New Orleans JAZZED about Engineering Education

Paper ID #15252

RFID Tag Detection in 3-D Space

Dr. Lash B. Mapa, Purdue University - Calumet

Lash Mapa is a Professor in Industrial/Mechanical Engineering Technology at Purdue University Calumet (PUC). His undergraduate and graduate degrees are in Chemical Engineering. He has several years' experience as a Chemical Engineer, Process and Project manager with European and U.S. manufacturing organizations. Currently, he is involved in the MS Technology program at PUC and has managed over thirty lean six sigma projects with manufacturing, service industry and educational institutions. He is a certified six sigma black belt and a certified quality engineer with ASQ

Ms. Suraiya Jannat Khan, Purdue University - Calumet

Suraiya Jannat Khan is a Masters' student at Department of Engineering Technology in Purdue University Calumet. Currently she is working as a part time engineer in Equip Manufacturing Inc., where she designs, builds and debugs control panels for local food industries. Suraiya has a passion to work with latest technologies. This urge has driven her into the field of Radio Frequency Identification (RFID). As a graduate student, Suraiya is currently working with Radio Frequency Identification (RFID) tag detection projects in Industrial Engineering Technology Laboratory.Her previous works include programming HMI with FactoryTalk View and RSLogix 5000, designing a low noise amplifier and designing a temperature and humidity meter with microprocessor 8086. Email: suraiyajkhan108@gmail.com

RFID Tag Detection in 3-D Space

Lash Mapa, Suraiya Jannat Khan

Abstract - Radio frequency identification (RFID) is a system used to create an automated tracking solution of items in real time. A reader, a tag and an antenna make up the basics of an RFID system. It is a reader and a tag communicating through a medium at a certain frequency. This paper focuses on the readability of RFID tags at a certain attenuation and at certain positions with different linear distances in 3-D space. In this research both the linear distances and the tag displacements were varied to determine the effect on antenna footprints based on tag readability in 3-D space in real time. The data is analyzed to obtain the graphical representation of the coverage area into a 3D footprint.

Introduction:

Radio frequency identification (RFID) is the latest technology applied for identification and tracking of items. The RFID system allows information to be read remotely by the use of radio frequency waves without human intervention. Therefore automatic scanning and data logging is possible with this technology.

RFID technology is considered to be advantageous because it does not require line of sight. Using this technology it is possible to read, write and update digital information. The RFID technology is very popular in Supply chain management system. The supply chain management system depend on the tracking of shipments, inventory and assets. Annual sale, Revenue, Seasonal sales, Manufacturing date, Expiration date needs to be tracked and documented from the suppliers to the end of line customer. These documentation used to be tracked by bar coding system, but nowadays it is being replaced by RFID Technology.

A typical RFID system consists of an antenna, a transponder (tag) and a microprocessor chip with memory. The effectiveness of a tracking system depends on RFID tagging readability. A basic knowledge of the spatial dimensions of RFID tags read capability makes it feasible for the users to plan their tracking system.

Tag readability depends on many variables, such as type of tag and antenna, distance from tag to antenna, tag orientation and tag placement. Also interferences with the surroundings due to other wireless devices might have some effects on tag readability. The major interest in this research is to obtain a foot print depending on the tag readability in 3-D space in real time.

EQUIPMENT

Researches performed with RFID system requires a specific Antenna, Tag and Receiver. There are two types of tags, active and passive tags. Active tags require a continuous source of power. They are either connected to a power infrastructure or they use energy from an integrated battery. On the other hand, passive tags do not require batteries or maintenance [3]. They are small and have indefinite lifetime.

This research uses passive tags for RFID tagging. For this research we have used a passive tag manufactured by Alien Technology®. This Gen 2 has been used throughout the whole experiment. (Take a picture of the RFID TAG)

Again, the RFID reader used to perform the experiment is also manufactured by Alien Technology®. Reader configuration is EPC Class 1. Model: ALR-9800. The objective of the EPC is to provide unique identification of physical objects. This is used to address and access information about individual objects from the computer network, similar to the internet protocol (IP) address allows the computers to identify, organize and communicate with one another [2].

The antenna used for data collection is an Alien Technology® RP circular Antenna with 6.0dbi Gain and operating frequency at 915MHz.

