A Near-Field Focused Planar Microstrip Array for 2.4 GHz RFID Readers

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Abstract – **A near-field focused planar microstrip array for 2.4 GHz Radio Frequency Identification (RFID) readers is proposed, by applying a proper microstrip feeding network to a conventional microstrip array. Its performance is presented and compared with those of its corresponding far-field focused array. It is a satisfactory trade-off between conventional far-field focused array and more complex and expensive near-field focused arrays.**

Index Terms **—Near-field focused planar microstrip arrays, RFID reader antennas.**

1. Introduction

In a typical RFID system applied to supply-chain or warehouse management, where tags usually locate within the near-field (NF) region (1-2 m) from the reader antenna and are very close to each other, the lightweight and low-cost planar microstrip array would be a good choice for the fixed reader antenna. A planar NF focused array can be realized by a conventional microstrip array with a proper microstrip feeding network which can apply a proper phase shift at each patch feeding current to obtain an in-phase summation at a given point.

In this paper, A NF focused array for RFID readers at 2.4 GHz has been proposed. Its performance will be shown and compared with those of its corresponding far-field focused array.

2. Design Model Of A Near-Field Focused Array For RFID Readers At 2.4 GHz

The array consists of 4×4 identical patches which radiate left-hand circularly polarized fields (LHCP radiation) to make the antenna well suited for the random tag orientations. The goal of the design is to maximize the antenna's field in a size-limited spot (10-20 cm diameter) at a distance of about 0.5 m from the antenna aperture center. All the models have been designed and optimized by Ansoft HFSS.

(1) Array unit

The array unit is a microstrip patch (Fig. 1) printed on a 1.6 mm FR4 substrate (ε_r=4.4) and fed by a 50 Ω microstrip line. Its two opposite corners are trimmed to realize LHCP.

Fig. 2 shows the reflection coefficient at the antenna feeding port. Fig. 3 shows the Axial Ratio (AR) at 2.4 GHz.

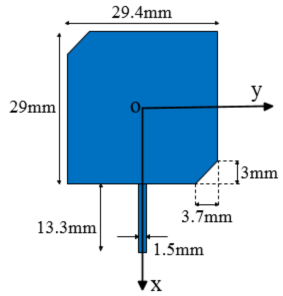

Fig. 1. The unit of the array.

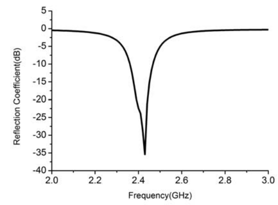

Fig. 2. Reflection coefficient of the unit in Fig. 1.

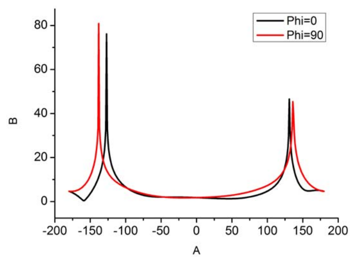

Fig. 3. Axial Ratio of the unit in the principle planes at $\phi = 0°$ and $\phi = 90°$ at 2.4 GHz.

(2) 4×4 Array

According to the formula $D = (\lambda r_0 / L) \times 0.886$ [1], where D is the diameter of the -3 dB circular spot area and r_0 =0.5 m is the distance where the antenna maximizes its field, to obtain a 20 cm spot area, the aperture size would be about L × L=30cm × 30cm (2.4 λ × 2.4 λ). Thus, the distance between patches would be about 0.6 λ.

Fig. 4 shows the procedure to calculate the phase shifts of feeding currents for each patch. According to (1) [2]

$$\phi_i = \frac{2\pi}{\lambda}(\sqrt{x_i^2 + y_i^2 + r_0^2} - r_0) \quad (1)$$

where (x_i, y_i) is the coordinate for any patch, the phase shifts can be calculated. In addition, to improve AR performance, all the patches in four 2×2 sub-arrays are rotated 90° in turn as shown in Fig. 4. Thus, the phase-lag due to the sequential rotation approach has also been included to the phase shifts. Then vary the length of the feeding lines reaching each patch according to the phase shifts (microstrip guided wavelength is 67.56 mm at 2.4 GHz for the 50 Ω microstrip line [2]). The array final layout is shown in Fig. 5.

