keywords*— coplanar strip line; thin loop antenna; thick loop antenna; wire antenna; ultra-wide band; nonuniform loop antenna

I. INTRODUCTION

As the need for more data is increasing, UWB needs present and future communication systems. High-speed data transmission requires greater band availability. Broadband antennas are used as transmitting and/or receiving components to meet the need for a greater bandwidth. Many UWB technologies include position and ground penetration radar monitoring. So far monopoly antennas have appeared as strong candidates to meet UWB applications requirements. Metamaterials or EBG structures were applied to the monopole antennas to increase the gain and other electrical and radiation characteristics. Dipole printed antennas fed with coplanar strip line (CPS) span the 3.1GHz to 11.4GHz bandwidth. In antenna architecture this structure has too many dimensional parameters[1]. A closed loop structure offers the researchers greater scope to contribute. A square printed loop with a portion of L shape to its arm provides excellent performance at the lower UWB system band, ranging from 3.1GHz to 5.1GHz[2]. The antenna shows a bandwidth of return loss of-10dB over the whole frequency band. The lower band is found to depend on the L portion of the loop antenna, however the taper transmission line determines the upper frequency limit. The level of antenna bandwidth is 48.78%. A printed loop antenna fed with coplanar waveguide will produce a 1GHz and 1.14GHz bandwidth. This antenna is suited to PCS and IMT 2000 devices applications. The antenna has a great gain with pattern of omnidirectional radiation[3]. A small loop antenna fed with a CPW line provides a bandwidth of 70 per cent. The low antenna size makes this useful for array applications[4]. There is a narrow circular polarized bandwidth in a single loop antenne. If this antenna is added as a passive element with another loop antenna, then a second band is created and the antenna combination produces a greater bandwidth with circular polarization[5]. The technique of band enhancement[2] was extended to a circular loop, and 88.6 percent bandwidth was achieved. The proposed work did not provide any justification for bandwidth enhancement and no consideration was paid to the effect of the proposed shape on the pattern of antenna radiation. Ease of Use A metamaterial is a substance designed to have a property not present in natural materials. These are made of multi-element structures, constructed from composite materials such as metals and plastics. Usually, the materials are arranged in repeating patterns, at scales smaller than the wavelengths of the phenomena they influence. Metamaterials derive their properties from their newly designed structures and not from the properties of the base materials**.**

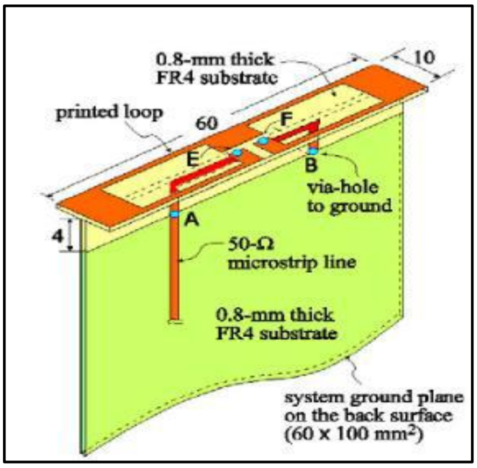

Figure 1: Penta-band printed loop antenna.

Chien-Wen Chiu and Yu-Jen Chi proposed a hepta-band printed loop antenna. A U-shaped tuning element printed on the back side of the circuit board is used to adjusts the resonant modes to cover GSM850/GSM900/DCS/PCS/UMTS/WLAN and Wi-MAX bands.

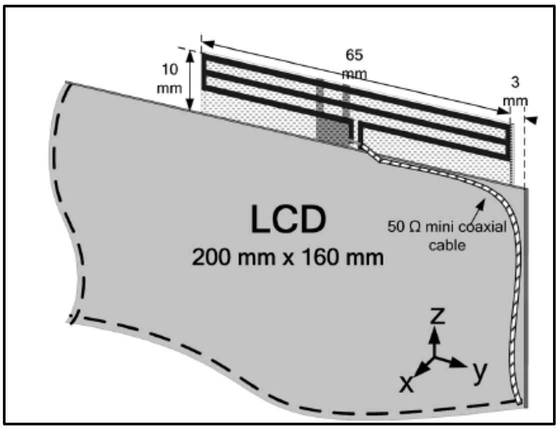

Figure 2: Hepta-band printed loop antenna.

II. METHODOLOGY

A wide band loop antenna is added with a SRR to obtain multibands. Therefore

1) a SRR will be designed to reject a particular band.

2) There is no particular method to place SRR to obtain multiband operations therefore location of SRR will be experimented.

3) Performance of the multiband will be improved by adding reconfigurable SRR.