METHODOLOGY

In a RFID system tags represent the basic building block of the RFID system. A tag is also known as transponder. When a tag is energized, it transmits the data stored in it via radio waves. The reader receives these waves and then communicates the necessary data to the host computer. Therefore it can be said that whenever an energized tag is in the vicinity of the antenna, the computer can read data stored in to the tag. In figure 1, this process has been described by using a block diagram.

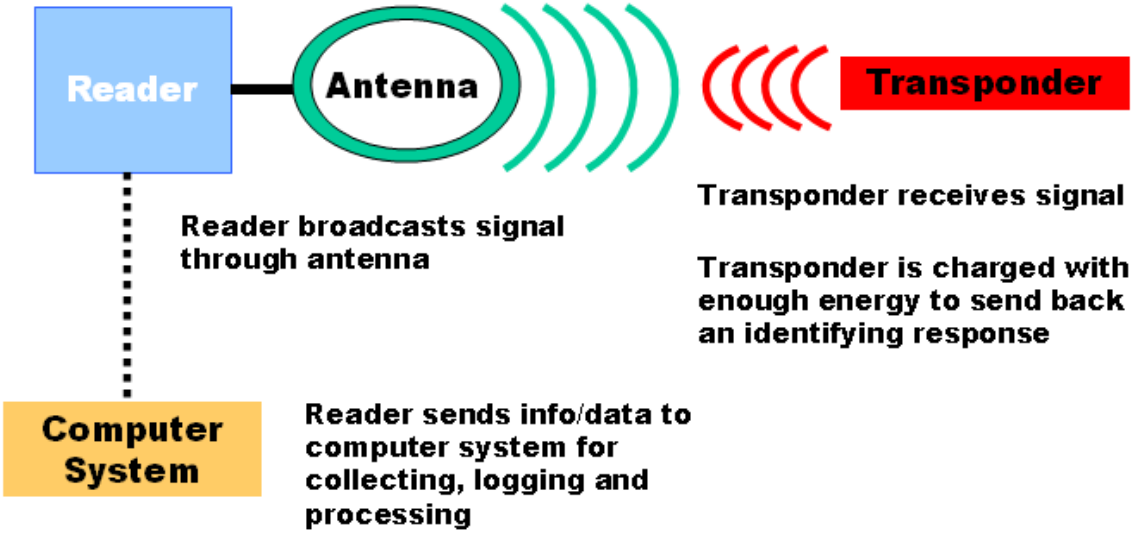

Figure 1: RFID technology process

Although RFID technology is gaining popularity, there always lies some limitations. There are some variables that decreases the readability of the tags. Distance of the Antenna to the tag, Height of the Antenna, Specifications of the antenna varies the readabilities largely.

For this research the variables that will be taken to consideration are the following:

- Height of the tags with reference to the antenna.
- Distance variability of the tag in forward direction.
- Distance variability of the tag direction across left and right.

The other variables that have effect on tag readability were controlled in this contrived lab experiment by keeping them constant.

For this research, the Antenna height was kept constant at 4 feet. Also the tag position was kept horizontal and facing the antenna.

Data Collection:

The data is collected in laboratory environment with minimal interference from external factors such as metal objects and interference from other antennas. For this experiment, the antenna and the receiver were connected above each other on a wooden pole. The antenna height was fixed at 4 feet from the ground. This setup has been shown in figure 2.

