



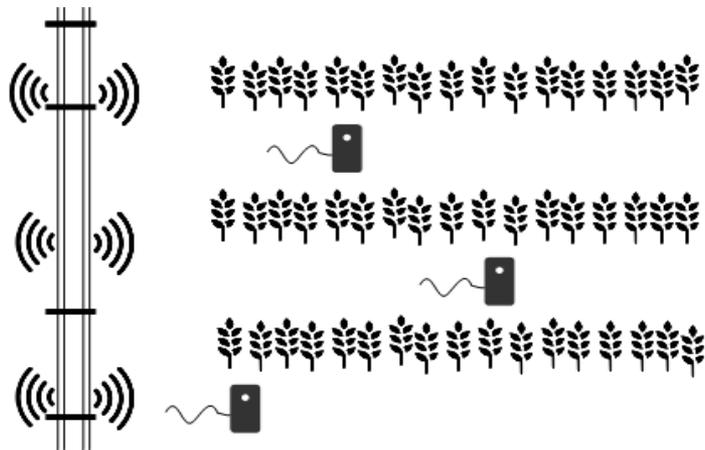
PULSEHV

OPPORTUNISTIC DATA TRANSMISSIONS OVER HIGH VOLTAGE
PULSES FOR SMART FARMING APPLICATIONS

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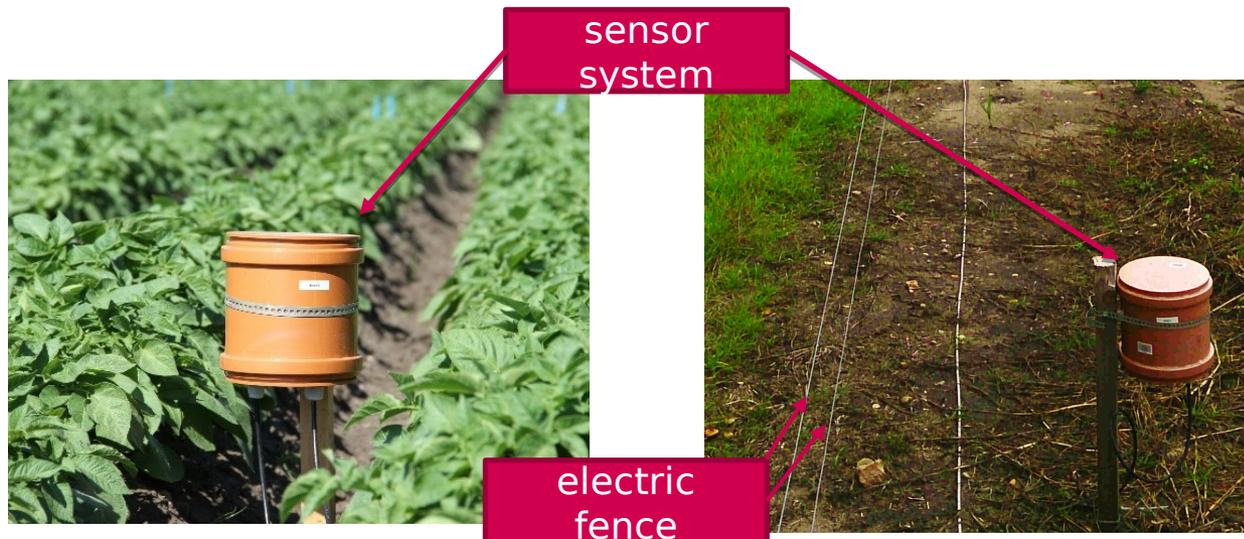
Introduction

- In this talk we are going to answer the question:
“Is it possible to establish a communication system with an electric fence as a sender?”



