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Design & development of an user identifcation authentication system using radio frequency identification (RFID) technology for long range communication scenarios

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Abstract: In a nutshell, this research article gives a brief idea about the design & development of an user identification authentication system using radio frequency identification (RFID) technology. The paper presents the design, implementation of the problem of verifying the authorization level of a user / employee and enabling hierarchical access to the resources in the organization. The paper is organized as follows. First, a brief introduction to the work in given with the need for a security system ; second, the design of the RFID system is dealt with ; third, the transmitter design ; fourth, the receiver design. Finally, the conclusions are drawn with its working.
Keywords: Radio Frequency, Transmitter, Receiver, Wireless communications.

1. Introduction Remarks

The paper is organized as follows. The need for a security system is presented in section 1. This is followed by the proposed solution in section 2. The design process is given in section 3. The functions of the user units is presented in section 4. The functions of the arbiter unit is presented in section 5. The encoding is presented in section 6. The transmitter design is presented in section 7. The power supply block is presented in section 8. The memory and control unit is presented in section 9. The modulation and transmitter part is well explained in section 10 followed by the receiver design, which is presented in section 11. The filtering sections is presented in section 12. The decoding or demodulation unit is presented in section 13. Finally, the conclusions are presented in section 14, followed by an exhaustive list of references.

RFID (Radio Frequency Identification) is a technology that uses radio waves to passively identify tagged objects. Its applications range from tracking items throughout a supply chain to managing borrowed materials in libraries, making it valuable in various commercial and industrial sectors. RFID (Radio Frequency Identification) technology, which relies on simple tags and devices to identify and find objects, is particularly successful for tracking and supply management. RFID, or radio frequency identification technology, is now used in a wide range of applications in everyday life [1][2].

RFID Scanner, like barcode technology, detects the location and identification of tagged goods, but instead of scanning laser light reflections from printed barcode labels, it collects and stores data using low-power radio waves. Radio frequencies are read by the transceiver and transmitted to an RFID tag. The work as the title suggests

is the "User authentication using RFID Tags" deals with the problem of verifying authorization level of a user and enabling hierarchical access to resources in the organization. This hierarchical privilege is based on rank and functional character of the user. Our work uses Radio Frequency IDentification (RFID) technique; which is why our work basically is an application of (Radio Frequency) RF communication technique. RF involves all those frequencies in the range of 9 KHz to thousands of GHz [3][4].

Passive UHF RFID tags can achieve reading distances of up to 12 meters, while active RFID tags can extend their range to approximately 100 meters. UHF RFID tags operate within the frequency range of 300 MHz to 3 GHz and are more susceptible to interference. RFID (Radio-Frequency Identification) is a technology that utilizes electromagnetic fields to identify and monitor tags affixed to various items. An RFID system consists of a radio transponder, a radio receiver, and a transmitter. When an electromagnetic interrogation pulse is emitted by a nearby RFID reader device, the tag, typically containing an identifying inventory number, responds by transmitting digital data back to the reader. This number is useful for inventory management purposes. Passive tags receive the energy needed for this process from the probing radio waves of the RFID reader, while active tags, being battery-powered, can be read from greater distances, sometimes extending to hundreds of meters.

The requirements of our work in a nutshell is to device a means of allowing a user to wirelessly transmit his status level to an arbiter so as to establish authority in real-time. Which necessitated the need for wireless communication schemes applicable up-to ranges of 100- 500 Mts. RF suits our needs perfectly due to a much regulated frequency bands and available communication topologies. Thus our system involves the [7][8]

- Transmission of the hierarchical level by the user (A Transmitter)
- A means of monitoring these transmissions (A Receiver)
- An Arbiter to authenticate a user (Computing terminal).

Our work involved conceptualizing, designing and implementing such a system to provide a security net in the organization to initially compliment the swipe card scheme at implemented at present and finally overhaul it.

1.1 Need for a security system…

Celetron India the organization that has commissioned this work is an ISO 2002 certified solutions provider mainly involved in providing technology solutions with specializations in Electronics and (Switch Mode Power Supply) SMPS. The organization maintains a number of Clean-rooms and also a very active Research center. It is obvious that selective security system must be installed for both quality control (W.r.t Clean rooms) and information security at the research centers [9][10].

It is necessary that a security net be enforced around such critical sections of the organization. This security net should have the capability of being used for access control to different sections within a restricted region that is it must have hierarchical lever discerning capability. At the same time the system should also be useful for restricting access to different sections on the organization allowing the same user different access levels in different regions in the organization. This can be illustrated with the help of an example [11][12]

Consider a simplistic model with 3 different restriction zones

1. Zone 1 Freely accessible.
2. Zone 2 Clean room region.
3. Zone 3 R & D region.

Similarly consider 3 hierarchical profiles

1. Class A access only to clean room.
2. Class B access only to Research facilities.
3. Class C access to all three zones.