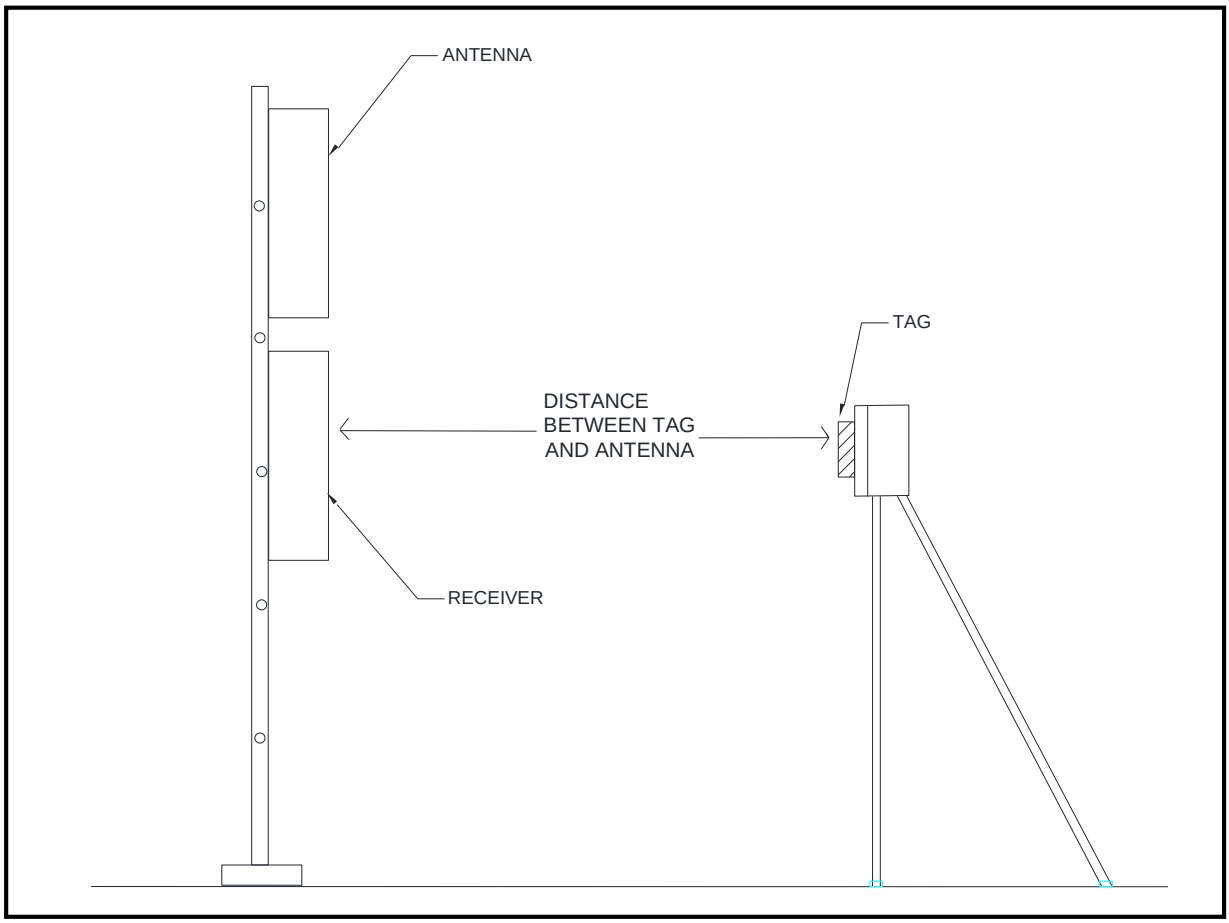

Figure 2: Experiment setup of RFID tag detection in 3-D space.

When a tag is placed facing the antenna, its reading is taken for 30 seconds. In an RFID reader the attenuation is one of the specifications that has to be adjusted by the user. The more the

attenuation increases, the power of the Radio Frequency decreases. For this experiment, the attenuation of the RFID antenna is set to 80 dB. This attenuation was chosen because it was not expected that more RF power would penetrate through the walls to reach the other rooms of the building [2].

For the experiment the tag is placed at some certain point facing the antenna. Then it was read through the antenna via Alien Technology® software. Figure 3 shows the screen shot of the software while it is reading tags.

Figure 3: Screen shot of the Alien Technology® software while reading a tag

A specific construction for space division has been used in this research. The antenna position is assumed fixed at position 0. The tag was moved to specific allotted points at on the space of construction. Figure 4 shows the space construction for this experiment. The tag is moved across and also in the forward direction.

In the space construction, each box represent 1 feet square. The tag was moved every 2 feet in the forward direction. Again across left and right, the tag was moved every 1 feet. For showing this in to a mathematical format, the graph has taken the center position as 0. Towards left (TDL) all the positions were marked as negative. Towards right (TDR) all the positions are marked as positive values.

