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# INDOOR-LOKALISIERUNGSSYSTEM FÜR LAGERLOGISTIK MIT SUB-20- $\mu$ W-UHF-WAKEUP-RECEIVER

20. VDE/ITG Fachtagung Mobilkommunikation  
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Fraunhofer-Institut für Integrierte Systeme und Bauelementetechnologie IISB

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# Indoor Tracking System for Logistics using Sub-20 $\mu$ W-Wake-Up Receivers

## Contents:

- Introduction into WakeUp Receivers
  - Principle
  - Technical Data
  - Scalable Data Rates and Current Consumption
- Beacon-based Localisation Method
- Adaption to Storage Hall
- 3-Band RX Module

# *efficient* - Fraunhofer IIS WakeUp Receiver Technology

## Enabler for Green Internet of Things and Smart Objects

Low latency RF listening is one major obstacle for:

- Large wireless sensor nets
- Internet of Things
- Smart objects
- Energy autonomous systems

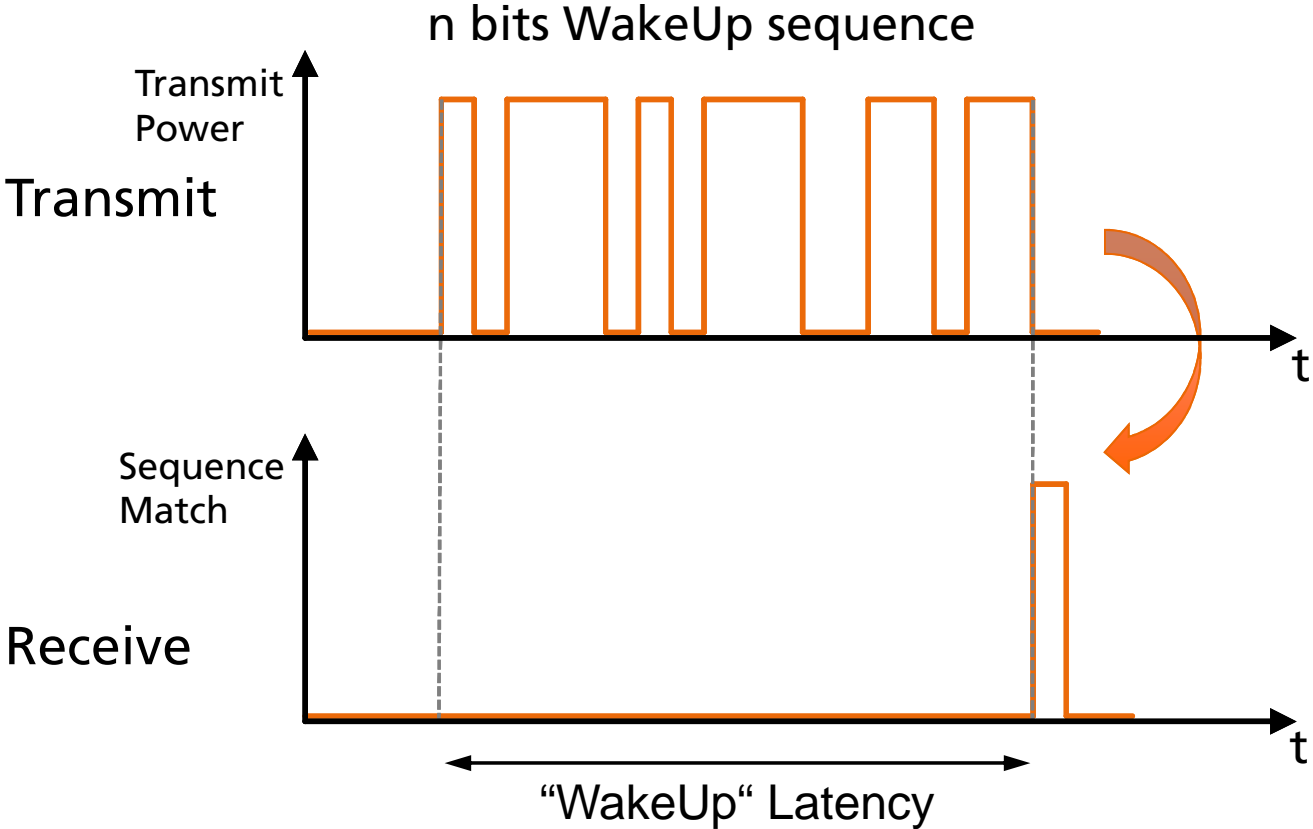


**Solution: Ultra low power integrated radio receiver**

- Continuous radio reception
- Short latency reaction on WakeUp sequence
- Suitable for battery operation up to ten years and energy harvesting

