Multiband Planar Inverted F Antennausing SRR for LTE Devices

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ABSTRACT
The new services of mobile broadband system can deal with the growth of mobile internet traffic and high data rate. Long Term Evolution (LTE) is one of the prospective solutions to future mobile broadband systems. In this paper, a novel antenna is presented with Split Ring Resonator (SRR) loading suitable for LTE in handheld devices. The radiating element is Planar Inverted F- Antenna (PIFA) constructed with 2x2 SRR array placed in innerside of the top plate. PIFAs are prefered to use for communication and handheld devices due to low SAR, light weight, etc. The substrate used for this antenna design is RT duroid 5880 with ε_{r1}= 2.2. The patch size is 10mm x 16mm and the height of the top plate is varied from 3mm to 6mm. The antenna is designed to operate in the LTE - FDD frequency bandsof 3410-3500MHz&3510–3600MHz; and LTE-TDD frequency bands of 3400–3600 MHz&3600–3800 MHz.This paper also presents the effect on the performace of antenna in terms of return loss, VSWR, gain and bandwidth due to the height variation of top plate with 2x2SRR loading.

Keywords
Broadband, Long Term Evolution (LTE), Multiband, Planar Inverted-F Antenna (PIFA), Return loss, Split Ring Resonator (SRR), VSWR.

1. INTRODUCTION
The growth of mobile internet traffic and high data rate demands new services for wireless mobile broadband system.Long Term Evolution (LTE) is one of the prospective solutions to future mobile broadband systems. LTE bands can be categorised based on their dependence like Time Division Duplex (TDD) andFrequency Division Duplex (FDD) bands [1,2]. Generally, the antenna proposed for wireless devices covers wideband of 1.6-2.7GHz but recently, an antenna has been designed which support additional 3.4-3.8GHz band [3].

Antennas proposed in the previous years for the use in wireless devices includes planar monopole,planar inverted-F, reconfigurable antenna, slot antenna[5-7].Planar Inverted -F Antennas (PIFA) are extensively used for cellular phone application and other communication devices due to its qualities of low SAR values, light weight and multiband operation [8,9].

A multiband PIFA has been reported for multiband mobile in[10].The majorconcernin designing a PIFA structure is to cover the desirable operating bandwidthand to achieve this,the height of PIFAgenerally taken in the range of 7-12mm above ground plane [11]. The antenna with these values of heightaffects appearance of the handsets resultingthicker phones. Thus, the height of PIFA can be choosen as small as 4mm which results in reduction in phone thickness, but results in narrow bandwidth coverage [12]. PIFA structure consists of a ground plane, a radiating plate i.e. a patch, a feed plate& one shorting plate to connect the top patch and the ground plane. There are numerous design parameters which can be varied and the desired antenna performace is achieved. Some of the design parameters are width, length and height of the top radiating patch, width and position of shorting plate, location of the feed plate, dimensions of the ground plane. For the past few years, many work have been reported on modifying the ground plane also by introducing slots on it & using it as a radiator along with the main patch [13-15].Several papers have been investigated to improve specific performance parameters of antennas using metamaterials such as reflective surfaces, artificial magnetic superstrates, dielectric slabs, and electromagnetic bandgap structures [16-19]. The paper [20] shows inclusion of edge-coupled Split Ring Resonator (SRR) on the inner side of the top plate.

2. ANTENNA CONFIGURATION
The configuration, i.e. the top view of a PIFAis shown in figure 1(a) and the bottom view of the patch with SRR loading is shown in figure 1(b). The ground plane dimensions are $L_{G1} \times W_{G1}$ and radiating top plate has dimensions $L_{P1} \times W_{P1}$. The antenna is designed on Rogers substrate of thickness (t_1) = 0.8mm, dielectric constant (ε_{r1}) = 2.2 and loss tangent = 0.009. The width and length of top plate are 10mm and 16mm, respectively. The width of the shorting plate (W_{s1}) and feed plate (W_{f1}) is 3mm and 4mm, respectively.The geometrical structure of SRR is shown in figure 1(c).