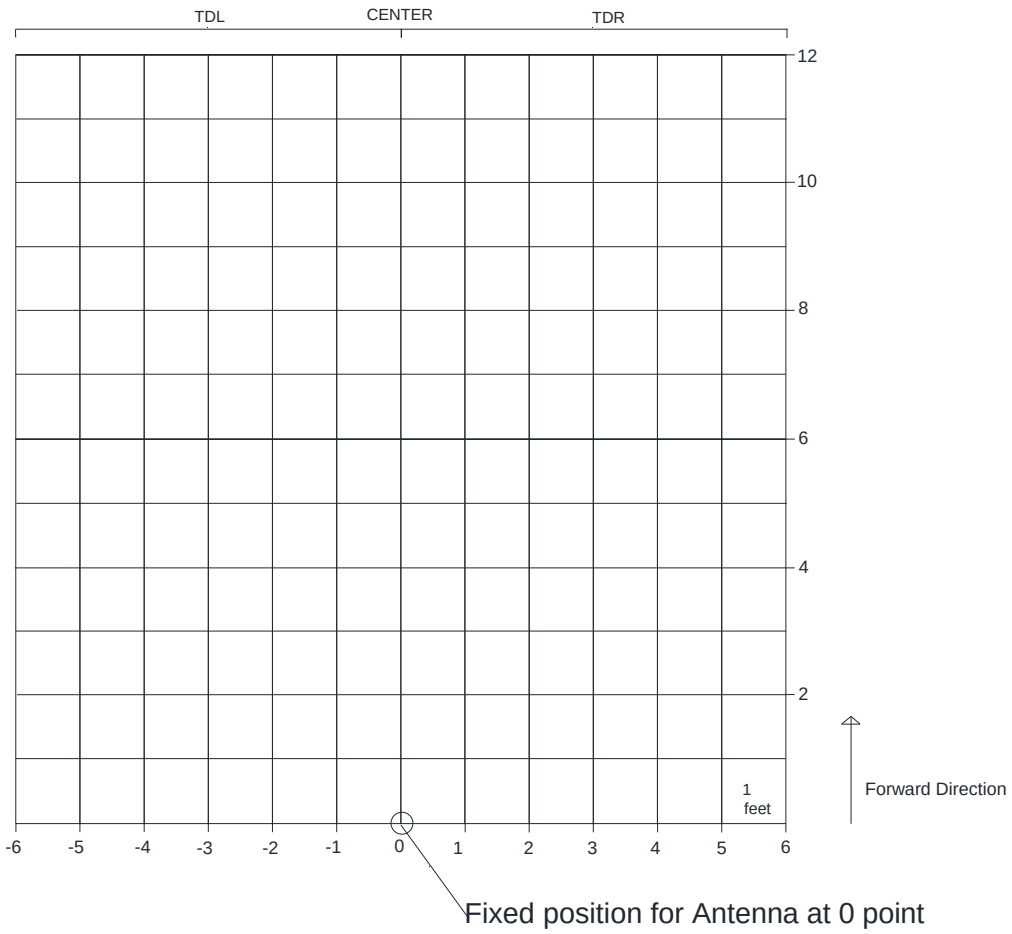

Figure 4: Space construction model

The data is collected at 4 different height positions of the tag. The tag was placed simultaneously at 2 feet, 3 feet, 4 feet and 5 feet height. At each height positions the tag was moved to 78 positions, left and right.

The data are given below at 4 different height positions. The empty spaces in the data sheet means the reading was zero at those position.

Tag facing Antenna

Tag height from ground: 2'

	← TDL →							← TDR →					
Distance in left to right direction → Distance in forward direction ↓	6'	5'	4'	3'	2'	1'	center	1'	2'	3'	4'	5'	6'
2'					130	249	175	93	15	5			
4'					188	250	236	237	30				
6'				2	32	143	156	66	14				
8'				5	59	152	7	38	53	33	5	10	
10'				1	45	116	12	62	35				
12'													

Tag facing Antenna

Tag height from ground: 3'

	TDL							TDR					
Distance in left to right direction → Distance in forward direction ↓	6'	5'	4'	3'	2'	1'	center	1'	2'	3'	4'	5'	6'
2'					80	260	246	136	101				
4'					244	246	251	251	28	4			
6'			17	3	46	151	27	89	30	31			
8'				51	24	143	97	24	7				
10'							5	43					
12'							1						

