@ ZERO Energy

Bluetooth Backscattering

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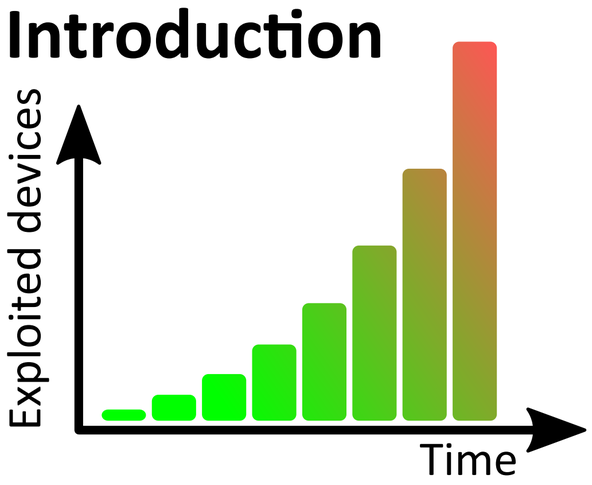
NWO Domain AES

Introduction

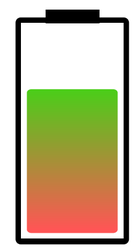


Large growth in wireless sensors has resulted in increased battery usage

Energy harvesting reduces the use of batteries.

Energy sources include:

- Light
- RF waves
- Temperature gradients
- Vibrations



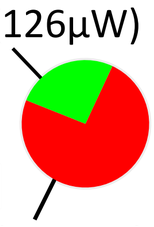
Sensors depending on batteries

- ✗ Maintenance cost
- ✗ Environmental impact
- ✓ Reliable power

Sensors with energy harvesting

- ✓ Low maintenance cost
- ✓ Sustainable
- ✗ Less reliable power

Motivation



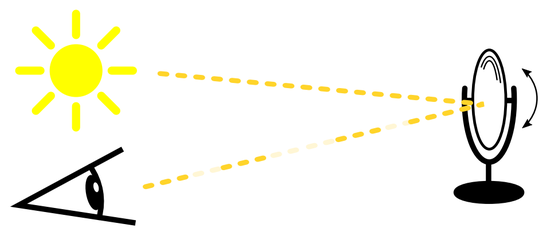
State-of-the-art LP BLE tx:

- 496µW @ -19 dBm [1]
- Mainly RF power
- Large powers problematic with harvesting

Backscattering:

- ✓ Only baseband circuits
- ✓ Includes harvesting

Method

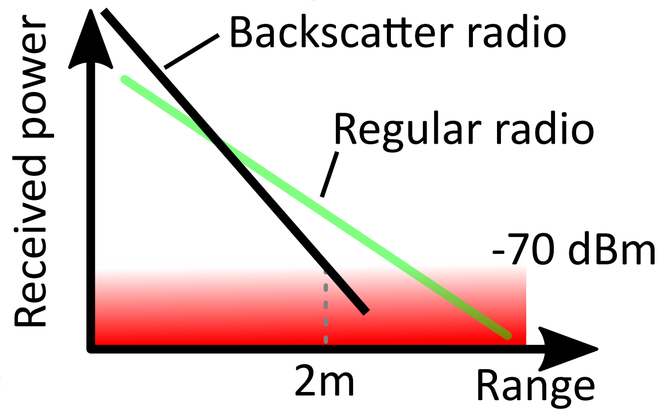


Backscattering minimizes RF power

- ✓ Reflect power from device with high power budget
- ✓ Use commercial Bluetooth receiver of e.g. a phone [2]
- ✓ Allows batteryless operation

