



## Improving the gain and bandwidth of microstrip antenna in electronic toll collection

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### Abstract

In this paper, the design indices of the antenna used in Electronic Toll Collection have been drawn out and then a right-hand circular polarization microstrip array antenna subject to the specification and In india, it is only implemented in UHF band from 300 MHz to 928MHz and so the gain and bandwidth of the antenna is obtained and presented. The simulation result obtained by ADS software show that the performances of the presented antenna meet the needs of system very well.

**Keywords—** ETC, RHCP, Microstrip Antenna, ADS Software

### INTRODUCTION

Electronic toll collection (ETC) is to eliminate the delay on toll roads by collecting tolls electronically. ETC determines whether the cars passing are enrolled in the program, alerts enforcers for those that are not, and electronically debits the accounts of registered car owners without requiring them to stop. It has facilitated the concession to the private sector of the construction and operation of urban freeways. Also, it has made feasible the improvement and the practical implementation of road congestion pricing schemes in a limited number of urban areas to restrict auto travel in the most congested areas.

Electronic Toll Collection(ETC) system is a kind of modern traffic toll collection means based on RFID technology. In india, it is only implemented in UHF band from 125 kHz to 928MHz By using the microwave dedicated short range communication (DSRC) operating at 5.8GHz between the tag or so-called on board unit(OBU), which are installed on the front window of vehicles and the reader or road side unit(RSU) on the ETC road of toll collection station, the passing vehicles' toll could be collected automatically without stopping.

In this paper, the design indices about the microstrip reader's antenna are listed and discussed, then a microstrip

array antenna resonating at 5.8GHz and providing a peak gain of about 15dBi at center frequency is developed with improving the gain and bandwidth of the antenna by increasing the lamda as  $3\lambda/2$ . It radiates right-hand circular polarization beam with half-power lobe-width  $18^\circ$  in the horizon plane and  $34^\circ$  in the vertical plane. And the 10dB return loss(RL) impedance bandwidth and 3dB axial ratio bandwidth of the antenna is greater than 200MHz.

### LITERATURE REVIEW

Research Paper on: "Design of Circular Polarization Microstrip Antenna in RFID Reader for 5.8GHz Electronic Toll Collection Application". A dual-band characteristic of single layer stacked rectangular microstrip antenna is experimentally studied. The variations of the length and width of the stacked rectangular patch antenna has been done and found dual resonance with increasing lower resonance frequency and almost constant upper resonance frequency with increases of the length & width of rectangular microstrip antenna. The VSWR has been measured with the help of Network analyzer. In this paper, rectangular patch antenna is designed by using parasitic stubs and slot. To eliminate stray electric field, remove the upper two corners of patch by using edge tapering. It has higher bandwidth than conventional antenna. The proposed antenna is implemented and fabricated on PTFE substrate with thickness of 1 mm.

### DESIGN INDICES

A microstrip antenna usually means an antenna fabricated using microstrip techniques on a printed circuit board. The patch is generally made of conducting material such as copper or gold and can take any possible shape. The radiating patch and feed lines are usually photo etched on the dielectric substrate.

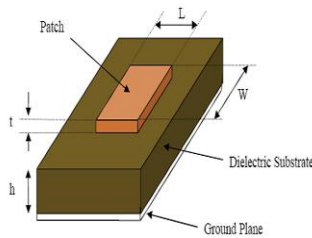


Fig.1. Microstrip patch antenna structure

For a rectangular patch, the length  $L$  of the patch is usually in the range of  $0.3334 \lambda_0 < L < 0.5 \lambda_0$ , where  $\lambda_0$  is the free space wavelength. The patch is selected to be very thin such that  $t \ll \lambda_0$  (where  $t$  is the patch thickness). The height  $h$  of the substrate is usually  $0.003 \lambda_0 \leq h \leq 0.05 \lambda_0$ . The dielectric constant of the substrate  $\epsilon_r$  is typically in the range  $2.2 \leq \epsilon_r \leq 12$ .

### ADVANTAGES AND DISADVANTAGES

In handheld wireless devices such as cellular phones, and in Satellite communications, microstrip antennas can be used embedded antennas.

Some of their principal advantages are given below:

- It is Light weight and low fabrication cost.
- Supports both, linear as well as circular polarization.
- It can be easily integrated with microwave integrated circuits.
- Capable of dual frequency and triple frequency operations.
- Mechanically robust when mounted on rigid surfaces.

Microstrip patch antennas suffer from more drawbacks as compared to conventional antennas. Some of their major disadvantages are given below:

- Sharp ended bandwidth.
- Low efficiency and low Gain.
- Extraneous radiation from feeds and junctions.
- Low power handling capacity.
- Surface wave excitation.

### FEED TECHNIQUES

Variety of methods can be used to feed the microstrip patch antennas. These methods can be classified into two categories- contacting and non-contacting. The contacting method, the RF power is fed directly to the radiating patch using a connecting element such as a microstrip line. Transfer power between the microstrip line and the radiating patch is to do the electromagnetic field coupling in non contacting schemes. The four most popular feed techniques used are the microstrip line, coaxial probe (both contacting

schemes), aperture coupling and proximity coupling (both non-contacting schemes).

