Performance of Ultra High Frequency Gen2 Passive Tags Radio Frequency Identification in Chemical Laboratory Environment

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Abstract: This research analyzes the performance of Ultra High Frequency (UHF) Gen2 Passive Tags Radio Frequency Identification (RFID) technology as sensing device in chemical laboratory environment. The purpose of this paper is to verify the effectiveness of using RFID for tracking chemical bottles during inventory process in a laboratory. In most laboratories, the chemical tracking process is still being done manually which is very time consuming. The advantages of RFID operaton will help to enhance the effectiveness of chemical inventory management and reduce the process time. An experiment in a laboratory was done to verify the performance of detection rate according to the specifications stated in the manual data sheet. Pre-programmed RFID passive tags were affixed onto chemical bottles and then scanned using RFID reader to detect all output data in a controlled environment. The result showed that certain conditions such as material of the container, tag-reader orientation and the size of chemical bottles play important role to get detected for this type of RFID. From the result, the paper suggested some guidelines to be taken care of during scanning process to get higher percentage of reading rates.

Key words: RFID tag detection rate · Bending diameter · Orientation sensitivity

INTRODUCTION

Radio Frequency Identication (RFID) is a technology that use radio waves to automatically identify people, animal or objects [1]. It is a wireless sensor technology which is based on the detection of electromagnetic signals [2] thus RFID tag scanning can be done remotely. It does not require direct line of sight to transfer information because it is sent via radio waves. Nowadays RFID technology has been used widely in all applications such as item-level tagging in suppply chain, construction, healthcare and many more [3, 4]. Asset tracking enables the user to track asset location, monitor asset usage status in real time by using mobile wireless sensor attached to each asset [5, 6]. It is chosen because it has better solution compared to barcode since it can be operated without the need of direct line-of-sight [7] thus it will save time and energy.

On the other hand some chemicals are highly hazardous to human skin thus Personal Protection Equipment (PPE) is required during handling such chemicals. In addition during manual chemical tracking, each chemical bottles has to be held one by one to read the information on the labels. Therefore more time is needed during inventory checking. By using RFID, no contact between chemicals and human skin is necessary since RFID data can be transfered remotely and tracking of chemicals will be easier and time saving. Therefore

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RFID technology is believed to be an efficient tool in accelarating the inventory process time of chemical management system. In this research, experiment was done to verify the data and performance of UHF Gen2 Passive RFID Tags according to the technical specifications in the data sheet.

MATERIALS AND METHODS

Materials: In this project adhesive type UHF passive tags namely "UPM Raflatac DogBone" were used (source: UPM Raflatag, 2009). The antenna size is 93 x 23 mm (3.7 x 0.9 inches). The tags operated in Global 860–960 MHz frequency and EPC Class 1 Gen 2 Protocol and consisted up to 240-bit EPC memory including 32-bit unique serial number.

The reader used in this project is Gen2 Mobile Reader MUHF H300. It is a handheld UHF scanner device with Bluetooth connectivity to Personal Digital Assistance (PDA). It operates in the frequency range of 902 – 928 MHz band and uses EPC Class 1 Gen 2 Tag Air Interfaces. The built-in software namely "RFID Asset Tagging" (RATI) is installed inside the PDA. The information captured was kept in a local database and could be exported to other computers through USB connection. The software was built on .Net Compact Framework 3.5 in Windows CE operating system. The program was written in C#.

Experimental Setup: This research was done to check on the detection rate of UHF Gen2 RFID tags in a real chemical laboratory environment. The experiment was done in Advanced Materials and Nanotechnology Laboratory (AMNL1), Institute of Advanced Technology, Universiti Putra Malaysia. A number of twenty five chemical samples were used in this experiment. The chemical containers were made of various types such as plastics, glass and metals with different shapes and sizes. The smallest container used in this experiment was a plastic bottle with 40 mm in diameter.