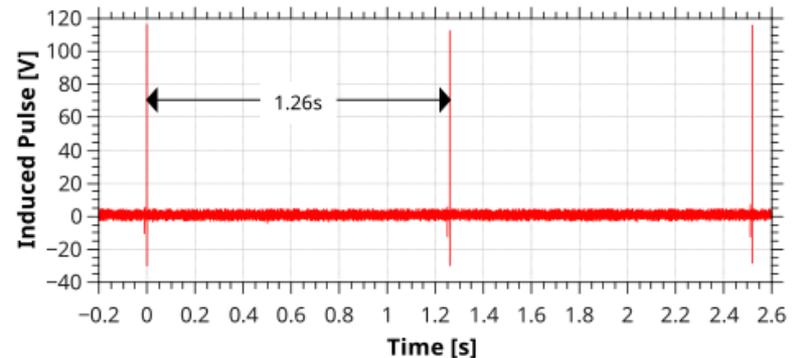
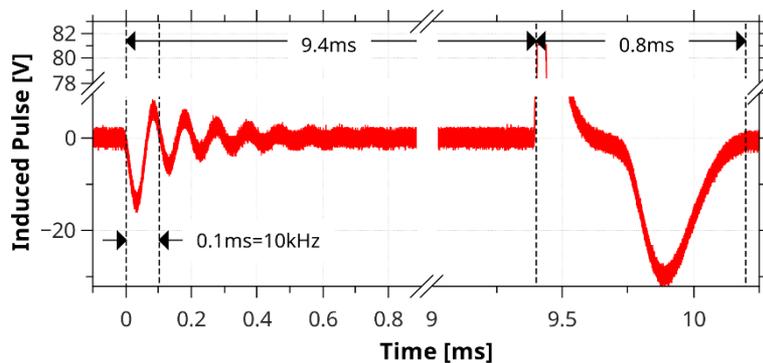
The ideas background

- Outdoor WSN Testbed *PotatoNet*
- Protected by an electric fence
- Pulses coupled into shielding
- Simple antenna enabled detection



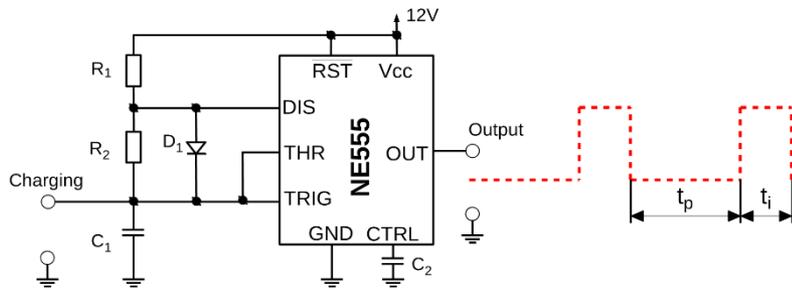
Choice of modulation

- Regulations on pulse duration and pauses due to health concerns
- Fences are used to keep animals at bay
 - Long pulse pauses are a strain to efficacy
- Pulse characteristics change with distance
 - Pulse timings stay constant → PPM is feasible



