International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2019): 7.583

# Effect of Circular Split Ring Resonator Array on Circular Microstrip Antenna Used for Intelligent Transportation System (ITS)

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**Abstract:** ***In this paper, Split Ring Resonator (SRR) array are loaded in substrate of a circular microstrip antenna used for intelligent transportation system (ITS). The operating frequency of this antenna is 5.9 GHz for ITS band. Dual band operation is also observed when the array of SRR designed whithin substrate for the RLAN application [5.47 – 5.725]. Thissimulation works had been done in CST Microwave Studio simulation software. The parameters that considered are return loss, bandwidth, resonant frequency, radiation pattern and gain.***

**Keywords:** circular patch antenna, car-to-car applications, split ring resonator, Intelligent Transportation System (ITS).

## 1. Introduction

Wireless technologies knew a development in various domains like Intelligent Transportation System (ITS). This system aims to provide innovative services, and appears for solve several problems [1]

It's a combination of three mains focus; data transmission, ITS elements and ITS subsystem [1][2]. The latter is an element very important for provide the good performance of ITS communication [3]

Metamaterials or left handed material is a media with simultaneously negative permeability and permittivity. This structure gives effect to several application that had been designed. It's a media where we can controlled response of material [4].

This structure also can miniaturize the size of the patch antenna or other medium that researcher used for its design [5].

There are many structure had been proposed by many researches, the most popular are split ring resonator(SRR), complementary split ring resonator (CSRR), artificial magnetic conductor (AMC), electromagnetic band gap (EBG) and photonic band gap (PBG) [6].

Split ring resonator has different types; Edge Coupled Split Ring Resonator (EC-SRR), Broadside- Couple Split Ring Resonator (BC-SRR), NonBiastropic Spilt Ring Resonator (NB-SRR), Spiral Split Ring Resonator (S-SRR) and Open Split Ring Resonator (O-SRR) [6].

Split ring resonator array is used to produce the negative magnetic permeability; it called Mu-NeGative material (MNG) [7].

In this paper, we interested a communication vehicle-vehicle, so the new standard 802.11p for improve wireless communication between their in Dedicated Short Range Communication at 5.9GHz for frequency. For band, it work between [5.850 – 5.925 GHz] in United State, and between [5.875 – 5.925 GHz] in Europe. The approach antenna used for this application is simple circular microstrip patch antenna placed on the substrate loaded of the Split Ring Resonator (EC-SRR) metamateriels feefed by microstrip line. We note that the full-wave analysis of the proposed designs were carried out using CST microwave studio which is a well-known electromagnetic simulator based on the finite-difference time-domain (FDTD) method.

## 2. Split Ring Resonator (SRR)

The SRR, as it was initially proposed by pendry [7] consists of two concentric metallic split rings printed on a microwave dielectric circuit board. SRR's parameters have effect on performance of microstrip patch antenna design. Some of these parameters are split ring resonator's shape, the gap between the split ring, the width of the rings, the number of split rings, and the size. The figure 1 shows the shape and equivalent circuit of EC-SRR which the ring behaves as LC resonator and the slots between the ring behaves as a distributed capacitance which is $C=\pi r C_{pul}$ where r is the mean radius of the EC-SRR ($r=r_{ext} - c - d/2$).

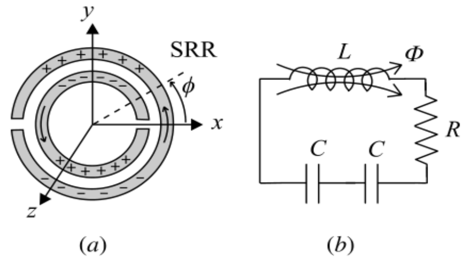


**Figure 1:** a : shape of EC- SRR, b : its equivalent circuit

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The dimension of the split ring resonator had been stated as g=0.25, c= 0.5, d=2, r1=3.5, r2=6, and distance between the center the rings is s=12.

## 3. Circular Patch Antenna

The circular patch antenna is one of the popular patch used of different applications especially telecommunication systems. It has one degree of freedom to control. The modes supported by the circular patch antenna are TMz. witch the dominant is $TM_{110}^{z}$ that the frequency defined by [8]:

$$(f_r)_{110} = \frac{1.8412}{2\pi a\sqrt{\mu\varepsilon}} = \frac{1.8412 v_0}{2\pi a\sqrt{\varepsilon_r}} \quad (1)$$

Unlike the rectangular path that has two freedom to control (width and length), the circular has only one of freedom to control; the radius a.

