

RFID

(Radio Frequency Identification)
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For what is RFID used?

- Retail theft prevention
- Supply chain / inventory management (the 363.63... kg gorilla)
- UPC replacement
- Access control / unintentional penetration prevention - logging
- Payment without swiping (EZ-pass, Speed-pass)
- Livestock tracking/co-traveling records
- Tool recovery verification
- Parameter collection / alarm
- Aircraft tracking
- More...

Technologies

- Backscatter (response signal is just a modulated reflection of interrogation signal)
 - passive
 - presence only
 - with ID
 - plus disable
 - with read / write memory
 - Semi-passive (sometimes called active)

Technologies (continued)

- Response powered by tag (active, but that term is often confused with semi-passive, above)
 - Power still from reader, but stored locally or delivered via separate channel
 - Using responder local power (e.g.; battery, aircraft power buss)

Frequencies

- UHF – 860 – 960 MHz (900 – 928 US, 868 – 869 EU), 433 Mhz DOD
- HF – 13.56 MHz
- VLF – 125 kHz, 131 kHz (RuBee, IEEE P1902.1)
- Other UHF not usually considered to be RFID, 1 GHz and 2.4 GHz
 - Aviation transponder / IFF, ZigBee based, WiFi based, Bluetooth

Frequencies Used for RFID

- Comments

VLF: 125, 131 kHz
RuBee, IEEE P1902.1

HF: 13.56 MHz

UHF: ~915, 433 MHz

Quasi-RFID
(aviation transponder, IFF, Zigbee, Bluetooth)

UNITED STATES FREQUENCY ALLOCATIONS

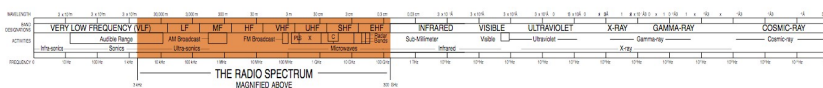
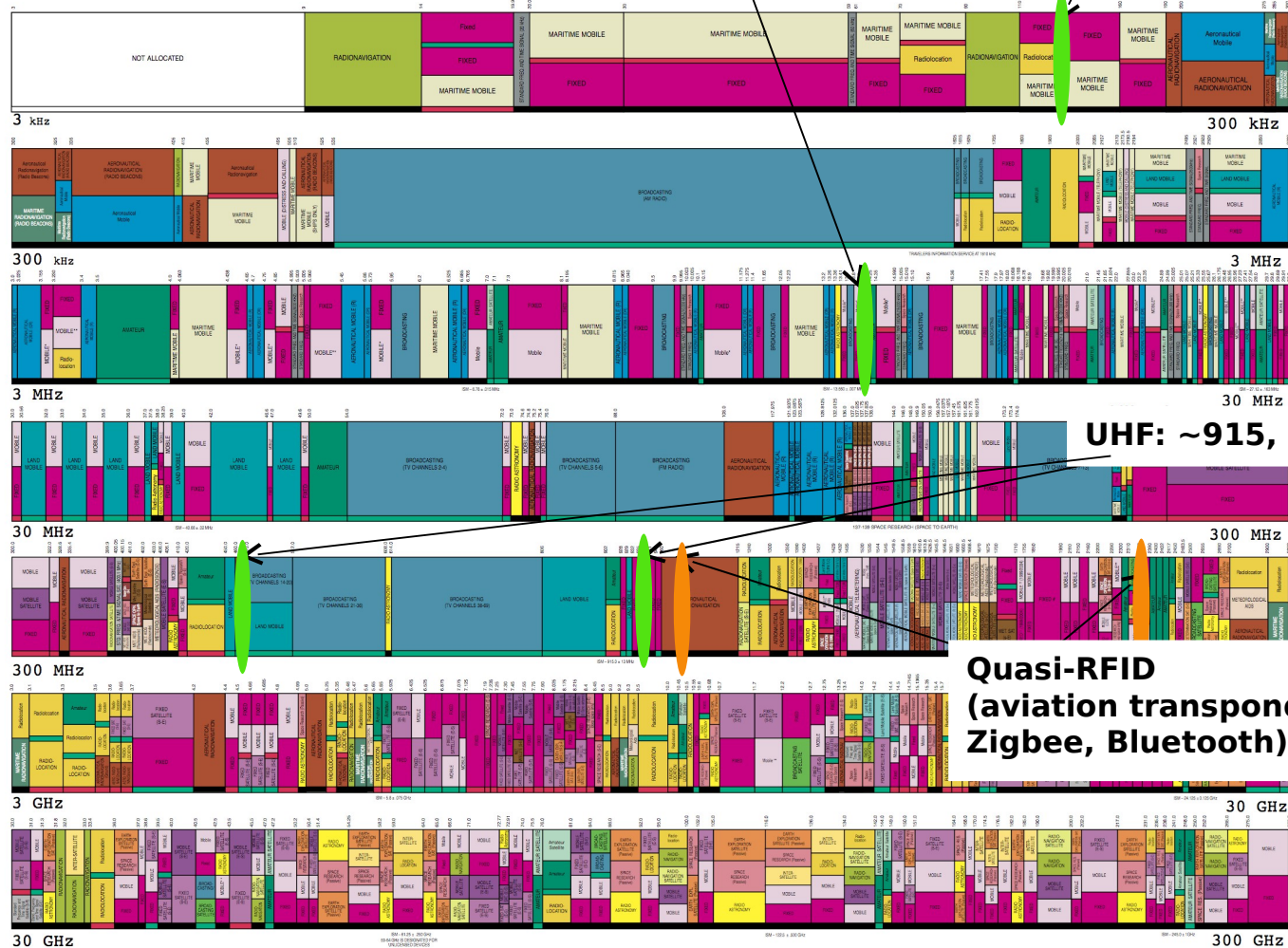
THE RADIO SPECTRUM

