Development of Antenna Module for the Intelligent RFID System

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***Abstract* — This work is aimed at studying the possibility of using antennas of different polarization, in particular linear and circular, to develop an antenna unit that will be used in RFID systems that perform identification and determine the location of objects marked with tags in space. Research and development of the antenna module will allow you to identify objects in space using a smaller number of antennas compared to the number of zones in which marked objects are located.**

Keywords* — *RFID, module, antenna, tags, CST, electrodynamic.

I. Introduction

Currently, the development of RFID (Radio Frequency Identification) systems includes many areas and possibilities of application in human life. Smart RFID systems simplify the search and identification of objects, which, for example, allows you to automate logistic processes [1] and other operations with items marked with RFID tags. In particular, one of the possible applications is described in [2] using the Smart Fitting Room system as an example, which helps a person get an exceptional service in retail clothing stores, as well as recommend additional products to the buyer based on his preferences.

Currently, most RFID systems can only determine the presence or absence of objects marked by the tags in the reading area. In this case, the presence of antennas in each zone is necessary, and the dimensions of these zones are determined mainly by the characteristics of the antennas. The aim of this paper is to study and model the antenna module, which will not only determine the presence of tags in a given zone, but also find their exact location in space, thereby implementing RTLS (Real Time Location System). This in turn will allow the use of one block of several antennas to localize objects in more areas.

II. Localization of Objects in Space

There are a large number of RTLS implemented on various technologies and using different localization methods. For example, in this paper [3] discuss BLE (Bluetooth Low Energy) systems, and for localization, the RSSI (Received Signal Strength Indicator) based method is used. Such systems operate at 2.4 GHz frequencies, which can adversely affect the propagation of radio waves in rooms with partitions or with volumetric obstacles. Also, BLE tags are significantly more expensive than passive RFID tags, which are now beginning to be actively used in various stores instead of barcodes, due to their low cost and ease of use. In view of the foregoing and the fact that such RFID systems operate in the frequency range of 860-940 MHz, RTLS based on RFID technology will have a wide range of possible applications.

Of the existing localization methods, a combination of RSSI method and trilateration method will be used in this paper. The rationale for choosing RSSI as the basis for an object localization system is that it is easy to find and use, unlike other methods such as TOA (Time of Arrival) and TDOA (Time Difference of Arrival), which require time synchronization on transceiver devices or POA phase methods and AOA (Phase / Angle of Arrival), requiring more antennas and computations. In article [4] the description of using algorithm with RSSI and trilateration method is described. However, it is not possible to determine the exact location of an object in space using only the RSSI value obtained by reading the tag. In this case, it is necessary, in addition to the tags on the objects to be identified, to have a certain number of control tags (beacon tags) that define the space. The exact number of such tags is selected based on the localization method used and the metric characteristics of the zones in which the objects will be located. The article [5] presents the development of a smart shelf, the objects on which should be identified. Thispaper amply demonstrates how, using beacon tags, it is possible to divide the shelf into different cells, while using a smaller number of antennas to identify objects (Fig. 1).

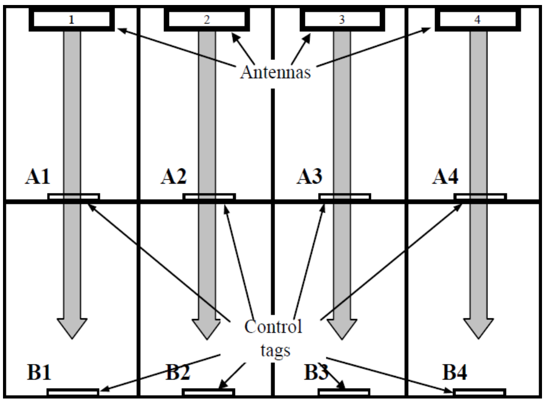

Fig. 1. Lighthouse tags

Using the RSSI value obtained it is possible to estimate the distance from the RFID reader to the tag using one of the radio wave propagation models: One-Slope Model, Linear

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Attenuation Model or Log-Normal Shadowing Mode. The latest model is the most commonly used empirical model of the propagation of electromagnetic waves. Having determined the distance from the beacon tags to the object and using the trilateration method, we can obtain the coordinates of the searched object in space.