Tag facing Antenna

Tag height from ground: 4'

	TDL							TDR					
Distance in left to right direction → Distance in forward direction ↓	6'	5'	4'	3'	2'	1'	center	1'	2'	3'	4'	5'	6'
2'					179	247	231	240	109	3			
4'			17	72	18	101	107	129	46	26	36		
6'			27	161	140	167	142	127	48				
8'		27	96	121	29	24	12	3	37	18	14	39	
10'	50	65	112	116	59	72	117	136	106	2	2		
12'			6						23	3	2		

Tag facing Antenna

Tag height from ground: 5'

	TDL							TDR					
Distance in left to right direction → Distance in forward direction ↓	6'	5'	4'	3'	2'	1'	center	1'	2'	3'	4'	5'	6'
2'					107	220	231	233	17				
4'				51	184	201	209	142	55	8			
6'				12	19	20	95	149	102				
8'					1	19	47	165	81	8			
10'							10						
12'													

Selection of a suitable frequency

RFID systems generate and radiate electromagnetic waves, they are legally classified as radio systems. The function of the other radio services must under no circumstances be disrupted or impaired by the operation of RFID systems. It is particularly important to ensure that RFID systems do not interfere with nearby radio and television, mobile radio services, marine and aeronautical radio services and mobile telephones.

For this reason, it is usually only possible to use frequency ranges that have been reserved specifically for industrial, scientific or medical applications. These are the frequencies classified worldwide as ISM frequency ranges (Industrial-Scientific-Medical), and they can also be used for RFID applications.

In addition to ISM frequencies, the entire frequency range below 135 kHz is also suitable, because it is possible to work with high magnetic field strengths in this range. Particularly when operating inductively coupled RFID systems.

The most important frequency ranges for RFID systems are therefore 0-135kHZ, And the ISM frequencies around 6.78, 13.56MHz, 27.125MHz, 40.68MHz, 433.92MHz, 869.0MHz, 915.0MHz, 2.45GHz, 5.8GHz and 24.125 GHz.

In USA and Australia, the frequency ranges 888-889MHz and 902-928MHz are available and are used by backscatter RFID systems.

The useable field strength in the operating range of the planned system exerts a decisive influence on system parameters. This variable therefore deserves further consideration. In addition, the bandwidth (mechanical) dimensions of the antenna coil and the availability of the frequency band should also be considered.

DATA ANALYSIS

After collection of data, the original data points have been put to prepare the surface plots. These plots represent the actual area in 3D surface where the tag can be read properly.

These plots give an idea of the RFID footprint reading. The graphs were put together by using Minitab® software's 3-D wireframe plot.

