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Tri-band small monopole antenna based on SRR units

Gehan Shehata [a], **Mahmoud Mohanna** [b,*], **Mohammed Lotfy Rabeh** [a]

[a] *Electrical Engineering Department, Shoubra Faculty of Engineering, Benha University, Cairo, Egypt*
[b] *NRIAG Earthquake Department, Egypt*

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Abstract In this paper a novel design for a tri-band monopole antenna coupled with metamaterial units is introduced. The proposed antenna was designed to cover WiMAX (2.5, 3.5) and WLAN (5.2) bands. In our proposal, a coplanar waveguide (CPW) fed circular-disk monopole antenna is coupled with three split ring resonator (SRR) units which exist on its back side. In our design a monopole antenna and SRR units are designed first to resonate at 5.2 GHz and 2.5 GHz respectively. In addition, antenna is loaded with post to force resonance at 3.5 GHz. SRR units are used for 2.5 GHz resonance to miniaturize antenna size, and our proposed antenna considered an electrically small antenna (ESA) at its first resonance frequency. Simulated and measured results exhibit a good agreement that validate our design.

1. Introduction

Spreading of wireless communication networks gives a great attention to the design of multi-band antennas that have low cost, low profile, compact size and light weight. Printed antennas have these advantages and can be designed to realize broadband or multi-bands responses.

Many printed monopole antennas were designed and fabricated for dual or multi-bands wireless applications (Liu and Wu, 2007; Song et al., 2011). Miniaturization is required, especially for new wireless generation devices. Many researchers rely on split ring resonators (SRR) to achieve electrically small antenna (ESA). For example, Alici et al. (2010) fabricated an antenna with size less than $\lambda/10$. In this design, two perpendicular SRRs with different electrical sizes were excited to resonate at 4.72 GHz and 5.76 GHz with efficiencies 15% and 40% respectively. They also studied in Alici and Ozbay (2007a) an ESA that is composed of monopole and SRR, in which the antenna resonates at 3.62 GHz with 43% efficiency. Malik and Kartikeyan (2012) reduced the physical size of microstrip patch antenna by loading patch with complementary split ring resonator (CSRR). Si and Lv (2008) composed a closed ring resonator and SRR for a compact multi-band planar antenna design.

* Corresponding author.
E-mail addresses: gehan_shehata@hotmail.com (G. Shehata), mahmoud2746@hotmail.com (M. Mohanna), lotfigomaa@gmail.com (M.L. Rabeh).

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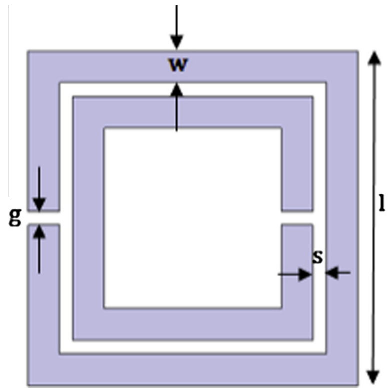


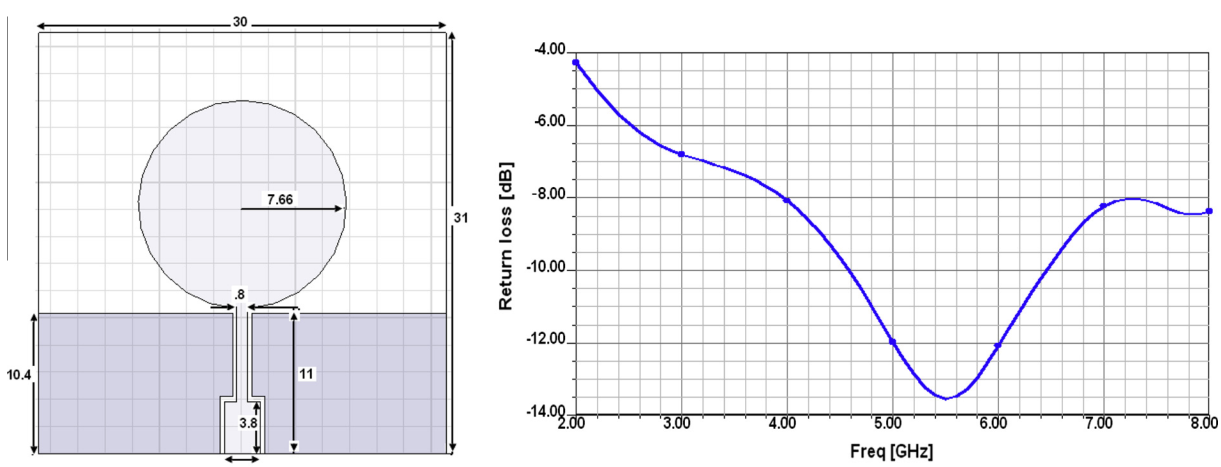
Figure 1 Split ring resonator with design parameters.

