Design and Simulation of Uhf- Rfid Wireless Repeater for Tracking

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Abstract—RFID (Radio Frequency Identification) emerges as one of the converging technologies. It is a powerful medium for identification of any object and leads all methods in auto ID umbrella. Tracking an object in an Industrial domain, logistics, garments, etc is mandatory nowadays. We use GPS, GPRS, Barcodes and RFID technology. In this passive UHF RFID is most suitable one. The reading range of this passive RFID is low compared with active RFID.

To improve communication range repeaters are used in any wireless system. But there is no suitable repeater system for RFID. In this paper, we propose a RFID wireless repeater which results better read range using single reader. The model is simulated using Matlab software.

Index Terms—RFID, RFID repeater and matlab.

I. INTRODUCTION

Presently we are using GPS (1), (2), (3) and GSM (4) for tracking an object. It gives solution for tracking, but it is very expensive. So, to solve this problem RFID based technology was proposed. Nowadays RFID is used in Indoor navigation, Logistics management, Library management, Form management (5), (6), (7), (8) etc. But it is having severe coverage/ read range problem (4).

In RFID technology, reader is more expensive and tracking data collection is tougher. Here we are proposing wireless repeater and antenna networking method to solve this issue. We can use wired repeater system. But for long distance applications the cable cost is high and sometimes the leakage current will break our system performance (8). So, in our system we use wireless repeater technology. In the previous research, repeater was proposed as a simple energizer for LF application. It will be used to energizes the tag not to boost received signal (9), (10). In our work we propose wireless repeater with switches to control the repeater to give better tracking information. It amplifies both energy signal and received data signal. It is better than the conventional repeater which doesn’t have switch control.

A. RFID

Radio frequency identification (RFID) technology has been in use for decades. Only recently, lower cost and increased capabilities made RFID technology to be a commercially viable one. There seems to be developments in support of the movement of inventory tracking and supply chain management toward RFID.

RFID is an auto ID device like Barcode, Smart cards, Biometric technologies (Retinal scans) and optical character recognition etc. Special feature of this technology is that there is no need of line of sight reception as required in some other technologies.

In RFID systems the items are marked with tags. These tags contain transponders that emit messages readable by specialized RFID readers. Most RFID tags store some sort of identification number; for example a customer number or product code. A reader retrieves information about the ID number from a database, and acts upon it accordingly. RFID tags can also contain writable memory, which can store information for transfer to various RFID readers in different locations. This information can track the movement of the tagged item, making that information available to each reader.

RFID tags fall into two general categories, active and passive, depending on their source of electrical power. Active RFID tags contain their own power source, usually an on-board battery. Passive tags obtain power from the signal of an external reader. RFID readers also come in active and passive varieties, depending on the type of tag they read. Then based on their frequency range of transmission it is classified as LF, HF, VHF and UHF tags.

B. Repeater

In wireless communication engineering, the part of repeaters is very important. It helps better signal reception and for good decision making. It is basically an amplifier which amplifies received command/energy signal from reader and retransmit it towards tags. This signal energises internal circuitry of RFID tag from incoming signal and retransmits it towards the repeater. Then this will be amplified and retransmitted to reader.

C. Switching

Switch is used to connect a signal from one node to another without overloading the source end. Here we are using 8ch MUX/DEMUX switches to select different repeater and antennas. The selection is managed by the control signal sent by the reader which enables one antenna to be connected with repeater and reader at a time.

D. Cell Structure

In mobile communication we are using hexagonal cellular architecture for better frequency resource management and coverage. The same principle is adopted here for antenna...
installation. Every antenna is considered as base station of the cell. This structure is more compact and efficient in coverage. It is given in Fig. 1.

![Cellular structure for antenna tower](image)

**E. Antenna Networking**

It is meant by connecting more number of antennas with reader to improve its efficiency in tracking range. Here we are using star network topology to connect antennas with the repeater ports. The repeater will be placed at the centre cell for better performance and less loss. It gives most efficient and suitable shortest path to our design.

**F. General Block Diagram**

The general block diagram of our proposed system is given in figure 6. Initially RFID reader transmits energy signal to the RFID tag through repeater, switch and antenna. Then the tag transmits the ID data to the reader through antenna, switch (MUX/DEMUX) and wireless repeater. Here wireless repeater plays major role in amplifying the weak signal from tag. The following sections will explain details of design procedures.

II. DESIGN AND IMPLEMENTATION

The system has following operating points. The first one is tagging; the second is hexagonal cell tower, third is RFID repeater and switch and final one is mapping of tracking data.

**A. Section 1 – Tagging**

RFID tags are fitted in to the animal ear for better performance. It is done using a special punch type tagging machine. We prefer UHF passive tags for better read range. We may use active tags for more coverage but it will not be cost effective and battery life is another factor. So, passive tag is comparatively better for this application. Its coverage is a maximum of 9 to 15 Meters operating at 865 MHz range. The particular animal ID number is stored in this tag.

**B. Hexagonal Cell with Antenna Tower**

Here we are proposing cellular architecture for implementing base station antenna. It gives greater performance in coverage for larger areas. The read error probability and antenna cabling issue is solved in this method. The physical area is divided by hexagonal cells and repeater antenna is placed in this cell by shortest route. For the given physical area number of cells, number of antennas and number of readers are calculated by following procedures.

Number of cells \((Cn) = \frac{\text{Farm Area} (Fa)}{2.59 \times D^2}\)

\(D\) is radius of hexagon.

