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METAMATERIAL ANTENNAS USED FOR WIRELESS APPLICATIONS

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ABSTRACT

In this review article, different structures of monopole antennas based on metamaterial concepts which have been developed for various wireless applications are presented. The antennas designed for wireless applications must be broad band, low profile, small size and have better performance. Monopole antennas embedded with Artificial magnetic conductors (AMC), Electromagnetic band gap structures (EBG), Complementary split ring resonators (CSRR), Transmission line metamaterial (TL-MTM), Simplified MTM (SMTL) are reviewed in this paper.

Keywords: monopole antennas, metamaterial, AMC, EBG, CSRR, TL-MTM, SMTL.

1. INTRODUCTION

Antenna is one of the key component, provides interfacing between Radio hardware & air-interface for wireless communication. The major design parameters of wireless antennas are Bandwidth enhancement, multiband operation and size reduction. Reduce the antenna size through conventional methods (such as shorting pins [1], meandering [2] and dielectric loading [3] often results in low radiation efficiencies narrow Bandwidth and undesired radiation pattern.

Meta materials are artificial composite material designed to have a negative value refractive index.[9,10,11,12] Antenna with meta material can refract electromagnetic waves more than conventional antennas which results in Antenna size reduction[13,14,15,16,17] without reducing too much of their frequency Bandwidth [1,2,3,4,5].

In this review article different structures of monopole antenna embedded with various MTM such as TL-MTM, CSRR, SMTL, NRI-TL, CRLH are reviewed[4,5,6,7,8,9,10].

2. METAMATEIAL ANTENNAS

Performance of the antennas can be improved by various metamaterials. When the dipole is embedded with DNG medium, the reactance of the dipole antenna is decreased which results in increase in radiated power. The DNG material matches the intrinsic reactance of this antenna system to free space. When microwave antennas are embedded with SRR provides good coupling efficiency and sufficient radiation efficiency.

Loading a planar metamaterial network of TLs with series capacitors and shunt inductors produces higher performance. This results in a large operating bandwidth while the refractive index is negative.

By combining right-handed (RHM) with left-handed materials (LHM) as a composite material (CRLH) construction, both a backward to forward scanning capability is obtained.

Thus using metamaterials we can improve the performance of antennas such as size reduction, bandwidth enhancement, provides good coupling efficiency, improve radiation properties of the antennas

3. WIRELESS ANTENNAS FOR BANDWIDTH ENHANCEMENT & SIZE REDUCTION

A. Dual band wireless antennas

In monopole antenna Dual band characteristics is achieved when it is embedded with TL_MTM & CSRR Metamaterials.

i) Monopole antenna with TL_MTM

If the monopole antenna is embedded with two-arm TL-MTM, which is nothing but five spiral inductor loaded transmission lines in microstrip. Each arm is designed to work at its own operating frequencies which is adjusted by loading the spiral inductors. A wideband characteristic is enabled when the corresponding two resonance frequencies are suitably merged into single pass band. By further detuning the two resonances frequencies, the proposed antenna can also be applied for dual band applications. The size of the patch without two arm TL-MTM is 812 mm^2& full bandwidth is 3.7%.when the patch is embedded with two-arm TL_MTM its size is decreased as 304mm^2 and bandwidth is 3.1%.Compared the above two results bandwidth reduction is tolerable with the size reduction.

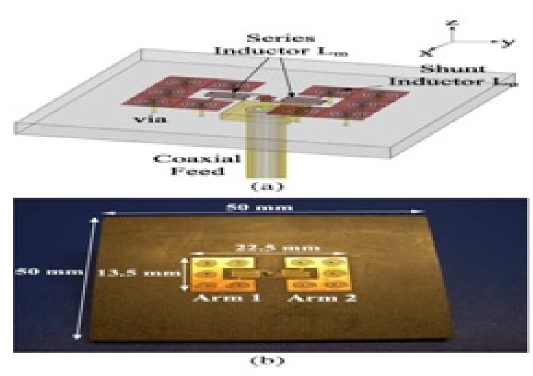

Figure-1. The two-arm TL-MTM antenna featuring a compact size and extended bandwidth. (a) 3D schematic

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and (b) top-view photograph of the fabricated prototype [1].

