

APPLICATION OF RADIO FREQUENCY IDENTIFICATION IN MANAGEMENT OF LABORATORY EQUIPMENT IN UNIVERSITIES

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ARTICLE INFO		ABSTRACT
Received:	03/12/2025	The management of public assets at the units today has applied information technology, some of them use barcodes; that is a step forward compared to the previous manual method. To increase accuracy and convenience, a more advanced type of management is needed. Radio Frequency Identification Technology is now very developed, allowing detection and positioning of objects from thousands of meters away. Using an experimental method, in this paper we propose a solution that applies Ultra High Frequency Radio Frequency Identification Technology for managing laboratory equipment at a university. The management of public assets will increase convenience by identifying assets using ultra-high frequency tags combined with computer programs. The results of the research on the experimental model on actual equipment components show that management and tracking have become more accurate and convenient than using barcodes.
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ỨNG DỤNG THẺ NHẬN DẠNG QUA SÓNG VÔ TUYẾN TRONG QUẢN LÝ THIẾT BỊ THÍ NGHIỆM TRONG TRƯỜNG ĐẠI HỌC

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THÔNG TIN BÀI BÁO	TÓM TẮT
Ngày nhận bài: 03/12/2025	Việc quản lý tài sản công hiện nay tại các đơn vị đã có áp dụng công nghệ thông tin, một số có sử dụng mã vạch; đó là bước tiến bộ so với phương pháp thủ công trước đây. Để tăng tính chính xác, thuận tiện hơn nữa, cần có một loại hình quản lý tiên tiến hơn. Công nghệ nhận dạng qua sóng vô tuyến - Radio Frequency Identification hiện nay đã rất phát triển, cho phép phát hiện, định vị đối tượng từ xa đến hàng nghìn mét. Sử dụng phương pháp thực nghiệm, trong bài báo này chúng tôi đề xuất một giải pháp ứng dụng công nghệ nhận dạng qua sóng vô tuyến tần số siêu cao để quản lý thiết bị phòng thí nghiệm tại trường đại học. Việc quản lý tài sản công sẽ tăng được tính thuận tiện bằng cách định danh các tài sản dùng thẻ nhận dạng qua sóng vô tuyến tần số siêu cao kết hợp với các chương trình máy tính. Các kết quả của nghiên cứu trên mô hình thực nghiệm trên các cấu thành thiết bị thực tế cho thấy việc quản lý, theo dõi đã trở nên chính xác hơn, thuận tiện hơn so với dùng mã vạch.
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1. Introduction

1.1. Radio Frequency Identification Technology: History and Today

RFID (Radio Frequency Identification) is a type of remote object identification technology that was born in the 40s of the 20th century and has been effectively applied in the military. This technology has been used to overcome the problem of mistakenly shooting down our own planes; because if only paying attention to the images on the radar screen, it is impossible to distinguish between enemy planes and friendly planes. There was a time when RFID technology was not interested in civil applications. But in recent years, RFID has been exploited and used in many fields of reality [1].

The outstanding feature of this technology is that since passive RFID transceivers do not have their own power source, they are virtually maintenance-free. RFID tags do not require direct contact with the reader and are also highly resistant to impact and environmental factors.

1.2. RFID operating principle

There are many types of RFID work in many different frequency bands. Radio waves have a range from 9 kHz to 3000 GHz. In fact, the frequency range used for RFID technology is in 3 frequency bands. These are Low Frequency (LF-Low Frequency) (About 125 KHz-150 KHz), High Frequency (HF-Hi Frequency) (10 - 15 MHz) and Ultra High Frequency (UHF) (850 - 950 MHz). Different frequencies are suitable for different applications.

There are three types of RFID: active, passive, semi-active. Active RFID is the type that has a built-in power source in the tag. Passive RFID is the type that has no power source in the tag. When the correct frequency is captured from the RFID transmitter/receiver, the power source for the tag's circuit is taken from the power source obtained from the transmitter/receiver. Semi-passive RFID also has a built-in power source in the tag; but when the signal is captured from the transmitter/receiver, the power source available in the tag will be cut off and at this time the tag's functional circuit uses the power source to rectify the signal current from the transmitter/receiver.