4) Loop with optimum performance will be manufactured and tested. Abbreviations and Acronyms

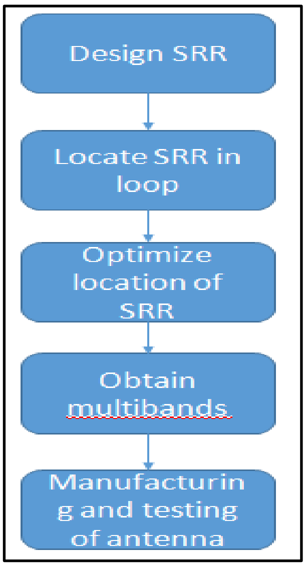

Figure .3: Methodology to obtain multiband loop antenna.

Need of Multiband**:** An UWB antenna covers 3.1 GHz to 10.6 GHz frequency range which includes already existing bands such as 5.2 GHz and 5.8 GHz. In order to avoid interference with the existing band, these bands must be rejected by antenna. The rejection can be obtained with the help of filter at the input of the antenna but it occupies larger area on board and is not recommended. A reconfigurable metamaterial is better alternate and can be added to antenna without occupying any additional area on the board.

III. UWB LOOP ANTENNA

A wide band nonuniform loop antenna covers a band from 3.4 GHz to 9.4 GHz. The development of the nonuniform printed loop has opened following opportunities:

1) Design of multiband reconfigurable printed antenna using metamaterials.

2) Design of reduced size or compact size UWB printed loop antenna.

3) Formulation of existing printed loop antenna.

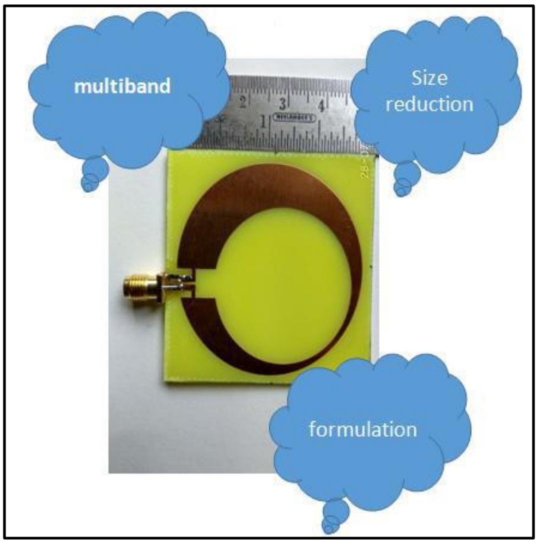

Figure 4: UWB loop antenna and scope

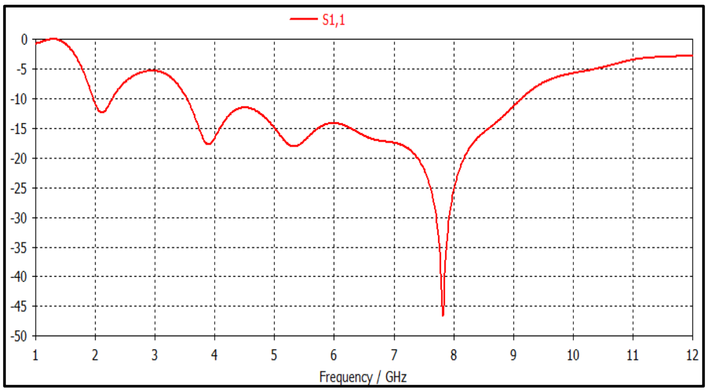

Figure 2.2: Frequency V/S reflection coefficient

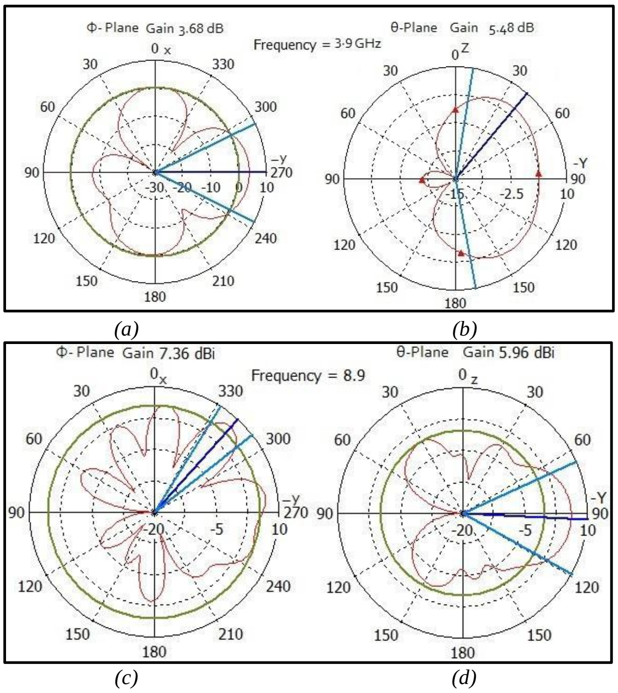

Figure 2.3: Radiation pattern of UWB printed loop antenna at 3.9 GHz and 8.9 GHz.