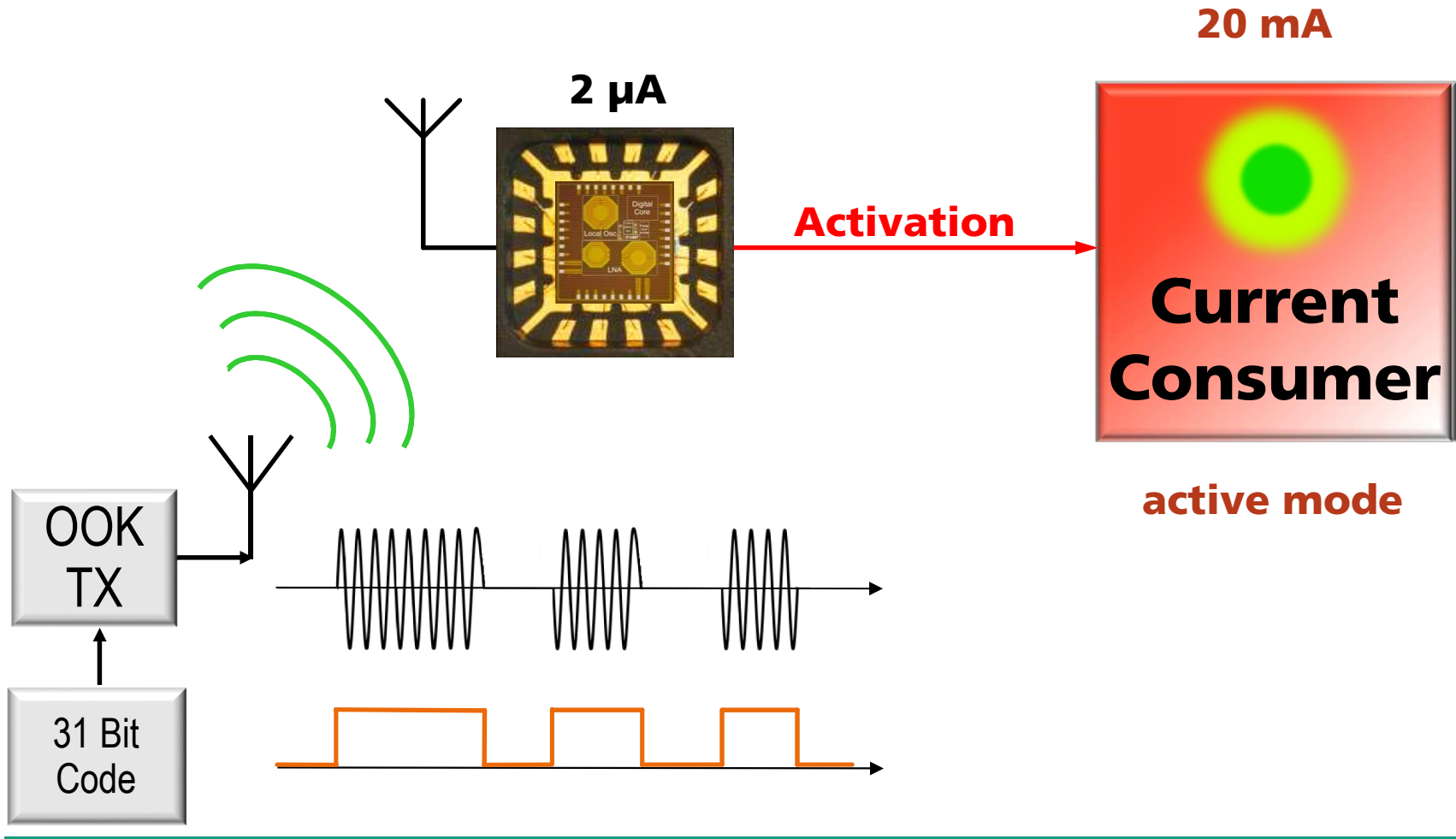
# WakeUp Receiver Technology

## Sequence Recognition via Correlation



# WakeUp Receiver Technology

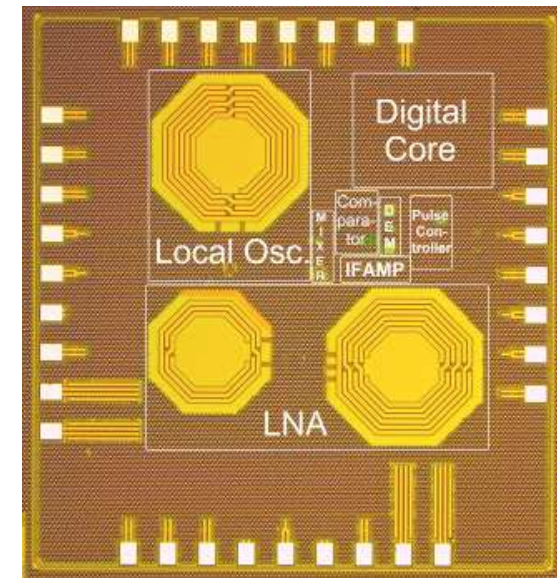
## Activation of Current Consumer



# Fraunhofer IIS WakeUp Receiver Technology

