RAIN RFID Reader Antenna Selection Guide

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Abstract— This poster presents a RAIN RFID reader antenna selection 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.

![Types of far-field antenna beam shapes](image)

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 RFID 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.
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.

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<td>Spherical beam</td>
<td><strong>Spotlight read zone</strong>&lt;br&gt;High gain&lt;br&gt;Symmetric HPBW, &lt;br&gt;50°</td>
<td>No stray reads, confined read zone, very long read distance, very easy to detect dense assets.</td>
<td>Times-7 A6034S (Indoor)&lt;br&gt;Kathrein WIRA 40 (Outdoor)&lt;br&gt;Invengo XC-AF26 (Indoor)</td>
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<td><strong>Floodlight read zone</strong>&lt;br&gt;Mid gain&lt;br&gt;Symmetric HPBW, 50° to 80°</td>
<td>Wider read area, long read distance, easy to detect dense assets</td>
<td>Zebra AN490 (Indoor)&lt;br&gt;Impinj JP-1100 (Outdoor)&lt;br&gt;RFMAX R9028LPV/B2658LPV (Outdoor)&lt;br&gt;ALIEN ALR-8697 (Outdoor)&lt;br&gt;IDRO IDRO256 (Indoor)&lt;br&gt;Times-7 AS010 (Outdoor)</td>
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<td><strong>Fog-light read zone</strong>&lt;br&gt;Low gain&lt;br&gt;Symmetric HPBW, 80° to 120°</td>
<td>Very wide area read, short read distance, suitable for non-dense assets</td>
<td>Times-7 A5020 (Outdoor)&lt;br&gt;ALIEN ALR-A0501 (Outdoor)&lt;br&gt;Zebra AN610 (Indoor)&lt;br&gt;Harting Ha-VIS RF-ANT-MR20 (Outdoor)</td>
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<td><strong>Narrow curtain read zone</strong>&lt;br&gt;High gain&lt;br&gt;Asymmetric HPBW, &lt;br&gt;30° and &gt; 60°</td>
<td>Very wide area read in one direction and narrow read area in the orthogonal direction, very long read distance, very easy to detect dense assets</td>
<td>Invengo XC-AF35 (Indoor)&lt;br&gt;Invengo XC-AF11 (Outdoor)&lt;br&gt;Times-7 A5531, A5060, A6034 (Indoor),&lt;br&gt;Times-7 A5530 (Outdoor)&lt;br&gt;Kathrein WIRA 30 ( Outdoor)</td>
<td>People portal and people tracking at entrance hallways, high-density asset tracking with very minimal stray reads in one direction.</td>
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<td><strong>Wide curtain read zone</strong>&lt;br&gt;Mid gain&lt;br&gt;Asymmetric HPBW, &lt;br&gt;50° and &gt; 75°</td>
<td>Wider read area in one direction and narrow read area in the orthogonal direction, long read distance, easy to detect dense assets</td>
<td>Zebra AN620 (Indoor)&lt;br&gt;Times-7 A6032 (Indoor)&lt;br&gt;Impinj Threshold (Indoor)</td>
<td>Retail applications to track assets in specific locations, integrated antennas in carts, shopping trolleys and vehicles.</td>
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<td><strong>Expanded curtain read zone</strong>&lt;br&gt;Low gain&lt;br&gt;Asymmetric HPBW, &lt;br&gt;65° and &gt;75°</td>
<td>Wide read area in one direction and slightly wide read area in the orthogonal direction, short read distance, suitable for non-dense assets</td>
<td>Times-7 B6031 (Indoor)</td>
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<td><strong>Fluorescent beam</strong>&lt;br&gt;360° Omni</td>
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