

Circular Polarized Antenna with Rotationally Positioned Microstrip Structures For UHF RFID Applications

Can Saka¹, Merih Palandöken²

¹Department of Electrical and Electronics Engineering /Faculty of Engineering and Architecture, Izmir Katip Celebi University, Turkey

² Department of Electrical and Electronics Engineering /Faculty of Engineering and Architecture, Izmir Katip Celebi University, Turkey

¹cansaka99@gmail.com Email of the corresponding author

(Received: 05 June 2023, Accepted: 20 June 2023)

(1st International Conference on Pioneer and Innovative Studies ICPIIS 2023, June 5-7, 2023)

ATIF/REFERENCE: Saka, C. & Palandöken, M. (2023). Circular Polarized Antenna with Rotationally Positioned Microstrip Structures For UHF RFID Applications. *International Journal of Advanced Natural Sciences and Engineering Researches*, 7(5), 83-87.

Abstract – With the use of wireless communication and the industry 4.0 revolution, RFID technology integration in production has increased. The large-scale preference of RFID systems is both cost-effective and significantly increasing production. It is an innovation that provides convenience for large production facilities such as product control, in-plant tracking, storage, inventory operations. In this paper, a compact circularly polarized (CP) reader antenna is presented for ultra-high frequency (UHF) radio frequency identification (RFID) applications. The proposed antenna consists of a circularly slotted ground plane and folded plus-shaped structures with vertical and horizontal positions. Microstrip line feeding technique is used in the vertically folded plus-shaped structure positioned on the front surface. The antenna has a 10 dB return loss bandwidth of 80 MHz (840-920) and a 3 dB axial ratio bandwidth of 20 MHz (855-875). The proposed antenna has dimensions of $75 \times 75 \times 1.6 \text{ mm}^3$. The size advantage of the single-layer and single-fed structure enables its applicability in portable systems.

Keywords – RFID, UHF, Circularly Polarized,

I. INTRODUCTION

Radio frequency identification (RFID) technology enables the recognition of objects carrying an electronic tag through the emission of electromagnetic waves [1]. RFID technology has facilitated management in various industries by enabling automatic identification of objects and living beings within its range, reducing errors, and thereby promoting its widespread adoption.

An RFID system is mainly composed of a reader and a tag. The passive tag is activated by the radio frequency emitted by the reader antenna and

provides the energy to send the information. UHF tag antennas are usually produced in linear polarization. Due to the random orientation of tags in real-world applications, an RFID reader antenna has to be circularly polarized for optimal efficiency in UHF RFID systems. The generation of Circular Polarization radiation is accomplished by exciting two orthogonal modes with equal magnitude and a 90-degree phase difference. In order to achieve circular polarization in the study [2], two ports and two strip lines of $\lambda/2$ length are supported, thus increasing the power efficiency and obtaining a complex structure. In the study [3], a method for

loading a semi-circular slot on a circular spreading patch has been introduced in order to achieve circular polarization with a single port, but a difficult to manufacture L-shaped feeding technique has been used to increase the CP bandwidth. In the study [4], a simplified structure with a single port and two asymmetric circular slots have been presented to obtain CP bandwidth, but they were able to obtain a limited bandwidth such as 6 MHz. In the study [5], a large sized circular polarized antenna is proposed for applications that require high gain and simple construction. In reference [6],[7], the performance of RFID antennas is increased by using machine learning-based models and prediction successes are presented. UHF RFID frequency varies by country. The frequency ranges used are 840.5–844.5 MHz and 920.5–924.5 MHz in China, 902–928 MHz in North America, 866–869 MHz in Europe, 852–855 MHz and 950–956 MHz in Japan, 865–867 MHz in India and 920–926 MHz in Australia [8]. The frequency band used can be expressed as 840-960 MHz. An antenna with a broad operating range is expected to radiate within this range. Various structures have been studied in the literature to increase the impedance bandwidth. The advantage of circular structures to obtain impedance bandwidth is mentioned in [9]. Additionally, these types of structures are low profile and easily manufactured. This paper introduces a compact circularly polarized antenna, consisting of vertically and horizontally positioned folded plus-shaped structures within a circular slot on a ground plane. The folded plus-shaped structure located on the front plane is fed using the microstrip line feeding technique. The antenna, with an impedance bandwidth of 840-920 MHz, has dimensions of $75 \times 75 \times 1.6 \text{ mm}^3$. In this paper, the geometry of the proposed antenna and the simulated results are examined and discussed.