RADIO SERVICES COLOR LEGEND

ACTIVITY CODE

ALLOCATION USAGE DESIGNATION

SERVICE	EXAMPLE	DESCRIPTION
Primary	FIXED	Capital Letters
Secondary	MOBILE	1st Capital with lower case letters
Permitted	BROADCASTING	Capital Letters between oblique strokes



PLEASE NOTE: THE SPECTRA ALLOTTED TO THE SERVICES IN THIS SPECTRUM ARE SHOWN AS SHOWN AND NOT NECESSARILY TO THE ACTUAL ALLOTMENT OF SPECTRUM RESOURCES.

Frequency and antenna size

- Tag antenna size generally limited by application (credit card sized, livestock ear tag, human implantable tag)
- Even in readers, only the higher frequencies can approach self resonant (half wavelength) scales: 11 m at 13.56 MHz, 16 cm at 915 MHz
- Radiation / reception efficiency decreases sharply much below half wavelength scales.

Frequency and propagation mode

- Extremely small antennas (compared to a wavelength) radiate or respond to EM waves (radio) poorly.
- Tiny dipoles antennas produce primarily dipole (in the far field) E fields.
- Tiny loop antennas (virtually all VLF RFID antennas) produce primarily dipole (in the far field) H fields.
- Of these, only EM waves can be considered to be radiation.

Frequency and battery life

- For tags whose transmission is powered by a battery, power consumption is a significant factor
- High speed integrated circuits and the need to radiate power both increase consumption
- VLF magnetic tags have already shown greater than 10 year battery lives from a button cell. (Protocol and number of reads over time are factors.)

Frequency and data rate

- Data rate is typically limited to a fraction of carrier frequency
 - RuBee achieves 1024 bps, leading to a limit of about 8 reads per second given current packet length and gaps
- Data rate is further limited by signal to noise ratio (after accounting for coding gain and dynamic range problems)
 - UHF systems, especially, can achieve substantially higher read rates than RuBee

Range

- Backscatter tags suffer from two hops and reflection inefficiency reduction from reader output to received signal, which must be detected with the reader still transmitting: UHF max 3.5 m; HF max 1 m; VLF maybe 40 cm
- RuBee (with relatively large reader antenna) has demonstrated spherical read volume > 10 m in diameter (15 m is probably a practical limit)
- Smaller ranges can be configured