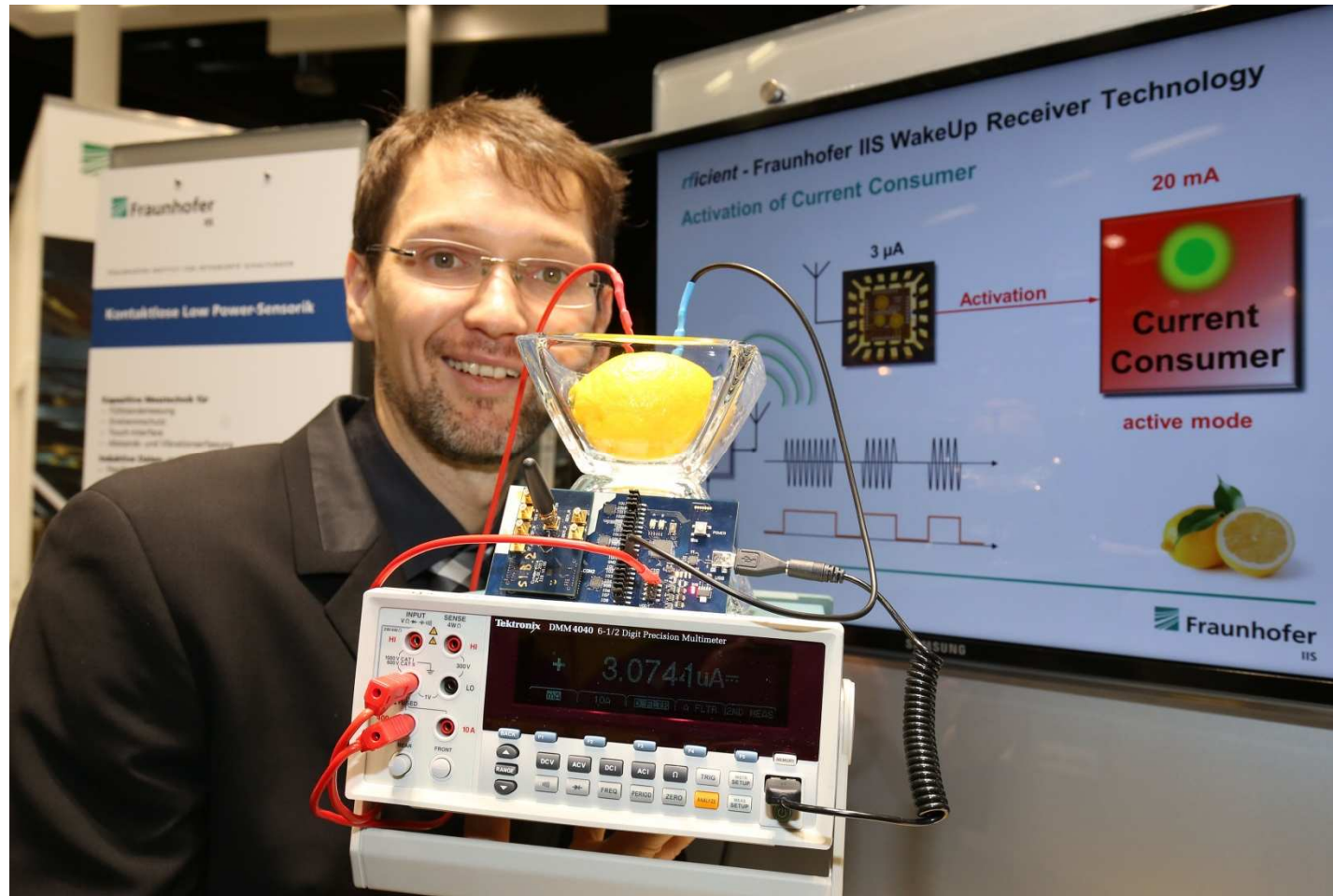
## Key Features

- Supply current: 2  $\mu$ A @ 2.5 V (1 kbps)
- Frequency bands: 433 MHz, 868 MHz, 915 MHz, 2.4 GHz
- Sensitivity: -80 dBm
- Continuous RF reception
- Operation without microcontroller
- Detection of two independent WakeUp events