In addition to the reduction of antennas size, SRR can also be used for filtering purposes. Yin et al. (2008) designed a circular monopole ultra wideband antenna with multiple band notches using SRR and L-type band stop filter. Kim et al. (2006) etched slot type SRR near the feeding point of UWB antenna to notch the antenna band at 5.2 GHz which is used for WLAN services. The composite closed ring resonators and SRR introduced in Si and Lv (2008) show a frequency notching function to achieve multi-band operation.

Our proposed antenna first relies on composing SRR units with monopole antenna to realize dual band; monopole antenna has a wide band response, and coupling SRR units with monopole result in dual band response exploiting filtering function of SRR. Second, using post with reactive loads to realize and adjust tri-band response.

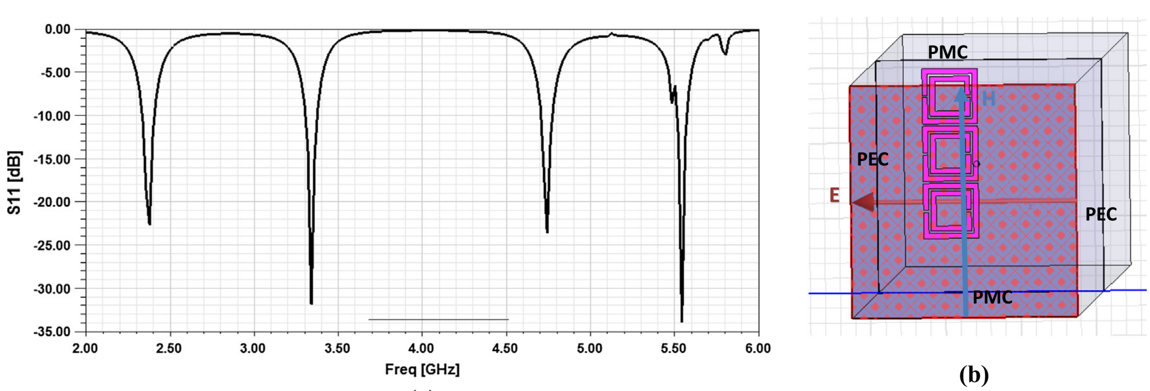
A genetic search optimization algorithm is used to optimize the location of the SRR units with respect to the radiating sections of the monopole antenna, and to optimize the location and dimensions of the reactive elements added to the antenna.

The dimensions of proposed antenna realize the limits of electrically small antenna at its first operating frequency 2.5 GHz, which is defined by Wheeler (1947), who defines electrically small antenna as one with maximum dimension less than $\lambda_0/(2\pi)$, or $k.a < 1$ where $k = 2\pi/\lambda_0$, λ_0 is the free space wavelength, and a is the radius of sphere enclosing the maximum dimension of the antenna.



(a) (b)

Figure 2 Monopole antenna with modified feeding structure (dimensions in mm) (a) geometry and (b) simulated return loss.



(a) (b)

Figure 3 (a) Simulated return loss of plane wave incident to post loaded SRRs array. (b) Boundary conditions of simulated incident plane wave on post loaded SRRs array.