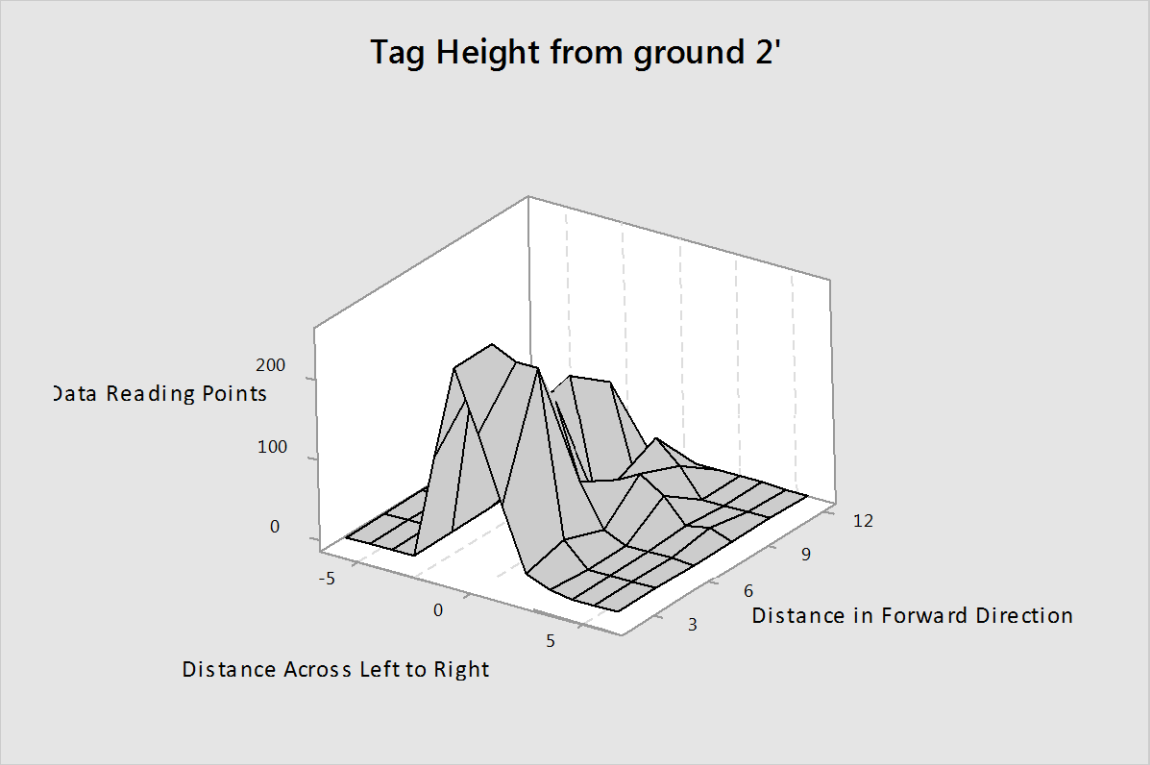

Figure 5: 3-D footprint of tag at height 2 feet from ground

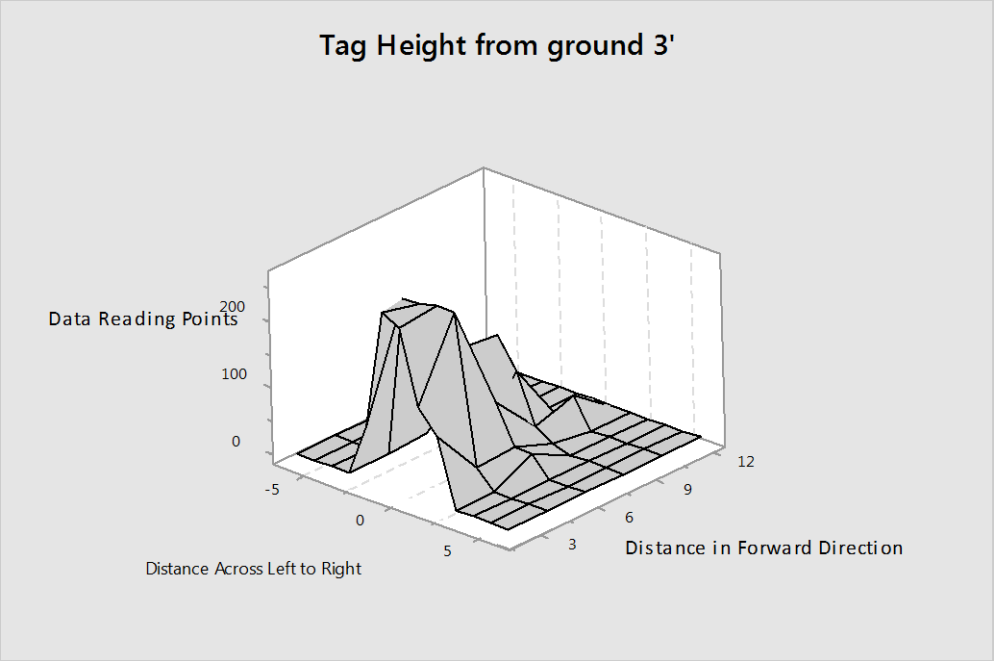

Figure 6: 3-D footprint of tag at height 3 feet from ground

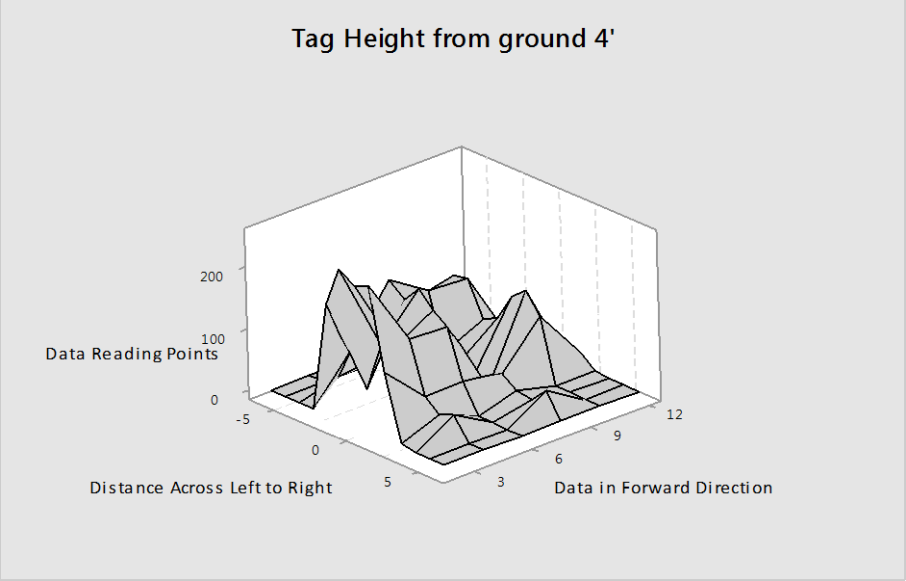

Figure 7: 3-D footprint of tag at height 4 feet from ground

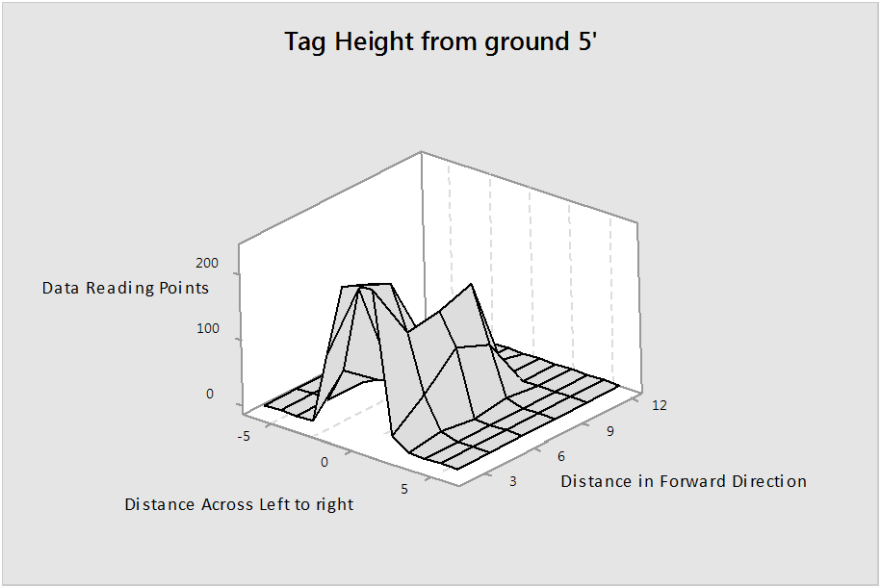

Figure 8: 3-D footprint of tag at height 5 feet from ground

It can be observed from Figure 5 to Figure 8 that the tag readability rate depends not only the distance across and distance forward but also on the tag position from the ground. Relatively higher readings are detected when the tag position is at 4 feet from the ground.

CONCLUSIONS:

In RFID technology it is extremely important to identify the tag position to get the best readings. But it has been observed that tag and antenna distance impact the readability. That is why the experiment shows success rate of tag readability by preparing a 3 dimensional footprint. It can be expected that this study on RFID footprint will serve as a reference and help to advance future researche.

Reference:

1. RFID HANDBOOK , Fundamentals and Applications in Contactless Smart Cards and Identification, Second edition, Klaus Finkenzeller
2. Reader Interface Guide, Alien Technology®, January 2007
3. Want, R. (2006). An introduction to RFID technology. *Pervasive Computing, IEEE, 5*(1), 25-33.