- FEC coded data reception
- Selective WakeUp with 16 Bit ID
- 3 different RSSI levels
- Low-cost 130 nm standard CMOS
- QFN32 package 5 x 5 mm<sup>2</sup>



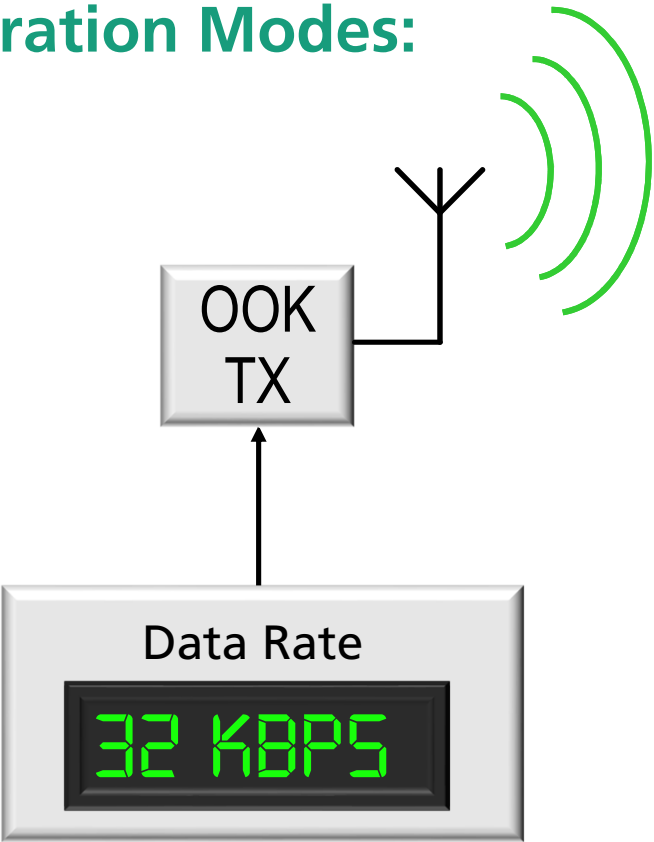
# Fraunhofer IIS WakeUp Receiver Technology

