A Broadband Flat Antenna on Corrugated Structure

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1. Introduction

Recently, Radio Frequency Identification (RFID) system becomes very popular to provide wireless identification and tracking in many applications such as indoor positioning system (IPS) [1-2] and global positioning system (GPS) [3]. The RFID communication [4-5] from point to point is very important. The antenna for this application should possess unidirectional pattern with narrow beamwith, low side and back lobes and high gain. Conventionally, the unidirectional beam antenna is achieved by using the typical antennas such as Yagi-Uda antenna [2], helical antenna with axial mode and microstrip antenna with fundamental mode. However, these antennas possess low directivity because the electrical structure is rather small. In order to enhance the directivity, the array must be arranged. The feeding network is rather complicated. The feeding loss becomes more pronounced. Therefore, the antenna on the reflector is an alternative solution. In this paper, the simple structure of square plate antenna is designed to achieve the broadband the low side and back lobe levels, narrow beamwidth and desired beam direction. Each country in world uses UHF RFID system with different frequencies such as 920-925 MHz in Thailand, 866–869 MHz in Europe, 902–928-MHz band in America and many countries. The universal antenna will be operated at the frequency of 860-960 MHz that can operate in all standard frequencies of RFID system over the world.

2. Antenna Structure

The antenna structure is composed of three layers as shown in Figure 1. The top plate is square plate of size *w*. The middle plate is rectangular structure with vertical wall plate connected between the top and middle structure.

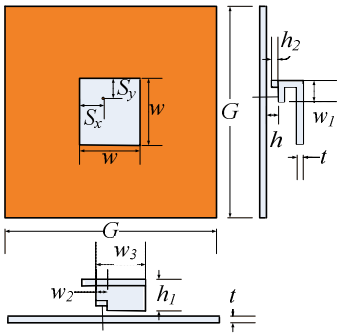


Figure 1 Geometry and associated dimensions of square plate on planar ground plane

Figure 1 shows the geometry and associated dimensions of square plate on planar ground plane. The antenna characteristics are shown. In Table 2, the parameters of the antenna are illustrated.

Table 1 Front-to-back ratio for square plate on planar ground plane of different sizes

Ground plane size (*G*)	Front-to-back ratio (dB)
0.5λ	7
1λ	19
1.5λ	25
2λ	25
2.5λ	27

Table 2 Geometric parameters of the proposed antenna

G (mm)	*w* (mm)	*h* (mm)	*Sx*, *Sy* (mm)	w_1,w_2 (mm)	*t* (mm)	w_3,h_1, h_2 (mm)
326	139	5	(31,-17.5)	40,15	1	65,10,1

The front-to-back ratio of the antenna on the planar ground plane can be further improved by using the corrugated structure to suppress the surface wave and thus prevents edge radiation. Hence, the back lobe radiation and the radiation at very low-elevation angles are reduced. The antenna property of the corrugated structure is capable of multipath cancellation at very low-elevation angles. The parameters of the ground plane with corrugated ring will be considered. Figure 2 shows the geometry and associated dimensions of corrugated ground plane. The antenna parameters are designed based on $t \le g/10$ and $\lambda/4 \le d \le \lambda/2$, where d is the cutoff depth of the channel width and is determined by using the relation of $g + t < \lambda/2$.