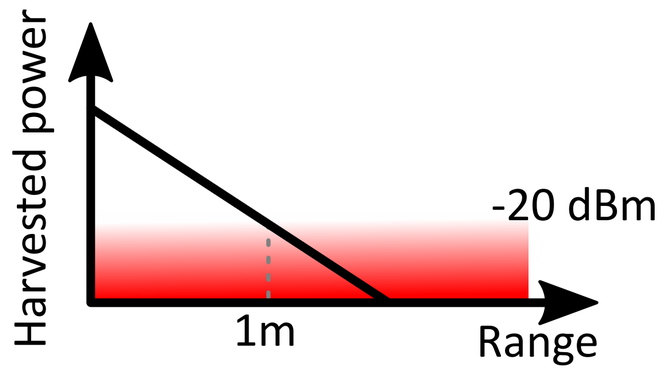
Challenges

Receive range



Range limit: 2m
with 20 dBm carrier [3]
Bluetooth Class I

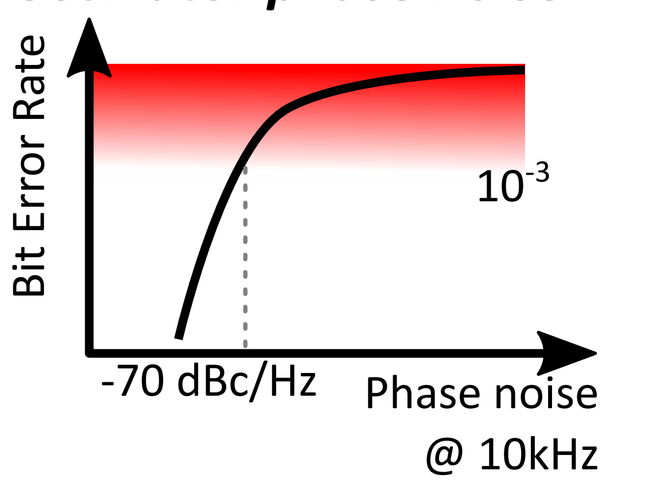
RF energy harvesting



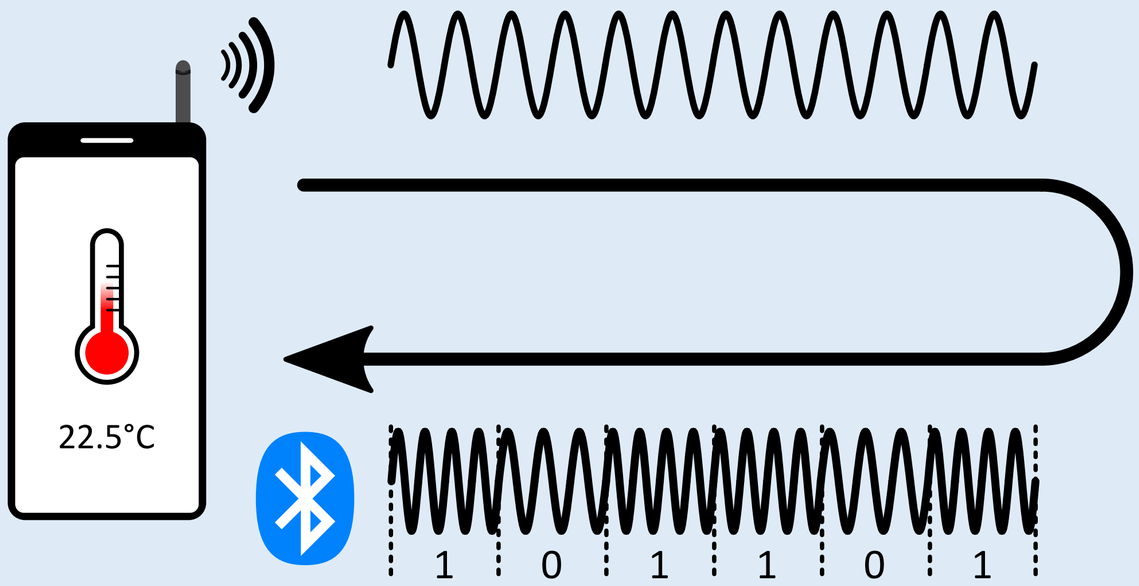
RF harvesting limit: 1m
with 50Ω antenna ($\frac{kT}{q}$ limited)

Higher antenna impedance increases range

Oscillator phase noise



Phase noise limits BER
RC oscillator: min. 1.5 µW
based on -160 dBc/Hz FOM



Conclusion

- ✓ Batteryless sensor possible
- ✓ Range up to 1m
- ✗ Current Bluetooth chip-sets do not allow full duplex, external carrier tx required

Could be applied to:

- Smart products
- Sensors in offices

Performance summary

Expected power consumption

- ✓ Oscillator: 1.5 µW
- ✓ Antenna switch: 1 µW

Available RF power

- ✓ At 1m: max. -20 dBm = 10 µW

Completely batteryless possible depending on sensor power

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[1] X. Chen et al., JSSC May 2019
[2] J.F. Ensworth and M.S. Reynolds, Int.Conf. RFID 2015
[3] J.D. Griffin and G.D. Durgin, IEEE MAP April 2009

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