II. MATERIALS AND METHOD

The detailed structure of the studied antenna is illustrated Figure 1. FR4 substrate, which is easily accessible and has a loss tangent of 0.025 with the thickness of 1.6 mm and a dielectric constant of 4.3, has been preferred for this study. As the port location, the midpoint of the W_f length shown in figure 1 is chosen. The plus shaped structures in the

ground plane are identical to each other in terms of their lengths. These structures are placed with rotational 90-degree shifts relative to the point in the center of the antenna. The distances of the structures whose details are given to the geometric boundaries of the antenna, the dimensions of their vertical and horizontal extensions are effective on the impedance and axial ratio bandwidths.

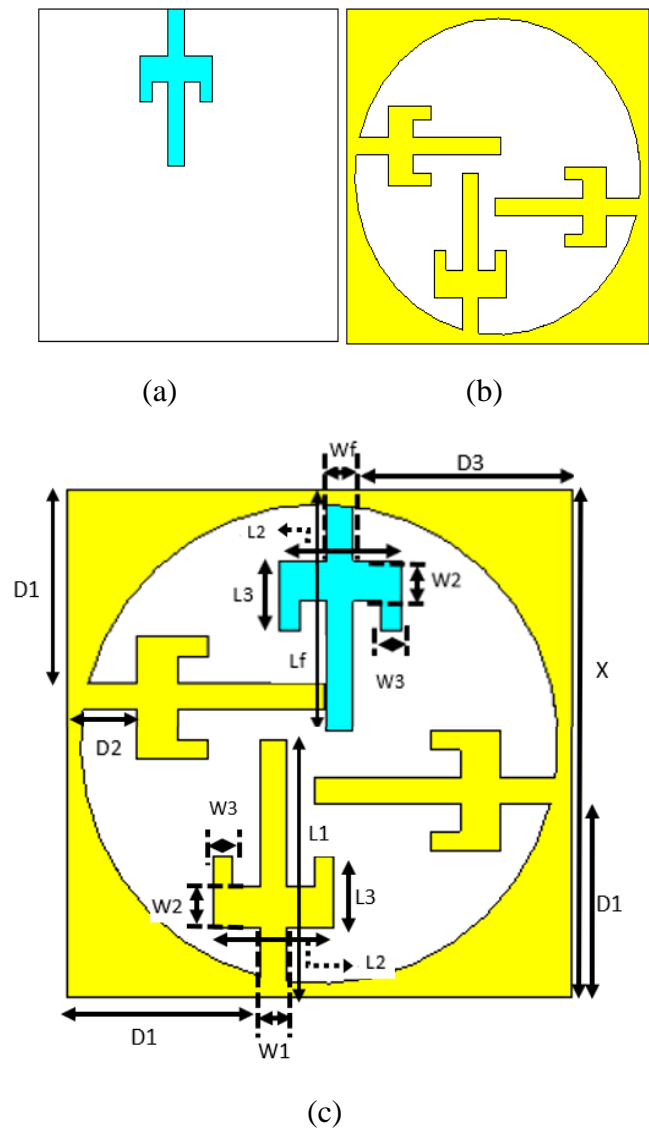


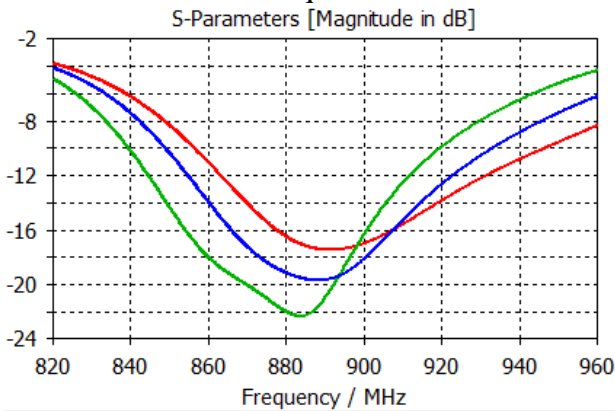
Fig. 1 (a) front view (b) rear (ground) view and (c) detailed geometry of the proposed antenna.

Parameters (mm) : $X=75$, $L1=37.3$, $L2=18$, $L3=10.5$, $L_f=35.4$, $W1=3.8$, $W2=6$, $W3=3$, $W_f=4$, $D1=28.8$, $D2=10.5$, $D3=32.5$, $R=35.4$.

