RAIN RFID Reader Antenna Selection Guide

Prabakar Parthiban
Department of Electrical and Electronic Engineering
Auckland University of Technology and Times-7 Research Ltd
New Zealand
prabakar.parthiban@aut.ac.nz

Giuliana Gilges-Richards
Marketing
Times-7 Research Ltd
New Zealand
giuliana@times-7.com

***Abstract*— This poster presents a RAIN RFID reader antenna selector guide for systems integrators. The specifications of commercial RAIN RFID reader antennas are analyzed to propose an antenna selector guide for different applications. Antennas are categorized based on their beam shape specifications, and an antenna selection guide is suggested. The proposed guide is comprehensive and simple to use.**

Keywords—UHF RFID, Beam shape, Fixed reader antenna.

I. INTRODUCTION

The preference for Radio-Frequency Identification (RFID) technology over other Automatic Identification (Auto-ID) techniques is growing in recent days due to its low complexity. Among the various types of RFID technologies, the UHF RFID is attractive due to its advantages such as low-cost tags availability, faster data rate, long-distance tag detection and so on. A global alliance that promotes UHF RFID for universal adoption is called Radiofrequency IdentificatioN (RAIN) [1]. It uses the GS1 GEN-2 protocol that is standardized by ISO/IEC 18000-63. The RAIN RFID system consists of a reader, reader antenna, tag and the software to communicate with the cloud server. There are a variety of RAIN RFID readers, reader antennas and tags in the market with different performance characteristics. Among these, reader antennas are often considered as trivial by the inexperienced RAIN RFID user. The RAIN RFID reader antennas are complicated and are not the same as the coils/loops used in LF and HF RFID. This poster presents a reader antenna selection guide for various RAIN RFID applications by evaluating commercial reader antennas' beam shape specifications.

II. COMMERCIAL RAIN RFID READER ANTENNAS

Theoretically, any antenna that works at the UHF RFID frequencies can be used with the reader for tag detection. As the members of RAIN RFID (reader antenna manufacturer category) comply with the RAIN Alliance's regulations, only those antennas are studied to propose the antenna selector guide. Members include reader antennas from Impinj, Zebra, Times-7, Kathrein, Alien, Invengo, tagitron, WNC, Arcadian, eCartes, IDRO, RAKO, Tyco, Convergence systems and Harting [2]. Commercially available passive RAIN RFID reader antennas can be broadly classified as near-field and far-field antennas based on their mode of operation. The former uses the inductive coupling, and the latter uses the capacitive/propagation coupling to read the RFID tags. Far-field antennas can further be categorized into different groups based on the electrical specifications such as gain, polarization, beam-width or by their mechanical specifications such as the size, environmental rating, antenna packaging and so on. RAIN RFID reader antennas are designed for two main frequency ranges namely 865-868 MHz and 902-928 MHz. Different countries have different frequency standards for RAIN RFID operations and the frequencies mentioned above (or their sub-bands) cover all the countries.

III. ANTENNA CATEGORIES

Commercial antennas can be broadly categorized based on their beam shape viz., spherical beam, fan beam and wave beam (fig.1). Spherical beams will have symmetric radiation whereas fan beams [3] will have asymmetric radiation in the antennas' azimuth and elevation planes. The antenna's gain and directivity are a function of the beam shape. A narrower spherical/fan beam antenna will have higher gain compared to a wider beam or a wave beam antenna. Most of the RAIN RFID far-field antennas are patch antennas with some exceptions such as the NeWave [4] which are omnidirectional wave beam antennas. A wider spherical beam is an outcome of a single radiating patch whereas a symmetric patch antenna array yields a narrower spherical beam. Fan beam antennas are asymmetric patch antenna arrays.

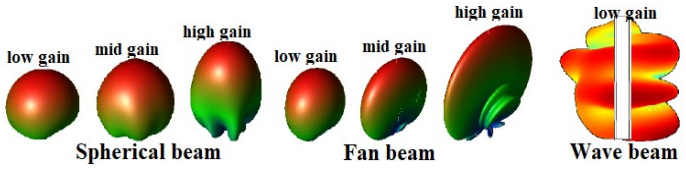


Fig.1. Types of far-field antenna beam shapes

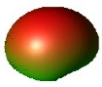
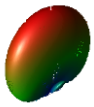
System integrators are often challenged with 100% tag detection accuracy and stray (unintended) tags isolation. Although the tag readability and stray tag filtering can be achieved using the features in the reader software [5], reader antennas do play a vital role in these aspects. An uncontrolled RF spill by far-field antennas causes stray tag detection while low power RF radiation leads to low tag detection read accuracy.

IV. ANTENNA SELECTION GUIDE

A beam shape specific antenna selection guide is proposed in this section. RAIN applications can be broadly classified into indoor and outdoor. Outdoor applications require physically robust antennas with outstanding environmental specifications such as the IP rating, high and low-temperature specs, ability to handle solar radiation, etc. The mechanical requirements for the indoor applications are different as they will have to be chemically resistant to cleaning reagents, able to bear loads in the case of shelving/cabinetry deployment and so on. Shelf antennas will also need to have even RF power distribution on its surface with no dead zones. The beam shape plays a vital role in both cases. Table. I elaborate on the antenna selection process.