To calculate this radius, we used the equation presented by [8]:

$$a = \frac{F}{\left(1+\frac{2h}{\pi\varepsilon_r F}\left[\ln\left(\frac{\pi F}{2h}\right)+1.7726\right]\right)^{1/2}} \quad (2)$$

Were

$$F = \frac{8.791\times10^{9}}{f_r\sqrt{\varepsilon_r}} \quad (3)$$

Because of the fringing along the circumference of the circular patch, the physical radius was replaced by the effective radius in [8], by this equation:

$$a_e = a\left\{1+\frac{2h}{\pi\varepsilon_r a}\left[\ln\left(\frac{\pi a}{2h}\right)+1.7726\right]\right\}^{1/2} \quad (4)$$

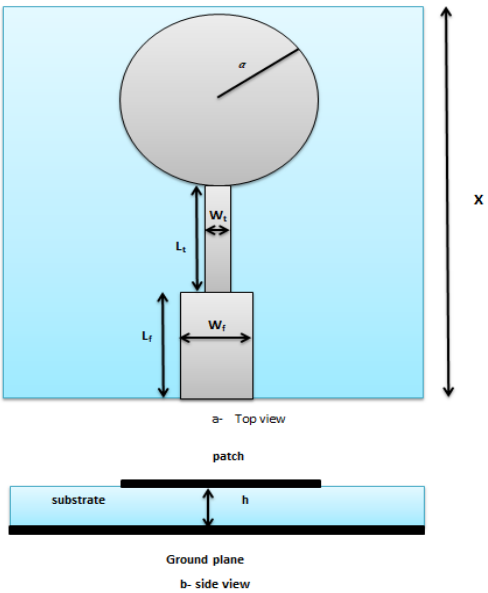



**Figure 2:** Microstrip patch antenna design in CST

Figure 2. shows the schematic diagram of the basic mictrostrip patch antenna design. This design is simulated in CST Microwave Studio Simulation Software. It's printed on the glass epoxy substrate with relative permittivity $\varepsilon_r$=4.2 and the loss tangent 0.02.

Table 1 shows the dimension of the normal microstrip patch antenna. The antenna has three major parts- patch, feed and feed end part.

**Table 1:** Dimension of simple microstrip patch antenna design

| *part* | *Symbol* | *Dimension (mm)* |
|---|---|---|
| Patch radius | a | 6.87 |
| Feed width | $w_t$ | 0.7 |
| Feed length | $l_t$ | 6.25 |
| Feed end width | $w_f$ | 7 |
| Feed end length | $l_f$ | 6.25 |

## 4. Antenna Loaded Array within Substrate

In this section we have focus the effect of the SRR array of the microstrip patch antenna design. Array consists of nine unit cell of SRR loaded within the substrate. They exists in h1 height from the ground plane.

Figure 3 shows the Split Ring Resonator array loaded within substrate.

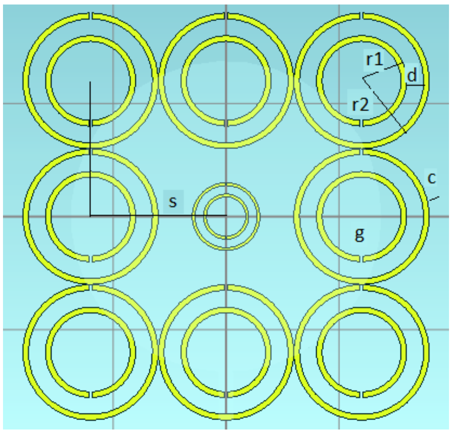



**Figure 3:** The SRR Array loaded within substrate

## 5. Results

The main parameters that consider in this work are, return loss, the voltage standing wave ratio (VSWR) and gain. Return loss is a convenient step to characterize the input and output signal source. This section consists two simulation works- basic patch antenna, the effect of split ring resonator array loaded within substrate.

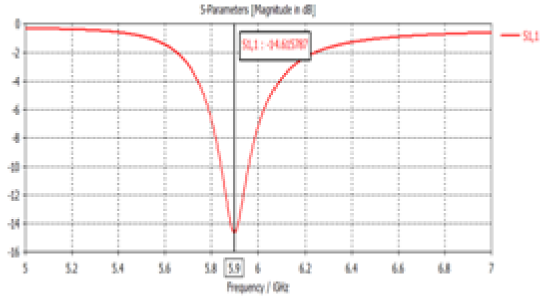
### 5.1 Basic antenna design

Figure 4. represents the return loss of normal microstrip patch antenna in CST Microwave Studio simulation software. The resonance frequency, fr for this antenna is 5.9 GHz with 14.61 dB of return loss performance. The bandwidth is 110 MHz in the frequency range betwwen 5.82 GHz for the lower frequency and 5.93 GHz for the higher frequency.

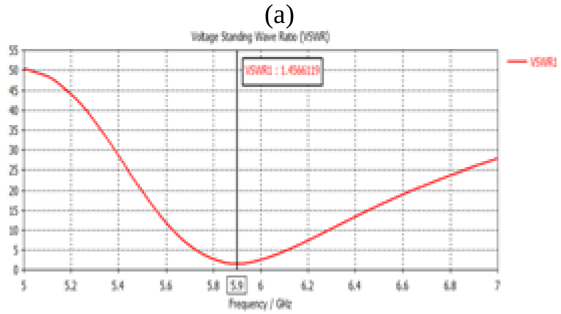
As VSWR describes the power reflected from the antenna, it's one of the parameters that are too important to calculate. As long as the VSWR is smaller, the antenna is better matched to the transmission line and more power is delivered to the antenna. Whenever the value of VSWR equal or near 1, the transmission line is perfectly or good matched with antenna input impedance.

