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The Myths of LF vs. HF

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Depending upon application requirements, low-frequency passive RFID tags and readers often outperform their high-frequency counterparts—so why do people believe otherwise?

By James E. Heurich

Dec. 21, 2009—Being on the sales front of RFID hardware for many years, and as a hands-on owner of an RFID hardware development and manufacturing firm to which I have dedicated my life and soul for nearly 20 years, I have voraciously read just about any available matter on the subject, while scoffing at some writings and deeply appreciating others. In so doing, I have begun to notice a trend—a myth, really: that being the assumption that low-frequency (LF) RFID is a technology of old, a variant that may have been at the dawn of the RFID field but is now largely written off as a solution of yesteryear. Part of that myth is the belief that high-frequency (HF) passive RFID tags and readers outperform LF passive RFID tags and interrogators in every respect.

It's not true, folks, and I intend to show you why.

I had initially noticed this trend during the sales process—in inquiries from trade shows, in requests for solutions directly from the Internet, and on visits to potential clients, whereby I first had to sell LF over HF before I could move on to marketing my products, in terms of performance and price. Then I began to notice it in articles and application stories, and when I noticed those articles were written by providers of HF products, I again smirked and thought, "But, of course."

In the past year, however, I have also begun to take note of articles published by RFID-focused magazines, journals and trade organizations, so I began to inquire as to why. A recent reply from an editor floored me: "This is all that I have read and been told in press releases, interviews, trade shows, other forms of RFID medium—be they blogs, articles, white papers or application stories." This seems to be the general answer.

My company sells both HF and LF RFID products, which I hope will earn me some impartiality points.

I intend to address two main issues in this writing: first, a fair and documented comparison of LF and HF, and second, a history of the RFID market's development, outlining why HF is more predominantly available than LF today. Let's touch on the second issue to begin with, then move back to the first in comparing LF and HF performance, and then wrap up by finishing with the second issue.

HF's Notoriety

The reason most folks have heard and read so much about HF in press releases is that the technology is practically all that is available these days from RFID tag and reader manufacturers (we'll exclude ultrahigh-frequency RFID hardware for the purpose of this argument). Why is that? There are three

reasons, all intertwined:

1. The market for larger-volume tag opportunities
2. The ISO standards on which HF RFID hardware is based
3. The growth of multiple sources of standard wafers (EEPROMs), allowing more entrants into the market—and those being HF

Back in the day, there were no wafers of standard EEPROMs, and there weren't three or four sources of wafer manufacturers with interchangeable chips, or knock-off interchangeable chips made in the Far East. The early RFID companies owned their own proprietary wafers and chips. It took 18 months (if you were lucky) and up to a million dollars in funding to develop one's own chip. The growth of HF wafer developers and providers enabled many aspiring tag and reader manufacturers to enter the RFID market without the long lead time and expense of manufacturing their own EEPROM chips. The growth of HF wafer developers and providers would not have occurred without reasons 1 and 2 above, nor could 1 and 2 be supported in the long term without the support of reason 3.

And yet, LF RFID still enjoys a healthy market share, though it is not as well-known since most hardware competitors exclusively carry HF nowadays (again, UHF not withstanding). Think about it: Aside from the animal ID market and prox security systems, there aren't nearly as many LF RFID hardware developers and manufacturers.

Comparing LF and HF Performance

As I mentioned earlier, my company also offers HF products in addition to LF. If, during the sales process, I believe HF to be the competently recommended frequency, I will say so. Whether my company wins a $100,000 sale for HF or LF makes little difference to me.

Now let's get straight to the chase. I have been told that HF RFID reads faster than LF, that HF generally outperforms LF, that it performs better in a metal environment, that HF read ranges are better than LF, that HF is the standard and can be multi-sourced due to the existence of the ISO 15693 and 14443 standards, and that it is less expensive than LF.