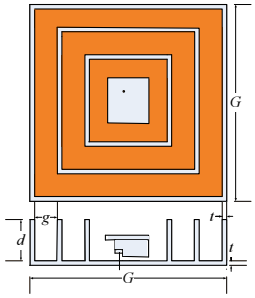


Figure 2 Geometry and associated dimensions of corrugated ground plane

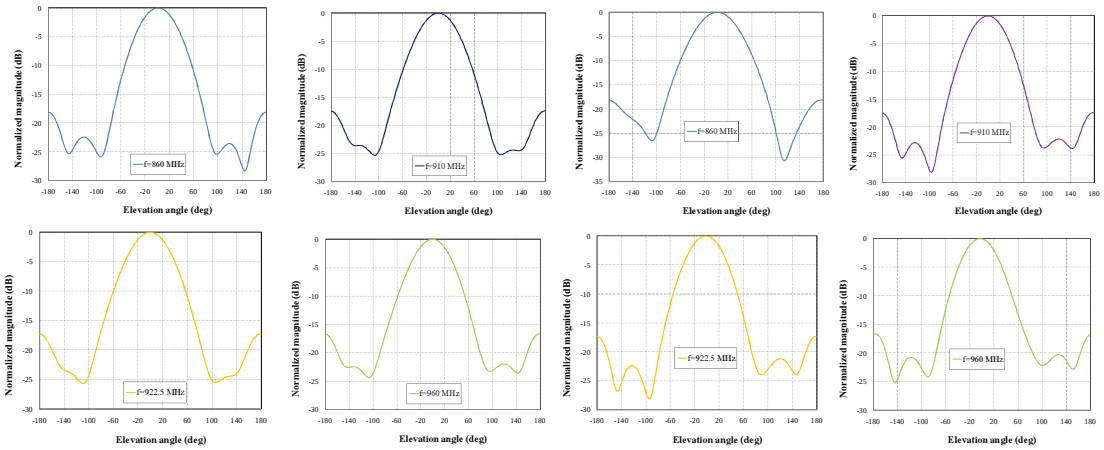
Figure 2 shows the geometry and associated dimensions of square plate on corrugated ground plane. The antenna structure is shown in Figure 2. Table 3 shows the parameters of the antenna that are used to compare the characteristics.

Table 3 Geometric parameters of the proposed corrugate Structure

G (mm)	*g* (mm)	*t* (mm)	*d* (mm)
326	20	1	82

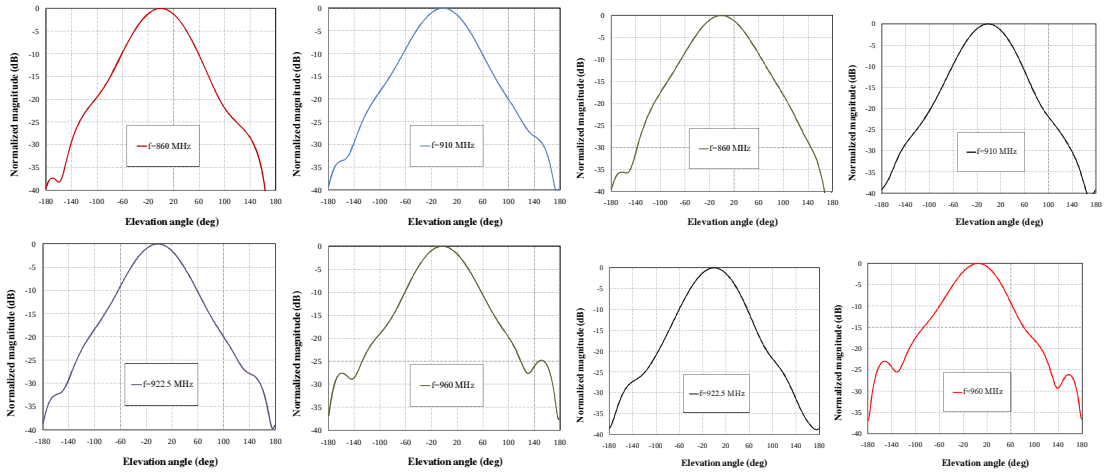
3. Results

Figure 3 and 4 shows the radiation pattern in E- and H-planes of the square plate on various ground planes such as without corrugated rings (planar) and three corrugated rings at the frequency of 860 MHz, 910 MHz, 960 MHz and 922.5 MHz following Thailand standard of UHF RFID frequency.



a) E-plane b) H-plane

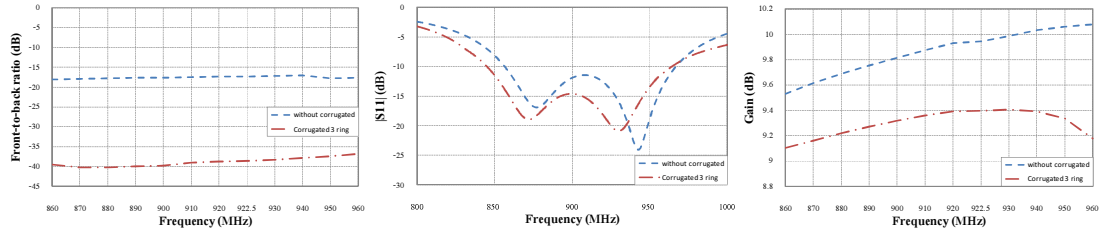
Figure 3 Radiation pattern of square plate without corrugated ring



a) E-plane b) H-plane

Figure 4 Radiation pattern of plate with three corrugated rings

Figure 5(a) shows the front-to-back ratio for square plate and inserted corrugated rings. It is found that the radiation pattern of the ground plane with the corrugated ring has narrower beamwidth and lower minor lobes than that without the corrugated ring. When increasing the number of the corrugated rings, the side and back lobes are better. The patterns of the antenna with more than 3 corrugated rings are slightly better. However, Figure 5(b) shows $|S_{11}|$ as a function of the frequency. The gain and polarization are also investigated. It is found that the antenna radiates vertically polarized unidirectional pattern with the maximum gain as shown in figure 5(c).