In this work, the VSWR=1.45 implies that the reflected power is 3.45% of the total power, therefore, dilevred power to antenna is 96.55%.

Figure 5 shows the location of antenna and the radiation patterns that represents the electromagnetic power distribution in free space. The gain of this simple antenna is 6.86 dB.

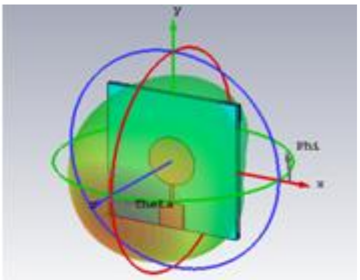



(a)

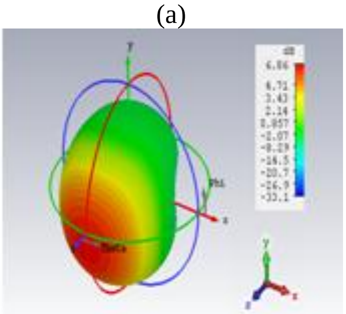



(b)

**Figure 4:** Parameters of antenna design (a) return loss (b) VSWR



(a)



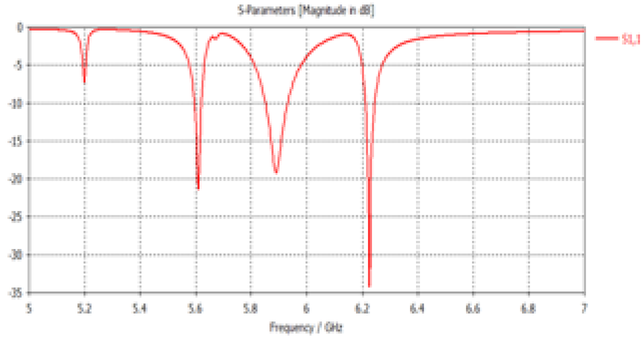
(b)

**Figure 5:** (a) The location of the antenna and its directivity, (b) Gain of antenna

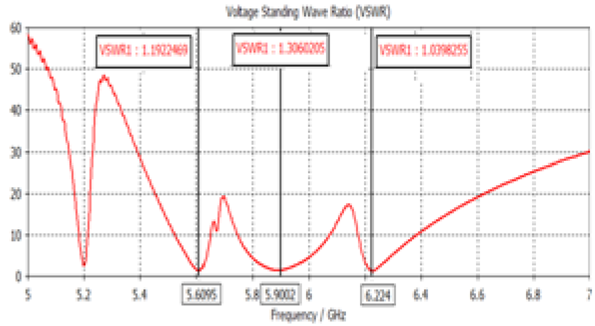
## 5.2 Patch antenna design with SRR array

Figure 6. represents the return loss and VSWR performances of the microstripe patch antenna with split ring resonator array loaded within substrate. From the observation, It shows that the addition of split ring resonator array leads to appear other cenre frequencies with increase the return loss compares to the simple patch antenna, therefore we obtain multiband microstrip antenna instead of one band patch antenna.

The VWSR is between 1 and 2, thus the reflected power for each center frequency is low, so the majority of the power is delievred to antenna.




(a)




(b)

**Figure 6:** Parameters of antenna a : return loss , b : VSWR

Table II shows the comparison of the various performances between the simple microstrip patch without split ring resonator array and microstrip patch antenna with split ring resonator array loaded within substrate. The return loss for center frequency 5.9 GHz increase, but there is a decrease for the gain.

For other frequencies, we have the interesting performances at level of return loss, VSWR and the gain.

**Table 2**: Comparison of parameters result between the antenna with and without split ring resonator array

| | *Resonant frequency GHz* | *Return loss (dB)* | *Bandwidth (MHz) Fl – Fh (GHz)* | *Gain* | *VSWR* |
|---|---|---|---|---|---|
| *Without SRR* | 5.9002 | - 14.61 | 110 (5.82-5.93) | 6.86 | 1.5 |
| *With SRR* | 5.9002 | -17.54 | 80 (5.85-5.93) | 6.79 | 1.3 |
| | 5.6095 | -21.15 | 28.1 (5.5941-5.6222) | 5.58 | 1.19 |
| | 6.224 | -34.18 | 32.8 (6.2109-6.2437) | 5.86 | 1.03 |

## 6. Conclusion

From the simulation work using CST Microwave studio, the circular Split Ring Resonator array loaded in substrate had improved the focusing parameters in this paper. The return loss of centre frequency of Intelligent Transportation System shown an increased compared to patch antenna without SRR, in add appearance of two other centers frequencies. In the future work, the antenna design can be improved by adding a PIN diode for achieve a reconfigurable antenna.

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