III. SYSTEM CONSTRUCTION

The system "Smart fitting room" based on RFID technology will be taken as a basis for antenna module development. In the original version of this system, a reader with an antenna is placed in each fitting room. However, with the improvement of the design, it is possible to achieve the use of 4 antennas, 2 with circular and 2 with linear polarization into 8 zones, in this case, fitting rooms. The system design is shown in Figure 2.

Fig. 2. System construction

Antennas with linear polarization are located on the edges of a number of rooms (L1, L2), and antennas with circular polarization on top (C1, C2). This location is due to the fact that the selected antennas with linear polarization have narrower radiation patterns, but more power, concluded in the main direction of radiation and antennas with circular polarization are mounted on top, as they have a wider radiation pattern and can cover four zones around them. The main idea of this arrangement of the antennas is their mutual work. If there were only linearly polarized antennas in this system, located as shown in Fig. 2, it could be a significant error with distance estimation in dynamics, because linearly polarized antennas are very sensitive to the location of tags on objects. The signal can change dramatically, when objects change their orientation in space but remain in the same point. Circular polarized antennas on the top of the system designed to solve this problem, because the tag orientation does not make a lot of sense to evaluating the signal strength.

IV. SYSTEM SIMULATION

The first stage in the development of the antenna module will be the study and configuration of the antennas. To do this, RFID antennas and tags will be constructed in the program for modeling electromagnetic structures of CST Studio, their radiation patterns will be obtained, from which later it will be possible to determine the necessary location of the antennas in the system. For a complete simulation of the system, it is necessary to construct an RFID tag and linear and circular polarization antennas [6]. In Fig. 4-6, the geometry and radiation patterns of antennas and tags (antennas inside it) obtained as a result of modeling are presented.