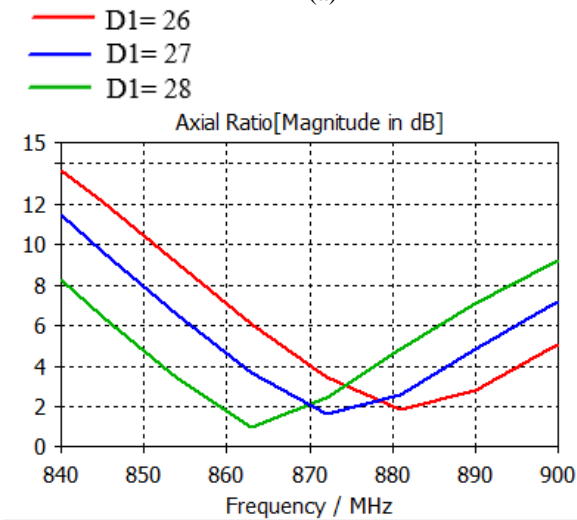
A. The effect of the location of cross-shaped structures ($D1$)

The $D1$ parameter defined in Figure 1 makes it easier to check and examine the antenna's response depending on the frequency. As we can see in Figure

2, as D1 increases, the 10 dB return loss bandwidth in S11 graph tends towards the lower frequencies. Likewise, the area under 3 dB on the AR values moves towards lower frequencies.



(a)



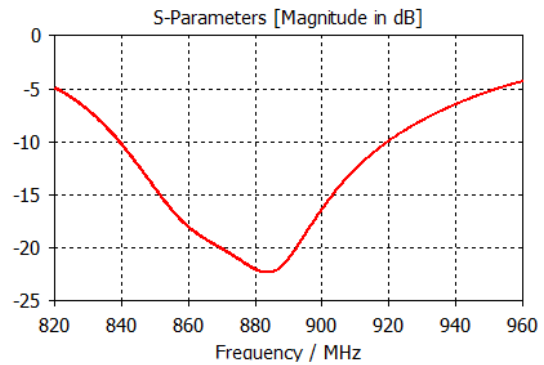
(b)

Fig. 2 (a) reflection coefficient (b) axial ratio according to various values of D1 .

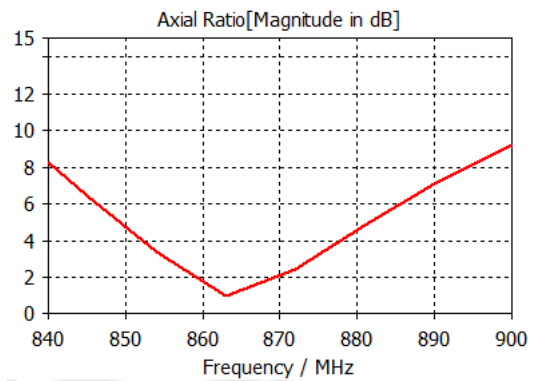
III. RESULTS

In this study, the numerical computations are done to obtain the S parameter and AR results for different geometric parameters of the proposed antenna so as to figure out the important design parameter .A 10 dB reflection coefficient with a bandwidth of 80 MHz, which is equivalent to a fractional value of 9.1%, is obtained between 840 and 920 MHz. The return loss within this range is -20 dB at 867 MHz. The simulated AR results cover a range of 20 MHz from 855 MHz to 875 MHz. The best simulated AR value is 1.1 dB, at 863 MHz. These data have been clearly given in Figure 3. The gain value of the proposed antenna is given in figure 3. The values it takes within this range vary between

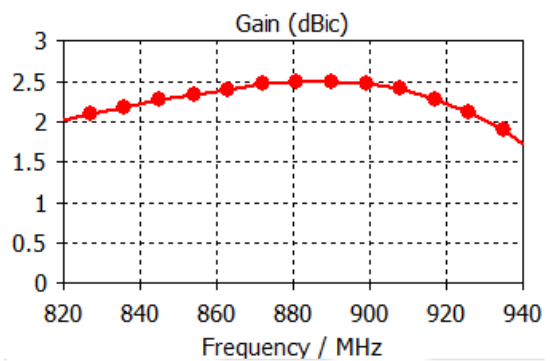
2.2 dBic and 2.5 dBic. It is seen that the gain value is stable at the operating frequency. In figure 3, the simulated radiation pattern results at 867 MHz are given.



(a)



(b)



(c)

Fig. 3 (a) reflection coefficient (b) axial ratio (c) gain of the proposed antenna over the operating frequency.

Farfield Directivity

Right Polarisation (Phi=0) Left Polarisation (Phi=0)

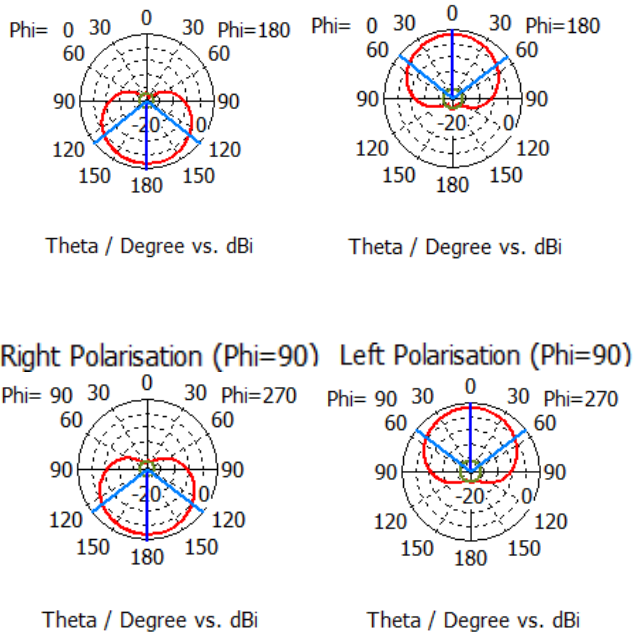


Fig. 4 Right and left hand side circular polarized radiation pattern at 867 MHz.