## Embedded World 2015: Organic Lemon Demonstrator

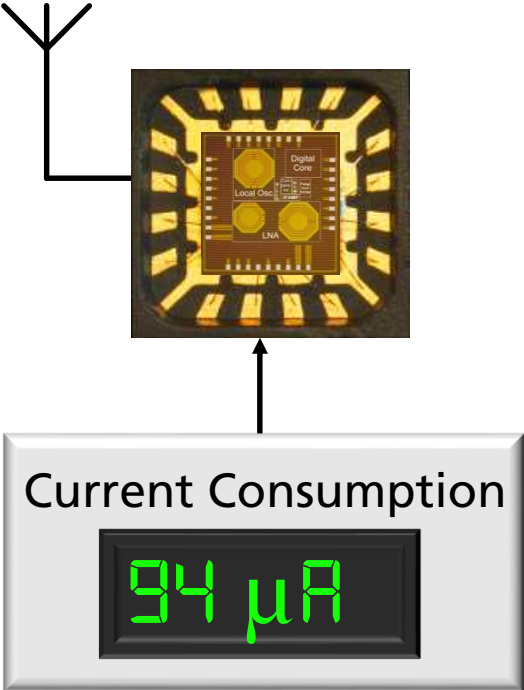


# WakeUp Receiver: Scalability of Data Rate and Current

## Operation Modes:



Fast Data



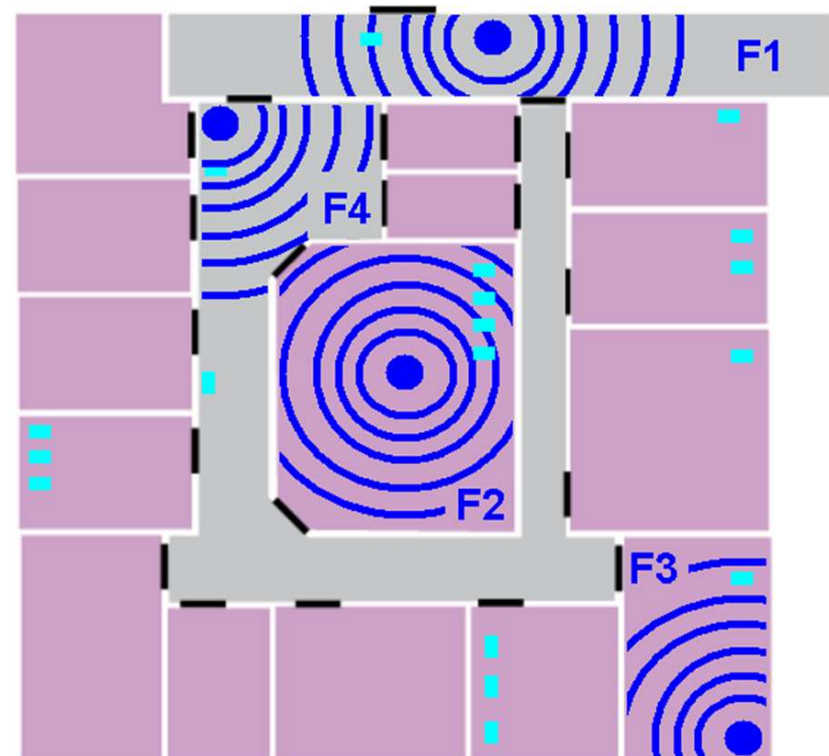
User Data Rate: 1057 bps



# WakeUp Receiver for Indoor Localisation

## Basic Idea: Beacon-based Localisation

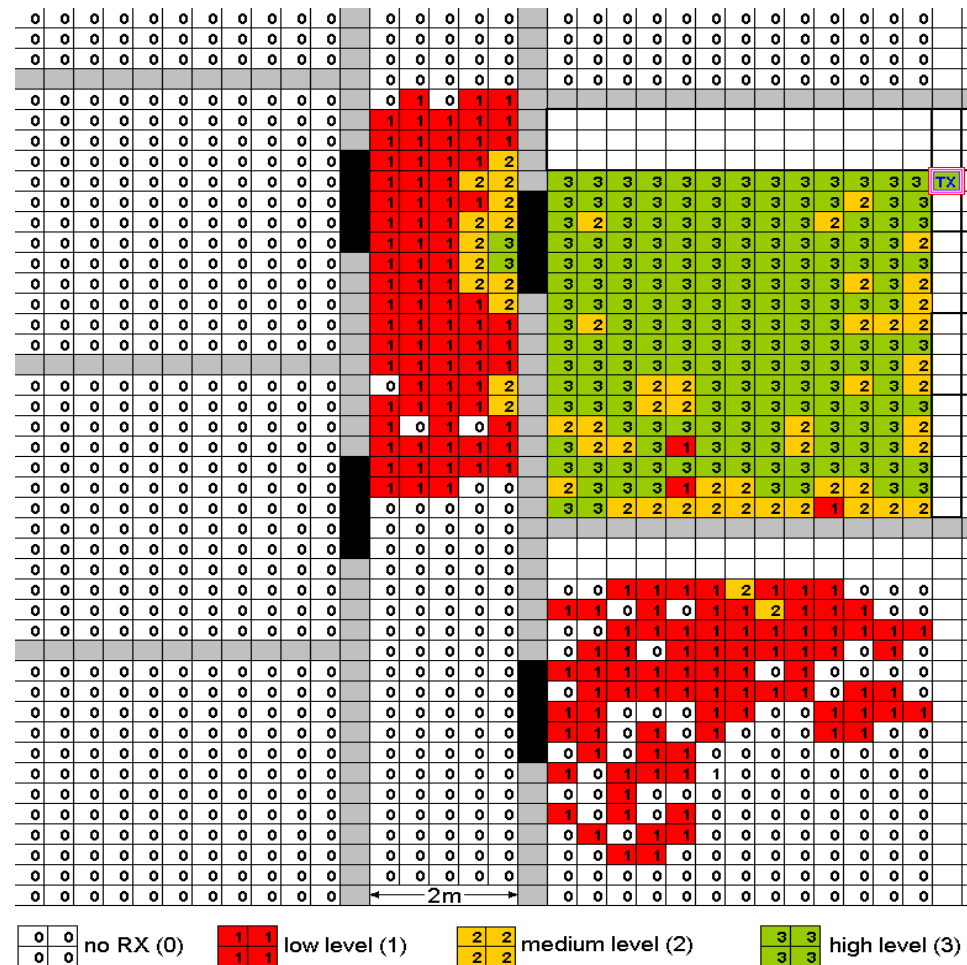
- Put a standard transmitter (TX) node at each room or marking zone
- use 433 MHz band
- periodic transmission of room number e.g. every 60 seconds
- TX power:  $< 100 \mu\text{W}$
- average current consumption:  $13 \mu\text{A}$
- runs 2 years with CR2032 button cell
- assumptions:
  - active current: 15 mA
  - telegram length: 50 ms