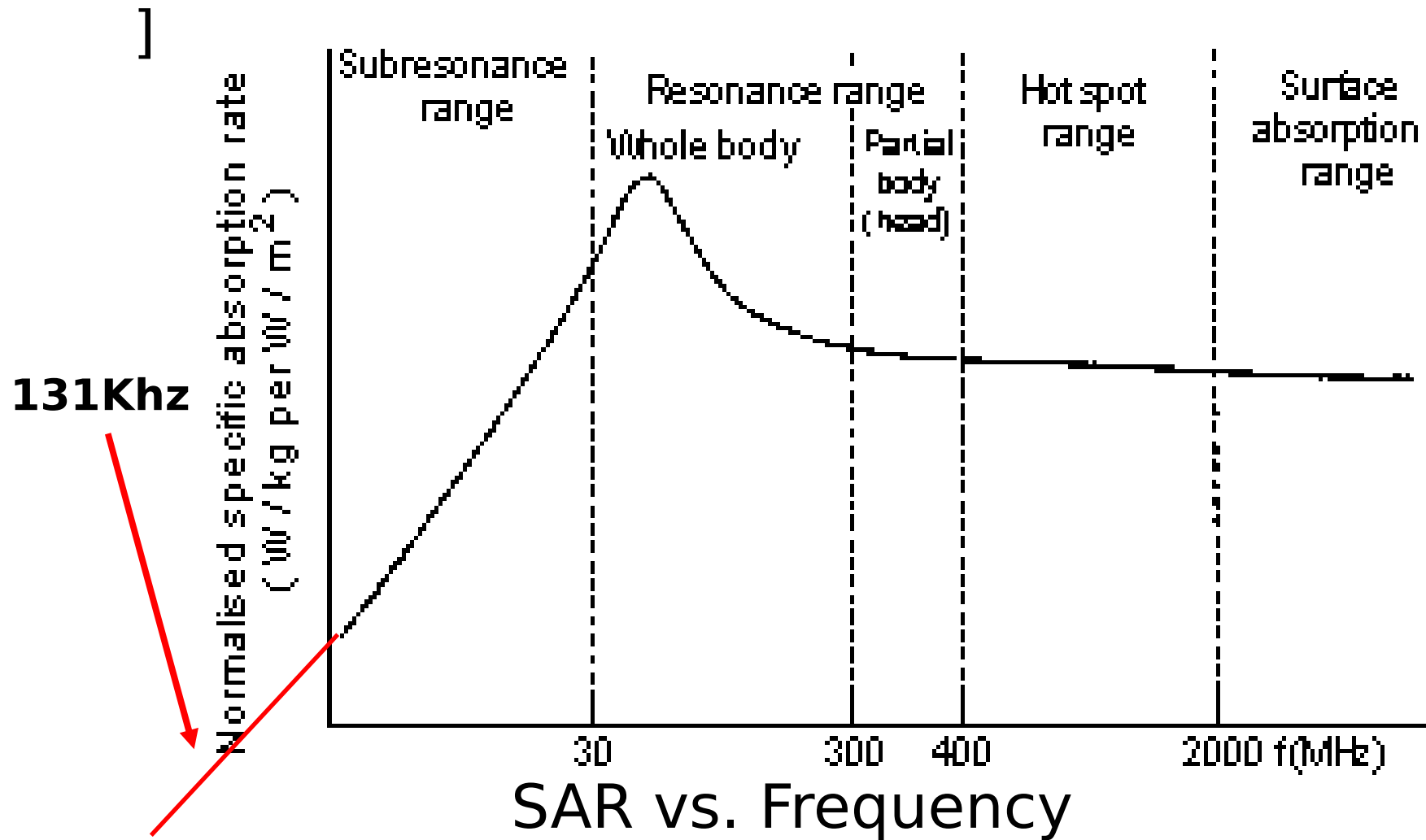
Environmental range factors

- Water and other liquids, such as that in the tissue of a cow's hide, interact with electric fields in a frequency dependent way, and can be a good shield against UHF and HF RFID signals
- Metals and other good broadband conductors shield against electric fields in general.
- Other than antenna circuit resonance shift, magnetically coupled systems are insensitive to liquids metals

Biological impact

- Demonstrated cancer risk from implanted tags may be due to packaging rather than fields.
- Tissue absorption is frequency dependent, significant at UHF and HF, leading to, for example, cataract risk from prolonged near field exposure to today's backscatter power levels
- VLF has negligible effect
- RuBee is both VLF and uses much lower power than backscatter systems