Area of the hexagon = \(2.59 \times R^2\)

If \(Fa = 10000 \text{ Sq.Met}, Cn = 100 \times 100/2.59 \times 81\)

No of Hexagon Cells = 47

No of Antennas per repeater \((Na) = 8\)

No of repeater = \(\frac{47}{8} = 6\)

No of reader = 1

So, we need Approximately 1 reader and 6 repeaters to cover 10000 Sq. Meters area. Proper division of land area and antenna placement will lead good results. Rough and tough uneven areas we have to choose special directional antennas for better results.

**C. Repeater Design**

Elements of repeaters are transmitting and receive purpose antennas, low noise and power amplifiers. Based on the distance and frequency range power loss is calculated. Amplifier gain is selected based on the loss in the particular site. Free-space path loss is proportional to the square of the distance between the transmitter and receiver, and also proportional to the square of the frequency of the radio signal.

The equation for FSPL is

\[
\text{FSPL (dB)} = 20 \log_{10} (d) + \log_{10} (f) + 32.45
\]

\[
\text{FSPL (dB)} = 10 \log_{10} ((4\pi df/c)^2)
\]

\[
\text{FSPL (dB)} = 20 \log_{10} (d_f) + \log_{10} (f) - 147.55
\]

where:

- \(\lambda\) is the signal wavelength (in metres),
- \(f\) is the signal frequency (in hertz),
- \(D\) is the distance from the transmitter (in metres),
- \(C\) is the speed of light in a vacuum, \(2.99792458 \times 10^8\) metres per second.

This equation is only accurate in the far field where spherical spreading can be assumed; it does not hold close to the transmitter.

**Free-space path loss in decibels**

A convenient way to express FSPL is in terms of dB:

\[
\text{FSPL (dB)} = 10 \log_{10} ((4\pi df/c)^2)
\]

\[
\text{FSPL (dB)} = 20 \log_{10} (d_f) + \log_{10} (f) - 147.55
\]

where the units are as before.

For typical radio applications, it is common to find \(f\) measured in units of MHz and \(d\) in km, in which case the FSPL equation becomes

\[
\text{FSPL (dB)} = 20 \log_{10} (d) + \log_{10} (f) + 32.45
\]

In our design we have to consider free space loss at tag to repeater and repeater to reader link. So, we have to design a power amplifier to compensate this loss for collect the data from repeater link.

**D. Multiplexer Switch Unit**

Here we are using MUX/DEMUX for switching RF signal between reader and tag. At any particular time of interval one port will be activated to collect data. Antenna networking is used instead of more readers. It will reduce cost of the network. The switching control signal will be sent to the repeater from reader and based on that it will activate specific
ports for communication.

In our design we have explained forward control path and return signal path from repeater antenna port. The signal path from tag to reader through repeater is very important in decision making for RFID data retrieval. Here we need 47 output ports to connect an antenna and 6 repeaters with 8Ch switch.

E. Antenna Installation

Antenna selection and installation is an important task in communication engineering. Here we are using star networking topology to connect the antennas. Every antenna is connected to its repeater and selection of the port is controlled by main reader. An Antenna is installed at the center of the base station. Here we have in this case we have designed 47 hexagon cells and therefore 47 base stations. So, we have to use 47 antennas. We must find out shortest path to connect antenna and network center for less wire loss. Our network is designed with 12dBi and 50 ohms antennas for better performance.

F. Mapping of Tracking Data

Mapping is identifying physical locations using graphical representation. Here the physical areas are structured by hexagonal cells. Every cell is represented by specific ID which gives its exact location. Actually the antenna selection control signal is sent from the reader. So, we can easily visualize the tags and location.

III. IMPLEMENTATION

We have used hexagonal cell structure for placing antenna tower. It is very efficient method for calculating number of antennas and readers for area mapping. It gives perfect solution for coverage issue. That is visibility will be more compare with mapping methods. Using wireless repeater and this hexagonal structure we can cover large physical area with less number of RFID readers. In the above mentioned calculation totally 1 reader, 6 repeater and 47 antenna ports are needed to cover 10000 Sq. Meter areas. It is very cheapest and closed loop algorithm to track the objects.

In this work we tried to solve reading range issue with switch controlled wireless repeater and antenna networking. The model is given by Fig. 6 and Fig. 7. We have taken the animal tracking as an example for our research. Here we are using passive RFID because of battery replacement and cost. For long range, life and low cost application UHF tags are more suitable. So we are using passive RFID tags to identify animals. Mobile communication technology uses cellular structure for base station management. Here also we tried the same approach to fix reading point antennas for successive read rate.

Every cell will have one antenna as a base station. It will identify the animal tag and based on the control signal information of particular port the location map is updated. Suppose the control signal is 1, then the first antenna of repeater will be activated and others will be off. If we read any tag in this time slot, means that it is transmitted from location corresponds to reader 1, cell 1. By this data we can locate particular object and its present location. Power spectrum and BER is simulated and displayed in Fig. 4 and Fig. 5. We have done test for read range and observed 12 meters and its performance was good.
Fig. 5. BER

Fig. 6. Block diagram

Fig. 7. Repeater model

Fig. 8. Simulation model in matlab
IV. CONCLUSION

In this work we have simulated 8 cells and one reader used to cover whole area. One multiplexer and one repeater were used. The location is mapped based on the port control signal and corresponding tag data was displayed. Here we have tested for 8 different tags which are placed in 8 different cells. The mapping chart was displayed for individual cases. We have done test for read range for each cell and observed 12 meters and its performance was good.

REFERENCES


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