

# Novel selective channels, narrow-band and compact inspired-metamaterial antenna for the cognitive radios

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## Abstract

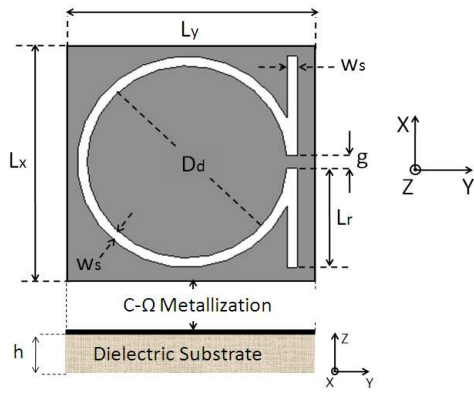
Novel selective channels, narrow-band and compact inspired metamaterial antenna is presented for the cognitive radios applications. The structure of the antenna is based on the finite arrays of the complementary  $\Omega$  (C- $\Omega$ ) resonators loaded square patch antenna. By adjusting the C- $\Omega$  geometrical parameter, the measurement results illustrate the frequency tuning capability.

## 1. Introduction

Recently, a cognitive radio (CR) concept has attracted some antenna designs. By monitoring, the FCC (Federal Communications Commission) has published a report that claims that the spectrum can be idle for 90% off the time [1]. In [2], the discussion about the antenna design requirements is derived from the CR concept. The authors suggest the differentiation between the sensor antenna that could have a wide band width in order to sense the idle (band, sub band or channel) and the operating antenna that should be tunable in terms of the frequency in order to transmit the data at the available band or channel, but there is no conventional scheme in the antenna design yet. In this paper a novel compact metamaterial antenna design is proposed for the CR operating antenna needs. The antenna must exhibit an ultra narrow band close to the bandwidth of a channel among the WLAN (802.11 a) channels [5]. The CR concept deployed in this antenna is based on the tuning of the frequency to the idle channel frequency. This technique can provide a minimum return loss with a maximum radiation efficiency at all of the channels of the WLAN (802.11 a). The antenna design approach associates a simple patch antenna to a finite array of metamaterial (MTM) resonators. More specifically, we use in this work a Complementary “ $\Omega$ ” metamaterial unit cell (C- $\Omega$ ) printed on the patch metallization, by means of the C- $\Omega$  geometrical parameters variation; we will illustrate the antenna tuning frequency ability. The impedance bandwidth and the radiation measurements are derived to validate the antenna design.

## 2. The inspired-MTM antenna design

The MTM unit cell resonator used in this work is a complementary “ $\Omega$ ” shaped cell. The authors have demonstrated that the medium based on the omega cell is anisotropic and exhibit a Double Negative Behavior (DNG), where both of the effective permittivity and permeability are simultaneously negative [3]. The DNG obtained is related to the coupling between the electrical dipole and the magnetic split ring resonators. However, to guarantee the DNG resonance, the  $\Omega$  unit cell ought to be correctly excited by an external electromagnetic field, the electrical field must be collinear with the dipole and the magnetic field should be perpendicular to the split ring, unfortunately this resonance condition has limited the use of the omega cell in the planar microwave structures. In order to overcome this limitation, we propose in this paper the design of the complementary omega metamaterial unit cell. In the complementary structures [4], due to the fact that the electric boundary conditions on the metal are exchanged with magnetic ones, the structures become effectively dual, and give rise to the planar applications. To this end, the C- $\Omega$  structure is proposed in the Figure.1, the C- $\Omega$  shape metallization is printed on RT/Duroid substrate ( $\epsilon_r = 2.2$ ,  $\tan\delta = 0.00027$ , and height  $h = 0.8\text{mm}$ ), the dimensions of the unit cell ( $L_x$ ,  $L_y$ ) should be close to  $0.08\lambda$ , the unit cell is designed to operate at 6 GHz, and detailed geometries are given in Table 1.



| Parameter  | Lx | Ly | Dd  | Ws  | Lr | h   | G   |
|------------|----|----|-----|-----|----|-----|-----|
| Value (mm) | 7  | 7  | 5.8 | 0.3 | 3  | 0.8 | 0.6 |