We have to design a system which is able to control access to Zones based on the profiles.

Our proposed solution…

Our proposal to overcome these problems was twofold, in the sense, for preventing the physical access and to consume low power, which are described as follows [13][14].

1) Prevent physical access to the code (unlike magnetic cards) by using encoding and modulating schemes.
2) Use wireless transmission methods consuming low power so that overheads may be reduced.

Based on the primary requirements of the security system spelt out earlier and the special considerations above we finalized the use of RF tags for this system.

2. The design process…

As with any design system we first decide on the functional blocks, setting up the goals for each block, thereby finalizing the specifications governing the realization of each block. At a broad level the system has two distinct modules the user module and the arbiter module as shown below in Fig. 1 [15][16]

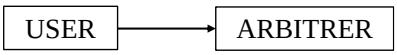

Fig. 1: Block diagram of the user & arbitrer module

Functions of the user units

The functions of the user units are briefly described as follows [17][18]

- To store the users unique details the personal identification number (PIN)
- To transmit the same as and when required.

Clearly from the above discussion the user unit should contain the following functional blocks.

- Power supply: - To supply power to run the unit.
- Memory unit: - To store the PIN.
- Transmission control unit: - To control the transmission of data.
- The data processing unit: - To process data making it suitable for transmission.
- The transmission unit: - To transmit the PIN in a suitable form.

Functions of the arbiter unit…

The functions of the arbiter units are given as follows [19][20]

- To receive the data being transmitted by the user unit.
- To decode the PIN from the data.
- To verify validity of PIN.

From the above discussion the Receiver section should contain the following sub blocks.

- Reception unit: - To receive the transmitted data.
- Signal-conditioning unit: - To condition and filter the signal
- Decoding Unit: - To obtain PIN from the received data.

Encoding

The tag is responsible for ‘encoding’ i.e. inserting clocks into the data stream according to a select coding scheme. The proposed block diagram of the RFID design process is shown in the Fig. 2, which shows a regulated power supply, a modem which is RFID based along with a transmitter Tx & a receiver Rx, series of motor drivers which are used to drive the motors and finally a liquid crystal display (LCD) for the display that the RFID tag is being detected [21][22].

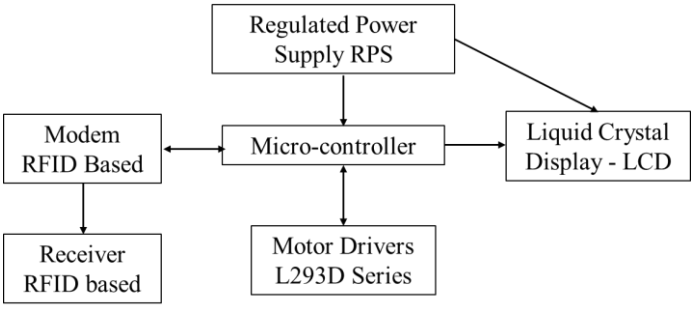

Fig. 2: Proposed block diagram of the RFID design process

3. Manchester Coding

In this section, we present the concept of the Manchester coding that is being utilized in our research work that is presented in this paper along with the diagrammatic representation in Fig. 2 [23][24].

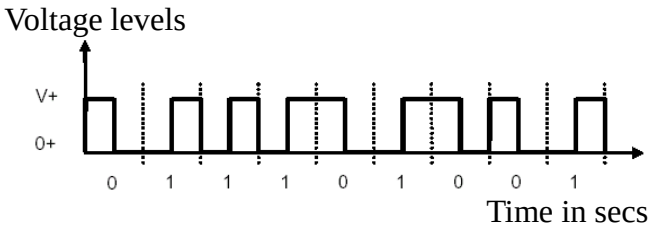

Fig. 3: Manchester codign timing diagram

This code is self-clocking

- There is a transition in the middle of each bit period
- A 1 to 0 transition represents a '0' bit
- A 0 to 1 transition represents a '1' bit
- The mid-bit transition is used as clock as well as data.
- The residual DC value is eliminated by having both polarities for every bit.
- The bandwidth required could be twice the bit rate (Efficiency of this code can be as low as 50%).