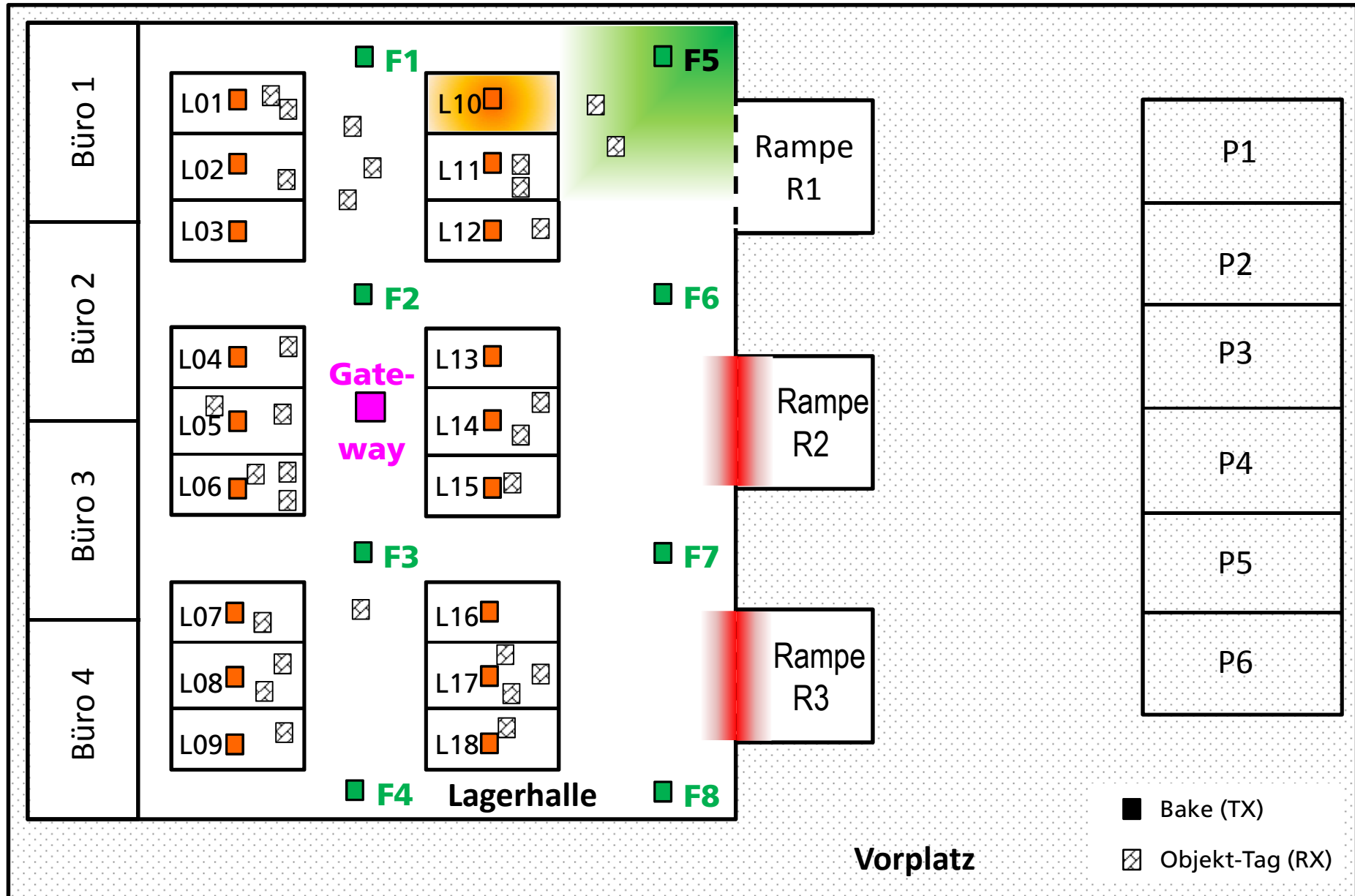
# WakeUp Receiver for Indoor Localisation

## Beacon-based Localisation: Measurement result

- Single beacon used
- 3 RSSI levels named 1, 2, 3
- localisation principle confirmed
- RX current consumption: 2 μA



