

# Brzzz - A Simplistic but Highly Useful Secondary Channel for WSNs

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## Motivation

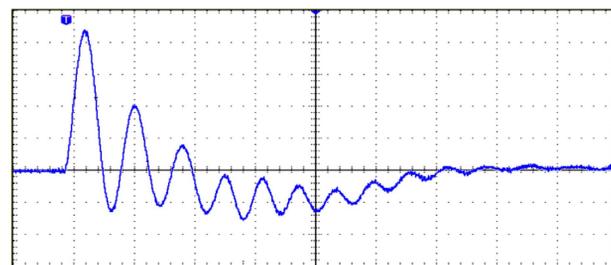
Time synchronization of several nodes is important for many WSN algorithms, components, and application scenarios. Therefore, it would be very beneficial if a low-cost method for such synchronization was available even for outdoor deployments. The same applies to low-power wakeup of nodes.

In this demo we present a concept that is based on an electric pulse generated by, e.g., a regular electric fence which can be detected and utilized by usual ultra low-power MCUs of a sensor node.

A broadcast signal that covers the entire network can be used as an almost cost-free side channel for triggering events, node synchronization or even unidirectional communication.

## Pulse of the Electric Fence

In lab-tests we measured the time domain as well as the frequency domain of the inducted signal. Awaiting a wide-band signal the actual signal of the electric fence has its center frequency at  $f_{brzz} = 25kHz$  and a bandwidth of about  $3kHz$ . The frequency between different generators might vary but the fading sine-shape equals.

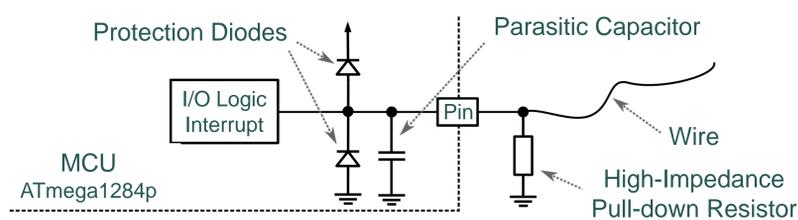


Pulse in Time Domain:  
X-Axis: 50  $\mu$ s/div,  
Y-Axis: 20.0 V/div

Considering that an electric fence usually fences a farmland with a perimeter of several hundreds of meters, such fences offer an ideal transmitting antenna for the signal with a wave-length of about  $\lambda = \frac{c}{f_{brzz}} = 11.96km$ .

## Pulse Detection

Actually a wire and a high-impedance pull-down of 4 M $\Omega$  are sufficient. The circuit for pulse detection is depicted in the following Figure:



The wire is connected to an interrupt pin of an ATmega1284p MCU of an INGA sensor node. The input pins of this MCU are fused by two diodes per default. Thus, the potentially high voltage that is induced in the wire cannot harm the MCU. A pin-change interrupt is used to trigger the rising and the falling edge of the signal while a timer is fired to measure the period of positive half-waves of the signal. The resulting pattern can be further used to filter the pulses from other interference.

## Utilization

As an external interrupt is able to wake-up an MCU even from deep-sleep states, a low-cost and area-wide wake-up is possible.

It turns out that the amount of detected half-waves gives an indication about the strength of the detected pulses. Considering several nodes with different distances to the electric fence, the center of a half-wave's period offers an anchor to synchronize the clock.

In theory it is also possible to establish a unidirectional broadcast communication by applying an asynchronous protocol (morse code).

According to DIN EN 60335-2-76 a minimum interval of 1s is prescribed. Thus, the achievable baud rate would be fairly low.

## Demonstration

We show the general proof-of-concept by a miniature testbed with a real electric fence and INGA sensor nodes.

Two nodes are deployed on the trial field. They detect and analyze the pulses and send the data via USB to a central server. A GUI displays all relevant parameters such as the amount and period of half-waves.

The jitter of the pulse detection is measured by using an XOR gate and an external timer. Moreover, the nodes use their own measurements to calculate the difference in time. Thus, we show the potential accuracy for synchronization.