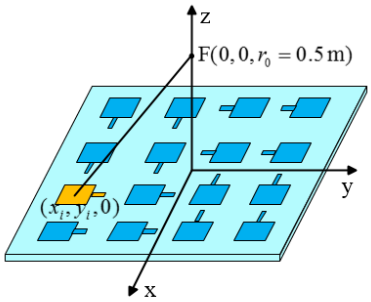

Fig. 4. Sketch of the array layout.

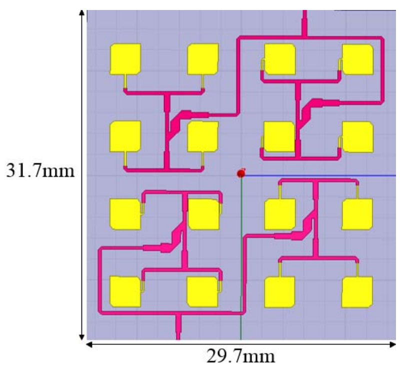

Fig. 5. The final layout for the array antenna (the two ports would be fed through a 3 dB power divider and 180° phase shifter).

3. Performance Of the Near-Field Focused Array Antenna for RFID Readers

The performance obtained by numerical simulations with Ansoft HFSS is presented, and is also compared with those of its corresponding uniform phase array (an array such as that in Fig. 4 but with all patches fed with the same phase).

Fig. 6 shows the contour plot of the normalized power density in a yoz plane (x=0). The -3 dB spot of the NF focused array appears at about 0.5 m. And the power density of the NF focused array apparently decays more rapidly than that of the uniform phase array. Fig. 7 shows the contour plot of the normalized power density evaluated in a xoy plane (z=0.5 m). The -3 dB spot exhibits the diameter of about 20 cm. it is in agreement with the theoretical value according to $D = (50\lambda / L) \times 0.886 = 18.5cm$ [1]. Fig. 10 shows the simulated normalized electromagnetic field along the x-direction at a distance of 0.5 m from the antenna aperture. We can see that the NF focused array does not exhibit any side lobes, which demonstrates the better focusing quality of the NF focused array

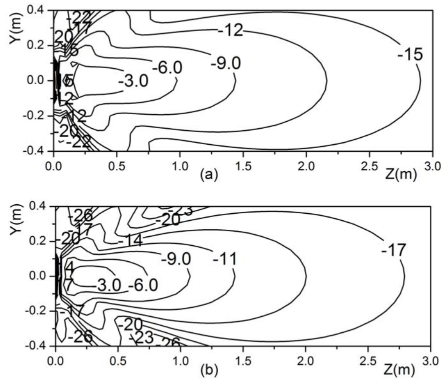

Fig. 6. Contour plot of the simulated normalized power density in a 0.8 m×3 m area on the yoz plane (x=0): (a) 4×4 NF focused array, (b) 4×4 uniform phase array.

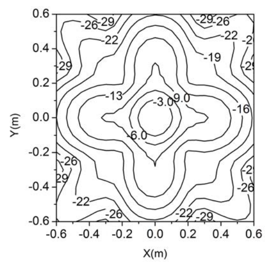

Fig. 7. Contour plot of the simulated normalized power density in a 1.2 m×1.2 m square area on the xoy plane (z=0.5 m).

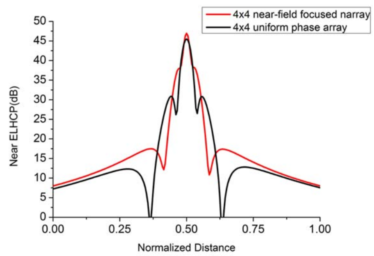

Fig. 8. Simulated normalized electromagnetic field along the x-direction (z=0.5 m) for both NF focused array and uniform phase array.

4. Conclusion

The NF focused planar array proposed here can be interchanged with a reader antenna. It is a satisfactory trade-off between conventional far-field focused array and more complex and expensive NF focused arrays.

References

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[2] A. Buffi, A. A. Serra, P. Nepa, H. T. Chou, and G. Manara, "A focused planar microstrip array for 2.4 GHz RFID readers," *IEEE Transaction on Antennas and Propagation*, vol. 58, no. 5, pp. 1536-1544, May. 2010.