### MICROSTRIP PATCH ANTENNA

It is a type of feed technique. In this type, straightly to the edge of the microstrip patch, a conducting strip is connected as shown in fig.2. The conducting strip is smaller in width as compared to the patch. It can be etched on same substrate to provide a planar structure is the advantage of this kind of feed arrangement.

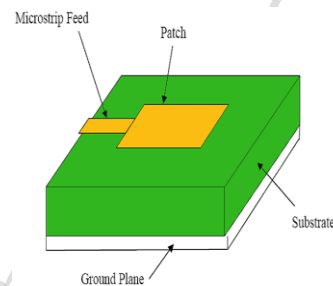


Fig.2. Structure of microstrip line feed

An inset cut can be incorporated into the patch in order to obtain good impedance matching without the need for any additional matching element. This can be successfully achieved by properly controlling the inset position. Hence this is an easy feeding technique, since it provides ease of fabrication and simplicity in modeling as well as impedance matching. This type of feeding technique results in undesirable cross polarization effects.

The microstrip line feed and the coaxial feed suffer from numerous disadvantages such as spurious feed radiation and matching problem by using a thick dielectric substrate to improve the bandwidth. The main advantage of this type of feeding scheme is that inside the patch in order to obtain impedance matching, it can be placed at any desired position. This feed method is easy to fabricate and has low spurious radiation effects. The major disadvantage of this feed technique is that it is difficult to fabricate due to multiple layers, which also increases the antenna thickness.

### SOFTWARE DESCRIPTION

The Advanced Designed System has been used to design proposed microstrip patch antenna. The performance of proposed antenna has been analyzed in terms of return loss (dB), directivity (dBi), gain (dB), impedance bandwidth (GHz), VSWR and antenna impedance (ohms). Selection of

substrate and thickness of the microstrip patch antenna. The length of the substrate ( $L_s$ ) is 125mm.

The antenna parameter can be measured by changing the substrate thickness from 1 mm to 4.0 mm for the inset feed rectangular microstrip patch antenna. The degradation of Antenna performance occurs when substrate material with higher dielectric constant in microstrip patch antenna design.

Fig.4 which indicates that the antenna has resonant frequency of 5.81 MHz with corresponding bandwidth of 528 MHz (300MHz to 928MHz )

### SOFTWARE RESULTS

A practical design, an eight-elements microstrip array antenna was implemented on the PTFE substrate with relative permittivity  $\epsilon_r = 2.55$ , thickness  $h = 1\text{mm}$  and loss tangent  $\tan\delta = 0.0015$ . The realistic geometry of array and the feed network is shown in Fig.3. The geometry of the single patch element and  $l_1$  and  $l_2$  are set to 15.5mm and 2mm, respectively, calculated and optimized using ADS software. The array could be divided into two sub-arrays that each of them is fed by the sequential feeding network described in Section II and there is 180° out of phase between the two sub-arrays. The input impedance of the array is carefully matched to 50Ω at the center frequency.

Fig.4 shows the amplitude of the RL at the range of 5.10GHz to 6.50GHz simulated by ADS software. The minimum RL, -29.4dB, is reached at the center frequency 5.82GHz and the return loss are both lower than -20 dB at the edge frequencies 5.78GHz and 5.85GHz. The 10 dB return loss impedance bandwidth is about 400MHz ranged from 5.6GHz to 6.0GHz. The graph is plotted between magnitude [dB] vs frequency [Hz].

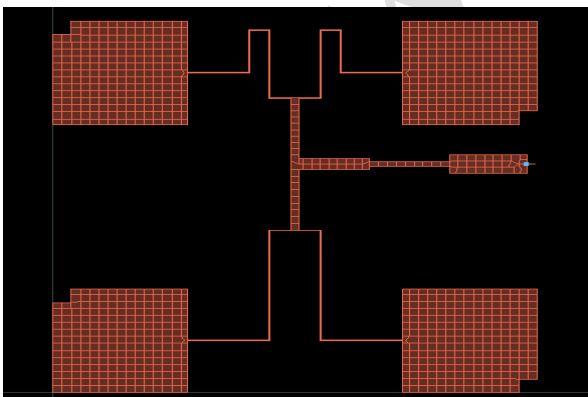
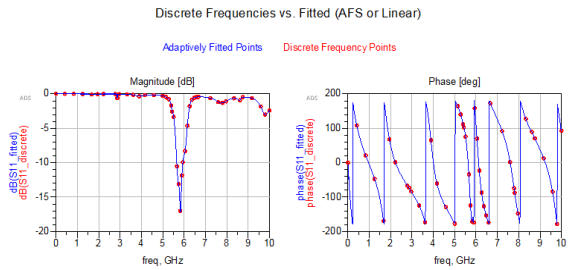


Fig. 3. Software model of the proposed antenna



M1-Frequency=5.820 GHz; M2-Frequency=5.780 GHz;  
 M3-Frequency=5.980 GHz;

The radiation patterns are shown in Fig.4(a) at  $\phi = 0^\circ$  corresponding to vertical plane and Fig.4(b) at  $\theta = 0^\circ$  corresponding to horizon plane at center frequency 5.82GHz. As the result, the half-power lobe width of the vertical plane is about  $34^\circ$  and that of horizon plane is  $18^\circ$  thus both lobe widths are less than the values listed.