Let's address these claims one at a time, after taking a look at a short video showing a demonstration involving eight passive LF RFID tags attached to a toy train passing 32 RFID antennas (www.youtube.com/wa). For those skeptics who will now claim this is a perfect lab environment, let's view another video in which the products are on display at a trade show (www.youtube.com/watch?v=Wx27TkjEOUU&fea

Read Speed. Each time the train does a loop, there is an occurrence of eight times 32 reads, and we have run this setup for days on end without missing a read—the U.S. Food and Drug Administration (FDA) demands such a high performance level in certain applications—so I would assume that is proof enough for readers. Although the speed is not documented, I challenge any HF company to match these speeds. Yes, HF has a higher bit-rate transmission rate from the tag. Why? Well, HF tags tend to have higher amounts of memory, and faster bit-rate transmissions are necessary. However most

current automation projects employ a tag's unique identification (UID) number, and those tags featured in the video are of a mere 8 bytes. While LF tags generally (though not always) tend to have smaller amounts of memory, it's not about the data-bit transmission rate, but rather the reader's decoding (demodulation) speed and the communication process from the reader to a host. A third video (www.youtube.c) shows the train completing a loop in just 7 seconds (256 reads), which equates to a read every 27 milliseconds.

Proximity of Readers and RF Interference. HF readers placed close to each other (5 inches apart) will interfere with one another, and a diminished or zero read range will result. There is no diminishment of performance in these LF systems, however. (Note: Not all LF systems are the same, and the intellectual property of those represented in the videos make the difference.)

Cross Talk. HF readers placed in such proximity to each other will result in cross talk—the reading of a second or third tag instead of the tag directly positioned to the interrogator. There is no cross talk with these LF systems.

Metal. While the video does not show metal, these products can be mounted on metal, and in highly metallic environments, without performance degradation. In fact, metal can help to strengthen read-range performance, due to the properties of RF reflection.

Read Ranges. LF actually exceeds HF in read-range performance. Just ask the folks in Charlotte, N.C., about their tests of HF vs. LF and read-range performance for the new NASCAR museum being put together. The LF system performed at 4 inches, versus 2 inches for the identical interrogator and tag size. There are LF tag and reader combinations that will read in excess of 1 meter (3.3 feet). Naturally, this takes an extremely large reader antenna (4 feet by 2 feet), and a tag nearly the size of a sheet of paper. I know of no HF systems that can perform as such, though there may very well be one or two I don't know about.

ISO Standards. Many users assume that by adopting HF RFID technology, they can better mitigate risk, because HF hardware based on ISO standards is available from multiple sources. In reality, however, conforming to ISO standards does not always equate to interchangeability.

Cost. Many assume that LF cannot compete in cost with HF—again, a fallacy.

Let's go into more depth on these points, beginning with the issue of metal and a very specific application: pharmaceuticals. I'm not referring to the well-publicized e-pedigree pharma app that has had some push and media coverage in recent years. There is a very large market for the home delivery of medicines and prescriptions from mail-order pharmaceutical companies—an application that has been dominated by LF products for 15 years. Briefly, the application involves the identification of pill bottles as they sit in a small, specially designed carrier called a puck. In the bottom of that puck sits an RFID tag, thus enabling the pill bottle to be transported throughout a warehouse facility on a small conveyor, from the initiation of an order to the routing and filling of the bottle at automated dispensers

that count out the number of pills, to the end of the process, where a vision system examines the contents for correctness and a pharmacist double-checks that the proper drugs are being shipped to consumers. The puck is also married to another, larger tote carrying the remaining pieces toward the order's completion, such as the pill bottle label, the mailing label, the size and specific cap for the bottle, prescription instructions, and the package in which the order is to be mailed. Yes, 100 percent accuracy and 100 percent read rates are demanded. It is a deadly serious business, due to the fact that if a mistake is made, someone could die.

An HF competitor stepped into the fray several years ago, and the ensuing installation was a disaster. To make a long story short, the project was plagued by missed reads and cross talk prevalent in the highly metallic environment of small conveyor systems, where readers are often close to one another. The HF installation resulted in a year-long delay of plant start-up, litigation, contractual fines for claims of non-performance, and project leaders and management heads who curiously took employment elsewhere—a disaster so huge that HF will never again be considered in this application. When I interviewed both the project's integrator and end user, neither had any knowledge of the points discussed herein regarding LF vs. HF. Yet, the fact remains that 99 percent of all mail-order pharmaceutical applications employing RFID tags have employed LF technology since the inception of the market, almost 20 years ago. Why? Because LF outperforms HF in meeting the demands of that particular application, and remains the prudent choice.

