Influence of the position of a UHF-RFID tag relative to the antenna in the information reading

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ABSTRACT

The main idea of this paper is to determine the influence of the position and the angle of a tag in the reading of an RFID system, therefore we have developed two different experiments. In the first one, a model with a tag was moved perpendicular to two antennas fixed to a vertical support. In the second one, the same model was moved through two vertical supports with two RFID-UHF antennas each. The results show that the position and the angle of the tag broadly affect the distance of the measurements obtained.

Keywords: RFID; tag positions, reading distances.

1. INTRODUCTION

The Radio Frequency Identification, also known as RFID, is a two-way automatic identification technology which is given between antennas, tags and a reader (or middleware), as seen in Figure 1, through radio waves, therefore requires no contact or line of sight [1].

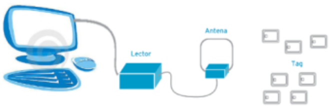


Figure 1. *RFID technology*

Even though this technology is being used more and more frequently, its application is not exempt from obstacles being the three most important challenges of this:

i) The effects generated by various materials in the antennas,
ii) The collision caused by simultaneous radio transmission, and
iii) The impact of the orientation between the tag and the antennas on the reception [2].

2. RFID AND LOGISTICS

Among the few contributions related to how the reception is affected by the orientation between the tag and the antennas, is the work of Laniel, et al in [3] who sought to determine the optimal placement of the antennas of Radio Frequency to achieve complete readability of the RFID tags placed inside a shipping container refrigerated to -25°C and fully loaded of bread. Likewise, is worth mentioning the work of Laniel, et al in [4] who studied the effect of the antenna position and the frequency in RF wave propagation within an empty container.

It is because of the lack of information on this topic that our research aims to provide new data on the last of the previously mentioned limitations that RFID technology still has, by developing various experiments to determine how the positions of the tags and the antennas affect the distance in which the tags can be read.

3. THE EXPERIMENT

As it can be seen in Figure 2, scenarios attempting to model actual work situations in logistics environments:

i) Simulating the reading of packages moving on a conveyor belt, modeled by approximating, perpendicularly, a cubic box of 0,30m aside in which has been adhered a tag, through two antennas placed one above the other at 0,60m between them and with the ground, and

ii) Simulating the operation in a load dock by passing the same box through the center of two poles faced at a distance of 2,55m and the antennas separate at 0,60m.

Once designed the two study scenarios, were decided diverse factors to be evaluated in each of them, related both to the positions in which the product is moved as in the surface and angle in which the tag is located.

At the same time settled 3 possible heights in which perform the measurements:

i) Height of the lower antenna center, i.e. 0,60m,
ii) 0,90m, and
iii) Height of the center of the upper antenna, i.e. 1,20m.

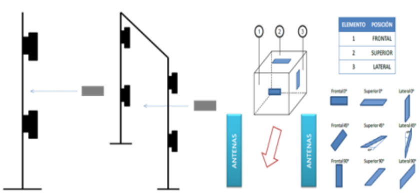
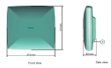
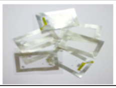


Figure 2. *Experiment design*

Table 1. Equipment used

Illustration	Equipment	Quantity
	Siemens antennas: SIMATIC RF600A	4
	Siemens middleware: SIMATIC RF660R	1
	Tags: Trace-Tech Id Solutions. Monza 4.	25

4. RESULTS

To determine the degree in which each of the studied factors relates to the reading distance, that is, height, position and angle, has been performed an analysis of variances ANOVA.

This showed that for trials carried out with 2 antennas, all variables have a significant relationship with distance, being in the following order: 1. Height, 2. Angle and 3. Position.

In experiments with four antennas, the analysis of variances showed that only two characteristics had significant influence on the distances, being the most relevant the angle at which the tag was placed, while the surface on which was located took second place of importance.

Similarly, it was determined whether the studied variables showed normal behavior in order to make future estimates, which was conducted using the analysis of the residual graphs.

Table 2. Analysis of variances (ANOVA)

	2 Antennas		4 Antennas	
Variable to be evaluated	Fisher F	P	Fisher F	P
Height	2.33	0.119	0.25	0.779
Surface	0.96	0.396	2.24	0.128
Angle	1.32	0.286	7.98	0.002

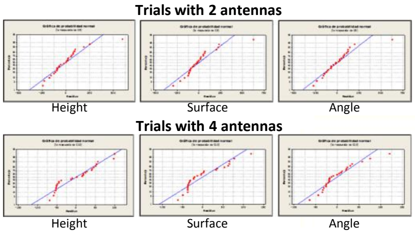


Figure 3. *Analysis of variances (ANOVA)*

The highest average distance, 9,27m, was reached by placing two antennas and passing the box 0,90m above the ground with a tag in the lateral face at an angle of 45°. The opposite occurred with an arrangement of two antennas and the tag placed at an angle of 45°, but on the upper surface and passing the box to a height of 1,20m, since the distances obtained were the lowest, with an average of 22,4cm. In the case of tests conducted with 4 antennas, the maximum distance, 2,159m, was achieved with a height of 0,60m and placing the tag on the top of the box with an inclination angle of 90°, while the minimum, 0,31m, was the result of passing the box to 1,20m with the tag on the front also at an angle of 90°. The entire results are showed in the next charts.