All the twenty five chemical samples were first to be assigned with ID numbers that were pre-programmed in the RFID passive tags. Each tag will be registered with chemical's particulars accordingly such as chemical's name, location and so on. Then the tags were going to be affixed onto the outer surface of chemical bottles following the suitability of the container's shape such that they would not cover the existing chemical labels. When applying the tags onto the bottles, two different

Table 1: List of chemical samples

Tag Id No.	Name of Chemicals	Location
35	Titanium (IV) Oxide	B2 AMNL1
36	Aluminium Nitrate Nanohydrate	B2 AMNL1
37	Bismuth (lll) Nitrate	B2 AMNL1
38	Bismuth (lll) Nitrate (2)	B2 AMNL1
39	Potassium Permanganate	B2 AMNL1
40	Iron (lll) Nitrate Nanohydrate 98+	B2 AMNL1
41	Nickel (ll) Nitrate	B2 AMNL1
42	Nickel (ll) Nitrate (2)	B2 AMNL1
43	Barium Peroxide 95%	B2 AMNL1
44	Iron (III) Chloride 6-hydrate	B2 AMNL1
46	Maleic Acid	B2 AMNL1
47	Yttrium (lll) Oxide	B2 AMNL1
48	Zinc Nitrate 6-hydrate (Hmbg)	B2 AMNL1
49	Zinc Nitrate 6-hydrate (BODI)	B2 AMNL1
50	Cyclopentanone	B1 AMNL1
51	Copper (ll) Nitrate Trihydrate	B1 AMNL1
52	Cobalt Powder	B1 AMNL1
53	Nickel Powder 99.8%	B1 AMNL1
54	Nickel Powder 99.5%	B1 AMNL1
55	Strontium Nitrate	B1 AMNL1
56	Silica Gel (Lab Reagent)	B1 AMNL1
57	Silica Gel (Bendisen)	B1 AMNL1
58	Iron (III) Oxide 99.5% (metal)	B1 AMNL1
59	Nickel Powder 99.8% (2)	B1 AMNL1
60	Nickel (ll) Oxide 99+%	B1 AMNL1

orientation of tagging the tags were to be considered; horizontally or vertically as shown in Figure 1. Then the bottles with affixed tags would be located and kept in two wooden compartments namely B1 and B2 respectively as shown in Figure 2. The list of all twenty five chemical samples used in this experiment is shown in Table 1.

Tags-Reader Detection Rate Test: An experiment was run to test the performance of reading rate or detection capabilities of the UHF Gen2 RFID tag-reader with different variables; scanning time (t), orientation of affixed tag on container (θ) and bending diameter of tag on container (d).

To start scanning, the RFID reader was brought in a horizontal plane nearby the bottles with the affixed RFID tags. The reader's antennas were aligned with the tag's antennas so that the degree of orientation (θ) would be 0° or 180°. For the first variable, the tags were scanned by RFID reader for 10 seconds (t = 10 sec) where the time was taken by using a stopwatch. The ID number of detected tags were displayed on the PDA's screen and the result was recorded. The detected tags was assigned as "1" and not detected tags would be assigned as "0". Then the experiment was repeated for second variables where the scanning time would be 20 seconds (t = 20 sec) under controlled environment where all containers were at the same spot on the shelf. The same experiment was repeated five times for each scanning time.
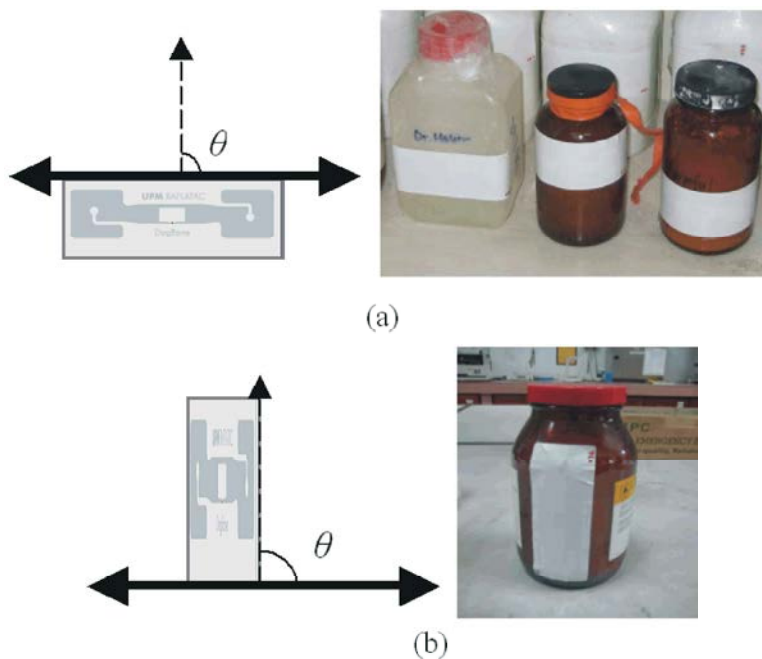