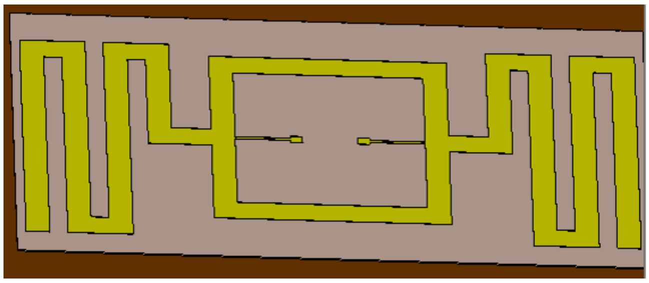

Fig. 3. The design of passive RFID tag

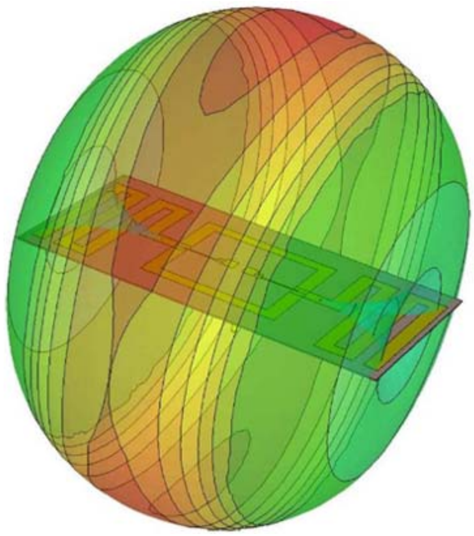

Fig. 4. The radiation pattern of passive RFID tag

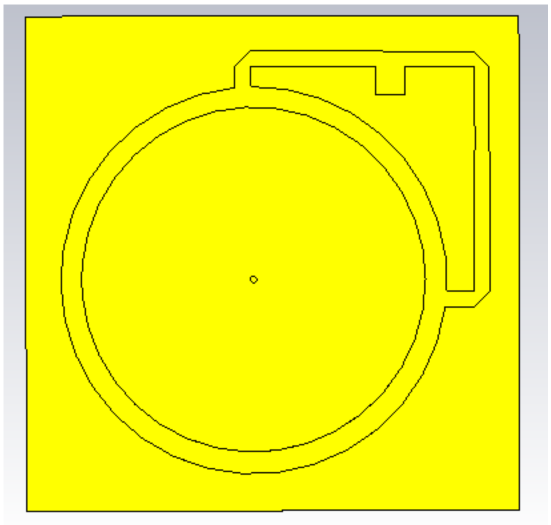

Fig. 5. The design of antenna with circular polarization

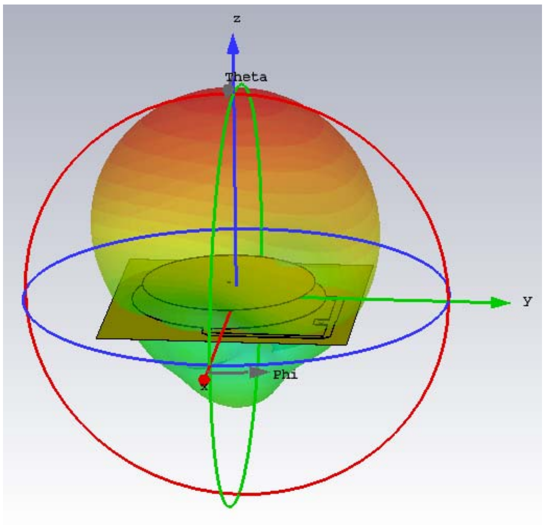

Fig. 6. The radiation pattern of circular polarized antenna

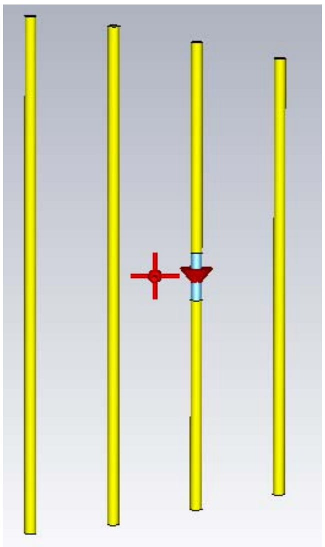

Fig. 7. The design of antenna with linear polarization (Model)

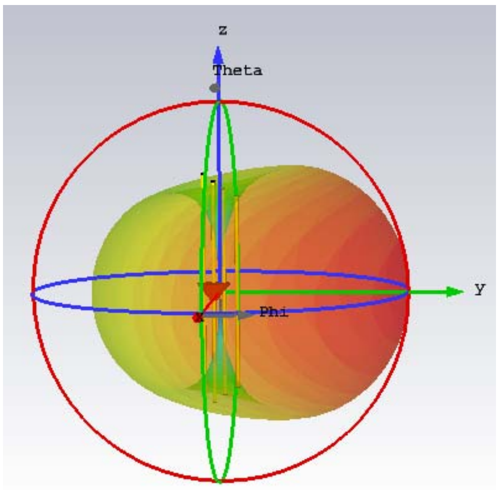

Fig. 8. The radiation pattern of linear polarized antenna

The next step is - simulation the system. The four rooms 2x2 m were constructed, to obtain the radiation patterns and the distribution of electromagnetic field in the system. Width of the walls equals 5 cm, material wood. Circular polarized antennas are located 50 cm above the intersection of two rooms and linear polarized antenna 20 cm left than the room section. The system design for the simulation is shown in figure 9.

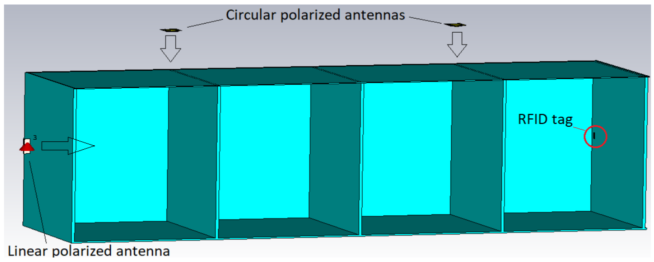

Fig. 9. The system design

Next, this paper shows radiation patterns of the antennas in the system with rooms (figure 10, 11), further, power characteristics, and electric field strength.