Table 3. The mean values with 2 antennas at a height of 60cm above the ground

Position	Angle	µ of measured distances	σ of measured distances	Confidence interval - (95%)	Confidence interval + (95%)
FRONT	90°	227,92	53,08	0,23	249,83
FRONT	45°	251,68	41,11	0,16	268,65
FRONT	0°	425,56	34,41	0,08	439,77
SUPERIOR	90°	174,76	28,34	163,06	186,46
SUPERIOR	45°	62,60	2,80	61,44	63,76
SUPERIOR	0°	154,08	17,66	146,79	161,37
LATERAL	90°	0	0	0	0
LATERAL	45°	197,00	20,39	188,58	205,42
LATERAL	0°	81,92	16,81	74,98	88,86

Table 4. The mean values with 2 antennas at a height of 90cm above the ground

Position	Angle	µ of measured distances	σ of measured distances	Confidence interval - (95%)	Confidence interval + (95%)
FRONT	90°	87,8	13,56	0,15	82,20
FRONT	45°	405,48	36,92	0,09	390,24
FRONT	0°	100,8	9,38	0,09	96,93
SUPERIOR	90°	205,36	17,12	0,08	198,29
SUPERIOR	45°	419,36	58,96	0,14	395,02
SUPERIOR	0°	253,76	96,55	0,38	213,90
LATERAL	90°	234,68	5,74	0,02	232,31
LATERAL	45°	927,92	28,59	0,03	916,12
LATERAL	0°	81,92	16,81	74,98	88,86

Table 5. The mean values with 2 antennas at a height of 120cm above the ground

Position	Angle	µ of measured distances	σ of measured distances	Confidence interval - (95%)	Confidence interval + (95%)
FRONT	90°	89	9,11	0,10	85,24
FRONT	45°	126,80	5,52	0,04	124,52
FRONT	0°	111,16	10,18	0,09	106,96
SUPERIOR	90°	187,04	23,49	0,13	177,34
SUPERIOR	45°	22,40	13,31	0,59	16,90
SUPERIOR	0°	206,16	12,90	0,06	200,84
LATERAL	90°	241,92	32,53	0,13	228,49
LATERAL	45°	280,24	10,30	0,04	275,99
LATERAL	0°	369,24	53,23	0,14	347,27

Table 6. The mean values with 4 antennas at a height of 60cm above the ground

Position	Angle	µ of measured distances	σ of measured distances	Confidence interval - (95%)	Confidence interval + (95%)
FRONT	90°	60,4	9,57	0,16	56,45
FRONT	45°	158,60	4,55	0,03	156,72
FRONT	0°	72,28	7,21	0,10	69,30
SUPERIOR	90°	215,88	4,84	0,02	213,88
SUPERIOR	45°	135,28	10,09	0,07	131,11
SUPERIOR	0°	102,96	11,53	0,11	98,20
LATERAL	90°	77,64	2,55	0,03	76,59
LATERAL	45°	162,60	4,00	0,02	160,95
LATERAL	0°	63	3,11	0,05	61,72

Table 7. The mean values with 4 antennas at a height of 90cm above the ground

Position	Angle	µ of measured distances	σ of measured distances	Confidence interval - (95%)	Confidence interval + (95%)
FRONT	90°	61,48	9,30	0,15	57,64
FRONT	45°	211,88	4,35	0,02	210,08
FRONT	0°	56	2,69	0,05	54,89
SUPERIOR	90°	170,68	7,26	0,04	167,68
SUPERIOR	45°	133,36	14,12	0,11	127,53
SUPERIOR	0°	104,2	7,20	0,07	101,23
LATERAL	90°	63,44	5,86	0,09	61,02
LATERAL	45°	165,40	3,08	0,02	164,13
LATERAL	0°	62,96	3,10	0,05	61,68

Table 8. The mean values with 4 antennas at a height of 120cm above the ground

Position	Angle	µ of measured distances	σ of measured distances	Confidence interval - (95%)	Confidence interval + (95%)
FRONT	90°	31,16	3,57	0,11	29,69
FRONT	45°	128,32	3,01	0,02	127,08
FRONT	0°	55,28	3,76	0,07	53,73
SUPERIOR	90°	124,64	13,46	0,11	119,08
SUPERIOR	45°	140,92	6,51	0,05	138,23
SUPERIOR	0°	115,64	5,13	0,04	113,52
LATERAL	90°	51,08	9,43	0,18	47,19
LATERAL	45°	153,84	2,13	0,01	152,96
LATERAL	0°	101,8	5,24	0,05	99,64

5. CONCLUSIONS

The largest distance was reached in trials carried out with two antennas, contrary to what one might have expected. This was consistent with the fact that, by comparing the results obtained with two and four antennas under the same combinations of the factors discussed, only five of the twenty casuistries studied, obtained greater distances using more antennas. Also, from the ANOVA analysis it was concluded that all the factors analyzed kept a strong relationship with the distance except the height to which the product is passed when performing tests with four antennas.

6. REFERENCES

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