Another example involves a company that approached RFID Inc. last year, to develop an RFID system capable of reading and writing to one of two tags sunk flush into metal separated by mere millimeters. The company was willing to—and did, in fact—pay my firm more than half a million dollars for the manufacturing rights. It allocated resources and time toward the project that more than tripled that dollar amount, and then rolled the solution out product-wide into the surgical medical industry, as part of its high-integrity solution. This company (which cannot be named here for reasons of NDA) studied intently the RFID solutions on the market, in order to determine which was right for its particular application. The reasons should be obvious why we recommended—and why the company's management selected—LF over HF.

As for cost, back in the early to mid 1990s, HF was conceived in order to address applications of large tag volume, whereby the tags must be less expensive than LF tags—which, at the time, cost well above $1 apiece, but that does not mean LF can not compete today. If we are talking about a large volume of tags that are minimally packaged—call it an inlay, a substrate, a label form factor—then yes, facts are facts: LF necessitates a more costly hard-copper coil as a tag antenna, whereas HF can use fluid, ink or etching processes to create a cheaper antenna coil. But if the application calls for any packaging of some integrity—plastic, high-temperature materials, ABS—then the playing ground levels out, and LF can not only compete, but beat HF in pricing. In fact, an LF tag employing an EM Microelectronic EM4102 or equivalent read-only chip will beat the price of an HF tag with 2 kilobits of memory or more.

However, LF tags cannot compete with HF tags in certain applications, such as library books, smart cards or passports, all of which receive a great deal of press. Not much attention or press, on the other

hand, is given to the fact that the high-volume tagging of beer kegs and LPG cylinders is typically accomplished with LF RFID.

Regarding standards, let's face it: In most applications, Americans simply don't care if a product is standard or not. The American thought process is that if a product can be made faster, cheaper and better, the public will not care about standards, but rather about performance and innovation. Yeah, that's right, I said it—standards can inhibit innovation. Just ask a rancher buying ISO 11784/5 animal ear tags for $3 to $5 apiece, when other markets enjoy a lower price for non-ISO-standard product.

Standards can be very necessary in terms of growing a market like supply chain visibility, (Wal-mart's and the U.S. Department of Defense's well-publicized initiatives, for example). But, if someone tomorrow were to invent a process involving 1-cent finished tags that could be read on liquid and metal without the need for spacing or backing materials, then EPC Gen 2 products would be tossed aside like day-old salad. However, I digress from what I mean to communicate, which is that just because HF RFID hardware may meet the ISO 15693 or ISO 14443 standard does not always mean the hardware is interchangeable between RFID vendors—and certainly not that they are equal in performance.

Here is an example: Let's say an automation project requires 500 interrogators and 10,000 tags meeting the ISO 15693 standards. Will the tags carry EEPROM chips complying with ISO 15693? Yes. Once the readers are installed, can the end user then go out and find replacements that operate identically to those initially installed? No. If the tags are initiated with a proprietary bit scheme prior to delivery, can they be made to be a single-source item (proprietary)? Yes. And yet, the whole system conforms to the ISO 15693 standard. Sounds like a crock to me.

Not that I don't appreciate hardware that complies with RFID standards. I do—and I sell a lot of it. It's just that in some instances, HF is chosen over LF due to the ISO standards, when in fact, they are anything but interchangeable, and this should not always be a basis for decision-making. The choice of LF versus HF is about having the right product for the application, as well as ROI and the bottom line. Without the right product, there is no ROI. And without ROI, there is no point in continuing.

The decision to move forward with ISO-standard-compliant product is normally based on a mitigation of risk—when, in fact, the lie will not be uncovered until it is too late, when the RFID manufacturer obsolesces the product, thereby stranding the end user with an ugly date named reality. There are ways to mitigate risk contractually, which include ensuring the product is ISO-standard-compliant, as well as placing the technology IP into escrow should, for whatever reason, the manufacturer not be capable of offering (or willing to provide) future support.

In summary, I hope this article educates and sets the record straight. LF RFID is not yesterday's product—it can outperform HF, depending upon the application requirements. It is not to be left out of the decision-making process due to risk mitigation, and it is equal in price to—and can be less expensive than—HF. At the same time, HF has its own distinct advantages, including larger tag memory; it is certainly closer to true standards, has driven the general growth of the RFID market and

supplies solutions to markets previously unavailable, and it can also be less expensive, depending upon the application.

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