a) b) c)

Figure 5 F/B ratio, $|S_{11}|$ and gain versus frequency

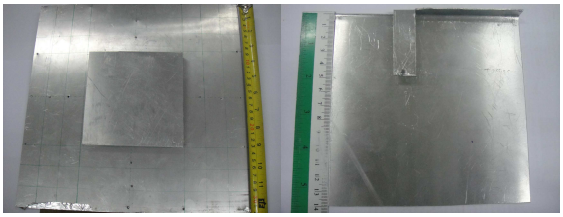
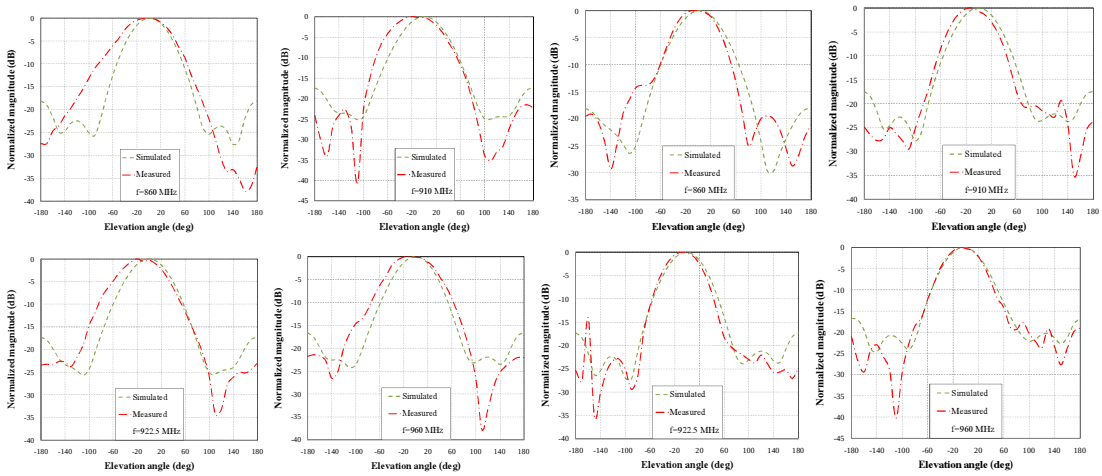


Figure 6 Photograph of prototyped square plate antenna

For preliminary results, this antenna is made of square plate without corrugated ground plane. The prototype antenna was fabricated as depicted in Figure 6. The radiation pattern and $|S_{11}|$ were measured and compared with the simulated results as shown in Figure 7 and Figure 8, respectively. It is apparent that the simulated and measured results are in good agreement, respectively. This antenna can be efficiently used as a high gain unidirectional antenna for broadband UHF RFID application. This antenna can be used following universal standard of UHF RFID system.



a) E-plane b) H-plane

Figure 7 Radiation pattern of square plate antenna

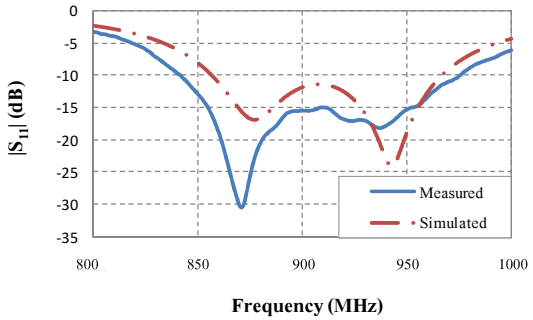


Figure 8 $|S_{11}|$ versus frequency

4. Conclusions

The antenna design of square plate with corrugated ring for broadband UHF RFID with unidirectional pattern, narrow beamwith, low side and back lobes and high gain is presented. The antenna characteristics such as radiation pattern, return loss and gain are investigated. It is found that the antenna radiates vertically polarized unidirectional pattern with the maximum gain of 10 dBi.

References

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