LIVESTOCK LOW POWER MONITORING SYSTEM

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MOTIVATION

Identification

Theft of livestock

Location of livestock
MOTIVATION

- Battery duration for months and some times years.
- Sensor should be embedded into the animal in order to support harsh environments.

EXISTING SOLUTIONS

<table>
<thead>
<tr>
<th>Limited autonomy</th>
<th>High cost</th>
<th>Build in collar solutions</th>
<th>Most of them use mobile communication networks</th>
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MAIN DIFFICULTIES

Proposed low power radio transceiver
- Theoretical current consumption: 0.3μA
- Real current consumption: 0.134mA

2 years maximum autonomy

Solution: use a WUR

SYSTEM ARCHITECTURE

Drone / Base Station
- Low Power – Low Bit Rate Radio Transceiver
- Backbone Communication (Mobile or proprietary)

LiveStock
- Low Power – Low Bit Rate Radio Transceiver
- Wakeup Radio
SYSTEM ARCHITECTURE

LIVESTOCK SENSOR

WUR based on a RF-DC converter
The selected processor was ATMEGA 328, which consumes 0.02µA in standby. Comparator consumes 1.26µA in standby and 4.21µA when operating.
LIVESTOCK SENSOR

Two antenna entries, one for the WUR and another one for the transmission system.

LIVESTOCK INTEGRATION

Accommodate the sensor around the horns of the cow.
LIVESTOCK INTEGRATION

PLA with 100% density - $\varepsilon_r = 2.2$.

LIVESTOCK INTEGRATION

$\varepsilon_r = 47.7769$
$tan\delta = 0.3698$
LAB MEASURED RESULTS

Output Voltage vs P_Rx

Output voltage [V]

Input power [dBm]

FIELD MEASUREMENT RESULTS

WUR Voltage versus received power
CURRENT PATTERN

Connection current pattern when connecting to the drone AP

Connection current pattern connected to the drone AP

\[ I_{on} = 0.28 \times 28mA + 0.72 \times 10mA = 15mA \]

ENERGY BUDGET

\[ I_{sleep} = 1.40\mu A \]
\[ I_{On} = 0.28 \times 28mA + 0.72 \times 10mA \]
\[ C_{Bat} = 2400mAh \]
\[ T_{on} = 10 \text{ seconds} \]
\[ T_{standby} = 6 \times 60 \times 60 - 10 \text{ seconds} = 21590 \text{ seconds} \]
\[ T_{Cycle} = T_{on} + T_{standby} \]
\[ T_{Cycle} = 10 + 21590 = 21600 \text{ seconds} \]
\[ D_{Don} = T_{on}T_{Cycle} \]
\[ D_{Don} = 1021600 \times 4.6296e^{-04} \]
\[ T_{T} = C_{bat}(I_{on} \times D_{on} + I_{sleep}(1 - D_{on})) \]
\[ T_{T} = 28700 \text{ horas} = 11958 \text{ dias} = 32.76 \text{ Years} \]
\[ T_{T} = T \times 0.8 = 32.76 \times 0.8 = 26 \text{ Years} \].
**DRONE SYSTEM**

- Drone Module made using COTS system

Low power Radio
GPS
GSM backbone

**CONCLUSIONS**

- Solution is viable for livestock monitoring
- Battery life is reasonable for the expected lifetime of a cow
- WUR is fundamental for increasing battery life
HISTORY OF BACKSCATTER RADIO

The Great Embassy Seal Bug

- Given as “gift” to US by USSR in 1946;
- Passive transduction of sound, interrogated from across the street in the Soviet Embassy;
- Undiscovered until 1952;
- Invented by Leon Theremin;
- Vibrating diaphragm changes capacitive load seen by antenna;
- Analog speech modulates the backscattered information;
- Reflected signal looks like small-carrier AM;

CHIPLESS TEMPERATURE MEASURING WITH BACKSCATTER
CHIPLESS TEMPERATURE MEASURING WITH BACKSCATTER

CHIPLESS TEMPERATURE MEASURING WITH BACKSCATTER

Temperature Variation - Tag Chicken 860 MHz

Temperature Variation - Tag Chicken
QUESTIONS?

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