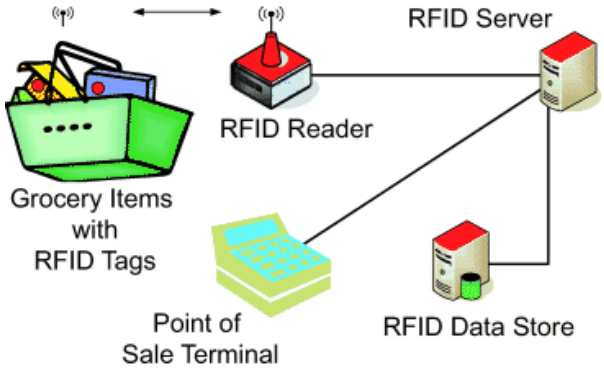

Fig. 4: Grocery store using RFID tags for entry in purchase [1]

3.1 The Transmitter Design…

The transmitter or tag is used to transmit the PIN to the arbiter, which is briefly described as follows. The basic block diagram of the transmitter has already been discussed. Here we shall give the detail chip lever description of the transmitter system [25][26].

We have the transmitter section having 4 Blocks.

- Power supply
- Memory and control
- Modulator
- Antenna.

3.2 The Power Supply Block

The power requirements of the tag are met by using a Lithium- Magnesium button cell CR-1220. It provides a nominal voltage of 3V which is used by all the ICs and circuits as supply voltage value. The requirements of the tag suggest that the weight of the tag and its dimensions be low. These considerations are dependant on choice of the battery. The CR-1220 satisfies our requirements in those [27][28].

3.3 The Memory And Control Unit

This unit is implemented using the PIC series of micro-controllers manufactured by Microchip Inc. The function of the PIC is to store the unique PIN and provide that to the modulation unit as and when required. As the

power supply is through a cell it would be unwise to continuously transmit the data we therefore program the PIC to transmit the PIN at fixed intervals of time. The PIN is stored in the memory of the PIC. The microchip PIC we use is 12C508 [29][30].

3.4 Modulation And Transmiter Section

Here, we describe the Amplitude (Amplitude Modulation) concepts that is being used in this paper. This is the method we use as it is the easiest to implement and serves our purpose of energy consumption as well. Amplitude modulation (Amplitude Shift keying as we are in the digital domain). Amplitude shift keying (ASK) involves having different amplitude levels for the two Digital logic levels. OOk is a modification of ASK where the logic level Zero is amplitude zero. The Fig. 3 gives the basic block diagrammatic module of a typical RFID section [31][32].

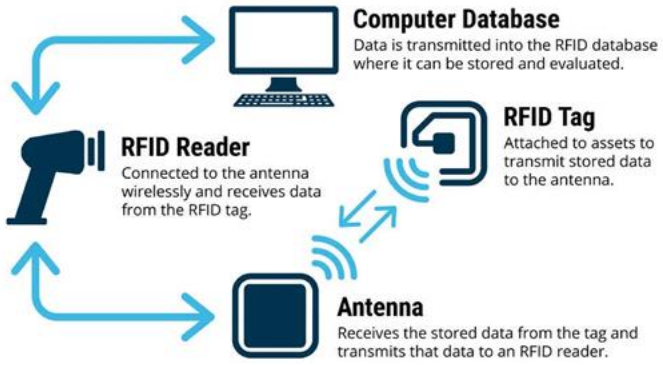

Fig. 5: RFID block diagrramatic module [1]

3.5 Receiver design

The receiver as we have already mentioned has the function of receiving the RF data and converting it into data that can be provided to the computer (which acts as the arbiter) in a form that is recognizable by it. The Receiver is also called as the reader. The reader as we have already discussed has 3 main modules or subsections [32][33].

3.6 The Receiving section

The Receiving section to receive or capture the RF waves from the atmosphere. We implement this by a ubiquitous antenna. Unlike a barcode, an RFID tag doesn't require direct line-of-sight with the reader, allowing it to be seamlessly integrated into the item being monitored. RFID falls under the category of Automatic Data Collection and Identification Systems (AIDC) and finds extensive application across various industries. For instance, in the automotive sector, RFID tags affixed during manufacturing can efficiently track each vehicle's progress along the assembly line. Pharmaceutical products equipped with RFID tags can be monitored as they move through warehouses, and RFID microchips implanted in livestock and pets offer a reliable means of individual animal identification. Within retail environments, these tags facilitate faster checkouts and serve as a deterrent against both customer and employee theft [34][35].

3.7 The Filtering Section & its applications

The filtering unit in which the signals, that are unwanted and picked up by the antenna are removed. We use RF and SAW filters for the same. The applications of the RFID are presented in as shown in the Fig. 5 [32]. Visions and Challenges for RFID Technology in the Future. With widespread deployment of radio-frequency identification technology, a number of critical challenges arise that must be addressed in order to reap the benefits of the technology. These additional difficulties include energy-efficient data collection and processing in large-scale contexts, software infrastructures to enable the Internet of Things, and security and privacy attacks [36][37].

