RF Tags - Introductory Basics

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This paper is intended to serve as a primer on the possibilities and limitations of RF tags for use in inventory control, supply chain management and expanded applications. Hopefully it will add context to the general industry hype and provide a basis in reality for what RF tagging really can do at present and what it is projected to do in the future.

An RF tagging system requires a minimum of two components, a tag and an interrogator. We often classify RF tags into three main categories. The categories are distinguished by primarily by functionality of the tag. The tag categories are: a) passive, b) semi-passive and c) active. The tags can be read only (e.g. RFID), read/write (e.g. medical dog tag), or sensor based (e.g. temp-tag). The interrogator is a specialized radio transmitter, receiver, antenna and computer that communicates with the tags. It ranges in complexity from the very simple to the very sophisticated depending on the application.

The passive tags use backscatter modulation to reflect incoming RF energy from the interrogator to communicate via a code sequence that may be either firmware (read only) or software based (preprogrammed or read/write). One can think of the tag as a small reflector that modulates the RF energy from the interrogator, reflecting a preset sequence of information (i.e.. an ID code, a status code, a security code, etc.) back to the interrogator which in turn filters and interprets the data. These passive tags do not contain a battery to run the electronics, but rather rely on the RF energy radiated by the interrogator to power the electronic components and activate the device. As a consequence the passive tags have an intrinsically short range which depends on many factors including the RF power in the interrogator, the frequency of operation, the configuration and size of the antenna, and the power consumption of the electronics. Passive tags range in size from millimeters to tens of centimeters. They can be ridged or flexible. When used with an unlicensed interrogator (i.e. less that 1 watt effective radiated power at the antenna) they have reliable read ranges from a few millimeters to about 3 meters. One might reasonably expect the range for reliable operation to extend to something over 10 meters in the near future. Current tags range in cost from about $2 for very simple tags to over $20 for more complex devices. The large demand for these devices is expected to drive prices below $0.25 for the very simple, short range devices. The short range devices might be expected to displace many bar code and magnetic strip applications currently in use by virtue of the ease of reading as the prices drop.

Semi-passive tags also use backscatter modulation to communicate with the interrogator. The difference is that they have an energy storage device on board (e.g. a battery) which powers the electronics. The interrogator wakes up the tag to begin communications. Since the RF field strength can be much less for this tag, the range of the tag is increased over that of an identical passive tag by over an order of magnitude. Presently one can expect read ranges in the 10 to 100 meter range again depending upon the design considerations. Ranges of up to 200 meters may be possible in the future. The on-board power also allows the tag to perform functions such as extended memory, switching and sensing. The disadvantage of the semi-passive tag is that the battery has a finite lifetime if it is not recharged and it adds to the cost of the tag. Battery recharging schemes based on parasitic RF power are being contemplated to enhance the useful life beyond the current calculated 30,000 read cycles. Currently semi-passive tags range in price from about $10 to $100 depending on functionality and volume. In the future one might expect these tags to drive down into the sub $5 range. Because of the cost, applications for these tags are

generally more limited to high performance areas such as high value item tracking, large data content storage QA, long range inventory, activation/deactivation theft protection, etc..

Active tags are distinguished by the presence of active RF transmitter on board. Depending on the type of RF communications incorporated, the read range of these tags can exceed easily 500m and the onboard power required by the transmitter can be used to power other functions such as active multiple sensors, intelligent processing of data, etc. The tags can be set up as beacons which transmit periodically or transponders which only speak when spoken to. Battery replacement/recharging is generally required more frequently because of the power consumption of the transmitter required to attain the range needed. These tags are the most versatile of the categories and generally the most expensive running from about $50 to $500 depending on function.

The interrogators can range from simple hand held devices, to brief case sized devices with fixed mount antennas. They may contain active displays for storing and displaying data or may be configured as relay devices to connect directly into an existing communications network depending on the application. They may be single or multiple functions (e.g. containing both RF and optical bar code input channels). Generally the current families of readers range in sold for $1,000 to 50,000 depending on power, compute capabilities, range, and functionality. In the future expect costs to drop into the sub $500 range as volumes increase and protocols standardize.

When considering an RF tag system, one should consider not only the cost of the system, but the cost of managing the data that results. Factors such as communications with central data bases, construction and maintenance of the data basses, monitoring and display capabilities, linkage with other systems, etc.

RF tags can be very versatile. The applications are just starting to emerge. The possibilities are endless. They can incorporate encryption or act totally stealth until activated by a security code. They can contain large amounts of accessible data (medical records, QA/QC records, shipment records, maintenance data, user instructions, transaction data, part assembly and lot numbers, warranty information, etc.) or simply contain a unique ID code. They can be used as security devices (e.g. seals, theft protection, authorized use only enabling, etc.). They can talk to one another when in the same RF field. They can contain single or multiple sensors for monitoring physical, chemical and biological threats. They can be remotely located with accuracies less than 0.1 meter.

They cannot do everything. Tags are subject to real RF constraints. They cannot be seen when shielded in a metallic enclosure without sufficient RF leakage or coupling antenna. They are generally orientation sensitive and subject to multi-path interference which limits sensitivity and communications speed in some environments. Tags, especially from different manufacturers, are not the same (many different communications protocols, frequencies and designs) requiring different interrogators and are generally not compatible with one another.

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