

# Left-handed compact MIMO antenna array based on wire spiral resonator for 5-GHz wireless applications

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**Abstract** A compact coplanar waveguide-fed multiple-input multiple-output antenna array based on the left-handed wire loaded spiral resonators (SR) is presented. The proposed antenna consists of a  $2 \times 2$  wire SR with two symmetrical microstrip feed lines, each line exciting a  $1 \times 2$  wire SR. Left-handed metamaterial unit cells are placed on its reverse side and arranged in a  $2 \times 3$  array. A reflection coefficient of less than  $-16$  dB and mutual coupling of less than  $-28$  dB are achieved at 5.15 GHz WLAN band.

## 1 Introduction

Nowadays, multiple-input multiple-output (MIMO) wireless communication technology is becoming increasingly popular due to increased data transmission rate and channel capacity [1, 2]. In a MIMO system, several antennas are employed at both transmitter and receiver system.

However, one of the critical issues faced by MIMO antenna's designers is the trade-off between size reduction and coupling between antenna elements. The influence of the mutual coupling on channel capacity and diversity performance of the MIMO system has been investigated by numerous researchers [3, 4]. Many methods are proposed to decrease mutual couplings in MIMO antennas, involving use of radiating patches with different orientation, neutralization lines, different slots, and shapes, as well as electromagnetic band gap (EBG) [5–7]. Nevertheless, these structures tend to be more complex, and they occupy a relatively large physical size.

Recently, the realization of metamaterial unit cell structures enabled the size miniaturization and performance improvement of MIMO antenna system [8–10]. Metamaterials (MTM) are artificially structured materials used to produce electromagnetic properties that are not usually existed in nature materials, particularly their negative permittivity, permeability, and refractive index values over some frequencies range [11]. They are commonly constructed of various periodic metallic structures called unit cells with dimensions that are remarkably smaller than the wavelength of the electromagnetic radiations.

Left-handed metamaterials with negative relative permeability and permittivity are two significant classes of metamaterials, which were firstly obtained by the periodic structure of split-ring resonators (SRR) and the metal wires, correspondingly [12, 13]. However, the use of conventional metamaterial structures to reduce mutual coupling of MIMO antennas usually involves bulky formations or multilayer structures. Such structures are challenging for cost-efficient commercial implementations and also difficult to miniaturize [14, 15]. Rather than using split-ring resonators (SRRs), a wire loaded spiral resonators (SR) can exhibit characteristics of a left-handed metamaterials with

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