OSHA Specific Absorption Rate



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Modulation schemes

- First data is encoded (NRZ, Biphase, Manchester, PWM, etc. - for a nice survey see “microID® 13.56 MHz RFID System Design Guide”, search for “RFID” at www.microchip.com)
- In all backscatter systems the encoded data is used to AM modulate the carrier
- Tag AM modulation is done by detuning the tag to actually decrease the energy that it absorbs from the reader signal
- The coder is synchronized to the carrier

RuBee modulation

- RuBee Biphase codes its data, transitions synchronized to the carrier
- Coder output selects whether or not to invert the carrier (you can still consider this AM, or as 0 – 180 degree only PM), or in lesser implementations, whether the carrier is on or completely off (definitely AM)
- Synchronous carrier detection is used, necessitating crystal control of carrier frequency at both ends

Collision avoidance / resolution

- Some applications require reading all of several tags located in the reader field
- A list of known tags can be confirmed easily with response selection by ID
- There are a number of proprietary schemes for resolving among several unknown tags
- A tag with a large signal may be discovered despite many simultaneous weaker responses, then told to shut up for a while, so weaker tags are found

Peer to Peer

- Tags which (like RuBee tags) power their own transmitter can be designed to act as (low power) readers
- Symmetry of interrogate and response modulation and coding schemes makes this easy.
- Self organizing networks (a la ZigBee) become possible
- Nominal readers can also intercommunicate within the protocol (though using WiFi makes more sense)

The larger system

- Data may be needed at central sites, rather than just at point of read
- Internet data transport, database server, and logging can all be arranged independently or a single vendor can supply an integrated solution
- Integrated systems offer reduced pre-deployment development, and are easier to qualify as Sarbanes-Oxley or 21 - CFR – Part 11 compliant.

Privacy risks

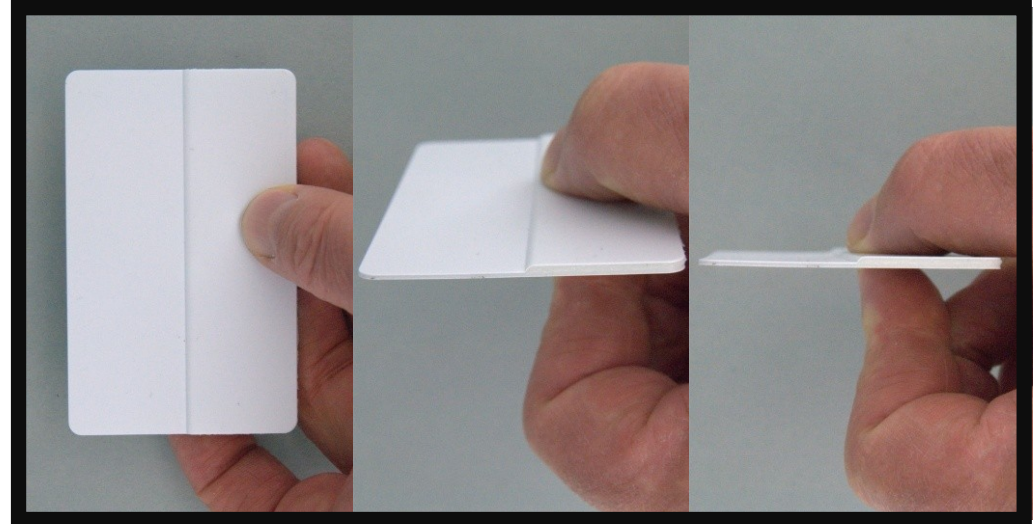
- Some applications may not present privacy risks, but some may surprise you
- Countermeasures, such as the shield cover on the new passports, may be less effective than billed, or subject to operator error
- When is “contactless” reading really required, or even very useful? Are bureaucrats just gadget happy with those passports?

RuBee Family of ID Tags.



ID Tag – 3.2" x 2.4" x 2mm thick.

The



2T Wallet Tag – 3.2" x 2.4" x 1mm thick on edge and 2mm on top. 2T cards work in your wallet.

The RuBee Tags

Form Factors

Small t-Tags Cell Phones



Large t-Tags For Heavy Steel



RuBee Family of Livestock Tags.



