

Overview

RFID system performance hinges, in large part, on tag performance. And the tag, in turn, relies on a handful of elements that determine its performance—the antenna being an especially critical one. This series of tech briefs examines the essential qualities of tag antennas, the keys to selecting the right tool for the job, as well as their performance characteristics across a variety of environmental and use conditions. This installment focuses on the role of the reader antenna in the RFID system.

The Reader Calls the Tune

Much of the discussion in this series has been concerned with tag performance with respect to the reader. But what role does the reader antenna play on the stage of tag performance?

In basic terms, an antenna converts electrical current into electromagnetic waves that are then radiated into space in a particular pattern at a given level of intensity. In an RFID application, this definition is most appropriate when applied to the *reader* antenna. The parameters of greatest interest to the tag are polarization (or the reader antenna wave's electric field vector, orientation, and direction) and the power level of the transmission.

A linearly polarized antenna radiates entirely in one plane in the direction of signal propagation (see Figure 1). Dipole antennas, for example, are most sensitive to RF fields whose polarization is aligned with the orientation of the element. As such, the application of linearly polarized antennas is somewhat restrictive; the success of the system depends on the proper orientation of the tag to the reader signal. That is, the receiving antenna must be co-polarized with the incident wave. If this optimal orientation is maintained, the result is the most efficient transfer of power. But given the diversity of applications, this may not always be possible.

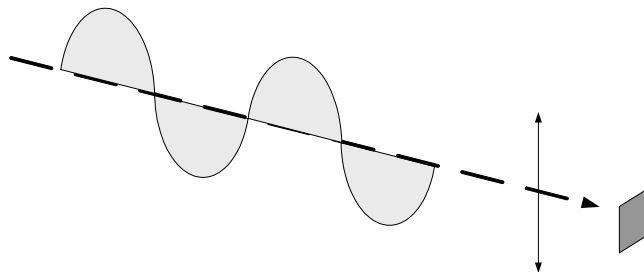


Figure 1 Linearly Polarized Reader Antenna

In a circularly polarized antenna, the plane of polarization rotates in a circular fashion (effectively a corkscrew when considered in time), making a complete revolution during one period of the wave. A graph of the radiated electric field would show the wave oriented one way in time (vertically), then in another direction at another point in time (horizontally), and so forth, as it makes its rotation (see Figure 2). As such, a single dipole within this field will be responsive to only those portions and durations of the wave that align to its particular orientation. The good news is that regardless of the tag's orientation, the wave will eventually come around to illuminating it. But because the reader antenna will have spent half its time radiating in a direction not friendly to the tag, the system will have lost half its effective power (3 dB) and 30% or more of its potential range. In this scenario, the tag (with a single half-wave dipole antenna) will still be read, but with reduced range. One solution to this problem is to use reader antennas with greater directivity, but the benefit of their higher gain comes at a cost of narrower beamwidth, and with it, a smaller read capture zone.

The Reader Antenna

A tag antenna can, however, be designed to take full advantage of the circularly polarized reader antenna. Imagine matching the reader's circular pattern with a similar geometric configuration at the tag. Such an example is Impinj's dual dipole Jumping Jack™ (see Figure 3), with its back-to-back quasi-spirals. Because of its dual axis orientation, it is highly responsive to all phases of the circular polarization.

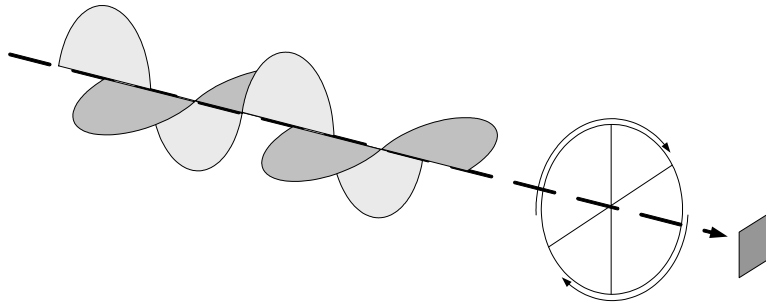


Figure 2 Circularly Polarized Reader Antenna

Multipath Fading

Another variable impacting system performance is the multipath effect. As a reader's RF waves propagate through an environment, they bounce off the floors and ceilings and are deflected by the walls. Other objects in the path also contribute signal reflections, all of which result in the radiated RF wave traveling multiple paths to the tag, some of which are time delayed, and consequently may be out of phase with one another. In other words, the peak of one wave may arrive at the tag while the valley of another arrives at the same time—the result of getting there just a little late. When this happens, the two signals effectively cancel each other out, and the result is no power to the tag. On the other hand, if both reflected waves arrive at the tag at precisely the same time, and are in-phase, the result is a doubling of the electric field strength, and an increase in range. A simple dipole in such an environment, therefore, has a 50-50 chance in any instance of getting either a good amount of power, or none at all. Antenna diversity minimizes this impact, as it provides the tag with two independent channels by which it can receive energy. Other elements of the multipath solution are tied to deployment issues such as the optimization of reader antenna placement and the removal of reflective objects in the general signal path.

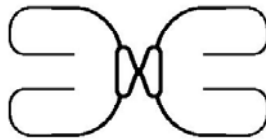


Figure 3 Impinj Jumping Jack™ Antenna Designs

Directivity

Directivity, as the term implies, is a measure of how well an antenna focuses or directs the energy it radiates; the greater the directivity, the more focused the energy. By contrast, an isotropic (omnidirectional) antenna has zero directivity. An antenna, then, can be arranged such that its radiation is focused in a single direction. With no increase in power from the transmitter, the amount of radiation in that particular direction is greater, creating the *impression* of gain, and an actual increase in read range with greater immunity to multipath effects.

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