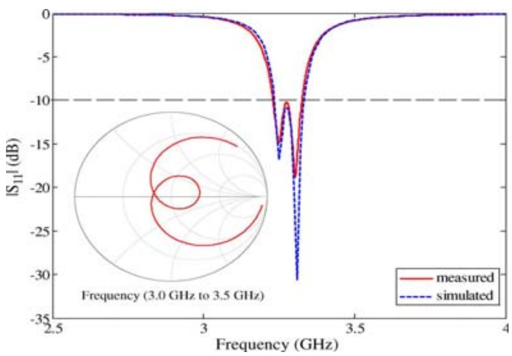

Figure-2. Measured and HFSS simulated return loss for the two-arm antenna.

A double resonance pattern is clearly observed within the passband [1].

ii) Monopole antenna with CSRR

If a Planar monopole antenna integrates with quasi-complementary split ring resonator in the feed line, dual frequency bands are obtained. The notched frequency bands can be easily controlled by the sizes & locations of the CSRR.

Geometry and simulated results are shown in figure.

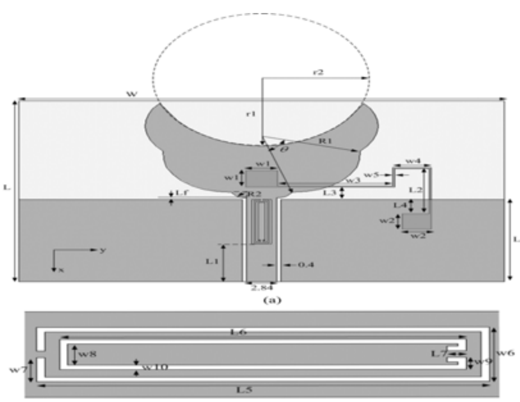

Figure-3. (a) Geometry of the antenna. (b) Geometry of quasi-CSRR (unit: millimeters) [2].

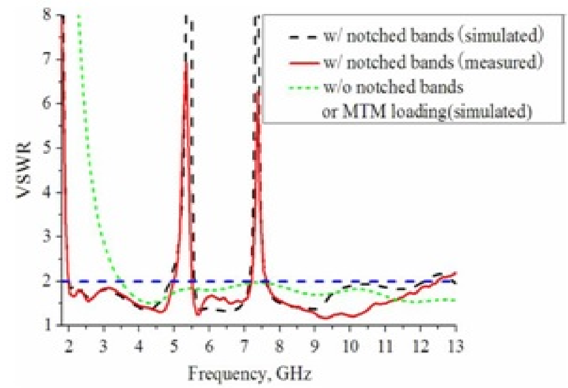

Figure-4. Simulated and measured VSWR of the antenna [2].

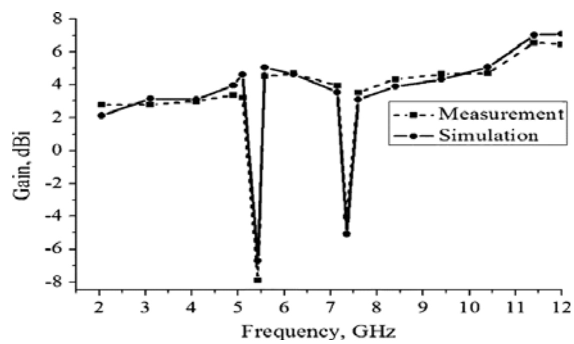

Figure-5. Measured and simulated gain of the antenna with notched bands [2].

The measured and simulated VSWR for the designed antenna has VSWR<2 for a wide band of 2.0-12.5 GHz and covers the 3G,Bluetooth Wimax and UWB Bands with Dual notched bands of 5.0-5.5 &7.2-7.6 GHz. The realized gain of the antenna is reduced at 5.3 & 7.4 GHz.

