Long-Range Ultra-Wideband Radio-Frequency Identification

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Radio Frequency Identification (RFID) is an automatic identification technology, similar to barcode, but with the distinct advantage that it does not require line-of-sight operation — it uses radio waves to communicate with the target tags. The key challenges in RFID technology are to assure connectivity to the tags, to determine accurate position, and to reliably communicate sensor status if needed, while reducing the costs of the infrastructure and tags. Since ultra-wideband (UWB) signals have been demonstrated to help in good connectivity and position fixing, in this project we explore the possibility of extending the use of UWB techniques to RFID.

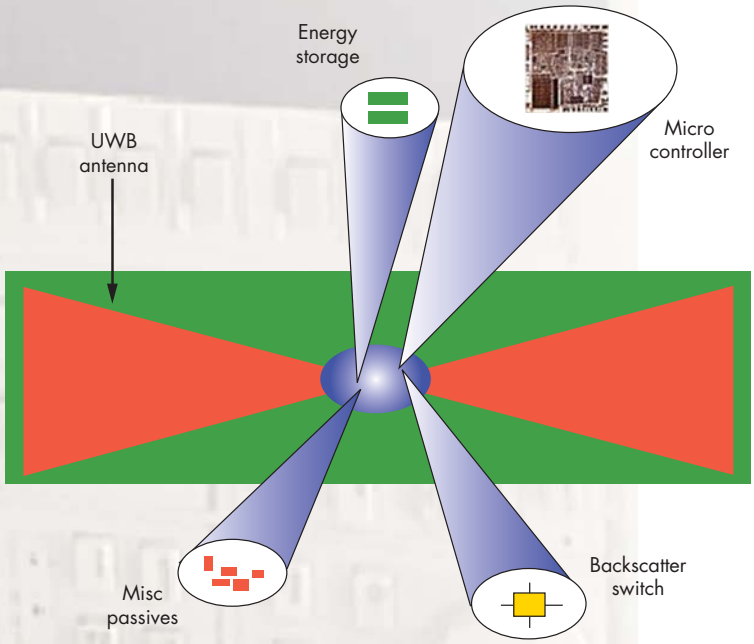

Figure 1. Schematic illustration of a UWB RF tag.

UWB RFID technology would encompass UWB pulse generation, remote powering of tags at longer distances, the steering of antennae, and defining an infrastructure matching the particulars of the environment.

Even state-of-the-art RFID systems, such as automatic identification and data capture (AIDC), are essentially short-range (less than 2 m), using narrowband inductive systems. On the other hand, target objects in areas of interest are often located in cluttered or harsh environments, so they are best tackled by wideband RF pulses.

The class of problems we plan to focus on is the use of labels in which passive RFID devices are imbedded onto disk drives, removable media, file folders, and other materials that physically contain classified or otherwise sensitive information. Ultimately, much will depend on whether we can achieve a cheap package with useful ranges and spatial resolutions. There are some concerns with the introduction of RF signals in classified environments, but the use of UWB signals may overcome many of these obstacles.

Project Goals

Generally, we plan to take advantage of UWB RF pulses to encompass: 1) longer range of tag interrogation, given equal average power from the interrogator (or conversely, greater range in sensitivity); 2) more immunity to signal degradation and multipath effects; 3) a higher degree of security and immunity to eavesdropping; 4) a greater potential for anti-collision in multi-tag environments; 5) more uniform coverage of a volume of space; and 6) the ability to focus the tag interrogation to a localized point in space.

Another important goal is to demonstrate the utility of integration of the appropriate COTS technology with LLNL-proprietary covert long-range UWB tags for CREM monitoring. In a phased, low-risk approach, we propose to implement passive UWB tags and tag readers with a range of about 10 m. COTS systems will also be custom deployed for laboratory testbed evaluation and performance comparison.

Relevance to LLNL Mission

On-demand real-time identification and tracking of devices using RFID tags is a powerful technology for improving Laboratory security. The need to make some classified items fully accountable has been identified. The vulnerabilities of commercial RFID products are only beginning to emerge.

FY2004 Accomplishments and Results

We have solved many of the key problems, described briefly as follows: system and block configurations of the UWB RFID have been completed, with simulation and analysis (see Figs. 1 and 2); the precise generation of a high-power UWB sub-ns duration transmitters have been demonstrated (see Fig. 3); the remote powering circuit that will switch on the tags (or controllers) for response has been completed; RFID systems for tests and analysis have been surveyed and acquired; theoretical analysis and laboratory experiments for range vs. peak voltage received at the tags for remote powering have been completed.

Initial experiments indicate that both the tag readers and the tags themselves will be small and eventually low-cost systems. The passive or semi-passive tags can be planted in places of interest without intervention for many years. Most of the unresolved technical problems that remain are concerned with the logistics of the deployment and application issues, such as speed of reading, number of tags, continuous or event-driven monitoring, and other integration, interface, testing and performance issues.

Related References

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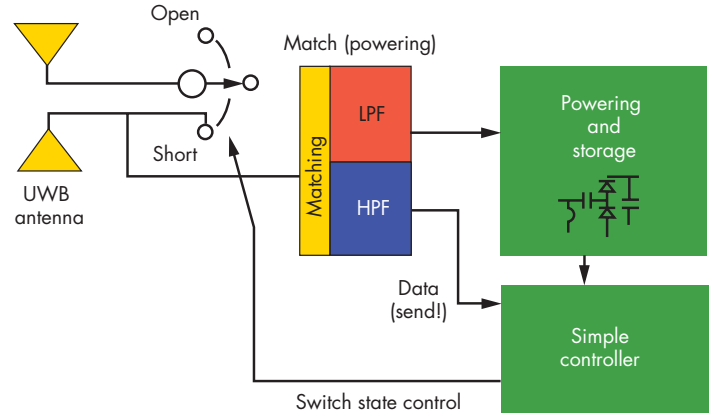

Figure 2. Block diagram of a long-range UWB tag.

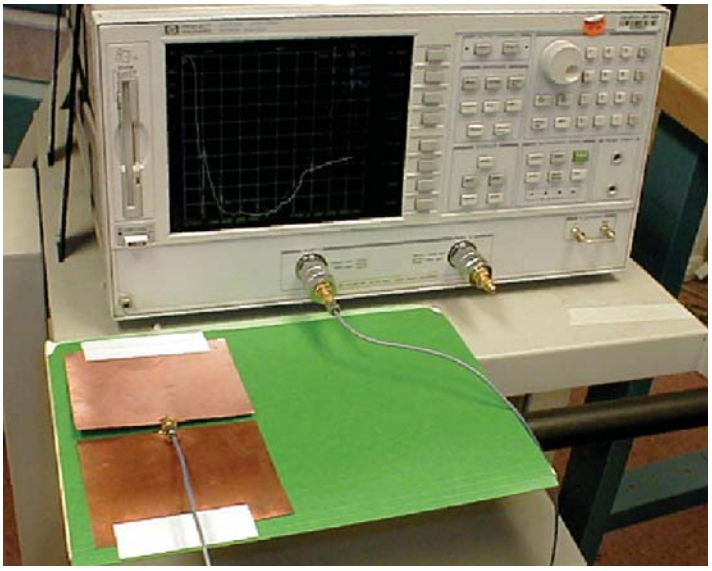

Figure 3. UWB tag antenna for folder identification.