Raindrop intervalometer

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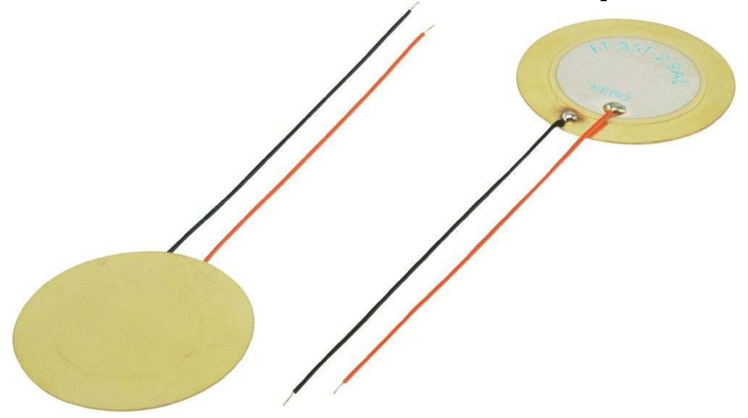
Theory

The idea is very simple. According to *Uijlenhoet & Stricker [1]*, rainfall that is more or less stable can be parameterized through one parameter, Λ. This implies that by measuring the intervals between drops hitting a surface, one should be able to estimate Λ and, thereby, most that is of interest regarding rainfall, including its radar cross section or backscatter. One could also simply measure the arrival rate of drops but the intervals add a bit robustness as they are supposed to follow a Poisson distribution. By simply keeping track of the first four moments of the interval distribution, one can estimate the associated Poisson distribution and derive variables such as the rainfall rate and drop-size distribution. One can also say something about the robustness of the underlying assumptions, such as the distribution being in equilibrium or not.

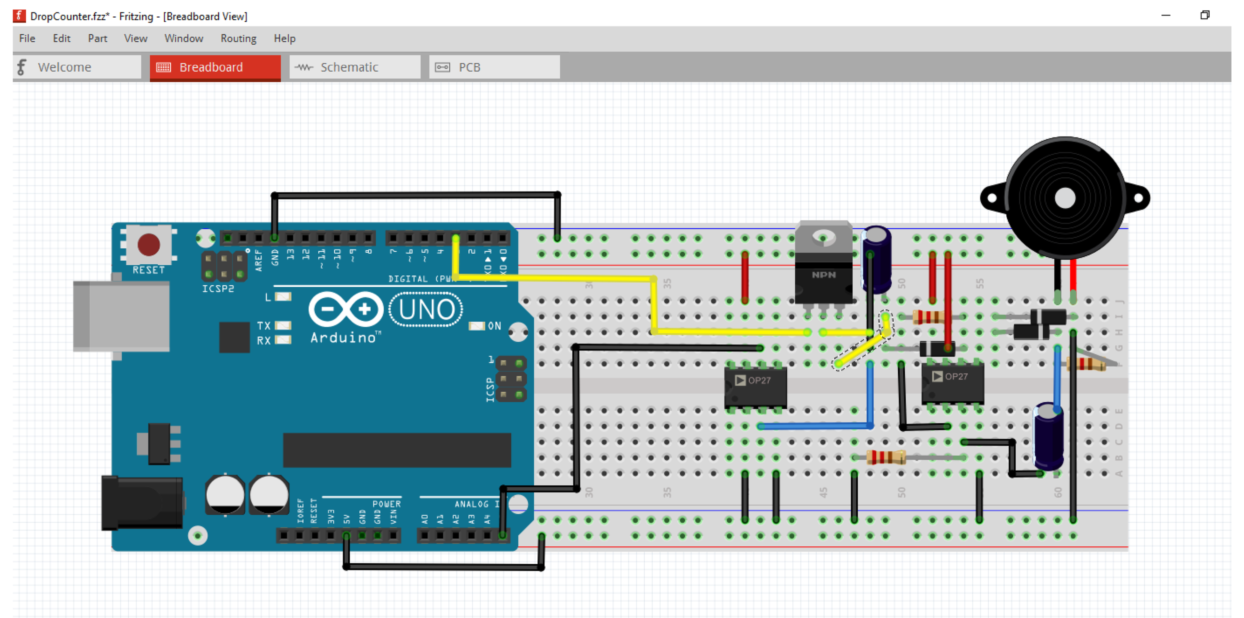
[1] Uijlenhoet, R., J. N. M. Stricker (1999). "A consistent rainfall parameterization based on the exponential raindrop size distribution." JoHyd 218(3): 101-127.

Design

To measure time intervals between rainfall drops, we make use of a simple piezo-electric element (€0.79) placed in a 3D-printed holder. To ensure that drops falling close to the holder are not registered, a simple laser-cut cork ring isolates the sensor acoustically. The signal from the piezo-element is amplified by a simple op-amp circuit that includes peak-detect-and-hold functionality. The output, or peak, is fed into an Arduino, which resets the circuit immediately after each detection through a MOSFET.