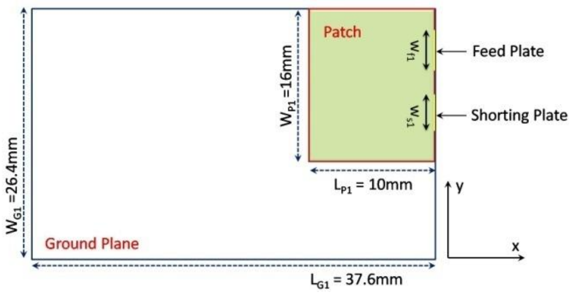

Fig.1(a): Top view of PIFA

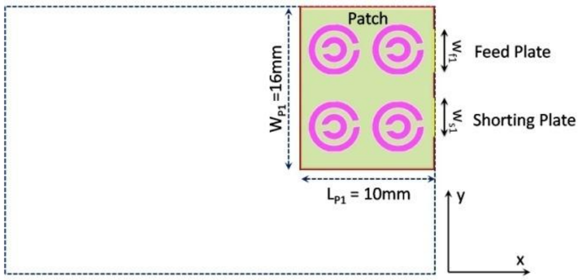

Fig.1(b): Bottom view of Patch loaded with SRR array

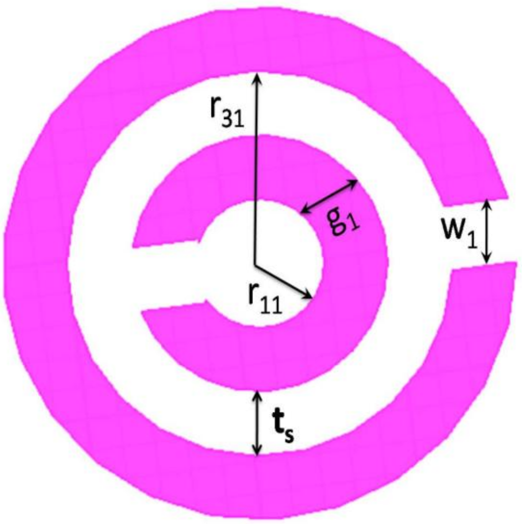

Fig. 1(c): Geometrical structure of SRR

This work is an extension of the previous work presented in [20].SRR have a pair of metallic rings, etched on a dielectric substrate, with slits on opposite sides. Each unit can be designed & have its own magnetic response. The effect of 2x2 SRR array loading on top plate of antenna with variation in height of top plate is observed.Table1describes the dimension of SRR.

Table 1: Dimension of Split Ring Resonator

Parameter	Dimension(mm)
r_{31}: Radius of Outer Ring	1.5
r_{11}: Radius of Inner Ring	0.5
g_1: Gap between inner and outer wall of ring	0.5
t_s: Gap between two rings	0.5
w_1: Slot in the ring	0.5

3. RESULT AND DISCUSSION

The 2x2 SRR array is placed in the inner side of the top plate. The height is varied in steps of 1mm keeping all other parameters constant.The height of the top plate is varied from 3-6mm and the return loss is observed for all variations. The software used for simulation is High Frequency Structure Simulator (HFSS). Figure 2(a) shows the return loss characterstics of PIFA with SRR loading and height variation.As the height of the top plate increases the resonating frequency shift towards lower frequency. From simulation results, it is observed that at Hp=5mm, the resonating frequency is 3.4GHz with bandwith 2GHz. But at Hp=6mm, the retrun loss is -33.5dB, resonating frequency is 2.7dB, and bandwidth is 1.6GHz.

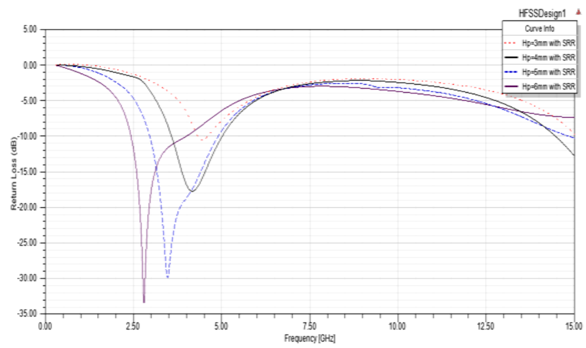

Fig. 2(a):Retrun loss comparison of antenna with SRR and variation in height of top plate

Figure 2(b) shows the return loss comparision of antenna without and with SRR loading at Hp=5mm. The SRR slots increases the electrical length and decreases the resonant frequency. The bandwidth is more at Hp=5mm, the antenna with SRR is considered for further observation. As observed from figure 2(b), at the height of 5mm without SRR, the resonant frequency is 3.6GHz and bandwidth is1.8GHz . The return loss of antenna is -25.7dB and -29.5dB withoutand with SRR respectively. The slight shift in resonant frequency and 200MHz increase in bandwith is observed when antenna is loaded with SRR.