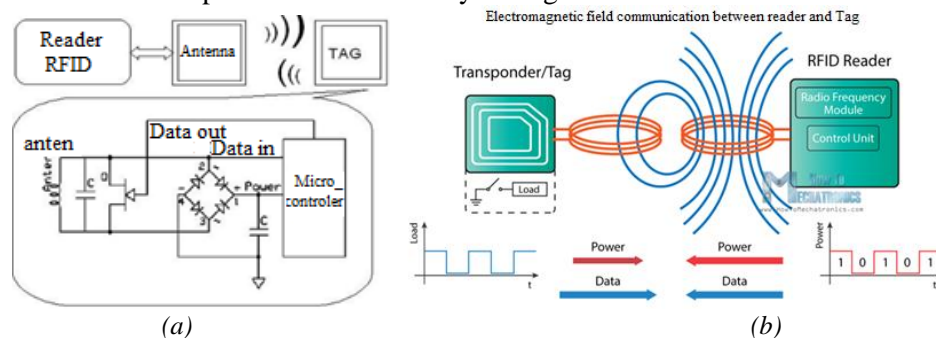


Figure 1. Schematic diagram (a): Tag and reader communication, (b): Power and data exchange [1]

The operation of the passive RFID system is described in Figure 1a: The passive RFID transmitter/receiver emits waves into the environment. When the tag is placed in a wave area, the resonant current received through the tag's antenna will be rectified into a DC current. This DC current will activate and feed the "control block on the tag". This block will send the tag's identification information to the reader RFID. This information will then be updated in the database of the controller or computer connected to the reader. Passive RFID is the most widely used type today. Passive RFID can work with all frequencies LF, HF, UHF...

Shapes of some types of readers and cards in practice (Figure 2): Due to the ability to read without contact at distances from near to very far (thousands of meters), there have been hundreds of types of RFID cards applied in practice. From common types used in normal conditions to types with special shapes. The most common and popular shapes today are cards

the size of credit cards and stickers on cars used in non-stop vehicle management [1] - [3] to special types (implanted in the human body) [4], and other fields [5] - [7].



Figure 2. Many types of RFID tags come in different shapes [8]

1.3. Some of RFID applications in Vietnam

Fields using RFID technology that are being widely used:

BOT (Build Operate Transfer) non-stop toll collection. This type uses UHF RFID.

Controlling entry/exit to agencies and factories; semi-automatic parking: these types use LF type RFID cards.

In medicine: Identification of newborns and patients: There have been cases of newborns being mistaken (intentionally or unintentionally) while still in the hospital after birth. To avoid this, after birth, the baby is given an RFID tag on its leg. To avoid confusion or being swapped, this tag cannot be removed. This tag is only discarded after discharge from the hospital.

Some other applications: Medical tape that detects the pH of wound fluid using RFID frequency helps to monitor patients in real-time. It is clear that RFID applications in the field of human health are very important. Research has been and will continue to be researched and applied. However, there is currently a problem in its use, which is the opinion about the privacy of individuals: if there is an RFID tag in the body, much private information of individuals is at risk of being exposed.

In the following section is the implementation of experimental research on the application of RFID technology in asset management.

2. Experimental study of RFID application in asset management

2.1. Old management methods

Traditional asset management involves using paper, writing, and painting on assets (or painting labels on assets). Recently, there has been a move toward using barcodes on assets. This allows for faster management when combining barcode readers with computer programs. However, there are still some challenges when using barcodes:

- When you want to read a barcode label, you have to get close to the asset because a normal barcode reader can only read at a distance of a few centimeters.
- Barcode readers cannot read labels in hidden locations.
- Barcodes are very easy to counterfeit.
- If the barcode is dirty, the reader will not read it accurately..

When using RFID for management, the disadvantages of using paint and barcodes will be completely overcome.

2.2. RFID solution

2.2.1. Block diagram

We have tested a system for managing experimental practice assets in a university. The system diagram is shown in Figure 3. The diagram consists of 2 parts: hardware and computer program.