IV. METAMATERIAL

It is a common practice to design multiband reconfigurable antenna by introducing reconfigurable metamaterials to wideband antennas such as wideband printed microstrip antenna or printed monopole antenna. Multiband operation is achieved by introducing metamaterial in ground plane of antenna or in the plane of antenna or both. It is also observed that such combination to achieve multiband operation is not common in loop antenna. Metamaterials are used for size reduction and bandwidth enhancement in loop antenna. The following work demonstrates application of reconfigurable metamaterial for the development of multiband loop antenna. Figure 3.1 shows the structure of split ring resonator (SRR) with the variables used to control the resonant frequency of the resonator.

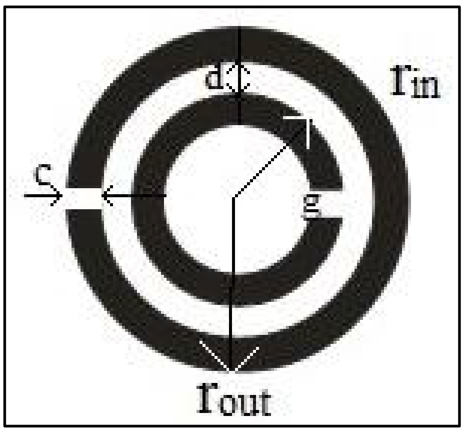

Figure 3.1. Circular split ring resonator (SRR).

Following is the mathematical relations to find out resonant frequency of the SRR.

$$f_0 = \frac{1}{2\pi}\sqrt{\frac{1}{L_r\, C_{eq}}}$$

fo is resonant frequency, LT is total equivalence inductor and Ceq is total equivalence capacitance.L_T and Ceq are given as

$$L_r = 0.0002L\,(2.303\log_{10}\frac{4l}{C} - \gamma)$$

$$Ceq = \frac{(\pi rr_{arg} - g)C_{pul}}{2} + \frac{\varepsilon_0 ct}{2g}$$

$$l = 2\pi r_{out} - g$$

$$C_{pul} = \frac{\varepsilon_0}{Co\ Zo}$$

l is the length of the of the SRR, γ is 2.451 for circular SRR and c is ring width and t is thickness of metallic rings. Cpul is defined as capacitance per unit length, Co is speed of light in free space, Zo is characteristic impedance of total length. All the dimensions are in mm.

$$\varepsilon_0 = 1 + \frac{\varepsilon_r - 1}{2}\frac{K(k')K(k_1)}{K(k)K(k_1')}$$

$$k = \frac{c/2}{\frac{c}{2+d}}$$

$$k_1 = \frac{\sinh\frac{\pi a}{2h}}{\sinh\frac{\pi b}{2h}}$$

For $0 \le k \le 0.7$,

$$\frac{K(k)}{K(k')} = \left[\frac{1}{\pi}\ln\left(2\,\frac{1+\sqrt{K'}}{1-\sqrt{K'}}\right)\right]^{-1}$$

For $0.7 \le k \le 1$

$$\frac{K(k)}{K(k')} = \left[\frac{1}{\pi}\ln\left(2\,\frac{1+\sqrt{K}}{1-\sqrt{K}}\right)\right]$$

Characteristic impedance Z0 is given by:

$$Z_0 = \frac{120\pi}{\sqrt{\varepsilon_e}}\frac{K(k)}{K(k')}$$

Table 1 shows the resonant frequencies for different dimensions of SRR. Larger dimension of SRR resonator resonates at smaller frequencies.

ring-gap, D	C gap-G	Ring width, C	outer-radius-outer-circle	outer-radius-inner-circle	F (GHz)
0.3	0.3	0.4	2.6	2	5
0.3	0.3	0.4	3	2.3	4.14
0.3	0.5	0.4	3	2.3	4.22
0.25	0.5	0.4	3	2.3	4.09
All dimensions of SRR are in mm					

Table 1: SRR showing change in frequency due to change in physical dimensions of SRR.

REFERENCES

[1] Chinthana J. Panagamuwa, Alford Chauraya, and J. (Yiannis) C. Vardaxoglou "Frequency and Beam Reconfigurable Antenna using Photoconducting Switches," IEEE Transactions on Antennas and Propagation, Vol. 54, No. 2, pp 449-454, February 2006.
[2] Abdelnasser Eldek, Abubaker Abdallah, Mahmoud Manzoul "Reconfigurable Microstrip Double-Dipole Antennas for Personal Wireless Communication," Wireless Engineering and Technology, Vol.2, pp. 60-69, 2011.
[3] Kin-Lu Wong and Chih-Hong Huang "Penta-Band Printed Loop Antenna for Mobile Phone", Proceedings of iWAT2008, Chiba, Japan, 2008.
[4] Chien-Wen Chiu and Yu-Jen Chi "Printed Loop Antenna With a U-Shaped Tuning Element for Hepta-Band Laptop Applications," IEEE Transactions On Antennas and Propagation, Vol. 58, No. 11, November 2010.