(a)

(b)

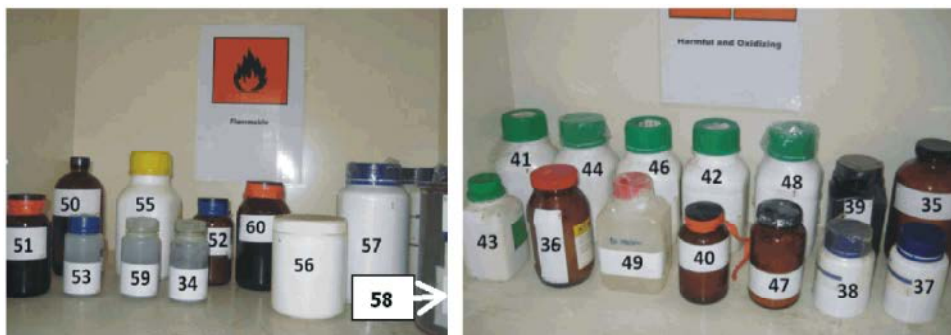Fig. 1: The affixed tags in (a) horizontal orientation (b) vertical orientation

Fig. 2: The Location of Chemical Bottles with ID number

RESULTS AND DISCUSSION

The overall result were recorded and tabulated as shown in Table 2. The percentage of detections for each tag were calculated for both times, t equals to 10 and 20 seconds.

It is commonly known that RFID does not work well around metal since metal will reflect the electromagnetic waves. As for comparison and controlled sample, one metal container was purposely used. Tag ID no. 58 was affixed on metal container as shown in Figures 3. Thus the result would never give 100% readings because of this phenomena. As can be seen in Table 2, this tag ID no. 58 could not be traced at all and gave "0" (undetected tag) result every time. This proves that this type of RFID does not work around metal.

As for degree of tags-reader orientation (θ), as shown in Figure 4, the result shows that the tags affixed horizontally on the bottles gave better chance of detected rates compared to vertically affixed tags. Note that tag with ID number 36, 39 and 57 had difficulties to be read because their degrees of orientations (θ) were 90°. The detected percentage for tag ID no. 36 were 20% for both scanning times, tag ID no. 39 were between 20-60% and tag ID no. 57 got 80% detected as shown in Table 2.

Figure 5 shows the orientation sensitivity of the tags used (source: UPM Raflatag Dogbone). According to the technical specifications, the reader will perform better if the tag is aligned to the reader's antenna. The best sensitivity is when the tag is placed 0° and 180° towards reader's antenna. The sensitivity is reducing towards orientation of the antenna. The sensitivity is almost zero

Table 2: Result for Detection Rate

Tag Id	t = 10 sec						t = 20 sec					
	1	2	3	4	5	% detection	1	2	3	4	5	% detection
34	0	0	0	1	0	20	0	1	1	0	1	60
35	1	1	1	1	1	100	1	1	1	1	1	100
36	1	0	1	1	0	60	1	1	0	0	1	60
37	1	1	1	1	1	100	1	1	1	1	1	100
38	1	1	1	1	1	100	1	1	1	1	1	100
39	0	0	0	0	1	20	0	1	1	1	0	60
40	1	1	1	1	1	100	1	1	1	1	1	100
41	1	1	1	1	1	100	1	1	1	1	1	100
42	1	1	1	1	1	100	1	1	1	1	1	100
43	1	1	1	1	1	100	1	1	1	1	1	100
44	0	0	1	1	0	40	1	0	1	0	1	60
46	0	1	1	1	1	80	1	1	1	1	1	100
47	1	1	1	1	1	100	1	1	1	1	1	100
48	1	1	1	1	1	100	1	1	1	1	1	100
49	1	0	1	1	1	80	1	1	1	1	1	100
50	1	1	1	1	1	100	1	1	1	1	1	100
51	1	1	1	1	1	100	1	1	1	1	1	100
52	1	1	1	1	1	100	1	1	1	1	1	100
53	1	1	0	0	0	40	0	1	0	0	1	40
55	1	1	1	0	1	80	1	1	1	1	1	100
56	1	1	1	1	1	100	1	1	1	1	1	100
57	1	1	1	0	1	80	0	1	1	1	0	80
58	0	0	0	0	0	0	0	0	0	0	0	0
59	0	0	1	1	0	40	0	0	1	1	0	40
60	1	1	1	1	1	100	1	1	1	1	1	100