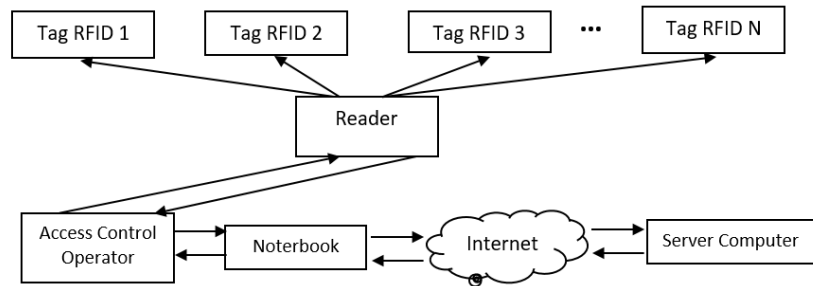


Figure 3. Diagram of RFID asset management system

System operation explanation: Each asset device that needs to be managed is attached with a passive UHF RFID tag. A field laptop is used with a Reader when checking assets at the units. The identity of the assets has been stored in the database on the server and in the laptop and is recorded in the tag attached to the asset. The location of the tag on the asset can be in hidden locations. However, do not stick them in locations that are too hidden. When the asset inspector brings the equipment and computer to the place to be inspected (can be in the room or outdoors), the tags stuck on the assets within the reader's coverage area will send information to the reader and this information will be displayed on the laptop's management software and sent to the server via the Internet.

2.2.2. Management of shared assets

A hypothetical case: there are three units that need to use the same electronic device for practice and internship. All three units are located in the same geographical area, bordering each other. With a distance of a few kilometers, it is entirely possible to organize the rotation of the use of the device between the units in a reasonable way without having to move the device. However, for the sharing to be effective and not overlapping in time, a system is needed to check the common usability of the device based on the actual usage schedule. This is included in the computer program.

Each shared device must be registered with a detailed usage schedule by the owner. When another unit wants to use a device, the system will check:

- Is the equipment in the list of shared assets?
- Is the equipment currently being used by the owning unit?
- If not busy, is the free time enough for the unit that wants to borrow the equipment to complete the work?

If these conditions are met, the system will send a notification to the unit that wants to use it to confirm permission to use it and register for a specific time period. On the contrary, if the device is busy or the free time is not enough, the system will notify rejection and suggest another option. The algorithm for checking the busy/free time of the asset is given in Figure 4.

2.2.3. Experiment

- Equipment used:
 - Reader: For large assets such as cars, cranes, houses, etc., checking using RFID UHF is also very easy. The assets that need to be checked in the experiment here are the type commonly used in offices and laboratory practice rooms. According to the current regulations on offices and classrooms in universities (TCVN 3981: 1985) [9], the area of classrooms and practice rooms is only up to 100 m². We will use the ZKTeco UHF 10 reader which can read distances up to 20 m (ie the reading area is 400 m²). This allows the solution to be fully practical. The reader used is the UHF type.

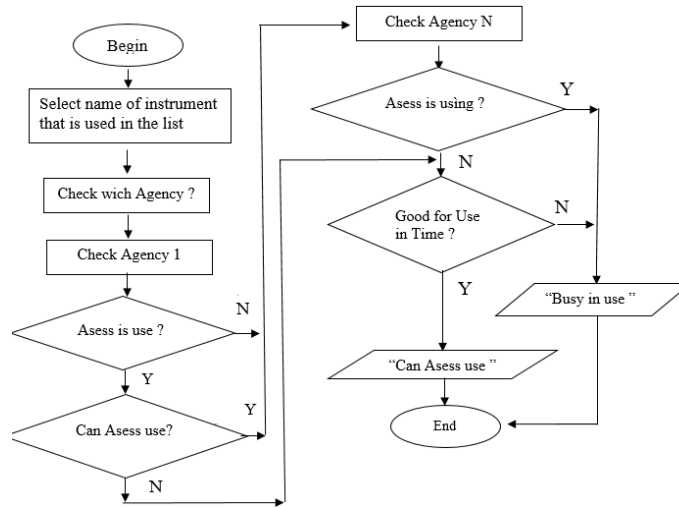


Figure 4. Check the busy/free status of shared assets.

