Position Tracking of an Active RFID tag using Magnetoquasistatic Fields

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***Abstract*—The ability to track an active radio-frequency identification (RFID) tag using wireless techniques is an area of increasing interest and research. In particular, applications where obstructions may interfere or inhibit the use of more common wireless techniques, such as ultra-wideband (UWB) and global positioning systems (GPS), are often encountered. In this poster we present a wireless position tracking approach using magnetoquasistatic fields and show that it is an excellent technique for locating an active RFID tag. Our approach enables long range position tracking of an active tag and is unimpeded by obstructions with weakly conducting dielectric, such as groups of people [1].**

Wireless position tracking is of increasing interest to society today owing to applications such as navigation and asset-tracking [2]. Despite numerous advances, current techniques suffer reduced performance when in proximity to weakly conducting dielectric bodies such as the human body or when in non-line-of-sight (NLoS) environments [2], [3]. These drawbacks significantly limit their use in some applications, such as sport events, where the line-of-sight (LoS) to the tag is blocked or the tag is in close proximity to large groups of people.

A technique using magnetoquasistatic fields was recently shown to enable long range position tracking, even in a NLoS environment or in close proximity to groups of people [1]. This technique uses quasistatic magnetic fields, which are only slightly perturbed by the presence of weakly conducting obstacles, to overcome traditional limitations of systems using electric fields or radiating waves, e.g. UWB, GPS, etc. In this poster we present an RFID system that builds upon the magnetoquasitatic tracking approach to develop an active RF tag which can be easily tracked, even in the presence of many obstructions. The tag consists of of a simple battery-operated low-frequency oscillating circuit driving an electrically-small loop, such as that shown in Fig. 1. Due to the small size of the loop and the long wavelength of the field, a magnetoquasistatic field is produced that can be sensed at long distances [1]. A receiving loop is used to measure the field strength and from that, the RF tag's distance can be calculated. By using multiple receiving antennas, both distance and spatial location of the RF tag can be determined.

The magnetoquasistatic fields generated by the RF tag, while excellent for NLoS environments, do induce non-negligible eddy-currents in electrically-large conducting bodies such as the earth. These eddy-currents create secondary fields that are also detected by the receiver, which results in an error in the distance estimation. These errors can be significantly reduced by accounting for the eddy-currents within the earth using complex image theory [1]. Since the problem space is significantly smaller in comparison to the radius of earth, we can approximate the problem as a source (active tag) above a semi-infinite conducting half-space. For the quasistatic case, the total fields above the half-space are well approximated as those due to the source above the half-space ($z = h$, where the conducting half-space is defined for $z \leq 0$) and an image of the source at a complex depth beneath the half-space ($z = -h - \delta(1 - j)$) [4]. The complex depth accounts for the finite conductance of the earth and allows us to calculate the the secondary fields generated by the induced currents within the earth. Using these and the primary fields, we can accurately calculate the distance of the RF tag from the receiver.

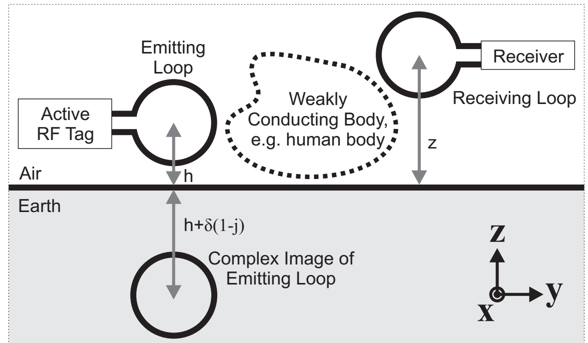

Fig. 1. Complex image theory for magnetoquasistatic fields generated by an active tag above earth. The active tag consists of a battery-operated oscillating circuit driving an electrically-small loop.

In this poster we will present our RF tag tracking concept and the application of complex image theory to accurately determine the tag's distance. We will show that the accuracy of this technique is comparable to, or better than, techniques such as GPS, UWB, and RFID, all of which operate best with a clear LoS. Because low frequency magnetic fields are not significantly altered by NLoS or proximity to lossy non-magnetic dielectrics, this technique offers further improvements in applications where radio wave propagation based techniques provide unreliable tracking.

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