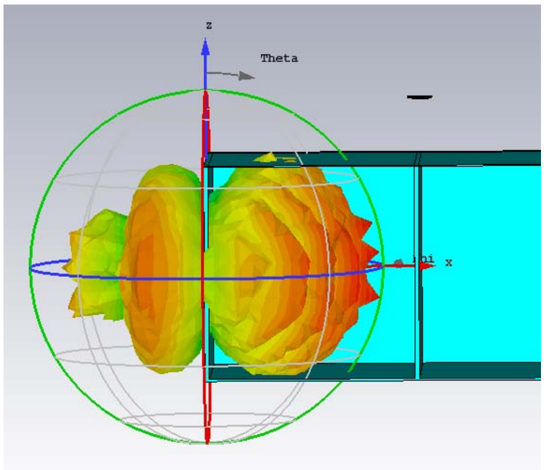

Fig. 10. The radiation pattern of linear polarized antenna in the system

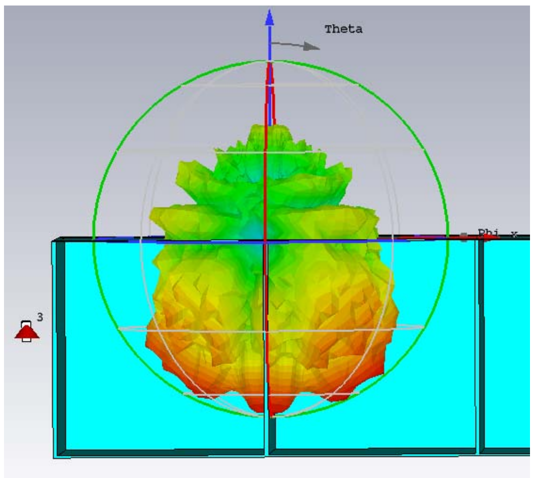

Fig. 11. The radiation pattern of circular polarized antenna in the system

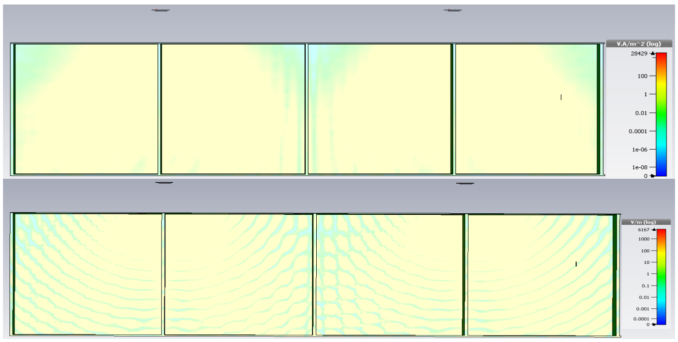

Fig. 12. Power (top) and electric field strength (bottom) characteristics for circular polarized antennas

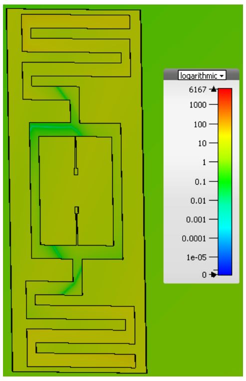

Fig. 13. Electric field strength on the tag from circular polarized antenna

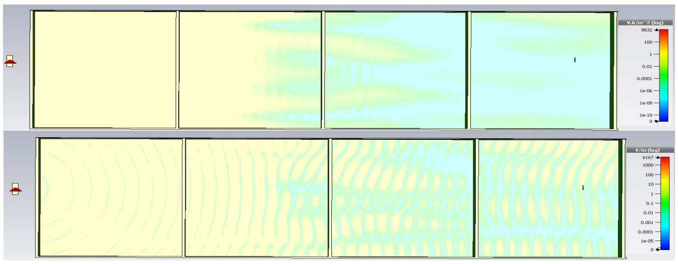

Fig. 14. Power (top) and electric field strength (bottom) characteristics for linear polarized antenna

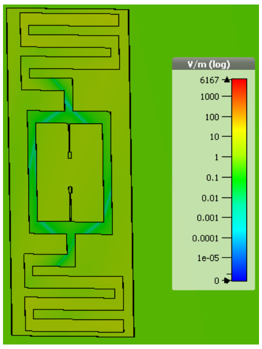

Fig. 15. Electric field strength on the tag from linear polarized antenna

According to the diagrams obtained as a result of modeling, we can conclude that the offered design will be operable. Further, in the process of work, the antenna module will be assembled and the objects localization algorithm will be implemented.

V. CONCLUSION

The paper described the structure of the development of the antenna module and provided the first steps for its creation at both physical and logical levels. Existing methods for localizing objects in space were explored and the most suitable for use with RFID technology was selected. Before directly assembling the antennas, we performed a modeling that shows the operability of the proposed design.

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