Figure 5 shows the ZKTeco UHF 10 RFID reader and the ZKTeco C3-200 central control unit mounted behind it.



(a)



(b)

Figure 5. (a) UHF RFID reader and (b) controller mounted behind the reader

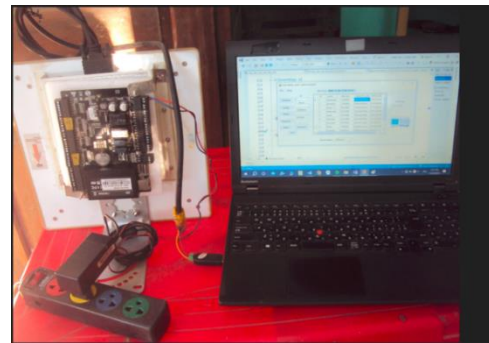


Figure 6. UHF RFID tag reader connect to laptop

Figure 6 shows the ZKTeco UHF 10 RFID reader paired with a computer via RS 485. The ZKTeco C3-200 central control unit is powered via a 220AC/12VDC power supply... The computer software is written in C# Visual Studio 2022. When bringing the reader and laptop to the room where the assets need to be checked. The information of the assets with RFID tags is displayed on the screen.

– ZKTeco C3-200 central controller (Figure 7): professional access control, designed to manage security for buildings and businesses. This device allows connecting 2 card readers and controlling access via LAN TCP/IP or RS485. In the experiment, we connected the device to the computer via RS485 with only 1 reader, the other reader was not used.

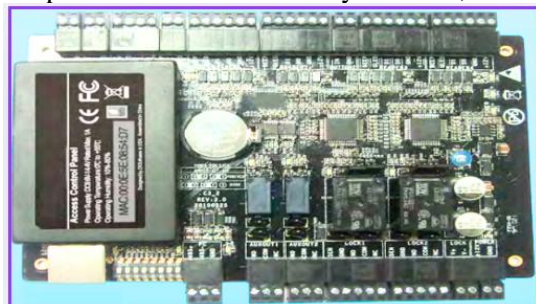


Figure 7. ZKTeco C3-200 Central Controller



Figure 8. UHF RFID tags that can be attached to assets

– Laptop: Use a laptop with normal configuration (Intel i5 Chip, 2.6 GHz, 8GB RAM, 256GB HDD).

– Tags: UHF tag is a thin tag that can be stuck on glass, wood, plastic, and metal materials.

Figure 8 is a picture of a tag attached to an asset. This type of tag is also attached to cars in non-stop inspection. At BOT stations, readers can read these tags while the car is running. In our experiment, the conditions are much more favorable because the tags attached to the assets are stationary.

- Experimental data collection in the field into a laptop.

The application program is written in C# programming language - VisualStudio 2022. The database stores the experimental data in SQLServer with the design in Figure 9.

Column Name	Data Type	Allow Nulls
ID	int	<input type="checkbox"/>
name	nvarchar(50)	<input checked="" type="checkbox"/>
date_buy	date	<input checked="" type="checkbox"/>
equipmen_user	nvarchar(50)	<input checked="" type="checkbox"/>
RFID_code	nvarchar(50)	<input checked="" type="checkbox"/>

Figure 9. Database on the laptop and on the server

Implementation: The user just needs to bring the reader and laptop to the lab or office where the asset product needs to be tested. Then, turn on the program on the laptop and all valid assets (with UHF passive management tags attached) will be displayed in the program on the laptop as illustrated in 10. As the tags on the assets have been read by the UHF RFID reader and the data is sent to the laptop.