Figure.1 Design of the C-Ω resonator

Table. 1 Geometry parameters of the C-Ω resonator

The geometry of the proposed antenna is shown in Figure.2. The antenna is based on the simple square patch, printed on the same dielectric substrate, using for the MTM unit cell. The patch is fed by 50Ω coaxial connector, and Figure.2.b shows that the patch antenna is loaded by 2 symmetrical C-Ω arrays, each array comprises two C-Ω unit cells. The position and the orientation of the MTM cells have been optimized in order to maximize the coupling with the patch electromagnetic near field and satisfy the resonance condition of the dual structures. As shown in the proposed configuration, the slit rings are oriented to be near region 1 and 2 of the square patch. It is widely known that in those regions, the maximum electrical field is present. Alternatively, it can be seen that the slit dipoles are oriented to be collinear with the magnetic near field of the patch. The square patch is designed and optimized to resonate at the same frequency (towards 6 GHz) such as the MTM unit cell. The detailed geometry dimensions are given in Table.2.

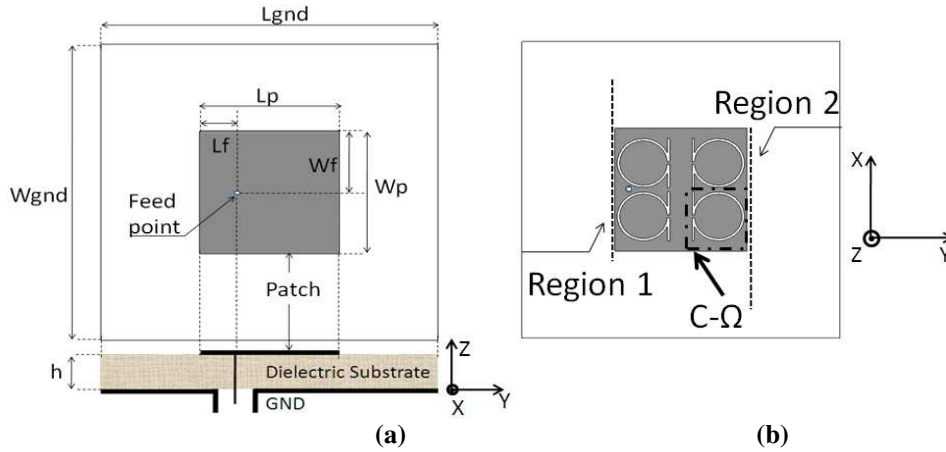


Figure.2 (a) The configuration of the square patch antenna, (b) The optimized C-Ω loaded patch antenna design

| Parameter  | Lgnd | Wgnd | Lp   | Wp   | Lf  | Wf  | H   |
|------------|------|------|------|------|-----|-----|-----|
| Value (mm) | 40   | 40   | 16.8 | 16.8 | 6.4 | 8.4 | 0.8 |

Table. 2 Design parameters of the optimized antenna

### 3. Results

The antenna structure is simulated under full wave simulator. Subsequently, the dual-gap widths of the C-Ωs are varied from 0.6 mm to 0.9 mm by 0.1 mm step, and then the simulated S11 parameters (Figure.3) shows a static frequency tuning ability according to the g variation, where the capability of selecting the WLAN (802.11 a) channels is observed, and therefore, every g variation case exhibits an ultra narrow antenna bandwidth ( $\approx 25$  MHz) close to the

WLAN (802.11 a) channels bandwidth [5]. We have noticed a shifting of the initially simple patch resonance frequency (6 GHz) to (5.3 GHz) when loading the C- $\Omega$ . So a 14% patch antenna electrical size reduction is achieved.