978-1-7281-1210-7/19/$31.00 ©2019 IEEE

TABLE I. COMMERCIAL RAIN RFID READER ANTENNA SELECTION GUIDE

Operating mode			Read zone definition	Advantages	Commercial antenna examples	Example Applications
Far-Field Antennas	Spherical beam	 High gain	***Spotlight*** read zone *Symmetric HPBW*, < 50º	No stray reads, confined read zone, very long read distance, very easy to detect dense assets.	Times-7 A6034S (Indoor) Kathrein WIRA 40 (Outdoor) Invengo XC-AF26 (Indoor)	Vehicle tolling and cleaning bays, race timing finish lines.
		 Mid gain	***Floodlight*** read zone *Symmetric HPBW*, 50º to 80º	Wider read area, long read distance, easy to detect dense assets	Zebra AN480 (Indoor) Impinj IPJ-A1100 (Outdoor) RFMAX R9028LPV/R8658LPV (Outdoor) ALIEN ALR-8697 (Outdoor) IDRO IDRO256 (Indoor) Times-7 A5010 (Outdoor)	General asset tracking in warehouses and retail, shelving and cabinetry applications.
		 Low gain	***Fog-light*** read zone *Symmetric HPBW*, 80º to 120º	Very wide read area, short read distance, suitable for non-dense assets	Times-7 A5020 (Outdoor) ALIEN ALR-A0501 (Outdoor) Zebra AN610 (Indoor) Harting Ha-VIS RF-ANT-MR20 (Outdoor)	Desktop and point-of-sale applications, billing kiosks.
	Fan beam	 High gain	***Narrow curtain*** read zone *Asymmetric HPBW*, < 30º and > 60º	Very wide read area in one direction and very narrow read area in the orthogonal direction, very long read distance, very easy to detect dense assets	Invengo XC-AF35 (Indoor) Invengo XC-AF11 (Outdoor) Times-7 A5531, A5060, A6034 (Indoor), Times-7 A5530 (Outdoor) Kathrein WIRA 30 (Outdoor)	People portal and people tracking at entrance hallways, high-density asset tracking with very minimal stray reads in one direction.
		 Mid gain	***Wide curtain*** read zone *Asymmetric HPBW*, < 50º and > 75º	Wider read area in one direction and narrow read area in the orthogonal direction, long read distance, easy to detect dense assets	Zebra AN620 (Indoor) Times-7 A6032 (Indoor) Impinj Threshold (Indoor)	Retail applications to track assets in specific locations, integrated antennas in carts, shopping trolleys and vehicles.
		 Low gain	***Expanded curtain*** read zone *Asymmetric HPBW*, < 65º and >75º	Wide read area in one direction and slightly wide read area in the orthogonal direction, short read distance, suitable for non-dense assets	Times-7 B6031 (Indoor)	Narrow point-of-sale, billing kiosks and smaller shelf-based inventory
	Wave beam		***Fluorescent beam*** 360º Omni	Omnidirectional read range. A wide read area can be covered.	WNC Wave Antenna (Indoor)	Shielded shelving and cabinets, shielded portals
Near Field Antennas			***Proximity*** read zone	No surface dead zones, no stray reads, suitable for liquid and metal assets	Times-7 A1030, A1001 (Indoor) Impinj Mini-Guardrail, Matchbox (Indoor) Kathrein LORA (Outdoor)	Medial vials, vaccines, surgical instruments, grocery asset tracking.

The suitability of different antenna beam shapes for different read zone configuration is analysed. Antennas with the high gain spherical beam are recommended to those applications that require a spotlight type read zone whereas a high gain fan beam is suggested for asymmetric read zone creation. The former will be useful for applications like vehicle tolling in different toll booth's lanes while the latter can be used in creating an RFID portal that has a very narrow RF spill to eliminate the stray tag reads but has a wide RF energy coverage within the portal. Since near-field antennas do not have a far-field radiation pattern, their read zone characterization is different compared to the far-field antennas [6]. As the wave antennas are not directional, their characterization is also different compared to the rest.

V. CONCLUSION AND FUTURE WORK

A beam shape-based antenna selection guide is proposed by comparing the commercial RAIN performance specifications. This guide can be used by systems integrators to choose the right antenna for their intended read zones, after analysing the requirements for the applications. Examples of commercial antennas with the read zone characteristics are also reported. In future, beam shape configurations will be studied in detail and a reconfigurable beam shaping antenna design will be proposed.

REFERENCES

[1] H. Farhat, P. Iliev, P. Marriage and N. Rolland, "An Added Value Alternative to RAIN RFID Items Characterization in Retail," in *IEEE Access*, vol. 6, pp. 32430-32439, 2018.

[2] Rain RFID members, 2018. [Online]. Available: https://rainrfid.org/member-directory/?keywords_search=&member_category=reader-antenna-manufacturer. [Accessed: 31- Jan- 2019]

[3] D. L. Runyon, "Optimum directivity coverage of fan-beam antennas," in *IEEE Antennas and Propagation Magazine*, vol. 44, no. 2, pp. 66-70, April 2002.

[4] WNC, 2018. [Online]. Available: http://www.wnc.com.tw/index.php?action=pro_cate_third_close&top_id=106&scid=124&tid=146

[5] A. Buffi and P. Nepa, "The SARFID Technique for Discriminating Tagged Items Moving Through a UHF-RFID Gate," in *IEEE Sensors Journal*, vol. 17, no. 9, pp. 2863-2870, 1 May1, 2017.

[6] D. Ding, J. Xia, L. Yang and X. Ding, "Multiobjective Optimization Design for Electrically Large Coverage: Fragment-Type Near-Field\/Far-Field UHF RFID Reader Antenna Design," in *IEEE Antennas and Propagation Magazine*, vol. 60, no. 1, pp. 27-37, Feb. 2018.