B. Trible band wireless antennas

i) Monopole antenna with CRLH

When monopole is embedded with CRLH unit cell, it produces three operating frequencies whereas conventional monopole antenna has single operating frequencies.

In this case, the first band of resonance is at 1.25 GHz is achieved by varying stub length& stub width. The second resonance frequency is at 1.7 GHz which is available in the left handed region of the CRLH unitcell . The third resonance frequency is at 2.6 GHz which is normal resonance of the monopole.

The modified CRLH based monopole antenna covers many communication standardards such as WIFI (2.4 GHz), WIMAX (2.5 GHz) & GPS (1.27&1.57 GHz).

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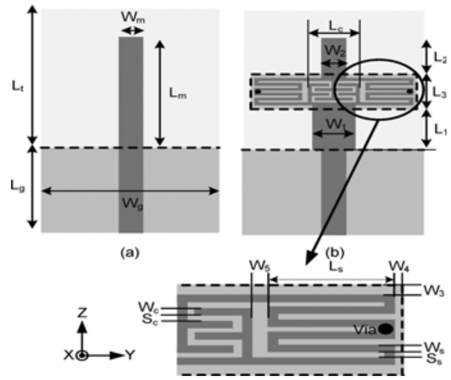

Figure-6. (a) Conventional microstrip-fed monopole antenna. (b) microstrip-fed monopole antenna loaded with a CRLH unit cell [3].

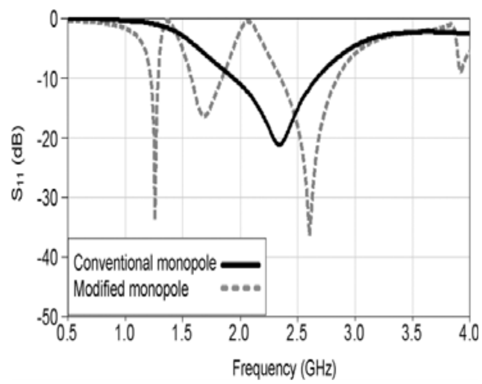

Figure-7. Simulated for the conventional monopole and the monopole loaded with modified CRLH unit cell [3].

ii) Monopole with SMTL

Monopole can act as wide band antenna when it is integrated with simplified MTLS (SMTLS).

SMTL is nothing but it is a combination of series of interdigital capacitors which provides wide impedance because of left handed capacitance.

Structure of Desired antenna is shown in fig 8. The reduced element is formed by two different sized SMTL unit cell using CPW feed.

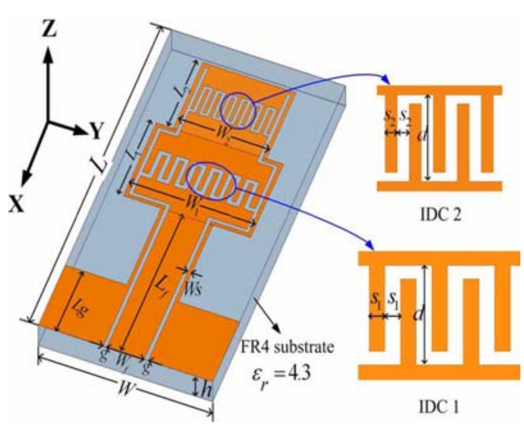

Figure-8. Configuration of the antenna [4].

Figure-9 Shows the simulated reflection co efficient for different Parameters (L1, L2& d) of the antenna. The resonance frequency of the antenna is inversely varied with the length of the antenna. The resonance frequency has been decreased when we changed from.9 to1.2 mm.