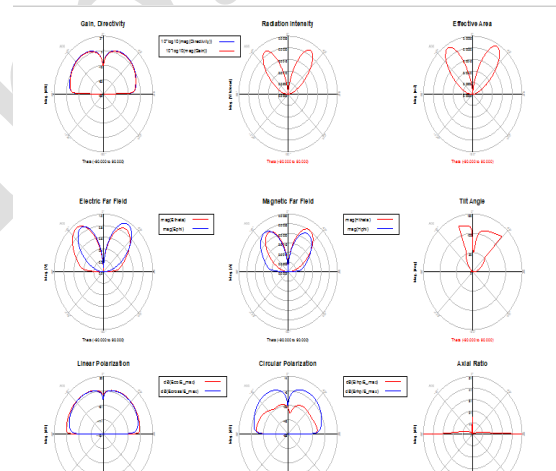


Fig.4(a) The radiation pattern at center frequency 5.82GHz (a)  $\theta = 0^\circ$

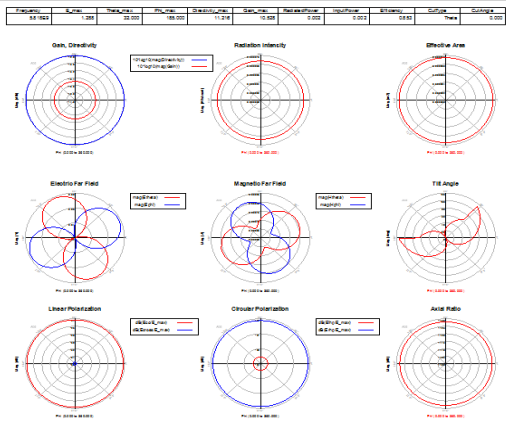


Fig.4(b) The radiation pattern at center frequency 5.82GHz (b) Phi=0°

The radiation patterns are shown in Fig.4(a) at phi=90° corresponding to vertical plane and Fig.4(b) at theta=90° corresponding to horizon plane at center frequency 5.82GHz. As the result, the half-power lobe width of the vertical plane is about 34° and that of horizon plane is 18° thus both lobe widths are less than the values listed.

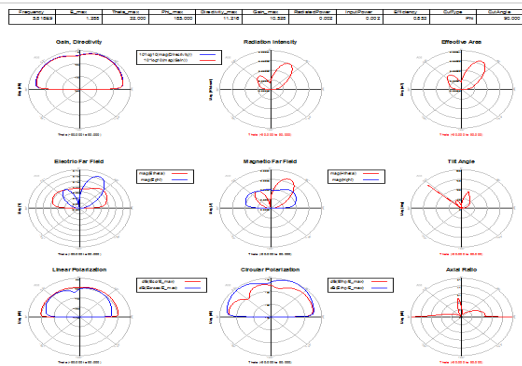


Fig.5. The radiation pattern at center frequency 5.82GHz (a) Phi=90°

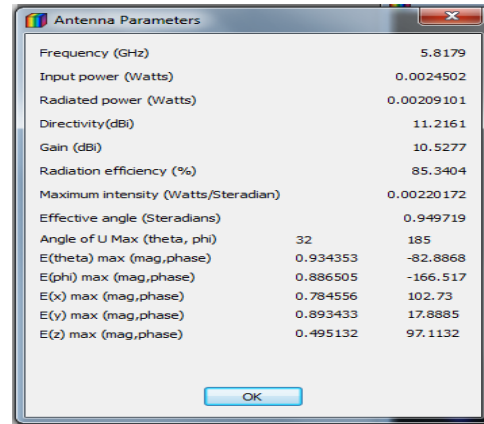


Fig.6. Antenna Parameters

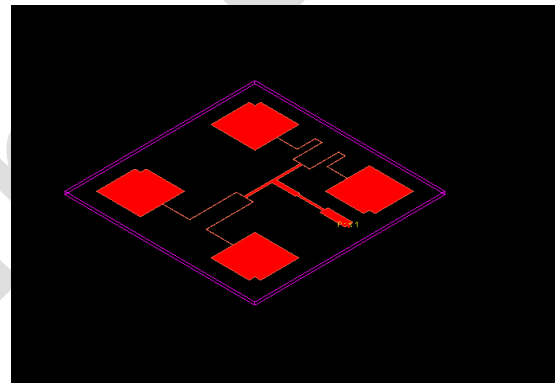


Figure 4.7 shows the power radiated in antenna

### CONCLUSION

In this paper, the design indices on the 5.80Hz ETC reader's antenna are drawn out from the national specifications of India on ETC&DSRC and then an eight elements microstrip array antenna fed by sequential feeding network is developed here which the performance meets the requirements of the specifications.

### ACKNOWLEDGEMENT

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