Over The Ear Aluminum
Has worked since 1867



Over The Ear Plastic,
also works as a
button tag

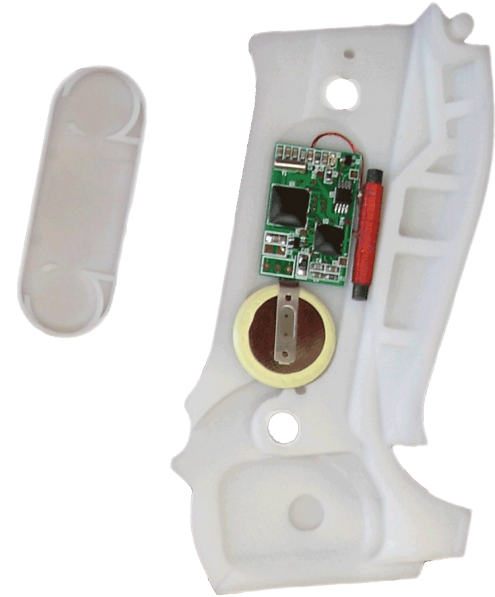


The Classic Dangle Flag-Tag



Bolus Tag with NIST Temperature

RuBee Family of Weapons



RuBee Base Routers Appliances

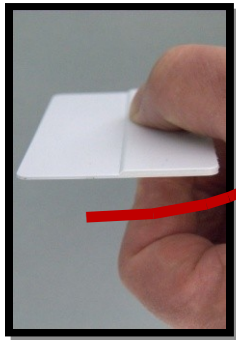


**Sidewinder™ – Network Appliance VPN
Full RuBee Linux Embedded Router
The Net Workhorse.**

RuBee Routers and RuBee Appliances

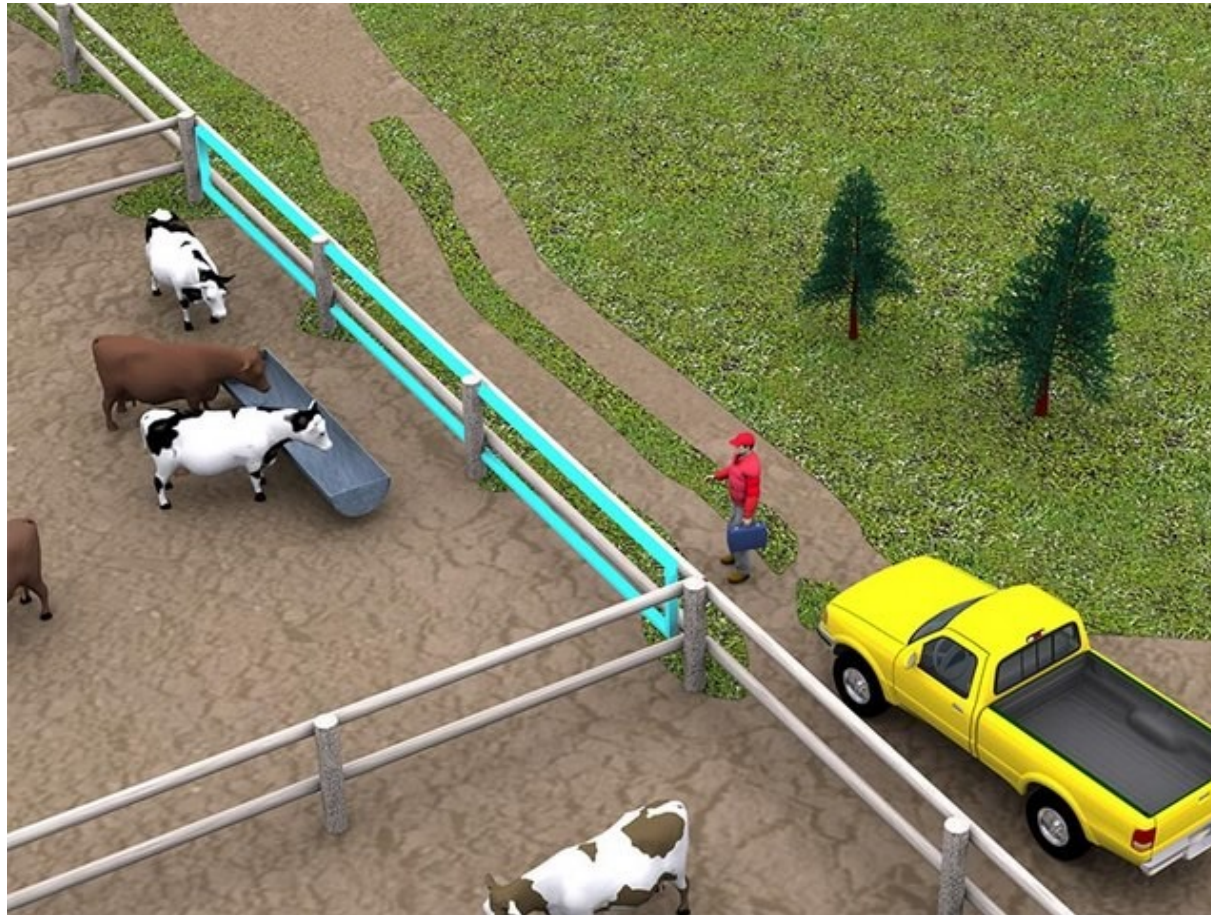
Challenge RuBee Keypad

In The Wallet 2T-Tag