Piezo element



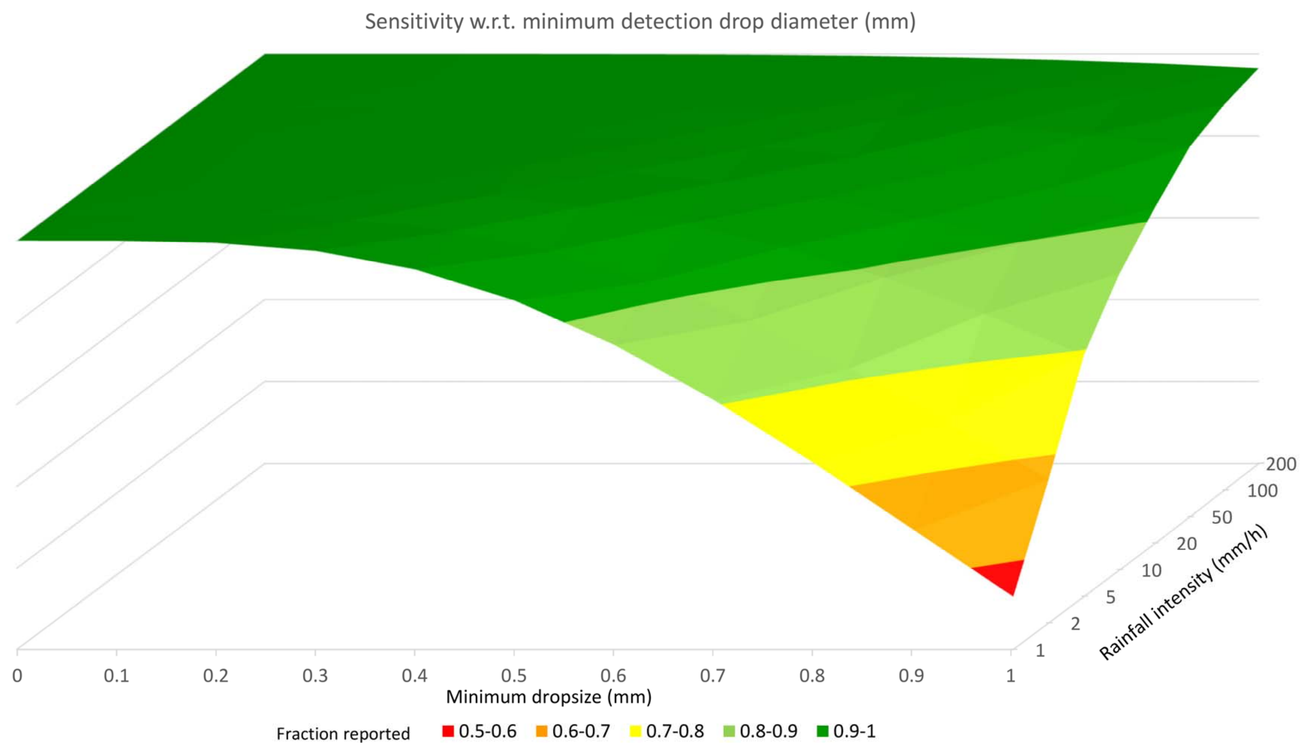
Basic circuit design

Detection thresholds

The piezo-electric element is not equally sensitive across its surface. A small drop in the middle will produce a signal comparable to that of a large drop at the edge. One could try to compensate for that effect but here we choose to make the sensor as sensitive as possible. By introducing a detection threshold, D_{min}, Eq. 61 in [1] becomes:

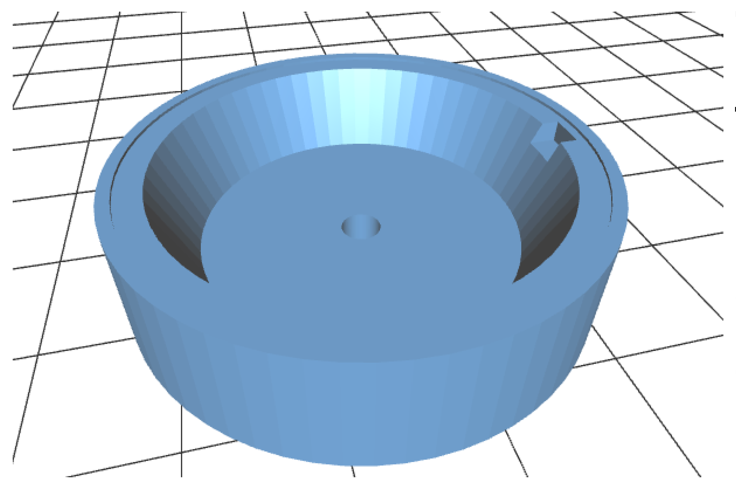
$$R = 6\pi \times 10^{-4} \alpha N_0 \Gamma(4+\beta, \Lambda \cdot D_{min})/(\Lambda^{4+\beta})$$

with R rainfall rate (mm/h), α=3.788 m/s, β=3 N_0=8000, and Γ now being the upper incomplete Gamma function (see figure).



Reported fraction of rainfall rate as function of smallest detected drop size and rainfall rate. For Dmin<0.6 mm, almost no correction is needed.

Open hardware



Piezo-element holder

The complete design follows the Open Hardware philosophy and all software used is either freeware, such as RDWorksV8, used for the laser-cutting of the cork isolation ring, and OpenSCAD used for the design of the piezo-element holder, or open source, such as the Arduino IDE.

Design files are, or will be, available at: https://github.com/nvandegiesen/Intervalometer

The design is meant to be used in citizen science projects but can also be used to test common assumptions underlying rainfall radar estimates.

open source hardware

BY

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