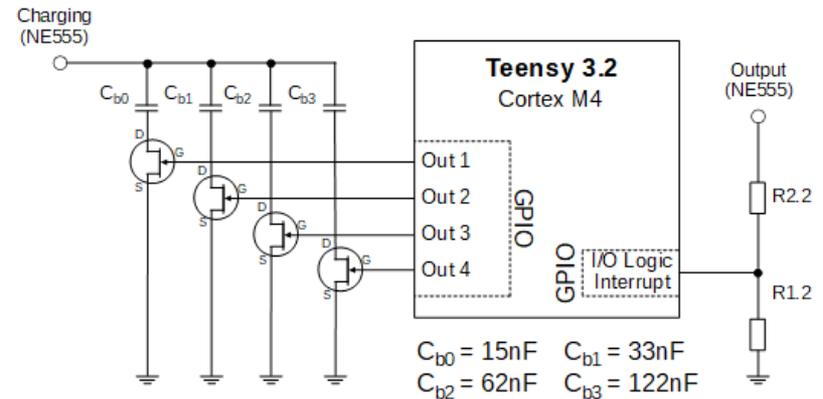
Sender implementation

- Pulse position modulation realised using NE555
 - Internal timing circuit



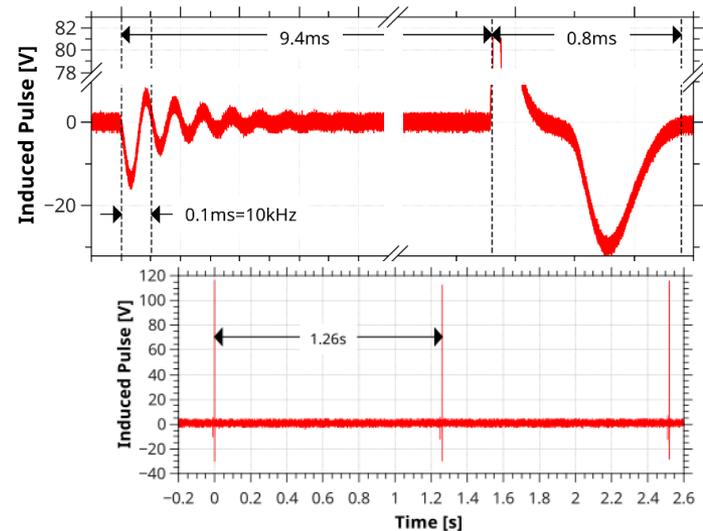
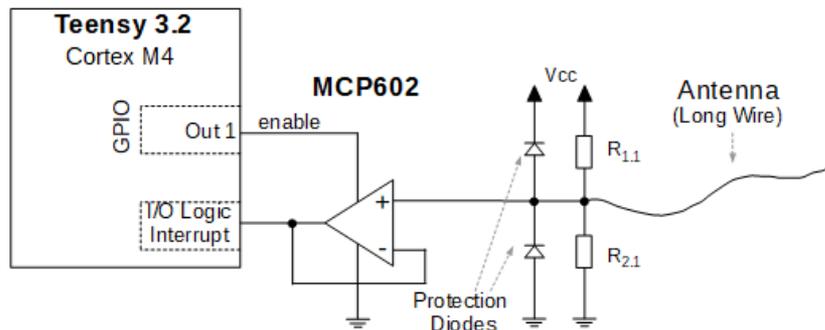
- Enlarging capacitor size linearly increases the interval between pulses and the pulse duration

- Sender incorporates array of capacitors to switch to signal, realizing PPM
- Exact timing for changes from NE555 output



Receiver implementation

- Simple wire antenna receiver
- Operational amplifier stabilizes signal



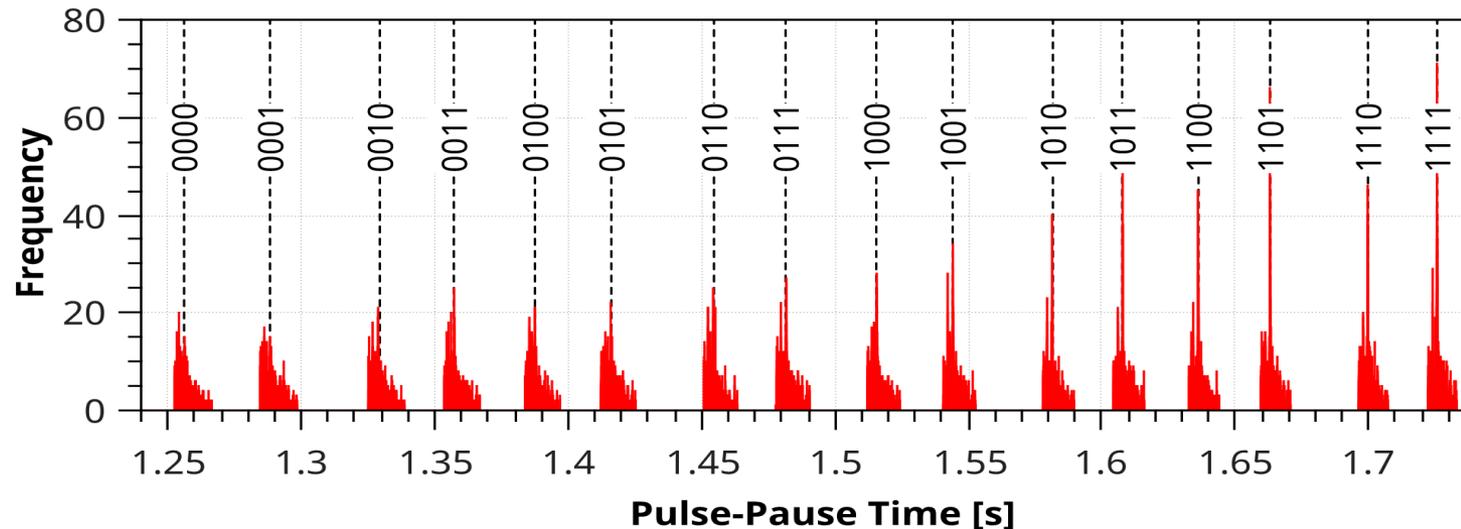
- Modulated words are detected as zero crossings in the signal
 - Pulses outside expected times are ignored