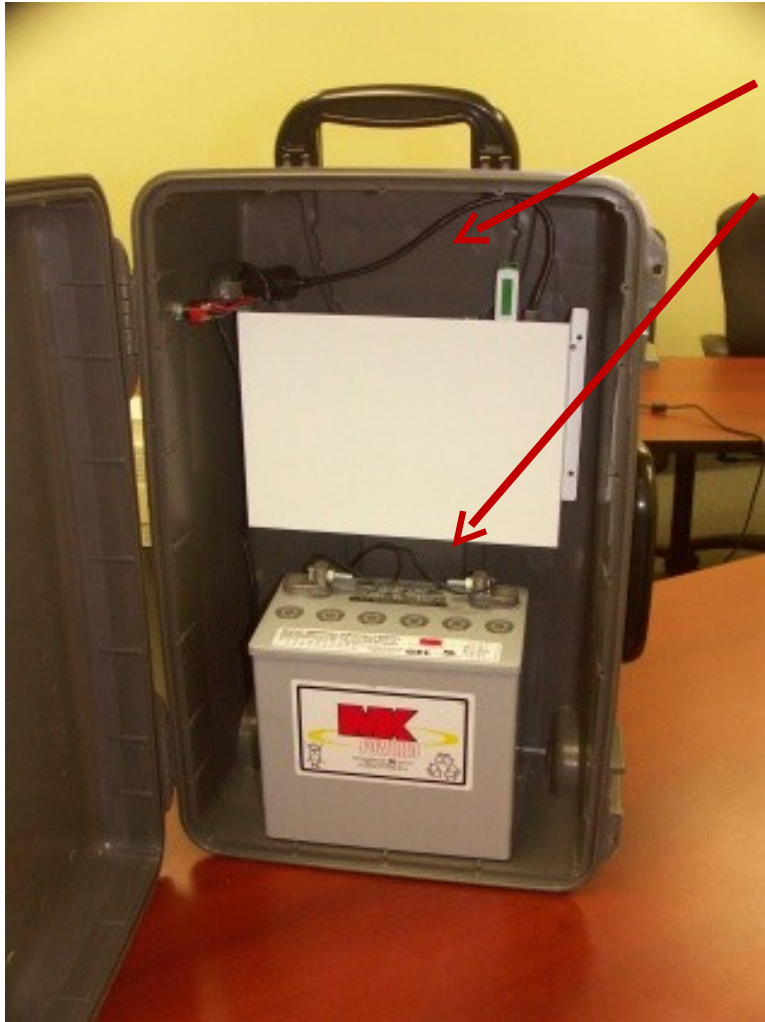
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RuBee QuickCount



The RuBee QuickCount package maybe used to capture herd inventory. Portable RuBee antennas are periodically placed on fences near a grain feed area. A portable battery operated RuBee Reader records visiting animals.

RuBee QuickCount Reader



Portable waterproof case

Inventory data is stored in thumb drive.

Battery power for three days

Uses a temporary portable “over the fence” antenna