IV. DISCUSSION

In order to evaluate the results of the proposed antenna with UHF band antennas in the literature, a performance comparison table is shown. [10] is an antenna with a good operating frequency bandwidth but low gain considering its size. Although [11],[12] is a high-gain antenna, it is disadvantageous in size.

Table 1. Performance Comparison Table

Antenna	-10 dB S ₁₁ BW [MHz]	3 dB AR BW [MHz]	Gain [dBic]	Dimension [mm ³]
[10]	820–880/60 830–928/98	864–887/19 899–913/14	1.6	90 × 90 × 1.6
[11]	860–930/70	-	3.7	110 × 110 × 5
[12]	854–889/35	857–975/118	6.45	129.2 × 129.2 × 26
Proposed	840–920/80	855–875/20	2.5	75 × 75 × 1.6

V. CONCLUSION

In this paper, a circular polarized small size antenna operating in the UHF band is proposed for RFID readers. The gain value varies tolerably throughout the operating frequency. As a result of the numerical calculations obtained, the proposed antenna offers advantages for positioning thanks to its circular polarization in real applications. It is suitable for portable applications with a sufficient gain level and small dimensions.

REFERENCES

- [1] R. Want, "An introduction to RFID technology," in *IEEE Pervasive Computing*, vol. 5, no. 1, pp. 25-33, Jan.-March 2006.
- [2] Chun, J., Chung, H. & Park, J. "A Circular Polarization Antenna Design for Improving the Reception of UHF RFID Reader". *Wireless Pers Commun* vol 60, 389–404 2011.
- [3] C. -Y. -D. Sim and C. -J. Chi, "A Slot Loaded Circularly Polarized Patch Antenna for UHF RFID Reader," in *IEEE Transactions on Antennas and Propagation*, vol. 60, no. 10, pp. 4516-4521, Oct. 2012.
- [4] HUO, Xing Ying; WANG, Jun Hong; CHEN, Mei E. "Circularly polarized microstrip antenna with two Asymmetric Circular slots for RFID application" in *2013 IEEE International Conference on Microwave Technology & Computational Electromagnetics. IEEE*, 2013. p. 184-187.
- [5] G. Güven and I. Akdag, "High-Gain Circularly-Polarized Square Patch UHF RFID Reader Antenna Design for Smart Factory Applications", *Avrupa Bilim ve Teknoloji Dergisi*, no. 34, pp. 689-692, 2022.
- [6] İ. Akdağ, C. Göçen, M. Palandöken and A. Kaya, "Estimation of the Scattering Parameter at the Resonance Frequency of the UHF Band of the E-Shaped RFID Antenna Using Machine Learning Techniques," *2020 4th International Symposium on Multidisciplinary Studies and Innovative Technologies (ISMSIT)*, 2020, pp. 1-5.
- [7] I. Akdag, "Estimation of Scattering Parameters of U-Slotted Rectangular RFID Patch Antenna with Machine Learning Models", *Journal of Artificial Intelligence and Data Science*, vol. 1, no. 1, pp. 63-70, 2021.
- [8] N.C. Wu, M.A. Nystrom, T.R. Lin, H.C. Yu, "Challenges to global RFID adoption", *Technovation*, Vol 26, 1317-1323, Issue 12, 2006.
- [9] *Modulation in Electronics and Telecommunications IntechOpen*, George Dekoulis, Jr., Ed. London, United Kingdom: Mar. 02, 2020.
- [10] Cao, R. and Kai Wang, C., "Frequency-reconfigurable circularly polarized antenna for UHF RFID reader", *Microw. Opt. Technol. Lett.*, 58, 2842-2845, 2016.

- [11] U. Ozkaya & L. Seyfi "Dimension optimization of microstrip patch antenna in X/Ku band via artificial neural network" *Procedia-Social and Behavioral Sciences*, 2015, 195, 2520-2526.
- [12] Akdag, Ismail, et al. "A novel circularly polarized reader antenna design for UHF RFID applications." *Wireless Networks* 28.6.2022: 2625-2636.