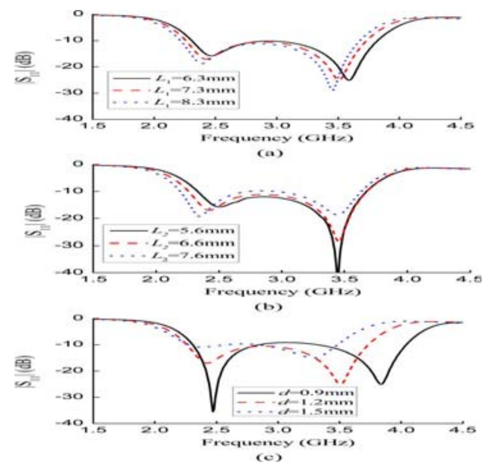

Figure-9. Simulated reflection coefficient of the antenna for various parameter with (a)L1 , (b)L2 , and (c)d .[46].

iii) Monopole with reactive loading

A triband is achieved by using reactive loading and defected ground plane monopole antenna is shown in Figure-10.

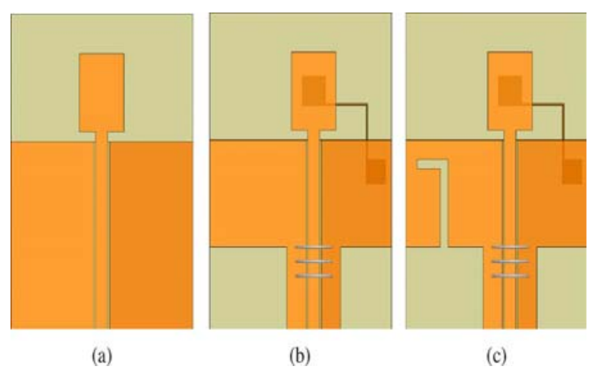

Figure-10. (a) Case 1: unloaded monopole antenna, (b) Case 2: dual-bandmonopole antenna with single-cell MTM loading and (c) Final: tri-bandmonopole antenna with single-cell MTM loading and a “defected” ground [5].

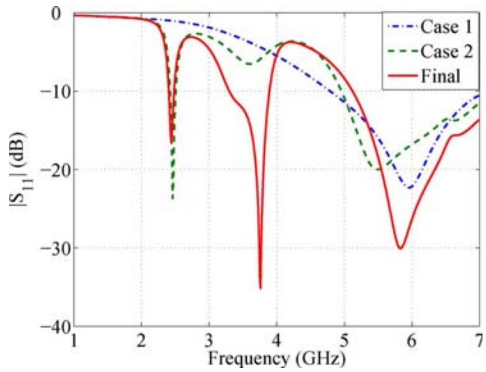

Figure-11. Simulated S_{11} for Case 1: unloaded monopole antenna.

Case 2: Monopole antenna with single-cell MTM loading and Final: Monopole antenna with single-cell MTM loading and a" defected" ground [5].

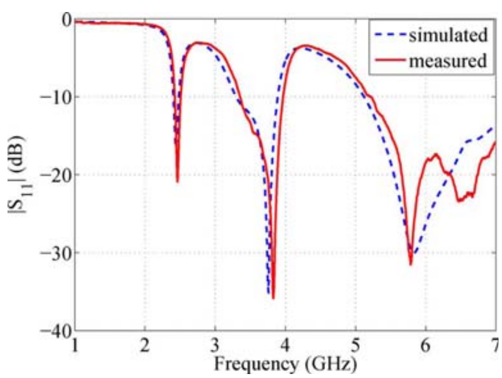

Figure-12. Measured and HFSS simulated S_{11} for the tri-band monopole antenna with single-cell MTM loading and a "defected" ground [5].

The below table indicates simulated and measured results of Gain and efficiency of tri band monopole antenna with single cell metamaterial loading and a defected ground plane.

Freque ncies	**Simulated Gain**(HFSS)	**Simulated efficiency** (HFSS)	**Measured Gain**	**Measured efficiency** (wheeler cap method**)**
2.45 GHz	0.98	69.8	1.14	67.4
3.50 GHz	1.25	80.8	1.15	86.3
5.50 GHz	2.05	85.9	1.78	85.3

4. CONCLUSIONS

This paper has been reviewed for dual band & Triple band antennas using monopole with different meta material structures such as TL-MTM, SMTL, CSRR, CRLH.

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