Evaluation

- Evaluation setup with one receiver, one sender, approx. 1 m apart
- Evaluations performed for
 - Consistency of detected pulse intervals
 - Throughput limits and communication errors
- Furthermore a Data Transmission Test Case was conducted

Consistency of Detected Pulse Intervals

- 20 hours of transmission of random 4-bit words
 - Resulting in 350,000 triggered events and 55,000 valid words
- Timings ± 7 ms of the mean duration, standard deviation around ± 3 ms



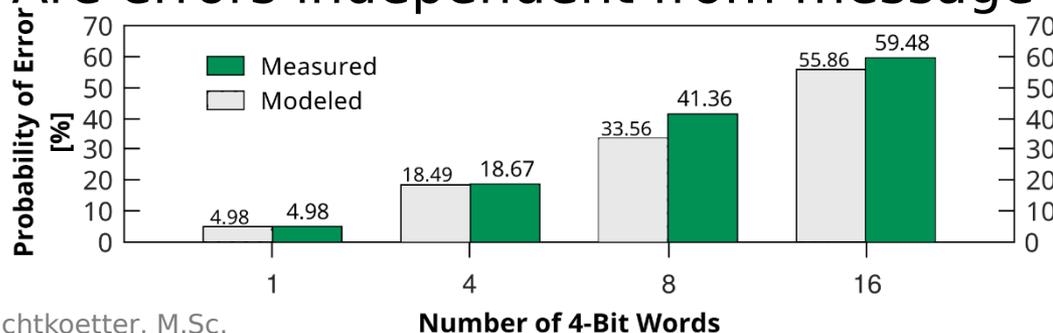
Throughput limits and communication errors

- Varying duration for 4-bit words (from 1.253 to 1.733 s)
 - Throughput on average 2.7 bit/s
- Errors are infrequent, but often occur in bursts

Analysis of time between errors

Min.	25 % quantile	Median	75 % quantile	Max.
0.13 s	1.54 s	62.58 s	183.61 s	4147.85 s

- Messages larger than 4-bit need to be fragmented
 - Are errors independent from message length?



Data Transmission Test Case

- 66 bits consisting of weather forecast and DCF77 time signal were composed
- 6 parity bits added to subparts
- Transmission as 18 4-bit words with preamble
 - 75 % of transmissions were successful
 - Many unsuccessful transmission only partially miss the preamble, as the information was not processed fast enough
- A shortened **demonstration** can be visited in the upcoming session

Conclusions

- A novel way to accomplish broadcast transmissions of control data has been created – relying on electric fences
- The application of pulse position modulation realizes a, from the receiver side, very low power communication system
 - Although throughputs are low
- First experiments showed very low channel errors
- Robustness could possibly be increased by including sender-side data coding

Any questions?



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