Note: 1=tag detected; 0= tag not detected

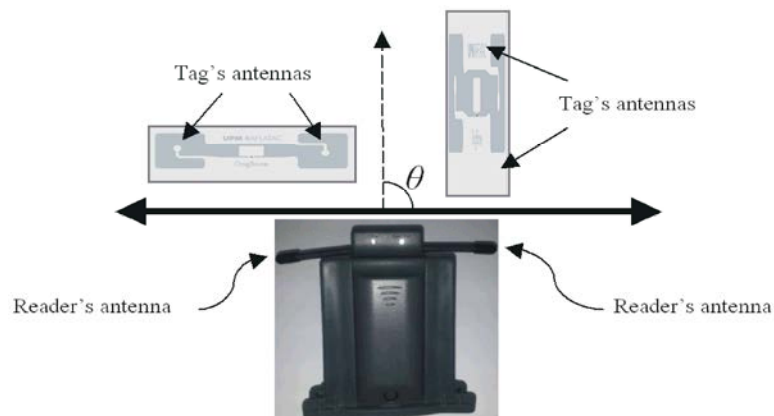Fig. 3: Metal container for Tag ID No. 58

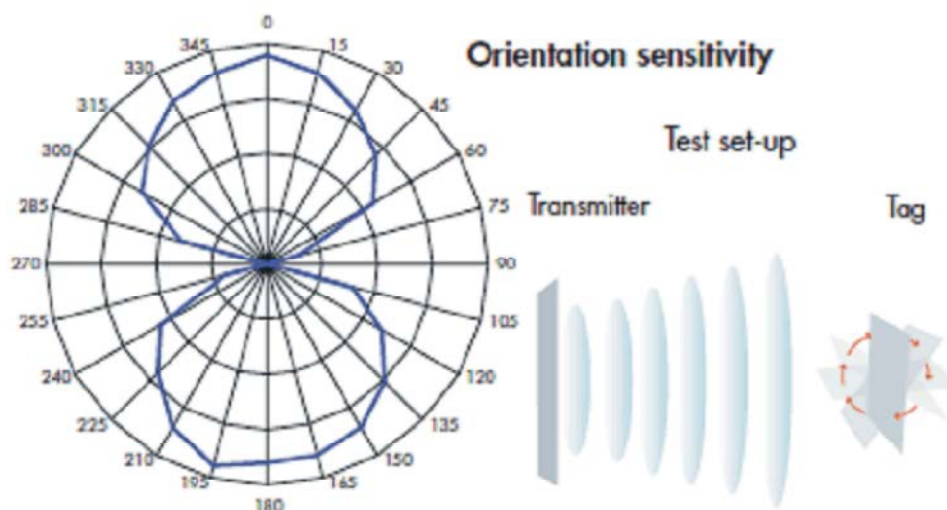Fig. 4: The Orientation Degree of Tags' Antennas and Reader's Antenna

Fig. 5: Technical Specifications for Tags Orientation Sensitivity

General characteristics of inlay	
Operating temperature	-40 °C to 85 °C -40 °F to 185 °F
Bending diameter (D)	> 50 mm, tension max. 10 N
Static pressure (P)	<10 MPa

Fig. 6: Technical Specifications for bending diameter

at 90° and 270°. The other reasons for this result might be the orientation between the reader and tags which did not cover the whole sensitivity angle ($0° < \theta < 90°$) during scanning process.

It is also found that the detection rate for tags ID no. 34, 53 and 59 were only 20-40%. The size of the containers with these tags were very small with the diameters only 40 mm. The applied tags had to be bent almost in a complete round thus most of the time the tags could not be detected. This result verified the technical specification of this type of tags (as in Figure 6) which says that the bending diameter should be more than 50 mm in order to be detected.

Finally, the other possibilities for some undetected tags might come from technical error (noise, collision etc.) happened during the scanning process.

CONCLUSION

This experiment shows that some considerations have to be followed in order to get the most detected tags. To get the best result, the orientation of tags-reader must be aligned, the diameter of the chemical bottles must be more than 50 mm and the container must not made of metal. This experiment also proves that longer scanning time will give better result too.

In conclusion, this project has shown that UHF Gen2 RFID device is a reliable and highly effective tool which adds value in time, efficiency and accuracy in a chemical laboratory environment provided that it follows the suggested procedures during scanning process.

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