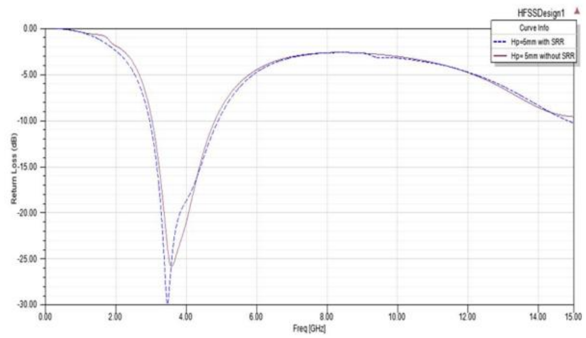

Fig. 2(b): Retrun loss comparison of antenna with SRR and without SRR

The gain of PIFA discussed in this paper without and with SRR loading at Hp=5mm is shown in figure 2(c) and 2(d), respectively.Figure 2(e) shows the VSWR plot of proposed antenna.The smaller value of VSWR shows the better matching and more power is deliverd to the antenna.

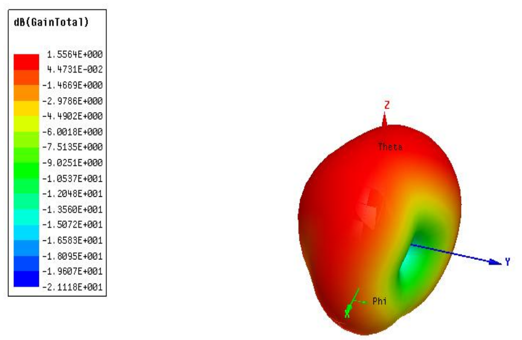

Fig. 2(c):Gain of proposed antenna without SRR and Height Hp=5mm

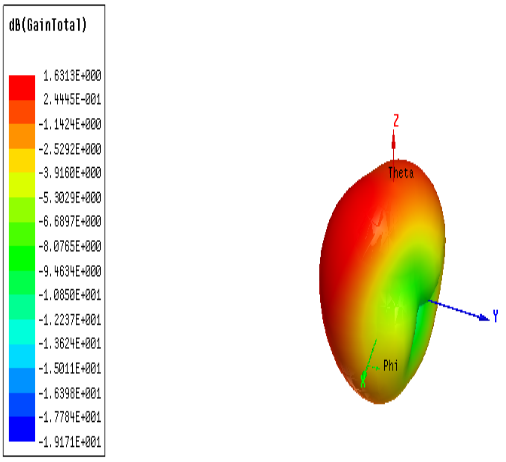

Fig. 2(d):Gain of proposed antenna with SRR and Height Hp=5mm

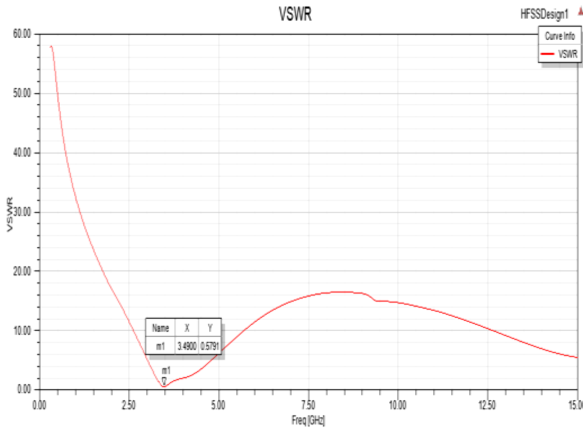

Fig. 2(e): VSWR plot of proposed antenna

4. CONCLUSION

An PIFA antenna is degined and simulated to analyse the effects of variation in height of the top plate and SRR array loading. For H_p=5mm, the antenna with SRR array loading shows frequency band for LTE frequency bands designedtooperate in the LTE - FDD bands of 3410-3500MHz&3510-3600MHz, and LTE-TDD frequency bands of 3400-3600MHz&3600–3800MHz. The bandwidth and gain observed without SRR loading is 1.8GHz and 1.5dB, respectively. The antenna at H_p =5mm with SRR loading shows the frequency band from 2.9 GHz to 4.9GHz. The bandwidth achieved for frequency band is 2GHz whereas the gain achieved is 1.6dB. The simulated antenna at H_p=5mm is possible candidate for Long Term Evolution (LTE) application.This antenna is suitable for mounting on the mobile phone due to its low profile, small size, and acceptable gain.

5. REFERENCES

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