OAK RIDGE NATIONAL LABORATORY
MANAGED BY UT-BATTELLE FOR THE DEPARTMENT OF ENERGY

Low Frequency Radio Identification

Low-Frequency Radio Identification Systems

Purpose: Low-frequency radio identification has unique tracking and inventory applications within secure facilities. The naturally rapid falloff of signal power reduces the likelihood of eavesdropping, and the signal propagation characteristics make it suitable for use on metallic and liquid objects.

Sponsor: Department of Energy Office of Health, Safety and Security.

Features:

- Short and controllable read range.
- Metallic objects can be tagged directly with no offset.
- Secure from both TRANSCON and COMSEC standpoints.
- Scalable deployment options.
- Low-cost hardware and easy installation.

Users: Stewards of high-valued assets, protective forces, DOE, NNSA, DOD.

Complementary ORNL Facilities:

- Safeguards and Security Laboratory.

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Low-frequency radio identification (LFRID) is of special interest with regard to high-valued asset tracking and inventory applications within secure facilities. Traditional technologies operating in the ultra-high-frequency (UHF) bands of 900 MHz to 2.4 GHz are not practical for use in many facilities due to frequency or transmitted power restrictions or poor tag operation on the intended asset. Poor tag performance is typically due to a high metallic content of the tagged item. LFRID uses an inductive signal at 131 kHz combined with semi-active (self-powered) tags which provide a controlled read range of up to 30 feet.

Why Use Low Frequency?

The LFRID system transmits the majority (99.9%) of its power using magnetic fields, which readily penetrate metal and are not attenuated by water. Both water and metal are traditionally major problems with radio-frequency identification (RFID). LFRID solves these problems and allows tags to be densely arranged and placed directly on metallic objects.

The use of a low-frequency signal also provides an important benefit related to wireless security. Because the signal power is contained in the magnetic field, the field strength falls off at $1/r^3$, where r is the radius from the transmitter. In practice, this nonlinear relationship of signal strength versus distance means that an adversary cannot detect a signal outside of the facility because the signal quickly drops to the noise floor as a receiver is moved from the transmitter. As a comparison, the field strength of traditional UHF RFID tags falls off at $1/r$.

An additional benefit is that the LFRID tags are self-powered and do not require a high-power (1–5 watt) carrier signal. High-power carrier signals are of concern in high-security areas due to both eavesdropping and TEMPEST issues. The LFRID tags use a sensitive amplifier stage to detect the interrogation signal from a reader. Active amplification on the tag means that the readers can transmit far less power compared to other RFID systems. A typical LFRID reader generates as little 4 nanowatts of RF power.

The trade-off of using low-frequency signals is that the data transmit speed is limited to about 1,200 bits per second, which equates to about seven tag reads per second per reader. The slow data rate is best suited where high data rates are not required, such as inventory applications.

Capabilities

LFRID has the following unique capabilities:

- Inherent security benefits due the physics of low frequency signals.
- The ability to work well around metal and water.
- Ultra-low power requirements, which lead to battery life in excess of 5 years (dependent on number of read cycles).
- Each tag contains a microprocessor and memory.
  - External sensor integration is possible.
  - The tags are capable of implementing encryption algorithms and/or authentication schemes.
- The reader antenna design requirements are highly flexible,

allowing for antenna configurations ranging from 6 inches in diameter to large loop antennas of 50 feet by 50 feet.

- The tags can be adapted to a wide variety of assets by specializing tag form factors or packaging.

Success Story: Tagged Weapons

LFRID systems have been successfully deployed in applications related to weapon, key, and tool inventory. The common link is that these items are small and typically have a high metal content. An example of a tagged weapon is shown in Figure 1.

For weapons, a sensor is included that enables shot counting. The total number of rounds fired can be read wirelessly and is useful data for maintaining the weapon.

Fig. 1. LFRID tagged Sig Sauer P226 handgun.

Success Story: Key Inventory

Key inventory applications use secure boxes which contain LFRID readers and key rings with LFRID key chains. An example of a key inventory system is shown in Figure 2. In this case, a touch screen monitor and badge reader are used to associate a particular user with the key being removed or replaced.

Fig. 2. LFRID key inventory system.

Success Story: Tool Inventory

Tool inventory applications make use of the LFRID's metal friendly properties to tag special tools for tracking or inventory purposes. In cases where the tool is too small for a tag, special enclosures can be used that combine an LFRID tag and sensors, which detect the presence of the tool.

System Integration

ORNL has developed a sophisticated software suite and associated peripheral hardware devices required to provide inventory solutions for almost any asset type. The system is fully scalable and can use an existing local area network to connect multiple readers together across rooms, buildings, or sites. A typical application is depicted in Figure 3. In this weapon inventory system, antennas are attached to storage racks and each weapon is individually tagged. A wall-mounted motion sensor is used to detect activity and trigger inventory update scans. A server controls the readers and collects the data into a secure database.

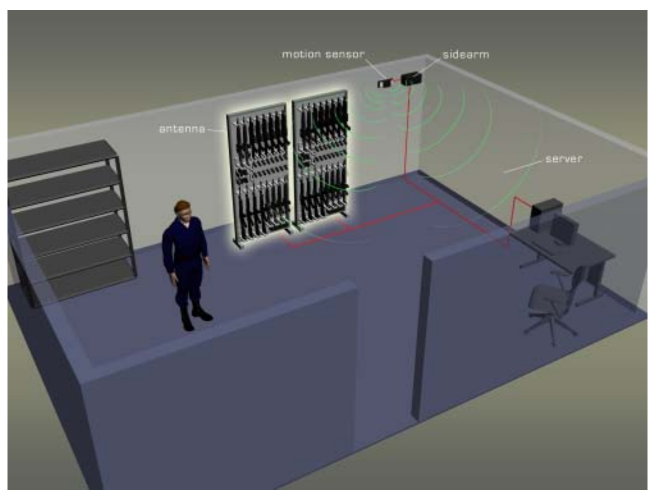

Fig. 3. Typical LFRID deployment, weapon armory.

Contact Information

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