3. Results and discussion

3.1. Results

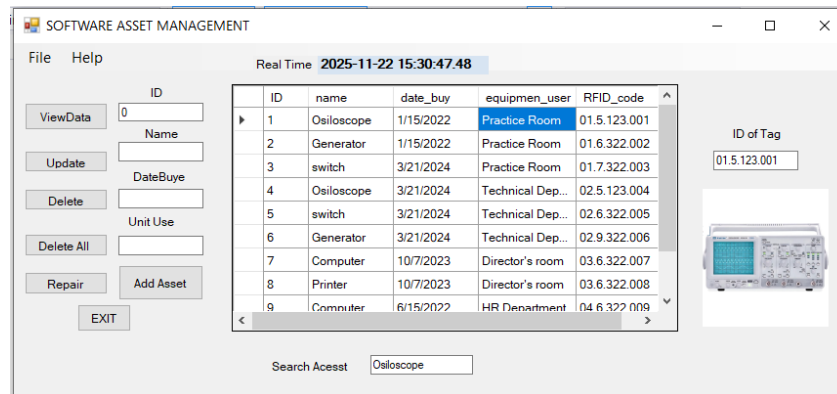


Figure 10. Program to collect data and write to database on notebook and also on Server

On the Server computer at the management center, there is also a similar computer program. Therefore, there is also a screen like Figure 10. The difference is that on the laptop the data is collected via the RS485 interface as shown in Figure 10. On the computer, the data is collected via the Internet. If the computer is permitted for use at other administrative locations, the data can also be viewed.

In addition to the common management functions: input, view, edit, delete, search, report as usual, the program also has the "Search" function. When typing the device name in the "Search Access" search box, the asset will be marked on the list and the asset photo will appear with the asset ID. In Figure 11, if one wants to search for an Osiloscope asset by entering keywords into the "Search Access" text box, the system will find that asset along with the information displayed in the program.

Shared check (described in section 3.2): This function can be used to check the “busy/free” status of your unit’s (or other units’) assets on the server via the “Program check for Shared Assets” form.

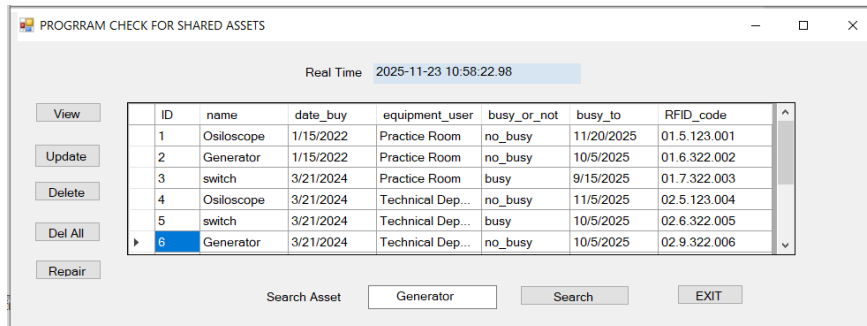


Figure 11. Search for asset is not using

The test was performed with 50 tags. Each tag was read 100 times. The results were all correct in reading the information on each tag (0% error) as shown in Table 1.

Table 1. Test Error Statistics Results

Order	Number of Tag	Number of Attempts	Correct result	Incorrect result	Wrong ratio
1	1	1	1	0	0%
2	2	2	2	0	0%
3	3	3	3	0	0%
...
50	50	100	100	0	0%

3.2. Discussion

Comment on the results: Experiments show that using UHF Radio Frequency Identification readers to detect automatically tags attached to assets and remotely combined with computer programs is completely accurate and can be applied in practice. The cost is not high and the complexity of the solution in the article is average. The exploitation of shared assets, if implemented, will increase the efficiency of the equipment. These reasons are the advantages of our solution.

When comparing RFID and barcode solutions in asset management, the advantages of RFID become even clearer for the following reasons:

- + RFID’s reading and processing speed is faster than barcodes because RFID uses UHF radio waves for reading and processing information, while barcodes use image processing.
- + RFID technology has a reading range of up to thousands of meters, while barcodes have a maximum range of only a few meters (with special types).
- + Verification efficiency: Bring a reader to the asset storage room with RFID tags and turn on the program; it will immediately read all the information from the tags. In contrast, using a barcoder requires reading each label individually.

4. Conclusion

The article has presented RFID technology and its application in asset management. Experiments have shown that: Using RFID UHF tags attached to assets allows for accurate and convenient control and inventory of fixed assets, in line with the trend of applying information technology 4.0. Management using RFID UHF can be completely applied not only in experimental practice equipment but can also be completely applied in the management of many other types of assets.

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