# Logistic Storage Hall with TX Beacons at 433 MHz band



# Indoor Localisation and Communication

## Three Frequency Bands

- Beacons: 433 MHz

**433  
MHz**



- Communication between Objects and Gateway: 863..870 MHz

**868  
MHz**

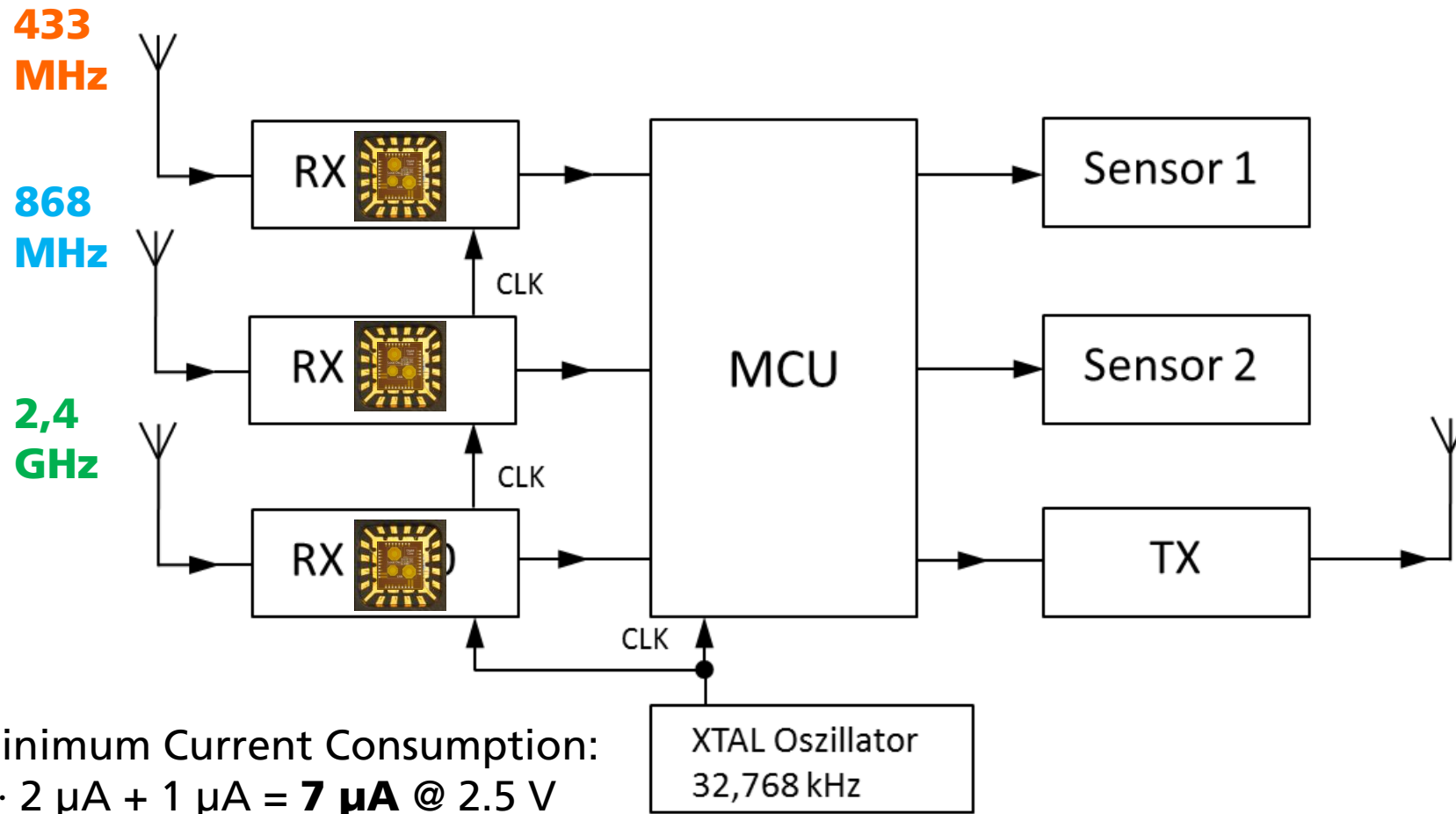


- Communication between Service Personnel and Object: 2.4 GHz

**2,4  
GHz**



## Multi-Band WakeUp Receiver Module within Object



Minimum Current Consumption:  
 $3 \cdot 2 \mu\text{A} + 1 \mu\text{A} = 7 \mu\text{A} @ 2.5 \text{V}$

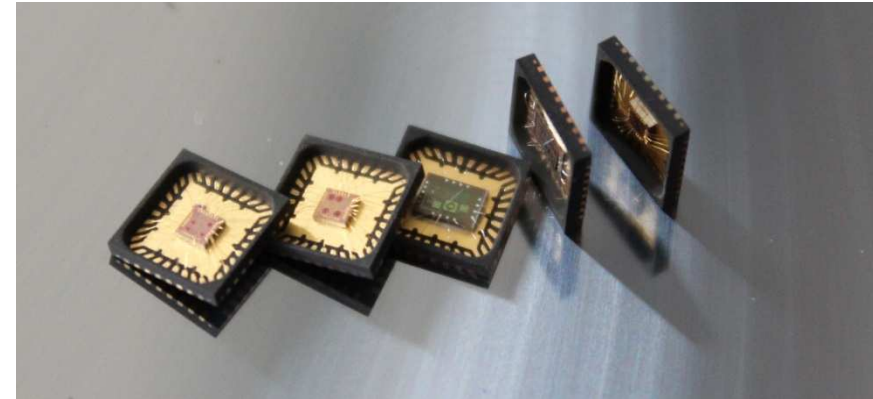
# Indoor Tracking System for Logistics using Sub-20 $\mu$ W- Wake-Up Receivers

## Summary

- WakeUp Receiver Approach was presented
- Multiple Frequency bands: 433 MHz, 868 MHz, 915 MHz, 2.4 GHz
- Beacon-based Localisation
- Objects detect their position autonomously
- Separate Communication between Objects and Central Gateway on demand
- Low Latency Capability
- Scalability of Number of Objects and Landmarks

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**Thank you for  
your attention !**



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