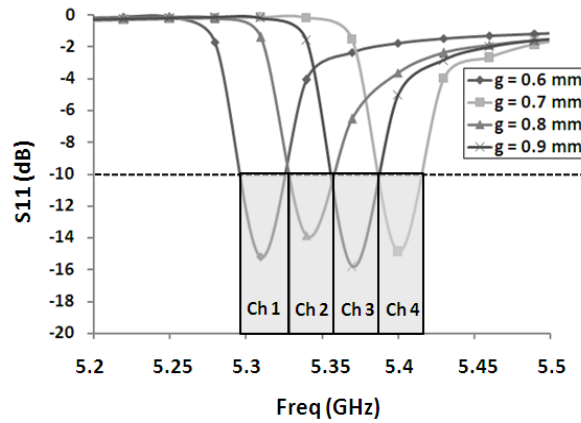


Figure.3 Variation of the C- $\Omega$  loaded patch antenna simulated S11 parameter according to  $g$

The antenna has been fabricated as Figure.4 shows and the measured S11 parameters (Figure.5.a) confirm the antenna frequency tuning response according to the  $g$  variation. However, a relative frequency shifting is observed and is related to the manufacturing uncertainty. The measured radiation patterns of the proposed antenna are plotted in (Figure.5.b), where ZY and ZX cut plans at ( $g = 1$  mm,  $f = 4.99$  GHz), are shown. As can be seen, the antenna features a small cross polarization radiation less than -20 dB and the realized peak gain is about 3 dBi.

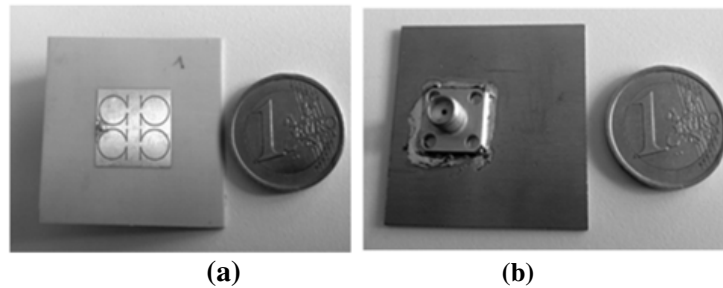


Figure.4 fabricated antenna (a) Top view (b) Bottom view

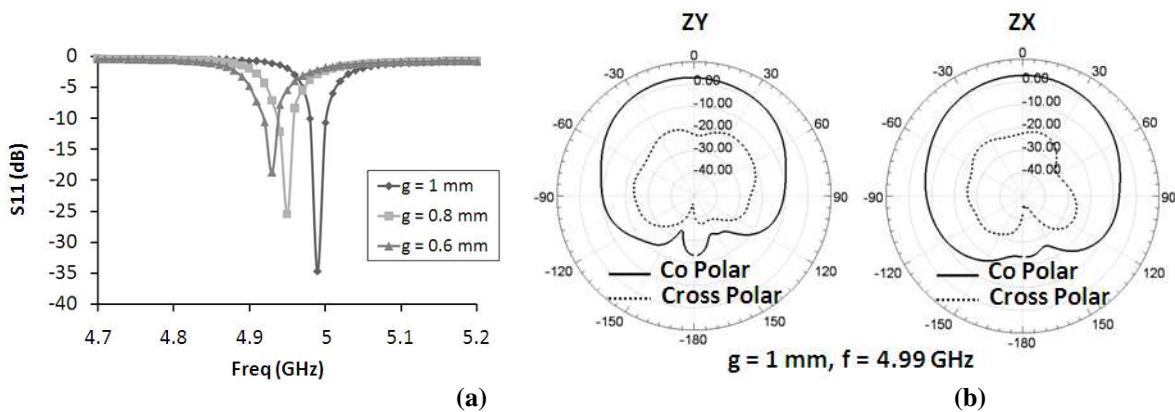


Figure.5 (a) Variation of the measured S11 parameter of the fabricated C- $\Omega$  loaded patch antenna according to  $g$  (b) Measured Radiation pattern of the C- $\Omega$  loaded patch antenna

## 4. Conclusion

A novel selective channels, narrow-band and compact inspired-metamaterial antenna, is proposed for the cognitive radios and WLAN (802.11 a) applications. Both of the simulation and the measurement results confirm 14% patch size reduction. The same results prove clearly the static frequency tuning ability according to C- $\Omega$  geometric parameters variation.

## 5. References

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