Increased acceptance will enable technology vendors to dig in for new ground-breaking breakthroughs, and the RFID industry is poised to enter a dramatic and monumental time. As the use of radio-frequency identification technology grows, so does the number of improvements that help make RFID more dependable and cost-effective. The following are some of the advancements:

- Memory Innovations

- Cloud based Computing Applications
- Integrating Sensors
- Chipless RFID's

Fig. 6: RFID Applications [32]

3.8 The decoding or demodulation unit

This unit converts the OOK modulated RF signal into Manchester coded Digital signal that can be provided to the arbiter. This is achieved by using the UAA3201 IC manufactured by Phillips. This is a remote control receiver IC. In addition to this we shall also be providing the Module to RS232 standard interfacing circuitry along with cable. As the data transfer is unidirectional handshaking is not required and the design is standard and simplified which is why we have not included it in this review. A complete review of the RS 232 standard is provided in the appendix as reference if needed. The Demodulation unit is basically implemented by the UAA3201 IC manufactured by Phillips. This is basically a VHF remote control receiver with the following characteristics [38].

It aims to ensure cashless transactions at toll plazas, resulting in near-constant traffic flow and, as a result, decongesting and streamlining the entire toll collection process. Every car can be uniquely identified using RFID technology, which employs an Electronic Produce Code (EPC). RFID scanners read data about the vehicle's class and corresponding account when it approaches the toll gates on MPTC's expressways, determining whether it has a sufficient balance to enter the tollgate. The obstacles will open after the transaction is completed.

FASTag will employ Radio Frequency Identification (RFID), which will allow vehicles to travel through toll booths without having to stop to pay the toll because the RFID will be automatically read by toll booth sensors. The National Highway Authority of India operates the FASTag electronic toll collecting system in India (NHAI). It uses Radio Frequency Identification (RFID) technology to pay tolls directly from a linked prepaid account or from the toll owner.

A radio transponder, radio receiver, and transmitter are all included in the RFID device. When an RFID reader is triggered, such as when going through a tollgate, the sticker transmits digital data back to the scanner and deducts the money without the need for a cashier's physical intervention. The electronic toll collecting system will ensure that when vehicles pass through toll tax booths, they will be able to pass through without pausing. The RFID card is used to deduct the toll amount. Those tags could be recharged and used again in the future. Some of the components that could be used in the RFID process are as follows.

- Oscillator with external Surface Acoustic Wave
- Resonator (SAWR)
- Wide frequency range from 150 to 450 MHz
- High sensitivity
- Low power consumption
- Automotive temperature range
- Super heterodyne architecture
- Applicable to fulfill FTZ 17 TR 2100 (Germany)
- High integration level, few external components

- Inexpensive external components
- IF filter bandwidth determined by application.

Fig. 7: RFID Applications in toll booth amount collection process

All electronic businesses demand automation as a basic necessity. Bar codes, smart cards, speech recognition, some biometric technologies (for example, retina scans), optical character recognition, and RF identification can all help achieve this goal. The radiofrequency identification module, or RFID, has been available for more than fifty years. The items are identified using an electromagnetic field. RFID stands for radiofrequency identification and refers to systems that employ radiowaves to automatically identify persons or objects. One of the simplest techniques of identifying is to record a serial number that identifies a person or an object, as well as some other pertinent information, on a microchip; these microchips are then connected to an antenna [37].

An antenna's purpose is to allow the microchip to transmit the specified information to the reader. The reader then translates the radio waves (RF) that are reflected back from the RFID Tag into digital signals or information. This technology is widely employed in a variety of applications, including commercial and industrial settings. On highways, we come across single or many booths where we must pay a set amount of money. Toll booths, or toll naka, are what these booths are called. The money we pay is a toll for utilising the road, which is sometimes known as a toll road or toll way. Since the majority of highways are funded by taxes levied by the state or national governments [37].

4. Conclusions

In conclusion, we discuss a few salient aspects of this work. As this was a commissioned feasibility pilot work money and turnout time were of paramount importance. Throughout the work our main function was conceptualizing the design rather than manual design of circuits. Most of the circuits used by us are standard reference circuits. In the course of this work we learnt about the importance or brainstorming and planning for the success of any work. In this regard the patience and dedication of those in the company was exemplary. More than anything it gave us a glimpse of work culture of an organization. The experiences gained by us during the course of this work will hopefully stand us in good stead.

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